Appendix F

Air Quality Technical Appendix

Method of Analysis

Mobile6 - Emission Factor Modeling

Vehicle emissions factors are a critical input parameter to the air quality dispersion modeling. The Puget Sound Regional Council (PSRC) provided the vehicle emission factors used in this analysis based on calculations with the latest U.S. EPA vehicle emissions factor model, Mobile6.2. This tool calculates average in-use fleet emission factors for hydrocarbons, oxides of nitrogen, and carbon monoxide, and estimates emission rates in terms of grams of pollutant per vehicle mile traveled based on average travel speed and a wide array of vehicle classes. Mobile6.2 incorporates information on basic emission rates, driving patterns, separation of start and running emissions, improved correction factors, and changing fleet composition. The Mobile6 input parameters applied by PSRC were consistent with those used in the development of the latest Washington State Implementation Plan for CO.

CAL3QHC Dispersion Modeling Parameters

The CAL3QHC dispersion model is designed to calculate pollutant concentrations caused by transportation sources (EPA 1992). Geomatrix used CAL3QHC Version 2 to estimate peak-hour CO concentrations near the most traffic-congested locations. This model considers "free-flow" and "queue" emissions (based on Mobile6 emission factors) together with roadway geometry, wind direction, and other meteorological factors.

The following assumptions and parameters were used in the CAL3QHC modeling and are consistent with the Washington State CO SIP, CO Maintenance Plan, and EPA guidance for dispersion modeling (EPA 1992).

- Critical meteorological parameters were a 3280.8 feet mixing height, low wind speed (3.28 feet/second), and a neutral atmosphere (Class D).
- The modeling evaluated 72 wind directions (in 5-degree increments) to ensure worst-case conditions were considered for each receptor location.
- A "background" 1-hour CO concentration of 4 ppm was assumed to represent other sources in the project area at all locations.
- The p.m. peak-hour traffic conditions provided by the City traffic consultant would lead to the highest possible 1-hour and 8-hour CO concentrations.
- Model-calculated 1-hour concentrations were converted to represent 8-hour concentrations using a "persistence factor" (i.e., the ratio of 8-hour to 1-hour CO concentrations) to represent variability in both traffic volumes and meteorological conditions. The calculated persistence factor of 0.75 was used and is discussed below.
- The modeling configuration considered road links extending up to 1,000 feet from most intersections. Using the procedures required for the CAL3QHC dispersion model, both free flow and queue links were configured approaching and departing the intersections evaluated. Near road receptors were placed 10 feet, 82.5 feet, 165 feet, and 330 feet from cross streets, 10 feet from the nearest traffic lane, and 5.7 feet above the ground to correspond to a typical sidewalk location at breathing height. Modeling considered up to 48 near road receptors near the intersections.

Persistence Factor Calculation

The "persistence factor" represents variability in both traffic volumes and meteorological conditions and is for converting 1-hour model predicted CO levels to 8-hour levels. The calculation is based on averaging the ratios of the highest 8-hour CO concentrations with the highest 1-hour concentration that occurs within that same 8-hour period. For this project, CO data measured over the past three winters (when maximum CO levels typically occur) near the intersection of 148th Avenue NE with NE 24th Street was requested from the Puget Sound Clean Air Agency (PSCAA). The CO levels in each year were ranked from highest to lowest concentrations and the 10 highest non-overlapping 8-hour periods were selected. Then, the maximum 1-hour CO level within the corresponding 8-hour timer period was determined and used for the persistence factor calculation. The worst 8-hour CO levels from 2004 through 2007 and corresponding maximum 1-hour levels are listed in **Appendix Table 1**.

Intersection Screening/Selection and Cumulative Delay

The air quality analysis focused on signalized intersections, with particular emphasis on the most congested intersections that would be most directly affected by changes in traffic operations due to the proposed plan. EPA guidance suggests modeling intersections where the LOS would deteriorate to a "D" or worse due to a project. After the project-affected intersections are identified based on LOS, the intersections to be modeled must be selected. In the typical selection process, a comparison is made between the intersections with the worst (most congested) LOS, and those with the highest daily or peak-hour volumes. Intersections can also be selected when it is shown that they would be directly affected by a project to the degree that the LOS would be degraded (EPA 1992). Because the LOS during the PM peak hour is generally worse than the LOS during the AM peak hour, the PM peak-hour traffic data and LOS in the design year were used to rank intersections for this project.

To establish which intersections to consider for this project, the traffic data for the most congested intersections (i.e., those with the greatest p.m. peak-hour delay) were selected as a basis for screening probable intersections for consideration with modeling. Because many project-affected intersections perform at LOS D or worse in the traffic study, the intersections were ranked by total cumulative delay (i.e., intersection volume x average vehicle delay). This provides a good metric to compare which intersections are most affected by traffic. Then, from the intersections with the highest expected cumulative delay with the Action alternative in 2030, the single most congested intersection was selected for modeling. Because EPA suggests modeling at least three intersections with the worst delays, two additional intersections were selected for quantitative analysis. For this analysis, the remaining two intersections in the selection process were also based on general geographic location within the study area. The intent of this study is to not only model the intersection(s) with the greatest potential to affect air quality, but also to determine the extent of potential impacts throughout the study area. Based on EPA guidance, two additional intersections were also modeled at the 148th Avenue NE/ NE 24th Street intersection because of their proximity to the major intersection – the intersections of 148th Avenue NE with the 520 on/off ramps. This selection approach resulted in detailed air quality modeling of the overall worst-case intersections/area and the most congested intersection in each of two additional study areas. Project-affected intersections are listed in **Appendix Table 2**.

Appendix Table 1. Persistence Factor Calculations - NE24th in Bellevue

Year	Observed Day & Hour	8-Hr CO	Max 1-hour CO	Ratio
9/2004 - 9/2005	2/23/2005 21:00	4	5.3	0.75
	1/5/2005 20:00	3.8	5.9	0.64
	2/24/2005 21:00	3.4	4.6	0.74
	2/2/2005 21:00	3.2	4.3	0.74
	2/10/2005 22:00	3	3.8	0.79
	12/20/2004 19:00	2.9	4.1	0.71
	1/24/2005 21:00	2.9	5	0.58
	11/4/2004 19:00	2.8	4	0.70
	12/18/2004 20:00	2.8	3.7	0.76
	2/18/2005 21:00	2.8	4	0.70
			Average	**0.71**
9/2005 - 9/2006	11/23/2005 20:00	3.2	4.5	0.71
	12/11/2005 19:00	3	3.8	0.79
	10/21/2005 21:00	2.9	4.3	0.67
	1/24/2006 21:00	2.9	3.7	0.78
	12/16/2005 20:00	2.6	3.6	0.72
	12/13/2005 18:00	2.5	4.6	0.54
	12/15/2005 17:00	2.4	2.9	0.83
	1/20/2006 19:00	2.4	3.4	0.71
	11/22/2005 15:00	2.3	2.4	0.96
	12/10/2005 20:00	2.3	2.4	0.96
			Average	**0.77**
9/2006 - 2/2007	12/8/2006 20:00	3.7	5.1	0.73
	12/7/2006 19:00	3.4	4.4	0.77
	12/18/2006 18:00	3.2	4.2	0.76
	12/17/2006 20:00	2.9	3.4	0.85
	1/29/2007 19:00	2.7	3.5	0.77
	2/2/2007 21:00	2.6	3.9	0.67
	12/6/2006 20:00	2.4	3.3	0.73
	2/1/2007 21:00	2.3	3.2	0.72
	12/7/2006 7:00	2.2	2.5	0.88
	12/8/2006 11:00	2.2	2.6	0.85
			Average	**0.77**
			Overall Average	**0.75**

Calculation is based on averaging the ratios of the highest 10, non-overlapping 8-hour CO concentrations with the highest 1-hour concentration associated with each 8-hour level.

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Appendix Table 2. Intersection Cumulative Delay and Ranking Order

Street			2012 No Action		2030			
ID	N-S	E-W	Cumulative Delay (hr)	Order	Cumulative Delay (hr)	No Action	Cumulative Delay (hr)	Action
1	**148th Ave NE**	**NE 24th St**	**111**	**2**	**311**	**5**	**143**	**2**
2	Bel-Red Rd	NE 24th St	29	16	63	15	76	21
6	152nd Ave NE	NE 24th St	15	26	71	29	19	16
10	***148th Ave NE***	***EB 520 offramp***	***14***	***27***	***24***	***28***	***22***	***29***
11	148th Ave NE	NE 22nd St	13	28	58	23	36	23
12	***148th Ave NE***	***EB 520 ramps***	***8***	***31***	***13***	***31***	***15***	***32***
19	140th Ave NE	NE 24th St	24	18	68	20	50	17
21	140th Ave NE	Bel-Red Rd	57	9	112	7	130	11
22	140th Ave NE	NE 20nd St	58	8	108	4	146	12
59	**WLSP**	**Leary/ WB 520**	**126**	**1**	**320**	**1**	**338**	**1**
65	156th Ave NE	Bel-Red Rd	27	17	64	9	100	19
66	156th Ave NE	NE 24th St	21	22	60	16	70	22
68	WLSP	EB 520 offramp	73	4	281	2	232	3
87	Bel-Red Rd	NE 20th St	21	21	36	21	46	26
93	148th Ave NE	Bel-Red Rd	88	3	213	8	123	4
117	148th Ave NE	NE 20th St	60	7	183	11	94	6
129	**148th Ave NE**	**NE 51st St**	**46**	**10**	**211**	**3**	**195**	**5**
130	148th Ave NE	NE 40th St	33	13	154	12	84	9
131	WB 520 frontage	NE 51st St	3	35	7	35	7	35
132	EB 520 frontage	NE 51st St	7	33	15	33	12	31
135	156th Ave NE	NE 51st St	15	25	63	22	37	20
137	156th Ave NE	NE 40th St	62	5	117	6	140	10
138	156th Ave NE	NE 31st St	23	20	51	19	54	24
142	156th Ave NE	NE 36th St	61	6	91	10	95	14
145	159th Pl NE	NE 40th St	9	29	13	32	14	33
147	WLSP	NE 51st St	30	15	167	24	33	7
151	WLSP/Bel-Red Rd	WLSP	20	23	72	30	17	15
152	Bel-Red Rd	NE 40th St	38	11	93	17	66	13
179	148th Ave NE	NE 35th St	16	24	156	14	82	8
199	148th Ave NE	WB 520 offramp	32	14	65	18	54	18
203	WLSP	Marymoor Pkwy	7	32	26	26	26	28
225	EB 520 frontage	NE 40th St	24	19	32	25	26	27
228	WB 520 frontage	NE 40th St	35	12	48	13	83	25
260	156th Ave NE	NE 45th St	4	34	8	34	8	34
276	150th Ave NE	NE 40th St	9	30	20	27	22	30
Plan-level Cumulative Delay:			**1148**		**3286**		**2559**	

Modeled intersections are indicated in Bold. Italicized intersections were selected due to proximity with major intersection.

Compiled by Geomatrix Consultants, Inc., 2007

Existing Conditions

Air quality is generally assessed in terms of whether concentrations of air pollutants are higher or lower than ambient air quality standards set to protect human health and welfare. Ambient air quality standards are set for what are referred to as "criteria" pollutants (e.g., carbon monoxide - CO, particulate matter, and sulfur dioxide - SO2). Three agencies have jurisdiction over the ambient air quality in Bellevue: the U.S. Environmental Protection Agency (EPA), the Washington State Department of Ecology (Ecology), and PSCAA. These agencies establish regulations that govern both the concentrations of pollutants in the outdoor air and rates of contaminant emissions from air pollution sources. Although their regulations are similar in stringency, each agency has established its own standards. Unless the state or local jurisdiction has adopted more stringent standards, the EPA standards apply. Applicable local, state, and federal ambient air quality standards are displayed in **Appendix Table 3**. Note that the "primary" federal standards are intended to protect human health with an adequate margin of safety, while the "secondary" standards are intended to protect against other effects like damage to vegetation.

Ecology and PSCAA maintain a network of air quality monitoring stations throughout the Puget Sound area. In general, these stations are located where there may be air quality problems, and so are usually in or near urban areas or close to specific large air pollution sources. Other stations located in more remote areas provide indications of regional or background air pollution levels. Based on monitoring information for criteria air pollutants collected over a period of years, Ecology and EPA designate regions as being "attainment" or "nonattainment" areas for particular pollutants. Attainment status is therefore a measure of whether air quality in an area complies with the federal health-based ambient air quality standards for criteria pollutants. Once a nonattainment area achieves compliance with the National Ambient Air Quality Standards (NAAQSs), the area is considered an air quality "maintenance" area. The purpose of this air quality assessment is to determine whether potential transportation improvements proposed in the updated neighborhood plan would comply with the NAAQSs and whether the updated plan presents any probable significant adverse environmental impacts to air quality.

Typical air pollution sources in the Redmond Overlake area include vehicular traffic, commercial and retail businesses, light industrial uses, and residential wood-burning devices. While many types of pollutant sources are present, the largest contributors of typical pollutant emissions are traffic on area roads and residential wood burning. For traffic sources, the pollutant typically used as an indicator of potential air pollution problems is carbon monoxide (CO). Other pollutants generated by traffic include the ozone precursors: hydrocarbons and nitrogen oxides. Fine particulate matter (PM_{10} and $PM_{2.5}$) is also emitted in vehicle exhaust and generated by tire action on pavement (or unpaved areas) although these levels are small compared with other sources (e.g., a wood-burning stove). Sulfur oxides and nitrogen dioxide are also both emitted by motor vehicles, but ambient concentrations of these pollutants are usually not high except near large industrial facilities. Some of these pollutants are discussed further below.

Appendix Table 3. Ambient Air Quality Standards for Criteria Pollutants

Pollutant	National (EPA)		Washington	Local
	Primary	Secondary	Ecology	PSCAA
Inhalable Coarse Particulate Matter (PM10)				
Annual Average ($\mu g/m^3$)	[a]		50	54 [c]
24-Hour Average ($\mu g/m^3$)	150 [b]		150 [b]	154 [d]
Fine Particulate Matter (PM2.5)				
Annual Average ($\mu g/m^3$)	15 [e]	15 [e]		15 [c]
24-Hour Average ($\mu g/m^3$)	35 [f]			35 [g]
Carbon Monoxide (CO)				
8-Hour Average (ppm) [b]	9		9	9.4
1-Hour Average (ppm) [b]	35		35	35

NOTES: $\mu g/m^3$ = micrograms per cubic meter; **ppm** = parts per million; **blank cells** indicate no standard

All values not to be exceeded except as noted; all averages arithmetic.

[a] Particles <10 micrometers in size; Federal annual PM10 standard revoked as of Sept. 21, 2006

[b] Not to be exceeded more than once per year

[c] The 3-year annual average of the daily concentrations must not exceed level

[d] The 3-year average of the 99th percentile (based on the number of samples taken) of the daily concentrations must not exceed level

[e] Attainment based on the 3-year average of the weighted annual mean PM2.5 concentrations from single or multiple community-oriented monitors not exceeding level

[f] Attainment based on the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area not exceeding level

[g] The federal 24-hour standard for PM2.5 was revised as of Sept. 21, 2006. The current PSCAA standard of 65 ppm is based on the previous federal standard but, has been superseded by the new federal limits. Although PSCAA has not yet adopted the new federal standard, it must do so soon. So as to avoid confusion, only the prevailing federal standard is reported to represent the maximum level that PSCAA can adopt.

Source: Geomatrix Consultants, Inc. based on most recent local, state, and federal rules.

Carbon Monoxide

Carbon monoxide is the product of incomplete combustion. It is generated by transportation sources and other fuel-burning like residential space heating, especially heating with solid fuels like coal or wood. Carbon monoxide is usually the pollutant of greatest concern related to roadway transportation sources because it is the pollutant emitted in the greatest quantity for which there are short-term health standards. CO is a pollutant whose impact is usually localized, and CO concentrations typically diminish within a short distance of roads. The highest ambient concentrations of CO usually occur near congested roadways and intersections during wintertime periods of air stagnation.

The Redmond-Overlake area is located in the central portion of the Puget Sound region CO nonattainment area established in 1991 that encompassed a large portion of the Everett-Seattle-Tacoma urban area. EPA redesignated the Central Puget Sound region as attainment for CO in 1997, and the region remains a CO air quality maintenance area. There have been no measured violations of the standards in many years, and measured CO levels at all monitoring locations have shown a decreasing trend in CO concentrations since the early 1990's (EPA 2007). These trends are the result of federal, state and local plans and vehicle emission control requirements designed to reduce vehicle emissions by implementing use of lower pollutant-emitting vehicles and cleaner fuels.

Particulate Matter (PM_{10} and $PM_{2.5}$)
Particulate matter air pollution is generated by industrial activities and operations, fuel combustion sources like residential wood burning, motor vehicle engines and tires, and other sources. Federal, state, and local regulations set limits for particles concentrations in the air based on the size of the particles and the related potential threat to health. When first regulated, particle pollution was based on "total suspended particulate," which included all size fractions. As sampling technology has improved and the importance of particle size and chemical composition have become more clear, ambient standards have been revised to focus on the size fractions thought to be most dangerous to people. At present, there are standards for PM_{10}, or particles less than or equal to about 10 micrometers (microns) in diameter as well as for $PM_{2.5}$, or particulate matter less than or equal to 2.5 microns in diameter. The latter size fraction is now thought to represent the most dangerous size fraction of airborne particulate matter because such small particles (e.g., a typical human hair is about 100 microns in diameter) can be breathed deeply into lungs. In addition, such particles are often associated with toxic substances that are deleterious in their own right that can adsorb to the particles and be carried into the respiratory system.

Based on the most recent studies, EPA has recently redefined the size fractions and set new, more stringent standards for particulate matter based on fine ($PM_{2.5}$) and coarse (PM_{10}) particulate matter. The new standards focus on the smaller size fractions.

There are several $PM_{2.5}$ monitoring stations in Puget Sound, including one at 305 Bellevue Way NE. Measured 24-hour and annual average concentrations of both PM_{10} and $PM_{2.5}$ at all monitoring locations in the Puget Sound area since 1997 have complied with the applicable ambient air quality standards (PSCAA 2007). But with adoption of a new more stringent standard for $PM_{2.5}$ (as of 9/21/06, EPA 2006), several areas of the Puget Sound region may once again be out of compliance with the federal fine particulate matter standard. As an example, in 2002 and 2003, the Bellevue Way monitor measured an exceedance or near exceedance of the new $PM_{2.5}$ 24-hour standard but measured concentrations decreased in the following two years to below-standard levels (PSCAA 2007).

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