Vancouver CO Maintenance Plan
2002 Seasonal Emission Inventory Detail

Appendix D

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Prepared by:
The Southwest Clean Air Agency, the Washington Department of Ecology
and
the Southwest Washington Regional Transportation Council

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1 Introduction and Summary

1.1 Background and Purpose

A base year Carbon Monoxide (CO) emissions inventory is part of the overall CO Limited Maintenance Plan (LMP) submittal for the Vancouver CO maintenance area as agreed upon in the Vancouver CO State Implementation Plan (SIP) development plan. This 2002 base year CO emission inventory for the maintenance area is used in the second 10-year maintenance plan to provide current estimates of wintertime CO emission levels in the Vancouver CO Maintenance Plan area. It can also be used in future years for CO emission inventory comparisons. Should the CO levels be thought to be increasing in the Vancouver CO maintenance plan area during the next 10 years, then comparisons can be made using this document to determine which CO emissions sources have changed significantly (if any).

The CO LMP option does not require an emissions budget. The 1995 EPA guidance memorandum by Joseph Paisie referenced in the Vancouver CO Plan states that the motor vehicles emission budgets (MVEB) in limited maintenance plan areas may be treated as essentially not constraining for the length of the maintenance period. This is because it is unreasonable to expect that the area will experience so much growth that a violation of the CO NAAQS will result. Therefore, regional conformity is presumed and regional emissions analyses and emission budget tests are not required.

The development of this wintertime CO emission inventory for the Vancouver CO maintenance area relied heavily on the previous emission inventory work at the Southwest Clean Air Agency (SWCAA) and the Washington State Department of Ecology (Ecology). SWCAA does annual point source emission inventories for a variety of reasons and Ecology prepared a comprehensive annual volatile organic compound (VOC), criteria pollutant, and toxic air pollutant (TAP) emission inventory for the entire state of Washington as required by the Environmental Protection Agency's Consolidated Emission Reporting Rule (CERR). Several of the calculations in this inventory were based on methodologies used in the 2002 Ecology National Emission Inventory (NEI) submittal.

1.2 CO Sources within the Vancouver CO Maintenance Area

The inventory includes estimates of the criteria pollutant CO for the sources shown in the table below.

Table 1-1 - Sources Inventoried

Source Category
Point Sources
Onroad Mobile Sources
Nonroad Mobile Sources from EPA NONROAD 2004 (Excluding Ships, Locomotives and Aircraft)
Ships
Locomotives
Aircraft
Residential Yard Waste Burning
Residential Trash Burning
Residential Wood Combustion
Residential and Commercial Fuel Combustion

1.3 Spatial Resolution

The inventory was developed for sources within the Vancouver CO maintenance area (or Air Quality Management Area) boundary unless specifically indicated otherwise. Several of the emission categories had to be calculated at the county level and then reduced to the CO maintenance area based on population, household, or other surrogate data.

1.4 Temporal Resolution

The inventory was developed for a typical winter day. Generally this meant that emissions were calculated as winter seasonal average daily emissions (except as noted in the text). Generally, Dec-Feb was classified as winter. Abbreviations used are tpy (tons per year) and tpsd (tons per season day).

1.5 Summary Table

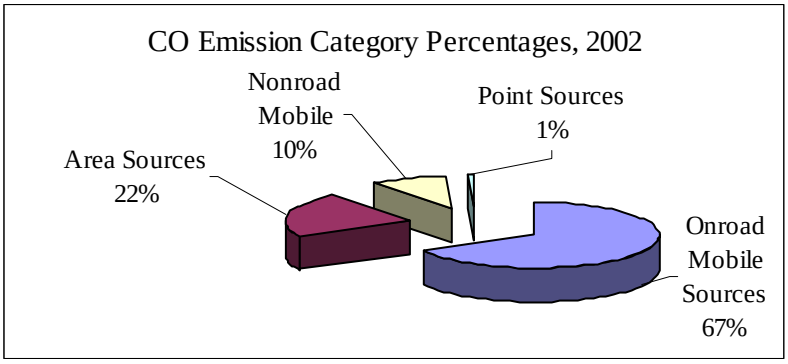
The following table is a summary of the base 2002 Vancouver CO maintenance area emission inventory for a typical winter day. The methodologies used for calculating emissions for each emission category are outlined in the remainder of this document.

Table 1-2: Summary Table

Vancouver CO Maintenance Area
Carbon Monoxide 2002 Emission Summary

Main Source Category		CO Emissions Pounds per Winter Day (lb/d)
Point Sources		
	Major Point Sources (>50 tpy each)	3,414
	Minor Point Sources (> 1 tpy each)	983
	Sub Total:	**4,396**
Onroad Mobile Sources		
	Freeway	80,751
	Arterial	259,080
	Ramp	21,413
	Local	21,414
	Intra-Zonal	401
	Sub Total:	**383,058**
Non-road Mobile Sources		
	Aircraft	1,070
	Commercial Marine Vessels	385
	Recreational Marine	182
	Railroads	380
	Railway Maintenance Equip.	60
	Lawn and Garden Equipment	14,871
	Recreational Vehicles	585
	Light Commercial equip.	24,689
	Industrial Equip.	6,204
	Construction Equip.	8,413
	Sub Total:	**56,837**
Area Sources		
	Small Industrial Sources < 1 tpy each	88
	Residential/Commercial Fuel Combustion	1,556
	Residential Wood Combustion	122,226
	Trash Burning	1,411
	Residential Yard Waste Burning	1,096
	Sub Total:	**126,377**
	Total:	570,669

Figure 1, Percentage of Emission Categories, based on lbs/winter day



2 County Demographics and Other General Activity Indicators

Emissions estimation methods for many source categories rely on surrogate parameters as indicators of activity. For example, to estimate the amount of woodstove activity, the number of households is required. County and CO maintenance area population and household estimates used in emissions calculations described under Section 3 are presented in Table 2-1.

For this work GIS was used to calculate the percentage of Clark County, Washington population and households that were living within the Vancouver CO maintenance area boundary. Census block group population GIS data was obtained from the Washington Office of Financial Management (OFM) to determine 2000 Census percentages that were then applied to intercensal population and housing estimates for 2002.

Table 2-1: 2002 Population and Households

Area	Population			Households		
	Incorporated	Unincorp.	Total	Incorporated	Unincorp.	Total
Clark County	187,690	175,710	363,400	77,421	65,573	142,994
Vancouver CO Maintenance Area	171,440	79,142	250,582	71,698	31,447	103,145

3 Base Year 2002 Emissions Estimates

CO emissions were estimated for the four major anthropogenic source categories. These source categories are point, area, nonroad mobile, and onroad mobile. The following sections describe the sources of data and the overall methodologies for calculating CO emissions for the Vancouver AQMA.

3.1 Point Sources

Stationary point sources for this inventory are stationary sources that emit CO emissions and lie within the CO maintenance area boundaries. Under EPA definition, a major CO point source is one with potential to emit 100 tons per year or more of carbon monoxide. Point sources with emissions 50 tpy were included in the 1992 inventory that was the basis for the 1996 plan because this information was readily available. For the purposes of this 2002 point emission inventory, all CO sources with emissions in 2002 > 1 tpy are included. Remaining point sources of CO emissions in 2002 that were less than one ton per year totaled 88 lb/day and were included

with the area source emissions. There is one major source inside the AQMA, Fort James Camas. Emission information on this source was obtained from Ecology.

3.1.1 Temporal Allocation

Individual facility operating schedules were used to convert tons per year data into pounds per typical winter day when available. For sources where data was not available, a work week of 8 hours a day and 5 days per week was assumed.

3.1.2 Emission Rates and Estimates

The emission summaries were compiled by query from SWCAA's Access database. Each facility's emissions estimates were summed. The point source emission summary includes a total in tons per year and pounds per typical winter day. The one remaining major point source for carbon monoxide is the Fort James Camas LLC paper mill. Table 3-1 details the 2002 point source CO emissions for the maintenance area.

Table 3-1: 2002 Vancouver CO Maintenance Area Point Source Emissions

Major Sources	SIC	CO (tpy)	CO (lbs/day)
Fort James Camas LLC	2611	623	3414
Small Point Sources	**SIC**	**CO (tpy)**	**CO (lbs/day)**
Boise White Paper, LLC	2621	1	4
Clark County Public Works/Salmon Creek	4952	1	9
Clark Public Utilities/ River Road Generating Project	4911	9	47
Evergreen School District No. 114	8211	2	18
Frito Lay, Inc.	2099	27	172
Great Western Malting	2083	3	15
Hannah Collision Center	7532	2	16
Hewlett-Packard Company	3674	1	9
Kyocera Industrial Ceramics Corp.	3679	1	11
Lakeside Ind./ Camas	2951	14	107
Landa Inc.	5046	8	63
Northwest Packing Company	2033	3	21
Northwest Pipeline / Washougal	4911	0	4
Pacific Rock Products, LLC/A2 - Orchards	2951	6	44
Pendleton Woolen Mills	2231	4	34
SEH America, Inc.	3674	3	18
SW WA Medical Center/ St. Joseph Campus	2951	2	18
Todd's Auto Body	7532	1	9
Vancouver Iron & Steel	3325	26	200
Vancouver School District No. 137	8211	3	25
Veteran's Administration Hospital	8069	2	14
WaferTech LLC	3674	1	6
Western States Asphalt Company / English Pit	2951	15	120
Small Point Source Summary		**135**	**984**
Total Major and Minor Point Sources		**758**	**4396**

3.2 Onroad Mobile Sources

Onroad mobile source emissions are those generated by operating vehicles on public roadways. Emissions from fuel combustion were estimated using the EPA mobile source emissions model MOBILE6.2. Emissions from mobile sources for a winter's day average was 383,058 lbs/day. The information used to calculate onroad mobile emissions is described below. The MOBILE6.2 input files can be found in the Mobile Section of Appendix E, Supporting Detail for Emission Inventory.

3.2.1 Activity Level and Spatial Allocation

The activity measurement for onroad mobile sources is the number of miles driven. The units are typically given in average daily vehicle miles traveled (ADVMT). ADVMT is normally estimated from traffic counts collected over a sampling area, or through use of travel demand models, which simulate vehicle travel patterns based on demographic and economic parameters and are validated with traffic counts.

For this inventory, ADVMT was calculated by the Southwest Washington Regional Transportation Council (RTC). A breakout of ADVMT was made to identify vehicles operating within Clark County originating from the Clark County I/M program, the Portland, Oregon I/M program, or neither area. For each link in the model transportation network , the link ADVMT estimate is further disaggregated into three time periods to account for variations in speed by facility throughout the day. The three time periods are the am peak 1-hour, pm peak 2-hour and remaining off-peak hours. Link speeds for these time periods are also estimated.

Table 3-2: 2002 Seasonally Adjusted ADVMT by Facility Type

Facility Type	ADVMT
Freeway	1,108,668
Arterial	3,725,487
Ramp	239,143
Local	364,097
Intra-Zonal	6,811
Total	5,444,206

3.2.2 Temporal Allocation

RTCs regional travel model produces ADVMT, which is an average of daily VMT for the entire year. As travel demand varies over the year, higher in the summer and lower in the winter, RTC seasonally adjusts the travel model ADVMT to winter and summer daily VMT using factors developed from traffic count data from local freeways and arterial/locals. Winter adjustment factors are 0.939 for freeways and 0.948 for arterials/locals. Summer adjustment factors are 1.054 for freeways and 1.035 for arterials/locals.

3.2.3 Emission Rates: MOBILE6.2

Emission rates in grams per mile were generated using the EPA model MOBILE6.2.[1] Emission rates were generated for unique combinations of: facility type, vehicle type, speed, and I/M area. Local data was used for the following input parameters: evaluation month, registration distribution, temperature, humidity, inspection and maintenance (I/M) program, speed by facility

type, and fuel parameters for Reid vapor pressure (RVP), fuel program, diesel sulfur content. The parameters are described below.

3.2.3.1 Registration Distribution

Washington has a substantially older fleet than the national average. To model the effect of the older fleet, local data from the Washington State Department of Licensing (DOL) was used to calculate the vehicle age registration distribution.[2]

3.2.3.2 Temperature and Humidity

Average monthly minimum and maximum temperatures for 2002 from the Vancouver 4NNE meteorological station were used to develop the MOBILE6.2 input temperature parameters.[3] Because information required to calculate average monthly humidity values for 2002 were not readily available, long-term average (1961-1990) humidity, and pressure from Portland, Oregon were used to develop the MOBILE6.2 input humidity parameters.[4]

The humidity value required in MOBILE6.2 is a mixing ratio in mass of water vapor per unit mass of dry air. A calculation formula based on relative humidity, temperature and pressure was distributed with MOBILE6.2.[5] EPA guidance for calculating the ratio states that the lowest ratio of the day(s) should be used (humidity is a daily, not hourly input). As an alternate, the highest ratio that does not result in a relative humidity greater than 100% can be used.[6]

Data from reference 4 was used to calculate the ratios. Average monthly relative humidity is available for four different hours: 4, 10, 16 and 22. In the vast majority of cases, hour 4 relative humidity is the highest, and hour 16 is the lowest. These hours roughly compare with the expected hours of the minimum and maximum temperatures. Using hour 4 and 16 relative humidity with the average daily pressure, and minimum and maximum temperatures, respectively, ratios were calculated. The minimum temperature and hour 4 relative humidity produced the lowest ratio, and kept the relative humidity from exceeding 100% even at the maximum temperature of the day. The calculation using the maximum temperature and hour 16 relative humidity produced a higher ratio, but often exceeded 100% relative humidity at the minimum temperature. The alternate guidance of using the highest ratio that does not result in a relative humidity greater than 100% produced higher ratios than the hour 4 calculations, but actual relative humidity rarely is 100%; therefore, the alternate EPA guidance was not used.

Table 3-4: Average Monthly Humidity Mixing Ratios, Longterm Averages

month	Portland
Jan	24
Feb	26
Mar	29
Apr	32
May	40
Jun	49
Jul	55
Aug	64
Sep	49
Oct	39
Nov	31
Dec	25

Table 3-5: Average Monthly Maximum Temperature, 2002

month	Vancouver
Jan	44.8
Feb	51.7
Mar	51.0
Apr	59.5
May	64.5
Jun	73.8
Jul	80.1
Aug	80.2
Sep	76.4
Oct	63.1
Nov	55.2
Dec	48.8

Table 3-6: Average Monthly Minimum Temperature, 2002

month	Vancouver
Jan	34.5
Feb	33.2
Mar	34.3
Apr	40.0
May	43.5
Jun	49.9
Jul	54.5
Aug	51.9
Sep	45.5
Oct	38.6
Nov	35.7
Dec	35.4

The values listed below are the average of the 2002 actual Dec, Jan, Feb monthly average values for minimum and maximum temperature and humidity The following temperature and humidity values were used for the 2002 emissions estimate:

Humidity – 25
Avg. Max Temp – 48.4
Avg. Min Temp – 34.4

3.2.3.3 Inspection and Maintenance (I/M) Program

A vehicle Inspection and Maintenance (I/M) program is operated in Clark County. Input parameters have been tracked by WDOE to allow modeling of the program.[7, 8, 9] Input parameters are as shown in the input files can be found in Appendix Mobile Section of Appendix E, Supporting Detail for Emission Inventory.

3.2.3.4 Facility Type and Speed

The ADVMT data was estimated by RTCs regional travel model using the Freeway, Arterial, Local and Ramp facility classes in MOBILE6.2. MOBILE6.2 facility class is a model link attribute.

The speeds chosen for this inventory are a combination of MOBILE6.2 fixed speeds for ramps and locals and RTC model link speeds for freeways and arterials. The fixed speed for locals was 12.9 mph and 34.6 mph was used for ramps. Speeds are not provided by vehicle type. Link speeds are estimated in the regional travel model by following three time periods: am peak 1-hour, pm peak 2-hour and remaining off-peak hours.

3.2.3.5 Reid Vapor Pressure (RVP)

RVP for Clark County varies by time of year. There are no CO Maintenance Plan related requirements for Clark County RVP in the wintertime. Fuel surveys to determine actual RVP are performed periodically by the Alliance of Automobile Manufacturers (AAM). The Environmental Protection Agency (EPA) made some of this data available to WDOE for 1999.[10] EPA did not collect data for years after 1999 and the data is expensive; therefore, the 1999 survey values were retained for 2002.

EPA also provided a methodology to calculate monthly RVP values in the 1996 and 1999 NEI. The methodology used the ASTM (American Society for Testing Materials) schedule of seasonal and geographical volatility classes to interpolate between summer and winter RVP values.[11, 12] Monthly RVP assignments are shown in the table below. The RVP value used in the winter CO daily emission inventory was 13.8 psi

Table 3-8: Clark County Fuel RVP Assignments, psi

Month	Clark
Jan	13.8
Feb	12
Mar	12
Apr	12
May	8.5
Jun	7.8
Jul	7.8
Aug	7.8
Sep	7.8
Oct	9.6
Nov	12
Dec	13.8

3.2.3.6 Oxygenated Fuels

The oxygenated fuel program began in 1992 for five counties in Washington: Clark, King, Pierce, Snohomish and Spokane.[13] The program was discontinued in all of the counties except Spokane County in 1996. However, in 2002 there were stations in Clark County (mainly ARCO) distributing oxygenated fuel with 10% Ethanol that accounted for approximately 35.95% of the total fuel supply purchased. This resulted in a county wide fuel oxygenate percentage of 1.24% using the calculation:

Gasoline oxygen wt = 0.3448 * volume % Ethanol * Ethanol Market Share
= 0.3448 * 0.1 * 0.3595
where 0.3448 is the conversion factor for Ethanol oxygen volume to weight.

3.2.3.7 Tier 2 Low Sulfur Fuel Phase-in

In calendar year 2000, gasoline sulfur content began to be affected by federal controls (Tier 2 low sulfur fuels rule). The rule phases in lower sulfur fuels over a several year period. The default values for Clark County, WA in MOBILE6.2 were used for this parameter.

3.2.3.8 Diesel Sulfur Content

Diesel sulfur content has no affect on CO emissions in MOBILE6.2.

3.2.4 Emissions Estimates

All vehicle emission rates in gram per mile were calculated in MOBILE6.2 for each I/M origination area; Clark County, WA I/M vehicles, Portland, OR I/M vehicles and non-I/M vehicles. The emission rates were multiplied by the seasonally adjusted link VMT estimates for each of the three I/M cases and across three time periods of the day by facility type and speed to produce the final mobile emissions estimate. The seasonal grams/day calculated by the MOBILE6.2 model for Winter CO are shown below.

Table 3-9: Mobile 6.2 output for Vancouver Winter CO emissions, seasonal gram/day

Road type	Winter CO, gr/day
Freeway	36,627,855
Arterial	117,515,879
Ramp	9,712,707
Local	9,713,120
Intra-Zonal	181,688
Total.	173,751,248

Emissions of CO from mobile sources in the Vancouver CO Maintenance area are 383,058 lbs/winter day. Table 3-10 shows the contribution from each road type source.

Table 3-10: 2002 Winter CO Emissions for Vancouver Ozone Maintenance Area

Road type	Pounds/Day
Freeway	80,751
Arterial	259,080
Ramp	21,413
Local	21,414
Intra-Zonal	401
Total	383,058

3.3 Nonroad Mobile Sources, Excluding Ships, Locomotives and Aircraft

The Nonroad Mobile category includes emissions estimates from gasoline, diesel, compressed natural gas (CNG) and liquefied petroleum gas (LPG) fueled equipment. In the EPA NONROAD2005 model,[14] equipment types are compiled into 12 categories:

Recreational Vehicles	Logging
Construction	Airport Service

Industrial	Underground Mining
Lawn and Garden	Oil Field
Agricultural	Railway Maintenance
Commercial	Marine Recreation

Emissions from Nonroad Mobile sources are shown below. Emissions from ships, locomotives and aircraft as discussed in sections 3.4, 3.5, and 3.6are included to show the complete nonroad emissions totals:

Table 3-11: Nonroad Mobile Source Emissions, lbs/winter day

Non-road Mobile Sources	Lbs/ winter day
Aircraft	1,070
Commercial Marine Vessels	385
Recreational Marine	182
Railroads	380
Railway Maintenance Equip.	60
Lawn and Garden Equipment	14,871
Recreational Vehicles	585
Light Commercial equip.	24,689
Industrial Equip.	6,204
Construction Equip.	8,413
Total	**56,837**

3.3.1 Activity Level

NONROAD2005 inputs were set to Clark County wintertime specific parameters. NONROAD2005 calculated county wide emissions for each of the categories listed above using default activity data that EPA has developed for Clark County, WA and put into files referenced by the model. The table below shows the specific parameters used.

Table 3-12 Nonroad Wintertime Specific Parameters

	Typical Winter Day
County	Clark
Gas RVP	13.8
Oxygen Wt%	1.24
Gas Sulfur Wt%	0.0383
Diesel Sulfur Wt%	0.2283
CNG/LPG Sulfur Wt%	0.0123
Min T (F)	34.48
Max T (F)	44.77
Avg. T (F)	39.63
Stage II Control %	0

3.3.2 Spatial Allocation

The NONROAD2005 model emissions estimates are reported by county for inventory year 2002. The County totals were adjusted to the Vancouver CO Maintenance area using different surrogates. The following table shows the surrogates used to reduce the county wide emissions to the Vancouver CO AQMA. Population and Household surrogates are based on 2002 Office of Financial Management (OFM) values.

Table 3-13: Nonroad Category Spatial Allocation Surrogates

NONROAD 2005 Category	Surrogate Used to Apportion Emissions	Estimated Fraction of County Emissions occurring within AQMA
Recreational	% of land in AQMA	25%
Construction	Population	83%
Industrial	Population	83%
Lawn and Garden	Households	85%
Agricultural	Agricultural Land	0%
Commercial	Population	83%
Logging	Timber Harvest	0%
Airport Service	% of airports in AQMA	80%
Underground Mining	Mining operations in AQMA	0%
Oil Field	Oil operation in AQMA	0%
Railway Maint. Equip.	% of major railway in AQMA	67%
Marine Recreation	% of Columbia and Lewis Rivers Bordering AQMA	50%

3.3.3 Temporal Allocation

The January monthly average temperature was used to calculate seasonal average temperatures.

3.3.4 Emission Rates

Winter time fuel parameters were set as shown in the table below. The wintertime Reid Vapor Pressure (RVP) was set to 13.8. Fuel oxygen content was calculated at 1.24 % using fuel throughput records for fuel suppliers using ethanol blends in Vancouver. SWCAA estimates that 10% ethanol by volume is blended into gasoline year round at ARCO and some BP stations.

Clark County currently has 35.95% of the gasoline blended even though it is not required. Therefore oxygen percentage was calculated using the following equation:

(Gasoline oxygen wt = 0.3448 * volume % Ethanol = 0.3448 * 0.1 * 0.3595).

The diesel sulfur content value was set to 0.228% and a CNG/LPG sulfur content of 0.0123was used. The CNG/LPG sulfur content was based on data from ODEQ and values used in Portland-Vancouver ozone modeling work. The diesel fuel sulfur content was based on the national average for land-based diesel engines from Chapter 3: Emission Inventory for EPA Tier 4 Nonroad Diesel Rule Regulatory Analysis. Gasoline sulfur content of 0.0383% was obtained from the MOBILE6.2 default files based on the low sulfur fuel phase-in schedule.

Table 3-14: Fuel Parameters

Fuel	Sulfur %
Gasoline sulfur %	0.0383
Diesel sulfur %	0.228
LPG/CNG sulfur %	0.0123
Fuel Oxygenate %	1.24
RVP	13.8

Temperature input parameters were based on the Vancouver NOAA meteorological site. RVP value from WDOE MOBILE6/6.1/6.2 Input Parameters and Processing document updated May 6, 2003 for Clark County wintertime (Oct-April). These values are shown in the table below.

Table 3-15: NONROAD (2005) Temperature, RVP, and Oxygenated Fuel Parameter Inputs

Aggregated County Title: Portland					
Counties (1)	**Season**	**min**	**max**	**January 2002 Avg Temp**	**RVP**
Clark	Winter	34.5	44.8	39.6	13.8

3.3.5 Emissions Estimates

Total emissions were generated with NONROAD2005. The model was set to calculate emissions in tons per seasonal day (tpsd) for Clark County. Emissions were allocated to the AQMA using the methodology described above in section 3.3.2. Snow blower emissions were deleted from the lawn and garden category of the NONROAD2005 output file as they are not a common source of emissions in the Clark County CO maintenance area. Emission rates for the County and AQMA area shown below.

Table 3-16: Nonroad Category Emissions

NONROAD (2005) Category	Clark County CO Emissions (tpsd*)	Vancouver CO AQMA Emissions (lbs/day)
Recreational Vehicles	1.17	585
Construction equip.	5.07	8413
Industrial equip.	3.74	6204
Lawn and Garden	8.75	14,871
Agricultural	0.03	0
Commercial equip.	14.87	24,689
Logging equip.	0.08	0
Airport Service	0.00	0
Underground Mining	0.00	0
Oil Field	0.03	0
Railway Maint. Equip.	0.04	60
Marine Recreation	0.18	182

*tons per seasonal day

3.4 Ships

The Washington State 2002 NEI submittal was based on a special project was undertaken through the Northwest Regional Technical Center (NWRTC) Demonstration Project to conduct an emissions inventory for ships (Corbett, 2001).[15] The main focus of the project was on ocean-going and harbor vessels traveling on the Columbia, Snake and Willamette Rivers. Emissions were estimated for 1999 based on a bottom-up fuel consumption approach. The estimates were provided by river segment consistent with segments reported in the US Army Corps of Engineers Waterborne Commerce publication.

3.4.1 Activity Level and Emission Rates

Activity level was based on the vessel traffic traveling the Columbia River. The emission rates are all based on the Corbett study done for the Western Regional Air Partnership. Unfortunately these emission calculations did not include data for carbon monoxide. A CO to NO_x ratio for Commercial Marine Vessels was calculated based on a ratio of emission factors used for marine vessel emissions. The Port of Portland established this relationship between NOx and CO terminal emissions in their 2000 Baseline EI in Section 6.1 Table 6-1. The CO/NOx ratio of 0.207 was applied to the AQMA portion of the CERR NOx ship emissions to calculate CO emissions for 2002 for the Clark County AQMA.

3.4.2 Temporal and Spatial Allocation

Emissions from ships were assumed to be uniform year-round. Using factors from the NWRTC Demonstration Project (the Corbett data), the 2002 CERR data was spatially resolved by several river links. Clark County emissions were allocated to the Vancouver CO maintenance area using simple GIS methods. The percentage of those river links falling adjacent to the Vancouver CO AQMA were used to apportion the county emissions. Seventy-four percent of the Columbia River bordering Clark County was estimated to border the Vancouver AQMA.

3.4.3 Emissions Estimates

Seasonal NO_x emissions in tons per year for Clark County were taken directly from the WDOE 2002 NEI submittal. NOx emissions for ships from the 2002 NEI were 917 tons. Half the NOx emissions from the 2002 NEI submittal were attributed to the Washington side of the river; 74% of the emissions were attributed to the Vancouver AQMA. Then, the CO to NO_x ratio for Commercial Marine Vessels (described above) was applied. The following formula shows the calculation:

(2002 CERR Columbia River NO_x Emissions/2) x 0.207 CO/NOx ratio x 0.74 (% of Columbia River bordering AQMA) = Vancouver AQMA tpy CO emissions = 70.2 tpy or 385 lbs/day

3.5 Locomotives

Locomotive emissions were calculated for Class 1 railroads based on EPA guidance.[16] Class 2 and 3 railroad locomotive emissions were not inventoried. A special AIRQUEST (formerly Northwest Regional Technical Center) project conducted by the Oregon Department of Environmental Quality (ODEQ) found that emissions from Class 2 and 3 railroad locomotives were a small percentage of total locomotive emissions.[17, 18]

3.5.1 Activity Level

Activity level is measured in gallons of diesel consumed by locomotives. The majority of the activity takes place on Class 1 railroads. Three Class 1 railroads operate in Washington: Burlington Northern Santa Fe (BNSF), Union Pacific and Amtrak. Union Pacific did not have any activity in the Vancouver AQMA. Fuel consumption data for the two railroads with activity was reported for 2002 to WDOE.[19, 20, 21] Gallons used for various railroad activities is shown in the table below.

Table 3-17: Locomotive Fuel Consumption in Gallons

County	Line Haul	Passenger	Yard
Clark	2,763,233	40,568	659,913

3.5.2 Temporal and Spatial Adjustments

The percentage of major railway within Clark County that falls within the Vancouver CO AQMA was calculated using GIS software. This fraction was used to apportion the amount of locomotive emissions that occurred within the CO maintenance area. The percentage of Clark County passenger track existing within the maintenance area is 67.4. This percentage was applied to Clark County passenger and line haul emissions. 100% of the yard emissions were assumed to occur at the Vancouver switchyard. Locomotives were assumed to operate uniformly year-round per EPA guidance.[22]

3.5.3 Emission Rates

CO Emission rates for the 2002 locomotive fleet were extracted from EPA's regulatory support document developed during the 1997 locomotive emissions standards rulemaking. EPA posted emission factor information by year and locomotive type (line-haul, switch, passenger) for 1999 through 2040.[23]

Table 3-18: Locomotive Emission Factors in grams per gallon fuel

Pollutant	Code	Line-haul	Passenger	Switch Yard
carbon monoxide	CO	2.66E+01	2.66E+01	3.81E+01

3.5.4 Emissions Estimates

Emissions were calculated using the following formula:

tpy = (gallons fuel) x (pollutant rate in g/gal) x (lbs/454 g) x (T/2000 lbs)

tpsd = tpy / (365 days/yr)

AQMA emissions from locomotives were 69 tpy and 380 lbs/day.

3.6 Aircraft

Aircraft emissions are based on 2004 values for landings and takeoffs from Airport Master Records obtained from the Federal Aviation Administration (FAA) website. 2002 data was not readily available and so 2004 data is used as a surrogate. Landing and takeoffs are counted separately in the Air Master Records reports, but landing and takeoff operations (LTOs) represent the complete cycle. The emission factor used to calculate CO emissions is from the U.S. Environmental Protection Agency, *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*. EPA-450/4-81-026d (Revised). Office of Air and Radiation. Research Triangle Park, NC, and Ann Arbor, MI. 1992.

There are four airports inside the CO maintenance area and two in Battleground, outside the CO maintenance area. Only landings and takeoff operations inside the Maintenance area were included in the emission calculations. Each complete LTO emits 12.104 lbs of CO. Airports inside the CO maintenance are had 32,500 LTOs.. The table below shows the area airports and CO emissions in tons per year. CO emissions from aircraft inside the Vancouver AQMA are 195 tons per year or 1,070 lbs/day.

Table 3.19: Vancouver Maintenance Area Aircraft LTOs and CO emissions, tons per year

City	Airport	Annual AQMA LTOs	Tons/year
Camas	Grove Field	3500	21.0
Vancouver	Evergreen	5000	30.0
Vancouver	Fly For Fun	1500	9.0
Vancouver	Pearson	22500	135.2
Total		**32,500**	***195.2***

3.7 Residential, Commercial, and Small Industrial Fuel Combustion

Residential, Commercial, and Small Industrial Fuel Combustion (other than Residential Wood Combustion) emissions are based on the amount of fuel used in the maintenance area primarily for heating. Coal, distillate oil, residual oil, natural gas, and LPG are fuels that are used in the state of Washington. Information on the amount of fuel consumed and emission factors can be found in the Vancouver CO Plan Appendix E- Supporting Detail for Emission Inventory. Industrial source emissions were not included in this source category, as SWCAA tracks industrial emissions separately and emissions from industrial fuel combustion are included in the point source totals.

3.7.1 Activity Level and Emission Rates

Fuel usage is provided at the state level in the State Energy Data Report (SEDR). The 2001 data report was used for this work as it was the most recent when this section was calculated. County specific natural gas usage was obtained from NW Natural Gas which is Clark County's only major natural gas supplier. The methodology for doing these calculations is outlined in the EIIP Vol. III: Area Sources.

Emission rates for the different fuel types were obtained from AP-42 Chapter 1: External Combustion Sources per the EIIP Vol. III. Table 1.5-1 (Oct. 1996 version) was used for LPG emissions; Table 1.4-1 (July 1998 version) was used for the natural gas combustion emissions; Table 1.3-1 (Sept. 1998 version) was used for fuel oil combustion emissions, and Table 1.1-3 (Sept. 1998) for coal combustion emissions.

Table 3-20: Residential and Commercial Emission Factors and Fuel Usage

Fuel Type	Units	Residential Emission Factor lbs CO /unit	Residential Usage	Commercial Emission Factor lbs CO/unit	Commercial Usage
Coal	Tons	275	98	10	980
Distillate Oil	1000 gal	5	3,900	5	2,477
Residual Oil	1000 gal	0	0	5	14
Nat. Gas	MMft^3	40	2,654	84	1,491
LPG	1000 gal	1.9	4,639	1.9	819

3.7.2 Temporal Adjustments

Wintertime seasonal adjustment factors (SAFs) for Residential, Commercial, and Industrial fuel use were used to reflect the CO season by using Table 5.8-1 and the first equation in section 5.8.4 of Procedures for the Preparation of Emission Inventories for Carbon Monoxide and Precursors of Ozone, Vol. 1: General Guidance for Stationary Sources EPA-450/4/91-016. The Residential Seasonal Adjustment Factor for CO is 1.7; the Commercial Seasonal Adjustment factor used for commercial use is 1.4.

3.7.3 Spatial Adjustments

Emissions were allocated to the Vancouver CO maintenance area using Clark County population ratios. Eighty-three percent of the population was inside the Vancouver AQMA using 2001 data from the Washington Office of Financial Management (OFM).

3.7.4 Emissions Estimates

CO emissions for Residential and Commercial fuel use were calculated by the methodologies explained above. Industrial emissions were not included to prevent double counting of CO emission from industrial point sources. This is consistent with the results of the emission inventory analysis for the 1996 Vancouver CO Maintenance Plan submittal.

Table 3-21: Residential and Commercial CO emissions, lbs/winter day

	lbs/CO day
Residential Total	754
Commercial Total	803
Residential/Commercial Fuel Combustion Total:	**1,556**

3.8 Residential Yard Waste Burning

Residential yard waste burning is outdoor burning of vegetative material. CO emissions for this category were calculated based on the methodology used by Ecology for the 2002 NEI submittal. SWCAA banned all outdoor burning in the CO maintenance area in 1995. However, this activity still occurs illegally and is a small source of CO in the area.

3.8.1 Activity Level and Spatial Allocation

The measure of activity for residential yard waste burning is the amount of material burned. In 2001, Washington State University under contract to the Idaho Department of Environmental Quality conducted a telephone survey of wood heating and outdoor burning habits in Idaho, Oregon and Washington.[24] The survey included questions to estimate the fraction of households that burned yard waste and the number of legal size piles (4') burned per household per year. In Washington, the survey defined four geographic groups in Washington: 1) incorporated cities, 2) unincorporated western WA, 3) unincorporated eastern WA with forest lands, and 4) unincorporated eastern WA without forest lands. A county's incorporated areas were assigned to the first group. For Clark County, unincorporated areas were assigned to the western WA group. The number of households in the Vancouver AQMA, as shown in Table 2.1, was 103,145.

To apportion the amount of residential yard waste burning within the Vancouver CO AQMA, the surrogate household data for the Maintenance area (see section 2) was used to calculate emissions. Results of the WSU survey describing the fractions of households burning yard waste, and the number of piles burned are shown in the table below.

Table 3-22: Amount of Yard Waste Burning

Area	Fraction Burning	Piles per Year
Incorporated	0.077	2.56
Western WA	0.265	3.37

The tons of material burned was estimated using the following equation:

HH x (fraction burning waste) x (piles/HH) x (lbs burned/pile) x (T/2000 lbs)
Where fraction burning and piles per year come from Table 3-11
Where HH information comes from Table 2.1
Where the weight of a legal size pile was approximately 125 lbs.[25]

The CO emission rate for unspecified forest burning were taken from EPA's AP-42 §13.1 (Oct. 1996) and are shown in the table below.[26] Emission rates are given in pounds of pollutant per ton of material burned. Tons of material burned is multiplied by the emission factor of 140 lbs/ton of material burned as shown in the table below.

Table 3-23: Emission Rates in Pounds per Ton Material Burned

Pollutant	Code	lbs/T
carbon monoxide	CO	140

3.8.2 Temporal Allocation

The survey included questions about seasonal burning habits. The fractions of activity occurring in each season are shown in the table below. The winter seasonal fraction was used to calculated tons per winter day for the Vancouver CO Maintenance Plan.

Table 3-24: Seasonal Activity Fractions, Residential Yard Waste Burning

Area	Fall	Winter	Spring	Summer
Incorporated	0.25	**0.25**	0.21	0.29
Western WA	0.21	**0.28**	0.22	0.29

3.8.3 Emissions Estimates

Emissions estimates were calculated with the equations below

tpy = HH x (fraction burning waste) x (piles/HH) x (lbs burned/pile) (T/2000 lbs) x (140 lbs CO/T material burned) x (T/2000 lbs)

tpsd = tpy x (winter seasonal fraction) /91 season days * 2000 lbs/1 ton = lbs/d - winter

Table 3-25: CO Emissions from Residential Yard Waste Burning

Seasonal Allocation	Maintenance Area Calculations	HH	Fraction of HH Burning	Piles per Year	Emissions (tpy)	Emissions (lb/d - winter)
Winter Western WA	Unincorporated	31,447	0.265	3.37	122.87	756.10
Winter Incorporated	Vancouver, Camas, Washougal	71,698	0.077	2.56	61.83	339.74
	Total	103,145			185	1096

3.9 Residential Trash Burning

Residential trash burning is outdoor burning of household waste. This is activity is banned in the state of Washington, but still occurs illegally indoors (fireplaces/stoves) and outdoors.

3.9.1 Activity Level and Spatial Allocation

The measure of activity for residential trash burning is the amount of material burned. The Washington State University telephone survey of wood heating and outdoor burning habits in Idaho, Oregon and Washington described in the section above included questions to estimate the fraction of households that burned trash. The geographic subgroups, county assignments, and number of households in each subgroup were the same as in that section. The fractions of households burning trash are shown in the table below.

Table 3-26: Fraction of Households Burning Trash

Area	Fraction Burning
Incorporated	0.050
Western WA	0.199

The amount of trash burned per household was taken from an Emission Inventory Improvement Program (EIIP) recommendation. The EIIP reported that the amount of trash actually burned was approximately 50% of the combustible trash produced.[27] This was the amount used in this inventory and was 5.4 lbs per household per day.

The tons of material burned were estimated using the following equation:

Tons material burned:
HH x (fraction burning trash) x (5.4 lbs/HH-day) x (365 days) x (T/2000 lbs),
where HH = the number of households from Table 2-1
where fraction of HH burning trash = value from Table 3-21
where the lbs of trash burned was 5.4 lbs/HH-day

Table 3-27: Tons of fuel burned annually

Maintenance Area Calculations	HH	Tons burned annually
Unincorporated (Western WA)	31,447	6,167
Vancouver, Camas, Washougal, (Incorporated)	71,698	3,533
Total	103,145	9,700

3.9.2 Emission Rates

The CO emission factors for trash burning from the EIIP[27] are shown below. The emission rate is given in pounds of pollutant per ton of material actually burned.

Table 3-28: Emission Rates in Pounds per Ton Material Actually Burned

Pollutant	Code	Lbs/T
carbon monoxide	CO	5.31E+01

3.9.3 Temporal Allocation

Trash burning is considered uniform year-round.

3.9.4 Emissions Estimates

Emissions estimates were calculated with the equations below.

tpy = (tons burned from section 3.91.) x (CO lbs/T = 53.1) x (T/2000 lbs)
lbs/day = (tpy x 2000) / (365 days/yr)

Table 3-29: CO Emissions for Winter Residential Trash Burning

	Tons burned annually	Emissions	Emissions
Maintenance Area Calculations		(tpy)	(lb/d - winter)
Unincorporated	6,167	163.74	897.20
Vancouver, Camas, Washougal	3,533	93.80	513.97
Total	9,700	257.54	1411.17

3.10 Residential Wood Combustion

Residential wood combustion consists of home heating and recreational use of woodstoves, fireplaces, fireplace inserts and central furnaces.

3.10.1 Activity Level

The measure of activity for residential wood combustion is the amount of wood burned. The Washington State University telephone survey of wood heating and outdoor burning habits in Idaho, Oregon and Washington described above included questions to estimate the number of households using each type of device (Central Furnace, Certified (Phase I, Phase II) and Non-certified Inserts and Woodstoves, and Fireplaces); how much wood was burned per device; and seasonal, daily and hourly usage rates. The geographic subgroups, county assignments, and number of households in each subgroup were the same as in the above section. The fractions of households using wood burning devices are shown in the table below.

Table 3-30: Wood Burning Device Usage

Device Type	Incorporated	W WA
Central Furnace	0.013	0.000
Fireplaces	0.381	0.150
Non-certified Insert	0.039	0.058
Certified Insert, Phase I	0.000	0.006
Certified Insert, Phase II	0.067	0.043
Non-certified Pellet stove	0.017	0.043
Certified Pellet stove, 1988 stds	0.004	0.006
Non-certified Woodstove	0.039	0.126
Certified Woodstove, Phase I	0.000	0.006
Certified Woodstove, Phase II	0.032	0.058
Total Equipment	**0.591**	**0.497**

The WSU survey gathered information on pellets, presto logs and cords of wood burned. A cord contains 128 ft^3 (4' x 4' x 8'). The solid volume may range from 60-100 ft^3. An average solid volume of 85 ft^3 was used in this inventory.[28, 29] The weight of a cord of wood varies with moisture content and species type. It was assumed that moisture content was 20% (legal moisture limit).[30] Species type was defined using several sources. In a 1985 survey done by Market Trends, Inc.,[31] species burned were identified for western and eastern Washington. The survey was used to identify species for western Washington. Average weight of a cord of wood was 2607 lbs in western Washington.

Table 3-31: Wood Species Weight[28] and Percent Use by Area

Species	Lbs/cord	% use WWA
Alder	2,540	56
Cedar	2,060	4
Cottonwood	2,160	4
Douglas Fir	2,970	16.5
Hemlock	2,700	16.5
Larch	3,330	
Lodgepole Pine	2,610	
Madrona	4,320	1
Oak	3,680	1
Ponderosa Pine	2,240	

The WSU survey provided information on the number of cords burned per device. Pellets used were given in number of 40 lb bags used, and presto logs as number of logs burned. A presto log manufacturer in Spokane estimated the weight of a log as 8 lbs. The total number of tons burned by device type is shown in Table 3-31.

Table 3-32: Tons Burned per Wood Burning Device

Device Type	Incorporated	Unincorporated
	W WA	W WA
Central Furnaces	1.3	0.0
Fireplaces	1.4	1.9
Inserts	2.5	4.4
Pellet stoves	4.1	2.0
Woodstoves	3.3	4.2

3.10.2 Emission Rates

The table below lists the various equipment types and the amount of CO emitted for each ton of wood products burned.

Table 3-33: CO Emission Factors in Pounds per Ton of Wood Products Burned

Equipment Type	CO
Central Furnace	230.8
Fireplaces	252.6
Non-certified Insert	230.8
Certified Insert, Phase I	122.6
Certified Insert, Phase II	123.9
Non-certified Pellet stove	52.2
Certified Pellet stove, 1988 stds	39.4
Non-certified Woodstove	230.8
Certified Woodstove, Phase I	122.6
Certified Woodstove, Phase II	123.9

3.10.3 Spatial and Temporal Allocation

The household surrogate data in Section 2 was used to apportion the emissions based on the number of households within the CO AQMA in both the incorporated and non-incorporated portions of the AQMA.

Temporal allocation data was acquired from the WSU survey questions about seasonal burning habits. The fractions of activity occurring in each season are shown in Table 3-33 below.

Table 3-34: Seasonal Activity Fractions, Residential Wood Combustion

Area	*Winter*	Spring	Summer	Fall
Incorporated	***0.44***	0.20	0.03	0.34
Western WA	***0.39***	0.25	0.07	0.29

3.10.4 Emissions Estimates

Annual and seasonal emissions for each wood burning device were calculated according to the following equations:

tpy = (HH) x (usage fraction) x (tons burned/device-yr) x (pllt lbs /T) x (T/2000 lbs)

tpsd = (tpy) x (winter seasonal fraction) / (91 days)

where HH = households (see Table 2-1), pllt = pollutant, days = number of days in the winter season (91 days)

Table 3-35: Clark County Residential Wood Combustion emissions

	Inc. W WA	Uninc. W WA	County Total
CO tpy	8863	10424	19288
CO tps	3900	4065	7965
CO lbs/winter day	85712	89351	175062

Table 3-36: Households, Fractions of Incorporated or Unincorporated Areas and Maintenance Plan Emissions

	Fraction of Incorp. or Uninc.		Total emissions	
Maintenance Area emissions	(%)	HH	lbs/day	tpy
Camas/Washougal/Vancouver (Inc.)	93	71,698	79,376	8,863
Unincorp. Remainder of MP Area	48	31,447	42,850	4,999
CO Maintenance Plan Area Totals:		103,145	122,226	13,863

3.11 Notable Sources Not Inventoried

Biogenic emissions - were not inventoried for this base year inventory. Biogenic CO emissions come from natural biomass burning and biogenic activity (both soils and oceans). CO emissions from the terrestrial biosphere are a result of photochemical degradation of plant matter. EPA calculated biogenic emissions for Clark County for the 2002 NEI using BEIS3 – BELD3. Ecology could offer very little refinement to this inventory, and recommended acceptance of the EPA estimates. Because the biogenic CO emissions are not anthropogenic and will stay relatively constant from year to year, SWCAA chose not to include this category in the emission estimates.

Agricultural Burning – Very little activity in Clark County can be considered agricultural burning. SWCAA is not aware of any agricultural burning in the Vancouver CO AQMA in the wintertime.

Landfill Emissions – It was determined in the 1996 CO Maintenance Plan that landfills are not a significant source of CO emissions in the Vancouver CO maintenance area.

Fires – Wild and Structure – It was determined in the 1996 CO Maintenance Plan emission inventory that these are not a significant source of CO emissions in the Vancouver CO maintenance area.

Prescribed Burning - Of the 39 prescribed burns in the DNR database for 2002, there is only one that may have been inside the CO maintenance area that occurred during the winter. Therefore, emissions from prescribed burning in the Vancouver CO are negligible and not included in the inventory.

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