

APPENDIX B2
Contribution to Regional Haze

Plymouth Generating Facility Contribution to Regional Haze

This study examines the potential contribution of the Plymouth Generating Facility to regional haze in Class I Areas within the BPA Service Area, the Columbia River Gorge National Scenic Area (CRGNSA), and the Mt. Baker Wilderness. Regional haze impacts are assessed following the techniques used in a Regional Air Quality Modeling Study¹ conducted by BPA. BPA's study examined potential air quality impacts associated with over forty recently proposed power projects in the Service Area. The Regional Air Quality Modeling Study suggests proposed power projects would probably not significantly contribute to sulfur and nitrogen deposition in Class I areas, the Class I PSD Increments, regional Class II PSD Increments or regional concentrations in excess of the National Ambient Air Quality Standards. The model simulations did suggest the proliferation of proposed projects in the Service Area could potentially degrade visibility within Class I and Scenic Areas should all the projects become operational.

Based on the results of the Regional Air Quality Modeling Study, BPA is now examining potential cumulative regional haze impacts on a case-by-case basis for each new project before issuing a Record of Decision (ROD). Since it is unlikely all the proposed power plants will be built, the analysis investigates the cumulative impacts from a Baseline Source Group consisting of projects that have all ready been issued a ROD, other recently permitted power projects not requesting access to BPA's transmission grid but within the Service Area, facilities well along in their permitting process, and the facility being considered for a ROD. The remainder of this document describes the Baseline Source Group, provides an overview of the dispersion modeling approach, presents the results of a cumulative analysis for the Baseline Source Group, and discusses the potential contribution of the Plymouth Generating Facility to regional haze.

Baseline Source Group. Peak emissions from the projects within the Baseline Source Group, including the Plymouth Generating Facility are listed in Table 1. Emissions are shown both for the primary and secondary fuels. The location of these projects, Class I areas, CRGNSA, Mt. Baker Wilderness, and the study domain are displayed in Figure 1.

Operating Scenarios. The analysis assumes all plants in Table 1 are operating at peak load with their primary fuel for the entire simulation period. An oil-firing scenario was also considered, where sources permitted to fire with fuel oil were assumed to operate in this manner over the winter season. Note, peak load operating assumptions likely overestimate impacts, and with the exception of the Fredonia Facility, the projects are not allowed to fire with fuel oil for an entire winter season.² In practice, virtually all proponents state that they intend to burn gas except in times of significant shortage.

The oil-burning scenario is a compromise solution to a potentially complex assessment. The present analysis likely overstates potential impacts attributable to the Chehalis Generating Facility because they cannot burn oil every day of the winter. The meteorology on the winter days producing the highest impacts may also not occur concurrently with the economic

¹ A *Modeling Protocol* and the *Phase I Results* of the Regional Air Quality Modeling Study can be found at <http://www.efw.bpa.gov/cgi-bin/PSA/NEPA/SUMMARIES/air2>.

² The Fredonia Facility near Mt. Vernon has requested fuel oil firing for all hours of the year as a secondary fuel. The Chehalis Generating Facility has requested fuel oil firing for 720 hours per year.

conditions likely to cause these power plants to burn oil. On the other hand, the impacts attributable to the Fredonia Facility (if they are allowed to burn oil every day) may be under predicted because the analysis limits their oil-fired emissions to winter months.

Modeling overview. The dispersion modeling techniques employed to evaluate potential regional haze impacts from the Plymouth Generating Facility are described in the *Modeling Protocol*.¹ Features of the model simulations include the following:

- The CALPUFF modeling system was applied in the simulations. CALPUFF is the EPA's preferred model for long-range transport assessments. CALPUFF treats plumes as a series of puffs that move and disperse according to local conditions that vary in time and space. CALPUFF incorporates algorithms for wet and dry deposition processes, aerosol chemistry, and is accompanied by post-processors designed to assess regional haze.
- Wind fields are based on the University of Washington's simulations of Pacific Northwest Weather with the MM5 model from April 1, 1998 to March 15, 1999. The MM5 data set used in the simulations has a horizontal mesh size of 12 kilometers and over 30 vertical levels. The model simulations are based on weather conditions during a single year and actual impacts may vary from year to year due to large-scale annual variability.
- The 696-km by 672-km study area includes Washington and portions of Oregon, Idaho, and British Columbia. Meteorological, terrain, and land use data were provided to the model using a horizontal grid mesh size of 12 km. The terrain data are based on an average for each grid cell, thus the simulations do not fully resolve potential local impacts in complex terrain. A six-kilometer mesh size sampling grid was used with receptor locations within 16 Class I Areas (3 National Parks, the Spokane Indian Reservation and 12 Wilderness Areas), the CRGNSA, and the Mt. Baker Wilderness.
- The aerosol concentrations used to characterize background extinction coefficients in the study represent excellent visual conditions. Background visibility parameters are presented in Table 4 of the *Modeling Protocol*. These parameters represent visibility on the best five percent of the days in the Class I Areas and the best twenty percent of days in the CRGNSA and the Spokane Indian Reservation. Background ozone and ammonia concentration data were also based on generally conservative assumptions and are presented in the *Modeling Protocol*.

- Building downwash effects are not considered in the analysis and emissions were characterized using a single stack for each facility. Note the simulations only include emissions from the turbines or heat recovery steam generators, not from ancillary sources (such as auxiliary boilers, gas heaters, and standby generators) associated with each project.
- The contribution of the Plymouth Generating Facility to background extinction was assessed using the post-processing utilities included with the CALPUFF model system. Since portions of the aerosol chemistry are non-linear, the contribution of the Plymouth Generating Facility considered the cumulative equilibrium conditions associated with the Baseline Source Group on an hour-by-hour and receptor-by-receptor basis. Post-processing utilities are applied to assess the contribution using simulations of both the Baseline Source Group with the Plymouth Generating Facility and the Plymouth Generating Facility in the absence of other sources.

Regional haze contribution from the Baseline Source Group with the Plymouth Generating Facility. The CALPUFF modeling system was applied to simulate emissions from the Baseline Source Group using a year of Pacific Northwest weather characterized by the MM5 numerical weather prediction model. The results of the simulations were post-processed and the 24-hour average extinction coefficient was used as a measure of regional haze. The extinction of the clean atmosphere (without any aerosols) is 10 inverse megameters (Mm^{-1})³. Increased extinction results in reduced visual range. For example extinction coefficients of 18.1 Mm^{-1} and 20 Mm^{-1} correspond to visual ranges of 216 km and 196 km, respectively. If the background extinction coefficient is 18.1 Mm^{-1} , then an increase in extinction of 1.9 Mm^{-1} caused by higher aerosol concentrations along the visual path length would decrease the visual range by about 10 percent. An annual average visual range of 216 km is representative of good (top five percent) visual conditions for most of the Class I areas considered in this analysis. If power plant emissions were to increase the extinction coefficient by 1.9 Mm^{-1} (e.g., from a background value of 18.1 to 20 Mm^{-1}), then the visual range at the affected Class I area would be reduced to 196 km.

The predicted maximum contribution of the Baseline Source Group when fired by natural gas to regional haze within the study area is displayed in Figure 2. This figure was constructed from the highest 24-hour extinction coefficient at each receptor predicted for the Baseline Source Group during an annual simulation. Relatively higher 24-hour maximum extinction coefficients are predicted for the lowland areas of western Washington, in northern Oregon just south of the Columbia River, and in the lower Columbia River Basin. The meteorological conditions conducive to formation of secondary aerosols from the power projects include high relative humidity, light winds, and cooler temperatures that generally occur during fair weather in the spring, fall, and winter. During such conditions, plumes from the power projects are primarily confined to the lower elevations within the study domain.

Figure 3 shows the predicted maximum 24-hour extinction coefficients for the winter oil-fired case. This figure was constructed from the highest 24-hour extinction coefficient at each receptor predicted for the Baseline Source Group during a winter simulation. This scenario assumes sources within the Baseline Source Group permitted for oil firing would use this fuel for the

³ The concept of an inverse megameter may be easier to comprehend if one thinks of the extinction coefficient as the amount of light that is lost as it passes through a more familiar unit of measure. If extinction was expressed in a more common U.S. measurement system, the extinction coefficient might be measured as “inverse feet” or “per foot.”

entire winter period. Since the hours of fuel oil firing are restricted for most of the facilities, the predictions likely over predict impacts.² Due to relatively high SO₂, PM₁₀, and NO_x emissions, the maximum extinction coefficients for the oil-fired case are potentially much higher than for the gas-fired case, especially in the airsheds influenced by the Fredonia Facility and the Chehalis Generation Facility.

The Federal Land Managers (FLMs) suggest the predicted change to the 24-hour average extinction coefficient as a visibility metric for assessing regional haze in Class I areas. According to the FLMs, a five percent change in extinction can be used to indicate a “just perceptible” change to a landscape and a ten percent change in extinction coefficient from the “natural” background is considered a significant incremental impact.⁴ As indicated above, the present analysis conservatively characterizes background visibility using seasonal aerosol concentration data on the days with the best visibility. Such good visual conditions are assumed for all days in the simulation and the analysis likely over estimates the joint probability of high source related impacts combined with low background aerosol concentrations.

Table 2 and Table 3 list the predicted number of days for each season with greater than five and ten percent change to background extinction, respectively. For both the annual natural gas and the winter oil-fired scenarios, the Baseline Source Group could potentially result in a “just perceptible” change to the extinction coefficient on a few days for several of the areas examined in the study. The areas most affected are the Class I Areas near the CRGNSA, Olympic National Park, Mt. Rainier National Park, and the Alpine Lakes Wilderness. In Mt. Rainier National Park the predicted change to background extinction for the winter oil-fired case exceeds the ten percent significance criterion on seven days. The Baseline Source Group exceeds the ten percent significance criterion on only one day in the Mt. Hood Wilderness and the CRGNSA when these sources are fired by natural gas.

Contribution of the Plymouth Generating Facility. An analysis was conducted to examine the Plymouth Generating Facility’s contribution to the overall regional haze impacts predicted for the Baseline Source Group. Maximum 24-hour extinction coefficients predicted for the Plymouth Generating Facility are displayed in Figure 4. This figure was constructed from the highest 24-hour extinction coefficient at each receptor predicted for the Plymouth Generating Facility during an annual simulation. The higher 24-hour extinction coefficients are predicted relatively close to the location of the proposed facility, extending west into the CRGNSA and northeast out of the lower Columbia River Basin towards Pullman and Spokane.

The relatively higher concentrations near the facility are caused by the PM₁₀ emitted directly from the turbines. With distance from the Plymouth Generating Facility, secondary aerosols formed through conversion of the NO_x and SO₂ emitted from the facility become important components of the extinction. Several of the worst-case meteorological episodes occur during the winter when fog, drizzle, and overcast conditions result in high relative humidity. Note, this analysis did not consider whether meteorological conditions causing the greatest impacts actually coincide with good “natural” background visibility. Background aerosol concentrations will likely be higher and fog, low clouds, precipitation and other obscuring weather phenomena may reduce visual ranges so in some instances the impacts of the projects considered in this analysis would not be perceptible.

⁴ USFS, NPS, USFWS, 2000. *Federal Land Managers’ Air Quality Related Values Workgroup (FLAG) Phase I Report*. Obtained from <http://www2.nature.nps.gov/ard/flagfree/FLAG--FINAL.pdf>, December 2000.

Table 4 summarizes potential changes to background extinction due to emissions from the Plymouth Generating Facility to the Class I areas, CRGNSA, and the Mt. Baker Wilderness. The modeling suggests the proposed facility would potentially increase daily background extinction by up to 2.20 percent and 1.57 percent in the Mt. Hood Wilderness and the CRGNSA, respectively. The project would contribute greater than 0.4 percent on only five days in any one area when the combined group's contribution is greater than five percent and on only one day when the group's contribution is greater than ten percent. The FLM's recommend 0.4 percent as a significance criterion for examining an individual source's contribution to cumulative impacts.^{4,5} Based on this criterion, the Plymouth Generating Facility would significantly contribute to regional haze on only one day at any of the Class I areas within the BPA Service Area, the CRGNSA, or the Mt. Baker Wilderness when the facilities considered in this analysis are fired by natural gas.

The episodes affecting the Mt. Hood Wilderness and the CRGNSA occur on days with easterly flow during the winter. Under these conditions the Plymouth Generating Facility plumes are embedded in cold moist air promoting the formation of nitrate particles. Note, concurrent weather observations at Pasco, Pendleton, and The Dalles indicate fog and poor existing visibility sometimes accompanied these episodes. During such cold air outbreak episodes high winds occur in the western end of the CRGNSA. The modeling analysis does not consider the simultaneous occurrence of such weather obscuring phenomena that in some instances would reduce the influence of the Plymouth Generating Facility emissions on regional haze. Nor does the analysis consider whether under such conditions the public would visit the CRGNSA and the Mt. Hood Wilderness and perceive a change to these scenic resources.

Table 5 shows the Plymouth Generating Facility contribution to predicted changes in extinction for the winter oil-fired scenario. This figure was constructed from the highest 24-hour extinction coefficient at each receptor predicted for the Plymouth Generating Facility during a winter simulation. Based on the FLM significance criterion,⁵ the Plymouth Generating Facility would not significantly contribute to regional haze in Mt. Rainier National Park caused when other facilities potentially use fuel oil during the winter.

⁵ According to FLM recommendations for cumulative regional haze assessments, an individual project's contribution is considered "significant" when that contribution causes 24-hour extinction to increase by greater than 0.4 percent and for the same period the cumulative increase caused by all the sources being considered is greater than ten percent.

**Table 1. Baseline Source Group Plus the Plymouth Generating Facility
Peak Emissions with Primary Fuel**

Num	Project Name	Owner	MW	Peak Emissions (lb/hr)		
				SO2	NOx	PM10
1	Fredonia Facility	Puget Sound Energy	108	3.5	23.2	6.8
2	Rathdrum Power	Rathdrum Power	270	2.7	29.8	21.4
3	Frederickson Power	West Coast	249	10.2	19.7	16.9
4	Coyote Springs 2	Avista	280	1.1	30.0	4.5
5	Goldendale Energy Project	Calpine	248	12.7	14.9	11.8
6	Hermiston Power Project	Calpine	546	2.5	71.7	38.1
7	Chehalis Generating Facility	Tractebel	520	20.8	40.9	31.6
8	Goldendale (The Cliffs)	GNA Energy	300	3.7	20.3	16.3
9	Big Hanaford Project	TransAlta	267	6.5	23.1	14.3
10	Mint Farm Generation	Mirant	319	4.0	25.1	23.1
11	Wallula Power Project	Newport Generation	1300	12.4	89.2	81.3
12	Satsop CT Project - Phase I	Duke Energy NW	650	6.7	43.4	47.0
13	Satsop CT Project - Phase II	Duke Energy NW	650	6.7	43.4	47.0
14	Wanapa Energy Center	Confed. Tribes	1200	13.9	98.8	124.8
15	Plymouth Generation	Plymouth Energy	307	17.3	18.4	24.0
Total			7214	125	592	509
Peak Emissions with Secondary Fuel						
1	Fredonia Facility (Oil-Fired)	PSE	104	51.2	23.2	12.2
7	Chehalis (Oil-Fired)	Tractebel	520	238.0	211.5	40.0

The Fredonia Facility has requested fuel oil firing for all hours of the year as a secondary fuel. The Chehalis Generating Facility has requested fuel oil firing for 720 hours per year.

**Table 2. Number of Days with Greater than Five Percent
Change to Background Extinction
Baseline Sources Plus the Plymouth Generating Facility**

Area	Natural Gas-Fired					Oil-Fired Winter
	Spring	Fall	Summer	Winter	Total	
Diamond Peak Wilderness	0	0	0	0	0	0
Three Sisters Wilderness	0	0	0	0	0	0
Mt. Jefferson Wilderness	0	0	0	1	1	1
Strawberry Mtn. Wilderness	0	0	0	0	0	0
Mt. Hood Wilderness	0	2	0	4	6	4
CRGNSA	0	5	0	2	7	4
Eagle Cap Wilderness	0	1	0	0	1	0
Hells Canyon Wilderness	0	0	0	0	0	0
Mt. Adams Wilderness	0	0	0	2	2	3
Goat Rocks Wilderness	0	0	0	0	0	2
Mt. Rainier National Park	2	1	0	1	4	20
Olympic National Park	0	5	0	2	7	5
Alpine Lakes Wilderness	2	0	0	0	2	4
Glacier Peak Wilderness	0	0	0	0	0	1
North Cascades National Park	0	0	0	0	0	1
Pasayten Wilderness	0	0	0	0	0	0
Mt. Baker Wilderness	0	0	0	1	1	3
Spokane Indian Reservation	0	0	0	0	0	1

Background extinction based on aerosol concentrations on days with the best visibility. For the CRGNSA and Spokane Indian Reservation based on top twenty percent, for all other areas based on the average of the top five percent.

The Oil-fired case assumes the Fredonia Facility and Chehalis Generating Facility would be using oil for all hours of a winter season.

**Table 3. Number of Days with Greater than Ten Percent
Change to Background Extinction
Baseline Sources Plus the Plymouth Generating Facility**

Area	Natural Gas-Fired					Oil-Fired Winter
	Spring	Fall	Summer	Winter	Total	
Diamond Peak Wilderness	0	0	0	0	0	0
Three Sisters Wilderness	0	0	0	0	0	0
Mt. Jefferson Wilderness	0	0	0	0	0	0
Strawberry Mtn. Wilderness	0	0	0	0	0	0
Mt. Hood Wilderness	0	0	0	1	1	1
CRGNSA	0	0	0	1	1	1
Eagle Cap Wilderness	0	0	0	0	0	0
Hells Canyon Wilderness	0	0	0	0	0	0
Mt. Adams Wilderness	0	0	0	0	0	0
Goat Rocks Wilderness	0	0	0	0	0	0
Mt. Rainier National Park	0	0	0	0	0	7
Olympic National Park	0	0	0	0	0	0
Alpine Lakes Wilderness	0	0	0	0	0	0
Glacier Peak Wilderness	0	0	0	0	0	0
North Cascades National Park	0	0	0	0	0	0
Pasayten Wilderness	0	0	0	0	0	0
Mt. Baker Wilderness	0	0	0	0	0	0
Spokane Indian Reservation	0	0	0	0	0	0

Background extinction based on aerosol concentrations on days with the best visibility. For the CRGNSA and Spokane Indian Reservation based on top twenty percent, for all other areas based on the average of the top five percent.

The Oil-fired case assumes the Fredonia Facility and Chehalis Generating Facility would be using oil for all hours of a winter season.

Table 4. Contribution of the Plymouth Generating Facility to Regional Haze in Class I Areas, Columbia River Gorge National Scenic Area, and Mt. Baker Wilderness – Firing by Primary Fuel

Area of Interest	Plymouth Maximum Extinction (1/Mm)	Plymouth Maximum Change to Background Extinction (%)	Number of Days When Plymouth Contribution > 0.4%	
			And Cumulative Change to Extinction > 5.0%	And Cumulative Change to Extinction > 10.0%
Three Sisters Wilderness	0.06	0.49	0	0
Mt. Adams Wilderness	0.13	0.55	1	0
Alpine Lakes Wilderness	0.06	0.40	0	0
Diamond Peak Wilderness	0.03	0.14	0	0
Eagle Cap Wilderness	0.09	0.51	1	0
Glacier Peak Wilderness	0.09	0.48	0	0
Goat Rocks Wilderness	0.09	0.48	0	0
CRGNSA	0.37	1.57	5	1
Hells Canyon Wilderness	0.07	0.37	0	0
Mt. Hood Wilderness	0.44	2.20	5	1
Mt. Jefferson Wilderness	0.08	0.42	1	0
Mt. Baker Wilderness	0.05	0.22	0	0
North Cascades National Park	0.07	0.36	0	0
Olympic National Park	0.08	0.34	0	0
Pasayten Wilderness	0.07	0.36	0	0
Mt. Rainier National Park	0.05	0.39	0	0
Spokane Indian Reservation	0.11	0.44	0	0
Strawberry Mtn. Wilderness	0.09	0.54	0	0

Notes:

For the Plymouth Generating Facility peak 24-hour gas-fired emissions were assumed for all days of the year. Cumulative predictions include emissions from the power projects listed in Table 1 fired by their primary fuel.

Predictions are from CALPUFF simulations of April 1, 1998 to March 15, 1999. Background extinction coefficients are based on aerosol concentrations during days with the top five percent best visibility for all areas except the CRGNSA and the Spokane Indian Reservation. The CRGNSA and Spokane Indian Reservation background extinction is based on the average for the top twenty percent at the Wishram monitoring site.

Table 5. Contribution of the Plymouth Generating Facility to Regional Haze in Class I Areas, Columbia River Gorge National Scenic Area, and Mt. Baker Wilderness For Applicable Sources Firing by Secondary Fuel Oil During Winter

Area of Interest	Plymouth Maximum Extinction (1/Mm)	Plymouth Maximum Change to Background Extinction (%)	Number of Days When Plymouth Contribution > 0.4%	
			And Cumulative Change to Extinction > 5.0%	And Cumulative Change to Extinction > 10.0%
Three Sisters Wilderness	0.01	0.09	0	0
Mt. Adams Wilderness	0.07	0.47	1	0
Alpine Lakes Wilderness	0.04	0.23	0	0
Diamond Peak Wilderness	0.01	0.04	0	0
Eagle Cap Wilderness	0.04	0.21	0	0
Glacier Peak Wilderness	0.09	0.48	0	0
Goat Rocks Wilderness	0.06	0.29	0	0
CRGNSA	0.37	1.57	2	1
Hells Canyon Wilderness	0.07	0.37	0	0
Mt. Hood Wilderness	0.44	2.20	4	1
Mt. Jefferson Wilderness	0.08	0.42	1	0
Mt. Baker Wilderness	0.03	0.15	0	0
North Cascades National Park	0.07	0.36	0	0
Olympic National Park	0.05	0.27	0	0
Pasayten Wilderness	0.07	0.36	0	0
Mt. Rainier National Park	0.05	0.71	0	0
Spokane Indian Reservation	0.11	0.44	0	0
Strawberry Mtn. Wilderness	0.09	0.54	0	0

Notes:

For the Plymouth Generating Facility peak 24-hour gas-fired emissions were assumed for all days of the year. The Oil-fired case assumes the Fredonia Facility and Chehalis Generating Facility would be using oil for all hours of a winter season. Predictions for all other sources are based on the emission rates in Table 1 for their primary fuel.

Predictions are from CALPUFF simulations of April 1, 1998 to March 15, 1999. Background extinction coefficients are based on aerosol concentrations during days with the top five percent best visibility for all areas except the CRGNSA and the Spokane Indian Reservation. The CRGNSA and Spokane Indian Reservation background extinction is based on the average for the top twenty percent at the Wishram monitoring site.

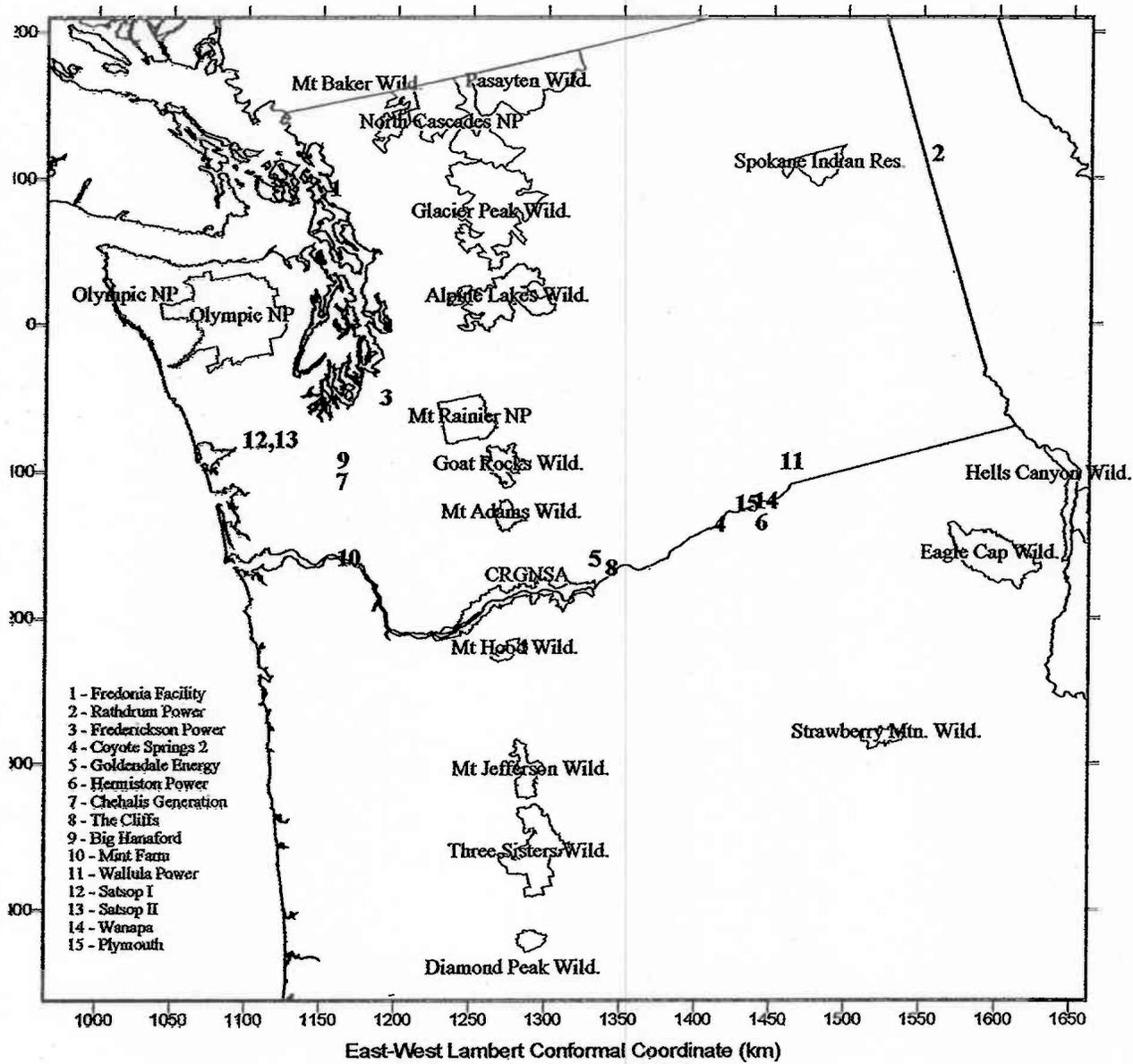


Figure 1.
Baselines
Sources with
Plymouth
Generating
Facility

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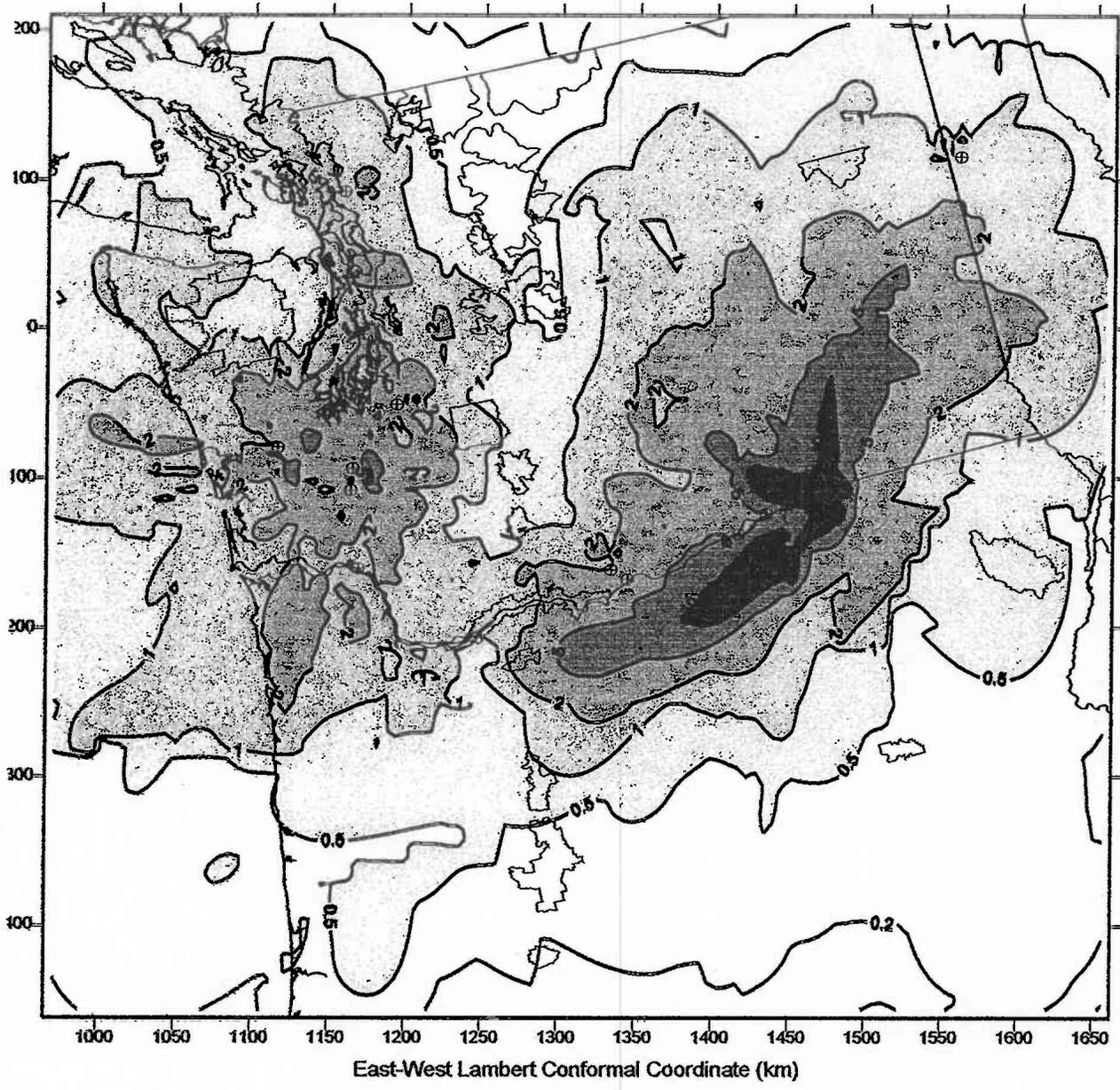


Figure 2.
Maximum 24-hour
Extinction
Coefficient
(1/Mm) at
Each
Receptor
Based on an
Annual
Simulation of
the Baseline
Sources (Gas-
fired) Plus the
Plymouth
Generating
Facility

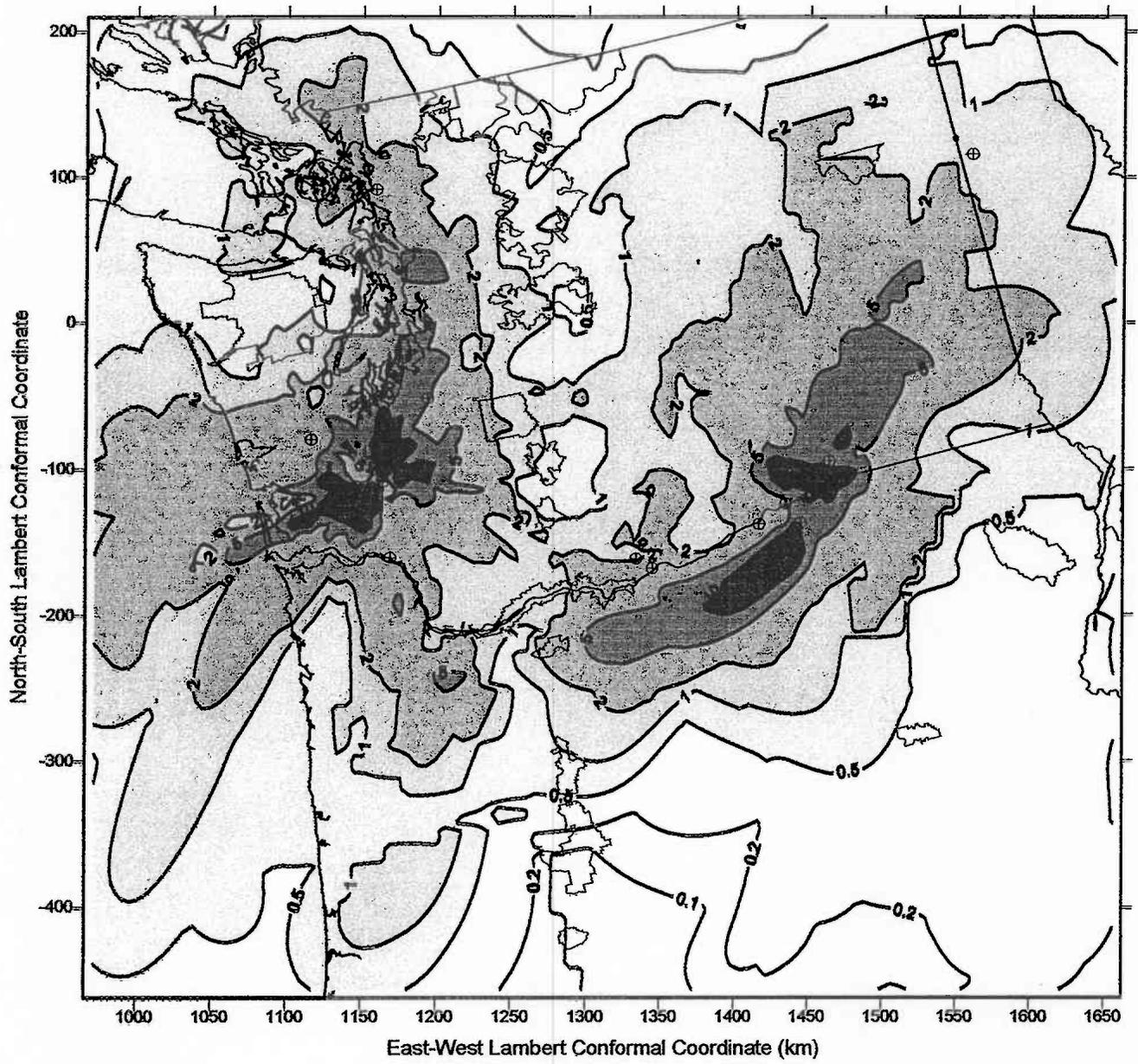


Figure 3. Maximum 24-hour Extinction Coefficient (1/Mm) at Each Receptor Based on a Winter Simulation of Baseline Sources (Oil-Fired)⁶ Plus the Plymouth Generating Facility

⁶ The Oil-fired case assumes the Fredonia Facility and Chehalis Generating Facility would be using oil for all hours of a winter season. Predictions for all other sources are based on the emission rates in Table 1 for their primary fuel.

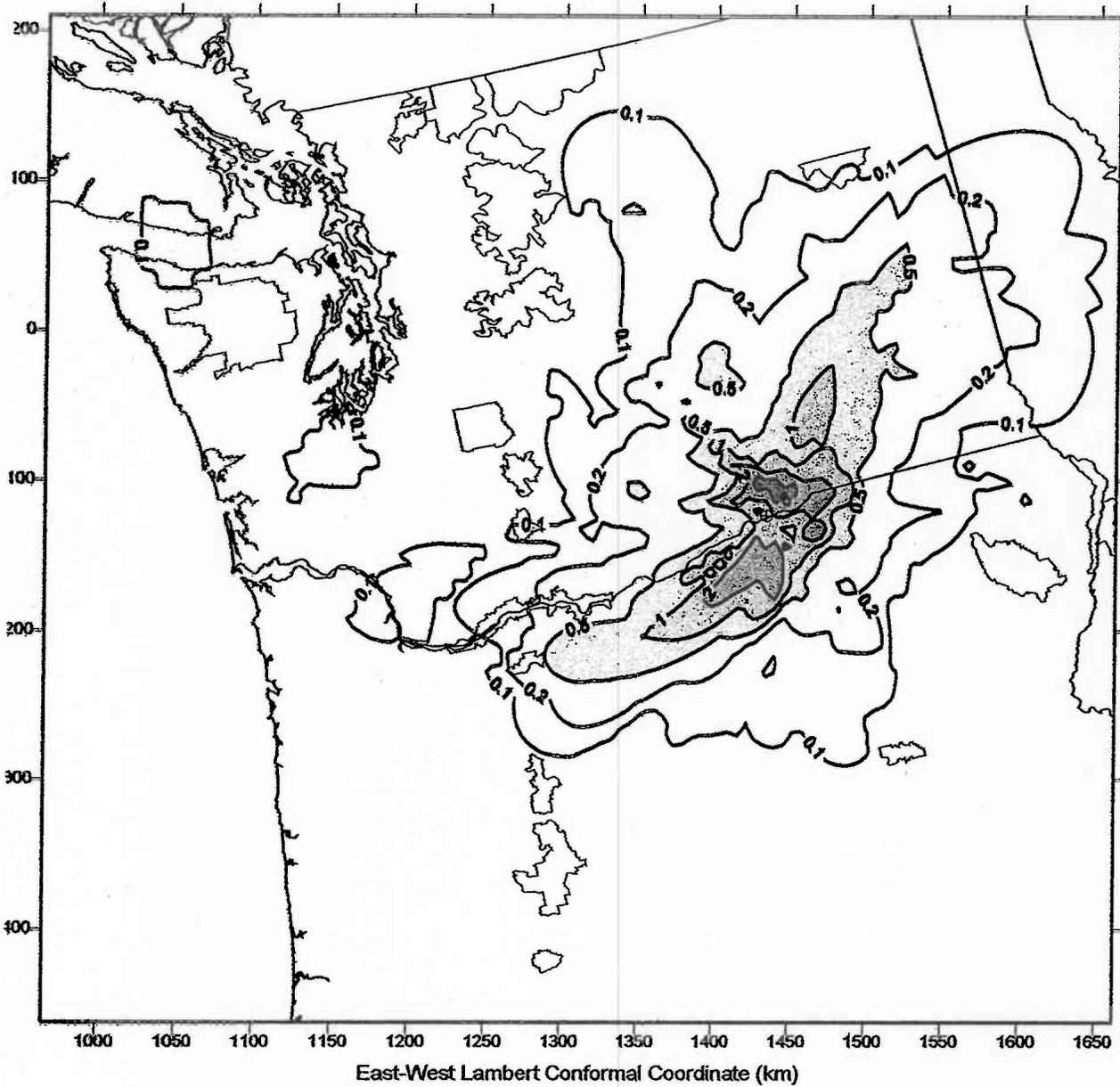


Figure 4.
Maximum 24-
hour
Extinction
Coefficient
(1/Mm) at
Each
Receptor
Based on an
Annual
Simulation of
the Plymouth
Generating
Facility Alone