AIR QUALITY ANALYSIS AND RELATED
RISK ASSESSMENT FOR THE BONNEVILLE
POWER ADMINISTRATION'S RESOURCE PROGRAM
ENVIRONMENTAL IMPACT STATEMENT

C. S. Glantz	M. T. Dana
K. W. Burk	G. L. Laws
C. J. Driver	L. A. Mahoney
J. C. Liljegren	K. Rhoads
D. A. Neitzel	
M. N. Schwartz	

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Pacific Northwest Laboratory
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SUMMARY

To meet the Pacific Northwest's growing energy demands, the Bonneville Power Administration (BPA) is considering 12 different alternatives for acquiring energy resources over the next 20 years. Each of the alternatives utilizes a full range of energy resources (e.g., coal, cogeneration, conservation, and nuclear); however, individual alternatives place greater emphases on different types of power-producing resources and employ different timetables for implementing these resources. The environmental impacts that would result from the implementation of each alternative and the economic valuations of these impacts, will be an important consideration in the alternative selection process.

In this report we discuss the methods used to estimate environmental impacts from the resource alternatives and present the results of these assessments. We focus on pollutant emission rates, ground-level air concentrations of basic criteria pollutants, the acidity of rain, particulate deposition, ozone concentrations, visibility attenuation, global warming, human health effects, agricultural and forest impacts, and wildlife impacts. The environmental impacts identified in our study are summarized in BPA's Draft 1992 Resource Programs Environmental Impact Statement (RPEIS).

For this study, pollutant emission rates are computed by processing BPA data on power production and associated pollutant emissions. The air concentrations of basic criteria pollutants and the dry deposition of particulates are computed using the Environmental Protection Agency (EPA)'s Industrial Source Complex - Short Term (ISCST) model. Acid rain and wet deposition are computed using a modified version of the EPA's Mesoscale Puff (MESOPUFF II) model. Ozone concentrations are computed using the EPA's Reactive Plume (RPM-IISS) model and visibility is computed using the EPA's Plume Visibility (PLUVUE II) model. Model results are presented for three study years: 1991, 2000, and 2010. Power plant emissions are assumed to occur at four regional release sites that are representative of existing and proposed facilities in western Washington, eastern Washington, northeastern Oregon, and southeastern Montana. When the data permit, separate estimates of

air quality impacts are presented for each combination of resource alternative, release site, and study year.

All of the resource alternatives are projected to involve significant increases in pollutant emissions during the study period (1991 through 2010). By themselves, pollutant emissions from power plants are not projected to cause dramatic decreases in regional air quality or major environmental impacts. However, in combination with emissions from other regional pollutant sources and other changes in pollutant background concentrations, increases in power plant emissions may contribute to local, regional, and global impacts on environmental quality.

Of the candidate resource alternatives, the Conventional Coal alternative tends to generate the greatest air quality impacts in each study year. Although "cleaner" than the Conventional Coal alternative, the Clean Coal and Imports alternatives consistently generate above-average air quality impacts. In the year 2000, the Base Case, Conservation, Nuclear, Renewables, and Cogeneration alternatives are projected to have air quality impacts that are lower than the average for all of the resource alternatives. In the year 2010, the High Conservation alternative is projected to have the lowest air quality impacts. The Fuel Switching alternative also generates "lower" air quality impacts in the year 2010, but the increased emissions from the expanded residential and commercial use of natural gas were not considered in our study.

The assessment of human health effects from basic criteria pollutant emissions indicates that lifetime cancer risks, acute mortality, and morbidity would increase as the level of pollutant emissions from power plants escalates during the period from 1991 through 2010. There are only small differences in human health impact as a function of the resource alternative. The Conventional Coal, Clean Coal, Imports, and Status Quo alternatives tend to have human health impacts that are near to above the average for all resource alternatives. The Base Case, Conservation, Nuclear, Combustion Turbine, Renewables, Cogeneration, High Conservation, and Fuel Switching alternatives tend to have human health impacts that are near to below the average for all resource alternatives.

The assessment of human health effects from ozone indicated little variation between the resource alternatives. Ozone formation and resulting human health impacts are heavily dependent on the ambient concentration of specific pollutants (i.e., reactive hydrocarbon compounds). Future changes in the background concentrations of these pollutants can have significant impacts on ozone concentrations. Such changes can increase the human health impacts from ozone and produce a greater variation in the impacts from different resource alternatives.

Impacts on plants, crops, and wildlife populations from power plant emissions are projected to be minimal for all resource alternatives. The exception to this would involve impacts that could potentially lead to the loss of even a few individuals of endangered or threatened species. This concern exists for all of the candidate resource alternatives.

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1.0 INTRODUCTION

The Northwest Power Planning Council's 1991 Northwest Conservation and Electric Power Plan examines probable changes in the Pacific Northwest's energy needs over the next 20 years and discusses resources that can be developed to meet these needs. Predicting future energy needs is a difficult task; regional energy demand is related to economic conditions (on a regional, national, and global scale), population, technological development, and climatic change. The Northwest Conservation and Electric Power Plan (NWPPC 1991) considers a series of the most likely scenarios for regional energy demand; these scenarios range from a future involving long-term regional economic recession (with a resulting slight decline in regional energy demand) to a long-term period of strong regional population and economic growth (with a resulting 2.5% annual growth rate in regional energy demand).

To plan for the Pacific Northwest's future energy demands, the Bonneville Power Administration (BPA) prepares a biannual resource program. To support this planning effort, BPA is assessing the potential environmental impacts of 12 different resource alternatives. These alternatives are listed in Figure 1.1., and are described in detail in the Resource Programs Environmental Impact Statement (RPEIS).

Each candidate resource alternative emphasizes a different type of energy resource and employs different timetables for implementing resources. For example, one alternative emphasizes the use of cogeneration units and gas turbines to meet future energy demands, another emphasizes the development of nuclear power, and a third emphasizes the construction of coal-fired power plants. However, each alternative considers and utilizes each type of power plant in varying amounts.

This document presents work conducted by the Pacific Northwest Laboratory (PNL) to provide preliminary estimates of the air quality impacts that would result from the operation of the new power-generating facilities called for in each candidate resource alternative.

Status Quo

Bonneville continues doing business as usual. Bonneville chooses new resources based upon minimizing system total cost, without accounting for environmental externalities.

Base Case

Bonneville includes environmental externalities in calculating total system cost. This is the benchmark case against which other cases will be compared.

Conservation

This alternative moves lost opportunity and discretionary conservation resources to the top of the resource stack.

High Conservation

A higher amount of conservation is emphasized than in the previous alternative, reflecting conservation measures expected to become cost effective within the planning horizon.

Conventional Coal

This alternative places conventional coal as the first resource added to meet new loads.

Clean Coal

Clean coal technology, including fluidized bed and coal-gasification, are moved to the top of the resource stack.

Nuclear

This scenario meets load requirements by accelerating the completion of nuclear plants WNP-1 and WNP-3.

Combustion Turbines

Combustion turbines will be the first resource used to meet load growth.

Renewables

Renewable resources (hydro, solar, wind, and geothermal) will be moved to the top of the resource stack.

Cogeneration

This alternative makes cogeneration resources the first to be completed to meet new loads.

Fuel switching

This alternative will model fuel switching (from electricity to other sources) as a program.

Imports

This alternative uses energy from long-term firm contracts with energy supplies outside of the region to supply new energy within the region.

FIGURE 1.1. Resource Program Scenarios Proposed by the RPEIS

Chapter 2 discusses pollutant inventories and emission rates. Chapter 3 discusses ground-level air concentrations of basic criteria pollutants. Chapter 4 discusses acid rain and particulate deposition. Modeling of ozone concentrations in the air is discussed in Chapter 5. Impacts on global warming are discussed in Chapter 6. Chapter 7 discusses impacts on visibility. Chapter 8 describes human health effects related to criteria pollutants. Human health effects related to ozone are discussed in Chapter 9. Chapter 10 discusses impacts of power plant emissions on surrounding wildlife populations. Chapter 11 describes the impacts of power plant emissions on crops and plants.

2.0 EMISSION INVENTORIES AND POLLUTANT EMISSION RATES

In this section we provide information on the power generation and resulting emission inventories for each resource alternative. In particular, we

- examine the location of existing power plants
- examine the proposed location (for air quality modeling purposes) of new power plants.
- review generic information on the emissions characteristic for each type of power plant
- describe available power allocation information
- discuss the procedure followed to determine the allocation of power generation capacity among the available power plants for each combination of study year, resource alternative, release site, type of power plant, and season
- analyze power plant emissions of oxides of nitrogen (NO_x), sulfur dioxide (SO_2), total suspended particulates (TSP), and carbon dioxide (CO_2) as a function of the release site, study year, and resource alternative.

2.1 POWER PLANT TYPES AND LOCATIONS

For estimating air quality impacts, all existing and new fossil-fuel combustion power generation facilities are assumed to be located at four sites. These sites are used to represent all power plant emissions in western Washington, eastern Washington, northeastern Oregon, and eastern Montana. For modeling purposes the specific sites chosen to represent power plant locations are Centralia, Washington (western Washington); Creston, Washington (eastern Washington); Boardman, Oregon (northeastern Oregon); and Colstrip, Montana (eastern Montana).

For characterizing pollutant emissions, 10 types of fossil fuel power plants are considered. These are

- existing conventional pulverized coal power plants
- new conventional pulverized coal power plants
- new atmospheric fluidized-bed coal power plants

- new integrated gasification combined-cycle coal power plants
- existing Northwest single- and combined-cycle combustion turbine (natural gas) power plants
- new Northwest combined-cycle combustion turbine (natural gas) power plants
- new natural gas cogeneration facilities
- existing California single- and combined-cycle combustion turbine (natural gas) power plants
- new California combined-cycle combustion turbine (natural gas) power plants
- new Canadian combined-cycle combustion turbine (natural gas) power plants.

The projected locations of new power plants in the BPA service region are summarized in Table 2.1

Although nuclear, hydroelectric, and other renewable energy sources are included in the resource alternatives, the assessment of any air quality impacts from these plants is beyond the scope of our analysis. Similarly, the assessment of residential and commercial emissions (e.g., from the increased use of natural gas in the Fuel Switching alternative) is also beyond the scope of our analysis. We also note that the impact of increased conservation measures on indoor air quality was not evaluated in our assessment of potential human health impacts.

TABLE 2.1. Location of New Power Generation Facilities. An "X" indicates a facility may be located at the indicated site and an "-" indicates a facility would not be located at the site.

<u>Type of Facility</u>	<u>Centralia</u>	<u>Creston</u>	<u>Boardman</u>	<u>Colstrip</u>
Conventional Coal	X	X	X	X
Fluidized Bed Coal	X	X	X	X
Gasified Coal	X	X	X	X
Combustion Turbine	X	X	-	-
Cogeneration	X	-	X	-

All existing coal-fired power plants use the conventional pulverized coal technology. These plants are the Colstrip and Jim Bridger plants at the eastern Montana study site; the Valmy and Boardman plants at the northeastern Oregon study site; and the Centralia plant at the western Washington study site. New power plants that would use the conventional pulverized coal technology are proposed in some resource alternatives for each of the four study sites. In the Clean Coal alternative, fluidized-bed and integrated gasification coal plants are proposed for each of the sites. None of the other resource alternatives use new coal-fired power plant technologies.

For modeling purposes, all existing natural gas-fired combustion turbines are assumed to be located at the western Washington site. New combustion turbines are also assumed to be located at the western Washington site; the Combustion Turbine alternative assumes half of new combustion turbines will be located at the eastern Washington site.

There are no existing natural-gas cogeneration facilities providing power to the BPA. For air quality modeling purposes, new BPA cogeneration facilities are assumed to be located both in western Washington and in northeastern Oregon. Bonneville assumed that all cogeneration facilities included in the alternatives would be natural gas-fired facilities.

For the Imports alternative, new combustion turbine power plants that will provide power to the region are assumed to be located in California and Canada. Emissions from these facilities are modeled as if they were located in the Pacific Northwest. In reality, these plants will have little or no impact on air quality in the Pacific Northwest, although they will impact air quality near their release locations.

New power-generating facilities in western Washington are assumed to be located near the existing Centralia, Washington, coal-fired power plant. This site is located about midway between the cities of Seattle and Portland and east of Interstate 5. The plant is approximately 12 km (7 mi) east-northeast of the city of Centralia, on Big Hanaford Rd, in the Hanaford Valley near the Thurston and Lewis County line. The elevation of the site is less than 200 m (650 ft) above mean sea level. The Gifford Pinchot National Forest is located

20 km (12.5 mi) east of the site; Olympia, Washington, the state capital, is 33 km (21 mi) to the north-northwest.

New power-generating facilities at the eastern Washington study site are assumed to be located 2.4 km (1.5 mi) north of the town of Creston, Washington on Mount View Rd. Creston is located in the northeastern portion of Washington, about 95 km (60 mi) west of Spokane. The town of Wilbur is approximately 13 km (8 mi) west of the postulated power-generation site. The elevation of the power generation site is about 750 m (2500 ft) above mean sea level. The Columbia River (behind Grand Coulee Dam) is about 10 km (6 mi) north of the site. The Colville Indian Reservation is located immediately north of the Columbia River.

New power-generating facilities in northeastern Oregon are assumed to be located near the existing Boardman, Oregon, coal-fired power plant. The Boardman site is 18 km (11 mi) south-southwest of the town of Boardman and 21 km (13 mi) north of the town of Ione. The elevation of the site is about 200 m (650 ft) above sea level. The Columbia River (behind John Day Dam) is about 15 km (9.5 mi) north of the site. The Umatilla National Forest covers a wide area in the northeastern part of Oregon. At its closest, the national forest is within 72 km (45 mi) of the Boardman site.

New power-generating facilities in eastern Montana are assumed to be located near the existing Colstrip, Montana, existing coal-fired power plants. Colstrip is located in southeastern Montana. The Custer National Forest is located 40 km (25 mi) southeast of the town and the Northern Cheyenne Reservation is located 22 km (14 mi) south of Colstrip. The Yellowstone River passes about 40 km (25 mi) north of the town.

2.2 DETERMINING POLLUTANT EMISSION RATES

The following sections describe the methods we used to determine pollutant emission rates.

2.2.1 Power Plant Emissions

Data on power plant emissions were provided by the BPA for each of the power plants described in Section 2.1. For each of the power plants, data on the amount (lbs) of pollutant released per million British thermal units (Btu)

were provided for oxides of nitrogen (NO_x), sulfur dioxide (SO_2), total suspended particulates (TSP), and carbon dioxide (CO_2) (Table 2.2).

Data were also provided on the number of Btus required to generate a kilowatt-hour of power for each type of plant. Using these data we computed the mass of each pollutant that would be generated by each type of power plant per megawatt hour of power generated. This was converted into the release pollutant rates presented in Table 2.3.

In addition to information on pollutant emission rates per megawatt hour of power generated, we needed to characterize other pollutant emission parameters to provide required input to our air quality models. These parameters include emission stack height, the inner diameter of the stack, effluent temperature, and effluent velocity. It is difficult to accurately estimate the value of these parameters for all the modeled facilities. For example, at coal-fired power plants these parameters vary as a function of such diverse factors as plant technology, size of the facility, local and regional environmental conditions, regulatory requirements, and public relations concerns. For purposes of this study we assume that all coal-fired power plants (both existing and proposed, conventional and non-conventional) have a stack height of 150 m, an exhaust velocity of 26 m/s, a stack diameter of 5.0 m, and an effluent temperature 77°C. This assumption is supported by information obtained from the BPA's Generic Coal Study (ECO Northwest 1987) and conversations with personnel at the Electric Power Research Institute.

All combustion turbine power plants and cogeneration facilities are assumed to have a stack height of 30 m, an exhaust velocity of 22 m/s, a stack diameter of 3 m, and an effluent temperature 156°C. These assumptions are based on conversations with personnel at Kaiser Engineering, Hanford; the Kettle Falls, Washington, cogeneration facility; and the Electric Power Research Institute. These assumptions were also based on material in the BPA's Comparative Electric Generation Study (BPA 1986).

2.2.2 Data on Power Generation at Each Release Site

Information on power plant operations for the years 1991 through 2050 was provided by the BPA. Our analysis focuses on emissions and air quality

impacts in three years, 1991, 2000, and 2010. Data on the seasonal power output (average megawatts) for each study year is presented for each plant.

TABLE 2.2. Emission Factors for Each Fossil Fuel-Fired Power Plant (All values are in lbs/mmBtu.)

<u>Generating Resource Types</u>	<u>NO_x</u>	<u>SO_x</u>	<u>TSP</u>	<u>CO₂</u>
Northwest Existing Simple Cycle Combustion Turbine	0.174	0.001	0.0133 ^a	117
Northwest Existing Combined Cycle Combustion Turbines	0.174	0.001	0.0133 ^a	117
Northwest New Combined Cycle Combustion Turbine	0.174	0.001	0.001	117
Northwest New Cogeneration	0.175	0.001	0.001	117
Northwest Existing Conventional Coal	0.5833 ^a	0.774 ^a	0.030	205
Northwest New Conventional Coal	0.500	0.2	0.030	205
Northwest Atmospheric Fluidized Bed Combustion Coal	0.134	0.080	0.015	205
Northwest New Integrated Gasification Combined Cycle Coal	0.105	0.040	0.0066	205
California Existing Combustion Turbines	0.118 ^a	0.0006 ^a	0.0133 ^a	117
California New Combined Cycle Combustion Turbines	0.0275 ^a	0.0006 ^a	0.001 ^a	117
Canadian New Combined Cycle Combustion Turbines	0.174	0.001	0.001	117

(a) These values are taken from the California Energy Commission, 1989, Staff Recommendations for Generic Power Plant Emission Factors.

TABLE 2.3. Pollutant Release Rates per Megawatt-Second of Power Generated. The unit label "mWs" stands for megawatt-seconds; values can be multiplied by 3,600 s/h to obtain the grams of pollutant released per megawatt-hour.

Type of Plant	NO _x (g/mWs)	SO ₂ (g/mWs)	TSP (g/mWs)	CO ₂ (g/mWs)
Conventional Pulverized Coal	0.68	0.82	0.042	280.
Atmospheric Fluidized Bed Coal	0.17	0.25	0.019	260.
Integrated Gasification Coal	0.12	0.11	0.0077	200.
Single Cycle Combustion Turbine	0.22	0.0014	0.0014	170.
Complex Cycle Combustion Turbine	0.15	0.00096	0.00096	110.
Cogeneration (natural gas) ^(a)	0.097	0.00063	0.00063	74.

(a) Emissions from cogeneration facilities only consider the increase in emissions required to generate power, it does not include the emissions required to generate heat for industrial applications.

The BPA uses four power generation seasons for the Pacific Northwest:

- September through December (i.e., fall)
- January - April (i.e., winter)
- May (i.e., spring)
- June - August (summer).

This seasonal breakdown is used because of its relationship to power demand, hydroelectric power supply, and system maintenance requirements. A sample of the power generation data received from the BPA is presented in Tables 2.4, 2.5, and 2.6.

To determine the total power generated in each season by each type of power plant at each of the four regional release sites, we summed up results for similar types of power plants and placed these data in forms that we created for this project. Sample forms are presented in Tables 2.7, 2.8, and 2.9. These forms were converted into formatted data files for processing to determine pollutant release rates.

TABLE 2.4. Seasonal Power Generation for the Year 1991. All values are in average megawatts.

<u>EXISTING - NUC</u>	<u>Fall</u>	<u>Winter</u>	<u>May</u>	<u>Summer</u>
TROJAN	877.	644.	0.	877.
WNP#2	853.	853.	0.	569.
<u>ACQUIRED - NUC</u>				
WNP 3	0.	0.	0.	0.
WNP 1	0.	0.	0.	0.
<u>EXISTING - HCOAL</u>				
VALMY1	87.	53.	16.	37.
VALMY2	88.	53.	1.	42.
BRDMAN	336.	129.	117.	168.
<u>ACQUIRED - HCOAL</u>				
Coal2 (E WA)	0.	0.	0.	0.
Coal3 (E OR)	0.	0.	0.	0.
Coal4 (NV)	0.	0.	0.	0.
Coal5 (W WA/OR)	0.	0.	0.	0.
FBCoal2 (E WA)	0.	0.	0.	0.
FBCoal3 (E OR)	0.	0.	0.	0.
FBCoal4 (NV)	0.	0.	0.	0.
FBCoal5 (W WA/OR)	0.	0.	0.	0.
GCoal2 (E WA)	0.	0.	0.	0.
GCoal3 (E OR)	0.	0.	0.	0.
GCoal4 (NV)	0.	0.	0.	0.
GCoal5 (W WA/OR)	0.	0.	0.	0.
<u>EXISTING - LCOAL</u>				
COLST1	131.	110.	1.	112.
COLST2	131.	110.	1.	111.
COLST3	415.	349.	82.	349.
COLST4	415.	349.	76.	349.
CENT#1	571.	480.	108.	457.
CENT#2	545.	421.	94.	391.
BRIG#1	156.	131.	4.	129.
BRIG#2	119.	131.	75.	129.
BRIG#3	158.	98.	76.	126.
BRIG#4	114.	134.	76.	127.
<u>ACQUIRED - LCOAL</u>				
Coal1 (E MT)	0.	0.	0.	0.
FBCoal1 (E MT)	0.	0.	0.	0.
GCoal1 (E MT)	0.	0.	0.	0.
<u>EXISTING - SCT</u>				
BEAVER	0.	0.	0.	0.
WHITH1	0.	0.	0.	0.
WHITH2	0.	0.	0.	0.
WHITH3	0.	0.	0.	0.
BETHEL	0.	0.	0.	0.
FREDK1	0.	0.	0.	0.
FREDK2	0.	0.	0.	0.
FREDQ1	0.	0.	0.	0.
FREDQ2	0.	0.	0.	0.
<u>ACQUIRED - CCT</u>				
Combined Cycle BPA	0.	0.	0.	0.
Combined Cycle Mix	0.	0.	0.	0.

TABLE 2.5. Seasonal Power Generation for the High Conservation Alternative in the Year 2000. All values are in average megawatts.

<u>EXISTING - NUC</u>	<u>Fall</u>	<u>Winter</u>	<u>May</u>	<u>Summer</u>
TROJAN	877.	644.	0.	877.
WNP#2	853.	853.	0.	569.
<u>ACQUIRED - NUC</u>				
WNP 3	0.	0.	0.	0.
WNP 1	0.	0.	0.	0.
<u>EXISTING - HCOAL</u>				
VALMY1	101.	101.	46.	77.
VALMY2	101.	101.	1.	74.
BROMAN	391.	249.	336.	336.
<u>ACQUIRED - HCOAL</u>				
Coal2 (E WA)	563.	563.	484.	442.
Coal3 (E OR)	0.	0.	0.	0.
Coal4 (NV)	0.	0.	0.	0.
Coal (W WA/OR)	0.	0.	0.	0.
FBCoal2 (E WA)	0.	0.	0.	0.
FBCoal3 (E OR)	0.	0.	0.	0.
FBCoal4 (NV)	0.	0.	0.	0.
FBCoal5 (W WA/OR)	0.	0.	0.	0.
GCoal2 (E WA)	0.	0.	0.	0.
GCoal3 (E OR)	0.	0.	0.	0.
GCoal4 (NV)	0.	0.	0.	0.
GCoal5 (W WA/OR)	0.	0.	0.	0.
<u>EXISTING - LCOAL</u>				
COLST1	131.	131.	1.	131.
COLST2	131.	131.	1.	131.
COLST3	415.	415.	146.	388.
COLST4	415.	415.	136.	410.
CENT#1	570.	545.	178.	492.
CENT#2	571.	571.	201.	522.
BRIG#1	156.	156.	7.	156.
BRIG#2	119.	156.	134.	156.
BRIG#3	158.	117.	136.	158.
BRIG#4	114.	159.	137.	159.
<u>ACQUIRED - LCOAL</u>				
Coal1 (E MT)	563.	563.	484.	563.
FBCoal1 (E MT)	0.	0.	0.	0.
GCoal1 (E MT)	0.	0.	0.	0.
<u>EXISTING - SCT</u>				
BEAVER	24.	5.	0.	7.
WHITH1	0.	0.	0.	0.
WHITH2	0.	0.	0.	0.
WHITH3	0.	0.	0.	0.
BETHEL	0.	1.	0.	0.
FREDK1	0.	0.	0.	0.
FREDK2	0.	0.	0.	0.
FRED01	0.	0.	0.	0.
FRED02	0.	0.	0.	0.
<u>ACQUIRED - CCT</u>				
Combined Cycle BPA	439.	139.	28.	73.
Combined Cycle Mix	352.	96.	8.	63.

TABLE 2.6.

Seasonal Power Generation for the High Conservation Alternative in the Year 2010. All values are in average Megawatts.

<u>EXISTING - NUC</u>	<u>Fall</u>	<u>Winter</u>	<u>May</u>	<u>Summer</u>
TROJAN	877.	644.	0.	877.
WNP#2	853.	853.	0.	569.
<u>ACQUIRED - NUC</u>				
WNP 3	967.	967.	967.	322.
WNP 1	975.	975.	975.	325.
<u>EXISTING - HCOAL</u>				
VALMY1	100.	97.	21.	99.
VALMY2	102.	99.	1.	102.
BRDMAN	391.	242.	160.	391.
<u>ACQUIRED - HCOAL</u>				
Coal2 (E WA)	563.	546.	231.	563.
Coal3 (E OR)	563.	546.	231.	563.
Coal4 (NV)	0.	0.	0.	0.
Coal5 (W WA/OR)	0.	0.	0.	0.
FBCoal2 (E WA)	0.	0.	0.	0.
FBCoal3 (E OR)	0.	0.	0.	0.
FBCoal4 (NV)	0.	0.	0.	0.
FBCoal5 (W WA/OR)	0.	0.	0.	0.
GCoal2 (E WA)	0.	0.	0.	0.
GCoal3 (E OR)	0.	0.	0.	0.
GCoal4 (NV)	0.	0.	0.	0.
GCoal5 (W WA/OR)	0.	0.	0.	0.
<u>EXISTING - LCOAL</u>				
COLST1	131.	131.	1.	131.
COLST2	131.	131.	1.	131.
COLST3	415.	415.	129.	415.
COLST4	415.	415.	120.	415.
CENT#1	570.	566.	153.	571.
CENT#2	571.	571.	178.	571.
BRIG#1	156.	156.	6.	156.
BRIG#2	119.	156.	119.	156.
BRIG#3	158.	117.	120.	158.
BRIG#4	114.	159.	121.	159.
<u>ACQUIRED - LCOAL</u>				
Coal1 (E MT)	1313.	1313.	1000.	1313.
FBCoal1 (E MT)	0.	0.	0.	0.
GCoal1 (E MT)	0.	0.	0.	0.
<u>EXISTING - SCT</u>				
BEAVER	0.	5.	0.	0.
WHITH1	0.	0.	0.	0.
WHITH2	0.	0.	0.	0.
WHITH3	0.	0.	0.	0.
BETHEL	0.	0.	0.	0.
FREDK1	0.	0.	0.	0.
FREDK2	0.	0.	0.	0.
FRED01	0.	0.	0.	0.
FRED02	0.	0.	0.	0.
<u>ACQUIRED - CCT</u>				
Combined Cycle BPA	408.	155.	0.	124.
Combined Cycle Mix	271.	77.	0.	63.

TABLE 2.7. Total Average Megawatts Produced in 1991 as a Function of the Season, Release Site, and Type of Power Plant

SEP - DEC					JAN - APR				
Pollutant	Colstrip	Creston	Boardman	Centralia	Pollutant	Colstrip	Creston	Boardman	Centralia
Old COAL	1639	0	511	1116	Old COAL	1412	0	235	901
New COAL	0	0	0	0	New COAL	0	0	0	0
NW SCCT	0	0	0	0	NW SCCT	0	0	0	0
CAL SCCT	0	0	0	0	CAL SCCT	0	0	0	0
New CCCT	0	0	0	0	New CCCT	0	0	0	0
COGEN	0	0	0	0	COGEN	0	0	0	0
CAN CCT	0	0	0	0	CAN CCT	0	0	0	0
F1B COAL	0	0	0	0	F1B COAL	0	0	0	0
GAS COAL	0	0	0	0	GAS COAL	0	0	0	0

MAY					JUN - AUG				
Pollutant	Colstrip	Creston	Boardman	Centralia	Pollutant	Colstrip	Creston	Boardman	Centralia
Old COAL	391	0	134	202	Old COAL	1432	0	247	848
New COAL	0	0	0	0	New COAL	0	0	0	0
NW SCCT	0	0	0	0	NW SCCT	0	0	0	0
CAL SCCT	0	0	0	0	CAL SCCT	0	0	0	0
New CCCT	0	0	0	0	New CCCT	0	0	0	0
COGEN	0	0	0	0	COGEN	0	0	0	0
CAN CCT	0	0	0	0	CAN CCT	0	0	0	0
F1B COAL	0	0	0	0	F1B COAL	0	0	0	0
GAS COAL	0	0	0	0	GAS COAL	0	0	0	0

TABLE 2.8. Total Average Megawatts Produced for the High Conservation Alternative in the Year 2000 as a Function of the Season, Release Site, and Type of Power Plant

SEP - DEC					JAN - APR				
Pollutant	Colstrip	Creston	Boardman	Centralia	Pollutant	Colstrip	Creston	Boardman	Centralia
Old COAL	1639	0	592	1141	Old COAL	1680	0	451	1100
New COAL	563	563	0	0	New COAL	563	563	0	0
NW SCCT	0	0	0	36	NW SCCT	0	0	0	0
CAL SCCT	0	0	0	0	CAL SCCT	0	0	0	0
New CCCT	0	0	0	10	New CCCT	0	0	0	18
COGEN	0	0	580	1420	COGEN	0	0	580	1420
CAN CCT	0	0	0	0	CAN CCT	0	0	0	0
F1B COAL	0	0	0	0	F1B COAL	0	0	0	0
GAS COAL	0	0	0	0	GAS COAL	0	0	0	0

MAY					JUN - AUG				
Pollutant	Colstrip	Creston	Boardman	Centralia	Pollutant	Colstrip	Creston	Boardman	Centralia
Old COAL	633	0	348	342	Old COAL	1583	0	407	921
New COAL	439	439	0	0	New COAL	550	368	0	0
NW SCCT	0	0	0	0	NW SCCT	0	0	0	0
CAL SCCT	0	0	0	0	CAL SCCT	0	0	0	0
New CCCT	0	0	0	0	New CCCT	0	0	0	0
COGEN	0	0	580	1420	COGEN	0	0	580	1420
CAN CCT	0	0	0	0	CAN CCT	0	0	0	0
F1B COAL	0	0	0	0	F1B COAL	0	0	0	0
GAS COAL	0	0	0	0	GAS COAL	0	0	0	0

TABLE 2.9. Total Average Megawatts Produced for the High Conservation Alternative in the Year 2010 as a Function of the Season, Release Site, and Type of Power Plant

SEP - DEC					JAN - APR				
Pollutant	Colstrip	Creston	Boardman	Centralia	Pollutant	Colstrip	Creston	Boardman	Centralia
Old COAL	1639	0	592	1141	Old COAL	1680	0	438	1137
New COAL	1313	563	563	0	New COAL	1313	546	546	0
NW SCCT	0	0	0	28	NW SCCT	0	0	0	10
CAL SCCT	0	0	0	0	CAL SCCT	0	0	0	0
New CCCT	0	0	0	790	New CCCT	0	0	0	283
COGEN	0	0	1760	2580	COGEN	0	0	1760	2580
CAN CCT	0	0	0	0	CAN CCT	0	0	0	0
F1B COAL	0	0	0	0	F1B COAL	0	0	0	0
GAS COAL	0	0	0	0	GAS COAL	0	0	0	0

MAY					JUN - AUG				
Pollutant	Colstrip	Creston	Boardman	Centralia	Pollutant	Colstrip	Creston	Boardman	Centralia
Old COAL	617	0	187	331	Old COAL	1721	0	593	1142
New COAL	1005	236	236	0	New COAL	1313	563	563	0
NW SCCT	0	0	0	0	NW SCCT	0	0	0	9
CAL SCCT	0	0	0	0	CAL SCCT	0	0	0	0
New CCCT	0	0	0	0	New CCCT	0	0	0	221
COGEN	0	0	1760	2580	COGEN	0	0	1760	2580
CAN CCT	0	0	0	0	CAN CCT	0	0	0	0
F1B COAL	0	0	0	0	F1B COAL	0	0	0	0
GAS COAL	0	0	0	0	GAS COAL	0	0	0	0

2.2.3 Combining Data on Emissions and Operations to Obtain Pollutant Release Rates

Using an in-house processing code created for this application, we used information on power generation (from the formatted data files) and pollutant emission rates (from Table 2.3) to compute seasonally averaged release rates for emissions from both 150 m (coal plants) and 30 m (natural gas plants) stacks for each combination of pollutant, release site, study year, and resource alternative (see Appendix A for these results). We also prepared an in-house processing code to compute the total average emission rates for each combination of pollutant, release site, study year, and resource alternative.

2.3 ANALYSIS OF POLLUTANT EMISSION RATES

The following sections discuss the emission rates projected for the four study sites.

2.3.1 Pollutant Emission Rates at the Western Washington Site

At the western Washington site, emissions in 1991 are coming from two coal-fired power plants at Centralia. In the years 2000 and 2010, additional pollutant emissions will come from the increased operation of the existing coal-fired power plants, the operation of new coal-fired power plants, existing simple-cycle combustion turbines, new combined-cycle combustion turbines, and new cogeneration facilities.^(a)

In Table 2.10, the emission rates for NO_x, SO₂, and TSP at the western Washington site are presented for each study year and resource alternative. In Table 2.11, the emission rates for CO₂ at the western Washington site are presented for each study year and resource alternative. In all of the resource alternatives there will be a significant increase in emissions of NO_x, SO₂, TSP,

^(a) The actual mix of generating resources varies by alternative.

TABLE 2.10. Average NO_x, SO₂, and TSP Emission Rates at Centralia. Values are provided for each study year and resource alternative. Emission rates are for all BPA power plants operating at the site in the indicated study year.

<u>Resource Alternative</u>	<u>Emission Rates (g/s) in the Year 1991</u>					
	<u>NO_x</u>	<u>SO₂</u>	<u>TSP</u>			
All Programs	678	900	35			
<u>Resource Alternative</u>	<u>Emission Rates (g/s) in the Year 2000</u>			<u>Emission Rates (g/s) in the Year 2010</u>		
	<u>NO_x</u>	<u>SO₂</u>	<u>TSP</u>	<u>NO_x</u>	<u>SO₂</u>	<u>TSP</u>
Status Quo	983	1036	41	1133	1071	44
Base Case 4	991	1032	41	1184	1073	44
Conservation	985	1032	41	1184	1073	44
Conventional Coal	1081	1089	48	1215	1115	50
Clean Coal	998	1050	42	1125	1081	44
Nuclear	939	1024	41	1189	1073	44
Combustion Turbine	1024	1032	41	1149	1073	44
Renewables	999	1034	41	1165	1073	44
Cogeneration	985	974	39	1165	1071	44
Fuel Switching	1022	1039	42	1136	1074	44
High Conservation	1020	1040	42	1119	1072	43
Imports ^(a)	1062	1067	45	1310	1087	48

(a) Includes emissions during generation of power for BPA from combustion turbines located in the southwestern United States.

and CO₂ between the years 1991 and 2000.^(a) By the year 2000 the emission rate for NO_x is projected to be from 38% (Nuclear) to 59% (Conventional Coal) greater than the 1991 rate. Similarly, the emission rate for SO₂ is projected to increase by 8% (Cogeneration) to 21% (Conventional Coal), the emission rate for TSP is projected to increase by 11% (Cogeneration) to 37% (Conventional Coal), and the emission rate for CO₂ is projected to increase by 61% (Nuclear) to 100% (Imports) over the corresponding 1991 values.

^(a) Energy resources in parentheses refer to BPA's EIS alternatives. The cited resource is emphasized in the alternative.

TABLE 2.11. Average CO₂ Emission Rates at Centralia. Emission rates are for all BPA power plants operating at the site in the indicated study year.

<u>Resource Alternative</u>	<u>CO₂ Emission Rates (kg/s) in the Year 1991</u>	
All Programs	238	
<u>Resource Alternative</u>	<u>CO₂ Emission Rates (kg/s) in the Year 2000</u>	<u>CO₂ Emission Rates (kg/s) in the Year 2010</u>
Status Quo	410	503
Base Case 4	416	536
Conservation	412	536
Conventional Coal	447	528
Clean Coal	416	520
Nuclear	384	539
Combustion Turbine	439	512
Renewables	421	523
Cogeneration	427	523
Fuel Switching	436	504
High Conservation	434	492
Imports ^(a)	476	646

(a) Includes emissions during generation of power for BPA from combustion turbines located in the southwestern United States.

For each of the resource alternatives there will also be a significant increase in emissions of NO_x, SO₂, TSP, and CO₂ between the years 2000 and 2010. By the year 2010, the emission rate for NO_x is projected to increase by 65% (High Conservation) to 93% (Imports) over the 1991 value. Similarly, the emission rate for SO₂ is projected to exceed the 1991 value by 19% (several alternatives) to 24% (Conventional Coal), the emission rates for TSP is projected to increase beyond the 1991 value by 23% (High Conservation) to 43% (Conventional Coal), and the emission rate for CO₂ will increase by 107% (High Conservation) to 171% (Imports) over the corresponding 1991 value.

2.3.2 Pollutant Emission Rates at the Northeastern Oregon Site

At the northeastern Oregon site, emissions in 1991 are coming from three coal-fired units that represent the Boardman (one unit) and Valmy (two units) power plants. In the year 2000, additional pollutant emissions will come from the increased operation of the existing coal-fired power plants and new cogeneration facilities. In the year 2010, additional pollutant emissions will come from the increased operation of the existing coal-fired power plants, operation of new coal-fired power plants, and increased cogeneration production. Of the three regional release sites active in 1991, the greatest percentage increase in pollutant emissions occurs at the northeastern Oregon release site.

In Table 2.12, the emission rates for NO_x , SO_2 , and TSP at the northeastern Oregon site are presented for each study year and resource alternative. In Table 2.13, the emission rates for CO_2 at the northeastern Oregon site are presented for each study year and resource alternative. In all of the resource alternatives there will be large increases in emissions of NO_x , SO_2 , TSP, and CO_2 between the years 1991 and 2000. By the year 2000 the emission rate for NO_x is projected to increase by between 79% (Nuclear) to 156% (Conventional Coal) over the 1991 rate. Similarly, the emission rate for SO_2 is projected to increase by between 50% (Cogeneration) to 67% (Conventional Coal), the emission rate for TSP is projected to increase by between 54% (several alternatives) to 138% (Conventional Coal), and the emission rate for CO_2 is projected to increase by between 102% (Nuclear) to 196% (Conventional Coal) over the corresponding 1991 value.

In each of the resource alternatives there will also be large increases in emissions of NO_x , SO_2 , TSP, and CO_2 between the years 2000 and 2010. By the year 2010, the emission rate for NO_x is projected to exceed its 1991 level by 284% (High Conservation) to 378% (Conventional Coal). Similarly, the emission rate for SO_2 is projected to increase by 102% (Cogeneration) to 130% (Conventional Coal), the emission rate for TSP is projected to increase by 230% (several alternatives) to 338% (Conventional Coal), and the emission rate for CO_2 will increase by 382% (several) to 494% (Clean Coal) over the corresponding 1991 value.

TABLE 2.12. Average NO_x, SO₂, and TSP Emission Rates at Boardman.
Emission rates are for all BPA power plants operating at the site in the indicated study year.

<u>Resource Alternative</u>	<u>Emission Rates (g/s) in the Year 1991</u>					
	<u>NO_x</u>	<u>SO₂</u>	<u>TSP</u>			
All Programs	245	325	13			
<u>Resource Alternative</u>	<u>Emission Rates (g/s) in the Year 2000</u>			<u>Emission Rates (g/s) in the Year 2010</u>		
	<u>NO_x</u>	<u>SO₂</u>	<u>TSP</u>	<u>NO_x</u>	<u>SO₂</u>	<u>TSP</u>
Status Quo	453	508	20	946	659	43
Base Case 4	450	504	20	944	660	43
Conservation	450	504	20	944	660	43
Conventional Coal	627	544	31	1172	748	57
Clean Coal	453	493	21	977	681	47
Nuclear	438	498	20	952	662	43
Combustion Turbine	451	504	20	944	660	43
Renewables	448	501	20	947	662	43
Cogeneration	505	486	20	998	658	43
Fuel Switching	455	511	20	949	663	43
High Conservation	453	508	20	943	659	43
Imports	465	522	21	1053	695	46

TABLE 2.13. Average CO₂ Emission Rates at Boardman. Emission rates are for all BPA power plants operating at the site in the indicated study year.

<u>Resource Alternative</u>	<u>CO₂ Emission Rates (kg/s) in the Year 1991</u>	
All Programs	86	
<u>Resource Alternative</u>	<u>CO₂ Emission Rates (kg/s) in the Year 2000</u>	<u>CO₂ Emission Rates (kg/s) in the Year 2010</u>
Status Quo	182	416
Base Case 4	181	415
Conservation	181	415
Conventional Coal	255	507
Clean Coal	207	511
Nuclear	174	419
Combustion Turbine	181	415
Renewables	180	416
Cogeneration	222	451
Fuel Switching	183	417
High Conservation	182	415
Imports	186	475

2.3.3 Pollutant Emission Rates at the Eastern Washington Site

At the eastern Washington site, there are no emissions in 1991. In the years 2000 and 2010, additional pollutant emissions will come from new coal-fired power plants. The level of emissions at the eastern Washington site in the years 2000 and 2010 is projected to be less than at any of the other regional release sites.

In Table 2.14, the emission rates for NO_x, SO₂, and TSP at the eastern Washington site are presented for each study year and resource alternative. The emission rates for CO₂ are shown in Table 2.15. All of the resource alternatives show a significant increase in the level of annual emissions of NO_x, SO₂, and TSP prior to the year 2000. The highest level of emissions for NO_x, SO₂, and TSP is projected for the Conventional Coal alternative. The highest level of emissions for CO₂ is projected for the Clean Coal alternative.

The lowest level of emissions for all four pollutants is projected for the Cogeneration alternative. Between the year 2000 and 2010 only a slight increase in emissions will occur as the power plants are used at a level closer to their maximum capacity. The highest level of emissions for NO_x , SO_2 , and TSP is projected for the Conventional Coal alternative and the highest level of emissions for CO_2 is projected for the Clean Coal alternative. Several alternatives are projected to show the lowest level of emissions.

TABLE 2.14. Average NO_x , SO_2 , and TSP Emission Rates at Creston. Emission rates are for all BPA power plants operating at the site in the indicated study year.

<u>Resource Alternative</u>	<u>Emission Rates (g/s) in the Year 1991</u>					
	<u>NO_x</u>	<u>SO_2</u>	<u>TSP</u>			
All Programs	0	0	0			

<u>Resource Alternative</u>	<u>Emission Rates (g/s) in the Year 2000</u>			<u>Emission Rates (g/s) in the Year 2010</u>		
	<u>NO_x</u>	<u>SO_2</u>	<u>TSP</u>	<u>NO_x</u>	<u>SO_2</u>	<u>TSP</u>
Status Quo	339	136	20	462	185	28
Base Case 4	338	135	20	343	137	21
Conservation	338	135	20	343	137	21
Conventional Coal	402	161	24	463	185	28
Clean Coal	354	146	23	391	161	25
Nuclear	332	133	20	344	137	21
Combustion Turbine	361	136	20	378	137	21
Renewables	340	136	20	344	137	21
Cogeneration	327	131	20	342	137	21
Fuel Switching	342	137	21	342	137	21
High Conservation	340	136	20	342	137	21
Imports _(a)	351	141	21	364	146	22

(a) Includes emissions during generation of power for BPA from combustion turbines located in Canada.

TABLE 2.15. Average CO₂ Emission Rates at Creston. Emission rates are for all BPA power plants operating at the site in the indicated study year.

<u>Resource Alternative</u>	<u>CO₂ Emission Rates (kg/s) in the Year 1991</u>	
All Programs	0	
<u>Resource Alternative</u>	<u>CO₂ Emission Rates (kg/s) in the Year 2000</u>	<u>CO₂ Emission Rates (kg/s) in the Year 2010</u>
Status Quo	139	189
Base Case 4	139	141
Conservation	139	141
Conventional Coal	165	190
Clean Coal	194	212
Nuclear	136	141
Combustion Turbine	154	164
Renewables	139	141
Cogeneration	134	140
Fuel Switching	140	140
High Conservation	139	140
Imports _(a)	144	149

(a) Includes emissions during generation of power for BPA from combustion turbines located in Canada.

2.3.4 Pollutant Emission Rates at the Eastern Montana Site

At the eastern Montana site, emissions in 1991 are coming from eight coal-fired power units that represent the Colstrip (four units) and Jim Bridger (four units) power plants. In the years 2000 and 2010, additional pollutant emissions will come from the increased operation of the existing coal-fired power plants and the potential operation of new coal-fired power plants. There are no cogeneration or combustion turbine plants included in eastern Montana in any of the alternatives. Of all the four regional release sites, the eastern Montana site has the highest rate of pollutant emissions in each of the study years. Actual pollutant emissions at this site are even greater, because the coal-fired power plants also generate electricity for utilities outside of the BPA

service area -- emissions associated with power production for non-BPA utilities are not considered in our analysis.

In Table 2.16, the emission rates for NO_x , SO_2 , and TSP at the eastern Montana Site are presented for each study year and resource alternative. In Table 2.17, the emission rates for CO_2 at the eastern Montana site are presented for each study year and resource alternative. In all of the resource alternatives there will be a significant increase in emissions of NO_x , SO_2 , TSP, and CO_2 between the years 1991 and 2000. By the year 2000 the emission rate for NO_x is projected to increase by between 44% (Cogeneration) to 71% (Conventional Coal) over the 1991 rate. Similarly, the emission rate for SO_2 is projected to increase by 20% (Cogeneration) to 30% (Conventional Coal), the emission rate for

TABLE 2.16. Average NO_x , SO_2 , and TSP Emission Rates at Colstrip.
Emission rates are for all BPA power plants operating at the site in the indicated study year.

<u>Resource Alternative</u>	<u>Emission Rates (g/s) in the Year 1991</u>					
	<u>NO_x</u>	<u>SO_2</u>	<u>TSP</u>			
All Programs	1086	1441	56			

<u>Resource Alternative</u>	<u>Emission Rates (g/s) in the Year 2000</u>			<u>Emission Rates (g/s) in the Year 2010</u>		
	<u>NO_x</u>	<u>SO_2</u>	<u>TSP</u>	<u>NO_x</u>	<u>SO_2</u>	<u>TSP</u>
Status Quo	1595	1767	85	2364	2082	131
Base Case 4	1591	1762	85	2105	1978	116
Conservation	1591	1762	85	2105	1978	116
Conventional Coal	1857	1878	101	2392	2104	133
Clean Coal	1651	1801	90	2182	2025	122
Nuclear	1585	1754	85	2106	1979	116
Combustion Turbine	1592	1763	85	2105	1978	116
Renewables	1602	1774	86	2105	1978	116
Cogeneration	1566	1730	84	2101	1974	116
Fuel Switching	1608	1781	86	2106	1976	116
High conservation	1605	1777	86	2105	1978	116
Imports	1603	1777	86	2135	2001	118

TSP is projected to increase by 50% (Cogeneration) to 80% (Conventional Coal), and the emission rate for CO₂ is projected to increase by 50% (Cogeneration) to 80% (Conventional Coal) over the corresponding 1991 value.

In each of the resource alternatives there will also be a significant increase in emissions of NO_x, SO₂, TSP, and CO₂ between the years 2000 and 2010. By the year 2010, the emission rate for NO_x is projected to increase by 93% (Cogeneration) to 120% (Conventional Coal) over the 1991 value. Similarly, the emission rate for SO₂ is projected to increase by 37% (Cogeneration) to 46% (Conventional Coal), the emission rate for TSP is projected to increase by 107% (for a number of alternatives) to 138% (Conventional Coal), and the emission rate for CO₂ will increase by 107% (Cogeneration) to 138% (Conventional Coal) over the corresponding 1991 value.

TABLE 2.17. Average CO₂ Emission Rates at Colstrip. Emission rates are for all BPA power plants operating at the site in the indicated study year.

<u>Resource Alternative</u>	<u>CO₂ Emission Rates (kg/s) in the Year 1991</u>	
All Programs	382	
<u>Resource Alternative</u>	<u>CO₂ Emission Rates (kg/s) in the Year 2000</u>	<u>CO₂ Emission Rates (kg/s) in the Year 2010</u>
Status Quo	583	898
Base Case 4	581	791
Conservation	581	791
Conventional Coal	689	908
Clean Coal	665	883
Nuclear	579	792
Combustion Turbine	582	791
Renewables	585	791
Cogeneration	572	790
Fuel Switching	588	792
High Conservation	586	791
Imports	586	803

2.3.5 Combined Pollutant Emission Rates

In this section we consider the emission rate for each pollutant summed over each of the four release sites. In Table 2.18, the emission rates for NO_x , SO_2 , and TSP are presented for each study year and resource alternative. In Table 2.19, the emission rates for CO_2 are presented for each study year and resource alternative. For all of the resource alternatives there will be a significant increase in emissions of NO_x , SO_2 , TSP, and CO_2 between the years 1991 and 2000. By the year 2000 the emission rate for NO_x is projected to increase by 72% (Fuel Switching) to 107% (Conventional Coal) over the 1991 rate. Similarly, the emission rate for SO_2 is projected to increase by 60% (Fuel

TABLE 2.18. Average NO_x , SO_2 , and TSP Emission Rates for All Sites Combined. *Emission rates are for all BPA power plant emissions in the indicated study year (including emissions from power plants operating in 1991).

<u>Resource Alternative</u>	<u>Emission Rates (g/s) in the Year 1991</u>					
	<u>NO_x</u>	<u>SO_2</u>	<u>TSP</u>			
All Alternatives	1705	2062	106			
<u>Resource Alternative</u>	<u>Emission Rates (g/s) in the Year 2000</u>			<u>Emission Rates (g/s) in the Year 2010</u>		
	<u>NO_x</u>	<u>SO_2</u>	<u>TSP</u>	<u>NO_x</u>	<u>SO_2</u>	<u>TSP</u>
Status Quo	3043	3378	179	4589	4883	255
Conservation	2954	3318	172	4202	4385	228
Conventional Coal	3537	4001	207	5094	5506	287
Clean Coal	3046	3417	176	4194	4490	229
Nuclear	2954	3318	172	4202	4385	228
Combustion Turbine	3023	3360	175	4219	4388	229
Renewable	2960	3309	172	4162	4385	229
Cogeneration	3100	3323	174	4314	4386	231
Fuel Switching	2934	3299	171	4160	4385	229
High Conservation	3012	3360	175	4161	4388	229
Imports _(a)	3161	3456	180	4392	4507	233

(a) Includes emissions during generation of power for BPA from combustion turbines in the southwestern United States and Canada.

Switching) to 94% (Conventional Coal), the emission rate for TSP is projected to increase by 61% (Fuel Switching) to 95% (Conventional Coal), and the emission rate for CO₂ is projected to increase by 80% (Nuclear) to 120% (Conventional Coal) over the corresponding 1991 value.

TABLE 2.19. Total Annual CO₂ Emissions at All Four Sites. Emission rates are for all BPA power plants operating in the indicated study year.

<u>Resource Alternative</u>	<u>Annual CO₂ Emissions in the Year 1991 (million metric tons/y)</u>	
All Programs	22.3	
<u>Resource Alternative</u>	<u>Annual CO₂ Emissions in the Year 2000 (million metric tons/y)</u>	<u>Annual CO₂ Emissions in the Year 2010 (million metric tons/y)</u>
Status Quo	41.5	63.4
Base Case 4	41.6	59.5
Conservation	41.5	59.5
Conventional Coal	49.2	67.4
Clean Coal	47.0	67.4
Nuclear	40.2	59.8
Combustion Turbine	42.8	59.5
Renewables	41.9	59.1
Cogeneration	42.8	60.2
Fuel Switching	42.5	58.5
High Conservation	42.4	58.1
Imports ^(a)	44.0	65.5

(a) Includes emissions during generation of power for BPA from combustion turbines in the southwestern United States and Canada.

In each of the resource alternatives there will also be a significant increase in the emissions of NO_x, SO₂, TSP, and CO₂ between the years 2000 and 2010. By the year 2010, the combined emission rate for NO_x is projected to increase by 144% (Fuel Switching) to 199% (Conventional Coal) over the 1991 value. Similarly, the emission rate for SO₂ is projected to increase by 113%

(several alternatives) to 167% (Conventional Coal), the emission rate for TSP is projected to increase by 115% (several alternatives) to 171% (Conventional Coal), and the emission rate for CO₂ will increase by 161% (High Conservation) to 202% (Conventional Coal and Clean Coal) over the corresponding 1991 value. In the year 2000, there is a difference of about 21% between the resource alternatives with the highest and lowest emission rates for NO_x, SO₂, and TSP. If the Conventional Coal alternative is omitted, this variation drops to less than 8%. In the year 2010, there is a difference of less than 26% between the resource alternatives with the highest and lowest emission rate for NO_x, SO₂, and TSP. If the Conventional Coal alternative is omitted, this variation drops to about 11%.

2.4 SUMMARY AND ASSESSMENT OF POLLUTANT EMISSION RATES

An examination of pollutant emission rate data indicates that NO_x, SO₂, TSP, and CO₂ power plant emissions will increase significantly in the BPA region under each resource alternative. This significant increase is in part due to the low level of current power plant emissions in the BPA region. However, the increase also reflects an increasing reliance on fossil-fuel power plants to meet the region's growing energy demands.

Of the 12 resource alternatives we have examined, the Conventional Coal alternative tends to produce the highest rate of pollutant emissions at each release site. In the year 2000, the Conservation, Nuclear, Renewable, and Fuel Switching alternatives are projected to have the lowest pollutant emission rates. If the Conventional Coal alternative is excluded, there is only about an 8% difference in the pollutant emission rates between the other 11 resource alternatives. In the year 2010, the Renewable, Fuel Switching, and High Conservation alternatives are projected to have the lowest pollutant emission rates. If the Conventional Coal alternative is again excluded, there is only about an 11% difference in the pollutant emission rates between the other 11 resource alternatives. If the second and third highest emitting resource alternatives (i.e., Status Quo and Import) are also excluded, there is less than a 5% difference in pollutant emission rates between the remaining nine resource alternatives.

3.0 GROUND-LEVEL AIR CONCENTRATIONS OF BASIC CRITERIA POLLUTANTS

In this section we estimate the average and maximum ground-level air concentrations for three basic criteria pollutants (i.e., NO_x , SO_2 , and TSP) emitted from fossil fuel-fired power plants. This task requires that we examine the pollutant concentrations for each combination of the following factors:

- pollutant type
- period of regulatory concern (e.g., annual average, 24-h maximums, 1-h maximums)
- resource alternative
- study year
- release site.

If we study three pollutants, three periods of regulatory concern, three study years, twelve resource alternatives (all twelve of which are active in two study years), and four release sites, we have about 900 different scenarios we need to investigate. In addition we need to model several different types of releases at each site (e.g., such as emissions from coal-fired power plants and natural gas-burning facilities) and we need to produce air quality estimates using a variety of modeling domains to meet the requirements for the long- and short-range analyses of air quality, health effects, and ecosystem impacts.

The product of all these combinations gives several thousand potential different scenarios that need to be investigated! The magnitude of this task strongly influenced the selection of an air quality model and the procedures adopted to conduct this study. By making several assumptions (which are described in this section), we reduced the required number of model runs from over 1,000 to less than 200.

3.1 DESCRIPTION OF THE ISCST MODEL

We considered a number of air quality models to use for our analysis before settling on the EPA's Industrial Source Complex Short-Term Model

(ISCST) (EPA 1986a). In our estimation, this model provided the best balance of technical sophistication, data input requirements, speed of operation, ease of use, ability to postprocess output, and overall flexibility for meeting this particular project's objectives.

The ISCST model is a steady-state Gaussian plume model designed to estimate pollutant concentrations from a wide variety of sources associated with industrial complexes (EPA 1986a). The model is appropriate for flat or rolling terrain, urban or rural environments, and is approved by the EPA for specific regulatory applications.

Input requirements for ISCST include a variety of parameters that define the source configuration and pollutant emission parameters (EPA 1986b). The user may define a variety of point, line, area, and volume sources. The ISCST model can assume a constant or a diurnally varying emission rate; diurnally constant but seasonal varying emission rates (as available from the BPA for this study) cannot be accommodated within a single model run.

Although primarily designed for use over modeling domains with a radius of less than 50 km, ISCST can be used to model pollutant concentrations out to distances of over 100 km from the source (EPA 1986b). The model assumes straight-line transport across the modeling domain based on the average wind direction and speed near the release location (as input into the model in a meteorological data file) at the release time. Although other models are available that will consider spatial and temporal variations in winds during pollutant transport, the meteorological data input requirements and the slower performance of such models would have made them a poor choice when a large number of simulations are required.

The ISCST model uses hourly meteorological data and estimates of atmospheric stability (i.e., the rate of turbulent mixing) to compute airborne dispersion. Plume rise, stack-tip downwash, and building wake can be considered when computing initial dispersion. The model explicitly treats dry deposition processes and also allows for the exponential decay of pollutants (through chemical transformation or radioactive decay).

Meteorological data for model runs can be obtained from the U.S. Environmental Protection Agency (EPA) (i.e., their electronic bulletin board

provides several years of hourly meteorological for selected meteorological monitoring stations), the National Climatological Data Center (NCDC), and other public and private institutions involved in the collection of meteorological data.

The model estimates average and maximum pollutant concentrations (or deposition values) on a user-specified modeling domain. The domain can be a Cartesian or polar domain, with the grid resolution, spacing, and receptor heights specified by the user. To supplement the standard grid, the user can also define additional receptor locations. At each point on the standard grid or at a supplementary receptor location, the model can

- compute the average pollutant concentration or deposition value over a simulation of "N" days duration
- track the highest, second highest, and third highest pollutant concentration or deposition value for each specified averaging period (e.g., N-day, 24-h, 8-h, 1-h) during a simulation.

Results from each model simulation are reported in a formatted data file that contains a wealth of scenario initialization data and model output products. Tabular output products report the average and maximum pollutant concentrations requested by the user at each grid point or receptor location.

3.2 PROCEDURE FOR ESTIMATING AIR QUALITY IMPACTS USING THE ISCST MODEL

To simplify our task, we reduced the number of required model simulations by running all simulations with unit release rates (i.e., 1 g/s or 1 kg/s). Because the model's conversion of emission rates to pollutant concentrations is linear, model output can be multiplied by emission conversion factors to convert normalized pollutant concentrations into actual pollutant concentration estimates. While this approach greatly reduces the number of required ISCST model runs, it creates the need for a larger postprocessing effort that includes the creation of specialized postprocessing programs. In the following sections we outline the procedure we followed to set up, run, and postprocess data to generate estimates of pollutant concentrations.

3.2.1 Procedure for Dealing with the Individual Pollutants

In this study, the ISCST model is used to estimate the average and maximum pollutant concentrations of NO_x , SO_2 , and TSP. Results are compared to existing ambient air quality standards (AAQS). The seven air quality standards involving these pollutants are

- annual average air concentrations of NO_x
- annual average air concentrations of SO_2
- 24-h maximum air concentrations of SO_2
- 3-h maximum air concentrations of SO_2
- 1-h maximum air concentrations of SO_2
- annual average air concentrations of TSP
- 24-h maximum air concentrations of TSP.

The current federal and Washington state ambient air quality standards for these pollutants are provided in Table 3.1.

TABLE 3.1. Ambient Air Quality Standards for NO_x , SO_2 , and TSP. Values are presented for federal and Washington state standards. The Washington state standards are as strict or stricter than other state standards in the BPA study region.

Pollutant	Averaging Time	Ambient Air Quality Standards		
		Federal Primary ($\mu\text{g}/\text{m}^3$)	Federal Secondary ($\mu\text{g}/\text{m}^3$)	State ($\mu\text{g}/\text{m}^3$)
NO_x	Annual	100	100	100
SO_2	Annual	80	---	60
	24-h	365	---	260
	3-h	---	1300	---
	1-h	---	---	1018
TSP	Annual	75	60	60
	24-h	260	150	150

As discussed above, all ISCST model runs involved the release of a normalized quantity of pollutant (e.g., 1 g/s or 1 kg/s). In ISCST simulations, NO_x is treated as a non-depositing, non-reactive pollutant. ISCST treats SO_2 as a chemically reactive pollutant whose airborne mass decreases with time (computed as a function of travel distance and wind speed) owing to chemical depletion. The ISCST model can compute the dry deposition (by gravitational settling) of particles. The model allows the user to specify the mass fraction and deposition velocity for particles in several size classes. Table 3.2 shows the parameterization of particle size used in our study.

Because of the small size of the particles emitted by each class of power plant, we assumed that the gravitational settling of TSP will not significantly alter airborne particulate concentrations. In tests conducted to test the validity of this assumption, TSP concentrations computed without considering gravitational settling were larger than concentrations computed with gravitation settling by only about a factor of two or less at most grid points. The computation of TSP concentrations without considering gravitational settling is conservative, but considering the relatively small emission rate of TSP (as compared to the much larger emission rates of NO_x and SO_2) this assumption should not have a major impact on our conclusions. The positive effect of this assumption is that it reduces by one-third the number of model simulations that are required (i.e., separate simulations for a depositing pollutant are not required).

Using this approach, two separate sets of ISCST model runs were performed for each scenario to estimate the normalized average and maximum air pollutant concentrations from NO_x and TSP (one set) and SO_2 (the other set).

3.2.2 Definition of Receptor Grids

Three modeling grid domains were established to estimate pollutant concentrations for different ISCST applications. The three domains are

- a polar grid with 160 receptor locations (16 locations on each of 10 sampling arcs). This domain has an 80-km (50-mi) radius and is designed to be compatible with the data input requirements of the models used to assess human health impacts. Sampling arcs are positioned at 1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 mi from the release site. Receptor locations are positioned at the 16 principal compass directions along these arcs (e.g., North, North-northeast, Northeast,...).

TABLE 3.2. Parameterization of Particle Mass Fractions and Deposition Velocity for Three Classes of Power-Generating Facilities

Conventional (Pulverized) and Fluidized Bed Coal-Fired Power Plants:

<u>Particle Size Range^(a) (μm)</u>	<u>Average Particle Diameter (μm)</u>	<u>Fraction of Total Mass</u>	<u>Average Deposition Velocity^(b) (cm/s)</u>
0.01 - 0.5	0.3	0.22	0.01
0.5 - 1.0	0.75	0.25	0.05
1.0 - 3.0	2.0	0.42	0.1
3.0 - 7.0	5.0	0.11	0.5

Natural Gas Combustion Turbine and Coal Gasification Power Plants:

<u>Particle Size Range^(c) (μm)</u>	<u>Average Particle Diameter (μm)</u>	<u>Fraction of Total Mass</u>	<u>Average Deposition Velocity^(b) (cm/s)</u>
<1.0	0.5 (estimated)	1.00	0.05

Cogeneration:

<u>Particle Size Range^(c) (μm)</u>	<u>Average Particle Diameter (μm)</u>	<u>Fraction of Total Mass</u>	<u>Average Deposition Velocity^(b) (cm/s)</u>
<1.0	0.5 (est.)	0.74	0.05
1.0 - 2.5	2.0	0.19	0.1
>2.5	4.0	0.07	0.5

(a) Price et al. 1980, Table 2.2.

(b) Houghton 1985, Chapter 27.

(c) Based on a personal communication from Don Rake of the California Air Resources Board, Technical Support Branch, that provides information on the "Weight Fraction for Particulate Matter Category by Size Distribution" for various pollution-generating sources. Combustion turbine data are based on the "Incineration-Gaseous Fuel" process and cogeneration is based on the "Wood Waste Combustion" process.

- a close-in Cartesian grid with 289 receptor locations. This domain covers an area of 32 km by 32 km, with a 2-km grid spacing, and is designed to provide the air quality and ecosystem research teams with information on impacts near pollutant release sites. This 17-by-17 grid point modeling domain covers an area of 256 km². Model output on this type of receptor grid can be displayed graphically to provide detailed information on pollution concentrations at key locations and to illustrate the differences in average and maximum pollution concentrations for the different resource alternatives.
- an expanded Cartesian grid with 289 receptor locations. This domain covers an area of 320 km by 320 km, with a 20-km grid spacing, and is designed to provide information on regional impacts (in particular to estimate impacts over broad agricultural and forest resource areas). This 17-by-17 grid point modeling domain covers 25,600 km². Model output on this type of receptor grid can be displayed graphically to provide detailed information on pollution concentrations at key locations and to illustrate the differences in average and maximum pollution concentrations for the different resource alternatives.

Using this approach, three separate sets of ISCST model runs (using each modeling domain) need to be run to produce air pollutant concentration estimates for each scenario.

3.2.3. Requirements for Meteorological Data

To obtain climatologically representative meteorological data for our analysis, we selected three years of meteorological data (1986, 1987, and 1988) for each release site. Meteorological data used in our work with the ISCST model were obtained from the EPA bulletin board's meteorological database and the U.S. Department of Energy's Hanford site meteorological database. Data available from these sources include observations of near-surface winds, surface temperatures, boundary layer mixing height, atmospheric stability, and other values. Meteorological data for each release site were based on observations at the following monitoring locations:

- western Washington Site -- Olympia, Washington
- northeastern Oregon - Pendleton, Oregon
- eastern Washington -- Spokane, Washington
- southeastern Montana -- Miles City, Montana.

The ISCST model can assume a constant pollutant emission rate or a diurnally varying emission rate. For this project, we have emission rates

that vary from season to season, but do not exhibit any diurnal variation. With a seasonally varying pollutant emission rate, we cannot compute annual air quality impacts in a single model run; separate model runs using a constant pollutant emission rate are required for each power generation season. The BPA-defined power generation seasons are

- September - December (i.e., fall) -- 33.3% of the year
- January - April (i.e., winter) -- 33.2% of the year
- May (i.e., spring) -- 8.5% of the year
- June - August (summer) -- 25% of the year.

To prepare model runs, the meteorological data files were broken down into seasonal files, with each file containing three years of meteorological data for the indicated season. The length of the seasons and limitations on how much data the ISCST model can process in a single simulation were key factors in determining the size of the meteorological database we would use in our analysis.

Using the approach outlined above, four separate sets of ISCST model runs must be run for each release site to represent the annual range of meteorological conditions.

Our decision to use three years of data is a compromise between our need to have a manageable data set and one that is climatologically representative. Three years of data provided a manageable data set that is climatologically representative for most applications. Four- and five-year data sets would more accurately represent local climatology but would have required extra model runs (i.e., the number of model runs required for some seasons would double because a maximum of 12 months of data can be processed in a single ISCST model run), and increased complexity of postprocessing.

3.2.4 Pollutant Source Characteristic and Release Site Combinations

There are five types of power generation facilities that are considered in this study. These facilities are conventional coal, fluidized bed coal, coal gasification, cogeneration, and combustion turbine power plants. Each of the five types of facilities can be characterized using one of two sets of stack height and effluent data (e.g., stack height, stack diameter, effluent

temperature, effluent velocity); one set is for coal-fired power plants and the second set is for cogeneration and combustion turbine plants. These release characteristics are discussed in detail in Section 2.2.1.

Both sets of power plants will operate in western and eastern Washington and northeastern Oregon; only coal-fired power plants will operate in southeastern Montana. Using this approach, two separate sets of ISCST model simulations need to be run to estimate the impact from both coal-fired and natural gas-fired releases at each of the western Washington, and eastern Washington, and northeastern Oregon release sites. Only one set of simulations is required for the coal-fired releases at the southeastern Montana release site. In total seven sets of model simulations were run to represent each combination of release site and release type for each scenario.

3.2.5 ISCST Model Simulations

Using the approach described above, individual ISCST model runs were made for each combination of

- two sets of pollutants (NO_x and TSP is one set; SO_2 is the other set)
- four seasons
- three modeling grids
- seven combinations of power-generation facility and release site.

In total, 168 separate ISCST model simulations were made (a vast reduction when compared to the more than one thousand scenarios that need to be studied). These simulations produced estimates of seasonal-average and short-term pollutant concentrations assuming a normalized release rate. Through the postprocessing of model output, the results of each of these model runs can be used to generate estimates of the air quality impact for each scenario.

3.2.6 Model Output

The ISCST model produces tabular output in the form of formatted files. These files contain information on model parameters, winds, and pollutant concentrations. In each file, the ISCST model can report the average, highest, second highest, and third highest pollutant concentrations for the

user-specified averaging period. The time and date at which maximum values occurred can also be generated. A sample model output file is presented in Appendix B.

To postprocess model output, each output file is divided into several files to separately present results for each averaging period. The names of the new files indicate the properties of the data contained within [e.g., a file named 1ANFL.NDY would contain output for Centralia (1), from coal-fired power-plant emissions (A,) of NO_x (N), during the fall (F), on the expanded Cartesian grid (L), averaged over the entire season (NDY)].

3.2.7 Postprocessing of ISCST Model Output

To determine air quality impacts for each study year, model results were extensively postprocessed. This postprocessing involves multiplying model output by the projected seasonal release rates for the specified combination of pollutant, resource alternative, study year, and release site. To convert seasonally-averaged pollutant concentrations to annual averages, each seasons's output file is multiplied by a seasonal weighting factor (the weighting factor is the number of days in a season divided by the number of days in a year). Finally, results for the different sets of power plants operating at a site are combined to obtain estimates of the total annual-average air quality impacts for the study site.

To determine the largest short-term maximum values (i.e., 1-, 3-, and 24-hour periods) for a particular pollutant, each season's short-term maximum values are compared. The largest value at each grid point is selected to get an array of the maximum short-term values of pollutant concentration for the indicated time period.

In total, over 450 postprocessed output files were produced to present information on annual-averaged pollutant concentrations for each unique combination of study year, release site, resource alternative, and model grid. Over 400 additional postprocessed output files were prepared to present information on the short-term maximum pollutant concentrations for each unique combination of study year, release site, resource alternative, and Cartesian grid.

3.3 ANALYSIS OF OUTPUT RESULTS

In this section, we present the results of our analysis of the air quality impacts of the basic criteria pollutants emitted in significant quantities by power-generating facilities. Information on pollutant concentrations is given in units of micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) and as a percent of the most stringent federal and state AAQS governing the pollutant. In computing annual average impacts for the Imports alternative, power plants located outside of the BPA region are assumed to be operating within the region (i.e., their emissions contribute to the annual air quality impacts); conversely, in computing short-term maximum impacts for the Imports alternative, emissions from outside of the BPA region are not considered.

3.3.1 Air Quality Impacts from Emissions at Centralia, Washington

In this section, estimates of air quality impacts are presented for emissions from the western Washington release site (i.e., Centralia). Contour plots of annual average pollutant concentrations, which were computed using the expanded Cartesian grid, are presented in Appendix C for each combination of pollutant, study year, and resource alternative. The highest and second highest annual average and short-term maximum pollutant concentrations, computed using the close-in grid, are presented in Appendix D for each combination of release site, pollutant, study year, averaging period, and resource alternative.

On an annual average basis, the contour plots in Appendix C show that ground-level pollutant concentration patterns are generally oriented in a northeast/southwest direction from the Centralia site. The highest pollutant concentrations are found to the northeast of the site. The prevailing winds in western Washington, as influenced by large-scale weather patterns and major topographical features (i.e., the Olympic and Cascade Mountain ranges), tend to cause higher air quality impacts in the Puget Sound region than at comparable distances in a southerly or southwesterly direction from the release site. Air quality impacts along the west slopes of the Cascades (to the east of Puget Sound) are somewhat greater than predicted for areas directly east and southeast of Centralia. Air quality impacts on the west slopes of the Cascades are also predicted to be larger than those experienced

on the Olympic Peninsula (in the northwestern portion of the state) and along the Washington State/Pacific coastline.

3.3.1.1 Air Quality Impacts in the Year 1991 from Centralia Emissions

In 1991, the highest annual-average concentrations on the close-in grid occur about 18 km north-northeast of the release site. At this point, the highest annual concentrations of NO_x , SO_2 , and TSP from power plant emissions are 2.2, 2.9, and $0.11 \mu\text{g}/\text{m}^3$, respectively. These concentrations are only a few percent or less of AAQS. On the expanded grid, the region of highest air quality impacts extends from a few kilometers northeast of the release site to the southern portion of Puget Sound. This region includes the I-5 corridor east of Olympia through Tacoma. In this area, the annual average concentrations of NO_x , SO_2 , and TSP from power plant emissions exceed 0.7, 1.2, and $0.05 \mu\text{g}/\text{m}^3$, respectively.

The highest values for the 24-, 3-, and 1-h maximum concentration of SO_2 , and the 24-h maximum concentrations of TSP, occur only several kilometers south and southwest of the release site. The highest values of the 24-, 3-, and 1-h maximum SO_2 concentrations from power plant emissions are 36, 187, and $431 \mu\text{g}/\text{m}^3$, respectively. These values correspond to 14, 14, and 42% respectively, of the AAQS. The highest value of the 24-h maximum TSP concentration from power plant emissions is $1.4 \mu\text{g}/\text{m}^3$, about 1% of the AAQS.

3.3.1.2 Air Quality Impacts in the Year 2000 from Centralia Emissions

In the year 2000, the Combustion Turbine, Cogeneration, and Fuel Switching alternatives produce the greatest ground-level air quality impacts for NO_x . The Nuclear alternative produces slightly lower NO_x impacts than most other alternatives. The alternatives with the highest ground-level NO_x impacts rely more heavily on natural-gas-fired power plants at Centralia than do the other alternatives. Natural-gas-fired plants tend to have lower smokestacks than coal-fired power plants (i.e., in our study we assume a 30 m stack height for a natural-gas plant and a 150 m stack height for a coal-fired power plant); with lower smokestacks, emissions from natural-gas-fired power plants generally have less time to disperse before reaching the ground. Because of this, the natural-gas-fired power plants in our study have higher ground-level impacts for NO_x than comparably sized coal-fired plants, even

though gas-fired plants have lower NO_x emissions per megawatt of power generated. In reality, the actual air quality impacts for the resource alternatives that rely heavily on natural-gas-fired emissions should be significantly less than we are presenting here; this is because the relatively small cogeneration and other natural-gas-fired plants (small in comparison to coal-fired power plants) will be scattered throughout the region rather than being concentrated at one site as is assumed in our modeling.

The Conventional Coal and Imports alternatives produce the highest ground-level air quality impacts for SO_2 . The Cogeneration alternative produces slightly lower SO_2 impacts than most other alternatives. The alternatives with the highest impacts rely more heavily on power production from coal-fired plants at Centralia than do the other alternatives. Natural-gas-fired plants have much lower SO_2 emission rates than coal-fired power plants.

The Imports alternative produces the highest ground-level air quality impacts for TSP and the Nuclear alternative produces the lowest maximum TSP impacts. The alternatives with the highest impacts rely more heavily on power production from the coal-fired power plants at Centralia than do the other alternatives. Natural-gas-fired plants have much lower TSP emission rates than coal-fired power plants.

The highest annual-average pollutant concentration recorded for each of the alternatives occurs 10 to 20 km north-northeast of the release site. The highest annual average concentrations of NO_x , SO_2 , and TSP produced by the Imports alternative are 7.5, 3.5, and $0.18 \mu\text{g}/\text{m}^3$, respectively. These concentrations are 7, 6, and 0.3%, respectively, of their AAQS. For comparison, the highest annual average concentrations of NO_x , SO_2 , and TSP produced by the Nuclear alternative are 5.7, 3.3, and $0.14 \mu\text{g}/\text{m}^3$, respectively.

On the expanded grid, the region of maximum air quality impact is the same as in 1991, although in this area annual average concentrations of NO_x , SO_2 , and TSP from power plant emissions would be in excess of 1.6, 1.2, and $0.06 \mu\text{g}/\text{m}^3$, respectively, for all alternatives.

The highest values for the 24-, 3-, and 1-h maximum concentration of SO₂ and the 24-h maximum concentrations of TSP occur only several kilometers northeast of the release site for all of the resource alternatives. The highest 24-h maximum concentrations of SO₂ and TSP produced by the Imports alternative are 47 and 2.0 µg/m³, respectively. These concentrations are 18 and 1%, respectively, of their AAQS. For comparison, the 24-h maximum concentrations of SO₂ and TSP produced by the Cogeneration alternative are 38 and 1.7 µg/m³, respectively. The highest 3-h maximum SO₂ concentrations from power plant emissions range from 229 µg/m³ (18% of the AAQS) for the Imports alternative to 192 µg/m³ for the Cogeneration alternative. The highest 1-h maximum SO₂ concentrations from power plant emissions is 461 µg/m³ (45% of the AAQS) for the Conventional Coal alternative; all the other alternatives report a maximum value of about 441 µg/m³.

3.3.1.3 Air Quality Impacts in the Year 2010 from Centralia Emissions

In the year 2010, the Imports, Nuclear, Base Case 4, and Conservation alternatives produce the greatest ground-level air quality impacts for NO_x. The Clean Coal alternative produces significantly lower NO_x impacts than the other alternatives. As described in Section 3.4.1.2, the alternatives with the highest ground-level NO_x impacts rely more heavily on natural-gas-fired power plants at Centralia than do the other alternatives. The relatively low concentration of NO_x for the Clean Coal alternative is the result of power production being shifted to other release sites.

The Conventional Coal and Imports alternatives produce the highest ground-level air quality impacts for SO₂. All the other resource alternatives produce slightly lower SO₂ impacts. The alternatives with the highest impacts rely more heavily on power production from coal-fired plants at Centralia than do the other alternatives.

The Imports alternative produces the highest ground-level air quality impacts for TSP and the High Conservation alternative produces the lowest TSP impacts. The elevated TSP impacts for the Imports alternative is the result of the highest level of both coal-fired and natural-gas-fired power production at Centralia for any resource alternative.

The highest annual-average pollutant concentrations recorded for each of the alternatives occurs 10 to 20 km north-northeast of the release site. The highest annual average concentrations of NO_x , SO_2 , and TSP produced by the Imports alternative are 11, 3.5, and $0.22 \mu\text{g}/\text{m}^3$, respectively. These concentrations are 11, 6, and 0.4%, respectively, of their AAQS. For comparison, the highest annual average concentrations of NO_x , SO_2 , and TSP produced by the Clean Coal alternative are 8.8, 3.5, and $0.16 \mu\text{g}/\text{m}^3$, respectively.

On the expanded grid, the region of maximum air quality impact is the same as in 1991, although in this area annual average concentrations of NO_x , SO_2 , and TSP from power plant emissions are in excess of 2.0, 1.5, and $0.06 \mu\text{g}/\text{m}^3$, respectively, for all alternatives.

The highest values for the 24-, 3-, and 1-h maximum concentration of SO_2 and the 24-h maximum concentrations of TSP occur only several kilometers from the release site for all of the resource alternatives. The highest 24-h maximum concentrations of SO_2 and TSP produced by the Conventional Coal alternative are 51 and $2.4 \mu\text{g}/\text{m}^3$, respectively. These concentrations are 20 and 2%, respectively, of their AAQS. For comparison, the 24-h maximum concentrations of SO_2 and TSP produced by most other alternatives are 49 and $2.1 \mu\text{g}/\text{m}^3$, respectively. The highest 3-h maximum SO_2 concentrations from power plant emissions are $246 \mu\text{g}/\text{m}^3$ (19% of the AAQS) for the Conventional Coal alternative; all the other alternatives report a maximum 3-h concentration of about $237 \mu\text{g}/\text{m}^3$. The highest 1-h maximum SO_2 concentration from power plant emissions is $462 \mu\text{g}/\text{m}^3$ (45% of the AAQS) for the Conventional Coal alternative; all the other alternatives report a maximum value of about $442 \mu\text{g}/\text{m}^3$.

3.3.2 Air Quality Impacts from Emissions at Creston, Washington

In this section, estimates of air quality impacts are presented for emissions from the eastern Washington release site (i.e., Creston). Contour plots of annual average pollutant concentrations computed using the expanded Cartesian grid are presented in Appendix C for each combination of pollutant, study year, and resource alternative. The highest and second highest annual average and short-term maximum pollutant concentrations computed using the

close-in grid are presented in Appendix D for each combination of release site, pollutant, study year, averaging period, and resource alternative.

On an annual average basis, the contour plots in Appendix C show that ground-level pollutant concentration patterns are generally oriented in a northeast/southwest direction from the Creston site. The highest pollutant concentrations are found to the northeast of the site. The prevailing winds in eastern Washington, as influenced by large-scale weather patterns and major topographical features (i.e., the Cascade Mountain Range and the Blue Mountains), tend to cause higher air quality impacts to the northeast than at comparable distances in a southwesterly or northwesterly direction.

The area that would be subjected to the highest air quality impacts on an annual-average basis includes portions of the Colville Indian reservation, the Spokane Indian reservation, the Coulee Dam National Recreation Area, and the Columbia River behind the Grand Coulee Dam (Lake Roosevelt). Under some meteorological conditions, emissions from Creston could cause an incremental degradation to the air quality in Spokane; however, annual average impacts to the east of Creston (in the direction of Spokane) are substantially less than those experienced to the northeast and southwest of Creston.

3.3.2.1 Air Quality Impacts in the Year 1991 from Creston Emissions

There are no power-generating facilities operating in the Creston area at the present time. Air quality impacts from the operation of proposed power-generating facilities at the Creston site would not be experienced until sometime in the mid- to late-1990s.

3.3.2.2 Air Quality Impacts in the Year 2000 from Creston Emissions

In the year 2000, the Combustion Turbine alternative produces the greatest ground-level air quality impacts for NO_x and the Cogeneration alternative produces the lowest ground-level maximum air quality impact for NO_x . The impacts are relatively low when compared to the maximum impacts for the other three release sites because of the relatively low level of power production at Creston. The Combustion Turbine alternative produces the greatest ground-level impact for NO_x because it is the only one of the 12 alternatives that calls for the construction and operation of natural-gas-fired power plants at Creston.

The Conventional Coal alternative produces the highest ground-level air quality impacts for SO_2 and the Cogeneration alternative produces the lowest maximum SO_2 impacts. The alternatives with the highest impacts rely more heavily on power production from coal-fired plants at Creston than do the other alternatives. As was the case for NO_x , the maximum SO_2 impacts for Creston are relatively low when compared to the maximum impacts for the other three release sites.

The Conventional Coal alternative produces the highest ground-level air quality impacts for TSP and the Cogeneration alternative produce the lowest maximum TSP impacts. The alternatives with the highest impacts require a higher level of power production from the coal-fired plants at Creston than do the other alternatives. As was the case for the other two pollutants, the maximum TSP impacts for Creston are relatively low when compared to the maximum impacts for the other three release sites.

The highest annual-average pollutant concentration recorded for each of the alternatives occurs less than 10 km north-northeast of the release site. The highest annual average concentrations of NO_x , SO_2 , and TSP produced by the alternatives are 1.5, 0.5, and $0.08 \mu\text{g}/\text{m}^3$, respectively. These concentrations are 2, 1, and 0.1%, respectively, of their AAQS.

On the expanded grid, the region of highest annual air quality impacts extends northeast from the site over the Colville Indian reservation, including a broad stretch of the Columbia River behind the Grand Coulee Dam. In this area, the annual average concentrations of NO_x , SO_2 , and TSP from power plant emissions exceed 0.3, 0.1, and $0.02 \mu\text{g}/\text{m}^3$, respectively. Another region of elevated air quality impact is located to the southwest of Creston, stretching toward the Moses Lake area.

The highest values for the 24-, 3-, and 1-h maximum concentration of SO_2 and the 24-h maximum concentrations of TSP occur only several kilometers southwest of the release site for all of the resource alternatives (the exact location may vary by a few kilometers for each case). The highest 24-h maximum concentrations of SO_2 and TSP produced by the Conventional Coal alternative are 7.7 and $1.2 \mu\text{g}/\text{m}^3$, respectively. These concentrations are 3 and 1%, respectively, of their AAQS. For comparison, the 24-h maximum

concentrations of SO_2 and TSP produced by the Cogeneration alternative are 6.7 and $1.0 \mu\text{g}/\text{m}^3$, respectively. The highest 3-h maximum SO_2 concentration from power plant emissions is $47 \mu\text{g}/\text{m}^3$ (4% of the AAQS) for the Conventional Coal alternative, $41 \mu\text{g}/\text{m}^3$ for the Clean Coal alternative, and about $36 \mu\text{g}/\text{m}^3$ for all the other alternatives. The highest 1-h maximum SO_2 concentrations from power plant emissions ranges from $78 \mu\text{g}/\text{m}^3$ (8% of the AAQS) for the Conventional Coal alternative to $59 \mu\text{g}/\text{m}^3$ (6% of the AAQS) for the Nuclear and Cogeneration alternatives.

3.3.2.3 Air Quality Impacts in the Year 2010 from Creston Emissions

In the year 2010, the Combustion Turbine alternative produces the greatest ground-level air quality impacts for NO_x , followed by the Conventional Coal and Status Quo alternatives. Several alternatives tie for producing the lowest ground-level maximum air quality impacts for NO_x . As was the case in the year 2000, maximum NO_x impacts are relatively low when compared to the maximum impacts at the other three release sites.

The Conventional Coal and Status Quo alternatives produce the highest ground-level air quality impacts for SO_2 and TSP; most of the other resource alternatives share the lowest maximum SO_2 and TSP impacts. The alternatives with the highest impacts for these pollutants have greater power production from coal-fired plants at Creston than do the other alternatives. As was the case for NO_x , the maximum SO_2 and TSP impacts for Creston are relatively low when compared to the maximum impacts for the other three release sites.

The highest annual average pollutant concentration recorded for each of the alternatives occurs less than 10 km north-northeast of the release site. The highest annual average concentrations of NO_x , SO_2 , and TSP produced by the alternatives are 1.8, 0.6, and $0.09 \mu\text{g}/\text{m}^3$, respectively. These concentrations are 2, 1, and 0.1%, respectively, of their AAQS.

On the expanded grid, the region of highest annual air quality impacts extends northeast from the site over the Colville Indian reservation, including a broad stretch of the Columbia River behind the Grand Coulee Dam. In this area, the annual average concentrations of NO_x , SO_2 , and TSP from power plant emissions exceed 0.4, 0.12, and $0.02 \mu\text{g}/\text{m}^3$, respectively.

Another region of elevated air quality impact is located to the southwest of Creston, stretching toward the Moses Lake area.

The highest values for the 24-, 3-, and 1-h maximum concentration of SO_2 and the 24-h maximum concentrations of TSP occur in different directions but are all within several kilometers of the release site for all of the resource alternatives. The highest 24-h maximum concentrations of SO_2 and TSP produced by the Conventional Coal alternative are 10.4 and $1.6 \mu\text{g}/\text{m}^3$, respectively. These concentrations are 4 and 1%, respectively, of their AAQS. For comparison, the 24-h maximum concentrations of SO_2 and TSP produced by the Fuel Switching alternative are 6.7 and $1.0 \mu\text{g}/\text{m}^3$, respectively. The highest 3-h maximum SO_2 concentrations from power plant emissions are $47 \mu\text{g}/\text{m}^3$ (4% of the AAQS) for the Status Quo alternative, $41 \mu\text{g}/\text{m}^3$ for the Clean Coal alternative, and about $36 \mu\text{g}/\text{m}^3$ for all the other alternatives. The highest 1-h maximum SO_2 concentrations from power plant emissions range from $104 \mu\text{g}/\text{m}^3$ (11% of the AAQS) for the Conventional Coal and Status Quo alternatives to $63 \mu\text{g}/\text{m}^3$ (6% of the AAQS) for the Fuel Switching alternative.

3.3.3 Air Quality Impacts from Emissions at Boardman, Oregon

In this section, estimates of air quality impacts are presented for emissions from the northeastern Oregon release site (i.e., Boardman). Contour plots of annual average pollutant concentrations computed using the expanded Cartesian grid are presented in Appendix C for each combination of pollutant, study year, and resource alternative. The highest and second highest annual average and short-term maximum pollutant concentrations computed using the close-in grid are presented in Appendix D for each combination of release site, pollutant, study year, averaging period, and resource alternative.

On an annual average basis, the contour plots in Appendix C show that ground-level pollutant concentration patterns are generally oriented in a northwest/southeast direction from the Boardman site. This distribution was computed using meteorological data from the nearest National Weather Service meteorological monitoring station--Pendleton, Oregon. Pendleton is located near the western foothills of the Blue Mountains. Winds at Pendleton are strongly influenced by local terrain features and do not exhibit the prevailing westerly direction observed in northern Oregon, between the Cascade

and Blue Mountain Ranges. The high frequency of northwesterly and southeasterly winds at Pendleton are probably the result of the local mountain-valley circulation. The Boardman power plant site is much closer than Pendleton to the Columbia River Gorge (with its prevailing winds from the west) and much further from the Blue Mountains. The winds at the Boardman site are probably more typical of a Columbia Gorge wind pattern than the pattern observed at Pendleton. As a result, the areas of maximum air quality impact reported for Boardman in the figures and tables presented in Appendix C and D should not be considered representative of projected transport directions.

3.3.3.1 Air Quality Impacts in the Year 1991 for Boardman Emissions

In 1991, the highest annual average concentrations would occur about 5 km from the release site. At this point, the highest annual concentrations of NO_x , SO_2 , and TSP from power plant emissions are 1.2, 1.6, and $0.06 \mu\text{g}/\text{m}^3$, respectively. These concentrations are only a few percent or less of AAQS. Over a broad region on the expanded grid, annual average concentrations of NO_x , SO_2 , and TSP from power plant emissions exceed 0.2, 0.2, and $0.01 \mu\text{g}/\text{m}^3$, respectively.

The highest values for the 24-, 3-, and 1-h maximum concentrations of SO_2 , and the 24-h maximum concentrations of TSP occur within 6 km of the release site. The highest values of the 24-, 3-, and 1-h maximum SO_2 concentrations from power plant emissions are 22, 102, and $208 \mu\text{g}/\text{m}^3$, respectively. These values correspond to 8, 8, and 20%, respectively, of the AAQS. The highest value of the 24-h maximum TSP concentration from power plant emissions is $0.8 \mu\text{g}/\text{m}^3$, about 1% of the AAQS.

3.3.3.2 Air Quality Impacts in the Year 2000 from Boardman Emissions

In the year 2000, the Cogeneration and Conventional Coal alternatives produce the greatest ground-level air quality impacts for NO_x and the Nuclear alternative produces the lowest ground-level maximum air quality impact for NO_x . The Cogeneration alternative produces one of the highest local ground-level NO_x impacts because it relies more heavily on natural-gas-fired power plants (cogeneration facilities) at Boardman than do the other alternatives. The actual air quality impacts from NO_x emissions for the Cogeneration

alternative (and to varying degrees for all the resource alternatives) should be significantly less than we are presenting here; this is because the proposed cogeneration and other "small" natural-gas-fired plants will be scattered throughout the region rather than being concentrated at one site as is assumed in our air quality modeling.

The Imports and Conventional Coal alternatives produce the highest ground-level air quality impacts for SO_2 and the Cogeneration alternative produces the lowest maximum SO_2 impacts. The alternatives with the highest impacts rely more heavily on power production from coal-fired plants at Boardman than do the other alternatives. It is interesting to note that the Cogeneration alternative produces the highest maximum ground-level air quality impact for NO_x and the lowest maximum ground-level air quality impacts for SO_2 .

The Conventional Coal alternative produces the highest ground-level air quality impacts for TSP and the Nuclear alternative produces the lowest maximum TSP impacts. The Conventional Coal alternative produces the highest TSP impact because it requires a higher level of power production from the coal-fired plants at Boardman than do the other alternatives. The Nuclear alternative has a lower utilization of coal-fired power at Boardman than do the other alternatives.

The highest annual average pollutant concentration recorded for each of the alternatives occurs within 5 km of the release site. The highest annual average concentrations of NO_x , SO_2 , and TSP produced by the alternatives are 4.3, 2.9, and $0.16 \mu\text{g}/\text{m}^3$, respectively. These concentrations are 4, 5, and 0.3%, respectively, of their AAQS. Over a broad region, the annual average concentrations of NO_x , SO_2 , and TSP from power plant emissions exceeds 0.5, 0.4, and $0.01 \mu\text{g}/\text{m}^3$, respectively.

The highest values for the 24-, 3-, and 1-h maximum concentration of SO_2 , and the 24-h maximum concentrations of TSP, occur within about 3 km of the release site. Although the Conventional Coal alternative has the highest annual-average impacts for SO_2 , the Imports, Fuel Switching, and Status Quo alternatives have higher short-term maximum concentrations of SO_2 . This is because these three alternatives are projected to have the highest rate of

coal-fired power production at Boardman during the spring and summer seasons when meteorological conditions can generate higher short-term maximum pollutant concentrations. The highest 24-h maximum concentration of SO_2 is $35 \mu\text{g}/\text{m}^3$ (13% of the AAQS). For comparison, the Cogeneration alternative only generates a 24-h maximum SO_2 concentration of $26 \mu\text{g}/\text{m}^3$. The Conventional Coal alternative produces the highest 24-h maximum concentration of TSP, $1.7 \mu\text{g}/\text{m}^3$ (1% of the AAQS), and the Cogeneration alternative produces the lowest maximum, under $1.1 \mu\text{g}/\text{m}^3$ (<1% of the AAQS). The Imports alternative produces the highest 3-h maximum SO_2 concentration, $152 \mu\text{g}/\text{m}^3$ (12% of the AAQS), and the Cogeneration alternative produces the lowest 3-h maximum SO_2 concentration, $119 \mu\text{g}/\text{m}^3$ (9% of the AAQS). The Imports alternative produces the highest 1-h maximum SO_2 concentration, $363 \mu\text{g}/\text{m}^3$ (36% of the AAQS), and the Cogeneration alternative produces the lowest 1-h maximum SO_2 concentration, $268 \mu\text{g}/\text{m}^3$ (27% of the AAQS).

3.3.3.3 Air Quality Impacts in the Year 2010 from Boardman Emissions

In the year 2010, the Cogeneration and Conventional Coal alternatives produce the greatest ground-level air quality impacts for NO_x and the Imports and Clean Coal alternatives produce the lowest ground-level maximum air quality impact for NO_x . As in the year 2000, the Cogeneration alternative produces one of the highest local ground-level NO_x impacts because it relies more heavily on natural-gas-fired power plants (cogeneration facilities) at Boardman than do the other alternatives.

The Imports and Conventional Coal alternatives produce the highest ground-level air quality impacts for SO_2 and the Cogeneration alternative produces the lowest maximum SO_2 impacts. The alternatives with the highest impacts rely more heavily on power production from coal-fired plants at Boardman than do the other alternatives. It is interesting to note that the Cogeneration alternative produces the highest maximum ground-level air quality impact for NO_x and the lowest maximum ground-level air quality impact for SO_2 .

The Conventional Coal alternative produces the highest ground-level air quality impacts for TSP and the High Conservation alternative produces the lowest maximum TSP impacts. The Conventional Coal alternative produces the highest TSP impact because it requires a higher level of power production from

the coal-fired plants at Boardman than do the other alternatives. The High Conservation alternative has a slightly lower utilization of coal-fired power at Boardman than do the other alternatives.

The highest annual average pollutant concentration recorded for each of the alternatives occurs within 5 km of the release site. The highest annual average concentrations of NO_x , SO_2 , and TSP produced by the alternatives are 8.3, 4.2, and $0.32 \mu\text{g}/\text{m}^3$, respectively. These concentrations are 8, 7, and 0.5%, respectively, of their AAQS. Over a broad region, the annual average concentrations of NO_x , SO_2 , and TSP from power plant emissions exceed 1.2, 0.5, and $0.03 \mu\text{g}/\text{m}^3$, respectively.

The highest values for the 24-, 3-, and 1-h maximum concentration of SO_2 and the 24-h maximum concentrations of TSP occur within about 3 km of the release site. The Conventional Coal alternative produces the highest maximum concentrations for regulatory time periods. The highest values for the 24-, 3-, and 1-h maximum concentration of SO_2 are $53 \mu\text{g}/\text{m}^3$ (20% of the AAQS), $231 \mu\text{g}/\text{m}^3$ (18% of AAQS), and $551 \mu\text{g}/\text{m}^3$ (54% of the AAQS). For comparison, the highest values for the 24-, 3-, and 1-h maximum concentrations of SO_2 for most other resource alternatives are $48 \mu\text{g}/\text{m}^3$ (18% of the AAQS), $206 \mu\text{g}/\text{m}^3$ (16% of AAQS), and $494 \mu\text{g}/\text{m}^3$ (48% of the AAQS). The Conventional Coal alternative produces the highest 24-h maximum concentration of TSP, $4.0 \mu\text{g}/\text{m}^3$ (3% of the AAQS), while most other alternatives produce maximums of about $3.0 \mu\text{g}/\text{m}^3$ (2% of the AAQS).

3.3.4 Air Quality Impacts from Emissions at Colstrip, Montana

In this section, estimates of air quality impacts are presented for emissions from the southeastern Montana release site (i.e., Colstrip). Contour plots of annual average pollutant concentrations were computed using the expanded Cartesian grid and are presented in Appendix C for each combination of pollutant, study year, and resource alternative. The highest and second highest annual average and short-term maximum pollutant concentrations were computed using the close-in grid and are presented in Appendix D for each combination of release site, pollutant, study year, averaging period, and resource alternative.

On an annual average basis, the contour plots in Appendix C show that ground-level pollutant concentration patterns are generally oriented in a northwest/southeast direction from the Colstrip site. This area encompasses a stretch of Highway 94 and the Yellowstone River to the northwest of the Colstrip and portions of the Northern Cheyenne Reservation and Custer National Forest to the southeast.

Some of the power currently generated at the Colstrip site is provided to the BPA and some of the power is provided to utilities outside of the BPA service region. This sort of power distribution will continue in the future for all of the studied scenarios. Our analysis of air quality impacts from power plant emissions focuses on the impacts associated only with power generated for the BPA; emissions associated with the power generated for other utilities are not included in our assessment of air quality impacts.

3.3.4.1 Air Quality Impacts in the Year 1991 from Colstrip Emissions

In 1991, the highest annual average concentrations would occur about 15 km east-southeast from the release site. At this point, the highest annual concentrations of NO_x , SO_2 , and TSP from power plant emissions are 2.4, 3.2, and $0.12 \mu\text{g}/\text{m}^3$, respectively. These concentrations are 2, 5, and 0.2%, respectively, of their AAQS. Over a broad region on the expanded grid, annual average concentrations of NO_x , SO_2 , and TSP from power plant emissions exceed 0.6, 1.0, and $0.04 \mu\text{g}/\text{m}^3$, respectively. The highest annual air quality impacts from Colstrip emissions tend to occur further from the release point than at the other three regional sites because all emissions at Colstrip are from the tall stacks of coal-fired power plants.

The highest values for the 24-, 3-, and 1-h maximum concentrations of SO_2 and the 24-h maximum concentration of TSP occur within several kilometers and to the northwest of the release site. The highest values of the 24-, 3-, and 1-h maximum SO_2 concentrations from power plant emissions are 78, 382, and $759 \mu\text{g}/\text{m}^3$, respectively. These values correspond to 30, 29, and 75%, respectively, of the AAQS. The highest value of the 24-h maximum TSP concentration from power plant emissions is $3.0 \mu\text{g}/\text{m}^3$, about 5% of the AAQS. The above estimates of the maximum short-term concentrations of SO_2 are approaching their respective regulatory limits; however, these estimates are

based on a number of quite conservative assumptions. For example, the assumption that all emissions are occurring at a single location can cause maximum short-term concentrations to be overestimated by a factor of two or more.

3.3.4.2 Air Quality Impacts in the Year 2000 from Colstrip Emissions

In the year 2000, the Conventional Coal alternative produces the greatest ground-level air quality impacts for NO_x , SO_2 , and TSP and the Cogeneration alternative produces the lowest ground-level maximum air quality impacts for these pollutants. The Conventional Coal alternative produces the highest local ground-level air quality impacts because it relies more heavily on coal-fired power plant emissions at Colstrip than any of the other alternatives.

The highest annual average pollutant concentration recorded for each of the alternatives occurs within 15 km of the release site. The highest annual average concentrations of NO_x , SO_2 , and TSP produced by the Conventional Coal alternative are 4.0, 4.1, and $0.22 \mu\text{g}/\text{m}^3$, respectively. These concentrations are 4, 5, and 0.4%, respectively, of their AAQS. Over a broad region, the annual average concentrations of NO_x , SO_2 , and TSP from power plant emissions exceeds 1.2, 1.5, and $0.06 \mu\text{g}/\text{m}^3$, respectively.

The highest values for the 24-, 3-, and 1-h maximum concentrations of SO_2 and the 24-h maximum concentration of TSP occur about 3 km to the northwest of the release site. The Conventional Coal alternative produces the highest maximum concentrations for both pollutants and each regulatory time period and the Cogeneration alternative produces the lowest maximums. The highest 24-h maximum concentration of SO_2 is $106 \mu\text{g}/\text{m}^3$ (29% of the AAQS). For comparison, the Cogeneration alternative generates a highest 24-h maximum SO_2 concentration of $91 \mu\text{g}/\text{m}^3$ (25% of the AAQS). The highest 24-h maximum concentration of TSP is $5.6 \mu\text{g}/\text{m}^3$ (4% of the AAQS), and the lowest maximum is under $4.4 \mu\text{g}/\text{m}^3$ (3% of the AAQS). The highest 3-h maximum SO_2 concentration is $503 \mu\text{g}/\text{m}^3$ and the lowest 3-h maximum SO_2 concentration is $431 \mu\text{g}/\text{m}^3$. The highest 1-h maximum SO_2 concentration is $1,036 \mu\text{g}/\text{m}^3$, and the lowest 1-h maximum SO_2 concentration is $887 \mu\text{g}/\text{m}^3$. Although there are no federal or Montana state regulations that limit the maximum 1-hr concentration of SO_2 , it is interesting to note that our study predicts that the highest maximum 1-h

SO₂ concentration from power plant emissions would exceed the Washington State regulatory limit of 1,018 µg/m³. Although these estimates are conservative (i.e., biased to overestimate impacts), the high concentrations predicted in our study indicate that care must be taken to ensure that the air quality impacts resulting from operation of a new power-plant at the Colstrip site do not exceed air quality regulations.

3.3.4.3 Air Quality Impacts in the Year 2010 from Colstrip Emissions

In the year 2010, the Conventional Coal and Status Quo alternatives produce the greatest ground-level air quality impacts for NO_x, SO₂, and TSP and the Cogeneration alternative produces the lowest ground-level maximum air quality impacts for these pollutants. The alternatives with the highest local ground-level air quality impacts rely more heavily on coal-fired power plant emissions at Colstrip than any of the other alternatives.

The highest annual average pollutant concentration recorded for each of the alternatives occurs within 15 km of the release site. The highest annual average concentrations of NO_x, SO₂, and TSP produced by the Conventional Coal alternative are 5.2, 4.6, and 0.29 µg/m³, respectively. These concentrations are 5, 6, and 0.5%, respectively, of their AAQS. Over a broad region, the annual average concentrations of NO_x, SO₂, and TSP from power plant emissions exceed 1.8, 1.5, and 0.1 µg/m³, respectively.

The highest values for the 24-, 3-, and 1-h maximum concentrations of SO₂ and the 24-h maximum concentrations of TSP occur about 3 km to the northwest of the release site. The highest 24-h maximum concentration of SO₂ is 118 µg/m³ (32% of the AAQS). For comparison, the Fuel Switching alternative only generates a highest 24-h maximum SO₂ concentration of 112 µg/m³ (31% of the AAQS). The highest 24-h maximum concentration of TSP is 7.3 µg/m³ (5% of the AAQS), and the Fuel Switching alternative produces the lowest maximum, 6.4 µg/m³ (4% of the AAQS). The highest 3-h maximum SO₂ concentration is 560 µg/m³ and the Fuel Switching alternative produces the lowest 3-h maximum SO₂ concentration, 530 µg/m³. The highest 1-h maximum SO₂ concentration is 1,152 µg/m³ and the Fuel Switching alternative produces the lowest 1-h maximum SO₂ concentration, 1,092 µg/m³. Although there are no federal or Montana state regulations that limit the maximum 1-hr concentration

of SO₂, it is interesting to note that here again the highest maximum 1-h SO₂ concentrations would exceed the Washington State regulatory limit of 1,018 µg/m³. Because our assessment is based on a number of conservative assumptions, actual air quality impacts would probably be significantly lower; however, our estimates indicate that care must be taken to ensure that air quality standards are not exceeded because of Colstrip emissions.

3.3.5 Summary of the Air Quality Assessment of Basic Criteria Pollutants

In comparing the resource alternatives, some of the alternatives tend to produce near- to above-average air pollutant concentrations, while others tend to produce near- to below-average concentrations. Considering all sites, the alternative with the greatest air quality impact is the Conventional Coal alternative. The Conventional Coal alternative tends to produce above-average pollutant concentrations at all release sites in both the 2000 and 2010 study years. The Clean Coal, Imports, and Status Quo alternative also tend to produce above-average air quality impacts for selected pollutants at one or more sites in the study years. The Cogeneration alternative tends to produce above-average NO_x impacts at two of the release sites in both study years, but near- to below-average SO₂ and TSP impacts at all of the release sites during the same periods. The Base Case, Conservation, Nuclear, Renewables, Fuel Switching, and High Conservation alternatives tend to produce near- to below-average pollutant impacts for all scenarios, except for some above-average NO_x impacts at Centralia in one or both study years. Differences in the air quality impacts among this final group of alternatives are generally slight.

Although we have identified a subset of resource alternatives that have lower than average air quality impacts when compared to the entire set of resource alternatives, all of the resource alternatives involve significant increases in pollutant emissions and air quality impacts. In western Washington, the increase in the emission of NO_x and SO₂ from power plants, coupled with increasing emissions from other pollutant sources, could contribute to instances where pollutant concentrations might exceed federal, state, or local air quality standards. In northeastern Oregon, the increased emissions of basic criteria pollutants could lead to a detectable degradation of air quality in neighboring agricultural and forested areas. In eastern Washington, the operation of power plants in the Creston area could lead to

the degradation of air quality in nearby Indian reservation and recreational areas. Similar problems may occur in southeastern Montana, which already has a high level of pollutant emissions from local power plants.

4.0 POLLUTANT DEPOSITION

As a result of natural atmospheric cleansing processes, pollutant materials (both particles and gas molecules) have a limited residence time in the atmosphere (Slinn 1988). Pollutants can be removed from the atmosphere by wet deposition (i.e., precipitation scavenging), dry deposition (i.e., gravitational settling), and chemical or physical transformations. Wet deposition involves the removal of pollutant material from the atmosphere by rain, snow, and other types of precipitation. Dry deposition involves the transport of particles and gas molecules to the surface through the processes of diffusion and gravitational settling.

The deposition of emissions from fossil fuel-fired power plants is a potential environmental concern. Toxic or radioactive particulates are directly emitted in varying quantities by power plants. Acidic compounds, or their precursors, are also emitted in varying quantities by power plants. Although many experiments have been conducted to determine the physics of deposition, there is still much uncertainty in quantifying deposition rates (Slinn 1984).

One objective of our study of pollutant deposition is to estimate the change in acid deposition that would result from the implementation of BPA's proposed resource alternatives. The deposition of acidic compounds has been an environmental concern for many years. Strongly acidic compounds are formed in the atmosphere as a result of chemical reactions involving the pollutants NO_x and SO_2 . As discussed earlier, these pollutants are emitted in significant quantities by a number of pollution sources in the Pacific Northwest, including fossil fuel-fired power plants. Once formed, acidic compounds can be removed from the atmosphere by both wet and dry deposition processes. The resulting flux of acidic material to the surface can have an impact on soils, water bodies, vegetation, wildlife, and man-made structures. This chapter provides data on projected changes in the acidity of precipitation due to power plant emissions.

Another objective of this study of pollutant deposition is to examine the deposition of non-acidic particulates emitted from power plants. Although pollution control equipment can remove a significant percentage of the

particulate by-products of power generation at coal and other fossil fuel-fired power plants, significant quantities of particulates, including heavy metals and radioactive elements, may still be released to the atmosphere. The impact of these particulates on soils, vegetation, wildlife, and human health needs to be assessed. This chapter provides data on particulate deposition that would be useful for such an assessment.

4.1 THE MESOPUFF II MODEL

The MESOscale PUFF II model, or MESOPUFF-II, is a regional-scale, Gaussian puff model (Scire et al. 1984) designed to calculate airborne concentrations of up to five pollutant species (i.e., SO_2 , sulfate, NO_x , nitric acid, and nitrate). The model is designed to account for spatial and temporal variation in transport, diffusion, chemical transformations, dry deposition, and wet removal processes. Although input meteorological data may reflect the impact of significant terrain features, the model does not explicitly treat complex terrain. The model uses a gridded field of receptors to model pollutant concentrations and allows the user to specify additional receptor locations. Hourly chemical rate constants are computed from empirical expressions derived from photochemical model simulations.

MESOPUFF II's input requirements include a variety of information that defines the source configuration and pollutant emission parameters. Up to 25 pollutant point sources and 5 area sources can be modeled in a single simulation. The model can use hourly meteorological data from up to 25 surface stations and 10 upper air stations. Although designed primarily for simulation durations of several days or less, the model's ability to handle longer durations allowed the simulation of continuous releases for periods up to several months. In its EPA-approved form, MESOPUFF II did not directly compute the gridded fields of pollutant deposition values required for the assessment of acid deposition. To obtain these data, the model was modified to compute and store deposition values for selected pollutants, thus providing information on the average pH of precipitation.

To run MESOPUFF II, the model provides two meteorological preprocessing codes (i.e., READ56 and MESOPAC II) to generate the required model input files. READ56 is used to read and process upper air data; MESOPAC II reads

upper air and surface meteorological data files and computes gridded fields of meteorological parameters for use by MESOPUFF II. A postprocessing code, MESOFILE, can be used to perform time averaging on model output products.

4.2 MESOPUFF INPUT PARAMETERS

MESOPUFF requires four types of data: simulation control parameters, meteorological data, surface classification (i.e., land-use) data, and source/emissions data. To prepare the gridded fields of meteorological data required by the MESOPUFF II model, the MESOPAC II code requires the following data:

- twice-daily upper air soundings of pressure, height, temperature, wind direction, and wind speed
- hourly information on cloud cover, ceiling height, precipitation type and amount, near-surface wind direction and speed, surface pressure, temperature, and relative humidity.

The surface classification data required by MESOPUFF II involves a characterization of land-use categories for each of MESOPUFF's grid cells. The model uses these data to compute surface roughness and canopy resistance values for the grid cells.

For point sources, as used in this study, MESOPUFF II requires information on source location, stack height, stack diameter, effluent exit velocity, stack gas temperature, and emission rate for each pollutant.

For our analysis of acid deposition, model domains consisting of 24 (east-west) by 28 (north-south) grid points with a spacing of 25 km between grid points were created for each studied release site. The pollutant release location for each simulation was located at or near the center of each grid, providing a minimum distance of 300 km from the release location to the edge of the model domain. A domain of this size allowed the assessment of short- to long-range acid deposition impacts on agricultural land, regional forests, and water resources.

All model simulations were run using a pollutant emission height of 100 m. Because we do not focus on close-in impacts in our study of acid deposition (as we did in our study of basic criteria pollutant concentrations

using the ISCST model), we do not have to distinguish between the pollutant release heights of coal-fired and natural gas-fired power plants. All emissions were assumed to have an effluent exhaust velocity of 20 m/s and an effluent temperature of 77°C.

Compared to the ISCST model used to assess basic criteria pollutant concentrations, the MESOPUFF II model has much greater data input requirements, is significantly more complex to initialize, requires the use of a more powerful computer, and has much longer simulation run times. As a result, a couple of key assumptions were made to reduce the number of individual model simulations that would be required for this study.

First, all model simulations were run using a pollutant release rate of 1,000 g/s of NO_x and 1,000 g/s of SO_2 . Model postprocessing was therefore required to convert deposition estimates generated using the normalized set of pollutant release rates to estimates for the various resource alternatives. The sulfur chemistry used in MESOPUFF II is completely linear, this allows us to obtain estimates of SO_2 -related acidic deposition by multiplying model results by the ratio of actual SO_2 emission rates to the normalized 1,000 g/s SO_2 emission rate. This postprocessing of sulfur-related acid deposition does not introduce any significant inaccuracies. On the other hand, NO_x chemistry is non-linear (i.e., the rate of conversion of NO_x to NO_3 and HNO_3 is a function of the NO_x concentration), as a result we are potentially introducing some inaccuracy into our NO_x -related acidity estimates by using a 1,000 g/s NO_x release rate in model simulations and attempting to linearly adjust output concentrations based on modelled NO_x emissions. There are a couple of factors acting to mitigate this particular problem:

- The studied NO_x emission rates range from a minimum of 245 g/s at Boardman in 1991 to a maximum of about 2,400 g/s at Colstrip in the year 2010; however most emission rates are within a factor of 2 or less of the assumed 1,000 g/s emission rate. Because all emissions are within at least a factor of 4 of the modeled emission rate and most are much closer, the non-linearity problem is considerably reduced.
- The contribution of NO_x to the acidity of rainfall is generally smaller than the sulfur contribution and it is not as prominent close to the source where the greatest change in pH is observed. Errors in NO_x -related acid deposition will therefore have only a secondary impact on the accuracy of acid deposition projections.

The second major assumption involved running the model for only two sites, Creston and Centralia, with the results from Creston used to represent the climatological and land-use characteristics in the vicinity of Boardman and Colstrip. For the Centralia site, hourly surface meteorological data were available from Toledo, Forks, Seattle, Olympia, Tacoma, and Yakima, Washington; and from Portland, Oregon. Upper air data were available from Forks (Quillayute), Washington. For the Creston site, hourly surface meteorological data were available from Kalispell and Missoula, Montana; Lewiston, Idaho; and Spokane, Stampede, and Yakima, Washington. Upper air data were available from Forks (Quillayute) and Spokane, Washington. All meteorological data used in MESOPUFF simulations were obtained from the National Climatic Data Center.

Separate MESOPUFF II model simulations were generated for each major release site and each season. Using the postprocessing described above, model output was processed to provide information on the variation in acid deposition as a function of the study year and resource alternative emissions.

4.3 ESTIMATES OF ACID DEPOSITION

Estimates of the average seasonal pH of precipitation are based on both the wet deposition of strongly acidic pollutants that result from power plant emissions and the natural background pH of rainfall. The process of calculating the average seasonal hydrogen ion concentration in rainfall at each model grid point involves

- estimating the hourly deposition of acidic pollutants (in units of g/m^2) from dissolved SO_2 , SO_4 , HNO_3 , and NO_3
- dividing the hourly deposition value for each acidic pollutant by the total rainfall in the hour to get an estimate of the concentration of each acidic pollutant in the rainfall (in units of g/m^3 of water)
- converting hourly estimates of acid concentrations in rainfall into estimates of hydrogen ion concentrations (in units of micromoles [μM] per liter). To do this, the concentration of each pollutant has to be changed to units of $\mu\text{M}/\text{L}$ (this involves using information on the molecular weight of the pollutants) and the concentration of hydrogen ions needs to be summed over all pollutants (note that two hydrogen ions are involved for SO_2 and SO_4) using the following relationship:

$$[\text{H}_+] = 2[\text{dissolved SO}_2] + 2[\text{SO}_4] + [\text{NO}_3](\text{from HNO}_3) + [\text{NO}_3] (\text{non-HNO}_3)$$

- summing hourly estimates of hydrogen ion concentrations over the course of a season
- dividing the summed hydrogen ion concentration by the total number of hours of precipitation during the season.

In Appendix E, we present plots of the average pH of precipitation for each combination of release site, season, and "high" and "low" SO_x pollutant emissions. The total effective acidity of the precipitation at each grid point is the sum of the acid deposition from power plant emissions and the natural acidity of precipitation due to the saturation of carbon dioxide in rain (i.e., 2 μM/L for a natural pH of 5.7). As a result of the natural pH of rainfall, a pH of 5.7 is the least acidic pH (i.e., the highest value) that can appear in our results.

It should be noted that the effective acidity we report for rainfall is in some respect exaggerated because it assumes that none of the acidic pollutants are neutralized by any natural airborne or plume constituents, and that no processes are encountered after contacting the ground that will immediately neutralize the acid in the rainfall. Conversely, our study does not consider the impact of other pollutant sources (e.g. industrial, residential, automotive) that may contribute to acid rain. The actual pH of rainfall for the studied times and locations may therefore be more or less acidic than our results indicate.

Results from the plots in Appendix E are summarized in Tables 4.1 through 4.4. Focusing on the most acid rainfall projected for any model grid point, a mean pH as low as 4.0 is projected to occur at a point near Colstrip during the summer of 2010. This compares to a mean pH as low as 4.2 that is estimated for the maximally impacted point near Colstrip in the summer of 1991. At Centralia, a mean pH as low as 4.4 is projected to occur during the summer of 2010. This is significantly more acidic than the mean pH of 5.2 estimated in the same area for the summer of 1991. At Boardman, a mean pH as low as 5.1 is projected during both the summer and winter of 2010. A mean pH as low as 5.4 is estimated for the same seasons in 1991. At Creston, a mean pH as low as 5.2 is projected during the summer of the year 2010. With no power plant emissions in 1991, the precipitation in that year is estimated to have a pH of 5.7 (the pH of natural rainfall).

TABLE 4.1. Average pH of Rainfall in the Centralia Study Areas

<u>Site Name</u>	<u>Year</u>	<u>Season</u>	<u>Resource Alternative with the Highest or Lowest SO_x Emissions</u>	<u>Average pH of Rainfall at</u>	
				<u>Maximally Impacted pt. Anywhere on Study Grid</u>	<u>Maximally Impacted pt. > 200 km from Source</u>
Centralia	1991	Fall	---	5.0	5.6
		Winter	---	5.3	5.5
		Spring	---	5.7	5.7
		Summer	---	5.2	5.5
Centralia	2010	Fall	Low	5.0	5.4
		Fall	Hi	4.9	5.4
		Winter	Low	5.0	5.3
		Winter	Hi	5.0	5.3
		Spring	Low	5.5	5.5
		Spring	Hi	5.1	5.2
		Summer	Low	4.4	5.1
		Summer	Hi	4.4	5.1

TABLE 4.2. Average pH of Rainfall in the Boardman Study Areas

<u>Site Name</u>	<u>Year</u>	<u>Season</u>	<u>Resource Alternative with the Highest or Lowest SO_x Emissions</u>	<u>Average pH of Rainfall at</u>	
				<u>Maximally Impacted pt. Anywhere on Study Grid</u>	<u>Maximally Impacted pt. > 200 km from Source</u>
Boardman	1991	Fall	---	5.4	5.6
		Winter	---	5.6	5.7
		Spring	---	5.7	5.7
		Summer	---	4.8	5.4
Boardman	2010	Fall	Low	5.1	5.5
		Fall	Hi	5.0	5.4
		Winter	Low	5.1	5.2
		Winter	Hi	5.0	5.1
		Spring	Low	5.1	5.4
		Spring	Hi	4.9	5.2
		Summer	Low	4.5	5.3
		Summer	Hi	4.3	5.1

TABLE 4.3. Average pH of Rainfall in the Creston Study Areas

<u>Site Name</u>	<u>Year</u>	<u>Season</u>	<u>Resource Alternative with the Highest or Lowest SO_x Emissions</u>	<u>Average pH of Rainfall at</u>	
				<u>Maximally Impacted pt. Anywhere on Study Grid</u>	<u>Maximally Impacted pt. > 200 km from Source</u>
Creston	1991	Fall	---	5.7	5.7
		Winter	---	5.7	5.7
		Spring	---	5.7	5.7
		Summer	---	5.7	5.7
Creston	2010	Fall	Low	5.3	5.6
		Fall	Hi	5.2	5.6
		Winter	Low	5.3	5.3
		Winter	Hi	5.3	5.3
		Spring	Low	5.4	5.5
		Spring	Hi	5.2	5.4
		Summer	Low	4.7	5.3
		Summer	Hi	4.5	5.2

TABLE 4.4. Average pH of Rainfall in the Colstrip Study Areas

<u>Site Name</u>	<u>Year</u>	<u>Season</u>	<u>Resource Alternative with the Highest or Lowest SO_x Emissions</u>	<u>Average pH of Rainfall at</u>	
				<u>Maximally Impacted pt. Anywhere on Study Grid</u>	<u>Maximally Impacted pt. > 200 km from Source</u>
Colstrip	1991	Fall	---	5.0	5.4
		Winter	---	5.0	5.0
		Spring	---	5.2	5.4
		Summer	---	4.2	4.9
Colstrip	2010	Fall	Low	4.8	5.2
		Fall	Hi	4.7	5.2
		Winter	Low	4.8	4.8
		Winter	Hi	4.7	4.8
		Spring	Low	4.7	5.0
		Spring	Hi	4.7	5.0
		Summer	Low	4.0	4.7
		Summer	Hi	4.1	4.7

It is interesting to note that in nearly all cases the lowest average pH of precipitation occurs in the summer season and not in the winter or fall when power plant emissions are at a maximum. The greater acidity in the summer season may be due to a greater intensity of precipitation on those occasions when precipitation tends to occur (e.g., during summer thunderstorms) and lower average wind speeds that may act to increase the concentration of acidic compounds in the atmosphere. Although rain may be more acidic in the summer, the amount of rain falling during this period is much lower than in the winter and fall seasons. As a result, a greater amount of acidic compounds are deposited on the surface in the fall and winter even though the average precipitation is less acidic.

4.4 ESTIMATES OF WET DEPOSITION

Estimates of wet deposition of particulates were obtained from the MESOPUFF II model runs discussed above. In particular, the model results for the deposition of sulfur compounds were used to estimate particulate deposition. In doing this, we summed the deposition values for SO_2 and SO_4 to get an estimate of total deposition for a continuous 1,000 g/s release of SO_2 . We next multiplied this estimate of total deposition results by the ratio of the emission rate for total suspended particulates (TSP) to the emission rate for SO_2 . This new value provides a rough estimate of the wet deposition of particulate emitted by power plants.

The method we used to estimate the wet deposition of particulates has significant uncertainties. First, the assumption is made that particulates will have a comparable dry deposition rate to that of SO_2 and SO_4 . This assumption is important because dry deposition can significantly deplete a plume prior to the beginning of a precipitation-scavenging event. If the dry deposition rate for particulates is significantly greater than the rate for sulfur compounds, there will be fewer particulates in the atmosphere available for wet deposition at the beginning of a precipitation-scavenging event. Next, the assumption is made that particulates will be removed from the atmosphere by wet deposition processes with the same efficiency that SO_2 and SO_4 are removed. A significant difference in removal efficiency will impact estimates of wet deposition. Another assumption is our neglecting of gas-to-

particle conversion. We neglect this process because particles formed through this process are not generally of concern in the assessment of the environmental impact from the deposition of toxic or radioactive particulates.

The validity of the above assumptions is difficult to quantify, especially because so little is known about the size distribution and chemical and physical properties of the particulates that may be omitted by proposed power plants. However, the results we obtain should provide an acceptable first approximation of the environmental impact for the wet deposition of particulates.

The estimates we obtained for the wet deposition of particulates are presented in Tables 4.5 through 4.8. Three wet deposition values are provided for each combination of release site, study year, and resource alternative.

The first point represents the maximally impacted grid point and is located about 25 km from the release site. The second point is about 130 km from the release site, along the path of greatest deposition. The third point is about 230 km from the release site, along the path of greatest deposition.

In 1991, the maximum amount of particulate wet deposition projected for a point near Centralia is 12.1 mg/m^2 . In the year 2000, the projection of the maximum amount of wet deposition ranges from 13.5 to 16.4 mg/m^2 . In the year 2010, the projection of the maximum amount of wet deposition ranges from 15.0 to 17.2 mg/m^2 .

In 1991, the maximum amount of particulate wet deposition projected for a point near Boardman is 1.7 mg/m^2 . In the year 2000, the projection of the maximum amount of particulate wet deposition ranges from 2.7 to 4.3 mg/m^2 . In the year 2010, the projection of the maximum amount of wet deposition ranges from 6.2 to 8.2 mg/m^2 .

In 1991 there are no power plant emissions at Creston. In the year 2000, the projection of the maximum amount of wet deposition ranges from 2.7 to 3.4 mg/m^2 . In the year 2010, the projection of the maximum amount of wet deposition ranges from 2.9 to 4.0 mg/m^2 .

TABLE 4.5. Cumulative Wet Deposition of Particulates at Centralia

Study Year: 1991

<u>Resource Alternative</u>	<u>Point 1 (mg/m²)</u>	<u>Point 2 (mg/m²)</u>	<u>Point 3 (mg/m²)</u>
All Programs	12.1	2.4	1.0

Study Year: 2000

<u>Resource Alternative</u>	<u>Point 1 (mg/m²)</u>	<u>Point 2 (mg/m²)</u>	<u>Point 3 (mg/m²)</u>
Status Quo	14.2	2.8	1.2
Base Case 4	14.2	2.8	1.2
Conservation	14.2	2.8	1.2
Conventional Coal	16.4	3.3	1.4
Clean Coal	14.5	2.9	1.2
Nuclear	14.0	2.8	1.2
Combustion Turbine	14.3	2.8	1.2
Renewables	14.3	2.8	1.2
Cogeneration	13.5	2.7	1.2
Fuel Switching	14.5	2.9	1.2
High Conservation	14.4	2.9	1.2
Imports	15.5	3.1	1.3

Study Year: 2010

<u>Resource Alternative</u>	<u>Point 1 (mg/m²)</u>	<u>Point 2 (mg/m²)</u>	<u>Point 3 (mg/m²)</u>
Status Quo	15.1	3.0	1.3
Base Case 4	15.2	3.0	1.3
Conservation	15.2	3.0	1.3
Conventional Coal	17.2	3.4	1.5
Clean Coal	15.2	3.0	1.3
Nuclear	15.3	3.0	1.3
Combustion Turbine	15.2	3.0	1.3
Renewables	15.2	3.0	1.3
Cogeneration	15.0	3.0	1.3
Fuel Switching	15.1	3.0	1.3
High Conservation	15.0	3.0	1.3
Imports	16.5	3.3	1.4

TABLE 4.6. Cumulative Wet Deposition of Particulates at Boardman

Study Year: 1991

<u>Resource Alternative</u>	<u>Point 1 (mg/m²)</u>	<u>Point 2 (mg/m²)</u>	<u>Point 3 (mg/m²)</u>
All Programs	1.7	0.5	0.2

Study Year: 2000

<u>Resource Alternative</u>	<u>Point 1 (mg/m²)</u>	<u>Point 2 (mg/m²)</u>	<u>Point 3 (mg/m²)</u>
Status Quo	2.9	0.9	0.4
Base Case 4	2.8	0.9	0.4
Conservation	2.8	0.9	0.4
Conventional Coal	4.3	1.4	0.6
Clean Coal	3.0	0.9	0.4
Nuclear	2.8	0.9	0.4
Combustion Turbine	2.8	0.9	0.4
Renewables	2.8	0.9	0.4
Cogeneration	2.7	0.9	0.4
Fuel Switching	2.9	0.9	0.4
High Conservation	2.9	0.9	0.4
Imports	3.0	1.0	0.4

Study Year: 2010

<u>Resource Alternative</u>	<u>Point 1 (mg/m²)</u>	<u>Point 2 (mg/m²)</u>	<u>Point 3 (mg/m²)</u>
Status Quo	6.2	1.9	0.8
Base Case 4	6.2	1.9	0.8
Conservation	6.2	1.9	0.8
Conventional Coal	8.2	2.5	1.1
Clean Coal	6.6	2.0	0.9
Nuclear	6.2	1.9	0.8
Combustion Turbine	6.2	1.9	0.8
Renewables	6.2	1.9	0.8
Cogeneration	6.2	1.9	0.8
Fuel Switching	6.2	1.9	0.9
High Conservation	6.2	1.9	0.8
Imports	6.6	2.2	1.0

TABLE 4.7. Cumulative Wet Deposition of Particulates at Creston

Study Year: 1991

<u>Resource Alternative</u>	<u>Point 1 (mg/m²)</u>	<u>Point 2 (mg/m²)</u>	<u>Point 3 (mg/m²)</u>
All Programs	0.0	0.0	0.0

Study Year: 2000

<u>Resource Alternative</u>	<u>Point 1 (mg/m²)</u>	<u>Point 2 (mg/m²)</u>	<u>Point 3 (mg/m²)</u>
Status Quo	2.9	1.0	0.4
Base Case 4	2.9	1.0	0.4
Conservation	2.9	1.0	0.4
Conventional Coal	3.4	1.1	0.5
Clean Coal	3.2	1.0	0.4
Nuclear	2.8	1.0	0.4
Combustion Turbine	2.9	1.0	0.4
Renewables	2.9	1.0	0.5
Cogeneration	2.7	1.0	0.4
Fuel Switching	2.9	1.0	0.5
High Conservation	2.9	1.0	0.5
Imports	3.0	1.0	0.5

Study Year: 2010

<u>Resource Alternative</u>	<u>Point 1 (mg/m²)</u>	<u>Point 2 (mg/m²)</u>	<u>Point 3 (mg/m²)</u>
Status Quo	4.0	1.3	.6
Base Case 4	3.0	.9	.4
Conservation	3.0	.9	.4
Conventional Coal	4.0	1.2	.6
Clean Coal	3.6	1.1	.5
Nuclear	3.0	.9	.4
Combustion Turbine	3.0	.9	.4
Renewables	3.0	.9	.4
Cogeneration	3.0	.9	.4
Fuel Switching	2.9	1.0	.5
High Conservation	3.0	.9	.4
Imports	3.2	1.1	.5

TABLE 4.8. Cumulative Wet Deposition of Particulates at Colstrip

Study Year: 1991

<u>Resource Alternative</u>	<u>Point 1 (mg/m²)</u>	<u>Point 2 (mg/m²)</u>	<u>Point 3 (mg/m²)</u>
All Programs	7.9	2.4	1.0

Study Year: 2000

<u>Resource Alternative</u>	<u>Point 1 (mg/m²)</u>	<u>Point 2 (mg/m²)</u>	<u>Point 3 (mg/m²)</u>
Status Quo	12.3	3.8	1.7
Base Case 4	12.3	3.8	1.7
Conservation	12.3	3.8	1.7
Conventional Coal	14.6	4.6	2.1
Clean Coal	13.0	4.1	1.8
Nuclear	12.2	3.9	1.7
Combustion Turbine	12.3	3.9	1.7
Renewables	12.4	3.9	1.7
Cogeneration	12.0	3.8	1.7
Fuel Switching	12.4	3.9	1.8
High Conservation	12.4	3.9	1.8
Imports	12.4	3.9	1.7

Study Year: 2010

<u>Resource Alternative</u>	<u>Point 1 (mg/m²)</u>	<u>Point 2 (mg/m²)</u>	<u>Point 3 (mg/m²)</u>
Status Quo	19.0	6.1	2.8
Base Case 4	16.7	5.3	2.4
Conservation	16.7	5.3	2.4
Conventional Coal	19.3	6.3	2.9
Clean Coal	17.6	5.8	2.7
Nuclear	16.7	5.3	2.4
Combustion Turbine	16.7	5.3	2.4
Renewables	16.7	5.3	2.4
Cogeneration	16.7	5.3	2.4
Fuel Switching	16.7	5.3	2.4
High Conservation	16.7	5.3	2.4
Imports	17.0	5.6	2.6

In 1991, the maximum amount of particulate wet deposition projected for a point near Colstrip is 7.9 mg/m^2 . In the year 2000, the projection of the maximum amount of wet deposition ranges from 12.0 to 14.6 mg/m^2 . In the year 2010, the projection of the maximum amount of wet deposition ranges from 16.7 to 19.3 mg/m^2 .

It is interesting to note that particulate wet deposition values at Centralia are comparable to, or greater than, the wet deposition values at Colstrip, even though Colstrip has a much higher emission rate for particulates. This occurs because the annual precipitation at Centralia and in the neighboring Cascade mountains is much greater than in the vicinity of Colstrip and the other pollutant release sites.

4.5 ESTIMATES OF DRY DEPOSITION

To estimate the dry deposition of particulates we used the ISCST model. For this analysis, the model was run in the deposition computation mode (as opposed to the pollutant concentration mode described in Section 3). As with wet deposition, there are a lot of uncertainties associated with estimating the rate of dry deposition for particulates. Assumptions made about the size distribution of the particulates (as presented in Table 3.1) and their chemical and physical properties can result in significant uncertainties in dry deposition rates.

In Tables 4.9 through 4.12, we present estimates of the cumulative dry deposition at the maximum impacted point in the vicinity of each release site. Results were computed using the close-in grid (the 32-km-wide modeling domain) described in Section 3.

In 1991, the maximum amount of particulate dry deposition projected for a point near Centralia is 0.21 mg/m^2 . In the year 2000, the projection of the maximum amount of dry deposition ranges from 0.24 to 0.29 mg/m^2 . In the year 2010, the projection of the maximum amount of dry deposition ranges from 0.28 to 0.38 mg/m^2 .

TABLE 4.9. Cumulative Annual Dry Deposition at the Point of Maximum Impact in the Vicinity of Centralia

<u>Resource Alternative</u>	<u>Maximum Dry Deposition</u> <u>year 1991</u> <u>(mg/m²)</u>	
All Programs	0.21	
<u>Resource Alternative</u>	<u>Maximum Dry Deposition</u> <u>year 2000</u> <u>(mg/m²)</u>	
Status Quo	0.26	0.29
Base Case 4	0.26	0.29
Conservation	0.26	0.29
Conventional Coal	0.29	0.33
Clean Coal	0.26	0.29
Nuclear	0.25	0.29
Combustion Turbine	0.26	0.29
Renewables	0.26	0.29
Cogeneration	0.24	0.28
Fuel Switching	0.26	0.29
High Conservation	0.24	0.29
Imports	0.28	0.30

TABLE 4.10. Cumulative Annual Dry Deposition at the Point of Maximum Impact in the Vicinity of Boardman

<u>Resource Alternative</u>	<u>Maximum Dry Deposition</u> <u>year 1991</u> <u>(mg/m²)</u>	
All Programs	0.15	
<u>Resource Alternative</u>	<u>Maximum Dry Deposition</u> <u>year 2000</u> <u>(mg/m²)</u>	
Status Quo	0.26	0.57
Base Case 4	0.25	0.57
Conservation	0.25	0.57
Conventional Coal	0.38	0.75
Clean Coal	0.27	0.58
Nuclear	0.25	0.57
Combustion Turbine	0.25	0.57
Renewables	0.25	0.57
Cogeneration	0.24	0.57
Fuel Switching	0.26	0.57
High Conservation	0.23	0.57
Imports	0.27	0.59

TABLE 4.11. Cumulative Annual Dry Deposition at the Point of Maximum Impact in the Vicinity of Creston

<u>Resource Alternative</u>	<u>Maximum Dry Deposition year 1991 (mg/m²)</u>	
All Programs	0.0	
<u>Resource Alternative</u>	<u>Maximum Dry Deposition year 2000 year 2010 (mg/m²) (mg/m²)</u>	
Status Quo	0.17	0.24
Base Case 4	0.17	0.18
Conservation	0.17	0.18
Conventional Coal	0.20	0.25
Clean Coal	0.19	0.22
Nuclear	0.16	0.18
Combustion Turbine	0.17	0.18
Renewables	0.17	0.18
Cogeneration	0.16	0.18
Fuel Switching	0.17	0.17
High Conservation	0.16	0.18
Imports	0.18	0.19

TABLE 4.12. Cumulative Annual Dry Deposition at the Point of Maximum Impact in the Vicinity of Colstrip

<u>Resource Alternative</u>	<u>Maximum Dry Deposition year 1991 (mg/m²)</u>	
All Programs	0.27	
<u>Resource Alternative</u>	<u>Maximum Dry Deposition year 2000 year 2010 (mg/m²) (mg/m²)</u>	
Status Quo	0.43	0.65
Base Case 4	0.42	0.58
Conservation	0.42	0.58
Conventional Coal	0.50	0.66
Clean Coal	0.45	0.60
Nuclear	0.42	0.58
Combustion Turbine	0.42	0.58
Renewables	0.43	0.58
Cogeneration	0.41	0.58
Fuel Switching	0.43	0.58
High Conservation	0.41	0.58
Imports	0.43	0.58

In 1991, the maximum amount of particulate dry deposition projected for a point near Boardman is 0.15 mg/m^2 . In the year 2000, the projected maximum amount of dry deposition ranges from 0.23 to 0.38 mg/m^2 . In the year 2010, the projected maximum amount of dry deposition ranges from 0.57 to 0.75 mg/m^2 .

In 1991 there are no power plant emissions at Creston. In the year 2000, the projection of the maximum amount of particulate dry deposition ranges from 0.16 to 0.20 mg/m^2 . In the year 2010, the projection of the maximum amount of particulate dry deposition ranges from 0.17 to 0.25 mg/m^2 .

In 1991, the maximum amount of particulate dry deposition projected for a point near Colstrip is 0.27 mg/m^2 . In the year 2000, the maximum projection for dry deposition ranges from 0.41 to 0.50 mg/m^2 . In the year 2010, the maximum projection for dry deposition ranges from 0.58 to 0.66 mg/m^2 .

Comparing wet deposition and dry deposition maximums, we see that the cumulative wet deposition values tend to be significantly larger than corresponding dry deposition values. If we had assumed a size distribution for emitted particles that projected a higher percentage of larger particles, or assumed greater deposition velocities, results for the maximum dry and wet deposition values might have been more comparable.

5.0 OZONE IMPACTS

High ozone concentrations in the lower atmosphere do not result from the direct emission of ozone by anthropogenic processes but from photochemical reactions involving a variety of air pollutants. Abundant sunlight, oxides of nitrogen (NO_x), and reactive hydrocarbon compounds are required for ozone formation in the lower atmosphere. Depending on the ratio in the background atmosphere of the concentration of NO_x to the concentration of reactive hydrocarbons, additional emissions of NO_x would contribute to a range of chemical reactions whose net result may be ozone formation or ozone depletion in the lower atmosphere.

Because ozone formation only occurs within a narrow range of conditions, ozone pollution tends to be episodic in nature. In some areas, the conditions required for ozone formation occur quite frequently. For example, the Los Angeles Basin with its sunny climate, characteristically high emissions of NO_x and hydrocarbons (from both industrial sources and automobiles), and high frequency of stagnant conditions, often suffers from high ozone concentrations. In areas like the Pacific Northwest, the frequency and severity of ozone incidents are much lower because of the region's high latitude, cloudy weather, low pollutant emission levels, low background pollutant concentrations, and low frequency of stagnant conditions. Episodes of significant ozone formation in the Pacific Northwest are generally limited to the summer months when days are long, skies are clear, and stagnant conditions can develop.

When meteorological conditions in the Pacific Northwest are not favorable for ozone formation, levels of ozone in the lower atmosphere are typically quite low. As a result, annual and seasonal average ozone concentrations are dominated by days with low levels of ozone.

To assess the levels that ozone concentrations can reach in the BPA's power generation area under conditions that are most favorable for ozone formation, a series of model simulations were conducted using the U.S. Environmental Protection Agency (EPA)-approved Reactive Plume Model (RPM-IISS). These simulations estimate ozone concentrations in the ambient air and within the plumes of pollution being released by the region's power plants.

The maximum ozone concentrations produced in these simulations do not represent the absolute worst-case ozone concentrations that can occur, but are instead representative of a "high-end" estimate that would only be exceeded on rare occasions.

5.1 RPM-IISS - THE REACTIVE PLUME MODEL

The RPM-IISS model is a numerical plume model designed to simulate the complex interaction of plume dispersion and nonlinear atmospheric photochemistry (Morris et al. 1985). It is used for estimating short-term concentrations of primary and secondary pollutants (including ozone) associated with pollutant emissions from a range of fixed pollutant sources. To model atmospheric dispersion, pollutants are distributed into rectangular grid cells that are transported by the mean wind and expand according to turbulent diffusion theory (Stewart and Liu 1981). The transfer of pollutants between cells is allowed through entrainment and diffusion processes.

The emphasis of RPM-IISS is on modeling atmospheric chemistry processes rather than atmospheric transport and diffusion; detailed information governing the model's simple straight-line transport of pollutant material and the rate of material diffusion must be input by the user. The RPM-IISS model requires that wind speed and ambient temperature data be provided as a function of time. The user may specify plume dispersion widths and depths as a function of distance downwind from the pollutant source or the model can calculate these values based on user-specified estimates of atmospheric stability (using the standard Pasquill-Gifford categories). Concentrations must be specified for all pollutants to be entrained into the plume. Time-varying ambient concentrations of pollutants may be specified by the user or calculated by the model.

The RPM model uses a modified version of the carbon-bond mechanism (Whitten, Kilus, and Hogo 1980) to simulate chemical kinetics. In addition to standard source term information (e.g., location, pollutant emission rates), the user must provide information on the rate of photolysis reactions. Rate constants for chemical reactions are provided through the model's chemistry preprocessor.

For output, the model provides a report of program control parameters, input data, and information on the pollutant plume. Plume information includes estimates of pollutant concentrations at user-specified locations, plume width, and plume depth. Output can be addressed to a printer or to a disk for storage.

5.2 MODEL TESTING

Initial development of model input files, model testing, and sample runs was conducted by Ralph Morris and his staff at Systems Applications International (SAI). The SAI team prepared five background atmospheres that reflect conditions in the Pacific Northwest:

- a clean rural background atmosphere
- a typical rural background atmosphere
- medium reactivity, low NO_x atmosphere (i.e., dirty rural conditions)
- medium reactivity, medium NO_x atmosphere (i.e., typical urban conditions)
- medium reactivity, high NO_x atmosphere (i.e., dirty urban conditions).

These atmospheres were based on previously developed background environments used in modeling exercises by SAI. Detailed information on the pollutant contents of these atmospheres are presented in Table 5.1.

Three sets of meteorological conditions were used in the test simulations. The first set assumes a July 1 release beginning at midnight and continuing for 24 hours. This release involves an unvarying wind direction (as required by the model) and a wind speed of 1.8 m/s (4 mph). At midnight, the atmosphere is assumed to have a near-surface air temperature of 16°C (60°F), a low level of mixing (i.e., stable conditions), and a relative humidity of 60%. After sunrise, temperatures increase and stability and humidity decrease. At 15:00, the atmosphere is assumed to have a temperature of 35°C (95°F), a high level of mixing (i.e., unstable conditions persisting for 3 to 7 hours), a relative humidity of 25%, and a maximum mixing depth of 1,500 m.

TABLE 5.1. Background Concentrations of Key Carbon-Bond-IV Species for Selected Atmospheres

<u>Atmosphere</u>	<u>Species</u>	<u>Concentration (ppb)</u>
Clean Rural	NO ₂	0.33
	NO	0.17
	OLE	0.425
	PAR	12.5
	ARO	0.168
	CARB	2.675
	ETH	0.425
Typical Rural	NO ₂	2.0
	NO	0.0
	OLE	0.6
	PAR	14.9
	ARO	0.204
	CARB	3.21
	ETH	1.02
Dirty Rural	NO ₂	2.0
	NO	0.9
	OLE	0.4
	PAR	35.0
	ARO	0.8
	CARB	15.0
	ETH	1.0
Typical Urban	NO ₂	4.5
	NO	1.6
	OLE	0.4
	PAR	35.0
	ARO	0.8
	CARB	15.0
	ETH	1.0
Dirty Urban	NO ₂	11.0
	NO	3.3
	OLE	0.4
	PAR	35.0
	ARO	0.8
	CARB	15.0
	ETH	1.0

NO₂ = nitrogen dioxide
 NO = nitric oxide
 OLE = olefins
 PAR = paraffins
 ARO = aromatic hydrocarbons
 CAR = carbonyls
 ETH = ethylene compounds

The second set of meteorological conditions is identical to the first set, except the wind speed is increased to 3.6 m/s (8 mph). The third set of meteorological conditions assumes a September 15 release beginning at midnight and continuing for 24 hours. The wind speed is a constant 1.8 m/s (4 mph). At midnight the atmosphere is assumed to have an air temperature of 10°C (50°F), a low level of mixing (i.e., stable conditions), and a relative humidity of 70%. After sunrise, temperatures increase and stability and humidity decrease. At 15:00, the atmosphere is assumed to have a near-surface air temperature of 27°C (80°F), a high level of mixing (i.e., unstable conditions that persist for 1 to 4 hours), a relative humidity of 35%, and a maximum mixing depth of 1,200 m.

Using each of the above meteorological data sets and two types of background atmospheres, three test simulations were conducted. The simulations use

- the first set of meteorological conditions with a dirty rural background atmosphere
- the second set of meteorological conditions with a typical rural background atmosphere
- the third set of meteorological conditions with a dirty rural background atmosphere.

The pollutant release rate for all three simulations involves 2,300 g/s of NO_x , 2,760 g/s SO_2 , and 140 g/s of TSP. The NO_x emissions are split so that 95% is in the form of NO and 5% is in the form of NO_2 .

The SAI team found that in all cases NO_x emissions initially deplete ozone, resulting in less ozone in the plume than in background air. For the first simulation, ozone concentrations within the plume first start to exceed ozone concentrations in the background air at a distance of about 100 km downwind of the release site. The maximum increase in ozone over background concentrations in this simulation is about 1 pphm (10 ppb). For the second simulation, ozone concentrations within the plume first start to exceed ozone concentrations in the background air at a distance of about 150 km downwind of the release site. For the third simulation, ozone concentrations within the plume never exceed ozone concentrations in the background air. Note that the initial conditions for the first and third simulations are identical except

for the time of year at which the simulated release is occurring (July versus September). Differences in the ozone concentrations projected in these simulations indicate that there is not enough available sunlight in September for photochemical reactions involving NO_x chemistry to switch from net ozone depletion to net ozone formation.

5.3 PARAMETERS USED TO ESTIMATE MAXIMUM OZONE CONCENTRATIONS

To obtain estimates of the largest ozone concentrations that could result in the presence of power plant emissions, we focus our attention on the atmospheric conditions, background pollutant concentrations, and power plant emission rates that would maximize ozone formation. In total, 47 simulations were conducted for this study using the RPM-IISS model.

A date of July 1 is used in all our simulations because emissions on or about this date have the greatest chance of producing elevated ozone concentrations. The intensity of sunlight, duration of daytime, and characteristically low frequency of clouds at this time of year would maximize the available sunshine for the photochemical reactions involved in ozone formation. Even though pollutant emission rates are often significantly higher in the fall and winter, the reduced intensity and duration of sunshine does not allow significant increases in ozone concentrations to occur in the cool seasons. Although there is sufficient sunlight in May for ozone formation to occur, emissions in May are generally lower than in the summer months.

To provide a moderate level of puff movement across the modeling domain (without overly diluting the puff), we assume a 4-mph wind speed with a constant wind direction in nearly all the simulations (three simulations ran with a 2-mph wind). A midnight release time is used in nearly all the simulations to allow the NO_x within the puff to mix with hydrocarbons in the ambient air before photochemical reactions would begin (three of the 47 simulations ran with a 6 a.m. start time). Only a single puff is released during each simulation; ozone concentrations are computed at ground-level directly beneath the puff's center of mass. The path of the puff over the entire duration of the simulation defines a pollutant plume.

For each of the four release sites (Boardman, Centralia, Creston, and Colstrip), a minimum of two of the five potential background air masses were used to model ozone concentrations. The background air masses are chosen to be characteristic of moderate to poor air quality at the site.

5.4 MODEL ESTIMATES OF MAXIMUM OZONE CONCENTRATIONS

Model results are presented in Appendix F for the 47 RPM-IISS simulations conducted for this study. Ozone concentrations are estimated on an hourly basis for the ambient atmosphere and the pollutant plume. In all model simulations, the initial effect of power plant emissions is to deplete nearly all the ozone from the pollutant plume. The entrainment of ambient air into the plume results in the reintroduction of some ozone several hours after the release, but the photochemical production of new ozone does not begin until after sunrise. In most simulations it is not until several hours into the afternoon before ozone concentrations begin to equal or exceed their ambient level. Maximum ozone concentrations are achieved a couple of hours before sunset (at 18:00).

The model simulations indicate that the current and projected level of pollutant emissions from power plants are producing maximum ozone concentrations that barely exceed ambient levels. For some sites and study years, the scenarios with the lowest pollutant emission rates produce slightly higher ozone concentrations than the scenarios with the highest pollutant emission rates. This is indicative of the non-linearity between ozone formation and power plant emissions, as will be illustrated in Section 5.5.

5.4.1 Maximum Ozone Concentrations Resulting from Centralia Emissions

Ozone concentrations in a dirty rural air mass (outside the power plant plume) are projected to rise to a maximum level of about 10.2 pphm. For 1991, the highest projected hourly ozone concentration within the power plant plume is 10.8 pphm. For both the lowest and highest levels of pollutant emissions from all of the resource alternatives in the year 2000, the highest projected hourly ozone concentrations at any point are 11.4 pphm. Maximum ozone concentrations of 11.2 pphm are projected to result from emissions into the dirty rural atmosphere in the year 2010. This slight decrease in the highest

hourly ozone concentration between the years 2000 and 2010 occurs despite an increase in pollutant emission rates.

For a dirty urban background air mass (high background NO_x and medium hydrocarbon reactivity), slightly higher ozone concentrations can occur in both the ambient atmosphere and the power plant plume. Ozone concentrations in the ambient urban atmosphere (outside the power plant plume) are projected to rise to a level of about 15.0 pphm. For the resource alternatives with the lowest and highest pollutant emission rates in the year 2000, the highest projected hourly ozone concentration at any point is 15.1 pphm, only 0.1 pphm above the maximum background concentration. For the year 2010, the highest projected hourly ozone concentration at any point is 15.0 pphm (the same concentration found in ambient air).

5.4.2 Maximum Ozone Concentrations Resulting from Boardman Emissions

Ozone concentrations in a dirty rural air mass (outside the power plant plume) are projected to rise to a maximum level of about 10.2 pphm. For 1991, the highest projected hourly ozone concentration within the power plant plume is 10.8 pphm. For the lowest level of pollutant emissions from any of the resource alternatives in the year 2000, the highest projected hourly ozone concentration at any point is 11.3 pphm. For the highest level of pollutant emissions from any of the resource alternatives in the year 2000, the highest projected hourly ozone concentration at any point is 11.5 pphm. In the year 2010, the resource alternative with the lowest level of pollutant emissions in the year 2010 produces slightly higher ozone concentrations (11.3 pphm) than the alternative with the highest emission level (11.2 pphm).

For urban background air (moderate background NO_x and medium hydrocarbon reactivity), slightly higher ozone concentrations occur in both the ambient atmosphere and the power plant plume. Ozone concentrations in the urban atmosphere (outside the power plant plume) are projected to rise to a level of about 11.3 pphm. For the resource alternatives with the lowest and highest pollutant emission rates in the year 2000, the highest projected hourly ozone concentration at any point is 13.1 pphm. Similar results are projected assuming urban background air for the year 2010. Interestingly, in the year 2010 the resource alternative with the lowest level of pollutant emissions

produces slightly higher ozone concentrations (13.1 pphm) than the alternative with the highest emission level (12.9 pphm).

5.4.3 Maximum Ozone Concentrations Resulting from Creston Emissions

Ozone concentrations in a dirty rural air mass (outside the power plant plume) are projected to rise to a maximum level of about 10.2 pphm. In 1991, there are no emissions from the Creston site. For the resource alternative with the lowest pollutant emissions level in the year 2000, the highest projected hourly ozone concentration is 11.0 pphm. For the resource alternative with the highest pollutant emissions level in the year 2000, the highest projected hourly ozone concentration is 11.2 pphm. For the resource alternatives with the lowest pollutant emissions level in the year 2010, the highest projected hourly ozone concentration is 11.2 pphm. For the resource alternatives with the highest pollutant emissions level in the year 2010, the highest projected hourly ozone concentration is 11.4 pphm.

5.4.4 Maximum Ozone Concentrations Resulting from Colstrip Emissions

Ozone concentrations in a dirty rural air mass (outside the power plant plume) are projected to rise to a maximum level of about 10.2 pphm. For 1991, the highest projected hourly ozone concentration within the power plant plume is 11.3 pphm. For the resource alternatives with the lowest pollutant emissions level in the year 2000, the highest projected hourly ozone concentration is 10.9 pphm. For the resource alternatives with the highest pollutant emissions level in the year 2000, the highest projected hourly ozone concentration at any point is 10.7 pphm. For the resource alternatives with the lowest pollutant emissions level in the year 2010, the highest projected hourly ozone concentration at any point is 10.5 pphm. For the resource alternatives with the highest pollutant emissions level in the year 2010, the highest projected hourly ozone concentration is 10.4 pphm. At this site the highest hourly ozone concentrations decrease as emissions increase. This is a result of a high level of NO_x emissions into a background atmosphere with a moderate to low level of reactive hydrocarbons.

5.4.5 General Observations for All Four Release Sites

The results of our model simulations indicate that there is little difference in the highest hourly ozone concentration between (1) the background air and the plume and (2) the lowest and highest pollutant emission levels for the resource alternative in a given study year. In some cases, higher NO_x emission rates produce lower maximum ozone concentrations. This illustrates the importance of the ratio between NO_x and reactive hydrocarbons for ozone formation. Model results indicate that the type and quantity of pollutants in the background air are more important than the quantity of power plant emissions in determining the highest hourly ozone concentration within the power plant plume.

5.5 ESTIMATING SEASONAL SEVEN-HOUR AVERAGE OZONE CONCENTRATIONS

In this section we present estimates of seasonal 7-h average ozone concentrations and describe the method used to come up with these estimates. Although the assessment of maximum ozone concentrations presented in the previous section is useful, estimates of average ozone concentrations are needed to evaluate some human health and ecosystem impacts.

5.5.1 The Method Used to Estimate Average Ozone Concentrations

The method used to estimate average ozone concentrations involves several steps. In the first step, the RPM-IISS model is used to compute summer hourly ozone concentrations (both in-plume and ambient) for a range of NO_x emission rates using each of the five available background atmospheres (i.e., clean rural to dirty urban atmospheres). Next, hourly plume and ambient ozone concentrations are averaged over the 7-h period from 10 a.m. to 5 p.m. (i.e., the period during which ozone levels within the plume are most likely to exceed background levels).

The difference between the 7-h average in-plume and ambient ozone concentrations for each NO_x emission rate is plotted for each background atmosphere in Figures 5.1 through 5.5. The peak ambient ozone concentration associated with each background atmosphere is provided for each figure. From Figures 5.1 through 5.5, the increase or decrease (over ambient values) of the

FIGURE 5.1. Plot of 7-Hour Average Ozone Increments as a Function of the NO_x Emission Rate for a Clean Rural Ambient Atmosphere (Assumed peak background ozone concentration is 4 pphm.)

FIGURE 5.2. Plot of 7-Hour Average Ozone Increments as a Function of the NO_x Emission Rate for a Typical Rural Ambient Atmosphere (Assumed peak background ozone concentration is 6 pphm.)

FIGURE 5.3. Plot of 7-Hour Average Ozone Increments as a Function of the NO_x Emission Rate for a Dirty Rural Ambient Atmosphere (Assumed peak background ozone concentration is 10 pphm.)

FIGURE 5.4. Plot of 7-Hour Average Ozone Increments as a Function of the NO_x Emission Rate for a Typical Urban Ambient Atmosphere (Assumed peak background ozone concentration is 12 pphm.)

FIGURE 5.5. Plot of 7-Hour Average Ozone Increments as a Function of the NO_x Emission Rate for a Dirty Urban Ambient Atmosphere (Assumed peak background ozone concentration is 15 pphm.)

7-h averaged ozone concentration for the given background atmosphere can be determined for any NO_x emission rate between 200 and 2,500 g/s. The figures show that increases in NO_x emissions beyond a certain rate tend to decrease 7-h average ozone concentrations below background levels.

The next step in the process involves estimating the frequency of occurrence of various background ozone concentrations. Measurements of background ozone concentrations are made at several rural locations in the Pacific Northwest (i.e., Enumclaw, Longmire, Pack Forest, Tolt Reservoir, and Everson). These measurements provide a rough idea of the number of episodes within the summer season during which ozone exceeds a certain concentration. For the Centralia and Creston sites (based on Enumclaw data), we obtained the following frequency distribution for background ozone concentrations:

- ozone exceeds 10 pphm about 2% of the time
- ozone is between 8 and 10 pphm about 4% of the time
- ozone is between 6 and 8 pphm about 9% of the time
- ozone is less than 6 pphm about 85% of the time.

For the Boardman and Colstrip sites, we obtained the following frequency distribution for background ozone concentrations:

- ozone exceeds 8 pphm about 2% of the time
- ozone is between 6 and 8 pphm about 4% of the time
- ozone is less than 6 pphm about 94% of the time.

The Boardman and Colstrip sites are assumed to experience lower background concentrations of ozone and ozone precursors because they are further from major cities than Centralia and Creston.

Because pollutant emission rates are assumed to be constant over the course of a season, we can use the information on the frequency of occurrence of various background ozone levels and the RPM-IISS model data in Figures 5.1 through 5.5, to estimate the frequency of occurrence of each 7-h average ozone increment for each release site and study year.

One final step is needed to convert ozone increments into ozone concentrations. A correction is needed to account for the shifting of wind

direction over the course of the summer season. Seasonally averaged ozone increments were multiplied by 0.25 to provide a conservative estimate of the amount of time that the plume might impact any location during the growing season.

5.5.2 Estimates of Average Ozone Concentrations

Seasonally averaged 7-h ozone increments are presented in Table 5.2. On average, power plant emissions are projected to act to slightly decrease average ozone concentrations at Colstrip and Centralia, and to slightly increase ozone concentrations at Creston. At Boardman, power plant emissions are projected to slightly increase average ozone concentrations in the year 2000 and slightly decrease ozone concentrations in the year 2010. It is important to note once again that ozone formation is very sensitive to the ratio of NO_x to reactive hydrocarbons. If there is a decrease in the ratio of the background concentration of NO_x to reactive hydrocarbons (either due to an increased rate of hydrocarbon emissions or tighter controls on NO_x emissions), the results of our model simulations could change significantly. In such a case, significant increases in episodic and average ozone concentrations could result from increased NO_x emissions by power plants.

TABLE 5.2. Estimates of the Seasonal Average 7-h Ozone Increment that Would Result from Power Plant Emissions. The ozone increment represents the change in ozone concentration for background levels. The 7-h period is used to represent the daytime period when ozone concentrations are generally at their maximum. Values are presented in parts per hundred million (pphm), where 1 ppm = 100 pphm.

Site Name	Study Year	Relative Emiss.	NO _x Emiss. (q/s)	7-h Average Increments in Ozone Concentration for Background Ozone Conc. of:			Growing Season 7-h Average Ozone Increment (pphm)
				4 pphm (pphm)	6 pphm (pphm)	10 pphm (pphm)	
Colstrip	1991	---	1100	-0.3	-0.4	-0.2	-0.08
Colstrip	2000	high	1960	-0.5	-0.8	-0.95	-0.13
Colstrip	2000	low	1610	-0.45	-0.7	-0.75	-0.12
Colstrip	2010	high	2490	-0.55	-0.9	-1.3	-0.14
Colstrip	2010	low	2230	-0.5	-0.85	-1.2	-0.13
Boardman	1991	---	190	0.65	0.7	0.8	0.16
Boardman	2000	high	560	0.15	0.15	0.5	0.04
Boardman	2000	low	390	0.35	0.35	0.7	0.09
Boardman	2010	high	1270	-0.3	-0.6	-0.45	-0.08
Boardman	2010	low	1030	-0.25	-0.4	-0.2	-0.06
Creston	2000	high	340	0.4	0.45	0.75	0.10
Creston	2000	low	250	0.6	0.65	0.8	0.15
Creston	2010	high	480	0.2	0.2	0.6	0.05
Creston	2010	low	360	0.35	0.45	0.75	0.09
Centralia	1991	---	640	0.05	0	0.4	0.01
Centralia	2000	high	1000	-0.25	-0.4	-0.15	-0.07
Centralia	2000	low	870	-0.15	-0.25	0.05	-0.04
Centralia	2010	---	1200	-0.3	-0.55	-0.35	-0.08

6.0 VISIBILITY ATTENUATION

Visibility attenuation is a reduction in visibility that occurs as a result of scattering and absorption by air pollutants. Emissions of NO_x , SO_2 , and particulates by power plants impact visibility either directly or by undergoing chemical transformation into pollutants that are involved in visibility attenuation. In our analysis of visibility attenuation, we use an EPA-approved model to compare the reductions in visual range that would occur at each of the four release sites for each combination of study year and resource alternative.

Our study of visibility attenuation is designed to provide a comparison of the visibility impacts of the different resource alternatives described in BPA's Resource Program Environmental Impact Statement. The results of our study were used by economists to provide the BPA with an estimate of the valuation of the population-based reduction in visual range that would occur for each resource alternative. Our study does not estimate visibility attenuation at Class I visibility sites (e.g., national parks, federal wilderness areas); at this point in time we do not have sufficient information on how power plants will be dispersed in the vicinity of the modeled release sites to appropriately address this issue.

6.1 PLUVUE II - THE PLUME VISIBILITY MODEL

To perform our analysis of visibility attenuation we elected to use EPA's PLUVUE II plume visibility model (Seigneur et al. 1984). This model computes reductions in visual range and other visibility parameters for a specific set of release characteristics, meteorological conditions, background pollutant air concentrations, and plume/observer geometries.

The PLUVUE II model is a Gaussian plume model designed to estimate visibility impairment resulting from emissions from a single source. The model assumes visibility impairment is caused by emissions of nitrogen oxides, sulfur oxides, and particulates. The model simulates selected atmospheric chemical processes. These processes are important for estimating visibility attenuation because emissions of SO_2 and NO_x are not directly involved in the scattering or absorption of light; however, chemical reactions in the

atmosphere convert these compounds into sulfate aerosols and NO_2 that can play key roles in visibility attenuation. In addition to modeling key atmospheric chemistry processes, the model also computes the reduction in airborne pollutant concentrations from dry deposition processes.

The PLUVUE II model requires the input of a variety of parameters. These requirements include information on the source configuration, pollutant emission characteristics, and plume/observer geometry. This specifically includes

- stack height and elevation
- emission rate of NO_x , SO_2 , and particulates
- flue gas flow rate and other effluent characteristics
- background air quality for such pollutants as SO_2 , sulfate, NO_x , NO_2 , nitrate, ozone, and various types of particulates.
- background visual range
- deposition velocities of SO_2 , NO_x , coarse particulates, and submicron particulates
- date and time of day (to compute solar angles and other information)
- observer position (in the observer-based mode)
- distance downwind from the stack through which the observer's line of sight will pass.

The meteorological parameters required by the model include

- wind direction
- wind speed
- atmospheric stability
- potential temperature lapse rate
- ambient air temperature
- ambient relative humidity
- mixing depth of the planetary boundary layer
- atmospheric pressure.

The model employs a simple parameterization of atmospheric transport; only a single wind direction and speed are used to define transport throughout the entire study area.

The model output provides information on the reduction of visual range along lines of sight that pass through specified points at various downwind distances from the power plant. The model can also compute visibility attenuation for nonhorizontal views of a pollutant plume against a clear sky background; horizontal views of white, gray, and black viewing objects; and views along the plume centerline.

6.2 PLUVUE II MODEL SENSITIVITY TESTING

A series of test simulations of the PLUVUE II model were conducted to determine the sensitivity of the model's estimates of the "percentage reduction of visual range" to changes in source term, meteorology, and plume/observer geometries. The results of 23 test simulations, the model inputs used in these test cases, and sample model input and output files are presented in Appendix G.

Model testing illustrated the impact individual parameters can have on visibility values. For example, the wind speed parameter has a significant impact on visibility; increasing the wind speed increases the dilution of pollutants as they are emitted to the atmosphere. This decreases pollutant concentrations in the plume and reduces visibility impacts. In one series of test cases, a doubling of the wind speed caused a 50% decrease in the reduction in visual range at all of the studied downwind distances from the stack.

The atmospheric stability parameter also has a major impact on visibility. Stability is a measure of the degree of thermally and mechanically induced turbulence in the atmosphere. The more stable the atmosphere, the less turbulence is present and the lower the rate of mixing of the plume with the surrounding atmosphere. As the atmosphere becomes less stable, there is more turbulence, a higher rate of mixing, and the pollutant plume becomes more diffuse. In our test cases, almost an order of magnitude difference in visual range values is seen between the stable and unstable

atmosphere cases for selected lines of sight, with the stable atmosphere's dense plume causing the largest reductions in visibility.

Pollutant emission rates clearly have major impacts on visibility. The higher the pollutant emission rate, the greater the concentration of light scattering and absorbing pollutants in the plume. The model is most sensitive to particulate emissions, but the production of visibility attenuating aerosol and gases (that form as a result of other pollutant emissions) also has major impacts.

Observer/plume geometry can have significant impacts on the reductions in visual range. Sun angles, the distance of the observer from the stack and plume, the orientation of the observer's line of sight with respect to the plume centerline, background pollutant concentrations, and background visual ranges can also impact visible range.

6.3 ESTIMATES OF THE REDUCTION OF VISUAL RANGE

Our PLUVUE II model sensitivity testing indicates how much visibility attenuation varies as a function of many different parameters. To compare the relative visibility impacts of the different resource alternatives, we focus our analyses on one set of meteorological conditions, a constant background environment, and a single sun angle (noon in mid-May). The meteorological conditions are selected to maximize reductions in visual range (i.e., a stable atmosphere with a characteristically low wind speed and a constricted mixing layer). Background pollutant concentrations are set to represent a "dirty" rural atmosphere. Two observer locations and three wind directions are used to characterize a variety of plume/observer combinations. The two observer locations involve an observer located:

1. 20 km directly south of the pollutant emission location, and
2. 20 km south and 40 km east of the of the pollutant emission location.

The three wind directions used in the study are winds from the west (270°), northwest (330°), and southwest (210°). The westerly wind produces a plume whose centerline passes no closer than 20 km to the observer locations. For the second observer location, the westerly wind causes visibility impacts over a larger angular extent than the other two wind directions. The

northwesterly wind produces a plume whose centerline passes fairly close to both observer locations. For the first observer location, the northwesterly wind causes visibility impacts over a larger angular extent than the other two wind directions. The southwesterly wind produces a plume that always has a component of motion away from the observer locations and impacts visibility over a smaller angular extent than the other two wind directions.

Reductions in visible range are determined for seven lines of sight extending from the observer through selected points downwind of the pollutant release location. These points were set at: 2, 10, 20, 30, 40, 50, and 60 km downwind of the pollutant source.

Additional model computations of reductions in visual range were also computed using less conservative neutral and unstable atmospheric conditions (representative wind speeds and mixing heights for these atmospheric conditions were also used in these simulations). Simulations using these atmospheric conditions were only conducted for a limited number of pollutant emission scenarios.

The model parameters used in our PLUVUE II model simulations are presented in Appendix H.

6.3.1 Estimates of the Maximum Reduction in Visual Range

Estimates of the maximum reduction in visual range from power plant emissions are calculated using the highest seasonal emission rate at a release site for each resource alternative and study year. Values are calculated for each combination of three wind directions, two observer locations, and seven lines of sight. In addition to reductions in visual range computed for stable conditions, some additional model simulations computed visibility impacts using neutral and unstable atmospheric conditions (these simulations modeled impacts for the Conventional Coal alternative during selected study years). All of the reductions in visual range computed using PLUVUE II results are presented in Appendix I.

Westerly Wind, Observer 20 km due South

For a westerly wind and an observer located 20 km directly south of the pollutant release location, the greatest reductions in visual range are

projected to occur for two lines of sight passing through points 2 and 40 km downwind of the release location. Emissions at Colstrip for the Conventional Coal alternative produce the greatest maximum reduction in visual range along any line of sight; a maximum value of 15.4% is projected for the year 2010 (more than doubling the maximum value of 7.1% in 1991). Emissions at Creston produced the smallest maximum reduction in visual range along any line of sight, a maximum value of 3.6% is projected for the year 2010 (there were no power plant-related reductions in visibility at this site in 1991).

A simple method for estimating the differences in reductions in visual range between resource alternatives, is to examine the range in the maximum values that would occur over all resource alternatives for a particular site and study year. In the year 2010, the maximum reduction in visual range at Centralia varied from 7.5 to 6.5% depending on the resource alternative. At the other sites, the maximum reductions in visual range varied from 7.5 to 6.0% at Boardman, 3.6 to 2.7% at Creston, and 15.4% to 12.6% at Colstrip.

Northwesterly Wind, Observer 20 km due South

For a northwesterly wind and an observer located 20 km directly south of the pollutant release location, the greatest reductions in visual range are projected to occur for two lines of sight passing through points 2 and 60 km downwind of the release location. Emissions at Colstrip for the Conventional Coal alternative produce the greatest maximum reduction in visual range along any line of sight; a maximum value of 28.2% is projected for the year 2010 (the maximum value in 1991 is 11.6%). Emissions at Creston produced the smallest maximum reduction in visual range along any line of sight, a maximum value of 5.9% is projected for the year 2010 (there were no power plant-related reductions in visibility at this site in 1991).

In the year 2010, the maximum reduction in visual range at Centralia varied from 12.1 to 10.7% depending on the resource alternative. At the other sites, the maximum reductions in visual range values varied from 12.0 to 9.7% at Boardman, 5.9 to 4.5% at Creston, and 28.2 to 23.1% at Colstrip.

Southwesterly Wind, Observer 20 km due South

For a southwesterly wind and an observer located 20 km directly south of the pollutant release location, the greatest reductions in visual range occur

for the lines of sight passing through points located 2 to 30 km downwind of the release location. Emissions at Colstrip for the Conventional Coal alternative produce the greatest maximum reduction in visual range along any line of sight; a maximum value of 34.4% is projected for the year 2010 (compared to a maximum value of 12.8% in 1991). Emissions at Creston produced the smallest maximum reduction in visual range along any line of sight, a maximum value of 7.4% is projected for the year 2010 (there were no power plant-related reductions in visibility at this site in 1991).

In the year 2010, the maximum reduction in visual range along any line of sight at Centralia varied from 12.9 to 11.6% depending on the resource alternative. At the other sites, maximum reductions in visual range varied from 13.3 to 11.0% at Boardman, 7.4 to 5.9% at Creston, and 34.4 to 28.2% at Colstrip.

All Winds, Observer 20 km due South, Neutral and Unstable Conditions

For all wind directions, the reductions in visual range under neutral and unstable conditions are a tenth to a half of those encountered under stable conditions. Unstable atmospheric conditions tend to produce smaller reductions in visual range for lines of sight that pass close to the pollutant release location than experienced under neutral conditions. Conversely, for lines of sight that pass through the plume at greater distances downwind, the unstable atmospheric conditions tend to produce larger reductions in visual range than are experienced under neutral conditions.

Westerly Wind, Observer 20 km South and 40 km East

For a westerly wind and an observer located 20 km south and 40 km east of the pollutant release location, the greatest reductions in visual range are projected to occur for the line of sight passing through a point 2 km downwind of the release location. Emissions at Colstrip for the Conventional Coal alternative produce the greatest maximum reduction in visual range along any line of sight; a maximum value of 28.1% is projected for the year 2010 (more than doubling the maximum value of 13.1% in 1991). Emissions at Creston produced the smallest maximum reduction in visual range along any line of sight, a maximum value of 5.9 is projected for the year 2010 (there were no power plant-related reductions in visibility at this site in 1991).

In the year 2010, the maximum reduction in visual range at Centralia varied from 12.9 to 11.0% depending on the resource alternative. At the other sites, maximum reductions in visual range values varied from 13.8 to 10.3% at Boardman, 5.9 to 4.5% at Creston, and 28.1 to 27.8% at Colstrip.

Northwesterly Wind, Observer 20 km South and 40 km East

For a northwesterly wind and an observer located 20 km south and 40 km east of the pollutant release location, the greatest reductions in visual range are projected for the line of sight passing through a point 2 km downwind of the release location. Emissions at Colstrip for all alternatives share the greatest maximum reduction in visual range along any line of sight; a maximum value of 27.7% is projected for the year 2010 (more than doubling the maximum value of 10.6% in 1991). Emissions at Creston produced the smallest maximum reduction in visual range along any line of sight, a maximum value of 4.8% is projected for the year 2010 (there were no power plant-related reductions in visibility at this site in 1991).

In the year 2010, the maximum reduction in visual range at Centralia varied from 10.5 to 8.9% depending on the resource alternative. At the other sites, maximum reductions in visual range values varied from 11.2 to 8.4% at Boardman, 4.8 to 3.6% at Creston, and are all 27.7% at Colstrip.

Southwesterly Wind, Observer 20 km South and 40 km East

For a southwesterly wind and an observer located 20 km south and 40 km east of the pollutant release location, the greatest reductions in visual range are projected for the line of sight passing through a point 2 km downwind of the release location. Emissions at Colstrip for the Conventional Coal and Status Quo alternatives produce the greatest maximum reduction in visual range along any line of sight; a maximum value of 16.6% is projected for the year 2010 (more than doubling the maximum 1991 value of 6.1%). Emissions at Creston produced the smallest maximum reduction in visual range along any line of sight, a maximum value of 2.7% is projected for 2010 (there were no power plant-related reductions in visibility at this site in 1991).

In the year 2010, the maximum reduction in visual range at Centralia varied from 6.1 to 5.2% depending on the resource alternative. At the other

sites, maximum reductions in visual range values varied from 6.4 to 4.8% at Boardman, 2.7 to 2.0% at Creston, and 16.6 to 13.6% at Colstrip.

All Winds, Observer 20 km South and 40 km East, Neutral and Unstable Conditions

For all wind directions, the maximum reductions in visual range under neutral and unstable conditions were a tenth to a half of the value encountered under stable conditions. Unstable and neutral atmospheric conditions tended to produce similar reductions in visual range for lines of sight that pass close to the pollutant release location. For lines of sight that pass through the plume at greater distances downwind, the unstable atmospheric conditions tended to produce slightly larger reductions in visual range than those experienced under neutral conditions.

6.3.2 Estimates of the Annual Average Reduction in Visual Range

We computed annual average reductions in visual range based on the model simulations presented in Appendix I. To convert estimates of maximum reductions in visible range to annual averages, we first estimated the reductions in visual range for each resource alternative for both neutral and unstable atmospheric conditions. This estimation involved multiplying each reduction in visual range computed for stable atmospheric conditions by a correction factor to produce estimates of the reduction in visual range for both neutral and unstable conditions. This correction factor involves taking the reduction in visual range computed for the Conventional Coal alternative using neutral or unstable atmospheric conditions, and dividing this value by the corresponding reduction in visual range computed for the Conventional Coal alternative under stable atmospheric conditions. There is a unique correction factor for each combination of release site, wind direction, observer location, and distance downwind from the pollutant release location.

The next step in computing annual average reductions in visual range involves computing the approximate fraction of the horizontal field of view that can be characterized by the reduction in visual range computed for each line of sight. For example, for a westerly wind and an observer located 20 km south of the pollutant release location, the observation angles from due north to the points located 2, 10, and 20 km downwind of the release location are

5.7, 26.6, and 45°, respectively. The angular extent from the midpoint between the 2 and 10 km points to the midpoint between the 10 and 20 km points is about 19.7°. This represents 5.4% of the observer's 360° viewing horizon. We can then assume that a reduction in visual range computed for the point 10 km downwind of the release location is representative of 5.4% of the viewer's total horizontal field of view. Fields of view for all combinations of observer location, wind direction, and studied downwind distances are presented in Table 6.1.

Next, we need to estimate the frequency of occurrence of each stability class. Based on regional averages, we assume stable and unstable conditions each occur about 25% of the time and neutral conditions exist the remaining 50% of the time.

Finally, we multiply each reduction in visual range for a particular release site, study year, wind direction, atmospheric stability, observer location, and resource alternative by its associated stability occurrence factor (0.25 or 0.5) and field of view factor (0.0 to 1.0) and sum over all stabilities and lines of sight. This provides us with an estimate of the annual noontime reduction in visible range over the entire viewing horizon for each combination of site, year, wind direction, and resource alternative.

TABLE 6.1. Fraction of the Horizontal Field Represented by the Studied Lines of Sight. A value of "1.0" would represent a line of sight that is characteristic of a 360° field of view, a value of "0.028" would represent a line of sight that is characteristic of a 10° field of view.

Observer Location S / E	Wind Direction (degrees)	Fraction of Field Represented by Lines of Sight Passing through Plume at Following Distances (km) Downwind from Pollutant Release Location						
		2	10	20	30	40	50	60
20 / 0	270	0.045	0.054	0.040	0.025	0.017	0.013	0.011
20 / 0	330	0.037	0.100	0.122	0.071	0.029	0.015	0.011
20 / 0	210	0.017	0.017	0.011	0.007	0.005	0.003	0.003
20 / 40	270	0.011	0.024	0.041	0.063	0.074	0.063	0.078
20 / 40	330	0.011	0.028	0.044	0.057	0.061	0.051	0.056
20 / 40	210	0.017	0.031	0.031	0.026	0.021	0.017	0.008

Assuming that the winds at each site are distributed with respect to the given observer location, we can sum the values estimated for each wind direction, divide by three, and generate an annual noontime average reduction in visible range over the entire viewing horizon for each combination of release site, study year, and resource alternative. These results are presented in Tables 6.2 through 6.9. Note that all of the annual average reductions in visual range are less than 1%.

For the observer located 20 km south of the pollutant release location, the average reduction in visible range averaged over the entire viewing horizon is highest for a wind from the northwest. This is because of the large horizontal extent over which a plume from the northwest obscures visibility at this observing location. For the observer located 20 km south and 40 km east of the pollutant release location, the average reduction in visible range averaged over the entire viewing horizon is highest for a wind from the west. Again, this is because of the large horizontal extent over which a plume from the west obscures visibility at this observing location.

TABLE 6.2. Average Percent Reductions in Visual Range at Centralia for an Observer Located 20 km South of Release Site

Site Name: Centralia Study Year: 1991

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			<u>Annual Avg.</u>
	<u>Specific Wind Directions</u> <u>270°</u>	<u>330°</u>	<u>210°</u>	
All Programs	.32	.58	.22	.37

Site Name: Centralia Study Year: 2000

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			<u>Annual Avg.</u>
	<u>Specific Wind Directions</u> <u>270°</u>	<u>330°</u>	<u>210°</u>	
Status Quo	.42	.73	.28	.47
Base Case 4	.42	.73	.28	.48
Conservation	.42	.73	.28	.47
Conventional Coal	.45	.80	.31	.52
Clean Coal	.42	.73	.28	.48
Nuclear	.39	.70	.27	.45
Combustion Turbine	.43	.76	.29	.49
Renewables	.42	.76	.28	.49
Cogeneration	.39	.69	.27	.45
Fuel Switching	.43	.76	.29	.49
High Conservation	.43	.76	.29	.49
Imports	.44	.79	.30	.51

Site Name: Centralia Study Year: 2010

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			<u>Annual Avg.</u>
	<u>Specific Wind Directions</u> <u>270°</u>	<u>330°</u>	<u>210°</u>	
Status Quo	.43	.78	.30	.50
Base Case 4	.46	.80	.32	.52
Conservation	.46	.80	.32	.52
Conventional Coal	.48	.86	.33	.56
Clean Coal	.43	.77	.29	.50
Nuclear	.46	.80	.32	.52
Combustion Turbine	.45	.78	.30	.51
Renewables	.46	.80	.31	.52
Cogeneration	.46	.80	.31	.52
Fuel Switching	.45	.78	.30	.51
High Conservation	.43	.77	.29	.50
Imports	.49	.87	.33	.56

TABLE 6.3. Average Percent Reductions in Visual Range at Centralia for an Observer Located 20 km South and 40 km East of Release Site

Site Name: Centralia Study Year: 1991

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			
	<u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
All Programs	.47	.39	.16	.34

Site Name: Centralia Study Year: 2000

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			
	<u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
Status Quo	.60	.50	.21	.43
Base Case 4	.60	.51	.21	.44
Conservation	.60	.50	.21	.43
Conventional Coal	.65	.55	.22	.47
Clean Coal	.60	.51	.21	.44
Nuclear	.57	.48	.20	.42
Combustion Turbine	.62	.52	.21	.45
Renewables	.60	.51	.21	.44
Cogeneration	.57	.48	.20	.42
Fuel Switching	.62	.52	.21	.45
High Conservation	.62	.52	.21	.45
Imports	.64	.54	.22	.47

Site Name: Centralia Study Year: 2010

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			
	<u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
Status Quo	.64	.54	.22	.47
Base Case 4	.68	.58	.23	.49
Conservation	.68	.58	.23	.49
Conventional Coal	.70	.59	.24	.51
Clean Coal	.62	.52	.22	.45
Nuclear	.68	.58	.23	.49
Combustion Turbine	.65	.56	.23	.48
Renewables	.66	.56	.23	.48
Cogeneration	.66	.56	.23	.48
Fuel Switching	.64	.55	.22	.47
High Conservation	.63	.54	.22	.46
Imports	.71	.60	.24	.52

TABLE 6.4. Average Percent Reductions in Visual Range at Boardman for an Observer Located 20 km South of Release Site

Site Name: Boardman Study Year: 1991

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u> <u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
All Programs	.14	.23	.09	.15

Site Name: Boardman Study Year: 2000

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u> <u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
Status Quo	.21	.37	.15	.24
Base Case 4	.21	.37	.15	.24
Conservation	.21	.37	.15	.24
Conventional Coal	.29	.52	.20	.34
Clean Coal	.21	.37	.15	.24
Nuclear	.21	.37	.14	.24
Combustion Turbine	.21	.37	.15	.24
Renewables	.21	.37	.15	.24
Cogeneration	.22	.39	.15	.25
Fuel Switching	.21	.37	.15	.24
High Conservation	.21	.37	.15	.24
Imports	.22	.38	.15	.25

Site Name: Boardman Study Year: 2010

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u> <u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
Status Quo	.40	.71	.27	.46
Base Case 4	.40	.71	.27	.46
Conservation	.40	.71	.27	.46
Conventional Coal	.49	.89	.34	.57
Clean Coal	.40	.71	.27	.46
Nuclear	.40	.71	.27	.46
Combustion Turbine	.40	.71	.27	.46
Renewables	.40	.71	.27	.46
Cogeneration	.42	.77	.27	.49
Fuel Switching	.40	.71	.27	.46
High Conservation	.40	.71	.27	.46
Imports	.45	.81	.27	.51

TABLE 6.5. Average Percent Reductions in Visual Range at Boardman for an Observer Located 20 km South and 40 km East of Release Site

Site Name: Boardman Study Year: 1991

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			
	<u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
All Programs	.19	.17	.07	.14

Site Name: Boardman Study Year: 2000

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			
	<u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
Status Quo	.30	.30	.10	.24
Base Case 4	.30	.30	.10	.24
Conservation	.30	.30	.10	.24
Conventional Coal	.42	.36	.14	.31
Clean Coal	.30	.30	.10	.24
Nuclear	.30	.26	.10	.22
Combustion Turbine	.30	.30	.10	.24
Renewables	.30	.30	.10	.24
Cogeneration	.31	.27	.11	.23
Fuel Switching	.30	.30	.10	.24
High Conservation	.30	.30	.10	.24
Imports	.31	.27	.11	.23

Site Name: Boardman Study Year: 2010

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			
	<u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
Status Quo	.56	.49	.19	.41
Base Case 4	.56	.49	.19	.41
Conservation	.56	.49	.19	.41
Conventional Coal	.70	.60	.24	.51
Clean Coal	.56	.49	.19	.41
Nuclear	.56	.49	.19	.41
Combustion Turbine	.56	.49	.19	.41
Renewables	.56	.49	.19	.41
Cogeneration	.59	.51	.20	.44
Fuel Switching	.56	.49	.19	.41
High Conservation	.56	.49	.19	.41
Imports	.63	.55	.22	.47

TABLE 6.6. Average Percent Reductions in Visual Range at Creston for an Observer Located 20 km South of Release Site

Site Name: Creston Study Year: 1991

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u> <u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
All Programs	.00	.00	.00	.00

Site Name: Creston Study Year: 2000

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u> <u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
Status Quo	.18	.32	.13	.21
Base Case 4	.18	.32	.13	.21
Conservation	.18	.32	.13	.21
Conventional Coal	.21	.37	.15	.24
Clean Coal	.18	.34	.13	.22
Nuclear	.18	.30	.13	.20
Combustion Turbine	.19	.33	.12	.21
Renewables	.18	.32	.13	.21
Cogeneration	.18	.30	.12	.20
Fuel Switching	.18	.32	.13	.21
High Conservation	.18	.32	.13	.21
Imports	.19	.34	.13	.22

Site Name: Creston Study Year: 2010

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u> <u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
Status Quo	.24	.41	.16	.27
Base Case 4	.18	.32	.13	.21
Conservation	.18	.32	.13	.21
Conventional Coal	.24	.41	.16	.27
Clean Coal	.20	.36	.13	.23
Nuclear	.18	.32	.13	.21
Combustion Turbine	.18	.32	.13	.21
Renewables	.18	.32	.13	.21
Cogeneration	.18	.32	.13	.21
Fuel Switching	.18	.32	.13	.21
High Conservation	.18	.32	.13	.21
Imports	.19	.34	.14	.22

TABLE 6.7. Average Percent Reductions in Visual Range at Creston for an Observer Located 20 km South and 40 km East of Release Site

Site Name: Creston Study Year: 1991

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			<u>Annual</u>
	<u>Specific Wind Directions</u>			<u>Avg.</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	
All Programs	.00	.00	.00	.00

Site Name: Creston Study Year: 2000

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			<u>Annual</u>
	<u>Specific Wind Directions</u>			<u>Avg.</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	
Status Quo	.25	.21	.09	.18
Base Case 4	.25	.21	.09	.18
Conservation	.25	.21	.09	.18
Conventional Coal	.29	.24	.10	.21
Clean Coal	.26	.23	.09	.20
Nuclear	.24	.21	.09	.18
Combustion Turbine	.27	.22	.10	.20
Renewables	.25	.21	.09	.18
Cogeneration	.24	.21	.09	.18
Fuel Switching	.25	.21	.09	.18
High Conservation	.25	.21	.09	.18
Imports	.27	.22	.09	.20

Site Name: Creston Study Year: 2010

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			<u>Annual</u>
	<u>Specific Wind Directions</u>			<u>Avg.</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	
Status Quo	.33	.27	.12	.24
Base Case 4	.25	.21	.09	.18
Conservation	.25	.21	.09	.18
Conventional Coal	.33	.27	.12	.24
Clean Coal	.28	.23	.09	.20
Nuclear	.25	.21	.09	.18
Combustion Turbine	.27	.23	.09	.20
Renewables	.25	.21	.09	.18
Cogeneration	.25	.21	.09	.18
Fuel Switching	.25	.21	.09	.18
High Conservation	.25	.21	.09	.18
Imports	.26	.23	.10	.20

TABLE 6.8. Average Percent Reductions in Visual Range at Colstrip for an Observer Located 20 km South of Release Site

Site Name: Colstrip Study Year: 1991

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u> <u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
All Programs	.48	.86	.32	.55

Site Name: Colstrip Study Year: 2000

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u> <u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
Status Quo	.70	1.27	.47	.81
Base Case 4	.70	1.27	.47	.81
Conservation	.70	1.27	.47	.81
Conventional Coal	.81	1.48	.55	.94
Clean Coal	.72	1.32	.49	.85
Nuclear	.70	1.26	.47	.81
Combustion Turbine	.70	1.27	.47	.81
Renewables	.71	1.28	.47	.82
Cogeneration	.68	1.25	.46	.80
Fuel Switching	.71	1.28	.47	.82
High Conservation	.71	1.28	.47	.82
Imports	.71	1.28	.47	.82

Site Name: Colstrip Study Year: 2010

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u> <u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
Status Quo	1.04	1.95	.70	1.23
Base Case 4	.89	1.65	.61	1.05
Conservation	.89	1.65	.61	1.05
Conventional Coal	1.05	1.95	.71	1.24
Clean Coal	.94	1.73	.63	1.10
Nuclear	.89	1.65	.61	1.05
Combustion Turbine	.89	1.65	.61	1.05
Renewables	.89	1.65	.61	1.05
Cogeneration	.89	1.65	.61	1.05
Fuel Switching	.89	1.65	.61	1.05
High Conservation	.89	1.65	.61	1.05
Imports	.91	1.66	.62	1.06

TABLE 6.9. Average Percent Reductions in Visual Range at Colstrip for an Observer Located 20 km South and 40 km East of Release Site

Site Name: Colstrip Study Year: 1991

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			
	<u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
All Programs	.68	.58	.24	.50

Site Name: Colstrip Study Year: 2000

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			
	<u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
Status Quo	.98	.84	.34	.72
Base Case 4	.98	.84	.34	.72
Conservation	.98	.84	.34	.72
Conventional Coal	1.14	.97	.40	.83
Clean Coal	1.02	.87	.36	.75
Nuclear	.98	.84	.34	.72
Combustion Turbine	.98	.84	.34	.72
Renewables	.99	.84	.35	.73
Cogeneration	.96	.82	.34	.71
Fuel Switching	.99	.84	.35	.73
High Conservation	.99	.84	.35	.73
Imports	.99	.84	.35	.73

Site Name: Colstrip Study Year: 2010

<u>Resource Alternative</u>	<u>Percentage Reductions in Visible Range (%)</u>			
	<u>Specific Wind Directions</u>			<u>Annual</u>
	<u>270°</u>	<u>330°</u>	<u>210°</u>	<u>Avg.</u>
Status Quo	1.42	1.24	.52	1.06
Base Case 4	1.24	1.08	.44	.92
Conservation	1.24	1.08	.44	.92
Conventional Coal	1.44	1.24	.52	1.06
Clean Coal	1.30	1.13	.46	.96
Nuclear	1.24	1.08	.44	.92
Combustion Turbine	1.24	1.08	.44	.92
Renewables	1.24	1.08	.44	.92
Cogeneration	1.24	1.08	.44	.92
Fuel Switching	1.24	1.08	.44	.92
High Conservation	1.24	1.08	.44	.92
Imports	1.27	1.11	.44	.94

7.0 THE POTENTIAL CLIMATIC IMPACTS OF GREENHOUSE GAS EMISSIONS

In this section we provide background information on the greenhouse effect, discuss the potential for climate change from increased concentrations of greenhouse gases in the atmosphere, examine observed trends in the global concentration of greenhouse gases, compare the impacts of the various resource alternatives on the regional emission rate of greenhouse gases, and discuss the potential impacts of global warming on regional climate.

7.1 THE GREENHOUSE EFFECT

Unlike the stark day-night temperature swings of Mars or the Moon, or the intense heat of Venus, Earth has a relatively moderate climate created by the interactions between the atmosphere, oceans, continents, ice sheets and sea-ice, and biota (i.e., the plants and animals on land and in the seas). This thermal stability is achieved by the balance between the solar energy reaching the Earth's surface from the Sun, and the thermal energy re-radiated to space from the Earth's surface and the atmosphere.

Incoming solar energy and outgoing terrestrial energy are concentrated in different regions of the electromagnetic spectrum. The extremely high temperature of the sun causes most of its energy emissions to be concentrated in the visible region of the spectrum (i.e., wavelengths of 0.4 to 0.7 μm). Nearly 99% of the solar energy incident on the earth is at wavelengths between 0.2 and 4 μm , with the maximum energy at about 0.55 μm . The much cooler temperature of the earth causes its energy emissions to be concentrated in the infrared portion of the spectrum (wavelengths of 0.75 to 100 μm). Approximately 99% of the energy emitted by the Earth-atmosphere system is in the infrared, with the maximum energy at about 15 μm . Because of the difference in wavelength, it is convenient to discuss atmospheric radiant energy in terms of solar short-wave and terrestrial long-wave radiation.

Only about 10% of the long-wave energy radiated to space is emitted directly from the Earth's surface. Ninety percent of the long-wave radiation is emitted by the atmosphere from water vapor (H_2O), carbon dioxide (CO_2), ozone (O_3), and other trace gases. Long-wave radiation from the surface is absorbed by these species and re-radiated downward, back to the surface, as

well as upward to other layers of the atmosphere and ultimately to space. This "atmospheric blanket" serves to reduce the rate of loss of long-wave energy to space while allowing the incoming solar short-wave radiation to pass essentially unaffected. The result is that the global average surface temperature is more than 30°C (54°F) higher than the nominal temperature that would occur without an atmosphere (Rind 1989).

Increasing the concentrations of these radiatively active gases in the atmosphere increases the "thickness" of the "blanket," reducing the rate at which infrared radiation is lost to space and causing the radiative balance to equilibrate at higher global atmospheric and surface temperatures. The process by which increases in atmospheric concentrations of radiatively active "greenhouse gases" leads to warming at the Earth's surface is referred to as the greenhouse effect. The term greenhouse gases refers to those gases which are highly transparent to solar radiation but relatively opaque to infrared radiation, similar to glass in a greenhouse. (A highly absorbing spectral region is said to be "opaque" whereas a minimally absorbing region is said to be "transparent.")

7.2 THE GREENHOUSE GASES

The gaseous constituents of the atmosphere are listed in Table 7.1 (Liou 1980). These are divided into two categories: those constituents that vary slowly with time and space, and those that are much more variable. Radiatively active gases are indicated by an asterisk.

The atmospheric constituents differ greatly in their absorptive properties (Luther and Ellingson 1985). The most abundant gases of the atmosphere (N_2 , O_2 , Ar, Ne, He, Kr, Xe and H_2) contribute very little to solar or infrared absorption. In addition, there is very little absorption in the visible region of the solar spectrum (0.4 to 0.7 μm). In the ultraviolet region (0.2 to 0.4 μm), ozone is the primary absorber. In the near-infrared region (0.7 to 4 μm), water vapor is the most important absorber; carbon dioxide also has absorption bands in this region.

7.2.1 Carbon Dioxide and Water Vapor

Many gases have absorption bands in the long-wave region. Among these, CO_2 , H_2O , and O_3 are the most important. CO_2 has strong absorption bands in the 15- μm region (12.5 to 16.5 μm). This region corresponds to the peak of the terrestrial long-wave spectrum. As a result, a small increase in CO_2 can significantly affect the emission of long-wave radiation to space. Water vapor absorption bands span most of the long-wave spectrum except for the region between 7 and 12 μm . In this region there is a weak continuous absorption which is important only in regions of high water vapor concentration. Other than this continuum absorption due to H_2O (and a narrow absorption band due to ozone at 9.6 μm), there is relatively little absorption in the region between 7 and 12 μm . Because the atmosphere is essentially transparent in this part of the long-wave spectrum, this band of wavelengths (centered at 10 μm) is referred to as the "atmospheric window" region.

When the atmospheric concentration of a radiatively active gas such as CO_2 is increased, the outgoing long-wave radiation in the spectral region where that gas absorbs is reduced. This decrease must be made up in some other part of the long-wave spectrum so that the total amount of outgoing long-wave energy continues to balance the net incoming short-wave radiation, which is only slightly affected by an increase in CO_2 . By absorbing more of the outgoing long-wave radiation and re-radiating it to the surface, the surface temperature increases. This, in turn, results in greater long-wave emission in the 10- μm window region where the atmosphere is highly transparent. As atmospheric temperatures increase, the long-wave emission increases in other regions of the infrared spectrum as well. This warming of the surface and atmosphere in response to the initial increase in CO_2 continues until the balance with the incoming solar radiation is restored.

7.2.2 Trace Gases

Other radiatively active gases listed in Table 7.1 such as methane (CH_4), nitrous oxide (N_2O), and the chlorofluorocarbons (CFC-11, CFC-12, and CFC-22) behave in a manner similar to CO_2 . They are essentially transparent to solar radiation but are opaque to long-wave radiation in specific spectral bands. As a result, they initially reduce the outgoing long-wave radiation to

TABLE 7.1. The Composition of the Atmosphere

Slowly Varying Constituents		Highly Variable Constituents	
Constituent	% by volume	Constituent	% by volume
Nitrogen (N ₂)	78.084	Water vapor (H ₂ O)*	0 - 0.04
Oxygen (O ₂)	20.948	Ozone (O ₃)*	0 - 12 x 10 ⁻⁴
Argon (Ar)	0.934	Sulfur dioxide (SO ₂)*	0.001 x 10 ⁻⁴
Carbon dioxide (CO ₂)*	0.033	Nitrogen dioxide (NO ₂)	0.001 x 10 ⁻⁴
Neon (Ne)	18.18 x 10 ⁻⁴	Ammonia (NH ₃)*	0.004 x 10 ⁻⁴
Helium (He)	5.24 x 10 ⁻⁴	Nitric oxide (NO)	0.0005 x 10 ⁻⁴
Krypton (Kr)	1.14 x 10 ⁻⁴	Hydrogen sulfide (H ₂ S)	0.00005 x 10 ⁻⁴
Xenon (Xe)	0.089 x 10 ⁻⁴	Nitric acid vapor (HNO ₃)*	0.0001 x 10 ⁻⁴
Hydrogen (H ₂)	0.5 x 10 ⁻⁴	CFC-11 (CFCl ₃)*	0.0002 x 10 ⁻⁴
Methane (CH ₄)*	1.5 x 10 ⁻⁴	CFC-12 (CF ₂ Cl ₂)*	0.00035 x 10 ⁻⁴
Nitrous oxide (N ₂ O)*	0.27 x 10 ⁻⁴	CFC-22 (CF ₂ HCl)*	0.00006 x 10 ⁻⁴
Carbon monoxide (CO)	0.19 x 10 ⁻⁴		

* Indicates radiatively active gases.

space which leads to a warming of the surface and lower atmosphere until the radiation balance is restored. In addition, these trace gases (so-called because they presently exist only in trace amounts) have non-overlapping absorption bands that lie within the atmospheric window. By not overlapping strong absorption bands of other constituents, absorption bands in the window region can be very effective in decreasing the long-wave radiation emitted to space. Moreover, many of these trace gases have very strong absorption bands. For example, CFC-11 has a band strength (which indicates the potential absorption due to that band) more than eight times greater than the 15- μ m CO₂ band. Because the concentration of CFC-11 is several orders of magnitude less than that of CO₂, the radiative effect of CFC-11 is much less than that of CO₂. However, the radiative effects of the trace gases could increase substantially in the future since their concentration is projected to increase due to anthropogenic sources.

7.2.3 Ozone

Ozone (O₃) differs from most of the other radiatively active gases in that it has strong absorption bands in the short-wave as well as the long-wave regions. Consequently, the effect of changes in O₃ on the radiation balance

depend on its vertical distribution. In the stratosphere (the region of the atmosphere above about 13 km), ozone absorbs incoming solar ultraviolet (UV) short-wave radiation. This warms the stratosphere but prevents the UV radiation from reaching and warming the troposphere (the region of the atmosphere below about 13 km) and the surface. However, the strong absorption band in the window region enables ozone to absorb a significant amount of long-wave radiation from the surface; simultaneously this energy is re-radiated back downward to the surface and upward to space. Direct climatic effects may follow from the fact that changes in ozone may change the manner in which it modulates short-wave and long-wave radiation. For example, a reduction in stratospheric ozone may lower the temperature of the stratosphere but, perhaps more importantly, would enable more solar UV to reach the surface and troposphere, causing a warming effect; however, the strength of the greenhouse effect would be reduced, leading to a cooling effect. Consequently, the effects on the troposphere and the surface depend on the relative strengths of these two competing effects.

Changes in ozone concentration in the stratosphere and troposphere arise from the chemically reactive nature of ozone. In the middle and upper stratosphere, ozone is produced from the photolysis of molecular oxygen (O_2) by solar UV radiation. The resultant oxygen atoms react rapidly with O_2 to produce O_3 . The destruction of O_3 comes about through the catalytic effects of various free radical species including nitrogen oxides (NO_x) from high-flying aircraft and chlorine oxides resulting from the photodissociation of CFCs by solar UV radiation. Tropospheric O_3 is derived in part from transport of O_3 from the stratosphere and in part from photochemical production involving NO_x . Thus, increased concentrations of stratospheric CFCs and NO_x could decrease stratospheric O_3 and allow more solar UV to reach the surface, while increased anthropogenic NO_x production at the surface could cause increased O_3 concentrations in the lower troposphere which would in turn increase the long-wave absorption in the lower atmosphere and enhance the greenhouse effect.

7.3 FEEDBACK MECHANISMS AND THE POTENTIAL FOR CLIMATIC CHANGE

The Earth's climate results from the interactions of the atmosphere, oceans, continents, ice sheets and sea ice, and the biota. A perturbation in one component may result in changes in the others due to the interactions between them. These interactions act as internal controls of the climate system, with characteristic response times ranging from hours for the lower troposphere to thousands of years for the continental ice sheets. The processes associated with different components of the climate system may display a coupling or mutual interaction among specific variables of the system. Such interactions or feedback mechanisms may act either to amplify anomalies of one of the interacting elements (positive feedback) or to damp them (negative feedback).

7.3.1 The Atmospheric-Ocean Interaction

Three-fourths of the Earth's surface is covered by oceans. Since most of the solar radiation incident upon the oceans is absorbed, the high heat capacity of the oceans represents an enormous energy reservoir and a buffer against changes in the global energy balance. In addition, the oceans exchange CO_2 with the atmosphere, and are thus involved in the chemical balance of the climatic system. Some of the most important climatic feedback mechanisms occur between the atmosphere and the oceans (Henderson-Sellers and McGuffie 1987).

As illustrated in Figure 7.1, momentum is transferred by friction from the atmospheric winds to the ocean surface. This momentum transfer drives the ocean currents which transfer absorbed solar energy poleward from the equatorial regions. The winds also mix the water near the ocean surface to an average depth of about 75 m. This process closely couples the temperature of the lower troposphere with the temperature of the ocean mixed layer.

Because the heat capacity of the ocean mixed layer is much greater than that of the atmosphere (which is equivalent to only about a 2.5 m depth of water), the mixed layer can absorb a substantial amount of heat from the atmosphere. However, because the density of sea water is a function of temperature and salinity, the ocean is usually stratified and, under most conditions, this well-mixed surface layer is virtually disconnected from the

deep ocean (depths greater than 1000 m). The result of this layering is that the mixed layer responds to surface temperature changes within a few years whereas the deep ocean takes centuries. Thus the mixed layer of the ocean will warm much more quickly than would be the case if the various layers of the ocean were closely coupled.

The projected radiative effect of doubling the concentration of CO_2 in the atmosphere would be to increase the net energy input to the surface by 4 W/m^2 (DOE Multi-Laboratory Climate Change Committee 1990). Although this is relatively small in comparison with the net amount of solar short-wave energy absorbed at the Earth's surface (240 W/m^2), it would be sufficient to increase the surface temperature by slightly more than 1°C (2°F) in the absence of feedbacks. However, the resulting heating of the ocean mixed layer would lead to increased evaporation of water from the surface. An increase in atmospheric water vapor would increase the long-wave H_2O continuum absorption

FIGURE 7.1. Interaction and Feedback Mechanisms Between the Atmospheric and Oceanic Processes (from Henderson-Sellers and McGuffie 1987)

in the atmospheric window region, creating further warming--a positive feedback--projected to be between 1.5 and 4.5°C (2.7 to 8.1°F) (DOE Multi-Laboratory Climate Change Committee 1990). On the other hand, increasing the amount of water vapor may also result in increased cumulus cloud formation in the troposphere. Cumulus clouds are effective reflectors of short-wave radiation and may reduce the solar heating of the surface, thus providing a negative feedback to offset the greenhouse warming. At present the effect of clouds on the Earth's radiation balance is highly uncertain.

7.3.2 The Uptake of Carbon Dioxide by the Oceans

The ocean is the primary sink for fossil fuel CO_2 ; each year it takes up an amount of CO_2 equal to approximately 40% of that produced by fossil fuel combustion (Henderson-Sellers and McGuffie 1987). This is accomplished by two means. First, photosynthetic activity by phytoplankton in ocean surface waters removes CO_2 from the seawater and fixes it into organic tissues. Oxygen is produced in this process, and ocean surface waters typically show a slightly higher O_2 concentration than would otherwise be expected for equilibrium conditions with the atmosphere. Although 90% of the organic matter thus produced is consumed by grazing sea animals, some falls to greater depths. At these depths (less than about 1,000 m), the organic material is oxidized (i.e., decomposes), consuming O_2 and producing CO_2 . Since the solubility of CO_2 increases with increasing pressure (depth) and decreasing temperature, the CO_2 produced by the oxidation of organic matter is dissolved in the deep ocean water. This process removes CO_2 from the surface waters and accounts for about 70% of the increase in CO_2 in the deep ocean (Baes, Björkström, and Mulholland 1985).

In addition, the increase in deep ocean CO_2 due to oxidation of organic matter lowers the pH (i.e., increases the acidity) of seawater, increasing its ability to dissolve calcium carbonate (CaCO_3). Surface seawater is supersaturated with respect to CaCO_3 , which is generated by marine organisms to form their shells and skeletons. The result of this supersaturation is that CaCO_3 "rains" down through the ocean and collects on the ocean floor. The solubility of CaCO_3 in seawater increases with increasing pressure and decreasing temperature. At a depth of about 5000 m, the calcium carbonate dissolves, increasing the pH (i.e., increasing the alkalinity) and the CO_2 .

This mechanism accounts for the remaining 30% of the transfer of CO_2 from the surface waters to the deep ocean.

The net effect of adding CO_2 to the surface ocean waters is to decrease the pH and increase the dissolution of CaCO_3 (which is supersaturated there). If this dissolution occurs, then the dissolved CO_2 increases but the pH increases. This increase in pH is necessary to maintain a constant rate of CO_2 uptake: for a constant pH, the rate of uptake of CO_2 decreases as the concentration of CO_2 in the seawater increases.

Although the ocean represents the ultimate sink for anthropogenic CO_2 and may provide a buffer against climatic change, the important question is how rapidly this uptake can occur. An increase in the alkalinity of the deep ocean due to increased CO_2 there would have very little immediate effect on rising atmospheric CO_2 levels, since the affected seawater would be sequestered in the deep ocean for centuries. Indeed, warming of the deep ocean due to the projected rise in surface temperatures associated with increased atmospheric CO_2 concentrations could decrease the solubility of CO_2 in seawater sufficiently to offset the effect of increased alkalinity and cause CO_2 to be released from the oceans. In fact, the last glaciation was apparently accompanied by massive CO_2 transfers to and from the ocean, the causes of which are poorly understood today (Webb and Wigley 1985).

7.4 OBSERVED TRENDS IN ATMOSPHERIC CO_2 CONCENTRATION

Observations of atmospheric CO_2 concentrations from the Mauna Loa Observatory in Hawaii are presented in Figure 7.2 (Keeling et al. 1989). These data constitute the longest continuous record of atmospheric CO_2 concentrations available in the world. Both the monthly and annual trends are shown. The data exhibit a 12% increase in mean annual concentration in 31 years, from 315 parts per million by volume of dry air (ppmv) in 1958 to 352 ppmv in 1989. The monthly data also reveal the natural annual variations in CO_2 . As vegetation consumes CO_2 in the late spring and summer, the concentration declines, reaching a minimum in September-October. As the biological demand for CO_2 declines during the fall and winter months, the atmospheric concentration increases, reaching a maximum in May.

FIGURE 7.2. The Mauna Loa Record of Atmospheric CO₂ Concentration Since 1958 (from Keeling et al. 1989)

In order to provide a frame of reference for these observations, measurements of CO₂ concentrations in air bubbles trapped in a 200-m ice core drilled in 1984 at Siple Station in the Antarctic (Neftel et al. 1985) are presented along with the Mauna Loa record in Figure 7.3.

These data indicate that the pre-industrial CO₂ concentration (circa 1750) was 280 ± 5 ppmv and has increased by 22.5% since then to 345 ppmv in 1984. These data are clearly in agreement with the Mauna Loa record, and indicate the substantial increase in atmospheric CO₂ concentration that has occurred since the Industrial Revolution due to human activity.

In order to provide a perspective on the climatic significance of this increase, the record of atmospheric CO₂ over the last 160,000 years is presented in Figure 7.4. These data were obtained from the 2,083-m ice core recovered by the Soviet Antarctica Expeditions at Vostok in Eastern Antarctica (Barnola et al. 1987).

FIGURE 7.3. Atmospheric CO_2 Concentrations Since 1750. Data are based on measurements of CO_2 concentrations in air bubbles trapped in an ice core from Siple Station in the Antarctic and compared with the Mauna Loa record (Keeling et al. 1989; Neftel et al. 1985).

FIGURE 7.4. The Atmospheric CO_2 Record for the Last 160,000 Years. Based on data from the Vostok ice core (Barnola 1987).

This record is probably the purest available, covering the last climatic cycle. There is good agreement between the Vostok record and other ice core data covering the past 30,000 to 40,000 years, with all showing the low CO₂ values (~200 ppmv) associated with the Last Glacial Maximum and the increased atmospheric CO₂ concentrations associated with the transition to the present inter-glacial period. Note that the atmospheric CO₂ concentration associated with the inter-glacial periods (260-280 ppmv) is in agreement with the Siple record for the pre-industrial level of 280 ppmv. The Vostok record indicates that the change in the atmospheric CO₂ concentrations associated with the advance and retreat of the continental ice sheets during the glacial and inter-glacial periods of the last 160,000 years is about 80 ppmv.

Although the causal relationship between the glacial cycle and the atmospheric CO₂ concentration is uncertain, it is clear that the present levels of atmospheric CO₂ are greater than at any time during the last 160,000 years and the increase of nearly 80 ppmv in atmospheric CO₂ concentration since the Industrial Revolution is comparable to the CO₂ concentration changes associated with major climatic changes.

7.5 OBSERVED TRENDS IN ANTHROPOGENIC CO₂ PRODUCTION

Total and per capita global CO₂ emissions by nation are presented in Table 7.2 in terms of millions of metric tons (2,200 lbs) of carbon equivalent. As the data indicate, the United States is the largest single source of fossil fuel-related CO₂ emissions, and ranks second in per person emissions (Boden, Kanciruk, and Farrell 1990). The United States accounts for about a quarter of the worldwide fossil-fuel CO₂ emissions, as do Western Europe and Japan, the Soviet Union, and Eastern Europe, and the developing countries. Together, the United States, Soviet Union, and China account for more than 51% of the total global emissions of CO₂ into the atmosphere.

Although not shown in the table, of equal (or greater) concern is the rate of growth of CO₂ emissions world-wide. Just as the amount of CO₂ emitted by the nations of the world primarily reflects population size and degree of industrialization, so too the increase in CO₂ emissions reflects increasing population and growing industrialization. For example, the high total CO₂ emission by the United States results from a large per capita emission due to

TABLE 7.2. The 1988 Global CO₂ Emissions by Nation in Millions of Metric Tons of Carbon

<u>Nation</u>	<u>Total CO₂ Emission</u>	<u>Population (millions)</u>	<u>Per Capita (metric tons)</u>	<u>Per Capita Rank</u>
United States	1301	243.3	5.3	2
Soviet Union	1067	279.5	3.8	6
China	582	1016.7	0.6	27
Japan	259	117.3	2.2	14
Germany FDR	178	59.5	3	10
India	158	828.6	0.2	30
United Kingdom	151	56.4	2.7	11
Poland	123	37.4	3.3	9
Canada	118	25.7	4.6	3
Italy	93	54.1	1.7	17
Germany DDR	88	16.3	5.4	1
France	84	54	1.6	18
Mexico	81	82.2	1	24
South Africa	76	33.3	2.3	13
Australia	65	16.1	4	5
Czechoslovakia	63	15.3	4.1	4
Romania	58	22.3	2.6	12
South Korea	52	39.6	1.3	22
Brazil	52	135.7	0.4	29
Spain	48	36.9	1.3	23
Saudi Arabia	45	12.7	3.5	8
Iran	42	51.3	0.8	26
North Korea	39	21.2	1.9	16
Indonesia	36	165	0.2	31
Yugoslavia	34	22.7	1.5	19
Bulgaria	33	8.8	3.8	7
Netherlands	32	14.4	2.2	15
Argentina	32	30.5	1	25
Turkey	30	49.1	0.6	28
Venezuela	28	18.2	1.5	20
Other Far East	27	16.4	1.4	21

extensive industrial development combined with a relatively large population. Japan and the industrial nations of Europe have a per capita emission rate comparable to (though significantly less than) that of the United States, but have much smaller populations.

The U.S. per capita CO₂ emissions have risen by only 17% since 1950; however, because the U.S. population has increased 24% since that time, total CO₂ emissions have increased 26%. This is in marked contrast to China where total CO₂ emissions have increased 28.1 times (2,810%) since 1950 and per capita emissions by a factor of 14.2 (1,420%). Total CO₂ emissions for India have increased 8.9 times and per capita emissions 3.9 times since 1950. The most dramatic increases have been in South Korea where total and per capita emissions are now 93 and 44.3 times the 1950 amounts, respectively. The lesson here is that although the major industrial nations of the world account for most of the present CO₂ emissions, the developing countries with their burgeoning populations and industrial expansion will contribute significantly to CO₂ emissions in the next century.

In striking contrast to the massive increases in emissions described above, the total CO₂ emissions in France declined 36% from their peak in 1979. France's per capita emissions have also declined since a 1973 high to close to their 1955 level. Extensive use of nuclear power has clearly restrained CO₂ emissions. France made a major commitment to nuclear power and nuclear power generation grew rapidly from about 1975 until it contributed 76% of the total electricity generation in 1987 (Boden 1990).

Although the increasing levels of CO₂ emissions due to fossil fuel combustion and the increasing atmospheric concentrations of CO₂ and other greenhouse gases are well documented, there is enormous uncertainty regarding future emission rates and atmospheric concentrations beyond the year 2000. Although early projections were merely extrapolations of existing trends, more recent projections have been based on models of economic and social factors and the implications of various policy decisions. The major factors in the model projections are 1) the rate of population growth, 2) the rate of increase of productivity (industrial expansion and modernization), 3) the rate of increase in the price of non-fossil fuels, and 4) the rate of increase of fossil fuel use. Accordingly, the best current estimate is that there exists

a 50% chance that the atmospheric concentration of CO₂ will reach 600 ppmv (i.e., double the 1950 level) between 2050 and 2100, a 25% chance that this doubling will occur prior to 2050, and a 5% chance that it will occur prior to 2035 (Nordhaus and Yohe 1983).

Fossil fuel-produced CO₂ emissions for states in the Pacific Northwest region of the United States for 1988 are listed in Table 7.3 along with regional totals and the U.S. average for comparison (Lashof and Washburn 1990). The total emission is broken down into categories by type of fuel, including gas (natural gas, propane, etc.), liquid (gasoline, kerosene, heating oil, etc.), and solid (coal, lignite, etc.).

TABLE 7.3. The 1988 CO₂ Emissions for States in the Pacific Northwest (in millions of metric tons of carbon)

<u>State</u>	<u>Total</u>	<u>Gas</u>	<u>Liquid</u>	<u>Solid</u>	<u>National Rank</u>
Washington	16.7	1.95	12.2	2.59	26
Oregon	7.09	1.16	5.86	0.08	42
Idaho	2.72	0.54	1.92	0.25	48
Total	26.5	3.65	20.0	2.92	--
U.S. Average	25.5	4.73	11.1	9.69	--

7.6 PROJECTED CO₂ EMISSIONS FOR PACIFIC NORTHWEST POWER GENERATION

The amount of CO₂ presently emitted into the atmosphere to provide power to the Pacific Northwest is estimated at 6.0 million metric tons of carbon (22 million metric tons of CO₂). This accounts for approximately 23% of the total CO₂ emissions in the Pacific Northwest region, a value that is well below the national average of 35% due to electrical power generation. However, by the year 2000, we estimate between 11.3 and 13.4 million metric tons of carbon (41.5 and 49.2 million metric tons of CO₂) will be released into the atmosphere to provide electrical power within the BPA's service region, roughly doubling the present emissions. These levels reflect annual rates of increase of 6.6 and 8.2%. By 2010, these emissions are projected to roughly treble the current CO₂ emission level to between 15.8 and 18.4 million metric tons of carbon per year (22 million metric tons of CO₂), representing growth rates of 5.0 to 5.9% per year. These rates of increase are significantly larger than the 4.2% increase in U.S. CO₂ emissions from 1987 to

1988 (the most recent years for which data are available), as well as the 3.7% increase in the global CO₂ emission rate from 1987 to 1988.

Historically, the global rate of CO₂ emission increased steadily by 4.6% per year from 1860 to 1973, then slowed to increase at a rate of 2.3% per year. BPA's projected rate of increase for CO₂ emissions substantially outstrips various projections of the global rate of increase of CO₂ emission of approximately 2.3% per year until 2025.

There are currently no international, national, or state limits on CO₂ emissions. However, if ongoing research shows a strong correlation between anthropogenic emissions of greenhouse gases and global climate change, legislation may be enacted to control the emission of greenhouse gases. Such legislation could have significant impacts on BPA's resource alternatives. Although there is a significant difference in CO₂ emissions between resource alternatives, all of the proposed resource alternatives involve significant increases in CO₂ emissions (see Figure 7.5). Although some of the resource alternatives may involve an increased emphasis on conservation, renewable resources, or nuclear power, this emphasis would only account for a portion of the region's increasing energy demand. It is important to keep in mind that all of the resource alternatives rely heavily on the development of new coal-fired, cogeneration, and combustion turbine power plants.

7.7 CLIMATIC CHANGE AND THE GREENHOUSE EFFECT

Although the CO₂ concentration is actually increasing slowly, it is easier to calculate what might happen if a large increase in the CO₂ concentration were to occur at once. With climatic feedback processes turned off, climate models developed by the Goddard Institute for Space Studies (GISS), the National Center for Atmospheric Research (NCAR), and the Geophysical Fluid Dynamics Laboratory (GFDL) are in close agreement that the global average surface air temperature will increase 1.2 to 1.3°C due to a doubling of CO₂ concentrations. However, when feedback processes are turned on, the models are not in close agreement; at equilibrium, such models indicate that doubling CO₂ concentration would increase the global average surface air temperature by 1.5 to 4.5°C (Schlesinger and Mitchell 1985; DOE

FIGURE 7.5. Carbon Dioxide Emissions from Each Resource Program Alternative

Multi-Laboratry Climate Change Committee 1990). Results from the three most recent general circulation models show a CO_2 -induced warming of 3.5 to 4.2°C (6.3 to 7.5°F). Although the better agreement of the models on the projected global sensitivity is encouraging, their projections of the regional pattern of such changes, especially with regard to precipitation, vary substantially depending on location.

Climate mode calculations also suggest that, on the time scale of decades, the combined climatic effects of increasing concentrations of trace gases such as N_2O , CH_4 , and CFCs, along with their induced changes in O_3 from climate-chemistry interactions, could be as large as those estimated from the expected increase in CO_2 concentration (Wang, Wuebbles, and Washington 1985).

Estimates of the rise in surface air temperature between the years 1850 and 1991, due to increased CO₂ concentration alone, range from about 0.5°C to more than 1.0°C (reflecting differences in the sensitivity of the models and differences in the projected time lag of the ocean response depicted by the models). As a result, the observed Northern Hemisphere temperature change of about 0.5°C neither confirms nor contradicts these predictions. However, analyses of past climates (i.e., "paleoclimatology") show that for most areas the mean annual surface temperature has been remarkably stable during the last 100,000 years, with variations not exceeding 1 or 2°C. If increased concentrations of CO₂ and trace gases raise the global mean surface temperatures by 1.5°C or more, the resultant average climate conditions will be beyond the range of climates that have existed during the historical past and during recent geological times (Webb and Wigley 1985).

7.7.1 Agricultural Impacts

American crop production is a critical and susceptible aspect of global agriculture. Economically, American agriculture provides more than \$40 billion in foreign exchange. The United States accounts for nearly half of the wheat and corn on the world market and approximately one-fifth of the rice. Changes anticipated in the climate of the northern United States by the year 2000, such as an increase in the CO₂ level of 400 ppmv and a mean warming of 1°C could extend the growing season by 10 days and cause more frequent droughts due to reduced precipitation and increased evaporation (Waggoner 1983; Rosenzweig 1990).

Although it is difficult to predict changes in real crops that might follow an increase in CO₂ concentration, experiments in growth chambers and greenhouses indicate that CO₂ enrichment to 400 ppmv may increase yields of well-tended crops by as much as 30% (EPA 1989, p. 97). (For comparison, yields of Illinois corn have increased four-fold in the last 50 years due primarily to hybridization and application of chemical fertilizers, herbicides, and pesticides.) In addition, researchers have found that some crops use water more efficiently in a CO₂-rich atmosphere (EPA 1989, p. 96). However, the warmer and drier climate projected to accompany increased atmospheric CO₂ concentrations may decrease yields over the entire grain belt by 5 to 10%, offsetting the advantage of CO₂ enhancement of photosynthesis.

While the effects of increased CO₂ concentration on American crops are projected to be modest, for other countries the impact may be more severe. This is especially true for developing nations lacking the agricultural research infrastructure or the agricultural flexibility that results from large capital investments in agriculture, rural transportation, farm credit and insurance, and marketing systems. Owing to the large rate of increase of population in the developing nations, even relatively small impacts on global agriculture could have substantial adverse consequences.

7.7.2 Ecological Impacts

Little is understood about how ecological systems will respond to rapid changes in climate. Ecological implications for forests commonly start with tree response (EPA 1989, p. 85). The EPA (1989) projects that forest species are likely to migrate in response to changes in climate. In the coastal mountains of Oregon, Douglas fir forests could shrink in the lowlands and be replaced by western pine species. Other species may migrate upslope, and some species would face extinction.

A change in the size and mix of forests could influence whether animals can continue to live in their present locations. Animals preferring old forests (many of which are endangered) may be particularly disrupted as old forests die off. Further, water resources may be affected by inundations, changes in the depth of the water table, and sea water intrusion. These changes will affect local animal and plant life, as well as migratory patterns for birds and animals.

Changes in water resources may also affect fishery habitats and populations. For example, preliminary research by PNL indicates that global warming could reduce spring chinook salmon production by 50% to 60% in some Northwest rivers (Chatters et al. 1991). The PNL researchers based their predictions on a study of the impacts to spring chinook salmon production in the Yakima River subbasin of the Columbia River System from a 2°C increase in temperature over the next century (Chatters et al. 1991).

Global warming is expected to cause numerous changes in the water temperature, sedimentation, flow volume, and timing of the freshet (high water

flow associated with spring thaws) in the Yakima River subbasin. These changes can affect salmon during several phases of their life cycle.

Increased water temperatures can cause an increase in disease among adult salmon returning to upstream spawning areas. This effect will be accentuated in the lower reaches where water temperature increases of as much as 5°C are expected. Increased sedimentation can suffocate salmon eggs and is expected to reduce the salmon egg-to-smolt survival rate by 15% in some spawning habitats. The freshet helps young salmon or smolts get to the ocean quickly. If the freshet occurs earlier in the year, fewer smolts will be ready for the journey. If drier conditions shorten the length of the freshet, it will take longer for the smolts to get to the ocean, increasing the chances for predation. Some streams in the steppe vegetation zone that are now year-round are expected to become intermittent, eliminating their ability to support any salmon smolts. This combination of effects could reduce chinook salmon populations to below levels needed for species survival (Chatters et al. 1991.)

7.7.3 Sea Level and Polar Impacts

The present rate of sea level rise of 10 to 20 cm per century is small when compared with the average rate of 1 m per century which has occurred over the past 15,000 years since the Last Glacial Maximum. The projected climatic warming due to increased atmospheric CO₂ concentrations will lead to a projected rise in sea levels of 40 cm just due to melting of continental (Greenland and Antarctic) ice sheets and alpine glaciers (Revelle 1983; DOE Multi-Laboratory Climate Change Committee 1990; Titus 1990). The increased radiative warming of the surface waters of the ocean is projected to cause sea levels to rise another 30 cm due to thermal expansion, for a total of 70 cm (with an uncertainty of ±25% or 18 cm)--close to the geologic average rate for the past 15,000 years.

7.7.4 Impacts on Regional Climate and Power Demands

It is uncertain what effect increases in the global concentration of greenhouse gases would have on the climate of the Pacific Northwest. Although we talk about increases in mean global temperature, some regions might experience dramatic increases in temperatures while other regions might

exhibit little or no change in average temperature (some locations might even experience a decrease in mean temperature due to changes in the global circulation pattern or cloud cover). In addition to considering the mean change in temperature at a site, it is also important to consider the seasonal nature of this temperature change. For example, would mean temperatures in the Pacific Northwest change, and if so, would this change be uniform throughout the year or would it be concentrated in one or more seasons? It is also important to consider temperature extremes as well as mean values. Even if mean seasonal temperatures remained the same, would global changes cause fewer or more incidents of extreme high and low temperatures?

Climate change would effect precipitation patterns as well as temperatures. At a particular location, global climate change could mean changes in total annual precipitation, the seasonal distribution of precipitation, and the frequency of extreme weather.

Temperature and precipitation are extremely important factors for power production in the Pacific Northwest, which relies heavily on hydro power. An important consideration for regional power production is the temperature at which precipitation falls. There is a significant relationship between power generation values and precipitation falling as rain and snow in the mountains. Heavy rains in the mountains are not as valuable as heavy snows in building the winter snowpack. The rate at which the temperature increases in the spring is also an important factor in determining the rate at which the snowpack melts. If there is a rapid runoff, less of the accumulated precipitation is available for power production.

It is hoped that ongoing studies on climate change will answer some of the questions about how the increase in the atmospheric concentration of greenhouse gases will affect the global climate, how global climate change will affect the climate of the Pacific Northwest, and how changes in climate will affect the energy demand and supply in the Pacific Northwest.

8.0 EVALUATION OF THE HUMAN HEALTH EFFECTS OF NITROGEN OXIDES, SULFUR OXIDES, AND TOTAL SUSPENDED PARTICULATES

The effects of air pollutant emissions on human health for each of the resource alternatives are estimated for populations within 80 km (50 mi) of four study sites. Results from the air quality analyses are coupled with population data to estimate collective exposure to the pollutants for which air quality standards have been established. These are combined with published risk estimates for acute morbidity and mortality to determine the health impact of airborne emissions from power-generating facilities in each region. Estimates of lifetime cancer risk are also developed for metals and radionuclides associated with airborne particulates. Finally, the health effects for each of the four study sites are summed to determine the total impact of each resource program alternative. Emissions are evaluated for the years 1991, 2000 and 2010.

8.1 AIR QUALITY ESTIMATES

Pollutants evaluated in this analysis included NO_x , SO_x , and TSP. Power plant sulfur oxide emissions are assumed in this study to be entirely SO_2 . This analysis also includes trace materials such as radionuclides and metals which are components of TSP. Population health risks are only estimated out to 80 km; beyond this distance, uncertainties in air concentration estimates (as generated using a Gaussian plume model) are too great to warrant inclusion in risk calculations.

8.2 POPULATION DISTRIBUTIONS

Population grids were developed for each of the four study sites using 1980 census data (Bureau of the Census 1982a, 1982b, 1982c, and 1982d). (Data from the 1990 census were not available in time for use in this study.) The populations for each sector are estimated from the populations of cities located within the sector and the average population density outside of cities on a county-by-county basis for the area within each individual sector. The population distributions for all four sites are listed in Table 8.1.

Uncertainties in the census data are discussed in the individual state summary documents (Bureau of the Census 1982a, 1982b, 1982c, and 1982d.) For purposes of this analysis, additional uncertainty is introduced by the assumption that the population located outside of the incorporated areas is uniformly distributed throughout the area of the applicable county.

TABLE 8.1. Population Distribution for BPA Resource Program Study Sites

Estimated number of persons living at a given location relative to source (Based on 1980 Census)										
Distance (miles from plant)										
Direction	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
Centralia, WA										
N	2	7	42	16	131	1097	4387	41463	1003	2618
NNW	2	7	11	16	131	1097	4387	7311	3039	11536
NW	2	7	11	59	131	1097	3127	951	5897	2436
WNW	2	7	11	16	20	633	2397	951	4578	3287
W	2	7	11	16	20	170	678	1132	1585	4948
WSW	2	7	11	16	20	11725	678	1131	1585	2038
SW	2	7	11	16	20	170	678	1130	1579	1213
SSW	2	7	11	16	20	6270	678	1402	2352	2020
S	2	7	11	16	20	170	2978	1948	4899	44820
SSE	2	7	11	16	20	170	678	1402	2737	3519
SE	2	7	11	16	20	170	678	1130	2159	2964
ESE	2	7	11	16	20	170	678	1130	3309	2034
E	2	7	11	16	20	170	1142	3170	5588	12079
ENE	2	7	11	16	20	633	4387	9801	18206	22124
NE	2	7	11	59	131	1616	5278	10218	17208	23887
NNE	2	7	11	16	131	1097	5667	23790	5679	169563
Creston, WA										
N	0	1	1	2	3	25	247	168	235	522
NNW	0	1	1	2	3	24	101	168	235	302
NW	0	1	1	2	3	23	96	168	288	688
WNW	0	1	1	2	3	22	87	152	3403	1344
W	0	1	1	2	3	22	1209	475	1059	1247
WSW	0	1	1	2	3	22	87	145	721	1659
SW	0	1	1	2	3	22	87	145	375	1078
SSW	0	1	1	2	3	22	87	1154	203	347
S	0	310	1	2	3	22	87	145	203	434
SSE	0	1	1	2	3	22	87	145	203	2060
SE	0	1	1	2	3	22	594	145	203	5315
ESE	0	1	1	2	3	22	1646	145	6472	19922
E	0	1	1	2	3	22	87	145	13161	185322
ENE	0	1	1	2	3	22	240	529	3080	8877
NE	0	1	1	2	3	22	293	657	1200	3070
NNE	0	1	1	2	3	22	317	657	919	1182

TABLE 8.1. (contd)

Estimated number of persons living at a given location relative to source
(Based on 1980 Census)

Direction	Distance (miles from plant)									
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
Boardman, OR										
N	0	1	1	2	2	245	980	1633	2286	2940
NNW	0	1	1	2	2	245	980	1633	7837	2814
NW	0	1	1	2	2	245	798	2624	11315	4499
WNW	0	1	1	2	2	132	616	420	1339	1855
W	0	1	1	2	2	20	165	338	588	757
WSW	0	1	1	2	2	20	79	613	129	162
SW	0	1	1	2	2	20	79	111	129	165
SSW	0	1	1	2	2	20	424	131	176	201
S	0	1	1	2	2	20	79	131	183	236
SSE	0	1	1	2	2	20	79	1936	183	236
SE	0	1	1	2	2	20	154	320	358	693
ESE	0	1	1	2	2	20	249	510	714	2548
E	0	1	1	2	2	20	306	12110	714	15439
ENE	0	1	1	2	2	720	3673	1072	1500	1251
NE	0	1	1	2	2	132	980	1633	36683	19525
NNE	0	1	1	2	2	132	2241	1633	4266	38544
Colstrip, MT										
N	0	1	1	2	2	20	79	131	183	236
NNW	0	1	1	2	2	20	79	131	2736	236
NW	1476	1	1	2	2	20	79	110	106	136
WNW	0	1	1	2	2	20	62	48	68	87
W	0	1	1	2	2	20	54	88	143	184
WSW	0	1	1	2	2	20	78	129	180	232
SW	0	1	1	2	2	20	78	129	180	232
SSW	0	1	1	2	2	20	79	129	180	232
S	0	1	1	2	2	20	79	130	182	234
SSE	0	1	1	2	2	20	79	131	183	236
SE	0	1	1	2	2	20	79	131	129	95
ESE	0	1	1	2	2	20	79	92	74	95
E	0	1	1	2	2	20	79	100	119	134
ENE	0	1	1	2	2	20	79	108	119	153
NE	0	1	1	2	2	20	79	131	140	153
NNE	0	1	1	2	2	20	79	131	183	215

8.3 HEALTH RISK ESTIMATES

Health risk estimates for acid aerosols from fossil fuel combustion are adapted from those developed for the Generic Coal Study (ECO Northwest 1987). In addition, an attempt was made to correlate lifetime cancer risk from metals and radionuclides in coal fly ash with TSP concentrations. Risk estimates for acute mortality, cancer mortality, and morbidity are then applied to the collective exposure at each of the four sites to obtain a total health impact for the various resource alternatives. A summary of the risk estimates for all pollutants and health effects is found in Table 8.2.

TABLE 8.2. Health Risk Factors for Air Pollutants Associated with Fossil Fuel Combustion

Pollutant	Health Risk Coefficients					
	Mortality		Morbidity (Effects/year per $\mu\text{g}/\text{m}^3$)			
	Cancer (lifetime per $\mu\text{g}/\text{m}^3$)	Acute (risk/y per $\mu\text{g}/\text{m}^3$)	Bronchitis	Lower Respiratory Disease	Cough	Colds
Nitrogen Oxides	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Sulfur Oxides	0.0E+00	4.0E-05	4.0E-04	2.0E-04	4.0E-04	3.6E-04
Particulates	0.0E+00	3.0E-06	3.6E-04	0.0E+00	0.0E+00	0.0E+00
Metals	1.7E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Radionuclides	1.8E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

8.3.1 Acute Mortality

Estimates of acute mortality risk for sulfur oxides and particulates were taken from the studies of Lave and Seskin (1978) and Lipfert (1984) as applied in the Generic Coal Study. A similar study by Mendelsohn and Orcutt (1979) reported results that were specific for sulfates and sulfur dioxide; however, those estimates are not used in this analysis because information about the relative composition of sulfur oxides in coal plant emissions was not available. The acute mortality risk estimates of $50\text{E}-06$ and $30\text{E}-06$ person-year per $\mu\text{g}/\text{m}^3$, respectively, from these studies were averaged to arrive at a risk from sulfur oxides of $40\text{E}-06/\text{person-year per } \mu\text{g}/\text{m}^3$. This average value is 40% of the risk estimated in the Mendelsohn and Orcutt study for sulfate, indicating that ambient sulfur oxides are probably a mixture of chemical forms that are less potent than sulfate alone.

Estimates of acute mortality for particulates are also taken from the above mentioned studies and averaged to obtain representative values for use in this evaluation. Risks from airborne particulates ranged from $1\text{E}-06$ to $5\text{E}-06$, and averaged $3\text{E}-06/\text{person-year per } \mu\text{g}/\text{m}^3$ ambient air concentration. Comparable risk levels for acute mortality following exposure to ozone were

found in the above studies, averaging $6\text{E-}06$ person-year per $\mu\text{g}/\text{m}^3$ ambient air concentration. No effect on acute mortality was found to be correlated with exposure to nitrogen oxides in the literature surveyed.

Although the impact of nuclear facilities was not specifically evaluated for this study, the dose associated with routine radionuclide releases from commercial nuclear power stations is typically low enough that their impact on cancer mortality and other health effects would not be observable (Baker 1992). Evaluation of the potential health effects of conservation measures, such as local use of alternative fuels (wood, kerosene, etc.) and decreased air exchange in buildings resulting from insulation and elimination of drafts, was also beyond the scope of this study. However the health impacts resulting from these measures, due to increased particulate emissions from wood-burning stoves or buildup of indoor air pollutants, for example, would not necessarily be negligible.

8.3.2 Acute Morbidity

Morbidity data related to ambient air pollution are less abundant than mortality data, and were only available for sulfates and particulates. Estimates given in the Generic Coal Study (based on Lunn et al. 1970, Ware et al. 1986, and EPA 1974) were applied using the assumption consistent with the mortality data that ambient sulfur oxides are 40% as effective as sulfate. It is assumed that exposure to ambient sulfur oxides carries a risk in units of person-year per $\mu\text{g}/\text{m}^3$ of pollutant concentration of $400\text{E-}06$ for coughs and bronchitis, $360\text{E-}06$ for colds, and $200\text{E-}06$ for lower respiratory disease.

8.3.3 Cancer Mortality

Estimates of lifetime risk for cancer mortality were developed based on the concentrations of metals and radionuclides in fly ash from coal burning. Estimates of air concentration for metals are calculated by multiplying the particulate concentration by the weight fraction of metals in respirable particulates emitted from coal-burning plants (Davison et al. 1974, Fisher et al. 1980, and Ondov et al. 1979). Risk estimates for inhalation of the metals arsenic, beryllium, and chromium were obtained from the EPA's on-line IRIS database, and a composite risk for the three metals is calculated as the sum of the risks from the individual metals based on their weighted concentration.

A similar procedure was used to estimate risk from the radionuclides U-238, Ra-226, Po-210, Pb-210, Th-230, and Th-232, based on their activity concentrations in particulates released from coal plants (Roeck et al. 1987). The dose equivalent from inhalation of each radionuclide is calculated based on the dose conversion factors recommended by DOE (1988) and an inhalation rate of 22,000 L/d for 70 years. The radiation dose is converted to lifetime cancer risk using the estimate 4.00×10^{-6} /person-rem recommended by EPA (1989).

8.3.4 Limitations and Uncertainty in Health Risk Data

Risk estimates for acute morbidity and mortality resulting from exposure to inhaled pollutants are associated with uncertainties that are comparable in magnitude to the estimates themselves (ECO-Northwest 1987). Estimates of lifetime cancer risk from inhalation of the metals may vary within a factor of 5 to 10 or greater, depending on the nature and quantity of experimental data available, and are assumed to be appropriate for the exposure levels and chemical forms encountered in the environment (EPA-IRIS). In addition, none of the lifetime cancer risks account for intake of metals or radionuclides as a result of particulate deposition and subsequent entry of the materials into food chain pathways. Ingestion pathways may be significant for those elements that accumulate in the environment or in food products consumed by humans.

Estimated health impacts of the pollutants considered in this analysis were treated as additive because no information was available to determine the effect of synergism or antagonism between various classes of pollutants. These estimates should therefore be treated as relative measures of the consequences of various Resource Program alternatives for the purpose of comparing them. Absolute estimates of health impacts are associated with additional uncertainty. An example of how risk factor information was combined with population data is shown in Table 8.3, which illustrates health risks and exposure levels for each pollutant type in one study year.

8.4 RESULTS

Results of the health effects analysis are summarized in Table 8.4. For all endpoints evaluated, there were relatively minor differences between the 12 resource program alternatives. Compared to the results for 1991, impacts

in the year 2000 increased by 29 to 59% for lifetime cancer risk, and by 13 to 27% for acute mortality and morbidity. Corresponding increases for the year 2010 were 56 to 94% for lifetime cancer risk and 26 to 34% for acute morbidity and mortality. Metals accounted for the majority of the lifetime cancer risk, and sulfur oxides dominated the risks for acute morbidity and mortality. Because of its larger surrounding population, impacts from the Centralia site account for the largest proportion of consequences for all scenarios. Compared to the results for 1991, the largest increases in health risk resulted from the Conventional Coal alternative, followed by the Imports alternative. The High Conservation and Cogeneration alternatives produced the smallest increases in health risk.

TABLE 8.3. Example of Approach for Analyzing Health Risks and Pollutant Type for Each Alternative

Bonneville Power Administration
Resource Program - Environmental Impact Statement
Health Effects Summary, Rev. 9/91
Scenario: 1
Year: 2000

Primary Resource Program: 1 - STATUS QUO
Total Impact of Existing and New Facilities

Cumulative Exposure (person- $\mu\text{g}/\text{m}^3$)					
<u>Pollutant</u>	<u>Total</u>	<u>Centralia</u>	<u>Creston</u>	<u>Boardman</u>	<u>Colstrip</u>
NOX	753679	671503	15411	54260	12506
SO ₂	549199	492568	6164	36624	13843
TSP	23919	20759	925	1567	669

Health Risk Coefficients						
<u>Pollutant</u>	<u>Cancer Mortality Lifetime</u>	<u>Other Mortality (deaths/y)</u>	<u>Bronchitis</u>	<u>Morbidity (Effects per year)</u>		<u>Colds</u>
				<u>Lower Resp</u>	<u>Cough</u>	
NOX	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
SO ₂	0.0E+00	4.0E-05	4.0E-04	2.0E-04	4.0E-04	3.6E-04
TSP	0.0E+00	3.0E-06	3.6E-04	0.0E+00	0.0E+00	0.0E+00
MET	1.7E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
RAD	1.8E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

Cumulative Health Risk						
<u>Pollutant</u>	<u>Cancer Mortality Lifetime</u>	<u>Other Mortality (deaths/y)</u>	<u>Bronchitis</u>	<u>Morbidity (Effects per year)</u>		<u>Colds</u>
				<u>Lower Resp</u>	<u>Cough</u>	
NO _x	0.00	0.00	0.00	0.00	0.00	0.00
SO ₂	0.00	21.97	219.68	109.84	219.68	197.71
TSP	0.00	0.07	8.61	0.00	0.00	0.00
MET	0.42	0.00	0.00	0.00	0.00	0.00
RAD	0.04	0.00	0.00	0.00	0.00	0.00
Total	0.46	22.04	228.29	109.84	219.68	197.71

**TABLE 8.4. Health Effects Summary for Bonneville Power Administration
Resource Program - Environmental Impact Statement**

Scenario:	Cumulative Health Risk					
	Mortality		Morbidity (Effects per year)			
	Cancer (lifetime)	Acute (deaths/y)	Bronchitis	Lower Respiratory Disease	Cough	Colds
Year: 1991 - Impact of Existing Facilities at Beginning of Study Period						
1 - ALL PROGRAMS	0.34	18.44	190.27	91.93	183.86	165.47
Year: 2000 - Impact of New and Existing Facilities						
1 - STATUS QUO	0.46	22.04	228.29	109.84	219.68	197.71
2 - BASE CASE 4	0.46	21.96	227.47	109.43	218.86	196.97
3 - CONSERVATION	0.46	21.96	227.43	109.42	218.84	196.96
4 - CONVENTIONAL COAL	0.54	23.24	241.62	115.78	231.56	208.40
5 - CLEAN COAL	0.48	22.30	231.24	111.14	222.29	200.06
6 - NUCLEAR	0.45	21.79	225.60	108.59	217.18	195.46
7 - COMBUSTION TURBINE	0.47	21.98	227.79	109.54	219.07	197.16
8 - RENEWABLES	0.47	22.01	228.09	109.69	219.38	197.44
9 - COGENERATION	0.45	20.79	215.54	103.58	207.15	186.44
10 - FUEL SWITCHING	0.48	22.15	229.69	110.37	220.73	198.66
11 - HIGH CONSERVATION	0.44	21.38	221.34	106.56	213.11	191.80
12 - IMPORTS ^(a)	0.54	22.70	236.31	113.09	226.19	203.57
Year: 2010 - Impact of New and Existing Facilities						
1 - STATUS QUO	0.55	23.35	242.99	116.31	232.62	209.36
2 - BASE CASE 4	0.55	23.28	242.33	115.99	231.98	208.78
3 - CONSERVATION	0.55	23.28	242.33	115.99	231.98	208.78
4 - CONVENTIONAL COAL	0.62	24.46	255.12	121.80	243.59	219.23
5 - CLEAN COAL	0.53	23.50	244.07	117.08	234.16	210.75
6 - NUCLEAR	0.56	23.30	242.56	116.08	232.17	208.95
7 - COMBUSTION TURBINE	0.55	23.27	242.13	115.93	231.87	208.68
8 - RENEWABLES	0.55	23.29	242.39	116.04	232.09	208.88
9 - COGENERATION	0.54	23.24	241.65	115.77	231.55	208.39
10 - FUEL SWITCHING	0.54	23.30	242.31	116.08	232.15	208.94
11 - HIGH CONSERVATION	0.55	23.28	242.11	115.95	231.90	208.71
12 - IMPORTS ^(a)	0.66	23.76	248.91	118.28	236.56	212.90

(a) Assumes emissions from combustion turbines in the southwestern United States and Canada actually occur in the BPA study area.

9.0 EVALUATION OF THE HUMAN HEALTH EFFECTS OF OZONE

Health effects due to ozone have been estimated based on air quality modeling data and health risk coefficients for ozone. For each of four study sites, typical "high" and "low" ambient ozone concentration applied to data on affected populations within 80 km of the sites to estimate cumulative exposures levels. The ambient ozone levels are representative of moderate-to-poor air quality for each site, and are independent of the pollutant levels from power production facilities. Ozone concentrations in the aggregate plume from each site are evaluated for the resource program alternatives with the highest and lowest pollutant emission levels for each study year (1991, 2000, and 2010). Cumulative exposures within each aggregate plume are calculated assuming that the plume is blowing toward the sector containing the largest share of the population within 80 km of the release site. The health risk coefficient is applied to the cumulative exposures at each site for each ambient ozone concentration and pollutant emission level to estimate the number of acute mortalities expected from the ozone concentrations.

9.1 AIR QUALITY MODELING

Estimates of ozone concentration were obtained using the RPM-II model as described in Section 5.0. Maximum ozone concentrations within the pollutant plumes were generally about 10 to 20% greater than the corresponding ambient concentration. Only a small fraction of the 80-km zone surrounding the source (less than 5%) is affected by the plume at any one time. To obtain a conservative estimate of population exposure, ozone concentrations within the plume are applied to the directional sector containing the largest population. Because the population distribution within the maximum sector is unknown, the exposed fraction of the population within that sector is assumed to be equal to the fraction of the area affected by the plume.

9.2 HEALTH RISK ESTIMATES

The health risk estimates for ozone are based only on acute mortality because no data were available for morbidity (ECO Northwest 1987). Risk levels for acute mortality following exposure to ozone were taken from studies

by Lave and Seskin (1978), Lipfert (1984), and Mendelsohn and Orcutt (1979). Averaging results from the studies resulted in a risk level of 6×10^{-6} per $\mu\text{g}/\text{m}^3$ of ozone in the ambient atmosphere. Because the available health effects information was applicable to annual average ambient ozone concentration, several assumptions were made to convert our estimate hourly ozone concentration to suitable quantities for use in the health effects analysis. These assumptions included the following:

- The ozone data for all times and distances in a given case are averaged to obtain a representative daily mean ambient ozone concentration for the entire 80-km zone and for the fraction of the sector affected by the plume. To perform this averaging we used the ozone concentrations computed by the RPM-II model for an 18 hour simulation to represent ozone concentrations for a full 24 hour day. We also assumed that ozone concentrations had a time dependence but were independent of downwind distance from the source (or alternatively, that the concentration represented an average for all distances). The errors introduced by these assumptions are difficult to quantify in the absence of more detailed data. However, the results obtained using these assumptions do provide a rough estimate of relative mortality impacts.
- Both plume and ambient ozone concentrations are applied to 25% of the days during the 3-month summer season (6.25% of the year), and ozone concentrations are assumed to be negligible for the remaining months.
- An average air temperature of 15°C and 76-cm Hg atmospheric pressure are used to convert the ozone concentrations in pphm to $\mu\text{g}/\text{m}^3$.
- The health risk coefficient for acute mortality is applicable at, and independent of, ozone concentrations encountered in this situation.

9.3 RESULTS

The "high" and "low" ambient ozone impacts are estimated for each study site, and the results for all four sites were added to obtain an overall range of potential impacts. Results of the evaluation are presented in Tables 9.1a and 9.1b. The impacts from ozone are projected to be greatest at the Centralia site because of the large surrounding population and the relatively high ambient ozone concentrations. The risk of acute mortality from background ozone levels is several times greater than for other pollutants emitted from power plants, based on the annual average concentrations for NO_x , SO_x , and TSP (see Section 8.0).

TABLE 9.1a. Health Effects Estimate for Ambient Ozone Levels

Acute Mortality Risk from Ambient Ozone Levels (deaths/y)

Site:	<u>Centralia</u>	<u>Creston</u>	<u>Boardman</u>	<u>Colstrip</u>	<u>Total</u>
Ozone Level:					
Low Ambient	23.1	6.2	18.7	0.3	48.3
High Ambient	30.1	8.6	21.6	0.6	60.7

Health Risk Coefficient for Acute Mortality (Deaths/y per $\mu\text{g}/\text{m}^3$): 6.0E-06
 Fraction of Year that Ambient Concentration Persists: 0.0625

Cumulative Exposure to Ambient Ozone Levels (person- $\mu\text{g}/\text{m}^3$ -y)

Site:	<u>Centralia</u>	<u>Creston</u>	<u>Boardman</u>	<u>Colstrip</u>
Ozone Level:				
Low Ambient	6.15E+07	1.66E+07	5.00E+07	8.87E+05
High Ambient	8.02E+07	2.28E+07	5.75E+07	1.49E+06

Site-Specific Information for Cumulative Exposure Calculation

Site:	<u>Centralia</u>	<u>Creston</u>	<u>Boardman</u>	<u>Colstrip</u>
Population:				
80-km Total	567068	276603	402244	12756
Plume Fraction	111192	107295	31830	1732
Ambient Fraction	455876	169308	370414	11024
Ozone Level:				
Low Ambient	D. Rural	T. Rural	D. Rural	C. Rural
High Ambient	Urban 2	D. Rural	Urban 1	D. Rural

Ambient Air Concentrations ($\mu\text{g}/\text{m}^3$)

<u>Time</u>	<u>Clean Rural</u>	<u>Typical Rural</u>	<u>Dirty Rural</u>	<u>Urban 1</u>	<u>Urban 2</u>
18-hr Average	80.48	98.06	134.86	155.23	175.88

Conversion to $\mu\text{g}/\text{m}^3$: 1 pphm O_3 = 20.3 $\mu\text{g}/\text{m}^3$ O_3
 (Assumes 15° C, 76 cm Hg)

Ambient Air Concentrations (pphm)

<u>Time</u>	<u>Clean Rural</u>	<u>Typical Rural</u>	<u>Dirty Rural</u>	<u>Urban 1</u>	<u>Urban 2</u>
18-hr Average	3.96	4.83	6.64	7.65	8.66

TABLE 9.1b. Health Effects Estimate for Ambient Ozone Levels

Time	Ambient Air Concentrations (pphm)					
	Plume Width (mi)	Clean Rural	Typical Rural	Dirty Rural	Urban 1	Urban 2
1:00	0.68	3.98	4.00	3.91	3.84	3.67
2:00	1.26	3.98	3.99	3.91	3.84	3.67
3:00	1.81	3.98	3.99	3.90	3.83	3.66
4:00	2.35	3.98	3.99	3.90	3.84	3.67
5:00	2.87	3.97	4.00	3.93	3.89	3.75
6:00	3.39	3.98	4.10	4.18	4.21	4.10
7:00	4.05	3.98	4.31	4.65	4.84	4.70
8:00	4.82	3.96	4.59	5.30	5.89	5.66
9:00	5.82	3.93	4.79	5.93	6.46	7.02
10:00	6.84	3.91	4.96	6.58	7.94	8.55
11:00	8.14	3.91	5.14	7.31	8.86	10.10
12:00	9.57	3.93	5.32	8.07	9.80	11.60
13:00	11.50	3.94	5.46	8.74	10.60	12.80
14:00	13.42	3.96	5.57	9.31	11.30	13.80
15:00	15.29	3.98	5.65	9.71	11.80	14.40
16:00	16.90	3.99	5.68	9.95	12.10	14.80
17:00	18.33	4.00	5.70	10.10	12.30	15.00
18:00	19.32	4.00	5.71	10.20	12.30	15.00
18-hr Average:	--	3.96	4.83	6.64	7.65	8.66

The impacts from ozone in power plant plumes (Tables 9.2a through 9.2f) are projected to be smaller than that of the background ozone concentrations, principally because of the smaller population affected. Annual mortality rates ranged from about 8 to 11 acute deaths per year, depending on the assumed ambient pollution levels. Mortality estimates did not show substantial variations as a function of the selected resource program alternative. Mortality estimates for ozone were comparable in magnitude to those for other types of pollutants. The analysis in BPA's RPEIS is based on the average of the concentration scenarios shown in Table 9.2a.

TABLE 9.2a. Health Effects Estimate for Ozone in Power Plant Plume

Acute Mortality Risk from Plume Ozone Levels (deaths/y)

Year: 1991		Concentration Scenarios	
Ambient Ozone Level:	Low	High	
Plume Emission Level:	All	All	
Site:			
Centralia	4.31	5.45	
Creston	N/A	N/A	
Boardman	1.35	1.55	
Colstrip	0.03	0.06	
Total:	5.7	7.1	
Year: 2000			
Ambient Ozone Level:	Low	Low	High
Plume Emission Level:	Low	High	Low
Site:			
Centralia	4.12	4.04	5.28
Creston	2.91	2.80	4.49
Boardman	1.29	1.25	1.48
Colstrip	0.03	0.03	0.06
Total:	8.3	8.1	11.3
Year: 2010			
Ambient Ozone Level:	Low	Low	High
Plume Emission Level:	Low	High	Low
Site:			
Centralia	3.92	3.92	5.10
Creston	2.78	2.65	4.38
Boardman	1.15	1.11	1.33
Colstrip	0.03	0.03	0.06
Total:	7.9	7.7	10.9

TABLE 9.2b. Health Effects Estimate for Ozone in Power Plant Plume

Health Risk Coefficient for Acute Mortality (Deaths/y per $\mu\text{g}/\text{m}^3$): 6.0E-06
 Fraction of Year that Ambient Concentration Persists: 0.0625

Cumulative Exposure to Plume Ozone Levels (person- $\mu\text{g}/\text{m}^3$ -y)

Year:	2000					2010				1991	
	Ambient Ozone Level:	Low	Low	High	High	Low	Low	High	High	Low	High
	Plume Emission Level:	Low	High	Low	High	Low	High	Low	High	All	All
Site:	Affected Population:										
Centralia	111192	1.1E+07	1.1E+07	1.4E+07	1.4E+07	1.0E+07	1.0E+07	1.4E+07	1.4E+07	1.1E+07	1.5E+07
Creston	107295	7.7E+06	7.5E+06	1.2E+07	1.2E+07	7.4E+06	7.1E+06	1.2E+07	1.1E+07	N/A	N/A
Boardman	31830	3.5E+06	3.3E+06	3.9E+06	3.8E+06	3.1E+06	3.0E+06	3.5E+06	3.4E+06	3.6E+06	4.1E+06
Colstrip	1732	7.0E+04	7.0E+04	1.6E+05	1.5E+05	7.0E+04	7.0E+04	1.5E+05	1.5E+05	7.4E+04	1.7E+05

Directional Sector Width at 50 mi from source:
 20 mi

Plume Width at 50 mi from source:
 11 mi

18-hour Average Plume Ozone Concentrations ($\mu\text{g}/\text{m}^3$)

Year:	2000				2010				1991	
Ambient Ozone Level:	Low	Low	High	High	Low	Low	High	High	Low	High
Plume Emission Level:	Low	High	Low	High	Low	High	Low	High	All	All
Site:										
Centralia	98.85	96.94	126.55	124.86	94.06	94.06	122.40	122.40	103.39	130.69
Creston	72.22	69.57	111.59	109.35	68.97	65.87	108.89	106.07	N/A	N/A
Boardman	108.39	104.74	124.07	119.92	96.28	93.23	111.52	108.33	113.50	130.03
Colstrip	40.55	40.27	90.02	87.52	40.31	40.32	85.86	84.65	42.61	95.69

Plume Ozone Concentrations (pphm) Conversion to $\mu\text{g}/\text{m}^3$
 1 pphm = $20.3 \mu\text{g}/\text{m}^3 \text{O}_3$

TABLE 9.2c. Health Effects Estimate for Ozone in Power Plant Plume

Plume Ozone Concentrations (pphm) as a Function of Time and Distance from Source

Site: Centralia			Year:	2000				2010		1991	
Time	Distance (mi)	Plume Width(mi)	Ambient: Emissions:	Low Low	Low High	High Low	High High	Low All	High All	Low All	High All
18-hr Average				4.87	4.78	6.23	6.15	4.63	6.03	5.09	6.44
1:00	4	0.68		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:00	8	1.26		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:00	12	1.81		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:00	16	2.35		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:00	20	2.87		0.10	0.09	0.11	0.10	0.09	0.10	0.12	0.13
6:00	24	3.39		0.44	0.42	0.48	0.45	0.40	0.43	0.54	0.58
7:00	28	4.05		0.96	0.91	1.02	0.97	0.87	0.92	1.16	1.22
8:00	32	4.82		1.55	1.46	1.63	1.54	1.36	1.45	1.84	1.93
9:00	36	5.82		3.10	2.95	3.38	3.21	2.73	2.99	3.57	3.85
10:00	40	6.84		4.73	4.54	5.39	5.19	4.28	4.92	5.24	5.87
11:00	44	8.14		6.28	6.08	7.49	7.31	5.79	7.04	6.76	7.96
12:00	48	9.57		7.64	7.44	9.51	9.34	7.17	9.09	8.13	9.94
13:00	52	11.50		8.86	8.66	11.40	11.30	8.37	11.00	9.32	11.80
14:00	56	13.42		9.79	9.60	12.90	12.80	9.34	12.60	10.20	13.20
15:00	60	15.29		10.50	10.30	14.00	13.90	10.10	13.70	10.70	14.20
16:00	64	16.90		11.00	10.90	14.70	14.60	10.60	14.50	11.20	14.80
17:00	68	18.33		11.30	11.20	15.00	14.90	11.10	14.80	11.40	15.10
18:00	72	19.32		11.40	11.40	15.20	15.10	11.20	15.00	11.50	15.30

TABLE 9.2d. Health Effects Estimate for Ozone in Power Plant Plume

Plume Ozone Concentrations (pphm) as a Function of Time and Distance from Source

Site: Creston			Year: 2000					2010				1991	
Time	Distance (mi)	Plume Width(mi)	Ambient: Emissions:	Low Low	Low High	High Low	High High	Low Low	Low High	High Low	High High	Low All	High All
18-hr Average				3.56	3.43	5.50	5.39	3.40	3.25	5.36	5.23	N/A	N/A
1:00	4	0.68		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:00	8	1.26		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:00	12	1.81		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:00	16	2.35		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:00	20	2.87		0.43	0.24	0.48	0.26	0.22	0.14	0.24	0.16	0.00	0.00
6:00	24	3.39		1.11	0.82	1.27	0.95	0.78	0.59	0.89	0.67	0.00	0.00
7:00	28	4.05		1.72	1.44	2.09	1.72	1.38	1.13	1.67	1.37	0.00	0.00
8:00	32	4.82		2.28	1.97	2.99	2.58	1.90	1.63	2.51	2.13	0.00	0.00
9:00	36	5.82		3.54	3.22	4.89	4.48	3.16	2.85	4.39	3.95	0.00	0.00
10:00	40	6.84		4.44	4.15	6.50	6.11	4.09	3.81	6.03	5.61	0.00	0.00
11:00	44	8.14		5.19	4.90	7.91	7.59	4.84	4.58	7.52	7.11	0.00	0.00
12:00	48	9.57		5.80	5.52	9.05	8.85	5.46	5.18	8.80	8.47	0.00	0.00
13:00	52	11.50		6.23	6.02	9.87	9.82	5.97	5.70	9.80	9.58	0.00	0.00
14:00	56	13.42		6.49	6.36	10.40	10.40	6.32	6.10	10.40	10.30	0.00	0.00
15:00	60	15.29		6.60	6.56	10.60	10.80	6.54	6.38	10.80	10.80	0.00	0.00
16:00	64	16.90		6.71	6.76	10.90	11.00	6.75	6.64	11.10	11.20	0.00	0.00
17:00	68	18.33		6.75	6.85	11.00	11.20	6.86	6.80	11.20	11.30	0.00	0.00
18:00	72	19.32		6.75	6.88	11.00	11.20	6.89	6.88	11.20	11.40	0.00	0.00

TABLE 9.2e. Health Effects Estimate for Ozone in Power Plant Plume

Plume Ozone Concentrations (pphm) as a Function of Time and Distance from Source

Site: Boardman			Year: 2000				2010				1991		
Time	Distance (mi)	Plume Width(mi)	Ambient: Emissions:	Low Low	Low High	High Low	High High	Low Low	Low High	High Low	High High	Low All	High All
18-hr Average				5.34	5.16	6.11	5.91	4.74	4.59	5.49	5.34	5.59	6.41
1:00	4	0.68		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:00	8	1.26		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:00	12	1.81		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:00	16	2.35		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:00	20	2.87		0.21	0.14	0.22	0.14	0.09	0.09	0.10	0.09	0.78	0.77
6:00	24	3.39		0.83	0.59	0.84	0.60	0.42	0.40	0.42	0.41	1.61	1.62
7:00	28	4.05		1.61	1.25	1.63	1.27	0.90	0.86	0.92	0.88	2.52	2.54
8:00	32	4.82		2.43	1.97	2.50	2.04	1.45	1.34	1.50	1.38	3.47	3.53
9:00	36	5.82		4.30	3.74	4.69	4.12	2.90	2.67	3.21	2.94	5.31	5.70
10:00	40	6.84		5.96	5.41	6.67	6.13	4.49	4.20	5.15	4.81	6.87	7.57
11:00	44	8.14		7.45	6.93	8.46	7.96	6.01	5.70	7.02	6.68	8.15	9.17
12:00	48	9.57		8.75	8.29	10.00	9.57	7.38	7.08	8.67	8.35	9.13	10.40
13:00	52	11.50		9.77	9.45	11.20	10.90	8.59	8.28	10.10	9.81	9.80	11.40
14:00	56	13.42		10.40	10.20	12.10	11.90	9.54	9.25	11.20	10.90	10.20	12.00
15:00	60	15.29		10.80	10.80	12.60	12.50	10.30	10.00	12.00	11.80	10.50	12.40
16:00	64	16.90		11.10	11.20	12.90	12.90	10.80	10.60	12.60	12.40	10.70	12.60
17:00	68	18.33		11.20	11.40	13.10	13.10	11.20	11.00	12.90	12.70	10.80	12.80
18:00	72	19.32		11.30	11.50	13.10	13.20	11.30	11.20	13.10	12.90	10.80	12.80

TABLE 9.2f. Health Effects Estimate for Ozone in Power Plant Plume

Plume Ozone Concentrations (pphm) as a Function of Time and Distance from Source

Site: Colstrip			Year: 2000					2010				1991	
Time	Distance (mi)	Plume Width(mi)	Ambient: Emissions:	Low Low	Low High	High Low	High High	Low Low	Low High	High Low	High High	Low All	High All
18-hr Average				2.00	1.98	4.43	4.31	1.99	1.99	4.23	4.17	2.10	4.71
1:00	4	0.68		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2:00	8	1.26		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3:00	12	1.81		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4:00	16	2.35		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5:00	20	2.87		0.09	0.09	0.09	0.10	0.10	0.11	0.10	0.11	0.09	0.09
6:00	24	3.39		0.38	0.41	0.41	0.43	0.43	0.46	0.45	0.47	0.37	0.41
7:00	28	4.05		0.76	0.80	0.84	0.86	0.85	0.89	0.90	0.94	0.76	0.89
8:00	32	4.82		1.06	1.10	1.28	1.28	1.15	1.19	1.29	1.33	1.11	1.41
9:00	36	5.82		1.72	1.71	2.47	2.36	1.73	1.75	2.30	2.29	1.86	2.84
10:00	40	6.84		2.34	2.31	3.90	3.70	2.32	2.32	3.59	3.52	2.52	4.42
11:00	44	8.14		2.87	2.84	5.40	5.17	2.84	2.83	5.01	4.90	3.05	5.95
12:00	48	9.57		3.26	3.24	6.76	6.51	3.24	3.23	6.34	6.20	3.43	7.32
13:00	52	11.50		3.55	3.53	7.98	7.73	3.53	3.53	7.56	7.42	3.70	8.53
14:00	56	13.42		3.77	3.74	8.95	8.69	3.73	3.73	8.52	8.39	3.91	9.49
15:00	60	15.29		3.92	3.88	9.74	9.48	3.87	3.87	9.30	9.16	4.08	10.20
16:00	64	16.90		4.04	3.99	10.30	10.10	3.97	3.94	9.87	9.73	4.22	10.80
17:00	68	18.33		4.10	4.04	10.80	10.50	4.01	3.98	10.40	10.20	4.32	11.20
18:00	72	19.32		4.10	4.02	10.90	10.70	3.97	3.92	10.50	10.40	4.37	11.30

10.0 EVALUATION OF POWER-GENERATION FACILITY EMISSIONS ON WILDLIFE

Air quality analyses for each of the resource alternatives are used to estimate the impact of production-facility emissions on the wildlife populations within 32 km of the study sites. Mortality estimates are made for important mammalian species at each of four study sites by using population densities reported by local wildlife biologists. Mortality estimates for avian species are based on the total number of adult breeding birds of all species per square mile of habitat type (Udvardy 1957 and 1958). Waterfowl production estimates are based on data from state wildlife biologists and the U.S. Fish and Wildlife Service. Acute mortality risk estimates for human populations exposed to airborne contaminants from power plants were used to calculate the deaths per year for wildlife species.

Data predicting acidification of surface waters within a 400-km radius of each study site are used to evaluate the potential impact of pollutant emissions on waterfowl production. The potential impact of metal contamination resulting from power plant emissions is estimated from particulate deposition data and the reported bioaccumulation rates for metals in the edible plant biomass. A hypothetical watershed is used to evaluate the potential effects of fly ash deposition on terrestrial animals dependent on aquatic vertebrate and invertebrate food sources. Impacts were evaluated using emission data for the study years 1991, 2000 and 2010.

10.1 AIR QUALITY, PARTICULATE DEPOSITION, AND WATER ACIDIFICATION ESTIMATES

As discussed in Section 3, air concentrations of SO_2 and TSP were determined for each alternative using local meteorological data and the emission characteristics of the power plants at each site. Wildlife mortality risks are estimated out to 32 km from the stack ($1,222 \text{ mi}^2$) because this is the range within which health effects are expected to occur and represents an area around the sites where human disturbance and habitat modification are low. Mortality estimates are not calculated for NO_x because of the lack of direct mortality-effect data for chronic low-level exposure to these compounds.

Data on the air concentrations of ozone are obtained from the RPM-II model discussed in Section 5. Because the initial effect of the power plant emissions is to deplete the ozone from the pollutant plume, the impact of ozone on wildlife populations is estimated for the downwind area having ozone concentrations exceeding ambient levels. This area varies among the sites but, in general, is located at a distance greater than 60 km from the stack. Data on ozone concentrations are available out to a downwind distance of 120 km. The corresponding plume width varies between 11 and 31 km along this 60-km length. The area potentially impacted by ozone downwind of each facility is listed in Table 10.1.

The available health effects data for ozone are based on annual average exposures rather than the hourly ozone values presented in Section 5. To convert model data to annual averages, "worst day" results are assumed to occur between 20 and 90 days during the year. The remaining days of the year are assumed to have negligible ozone concentrations. Ambient ozone levels used in this analysis are those generated by the RPM-II model for a "dirty rural environment."

Potential acidification of surface water is estimated from the acid precipitation model results described in Section 4.0. The area within 400 km of the stack where the projected pH of the rainfall is less than or equal to 5.0 was compared with data on the surface water alkalinities of that area. Areas with total alkalinity of less than 200 $\mu\text{eq/L}$ are considered sensitive to acidification (Kaplan et al. 1981, Hendrey et al. 1980).

Metal contamination is estimated using particulate deposition (mg/m^2) data described in Sections 4.0 and 8.0 and information on the metal composition of coal fly ash (Table 10.2). These values are used to estimate the potential metal deposition (mg/m^2) to soil and aquatic environments during a year. This report addresses the potential impact of only those metals with known avian or mammalian toxicity and that are above natural levels in soils (Table 10.2). Because metal toxicosis can be related to water acidification, a 400-km study radius is used.

10.2 ACUTE MORTALITY ESTIMATES

Little is known about the toxic effects of power-production emissions on animals functioning in natural communities; therefore, the human mortality risks for sulfur oxides, ozone, and particulate emissions applied in the Generic Coal Study (ECO Northwest 1987) are used. The dose-response coefficients are derived from epidemiological research by Lipfert (1984) and Lave and Seskin (1978). Averaging the acute mortality risk estimates of the two original studies, the risk coefficient for sulfur oxides exposure is 4×10^{-5} /animal-year per $\mu\text{g}/\text{m}^3$ of pollutant and 3×10^{-6} /animal-year per $\mu\text{g}/\text{m}^3$ for particulates. The risk of mortality from exposure to a daily average ozone concentration of $1 \mu\text{g}/\text{m}^3$ for one year is 13×10^{-6} (Lipfert 1984). No effect on acute mortality from nitrogen oxide exposure is available from the literature surveyed.

The risk coefficient for each pollutant is applied to the cumulative exposure at each site to estimate the number of acute mortalities expected in populations of birds and mammals within 32 km of the stack. The current animal populations for each site are shown in Table 10.3. Summation of the mortality assessments for each pollutant provided an estimate of overall wildlife loss per year for each combination of resource alternative and release site.

The uncertainty around the risk coefficient values is large; it is comparable in magnitude to the estimates themselves (ECO Northwest 1987). Application of these coefficients of risk to wildlife populations assumes that wild animals have about the same sensitivity to air pollutants as humans and receive, on a body weight basis, equivalent doses in the environment. However, it has been shown that the volume of air breathed per minute per unit of body weight (i.e., the weight-specific minute ventilation) varies greatly among mammals (Phalen 1984). Generally, the smaller the animal the more air per minute per gram is inhaled. Compared to humans, rabbits ventilate 3 times greater volumes of air and small rodents ventilate 8 to 13 times greater volumes of air on a per-body-weight basis (Phalen 1984). Larger animals such as deer and elk receive smaller doses than humans during inhalation exposures. Birds may be at even greater risk than represented in the human mortality risk coefficients because their respiratory rates are generally higher than mammals

of comparable size. In addition, migration, seasonal physiological changes, activities (e.g. flying), breathing zones differences (e.g., near the turbulent ground surface) and greatly varying home ranges further complicate the extrapolation of the human risk coefficients to wild animals. Therefore, the mortality measures for wild animals should be viewed as relative estimates of the consequences of the various resource alternatives.

10.3 METAL TOXICOSIS

Long-term atmospheric deposition of fly ash particulates increases the concentrations of trace metals available for plant and aquatic organism uptake (Straughan et al. 1978; Adriano et al. 1980; Mbagwa 1983). Direct foliar absorption of deposited metals may occur if the metalloid is not resuspended or leached off the leaves by rainfall. Although most particulates are rapidly leached off leaf surfaces, certain metals (i.e., cadmium, lead, zinc, manganese, and chromium) are retained on foliar surfaces. In general, small particles ($< 7 \mu\text{m}$ in diameter) are retained by surface tension effects of water. Metals soluble in absorbed water enter the plant through stomatal and cuticular routes (Dybing and Currier 1961).

Trace metal availability to plants through root uptake is determined by the composition of the soil solution (pH, organic matter, etc.) and the soluble chemical species present in the rhizosphere (Cataldo and Wildung 1978). Root cells are capable of concentrating the elements within the root, altering the form of the elements within the symplast, and regulating transport to other tissues (Clarkson and Hanson 1980). From a relatively dilute soil solution, plants can concentrate metals in the root and/or the above-ground biomass to high levels (Rogers et al. 1978; Adriano et al. 1980; Tolle et al. 1983; Gutenmann et al. 1976). Subsequently, animals feeding on these plants accumulate high body burdens of the metals (Furr et al. 1978; Stoewsand et al. 1978; Mandisodza et al. 1979). Similar bioconcentrations of metalloids have been observed in aquatic organisms inhabiting contaminated watersheds (Vaughn et al. 1975; Thompson et al. 1972; Ng et al. 1969).

Maximum dietary uptake of deposited metals is determined for each of the resource alternatives at each site by assuming bio-concentration of the metals in food sources and dependence on the contaminated food for all daily dietary

needs of local populations of wild animals. The above-ground biomass of plants and aquatic organisms are considered as primary food sources. The concentration of particulate matter available for uptake by plants is calculated assuming total incorporation of deposited particulate into the soil to the depth of a typical forage rhizosphere (15 cm) and a soil bulk density of 1.5 g/cm³ (Brady 1974). Assuming total availability of the metals for uptake by plants, bioconcentration of the metals is calculated using reported concentration ratios (Vaughan et al. 1975).

Maximum annual uptake of metals from aquatic organisms is estimated by calculating the maximum annual deposition to a hypothetical watershed and the bioconcentration factors reported by Thompson et al. (1972) and Ng et al. (1969). The receiving watershed was assumed to be 4 km² with an instantaneous volume of 7,500 m³ of water and all metals deposited to the watershed were assumed to be in a chemical form available for accumulation by aquatic biota.

10.4 WATERFOWL PRODUCTION ESTIMATES

Acid precipitation can alter the abundance and diversity of aquatic organisms which are principal components of the diet of water birds. Anatids (ducks, geese, and swans) are particularly vulnerable because of their requirement for protein-rich invertebrates for egg production (Swanson and Meyer 1973; Reinecke and Owen 1980) and duckling growth (Sugden 1973; Reinecke and Owen 1979). Acidification of wetland habitat has recently been shown to adversely affect growth, physiological condition and survival of ducklings by reducing food availability (Rattner et al. 1987).

To estimate the reduction in waterfowl production from acid deposition, data on waterfowl production per acre is multiplied by the estimated acres of appropriate habitat receiving acid deposition of pH 5.0 and below. This product is multiplied by 0.38 to represent the duckling mortality seen on acidified wetlands (pH 5.0) minus the mortality observed on control wetlands (pH 6.8) (Haramis and Chu 1987). The brood size is assumed to be seven young per pair of adults.

The acid neutralizing capacity of the soils and waters of all sites, except Centralia, exceeded 200 µeg/L; thus, these sites are probably not

sensitive to acidification from acid rainfall. Therefore, duckling mortality from acidification was calculated only for the Centralia site. The area within 400 km of Centralia that may receive acid precipitation in the year 2010 is shown in Figure 10.1. Twenty-five percent of the lakes and ponds in this area were assumed to be located at altitudes that support waterfowl production, to be used by dabbling ducks (Stromberg and Longcore 1987), and not to be actually enhancing dabbling duck brood survival as a result of acidification (Eriksson 1979; Pehrsson 1979). Acreage values were obtained from "Lakes of Washington, Volume I, Western Washington," by E. E. Wolcott (1973). The acreage reported does not include streams, ditches, and other wetlands within the area that may provide breeding habitat for waterfowl.

10.5 RESULTS

The impacts of airborne contaminants, including TSP, SO₂, and ozone; metal deposition; and acidification are described below.

10.5.1 Impacts of Airborne Contaminants

Estimates of the wildlife mortality from SO₂ and TSP emissions for each resource alternative at each site for the years 1991, 2000, and 2010 are shown in Appendix J. The overall wildlife losses at all sites for each alternative are shown in Tables 10.4, 10.5, and 10.6. The number of additional deaths of birds and mammals (over background mortality) that would occur from exposure to ozone in the power plant plumes is shown in Table 10.7. The number of SO₂- and TSP-induced deaths of wild birds and mammals living within a 32-km radius of the pollutant release site is highest for avian species and for small rodents. Although some of the mortality estimates appear large (e.g., over 900 birds and 64,000 rodents in the year 2010), these values represent reductions in local populations of less than 0.02%.

Ozone exposure predictions also indicate minimal impact to large mammal populations or wild bird communities. The minimum exposure scenario (i.e., 20 days of atmospheric conditions conducive to ozone production) results in additional deaths only for rodent populations. Death rates of typical small rodent populations even under the maximum conditions would increase by less

than 4 to 10%. Under maximum exposure conditions, one to four additional avian deaths may occur per year.

The reductions due to ozone, like those for SO₂ and TSP, will have minimal impact unless endangered or threatened species are present in the downwind areas. Loss of even a few individuals from a limited population can have profound impact on the species survival in that area. The habitat of all four sites supports several state or federally listed endangered and threatened birds and/or mammals.

The spotted owl (*Strix occidentalis*), grey wolf (*Canis lupus*), and Columbia white-tailed deer (*Odocoileus virginianus leucurus*) are endangered species listed by the federal government that may occur in the Centralia impact area. The bald eagle (*Haliaeetus leucocephalus*) (Federal Threatened Species List) and the osprey (*Pandion haliaetus*) (one occurrence and two nests) have been observed near the Centralia power plant.

One occurrence of peregrine falcon (*Falco peregrinus*) (Federal Endangered List) has been recorded for the Boardman area. The area potentially impacted by the Boardman emissions (including part of the Columbia River) may be a seasonal home to the Aleutian Canada goose (*Branta canadensis leucopareia*) (Federal Endangered Species List), American white pelican (*Pelecanus erythrorhynchos*), sandhill crane (*Grus canadensis*), ferruginous hawk (*Buteo regalis*) (Washington State Endangered Species List), the bald eagle, and the sage grouse (*Centrocercus urophasianus*) (Federal Candidate Level II species).

Habitat surrounding the Colstrip area supports golden eagles (*Aquila chrysaetos*) (Montana State Threatened Species List) and is favorable for the black-footed ferret although none have been observed in the area. Three dancing grounds of the sharp-tailed grouse (*Pedioecetes phasianellus*) (Federal Candidate Level II species) lay within the Colstrip impact area.

The Creston area contains peregrine falcon, ferruginous hawk, bald eagle, golden eagle, Swainsons hawk (*Buteo swainsoni*) (Washington State Threatened Species List) and northern goshawk (*Accipiter gentilis*) (Washington State Threatened Species List) habitat. In addition, the western bluebird (*Sialia mexicana*), sage thrasher (*Oreoscoptes montanus*), loggerhead shrike (*Lanius ludovicianus*) and sage sparrow (*Amphispiza belli*) are Washington State

Candidate species that also inhabit the area around the Creston site. Two occurrences of burrowing owls (*Athene cunicularia*) (Washington State Candidate Species List), one sighting of a sharp-tailed grouse, and two occurrences of long-billed curlews (*Numenius americanus*) have been documented in the area. Sightings of Townsends big-eared bat (*Plecotus townsendii*), a Federal Candidate Level II Species, and Merriam shrew (*Sorex merriami*) (Washington State Candidate Species) have also been reported in the area around Creston. It should be noted that incidence of mortality will be less for species receiving seasonal exposure to the plume than for those animals receiving a year-round or critical season exposure (e.g., summer for ozone production).

10.5.2 Impact of Metal Deposition

Estimated values of annual uptake of metals by plants and the dietary levels of the metals known to cause toxic responses in animals were calculated for the resource alternative (Conventional Coal) that would generate the largest amount of particulates deposited within 400 km of each release site. All of the metals in the plants are projected to be below threshold toxicity levels reported for laboratory rats (Bowen 1979). Therefore, metal uptake by plants and animals was not calculated for the other, less polluting, alternatives. Whether the rat adequately represents the sensitivity of all wildlife species to metal toxicosis has not been determined; however, it appears that short-lived wildlife foraging on plant biomass at the sites would not be at risk of metal toxicosis.

A potential adverse effect on plants could occur near Centralia and Colstrip. At these sites, annual deposition totals for copper, manganese, and molybdenum levels are below all reported threshold toxicity levels but the accumulation of these metals over a number of years could result in soil concentrations that could exceed toxicity levels for certain plant species (Welch 1981; Bollard 1983; Shrif 1969; Rosenfeld and Beath 1964).^(a) Changes in plant biomass or plant community structure can affect the number and distribution of wildlife and wildlife species in the impacted area. However, the estimated concentrations of these metals in the plants are made on the assumption that all of the metal deposited is available for uptake by

^(a) More detailed information on plant toxicity is presented in Section 11.2

the plants. Actual bioavailability is often much less and is dependent on the water and soil composition and the physiology of the plant species. Therefore, plant loss or community changes from metal deposition are not anticipated. The exception may be for those areas in the Centralia region that are susceptible to acid deposition. The lowered pH increases the solubility of several metals (Dickson 1980) which then increases their uptake by plants.

Two metals, arsenic and selenium, pose a potential health problem to wildlife feeding on aquatic vertebrates. All resource alternatives at Centralia and Colstrip introduce potentially toxic levels of arsenic into the food chain during 1991, 2000, and 2010. Toxic levels are introduced only by the Conventional Coal alternative at Creston in the year 2010 and at Boardman in the year 2000. All resource alternatives contributed toxic levels of arsenic at Boardman in 2010. Because the actual concentration of arsenic that would be available to aquatic organisms is probably much less than the total availability assumed for our concentration estimates (Eisler 1988), and because arsenic is more bioavailable under basic conditions, the impact of the arsenic load to the watersheds will probably be seen only at Colstrip. However, arsenic levels in the water at Colstrip would probably not exceed the criteria levels for protection of natural resources (Eisler 1988). Long-lived, resident (non-migrating) wildlife feeding on the aquatic biota at all of the sites may acquire toxic levels of arsenic in their tissues. An estimation of the potential population impacts of such a chronic exposure is precluded by the lack of information on the arsenic species that would predominate at the sites and the absorption/excretion rates of the wildlife species.

Although selenium concentrations probably will not reach levels that may pose a direct threat to wild animals feeding on aquatic organisms for any of the resource alternatives at any of the sites, selenium concentrations in the water may greatly alter the food resources of wildlife at Centralia and Colstrip. Selenium concentrations in surface waters at these sites may exceed 20 $\mu\text{g/L}$. The conventional coal resource at Boardman in the year 2010 may also introduce potentially harmful levels (13 $\mu\text{g/L}$) of selenium into the aquatic environment which, subsequently, may impact wildlife populations. Wildlife

impacts at these concentrations are related to the severe effects that selenium can have on fish populations. At concentrations between 9 and 12 $\mu\text{g/L}$, whole populations of certain fish species have been eliminated from waters receiving seleniferous fly ash from coal-fired power plants (Lemly 1985, Cumbie and Van Horn 1978, and Gillespie and Bauman 1986). Migratory birds that rely on aquatic biota for food may be affected by these changes in the aquatic food web. For example, loss of fish due to selenium contamination may adversely effect populations of piscivorous species such as the osprey and common loon (*Gavia immer*), but may benefit insectivorous species such as the hooded merganser (*Lophodytes cucullatus*) and common goldeneye (*Bucephala clangula*).

10.5.3 Impacts of Acidification

Lakes and streams in the Pacific Northwest, along the Cascade range, are particularly vulnerable to acid deposition and can receive episodic acidification from rapid snowmelt and run-off that can be many more times acidic than the precipitation. This episodic acidification can significantly impact waterfowl production because it coincides with two critical waterfowl dependencies on aquatic biota, i.e., the need by female waterfowl to consume aquatic organisms during late winter to meet elevated requirements for calcium and protein for egg production and the requirement for protein-rich aquatic organisms by ducklings during the first 2 months of life for normal growth and development.

Acid deposition in unbuffered systems has been shown to reduce the quantity and quality of avian food items and result in reduced reproductive success for a great diversity of birds including passerines, raptors, and both diving and dabbling waterfowl (DeGranges and Rodrigue 1986; Raddum and Steigen 1981; Glooschenko et al. 1986; Havas and Hutchinson 1983; Driver et al. 1974; Eriksson 1986). However, avian mortality rates due to wetland acidification are available only for dabbling ducks. Haramis and Chu (1987) found that mallard ducklings feeding on acidified ponds died at a rate 38% higher than ducklings raised on ponds with a pH above 5.0. When this mortality rate is applied to the estimated number of dabbling ducks (one breeding pair/acre) for the potentially acidified Centralia area (Figure 10.1), about 2,000 additional

dabbling duckling deaths per year may be anticipated under the assumptions and data constrictions mentioned in the Waterfowl Production Estimates section.

Although reduced survival or breeding success has been observed in waterfowl populations near acidic lakes (McNichol et al. 1987; Blancher and McAuley 1989), some studies have shown that acidic (fish-free) lakes may actually be preferred by dabbling ducks (Ericksson 1979; Pehrsson 1979) and waterfowl production increased. It should be noted that the mortality rates used in this report were established in studies with captive ducks on emergent wetlands and may not reflect the trophic interactions or natural behaviors of free-ranging birds.

FIGURE 10.1. Acid Precipitation at Centralia, Washington, as Projected for 2010. Outlined area was used for waterfowl production estimates.

TABLE 10.1. Downwind Impact Areas Having Ozone Concentrations in Excess of Ambient Levels (in km² (mi²))

Year	Production Facility Location			
	<u>Centralia</u>	<u>Creston</u>	<u>Boardman</u>	<u>Colstrip</u>
1991	960 (364)	1276 (486)	1276 (486)	1276 (486)
2000	802 (305)	1115 (424)	1115 (424)	702 (267)
2010	802 (305)	1115 (424)	1276 (486)	292(111)

TABLE 10.2. Ranges of Metal Concentrations in Fly Ash

<u>Metal</u>	<u>Fly Ash (ppm)</u>	<u>Soil (ppm)</u>	<u>Percentage Composition</u>
Aluminum	1000-173,000	10,000-30,000	17.3
Arsenic	2-6,300	0.1-40	0.63
Beryllium	up to 8000	--	--
Cadmium	0.7-130	0.01-2	0.013
Chromium	10-1,000	5-1,500	--
Cobalt	7-520	0.05-65	0.052
Copper	14-2,800	2-250	0.28
Lead	3-5,000	2-600	0.50
Manganese	58-3,000	20-10,000	0.30
Mercury	up to 33	0.01-0.5	0.0033
Molybdenum	7-160	0.1-40	0.16
Nickel	6-4,300	2-750	0.43
Selenium	10-3,500	0.01-2	0.35
Zinc	10-3,500	1-900	0.35

Source: Mattigod, S. V. and A. L. Page 1983.

TABLE 10.3. Total Species Populations at Each Location (number per mile²)

Species	Centralla	Creston	Colstrip	Boardman	Total
Small Rodent	103600	103600	103600	103600	414400
Beaver	6	6	0	6	18
Ground Squirrel	0	30	30	30	90
Mink	2	0	2	2	6
Black Tailed Deer	20	0	0	0	20
Mule Deer (arid lands)	0	0	0	12	12
Mule Deer (other)	0	0	0	20	20
Mule Deer	0	0	2	32	34
Mule & White Tailed Deer	0	8	0	0	8
Deer (all species)	20	8	2	32	62
Elk	1	1	0	1	3
Avian (all species)	2560	1024	1024	1024	5632

TABLE 10.4. Animal Mortalities Due to SOx and TSP Exposures for Each Alternative in 1991

Mortality per Year Associated with SOx Exposure
by Primary Number: 1991

Species:	Status Quo	Base Case	Fuel Switching	Nuclear	Imports	Cogeneration	Combustion Turbines	Pulverized Coal	Clean Coal	High Conservation	Conservation	Renewables
Small Rodent	39270	39270	39270	39270	39270	39270	39270	39270	39270	39270	39270	39270
Beaver	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
Ground squirrel	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
Mink	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Deer (all Species)	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Elk	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Avian spp.	607	607	607	607	607	607	607	607	607	607	607	607

Mortality per Year Associated with TSP Exposure
by Primary Number: 1991

Species:	Status Quo	Base Case	Fuel Switching	Nuclear	Imports	Cogeneration	Combustion Turbines	Pulverized Coal	Clean Coal	High Conservation	Conservation	Renewables
Small Rodent	1518	1518	1518	1518	1518	1518	1518	1518	1518	1518	1518	1518
Beaver	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Ground squirrel	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Mink	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Deer (all Species)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Elk	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Avian spp.	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5

TABLE 10.5. Animal Mortalities Due to SO_x and TSP Exposures for Each Alternative in 2000

Mortality per Year Associated with SO _x Exposure by Primary Number: 2000												
Species:	Status Quo	Base Case	Fuel Switching	Nuclear	Imports	Cogeneration	Combustion Turbines	Pulverized Coal	Clean Coal	High Conservation	Conservation	Renewables
Small Rodent	53630	53270	54042	52652	55123	50799	53321	56461	53630	51314	53270	53270
Beaver	1.98	1.94	1.97	1.91	2.04	1.82	1.94	2.05	1.93	1.84	1.94	1.93
Ground squirrel	10.6	10.5	10.7	10.3	10.9	10.0	10.5	11.1	10.5	10.1	10.5	10.5
Mink	0.99	0.98	1	0.97	1.02	0.94	0.98	1.04	0.99	0.95	0.98	0.98
Deer (all Species)	8.3	8.2	8.4	8.1	8.6	7.7	8.2	8.6	8.1	7.8	8.2	8.2
Elk	0.33	0.32	0.33	0.32	0.34	0.3	0.32	0.34	0.32	0.31	0.32	0.32
Avian spp.	784	780	790	771	807	742	780	825	788	754	780	781

Mortality per Year Associated with TSP Exposure by Primary Number: 2000												
Species:	Status Quo	Base Case	Fuel Switching	Nuclear	Imports	Cogeneration	Combustion Turbines	Pulverized Coal	Clean Coal	High Conservation	Conservation	Renewables
Small Rodent	2640	2635	2707	2573	2882	2579	2666	3222	2779	2522	2630	2645
Beaver	0.1	0.1	0.1	0.09	0.11	0.09	0.1	0.12	0.1	0.09	0.1	0.1
Ground squirrel	0.55	0.54	0.55	0.53	0.56	0.53	0.55	0.69	0.58	0.52	0.54	0.54
Mink	0.04	0.04	0.05	0.04	0.05	0.04	0.04	0.05	0.05	0.04	0.04	0.04
Deer (all Species)	0.37	0.37	0.38	0.36	0.42	0.36	0.37	0.48	0.39	0.35	0.37	0.37
Elk	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Avian spp.	37.2	37.3	38.7	36.3	42.5	36.5	37.8	44.5	39.2	35.5	37.1	37.5

TABLE 10.6. Animal Mortalities Due to SO_x and TSP Exposures for Each Alternative in 2010

Mortality per Year Associated with SO _x Exposure by Primary Number: 2010												
Species:	Status Quo	Base Case	Fuel Switching	Nuclear	Imports	Cogeneration	Combustion Turbines	Pulverized Coal	Clean Coal	High Conservation	Conservation	Renewables
Small Rodent	63461	61505	61659	61608	57902	61350	61505	66806	63100	61505	61505	61608
Beaver	2.32	2.27	2.28	2.28	2.05	2.27	2.27	2.5	2.34	2.27	2.27	2.28
Ground squirrel	13.3	12.7	12.7	12.7	13.2	12.6	12.7	14.0	13.1	12.7	12.7	12.7
Mink	1.16	1.14	1.14	1.14	1.07	1.14	1.14	1.23	1.16	1.14	1.14	1.14
Deer (all Species)	10.1	10.0	10.1	10.1	9.4	10.0	10.0	11.0	10.3	10.0	10.0	10.1
Elk	0.39	0.38	0.38	0.38	0.34	0.38	0.38	0.42	0.39	0.38	0.38	0.38
Avian spp.	890	871	873	872	755	870	871	934	888	871	871	872

Mortality per Year Associated with TSP Exposure by Primary Number: 2010												
Species:	Status Quo	Base Case	Fuel Switching	Nuclear	Imports	Cogeneration	Combustion Turbines	Pulverized Coal	Clean Coal	High Conservation	Conservation	Renewables
Small Rodent	4117	3840	3814	3855	3829	3798	3840	4560	3927	3814	3840	3840
Beaver	0.15	0.15	0.15	0.15	0.17	0.14	0.15	0.18	0.15	0.15	0.15	0.15
Ground squirrel	0.94	0.85	0.85	0.85	0.78	0.85	0.86	1.05	0.91	0.85	0.85	0.85
Mink	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.07	0.07	0.07	0.07
Deer (all Species)	0.63	0.62	0.62	0.63	0.69	0.62	0.62	0.76	0.63	0.62	0.62	0.62
Elk	0.03	0.02	0.02	0.02	0.03	0.02	0.02	0.03	0.02	0.02	0.02	0.02
Avian spp.	53.8	51.4	50.6	51.6	54.9	50.2	51.1	58.8	50.6	50.8	51.4	51.2

TABLE 10.7. Animal Mortalities Due to Ozone Exposure for All Alternatives in 1991, 2000, and 2010

		YEAR 1991		YEAR 2000		YEAR 2010	
		Minimum (20 days)	Maximum (90 days)	Minimum (20 days)	Maximum (90 days)	Minimum (20 days)	Maximum (90 days)
Species:	No./mi ²	0.05 ug Ozone/m ³	0.05 ug Ozone/m ³	0.02 ug Ozone/m ³	0.21 ug Ozone/m ³	0.03 ug Ozone/m ³	0.15 ug Ozone/m ³
Small Rodent	414400	77	379	20.54	423	72	316
Beaver	18	0	0.02	0	0.02	0	0.02
Ground squirrel	90.0	0.0	0.1	0.02	0.1	0.0	0.1
Mink	6	0	0	0.0	0	0	0
Deer (all Species)	55.0	0.0	0.1	0.01	0.1	0.0	0.1
Elk	3	0	0	0.2	0	0	0
Avian spp.	10240	2	9	2	10	2	8

11.0 EVALUATION OF POWER-GENERATION FACILITY EMISSIONS ON PLANTS AND CROPS

Air quality analyses for each of the resource program alternatives are used to estimate the impact of power plant emissions on the terrestrial vegetation within the plume predicted for Creston, Boardman, Centralia, and Colstrip. Land-use areas are estimated for each of the sites. Land-use estimates are partitioned into croplands, timber, and pasture (Table 11.1). Impacts to vegetation are given as production loss for several types of crops. Crop production estimates were obtained from Agricultural Stabilization and Conservation Service (ASCS) offices in the Washington, Oregon, Idaho, Montana, and North Dakota counties that are projected to be affected by the plumes. The total acreage estimates provided by the ASCS offices were adjusted for the percentage of the county affected by pollutant transport or deposition. The effects of metals, SO_2 , NO_x , and ozone are estimated using results published in the cited literature. Only the greatest pollutant concentrations predicted to occur in the study areas were used to estimate potential impacts. Projected impacts are given for the years 1991, 2000, and 2010.

11.1 AIR QUALITY, PARTICULATE DEPOSITION, AND OZONE ESTIMATES

Air concentrations of SO_2 , NO_x , TSP, and ozone, were modeled as described in Sections 3 and 5 of this report. Airborne concentrations of the pollutants were determined for each resource alternative using meteorological data and the emission characteristics of the power plants at each study site. Vegetation production effects are calculated for the entire impacted area. Production effects are not calculated for NO_x because of lack of direct production effects data for chronic low-level exposure to these compounds.

Air concentrations of ozone were obtained from the RPM-II model. Ozone concentrations were initially provided as hourly estimates both in plume and in the background atmosphere. Because the effects of ozone on vegetation production are given as 7-hour/day averages, the ozone data are analyzed in this manner. The maximum 7-hour/day averages for the years 1991, 2000, and 2010 are compared to production response curves for five crops.

Metal contamination was calculated using particulate deposition estimates obtained from Section 4, and published metal concentrations of coal

fly ash (Table 11.2). These values are used to estimate the potential metal deposition to the soil and vegetation. This report addresses the potential impact of only those metals with known plant toxicity.

11.2 PLANT TOXICITY

Plant toxicity for SO_2 was assessed by comparing the maximum short-term concentrations expected in the plumes during the years 2000 and 2010 (Table 11.3). The maximum projected concentration at any of the sites was about 1.2 ppm. This compares to potential toxic concentrations of 18 to 165 ppm (Moriarty 1983). Based on the difference between the maximum projected concentrations and the potential toxic concentration, no potential impact is expected.

The potential toxicity from metals was based on the potential toxicity of the metal component in TSP. Based on the metal composition of the fly ash reported by Mattigod and Page (1983) the potential toxicity of eight metals was assessed (Tables 11.4 and 11.5). The cumulative deposition values for metals were obtained using information presented in Section 4. The composition of TSP (Mattigod and Page 1983) was used to determine the deposition values for each metal. The plant concentration ratio was determined for each metal. Given the depth of the rhizosphere as 15 to 20 cm, there is $150,000 \text{ cm}^3$ of soil for each square meter of soil surface area within the plume. Given an average soil bulk density of 1.5 gm/cm^3 , there is 225,000 gm of soil in each meter of soil surface. Therefore, for each mg of metal that is deposited, there is 4.44×10^{-6} mg of metal per gram of soil.

The toxicity is then determined by multiplying the plant concentration ratios by the amount of metal deposited on the soil. The potential for a reduction in plant productivity is possible when metal concentration is greater than the toxicity level. There are no values during the years 2000 and 2010 for which the metal concentration factor is greater than the reported toxic levels. However, the accumulation of metals in the soil as a result of many years of metal deposition from power plant emissions could produce metal concentration factors that may exceed toxic levels for certain plant species.

The percent yield reduction for crops resulting from ozone concentrations is determined by a relationship between the seasonal 7-h/day mean ozone concentration and crop yield, which were developed by Heck et al. (1982). There are linear relationships between ozone concentration and the percent reduction for corn, soybean, kidney bean, lettuce, spinach, turnip, and wheat crops (see Table 11.6). The ozone data used for this assessment is the incremental increase in ozone concentration at the study sites (From Chapter 5). The incremental increase is given as the increase in the seasonal 7-h day ozone concentration. Since the absolute concentration is not given, the potential change in yield for each crop was estimated by multiplying the slope for each of the linear functions in Heck et al. (1982) by the change in ozone concentration predicted for each site in the years 1991, 2000, and 2010.

At Colstrip, the seasonal 7-h average incremental increase is negative for all estimates. This provides an estimated change in yield that is negative, in other words, a positive impact. These positive effects on yields should be considered as neutral or no potential change.

At Boardman, the seasonal 7-h average incremental increase is negative for the 2010 estimates. The increase is positive for 1991 and 2000. All estimates indicate less than a 1% reduction in yield except for lettuce and turnips during 1991. A liberal estimate of potential impacts near Boardman would be that crop yield is reduced by 1% during 1991 and 2000.

At Creston, the seasonal 7-h average incremental increase is positive for the 2000 and 2010 estimates. There are no power plant emissions at this site in 1991. All estimates for the years 2000 and 2010 indicate a less than 1% reduction in yield except for turnips during 2000. A liberal estimate of potential impacts near Creston would be that crop yield is reduced by 1% during future study years.

At Centralia, the seasonal 7-h average incremental increase is negative for all estimates except for the 2000 high emission values. These estimates indicate less than a 0.1% reduction in yield. A liberal estimate of potential impacts would be that crop yield is reduced by 0.1% during future study years near Centralia.

These results are based on the projected ozone concentrations presented in Section 5. As discussed there, changes in background pollutant concentrations in future years can significantly alter the effect of power plant emissions on ozone formation.

11.3 ACID PRECIPITATION AND THE AQUATIC ENVIRONMENT

The pH of the rain and snow can effect the pH of surface waters. Changing the pH of surface waters used by fish can adversely affect fish production. In some places, low pH levels have resulted in the loss of fish populations and caused other changes to the aquatic environment. These adverse effects are related to precipitation pH levels that are less than 4.5. Because none of the estimated precipitation levels in regions with substantial surface water concentrations approach this pH level, adverse impacts to the surface water environment are expected to be negligible.

TABLE 11.1a. Acreage Under Plume from Plant Facility at Boardman

State	County	Km2 in County	KM2 in Plume	Cropland in Plume	Timber in Plume	Pasture in Plume	Major Crops in each County
Washington	Benton	4442	2433	1427	0	40	wheat, barley, oats, corn, hay, mint potatoes, asparagus, carrots, peas, onions
	Grant	6889	2541	1654	0	158	wheat, barley, oats, corn, hay, mint, beans potatoes, asparagus, carrots, peas, onions
	Franklin	3219	3219	2674	0	249	wheat, barley, oats, corn, hay, beans potatoes, asparagus, carrots, onions
	Walla Walla	3266	2524	2067	75	38	wheat, barley, oats, corn, hay, potatoes asparagus, peas, onions
	Columbia	2238	184	107	49	1	wheat, barley, oats, hay
	Whitman	5571	3867	3948	31	69	wheat, barley, oats, hay, peas
	Garfield	1829	256	192	41	1	wheat, barley, oats, hay, peas
	Adams	4978	4978	4726	0	91	wheat, barley, oats, corn, hay, mint beans, asparagus, carrots, onions
Oregon	Union	5983	2196	2197	94	30	wheat, barley, oats, hay
	Umatilla	8368	1302	465	1203	236	wheat, other grains, peas, hay orchard fruit
Idaho	Morrow	5307	173	53	0	0	wheat, potatoes, alfalfa
	Kootenai/ Shoshone	12069	1576	55	667	24	wheat, barley, lentils, bluegrass
	Benewah/ Shoshone	10888	3345	106	1742	31	wheat, barley, lentils, bluegrass
Montana	Latah	2789	1330	514	740	62	wheat, barley, peas, lentils, rape
	Mineral	3149	409	0	2	2	wheat, hay
	Sanders	7120	360	1	360	0	wheat, barley, oats, hay
Totals		68107	30692	20185	5003	991	

TABLE 11.1b. Acreage Under Plume from Plant Facility at Colstrip

State	County	Km2 in County	Km2 in Plume	Cropland In Plume	Timber In Plume	Pasture in Plume	Major Crops In County
Montana	Rosebud	13033	7049	352	285	190	Wheat, hay, corn, sugar beets
	Custer	9712	9712	340	300	125	Wheat, oats, corn
	Powder River	8508	3633	255	396	310	Oats, hay
	Carter	8581	4637	215	161	214	Wheat, hay
	Fallon	4229	3203	421	0	337	Wheat, oats
	Wibaux	2302	2302	532	20	187	Wheat, oats
	McCone	6718	4076	1534	5	272	Wheat, barley
	Prairie	4473	4473	489	0	152	Wheat, barley, corn, sugar beets
	Garfield	11901	1314	261	0	70	Wheat, barley, oats
	Richland	5348	4611	1710	12	303	Wheat, oats, corn, sugar beets
	Dawson	5478	5478	1573	17	285	Wheat, oats, corn, sugar beets
North Dakota	McKenzie	7132	5025	667	68	227	Wheat, hay, oats, barley, sugar beets, dry beans, corn
	Dunn	5182	492	90	0	66	Hay, wheat, oats, barley, corn
	Slope	3158	367	64	0	25	Wheat, barley, oats, corn, rye
	Stark	3464	711	223	0	116	Wheat, oats, barley, corn
	Golden Valley	2597	2597	499	0	134	Wheat, hay, barley, oats, corn
	Billings	2982	2767	223	0	283	Hay, wheat, oats, barley
Total		104780	62447	9448	1265	3297	

TABLE 11.1c. Acreage Under Plume from Plant Facility at Creston

State	County	Km2 in county	Km2 in plume	Cropland in Plume	Timber in Plume	Pasture in Plume	Major Crops in County
Washington	Ferry	5698	3	2	3	0	wheat, barley, oats, hay
	Stevens	6392	3018	1004	2345	104	wheat, barley, oats, potatoes
	Pend Oreille	3626	1536	107	1358	40	wheat, barley, oats, hay
	Spokane	4569	35	19	11	2	wheat, barley, oats, hay, lettuce
	Lincoln	5983	537	537	130	7	wheat, barley, oats, corn, hay
Idaho	Boundary	3284	158	12	18	373	wheat, barley, oats, hops
	Bonner	4473	565	43	614	13	wheat, barley, lentils, bluegrass
Totals		34025	5850	1724	4479	539	

TABLE 11.1d. Acreage Under Plume from Plant Facility at Centralia

State	County	Km2 in County	Km2 in Plume	Cropland in Plume	Timber in Plume	Pasture in Plume	Major Crops in County
Washington	Pacific	2352	907	54	804	10	hay
	Wahkiakum	676	737	64	635	0	corn, hay, carrots
	Cowlitz	2950	942	49	819	6	corn, hay, carrots
	Thurston	1883	1046	128	708	26	wheat, barley, oats, corn hay, peas
	Lewis	6239	3315	263	2828	103	corn, hay
	Pierce	4338	1651	90	1187	13	corn, hay, lettuce
	King	5512	536	22	387	4	corn, hay, lettuce
Oregon	Clatsop	2261	612	28	518	0	
Totals		26211	9746	698	7887	162	

TABLE 11.2. Ranges of Metal Concentrations in Fly Ash

<u>Metal</u>	<u>Fly Ash (ppm)</u>	<u>Soil (ppm)</u>	<u>Percent Composition</u>
Arsenic	2-6,300	0.1-40	0.63
Cadmium	0.7-130	0.01	0.013
Copper	14-2,800	2-250	0.28
Lead	3-5,000	2-600	0.50
Molybdenum	7-160	0.1-40	0.16
Nickel	6-4,300	2-750	0.43
Selenium	10-3,500	0.01	0.35
Zinc	10-3,500	1-900	0.35

From: Mattigod, S. V. and A. L. Page 1983.

TABLE 11.3. Maximum Air Pollutant Concentrations (in ppb) for NO_x, SO₂, and O₃

Site	NO _x , Yr 2000	NO _x , Yr 2010	SO ₂ , Yr 2000	SO ₂ , Yr 2010	O ₃ , Yr 2000	O ₃ , Yr 2010
Boardman	0.765	1.476	0.360	0.552	131	131
Centralia	1.972	2.932	0.876	0.902	151	150
Creston	0.346	0.389	0.095	0.112	112	114
Colstrip	1.308	1.967	1.109	1.243	109	107

TABLE 11.4. Estimates of Metal Deposits from Plume and Potential Plant Toxicity in 2000

Site	Metal Deposited ug/m2	Metal	Metal % of Deposited Mass	Plant Concn. Ratio	Metal Deposition (ug/m2)	Metal Concn. In Plants - ppm	Plant Toxicity -ppm	Metal Concn. minus toxicity	Plant Toxicity/ Metal Concn.
Centralia	16432	Arsenic	0.0063	4.2	103.5	0.002	0.02 to 7.5	-0.018	10.3
Creston	3350		0.0063	4.2	21.1	0.000	0.02 to 7.5	-0.020	50.8
Boardman	4297		0.0063	4.2	27.1	0.001	0.02 to 7.5	-0.019	39.6
Colstrip	14574		0.0063	4.2	91.8	0.002	0.02 to 7.5	-0.018	11.7
Centralia	16432	Cadmium	0.00013	222	2.1	0.002	0.5	-0.498	237.2
Creston	3350		0.00013	222	0.4	0.000	0.5	-0.500	1163.6
Boardman	4297		0.00013	222	0.6	0.001	0.5	-0.499	907.2
Colstrip	14574		0.00013	222	1.9	0.002	0.5	-0.498	267.5
Centralia	16432	Copper	0.0028	1000	46.0	0.204	0.5 to 10.0	-0.296	2.4
Creston	3350		0.0028	1000	9.4	0.042	0.5 to 10.0	-0.458	12.0
Boardman	4297		0.0028	1000	12.0	0.053	0.5 to 10.0	-0.447	9.4
Colstrip	14574		0.0028	1000	40.8	0.181	0.5 to 10.0	-0.319	2.8
Centralia	16432	Lead	0.005	2	82.2	0.001	3 to 20	-2.999	4107.8
Creston	3350		0.005	2	18.8	0.000	3 to 20	-3.000	20149.3
Boardman	4297		0.005	2	21.5	0.000	3 to 20	-3.000	15708.6
Colstrip	14574		0.005	2	72.9	0.001	3 to 20	-2.999	4631.5
Centralia	16432	Molybdenum	0.0018	900	26.3	0.105	0.5 to 2.0	-0.395	4.8
Creston	3350		0.0018	900	5.4	0.021	0.5 to 2.0	-0.479	23.3
Boardman	4297		0.0018	900	6.9	0.028	0.5 to 2.0	-0.472	18.2
Colstrip	14574		0.0018	900	23.3	0.093	0.5 to 2.0	-0.407	5.4
Centralia	16432	Nickel	0.0043	331	70.7	0.104	10 to 50	-9.896	96.2
Creston	3350		0.0043	331	14.4	0.021	10 to 50	-9.979	471.9
Boardman	4297		0.0043	331	18.5	0.027	10 to 50	-9.973	367.9
Colstrip	14574		0.0043	331	62.7	0.092	10 to 50	-9.908	108.5
Centralia	16432	Selenium	0.0035	4	57.5	0.001	2	-1.999	1956.1
Creston	3350		0.0035	4	11.7	0.000	2	-2.000	9594.9
Boardman	4297		0.0035	4	15.0	0.000	2	-2.000	7480.3
Colstrip	14574		0.0035	4	51.0	0.001	2	-1.999	2205.5
Centralia	16432	Zinc	0.0035	40	57.5	0.010	60 to 400	-59.990	5868.3
Creston	3350		0.0035	40	11.7	0.002	60 to 400	-59.998	28784.6
Boardman	4297		0.0035	40	15.0	0.003	60 to 400	-59.997	22440.9
Colstrip	14574		0.0035	40	51.0	0.009	60 to 400	-59.991	6616.5

TABLE 11.5. Estimates of Metal Deposits from Plume and Potential Plant Toxicity in 2010

Site	Metal Deposited ug/m2	Metal	Metal % of Deposited Mass	Plant Concen. Ratio	Metal Deposition (ug/m2)	Metal Concen. in Plants - ppm	Plant Toxicity -ppm	Metal Concen. minus toxicity	Plant Toxicity/ Metal Concen.
Centralia	17218	Arsenic	0.0063	4.2	108.5	0.002	0.02 to 7.5	-0.018	9.9
Creston	3995		0.0063	4.2	25.2	0.000	0.02 to 7.5	-0.020	42.6
Boardman	8165		0.0063	4.2	51.4	0.001	0.02 to 7.5	-0.019	20.8
Colstrip	19250		0.0063	4.2	121.3	0.002	0.02 to 7.5	-0.018	8.8
Centralia	17218	Cadmium	0.00013	222	2.2	0.002	0.5	-0.498	226.4
Creston	3995		0.00013	222	0.5	0.001	0.5	-0.499	975.8
Boardman	8165		0.00013	222	1.1	0.001	0.5	-0.499	477.4
Colstrip	19250		0.00013	222	2.5	0.002	0.5	-0.498	202.5
Centralia	17218	Copper	0.0028	1000	48.2	0.214	0.5 to 10.0	-0.286	2.3
Creston	3995		0.0028	1000	11.2	0.050	0.5 to 10.0	-0.450	10.1
Boardman	8165		0.0028	1000	22.9	0.102	0.5 to 10.0	-0.398	4.9
Colstrip	19250		0.0028	1000	53.9	0.240	0.5 to 10.0	-0.260	2.1
Centralia	17218	Lead	0.005	2	86.1	0.001	3 to 20	-2.999	3920.3
Creston	3995		0.005	2	20.0	0.000	3 to 20	-3.000	16896.1
Boardman	8165		0.005	2	40.8	0.000	3 to 20	-3.000	8267.0
Colstrip	19250		0.005	2	96.3	0.001	3 to 20	-2.999	3506.5
Centralia	17218	Molybdenum	0.0018	900	27.5	0.110	0.5 to 2.0	-0.390	4.5
Creston	3995		0.0018	900	6.4	0.026	0.5 to 2.0	-0.474	19.6
Boardman	8165		0.0018	900	13.1	0.052	0.5 to 2.0	-0.448	9.6
Colstrip	19250		0.0018	900	30.8	0.123	0.5 to 2.0	-0.377	4.1
Centralia	17218	Nickel	0.0043	331	74.0	0.109	10 to 50	-9.891	91.8
Creston	3995		0.0043	331	17.2	0.025	10 to 50	-9.975	395.7
Boardman	8165		0.0043	331	35.1	0.052	10 to 50	-9.948	193.6
Colstrip	19250		0.0043	331	82.8	0.122	10 to 50	-9.878	82.1
Centralia	17218	Selenium	0.0035	4	60.3	0.001	2	-1.999	1866.8
Creston	3995		0.0035	4	14.0	0.000	2	-2.000	8045.8
Boardman	8165		0.0035	4	28.8	0.001	2	-1.999	3936.7
Colstrip	19250		0.0035	4	67.4	0.001	2	-1.999	1669.8
Centralia	17218	Zinc	0.0035	40	60.3	0.011	60 to 400	-59.989	5600.5
Creston	3995		0.0035	40	14.0	0.002	60 to 400	-59.998	24137.3
Boardman	8165		0.0035	40	28.8	0.005	60 to 400	-59.995	11810.0
Colstrip	19250		0.0035	40	67.4	0.012	60 to 400	-59.988	5009.3

TABLE 11.6. Percent Reduction in Crop Yield Due to Incremental Increase in Ozone Concentration

crop	slope	colstrip 1991		colstrip 2000 high		colstrip 2000 low		colstrip 2010 high		colstrip 2010 low	
		Δx (ozone)	Δy (yield)	Δx (ozone)	Δy (yield)	Δx (ozone)	Δy (yield)	Δx (ozone)	Δy (yield)	Δx (ozone)	Δy (yield)
corn	108	-0.0008	-0.0864	-0.0013	-0.1404	-0.0012	-0.1296	-0.0014	-0.1512	-0.0013	-0.1404
soybean	621	-0.0008	-0.4968	-0.0013	-0.8073	-0.0012	-0.7452	-0.0014	-0.8696	-0.0013	-0.8073
soybean	443	-0.0008	-0.3544	-0.0013	-0.5759	-0.0012	-0.5316	-0.0014	-0.6202	-0.0013	-0.5759
soybean	353	-0.0008	-0.2824	-0.0013	-0.4589	-0.0012	-0.4236	-0.0014	-0.4942	-0.0013	-0.4589
kidney bean	193	-0.0008	-0.1544	-0.0013	-0.2509	-0.0012	-0.2316	-0.0014	-0.2702	-0.0013	-0.2509
lettuce	652	-0.0008	-0.5216	-0.0013	-0.8476	-0.0012	-0.7824	-0.0014	-0.9128	-0.0013	-0.8476
spinach	527	-0.0008	-0.4216	-0.0013	-0.6851	-0.0012	-0.6324	-0.0014	-0.7378	-0.0013	-0.6851
spinach	517	-0.0008	-0.4136	-0.0013	-0.6721	-0.0012	-0.6204	-0.0014	-0.7238	-0.0013	-0.6721
spinach	594	-0.0008	-0.4752	-0.0013	-0.7722	-0.0012	-0.7128	-0.0014	-0.8316	-0.0013	-0.7722
spinach	599	-0.0008	-0.4792	-0.0013	-0.7787	-0.0012	-0.7188	-0.0014	-0.8386	-0.0013	-0.7787
turnip	818	-0.0008	-0.6544	-0.0013	-1.0634	-0.0012	-0.9816	-0.0014	-1.1452	-0.0013	-1.0634
wheat	290	-0.0008	-0.232	-0.0013	-0.377	-0.0012	-0.348	-0.0014	-0.406	-0.0013	-0.377
wheat	405	-0.0008	-0.324	-0.0013	-0.5265	-0.0012	-0.486	-0.0014	-0.567	-0.0013	-0.5265
wheat	250	-0.0008	-0.2	-0.0013	-0.325	-0.0012	-0.3	-0.0014	-0.35	-0.0013	-0.325
crop	slope	boardman 1991		boardman 2000 high		boardman 2000 low		boardman 2010 high		boardman 2010 low	
		Δx (ozone)	Δy (yield)	Δx (ozone)	Δy (yield)	Δx (ozone)	Δy (yield)	Δx (ozone)	Δy (yield)	Δx (ozone)	Δy (yield)
corn	108	0.0016	0.1728	0.0004	0.0432	0.0009	0.0972	-0.0008	-0.0864	-0.0006	-0.0648
soybean	621	0.0016	0.9936	0.0004	0.2484	0.0009	0.5589	-0.0008	-0.4968	-0.0006	-0.3726
soybean	443	0.0016	0.7088	0.0004	0.1772	0.0009	0.3987	-0.0008	-0.3544	-0.0006	-0.2658
soybean	353	0.0016	0.5648	0.0004	0.1412	0.0009	0.3177	-0.0008	-0.2824	-0.0006	-0.2118
kidney bean	193	0.0016	0.3088	0.0004	0.0772	0.0009	0.1737	-0.0008	-0.1544	-0.0006	-0.1158
lettuce	652	0.0016	1.0432	0.0004	0.2608	0.0009	0.5868	-0.0008	-0.5216	-0.0006	-0.3912
spinach	527	0.0016	0.8432	0.0004	0.2108	0.0009	0.4743	-0.0008	-0.4216	-0.0006	-0.3162

TABLE 11.6. Percent Reduction in Crop Yield Due to Incremental Increase in Ozone Concentration (contd)

spinach	517	0.0016	0.8272	0.0004	0.2068	0.0009	0.4653	-0.0008	-0.4136	-0.0006	-0.3102
spinach	594	0.0016	0.9504	0.0004	0.2376	0.0009	0.5346	-0.0008	-0.4752	-0.0006	-0.3564
spinach	599	0.0016	0.9584	0.0004	0.2396	0.0009	0.5391	-0.0008	-0.4792	-0.0006	-0.3594
turnip	818	0.0016	1.3088	0.0004	0.3272	0.0009	0.7362	-0.0008	-0.6544	-0.0006	-0.4908
wheat	290	0.0016	0.464	0.0004	0.116	0.0009	0.261	-0.0008	-0.232	-0.0006	-0.174
wheat	405	0.0016	0.648	0.0004	0.162	0.0009	0.3645	-0.0008	-0.324	-0.0006	-0.243
wheat	250	0.0016	0.4	0.0004	0.1	0.0009	0.225	-0.0008	-0.2	-0.0006	-0.15
crop	slope	creston 1991		creston 2000 high		creston 2000 low		creston 2010 high		creston 2010 low	
		Ex (ozone)	Ey (yield)	Ex (ozone)	Ey (yield)	Ex (ozone)	Ey (yield)	Ex (ozone)	Ey (yield)	Ex (ozone)	Ey (yield)
corn	108	not appl.	ERR	0.001	0.108	0.0015	0.162	0.0005	0.054	0.0009	0.0972
soybean	621	not appl.	ERR	0.001	0.621	0.0015	0.9315	0.0005	0.3105	0.0009	0.5589
soybean	443	not appl.	ERR	0.001	0.443	0.0015	0.6645	0.0005	0.2215	0.0009	0.3987
soybean	353	not appl.	ERR	0.001	0.353	0.0015	0.5295	0.0005	0.1765	0.0009	0.3177
kidney bean	193	not appl.	ERR	0.001	0.193	0.0015	0.2895	0.0005	0.0965	0.0009	0.1737
lettuce	652	not appl.	ERR	0.001	0.652	0.0015	0.978	0.0005	0.326	0.0009	0.5868
spinach	527	not appl.	ERR	0.001	0.527	0.0015	0.7905	0.0005	0.2635	0.0009	0.4743
spinach	517	not appl.	ERR	0.001	0.517	0.0015	0.7755	0.0005	0.2585	0.0009	0.4653
spinach	594	not appl.	ERR	0.001	0.594	0.0015	0.891	0.0005	0.297	0.0009	0.5346
spinach	599	not appl.	ERR	0.001	0.599	0.0015	0.8985	0.0005	0.2995	0.0009	0.5391
turnip	818	not appl.	ERR	0.001	0.818	0.0015	1.227	0.0005	0.409	0.0009	0.7362
wheat	290	not appl.	ERR	0.001	0.29	0.0015	0.435	0.0005	0.145	0.0009	0.261
wheat	405	not appl.	ERR	0.001	0.405	0.0015	0.6075	0.0005	0.2025	0.0009	0.3645
wheat	250	not appl.	ERR	0.001	0.25	0.0015	0.375	0.0005	0.125	0.0009	0.225

TABLE 11.6. Percent Reduction in Crop Yield Due to Incremental Increase in Ozone Concentration (contd)

crop	slope	centralia 1991		centralia 2000 high		centralia 2000 low		centralia 2010 high		centralia 2010 low	
		Ex (ozone)	Ey (yield)	Ex (ozone)	Ey (yield)	Ex (ozone)	Ey (yield)	Ex (ozone)	Ey (yield)	Ex (ozone)	Ey (yield)
corn	108	not appl.	ERR	0.0001	0.0108	-0.0007	-0.0756	-0.0004	-0.0432	-0.0008	-0.0864
soybean	621	not appl.	ERR	0.0001	0.0621	-0.0007	-0.4347	-0.0004	-0.2484	-0.0008	-0.4968
soybean	443	not appl.	ERR	0.0001	0.0443	-0.0007	-0.3101	-0.0004	-0.1772	-0.0008	-0.3544
soybean	353	not appl.	ERR	0.0001	0.0353	-0.0007	-0.2471	-0.0004	-0.1412	-0.0008	-0.2824
kidney bean	193	not appl.	ERR	0.0001	0.0193	-0.0007	-0.1351	-0.0004	-0.0772	-0.0008	-0.1544
lettuce	652	not appl.	ERR	0.0001	0.0652	-0.0007	-0.4564	-0.0004	-0.2608	-0.0008	-0.5216
spinach	527	not appl.	ERR	0.0001	0.0527	-0.0007	-0.3689	-0.0004	-0.2108	-0.0008	-0.4216
spinach	517	not appl.	ERR	0.0001	0.0517	-0.0007	-0.3619	-0.0004	-0.2068	-0.0008	-0.4136
spinach	594	not appl.	ERR	0.0001	0.0594	-0.0007	-0.4158	-0.0004	-0.2376	-0.0008	-0.4752
spinach	599	not appl.	ERR	0.0001	0.0599	-0.0007	-0.4193	-0.0004	-0.2396	-0.0008	-0.4792
turnip	818	not appl.	ERR	0.0001	0.0818	-0.0007	-0.5726	-0.0004	-0.3272	-0.0008	-0.6544
wheat	290	not appl.	ERR	0.0001	0.029	-0.0007	-0.203	-0.0004	-0.116	-0.0008	-0.232
wheat	405	not appl.	ERR	0.0001	0.0405	-0.0007	-0.2835	-0.0004	-0.162	-0.0008	-0.324
wheat	250	not appl.	ERR	0.0001	0.025	-0.0007	-0.175	-0.0004	-0.1	-0.0008	-0.2

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APPENDIX A

AVERAGE SEASONAL POLLUTANT EMISSION RATES

APPENDIX A

AVERAGE SEASONAL POLLUTANT EMISSION RATES

In this appendix, we present average seasonal pollutant emission rates for each resource alternative, study year, and release site. Separate emission rates are provided for releases from both 150 m (coal plants) and 30 m (natural gas plants). All emission rates are provided in units of grams per second. The abbreviation "COL" stands for Colstrip, "CRS" for Creston, "BDM" for Boardman, and "CEN" for Centralia.

ALL RESOURCE ALTERNATIVES

YEAR: 1991

SEASDN /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO _x HI STACK	NO _x LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	1264.59	.00	1678.02	.00	65.04	.00
CRS	.00	.00	.00	.00	.00	.00
BDM	389.76	.00	517.19	.00	20.05	.00
CEN	839.74	.00	1114.28	.00	43.19	.00
JAN-APR						
COL	1089.44	.00	1445.62	.00	56.03	.00
CRS	.00	.00	.00	.00	.00	.00
BDM	179.24	.00	237.85	.00	9.22	.00
CEN	677.96	.00	899.61	.00	34.87	.00
MAY						
COL	301.68	.00	400.31	.00	15.52	.00
CRS	.00	.00	.00	.00	.00	.00
BDM	102.21	.00	135.62	.00	5.26	.00
CEN	152.00	.00	201.69	.00	7.82	.00
JUN-AUG						
COL	1104.88	.00	1466.10	.00	56.83	.00
CRS	.00	.00	.00	.00	.00	.00
BDM	188.40	.00	249.99	.00	9.69	.00
CEN	638.08	.00	846.69	.00	32.82	.00

RESOURCE ALTERNATIVE: STATUS QUO

YEAR: 2000

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	1649.57	.00	1832.02	.00	88.14	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	452.31	70.79	600.18	.40	23.26	.40
CEN	858.55	253.27	1139.24	1.45	44.16	1.45
JAN-APR						
COL	1681.20	.00	1873.99	.00	89.77	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	344.00	70.79	456.46	.40	17.69	.40
CEN	839.74	184.70	1114.28	1.06	43.19	1.07
MAY						
COL	759.22	.00	739.95	.00	41.52	.00
CRS	272.85	.00	109.14	.00	16.37	.00
BDM	255.52	70.79	339.06	.40	13.14	.40
CEN	246.05	157.06	326.50	.90	12.65	.90
JUN-AUG						
COL	1685.15	.00	1879.86	.00	89.96	.00
CRS	294.84	.00	117.94	.00	17.69	.00
BDM	383.66	70.79	509.09	.40	19.73	.40
CEN	772.77	177.44	1025.42	1.01	39.74	1.01

RESOURCE ALTERNATIVE: STATUS QUO

YEAR: 2010

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	2418.84	.00	2139.73	.00	134.29	.00
CRS	484.93	.00	193.97	.00	29.10	.00
BDM	838.37	194.66	755.31	1.11	46.42	1.11
CEN	858.55	397.69	1139.24	2.28	44.16	3.15
JAN-APR						
COL	2450.48	.00	2181.70	.00	135.92	.00
CRS	480.40	.00	192.16	.00	28.82	.00
BDM	710.70	194.66	589.71	1.11	39.82	1.11
CEN	858.55	303.71	1139.24	1.74	44.16	2.06
MAY						
COL	1452.54	.00	1028.01	.00	83.02	.00
CRS	228.24	.00	91.30	.00	13.69	.00
BDM	323.88	194.66	273.07	1.11	18.11	1.11
CEN	221.22	251.07	293.55	1.43	11.38	1.43
JUN-AUG						
COL	2482.11	.00	2223.68	.00	137.55	.00
CRS	484.93	.00	193.97	.00	29.10	.00
BDM	833.03	194.66	748.23	1.11	46.15	1.11
CEN	859.30	292.59	1140.24	1.67	44.20	1.90

RESOURCE ALTERNATIVE: BASE CASE 4

YEAR: 2000

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	1649.57	.00	1832.02	.00	88.14	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	452.31	70.79	600.18	.40	23.26	.40
CEN	858.55	249.84	1139.24	1.43	44.16	1.43
JAN-APR						
COL	1681.20	.00	1873.99	.00	89.77	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	344.00	70.79	456.46	.40	17.69	.40
CEN	839.74	209.58	1114.28	1.20	43.19	1.20
MAY						
COL	768.72	.00	748.76	.00	42.04	.00
CRS	276.73	.00	110.69	.00	16.60	.00
BDM	258.57	70.79	343.10	.40	13.30	.40
CEN	249.82	170.33	331.49	.97	12.85	.97
JUN-AUG						
COL	1667.58	.00	1857.81	.00	89.05	.00
CRS	290.96	.00	116.38	.00	17.46	.00
BDM	369.93	70.79	490.87	.40	19.03	.40
CEN	759.23	186.53	1007.44	1.07	39.05	1.07

RESOURCE ALTERNATIVE: BASE CASE 4

YEAR: 2010

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	2162.42	.00	2037.16	.00	118.91	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	837.60	194.66	754.30	1.11	46.38	1.11
CEN	858.55	448.05	1139.24	2.57	44.16	3.45
JAN-APR						
COL	2194.05	.00	2079.13	.00	120.54	.00
CRS	353.03	.00	141.21	.00	21.18	.00
BDM	707.75	194.66	592.77	1.11	39.60	1.11
CEN	855.54	352.72	1135.25	2.02	44.00	2.25
MAY						
COL	1159.17	.00	904.94	.00	65.47	.00
CRS	152.59	.00	61.04	.00	9.16	.00
BDM	304.14	194.66	253.87	1.11	17.03	1.11
CEN	249.06	300.84	330.49	1.72	12.81	1.72
JUN-AUG						
COL	2225.68	.00	2121.11	.00	122.16	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	837.60	194.66	754.30	1.11	46.38	1.11
CEN	859.30	342.20	1140.24	1.96	44.20	2.19

RESOURCE ALTERNATIVE: CONSERVATION

YEAR: 2000

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (q/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	1649.57	.00	1832.02	.00	88.14	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	452.31	70.79	600.18	.40	23.26	.40
CEN	858.55	249.84	1139.24	1.43	44.16	1.43
JAN-APR						
COL	1681.20	.00	1873.99	.00	89.77	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	344.00	70.79	456.46	.40	17.69	.40
CEN	839.74	192.88	1114.28	1.10	43.19	1.10
MAY						
COL	768.72	.00	748.76	.00	42.04	.00
CRS	276.73	.00	110.69	.00	16.60	.00
BDM	258.57	70.79	343.10	.40	13.30	.40
CEN	249.82	170.33	331.49	.97	12.85	.97
JUN-AUG						
COL	1667.58	.00	1857.81	.00	89.05	.00
CRS	290.96	.00	116.38	.00	17.46	.00
BDM	369.93	70.79	490.87	.40	19.03	.40
CEN	759.23	186.53	1007.44	1.07	39.05	1.07

RESOURCE ALTERNATIVE: CONSERVATION

YEAR: 2010

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (q/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	2162.42	.00	2037.16	.00	118.91	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	837.60	194.66	754.30	1.11	46.38	1.11
CEN	858.55	448.05	1139.24	2.57	44.16	3.45
JAN-APR						
COL	2194.05	.00	2079.13	.00	120.54	.00
CRS	353.03	.00	141.21	.00	21.18	.00
BDM	707.75	194.66	592.77	1.11	39.60	1.11
CEN	855.54	352.47	1135.25	2.02	44.00	2.23
MAY						
COL	1159.17	.00	904.94	.00	65.47	.00
CRS	152.59	.00	61.04	.00	9.16	.00
BDM	304.14	194.66	253.87	1.11	17.03	1.11
CEN	249.06	300.84	330.49	1.72	12.81	1.72
JUN-AUG						
COL	2225.68	.00	2121.11	.00	122.16	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	837.60	194.66	754.30	1.11	46.38	1.11
CEN	859.30	342.20	1140.24	1.96	44.20	2.19

RESOURCE ALTERNATIVE: CONVENTIONAL COAL

YEAR: 2000

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	1905.99	.00	1934.59	.00	103.52	.00
CRS	484.93	.00	193.97	.00	29.10	.00
BDM	710.39	70.79	704.12	.40	38.74	.40
CEN	985.84	228.52	1190.16	1.31	51.79	1.31
JAN-APR						
COL	1937.63	.00	1976.56	.00	105.15	.00
CRS	417.04	.00	166.82	.00	25.02	.00
BDM	515.70	70.79	481.31	.40	28.40	.40
CEN	958.81	179.17	1175.86	1.02	50.20	1.04
MAY						
COL	1039.70	.00	892.19	.00	57.98	.00
CRS	200.44	.00	80.13	.00	12.03	.00
BDM	292.21	70.79	295.76	.40	15.88	.40
CEN	301.48	160.38	369.59	.92	15.79	.92
JUN-AUG						
COL	1955.37	.00	2000.11	.00	106.06	.00
CRS	337.51	.00	135.00	.00	20.25	.00
BDM	494.34	70.79	496.09	.40	26.90	.40
CEN	860.98	173.40	1073.95	.99	44.91	.99

RESOURCE ALTERNATIVE: CONVENTIONAL COAL

YEAR: 2010

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	2418.84	.00	2139.73	.00	134.29	.00
CRS	484.93	.00	193.97	.00	29.10	.00
BDM	1095.01	190.24	857.97	1.09	61.82	1.09
CEN	986.53	343.50	1190.43	1.97	51.84	1.97
JAN-APR						
COL	2450.48	.00	2181.70	.00	135.92	.00
CRS	484.93	.00	193.97	.00	29.10	.00
BDM	949.76	190.24	681.09	1.09	54.20	1.09
CEN	970.86	281.53	1184.86	1.61	50.89	1.61
MAY						
COL	1779.99	.00	1292.01	.00	101.44	.00
CRS	218.54	.00	87.42	.00	13.11	.00
BDM	369.92	190.24	280.89	1.09	20.97	1.09
CEN	248.53	249.97	303.77	1.43	13.02	1.43
JUN-AUG						
COL	2482.11	.00	2223.68	.00	137.55	.00
CRS	484.93	.00	193.97	.00	29.10	.00
BDM	1077.64	190.24	842.54	1.09	60.85	1.09
CEN	975.65	276.69	1186.78	1.58	51.18	1.58

RESOURCE ALTERNATIVE: CLEAN COAL

YEAR: 2000

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (q/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	1696.22	.00	1855.63	.00	92.40	.00
CRS	410.67	.00	169.22	.00	26.10	.00
BDM	479.77	70.79	617.13	.40	26.29	.40
CEN	858.55	261.82	1139.24	1.50	44.16	2.14
JAN-APR						
COL	1727.85	.00	1897.60	.00	94.02	.00
CRS	365.07	.00	150.66	.00	23.28	.00
BDM	340.33	70.79	434.79	.40	18.90	.40
CEN	854.79	187.55	1134.25	1.07	43.96	1.20
MAY						
COL	868.03	.00	827.59	.00	48.88	.00
CRS	177.00	.00	73.18	.00	11.35	.00
BDM	187.25	70.79	242.63	.40	10.12	.40
CEN	268.63	157.06	356.45	.90	13.82	.90
JUN-AUG						
COL	1748.69	.00	1925.25	.00	95.10	.00
CRS	320.90	.00	132.33	.00	20.44	.00
BDM	374.84	70.79	485.45	.40	20.27	.40
CEN	788.57	176.53	1046.38	1.01	40.56	1.17

RESOURCE ALTERNATIVE: CLEAN COAL

YEAR: 2010

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (q/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	2209.07	.00	2060.77	.00	123.17	.00
CRS	410.67	.00	169.22	.00	26.10	.00
BDM	902.78	70.79	784.18	.40	51.80	.40
CEN	878.17	250.43	1146.71	1.43	45.39	1.43
JAN-APR						
COL	2240.70	.00	2102.74	.00	124.80	.00
CRS	410.03	.00	168.96	.00	26.06	.00
BDM	734.44	70.79	597.96	.40	42.77	.40
CEN	878.92	188.63	1147.71	1.08	45.43	1.08
MAY						
COL	1570.22	.00	1213.05	.00	90.31	.00
CRS	181.80	.00	75.14	.00	11.62	.00
BDM	343.80	70.79	352.96	.40	19.12	.40
CEN	255.62	157.06	330.14	.90	13.26	.90
JUN-AUG						
COL	2272.34	.00	2144.72	.00	126.42	.00
CRS	410.67	.00	169.22	.00	26.10	.00
BDM	875.09	70.79	761.15	.40	50.26	.40
CEN	878.92	182.95	1147.71	1.05	45.43	1.05

RESOURCE ALTERNATIVE: NUCLEAR

YEAR: 2000

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	1649.57	.00	1832.02	.00	88.14	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	452.31	63.04	600.18	.36	23.26	.36
CEN	858.55	187.84	1139.24	1.07	44.16	1.07
JAN-APR						
COL	1681.20	.00	1873.99	.00	89.77	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	344.00	63.04	456.46	.36	17.69	.36
CEN	835.98	161.03	1109.29	.92	43.00	1.01
MAY						
COL	798.86	.00	777.98	.00	43.69	.00
CRS	287.73	.00	115.09	.00	17.26	.00
BDM	269.25	63.04	357.27	.36	13.85	.36
CEN	261.85	151.26	347.46	.86	13.47	.86
JUN-AUG						
COL	1634.66	.00	1816.04	.00	87.34	.00
CRS	261.22	.00	104.49	.00	15.67	.00
BDM	348.57	63.04	462.53	.36	17.93	.36
CEN	738.91	157.10	980.49	.90	38.00	.90

RESOURCE ALTERNATIVE: NUCLEAR

YEAR: 2010

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	2162.42	.00	2037.16	.00	118.91	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	838.37	200.19	755.31	1.14	46.42	1.14
CEN	858.55	451.05	1139.24	2.58	44.16	3.45
JAN-APR						
COL	2194.05	.00	2079.13	.00	120.54	.00
CRS	353.03	.00	141.21	.00	21.18	.00
BDM	707.75	200.19	592.77	1.14	39.60	1.14
CEN	855.54	358.99	1135.25	2.05	44.00	2.36
MAY						
COL	1174.23	.00	916.68	.00	66.32	.00
CRS	163.58	.00	65.43	.00	9.81	.00
BDM	326.46	200.19	272.69	1.14	18.27	1.14
CEN	252.83	305.27	335.48	1.74	13.00	1.74
JUN-AUG						
COL	2225.68	.00	2121.11	.00	122.16	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	838.37	200.19	755.31	1.14	46.42	1.14
CEN	859.30	346.45	1140.24	1.98	44.20	2.21

RESOURCE ALTERNATIVE: COMBUSTION TURBINE

YEAR: 2000

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	1649.57	.00	1832.02	.00	88.14	.00
CRS	364.02	39.75	145.61	.23	21.84	.23
BDM	452.31	70.79	600.18	.40	23.26	.40
CEN	858.55	265.39	1139.24	1.52	44.16	1.52
JAN-APR						
COL	1681.20	.00	1873.99	.00	89.77	.00
CRS	364.02	19.54	145.61	.11	21.84	.11
BDM	344.00	70.79	456.46	.40	17.69	.40
CEN	839.74	245.34	1114.28	1.40	43.19	1.40
MAY						
COL	778.99	.00	758.59	.00	42.61	.00
CRS	281.26	.00	112.50	.00	16.88	.00
BDM	262.38	70.79	348.17	.40	13.49	.40
CEN	252.83	225.63	335.48	1.29	13.00	1.29
JUN-AUG						
COL	1667.58	.00	1857.81	.00	89.05	.00
CRS	290.96	8.35	116.38	.05	17.46	.05
BDM	369.93	70.79	490.87	.40	19.03	.40
CEN	759.23	234.15	1007.44	1.34	39.05	1.34

RESOURCE ALTERNATIVE: COMBUSTION TURBINE

YEAR: 2010

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	2162.42	.00	2037.16	.00	118.91	.00
CRS	364.02	67.31	145.61	.39	21.84	.39
BDM	837.60	194.66	754.30	1.11	46.38	1.11
CEN	858.55	380.74	1139.24	2.18	44.16	3.07
JAN-APR						
COL	2194.05	.00	2079.13	.00	120.54	.00
CRS	353.03	24.22	141.21	.14	21.18	.14
BDM	707.75	194.66	592.77	1.11	39.60	1.11
CEN	855.54	328.25	1135.25	1.88	44.00	2.09
MAY						
COL	1159.17	.00	904.94	.00	65.47	.00
CRS	152.59	.00	61.04	.00	9.16	.00
BDM	304.14	194.66	253.87	1.11	17.03	1.11
CEN	249.06	300.84	330.49	1.72	12.81	1.72
JUN-AUG						
COL	2225.68	.00	2121.11	.00	122.16	.00
CRS	364.02	19.04	145.61	.11	21.84	.11
BDM	837.60	194.66	754.30	1.11	46.38	1.11
CEN	859.30	323.16	1140.24	1.85	44.20	2.08

RESOURCE ALTERNATIVE: RENEWABLES

YEAR: 2000

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	1649.57	.00	1832.02	.00	88.14	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	452.31	70.79	600.18	.40	23.26	.40
CEN	858.55	290.44	1139.24	1.66	44.16	1.82
JAN-APR						
COL	1681.20	.00	1873.99	.00	89.77	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	344.00	70.79	456.46	.40	17.69	.40
CEN	839.74	195.90	1114.28	1.12	43.19	1.21
MAY						
COL	850.41	.00	828.64	.00	46.51	.00
CRS	305.83	.00	122.33	.00	18.35	.00
BDM	285.27	70.79	378.53	.40	14.67	.40
CEN	278.41	163.57	369.43	.93	14.32	.93
JUN-AUG						
COL	1683.52	.00	1877.06	.00	89.88	.00
CRS	285.79	.00	114.31	.00	17.15	.00
BDM	352.39	70.79	467.59	.40	18.12	.40
CEN	756.97	180.19	1004.45	1.03	38.93	1.08

RESOURCE ALTERNATIVE: RENEWABLES

YEAR: 2010

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	2162.42	.00	2037.16	.00	118.91	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	838.37	194.66	755.31	1.11	46.42	1.11
CEN	858.55	427.64	1139.24	2.45	44.16	3.34
JAN-APR						
COL	2194.05	.00	2079.13	.00	120.54	.00
CRS	353.03	.00	141.21	.00	21.18	.00
BDM	707.75	194.66	592.77	1.11	39.60	1.11
CEN	856.29	332.47	1136.25	1.90	44.04	2.10
MAY						
COL	1163.96	.00	906.85	.00	65.76	.00
CRS	163.58	.00	65.43	.00	9.81	.00
BDM	325.69	194.66	271.68	1.11	18.23	1.11
CEN	250.57	280.93	332.49	1.61	12.89	1.61
JUN-AUG						
COL	2225.68	.00	2121.11	.00	122.16	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	838.37	194.66	755.31	1.11	46.42	1.11
CEN	859.30	322.54	1140.24	1.84	44.20	2.09

RESOURCE ALTERNATIVE: COGENERATION

YEAR: 2000

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (q/s)					
	NO _x		SO ₂		TSP	
	HI STACK	LO STACK	HI STACK	LO STACK	HI STACK	LO STACK
SEP-DEC						
COL	1649.57	.00	1832.02	.00	88.14	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	452.31	139.36	600.18	.80	23.26	.80
CEN	857.80	283.18	1138.24	1.62	44.12	1.67
JAN-APR						
COL	1681.20	.00	1873.99	.00	89.77	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	344.00	139.36	456.46	.80	17.69	.80
CEN	767.50	241.59	1018.43	1.38	39.47	1.47
MAY						
COL	818.73	.00	797.37	.00	44.78	.00
CRS	294.84	.00	117.94	.00	17.69	.00
BDM	276.11	139.36	366.38	.80	14.20	.80
CEN	270.13	227.14	358.45	1.30	13.89	1.30
JUN-AUG						
COL	1549.65	.00	1713.38	.00	82.87	.00
CRS	239.23	.00	95.69	.00	14.35	.00
BDM	308.91	139.36	409.90	.80	15.89	.80
CEN	673.45	235.49	893.62	1.35	34.64	1.38

RESOURCE ALTERNATIVE: COGENERATION

YEAR: 2010

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (q/s)					
	NO _x		SO ₂		TSP	
	HI STACK	LO STACK	HI STACK	LO STACK	HI STACK	LO STACK
SEP-DEC						
COL	2162.42	.00	2037.16	.00	118.91	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	838.37	249.97	755.31	1.43	46.42	1.43
CEN	858.55	399.14	1139.24	2.28	44.16	2.32
JAN-APR						
COL	2194.05	.00	2079.13	.00	120.54	.00
CRS	353.03	.00	141.21	.00	21.18	.00
BDM	707.75	249.97	592.77	1.43	39.60	1.43
CEN	855.54	354.21	1135.25	2.03	44.00	2.03
MAY						
COL	1105.67	.00	859.94	.00	62.48	.00
CRS	145.48	.00	58.19	.00	8.73	.00
BDM	289.75	249.97	241.75	1.43	16.22	1.43
CEN	235.52	305.27	312.52	1.74	12.11	1.74
JUN-AUG						
COL	2225.68	.00	2121.11	.00	122.16	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	833.03	249.97	748.23	1.43	46.15	1.43
CEN	859.30	329.82	1140.24	1.89	44.20	1.89

RESOURCE ALTERNATIVE: FUEL SWITCHING

YEAR: 2000

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (q/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	1649.57	.00	1832.02	.00	88.14	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	452.31	70.79	600.18	.40	23.26	.40
CEN	857.80	315.53	1138.24	1.81	44.12	2.63
JAN-APR						
COL	1681.20	.00	1873.99	.00	89.77	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	344.00	70.79	456.46	.40	17.69	.40
CEN	839.74	214.02	1114.28	1.22	43.19	1.38
MAY						
COL	869.51	.00	847.00	.00	47.56	.00
CRS	312.94	.00	125.18	.00	18.78	.00
BDM	292.13	70.79	387.64	.40	15.02	.40
CEN	284.43	171.83	377.42	.98	14.63	.98
JUN-AUG						
COL	1702.81	.00	1902.66	.00	90.88	.00
CRS	294.84	.00	117.94	.00	17.69	.00
BDM	379.85	70.79	504.03	.40	19.54	.40
CEN	771.27	196.32	1023.42	1.12	39.67	1.32

RESOURCE ALTERNATIVE: FUEL SWITCHING

YEAR: 2010

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (q/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	2162.42	.00	2037.16	.00	118.91	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	837.60	194.66	754.30	1.11	46.38	1.11
CEN	858.55	393.24	1139.24	2.25	44.16	2.77
JAN-APR						
COL	2194.05	.00	2079.13	.00	120.54	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	707.75	194.66	592.77	1.11	39.60	1.11
CEN	855.54	305.54	1135.25	1.75	44.00	2.01
MAY						
COL	1196.81	.00	931.44	.00	67.62	.00
CRS	312.94	.00	125.18	.00	18.78	.00
BDM	355.93	194.66	297.21	1.11	19.92	1.11
CEN	259.60	255.50	344.47	1.46	13.35	1.46
JUN-AUG						
COL	2215.65	.00	2107.80	.00	121.65	.00
CRS	294.84	.00	117.94	.00	17.69	.00
BDM	837.60	194.66	754.30	1.11	46.38	1.11
CEN	859.30	298.18	1140.24	1.71	44.20	1.90

RESOURCE ALTERNATIVE: HIGH CONSERVATION

YEAR: 2000

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	1649.57	.00	1832.02	.00	88.14	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	451.54	70.79	599.17	.40	23.22	.40
CEN	858.55	308.74	1139.24	1.77	44.16	2.21
JAN-APR						
COL	1681.20	.00	1873.99	.00	89.77	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	344.00	70.79	456.46	.40	17.69	.40
CEN	847.26	211.09	1124.26	1.21	43.58	1.31
MAY						
COL	869.51	.00	847.00	.00	47.56	.00
CRS	312.94	.00	125.18	.00	18.78	.00
BDM	292.13	70.79	387.64	.40	15.02	.40
CEN	285.18	176.34	378.42	1.01	14.67	1.01
JUN-AUG						
COL	1688.15	.00	1883.21	.00	90.12	.00
CRS	285.79	.00	114.31	.00	17.15	.00
BDM	371.46	70.79	492.90	.40	19.10	.40
CEN	762.99	194.81	1012.44	1.11	39.24	1.24

RESOURCE ALTERNATIVE: HIGH CONSERVATION

YEAR: 2010

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	2162.42	.00	2037.16	.00	118.91	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	836.84	194.66	753.29	1.11	46.34	1.11
CEN	858.55	365.59	1139.24	2.09	44.16	2.09
JAN-APR						
COL	2194.05	.00	2079.13	.00	120.54	.00
CRS	353.03	.00	141.21	.00	21.18	.00
BDM	707.75	194.66	592.77	1.11	39.60	1.11
CEN	855.54	292.19	1135.25	1.67	44.00	1.76
MAY						
COL	1163.27	.00	906.58	.00	65.72	.00
CRS	149.36	.00	59.74	.00	8.96	.00
BDM	296.91	194.66	247.44	1.11	16.63	1.11
CEN	249.06	252.18	330.49	1.44	12.81	1.44
JUN-AUG						
COL	2225.68	.00	2121.11	.00	122.16	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	836.84	194.66	753.29	1.11	46.34	1.11
CEN	859.30	285.68	1140.24	1.63	44.20	1.79

RESOURCE ALTERNATIVE: IMPORTS

YEAR: 2000

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	1649.57	.00	1832.02	.00	88.14	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	452.31	79.65	600.18	.46	23.26	.46
CEN	858.55	392.78	1139.24	2.16	44.16	6.60
JAN-APR						
COL	1681.20	.00	1873.99	.00	89.77	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	344.00	69.84	456.46	.40	17.69	.40
CEN	855.54	222.11	1135.25	1.24	44.00	2.60
MAY						
COL	829.77	.00	808.22	.00	45.38	.00
CRS	298.72	.00	119.49	.00	17.92	.00
BDM	279.16	63.04	370.43	.36	14.36	.36
CEN	279.16	149.32	370.43	.85	14.36	.85
JUN-AUG						
COL	1696.90	.00	1896.72	.00	90.56	.00
CRS	335.57	.00	134.23	.00	20.13	.00
BDM	417.98	67.32	554.64	.38	21.50	.38
CEN	833.72	165.64	1106.29	.95	42.88	1.53

RESOURCE ALTERNATIVE: IMPORTS

YEAR: 2010

SEASON /SITE	AVERAGE SEASONAL POLLUTANT EMISSION RATES (g/s)					
	NO HI STACK	NO LO STACK	SO ₂ HI STACK	SO ₂ LO STACK	TSP HI STACK	TSP LO STACK
SEP-DEC						
COL	2162.42	.00	2037.16	.00	118.91	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	837.60	328.15	754.30	1.88	46.38	1.88
CEN	858.55	704.11	1139.24	3.92	44.16	9.58
JAN-APR						
COL	2194.05	.00	2079.13	.00	120.54	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	729.30	231.27	610.58	1.32	40.81	1.32
CEN	859.30	458.99	1140.24	2.58	44.20	5.02
MAY						
COL	1523.56	.00	1189.44	.00	86.05	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	724.72	179.18	604.51	1.02	40.57	1.02
CEN	352.15	236.69	467.28	1.35	18.11	1.35
JUN-AUG						
COL	2225.68	.00	2121.11	.00	122.16	.00
CRS	364.02	.00	145.61	.00	21.84	.00
BDM	837.60	237.06	754.30	1.36	46.38	1.36
CEN	859.30	341.84	1140.24	1.96	44.20	3.38

APPENDIX B

SAMPLE ISCST MODEL RUN

APPENDIX B

SAMPLE ISCST MODEL RUN

In this appendix, we present the output file from a sample ISCST model run. This output presents air quality impacts on the expanded Cartesian grid for NO_x emissions from Centralia. Specifically, the file contains information on model parameters, winds, and pollutant concentrations. In this file, the ISCST model reports the "N-DAY" average, highest 1-h, highest 3-h, highest 8-h, and highest 24-h concentration of NO_x at each model grid point. "N-Day" average results are used to compute annual pollutant concentrations for NO_x and TSP. "24-h" concentrations are used to compute maximum 24-h pollutant concentrations for TSP. The 1-h, 3-h, and 8-h values for NO_x are not used in our study.

```

15CST      (DATE 90346)

*** SITE 1, 250M STACK, NOX, FAL, LARGE GRID ***

CALCULATE (CONCENTRATION=1, DEPOSITION=2)
RECEPION GRID SYSTEM (RECTANGULAR=1 OR 3, POLAR=2 OR 4)
DISCRETE RECEPION SYSTEM (RECTANGULAR=1, POLAR=2)
ELEVATIONS ARE READ (YES=1, NO=0)
CALCULATIONS ARE WRITTEN TO TAP (YES=1, NO=0)
LIST ALL INPUT DATA (NO=0, YES=1, MET DATA ALSO=2)

COMPUTE AVERAGE CONCENTRATION (OR TOTAL DEPOSITION)
WITH THE FOLLOWING TIME PERIODS:
HOURS (YES=1, NO=0)
2-HOUR (YES=1, NO=0)
3-HOUR (YES=1, NO=0)
4-HOUR (YES=1, NO=0)
6-HOUR (YES=1, NO=0)
8-HOUR (YES=1, NO=0)
12-HOUR (YES=1, NO=0)
24-HOUR (YES=1, NO=0)
PRINT 'N'-DAY TABLE(S) (YES=1, NO=0)

PRINT THE FOLLOWING TYPES OF TABLES WHOSE TIME PERIODS ARE
SPECIFIED BY ISM(7) THROUGH ISM(14):
DAILY TABLES (YES=1, NO=0)
HIGHEST & SECOND HIGHEST TABLES (YES=1, NO=0)
MAXIMUM TO TABLES (YES=1, NO=0)
METEOROLOGICAL DATA INPUT METHOD (PRE-PROCESSED=1, CARD=2)
RURAL-URBAN OPTION (RU=0, UR, MODE 1=1, UR, MODE 2=2, UR, MODE 3=3)
WIND PROFILE EXPONENT VALUES (DEFAULTS=1, USER ENTERED=2, 3)
VERTICAL POT. TEMP. GRADIENT VALUES (DEFAULTS=1, USER ENTERED=2, 3)
SCALE EMISSION RATES FOR ALL SOURCES (NO=0, YES=1)
PROGRAM CALCULATES FINAL PLUME RISE ONLY (YES=1, NO=2)
PROGRAM ADJUSTS ALL STACK HEIGHTS FOR DOWNWIND (YES=2, NO=1)
PROGRAM USES BUOYANCY INDUCED DISPERSION (YES=1, NO=2)
CONCENTRATIONS DURING EACH PERIOD SET = 0 (YES=1, NO=2)
REG. DEFAULT OPTION CHOSEN (YES=1, NO=2)
TYPE OF POLLUTANT TO BE MODELLED (1=SO2, 2=OTHER)
DEBUG OPTION CHOSEN (YES=1, NO=2)
ABOVE GROUND (FLAGDLE) RECEPIONS USED (YES=1, NO=0)

NUMBER OF INPUT SOURCES
NUMBER OF SOURCE GROUPS (=0, ALL SOURCES)
TIME PERIOD INTERVAL TO BE PRINTED (=0, ALL INTERVALS)
NUMBER OF X (RANGE) GRID VALUES
NUMBER OF Y (RANGE) GRID VALUES
NUMBER OF DISCRETE RECEPIONS
NUMBER OF HOURS PER DAY IN METEOROLOGICAL DATA
NUMBER OF DAYS OF METEOROLOGICAL DATA
SOURCE EMISSION RATE UNITS CONVERSION FACTOR
HEIGHT ABOVE GROUND AT WHICH WIND SPEED WAS MEASURED
LOGICAL UNIT NUMBER OF METEOROLOGICAL DATA
ALLOCATED DATA STORAGE
REQUIRED DATA STORAGE FOR THIS PROBLEM RUN

ISM(1) = 1
ISM(2) = 3
ISM(3) = 1
ISM(4) = 1
ISM(5) = 0
ISM(6) = 1

ISM(7) = 1
ISM(8) = 0
ISM(9) = 1
ISM(10) = 0
ISM(11) = 0
ISM(12) = 1
ISM(13) = 0
ISM(14) = 1
ISM(15) = 1

ISM(16) = 0
ISM(17) = 1
ISM(18) = 0
ISM(19) = 2
ISM(20) = 0
ISM(21) = 1
ISM(22) = 1
ISM(23) = 0
ISM(24) = 2
ISM(25) = 2
ISM(26) = 1
ISM(27) = 2
ISM(28) = 2
ISM(29) = 2
ISM(30) = 2
ISM(31) = 0

NSOURC = 1
NGROUP = 0
ZPRD = 0
NXPRTS = 1
NXPRTS = 1
NXPRTS = 0
NHOURS = 24
NDAYS = 365
IC = 100000007
ZR = 1000 METERS
IMEI = 1
LIMT = 43500 WORDS
NIMT = 43500 WORDS

*** SITE 1, 250M STACK, NOX, FAL, LARGE GRID ***

*** UPPER BOUND OF FIRST THROUGH FIFTH WIND SPEED CATEGORIES ***
(METERS/SEC)

1 54. 3 08 5 14. 8 23 10 30.

*** WIND PROFILE EXPONENTS ***

STABILITY CATEGORY      1      2      3      4      5      6
A      70000E-01      70000E-01      70000E-01      70000E-01      70000E-01      70000E-01
B      70000E-01      70000E-01      70000E-01      70000E-01      70000E-01      70000E-01
C      10000E+00      10000E+00      10000E+00      10000E+00      10000E+00      10000E+00
D      15000E+00      15000E+00      15000E+00      15000E+00      15000E+00      15000E+00
E      35000E+00      35000E+00      35000E+00      35000E+00      35000E+00      35000E+00
F      55000E+00      55000E+00      55000E+00      55000E+00      55000E+00      55000E+00

*** VERTICAL POTENTIAL TEMPERATURE GRADIENTS ***
(DEGREES KELVIN PER METER)

STABILITY CATEGORY      1      2      3      4      5      6
A      00000E+00      00000E+00      00000E+00      00000E+00      00000E+00      00000E+00
B      00000E+00      00000E+00      00000E+00      00000E+00      00000E+00      00000E+00
C      00000E+00      00000E+00      00000E+00      00000E+00      00000E+00      00000E+00
D      00000E+00      00000E+00      00000E+00      00000E+00      00000E+00      00000E+00
E      00000E+00      00000E+00      00000E+00      00000E+00      00000E+00      00000E+00
F      00000E+00      00000E+00      00000E+00      00000E+00      00000E+00      00000E+00

*** X-COORDINATES OF RECTANGULAR GRID SYSTEM ***
(METERS)

0. 20000.0. 40000.0. 60000.0. 80000.0. 100000.0. 120000.0. 140000.0. 160000.0. 180000.0.
200000.0. 220000.0. 240000.0. 260000.0. 280000.0. 300000.0. 320000.0

*** Y-COORDINATES OF RECTANGULAR GRID SYSTEM ***
(METERS)

0. 20000.0. 40000.0. 60000.0. 80000.0. 100000.0. 120000.0. 140000.0. 160000.0. 180000.0.
200000.0. 220000.0. 240000.0. 260000.0. 280000.0. 300000.0. 320000.0.

```

```

*** SITE 1,150M STACK, WIND, FALL, LARGE GRID ***
*** SOURCE DATA ***
EMISSION RATE      TEMP      EXIST VEL.
TYPE=0,1          TYPE=0      TYPE=0
(GRAMS/SEC)      (DIG. K)    (M/SEC)
Y & NUMBER        VERT. DTM  HORIZ. DTM  DIAMETER  HEIGHT  LENGTH  BLDG.  BLDG.  BLDG.
SOURCE # & PART  (GRAMS/SEC)  X      Y      ELEV.  HEIGHT  TYPE=1  TYPE=1,2  TYPE=0  TYPE=0  TYPE=0
NUMBER & S. CATS  (METER=2) (METERS) (METERS) (METERS) (METERS) (METERS) (METERS) (METERS) (METERS) (METERS)

1  D  0  .10000E+04  160000.0  160000.0  200.0  150.00  350.00  25.00  5.00  .00  .00  .00

*** SITE 1,150M STACK, WIND, FALL, LARGE GRID ***

* SOURCE-RECEPTOR COMBINATIONS LESS THAN 100 METERS OR THREE BUILDING
  HEIGHTS IN DISTANCE. NO AVERAGE CONCENTRATION IS CALCULATED *

- - RECEPTOR LOCATION - -
X (METERS)
SOURCE OR RANGE OR DIRECTION DISTANCE
NUMBER (METERS) (DEGREES) BETWEEN
(METERS)

1 160000.0 160000.0 .00

*** SITE 1,150M STACK, WIND, FALL, LARGE GRID ***

* 366-DAY AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTOR GRID *
* MAXIMUM VALUE EQUALS 2.29121 AND OCCURRED AT ( 180000.0, 200000.0 ) *

Y-AXIS / X-AXIS (METERS)
(METERS) /

180000.0 200000.0 220000.0 240000.0 260000.0 280000.0 300000.0 320000.0 340000.0 360000.0

320000.0 / .0842 .0782 1.0016 1.1689 1.6624 1.1984 .1943 1.2429 .29910
300000.0 / .0802 .1191 .0791 1.2581 1.0767 2.1926 2.1680 1.0467 1.4314
280000.0 / .1340 1.0467 1.1423 1.0458 1.7484 1.0480 1.6324 1.1438 1.0144
260000.0 / 1.1856 1.6474 1.0410 1.4259 1.0679 1.4644 2.1603 1.8827 1.4813
240000.0 / 1.4386 1.9505 1.9611 1.3611 1.7702 1.5938 2.6762 3.1009 5.9938
220000.0 / .08702 1.2439 1.7571 1.0387 2.1257 2.1101 2.0550 2.7179 1.8400
200000.0 / .06119 1.5168 1.8682 1.1684 2.2988 2.5112 2.6011 3.7619 1.10219
180000.0 / .08754 1.0620 0.7640 0.7641 2.2630 1.4150 2.1518 3.1223 1.60387
160000.0 / 0.7893 1.0483 1.0009 1.1479 1.2477 1.0251 2.0519 2.6333 1.00000
140000.0 / 2.0562 1.3547 1.6033 1.6636 3.1668 3.0240 1.4524 1.7076 1.6266
120000.0 / 1.9556 2.6467 2.2844 3.1147 4.6757 5.7640 6.2581 5.5450 5.9082
100000.0 / 1.6933 2.9456 3.3456 3.1507 4.0131 4.4567 5.5930 4.1767 4.2692
80000.0 / 2.6428 2.2602 1.4002 2.5249 3.9296 4.0136 3.4124 3.6406 3.3406
60000.0 / 2.2403 2.6207 1.9399 3.3095 2.5620 2.7352 2.6308 2.4862 2.7307
40000.0 / 2.2428 1.6422 2.4862 1.8219 3.3259 2.4634 2.3206 2.0733 2.3206
20000.0 / 1.5237 1.2633 1.6343 2.8521 1.7529 2.3157 2.4088 2.0255 1.9870
0 / 2.2731 1.4903 2.2016 2.1262 1.9187 1.5378 2.6409 2.0387 1.1455

*** SITE 1,150M STACK, WIND, FALL, LARGE GRID ***

* 366-DAY AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTOR GRID *
* MAXIMUM VALUE EQUALS 2.29121 AND OCCURRED AT ( 180000.0, 200000.0 ) *

Y-AXIS / X-AXIS (METERS)
(METERS) /

180000.0 200000.0 220000.0 240000.0 260000.0 280000.0 300000.0 320000.0 340000.0 360000.0

320000.0 / .49595 .61227 1.0256 1.5968 5.0191 1.4446 3.1381 3.7891 4.3053
300000.0 / .46853 1.1786 1.0784 1.2005 6.1171 35.044 4.3015 21.253 21.253
280000.0 / .44809 1.6754 1.2552 1.6035 4.1403 1.4973 2.2211 2.9553 2.9553
260000.0 / .60747 1.8456 1.4152 1.4813 5.8940 2.7452 3.5463 2.0452 2.0452
240000.0 / 1.15932 1.21562 1.7771 1.2265 1.3636 3.5629 1.9030 2.3532 2.3532
220000.0 / 1.29964 1.41494 1.3131 1.6569 2.8359 3.0633 2.1440 1.3087 1.3087
200000.0 / 2.29121 1.29462 1.7313 4.3774 2.3618 1.9599 2.1263 1.6147 1.6147
180000.0 / 1.94232 1.4464 3.6183 2.9620 1.6073 1.2915 1.2465 1.2205 1.2205
160000.0 / 2.4079 2.0134 1.5290 1.2106 1.0943 1.0299 0.7250 0.6184 0.6184
140000.0 / 1.3745 1.1959 0.9605 1.3167 1.0270 1.0967 0.7114 0.7104 0.7104
120000.0 / 1.4645 1.3428 1.1805 1.0969 0.7739 1.0500 0.6301 0.7588 0.7588
100000.0 / 1.4692 1.0639 1.0128 0.9925 0.4954 0.8176 0.7169 0.4488 0.4488
80000.0 / 1.6087 0.9234 0.4894 0.6670 1.6494 0.7368 0.2555 0.5581 0.5581
60000.0 / 1.0631 1.8427 1.4079 0.3098 0.5681 0.4645 0.1750 0.1782 0.1782
40000.0 / 1.0952 1.2620 1.6741 0.3983 0.2181 0.4965 0.3530 0.5838 0.5838
20000.0 / 1.0137 1.0953 0.6936 0.3293 0.3612 0.1912 0.4422 0.2980 0.2980
0 / 1.1748 0.9121 0.5605 0.3530 0.2681 0.2953 0.1644 0.3985

HIGH 1-HR
GROUP 1

```

*** SITE 1, 150M STACK, NOX, FALL, LARGE GRID ***

HIGHEST 1-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER)
FROM ALL SOURCES
FOR THE RECEPTOR GRID

MAXIMUM VALUE EQUALS 152.03020 AND OCCURRED AT (150000.0, 140000.0)

Y-AXIS / (METERS) /	0	20000.0	X-AXIS (METERS) 40000.0	60000.0	80000.0
320000.0 /	21.74188 (261.10)	25.24573 (300.16)	26.85664 (325.10)	31.23289 (372.14)	32.10726 (392.13)
300000.0 /	24.10309 (312.11)	24.23218 (281.10)	20.40701 (247.03)	27.87161 (335.10)	24.60127 (309.24)
280000.0 /	24.79743 (280.24)	30.61994 (312.11)	27.70068 (281.10)	28.46317 (247.03)	30.95301 (253.22)
260000.0 /	24.78909 (281.23)	27.23213 (247.22)	36.22894 (312.11)	32.32773 (281.10)	42.52436 (247.03)
240000.0 /	28.38715 (308.16)	34.36748 (308.10)	31.03948 (254.20)	36.36748 (312.11)	39.09200 (261.10)
220000.0 /	26.81111 (264.10)	31.94304 (287.03)	35.52952 (308.16)	44.20481 (303.10)	39.69609 (280.24)
200000.0 /	29.05121 (300.03)	39.52796 (300.03)	33.61468 (323.20)	39.78276 (314.10)	46.90558 (308.16)
180000.0 /	28.64272 (296.21)	31.09588 (342.13)	45.18222 (330.14)	43.64780 (310.14)	49.25615 (300.03)
160000.0 /	28.38786 (285.03)	31.25364 (285.03)	34.70068 (293.03)	34.62445 (292.03)	42.81922 (293.03)
140000.0 /	29.05409 (296.14)	31.84708 (280.19)	36.02343 (313.14)	39.24582 (282.03)	50.18678 (342.10)
120000.0 /	34.05442 (342.10)	40.58407 (286.03)	40.46369 (244.22)	46.84074 (349.16)	50.31576 (342.10)
100000.0 /	27.84183 (350.12)	34.18726 (322.15)	35.62046 (343.16)	42.58226 (307.14)	41.31544 (294.13)
80000.0 /	27.85576 (243.16)	34.34753 (309.11)	42.05935 (294.11)	41.83245 (294.12)	49.14293 (302.12)
60000.0 /	24.87955 (307.14)	30.25252 (336.11)	32.04425 (332.15)	41.39420 (302.10)	35.83895 (304.13)
40000.0 /	25.17771 (284.13)	28.92654 (315.14)	35.68107 (302.22)	24.61481 (359.20)	38.77420 (318.10)
20000.0 /	26.02493 (315.14)	31.38029 (302.12)	26.44990 (305.10)	32.50907 (351.16)	35.25087 (308.10)
0 /	28.05193 (360.12)	25.54384 (305.10)	27.73545 (321.11)	26.35216 (285.18)	27.91011 (301.12)

HIGH
1-HR
GROUP 1

*** SITE 1, 150M STACK, NOX, FALL, LARGE GRID ***

HIGHEST 1-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER)
FROM ALL SOURCES
FOR THE RECEPTOR GRID

MAXIMUM VALUE EQUALS 152.03020 AND OCCURRED AT (150000.0, 140000.0)

Y-AXIS / (METERS) /	100000.0	120000.0	X-AXIS (METERS) 140000.0	160000.0	180000.0
320000.0 /	27.35539 (335.24)	26.35617 (302.03)	37.5215 (268.15)	26.25481 (304.16)	24.22395 (328.14)
300000.0 /	37.21693 (274.12)	39.51882 (245.03)	36.25423 (264.16)	31.68210 (304.16)	31.64831 (340.16)
280000.0 /	40.89927 (302.13)	44.29249 (304.10)	34.40364 (363.21)	34.51415 (304.10)	43.14879 (289.13)
260000.0 /	45.35779 (332.14)	41.92010 (274.03)	41.3506 (321.03)	39.60278 (264.03)	41.46133 (357.03)
240000.0 /	46.98799 (235.10)	53.12976 (202.12)	59.35334 (307.03)	46.15210 (264.03)	61.87553 (293.11)
220000.0 /	51.01217 (261.10)	59.63732 (284.18)	59.4476 (304.10)	55.89401 (264.03)	54.86656 (255.13)
200000.0 /	49.58186 (284.03)	70.94125 (281.10)	70.37764 (258.03)	56.47491 (253.10)	57.69258 (285.13)
180000.0 /	48.80227 (323.20)	70.33657 (268.03)	72.68710 (261.10)	73.79910 (293.10)	72.87180 (281.10)
160000.0 /	48.24934 (341.03)	64.74218 (351.10)	72.61078 (351.10)	70000 (0.00)	77.52617 (353.15)
140000.0 /	72.71088 (244.12)	65.63560 (243.16)	60.34999 (314.11)	52.03020 (342.16)	67.53860 (259.12)
120000.0 /	67.86664 (284.11)	71.28006 (302.12)	78.7670 (364.16)	63.90509 (342.16)	67.06381 (293.03)
100000.0 /	59.52741 (302.12)	64.71335 (316.10)	74.16227 (301.11)	70.81280 (342.16)	64.66206 (344.16)
80000.0 /	48.38477 (351.16)	49.34631 (301.13)	49.99429 (301.12)	46.39910 (347.16)	53.00167 (313.15)
60000.0 /	42.51384 (308.10)	48.62448 (307.10)	57.88846 (380.13)	39.41738 (318.03)	29.47640 (271.15)
40000.0 /	35.92696 (301.13)	42.56572 (301.17)	40.61721 (239.03)	35.26811 (318.03)	74.74336 (243.16)
20000.0 /	31.35284 (307.10)	32.25640 (331.16)	28.71697 (229.03)	31.89318 (318.03)	72.76672 (343.16)
0 /	32.75574 (301.17)	28.62114 (245.20)	38.17158 (281.03)	29.87428 (318.03)	29.05410 (292.24)

HIGH
1-HR
GROUP 1

*** SITE 1, 150M STACK, NOX, FALL, LARGE GRID ***

HIGHEST 1-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER)
FROM ALL SOURCES
FOR THE RECEPTOR GRID

MAXIMUM VALUE EQUALS 152.03020 AND OCCURRED AT (160000.0, 140000.0)

Y-AXIS / (METERS) /	200000.0	220000.0	X-AXIS (METERS) 240000.0	260000.0	280000.0
320000.0 /	37.01463 (293.11)	35.85347 (262.03)	31.88241 (254.03)	28.62207 (293.03)	25.84506 (323.11)
300000.0 /	37.01196 (323.01)	31.75315 (294.10)	32.17878 (334.16)	31.78276 (258.18)	29.46781 (248.10)
280000.0 /	37.83836 (255.03)	40.64401 (254.03)	34.05060 (380.10)	32.78482 (354.16)	33.44248 (269.12)
260000.0 /	43.73687 (282.03)	40.51386 (323.13)	41.04861 (354.16)	39.21495 (288.14)	29.44446 (317.24)
240000.0 /	68.96930 (254.03)	47.07050 (323.11)	46.87521 (384.18)	33.71818 (244.10)	26.75026 (340.11)
220000.0 /	56.93624 (253.03)	58.46827 (249.12)	45.04612 (364.13)	42.38980 (351.10)	33.24959 (251.03)
200000.0 /	76.22956 (249.12)	63.00249 (340.11)	44.81133 (336.18)	35.46623 (266.03)	34.02347 (289.03)
180000.0 /	79.73731 (293.10)	60.25595 (289.03)	53.23051 (251.03)	36.47610 (381.21)	34.61943 (350.20)
160000.0 /	67.31158 (398.11)	58.20842 (359.11)	48.54070 (357.11)	40.86486 (359.11)	35.43974 (293.20)
140000.0 /	84.34434 (251.03)	48.34774 (294.13)	43.62546 (357.22)	37.83251 (268.03)	41.14075 (244.03)
120000.0 /	58.96584 (284.16)	64.16048 (281.10)	46.83866 (251.03)	36.31338 (311.13)	31.64467 (353.03)
100000.0 /	45.32320 (332.03)	45.87128 (244.16)	38.30217 (284.03)	30.93242 (285.15)	33.40024 (264.21)
80000.0 /	42.32844 (283.03)	38.94248 (352.16)	36.38951 (264.16)	41.04451 (307.16)	48.55359 (297.12)
60000.0 /	37.52055 (312.16)	35.49697 (350.24)	27.73702 (313.03)	31.30514 (285.03)	37.41748 (302.16)
40000.0 /	37.12702 (261.12)	33.03851 (253.03)	30.24452 (343.03)	29.79234 (294.13)	27.59709 (289.03)
20000.0 /	39.31601 (307.13)	29.58442 (359.24)	25.71674 (357.03)	23.72001 (363.03)	24.77173 (298.03)
0 /	32.38618 (313.15)	24.05120 (313.03)	74.94044 (293.03)	20.93058 (310.24)	24.47381 (352.18)

HIGH
1-HR
GROUP 1

*** SITE 1, 150M STACK, NOX, FALL, LARGE GRID ***

HIGHEST 1-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER)
FROM ALL SOURCES
FOR THE RECEPTOR GRID

MAXIMUM VALUE EQUALS 152.03020 AND OCCURRED AT (160000.0, 140000.0)

Y-AXIS / (METERS) /	300000.0	320000.0	X-AXIS (METERS)
320000.0 /	25.28272 (262.10)	26.21460 (249.12)	
300000.0 /	29.24438 (289.12)	29.47441 (267.03)	
280000.0 /	28.31641 (267.03)	24.37544 (322.19)	
260000.0 /	30.05519 (347.13)	28.52448 (359.10)	
240000.0 /	32.93285 (361.13)	27.14468 (287.03)	
220000.0 /	30.42438 (314.13)	27.47588 (313.17)	
200000.0 /	32.93307 (332.10)	30.24566 (251.03)	
180000.0 /	32.07805 (307.11)	28.66074 (335.03)	
160000.0 /	32.11111 (239.20)	29.23532 (293.20)	
140000.0 /	34.72627 (244.19)	29.13348 (251.03)	
120000.0 /	30.52407 (311.17)	28.35106 (357.22)	
100000.0 /	35.21624 (311.17)	27.66503 (357.21)	
80000.0 /	32.93285 (312.20)	27.25345 (384.21)	
60000.0 /	32.70164 (291.16)	21.56572 (280.24)	
40000.0 /	28.89202 (302.16)	23.93657 (289.03)	
20000.0 /	24.66675 (288.03)	21.73721 (302.16)	
0 /	22.93370 (289.03)	22.39844 (289.03)	

HIGH
1-HR
GROUP 1

*** SITE 1,150M STACK, MON. FALL, LARGE GRID ***

* SECOND HIGHEST 1-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTION GRID *

* MAXIMUM VALUE (EQUALS 122.23600 AND OCCURRED AT (160000.0, 180000.0) *

Y-AXIS (METERS)	0	20000.0	X-AXIS (METERS) 40000.0	60000.0	80000.0
320000.0	21.58930 (244.3)	23.33288 (267.7)	24.85740 (284.6)	26.82376 (300.2)	27.22976 (290.1)
300000.0	23.21634 (336.6)	23.95143 (244.3)	25.54236 (272.8)	27.37644 (290.1)	28.07418 (346.4)
280000.0	24.53876 (246.6)	25.43288 (349.8)	26.91227 (244.3)	32.87147 (272.8)	30.76694 (339.9)
260000.0	24.49271 (331.23)	26.40290 (273.3)	29.63109 (306.20)	30.94889 (244.3)	35.56043 (272.8)
240000.0	27.11170 (262.21)	26.23014 (323.19)	30.96189 (257.4)	33.23447 (330.17)	36.63921 (314.10)
220000.0	26.55618 (291.23)	30.07181 (294.6)	32.77085 (282.21)	36.17385 (276.2)	39.05715 (254.22)
200000.0	26.41903 (305.2)	31.15172 (276.3)	32.49876 (346.20)	34.44697 (354.21)	43.54407 (262.21)
180000.0	28.52786 (341.3)	30.42614 (353.22)	35.00971 (356.4)	34.49917 (341.3)	43.77787 (305.2)
160000.0	27.48264 (341.4)	30.12265 (341.4)	33.35678 (341.4)	37.31586 (341.4)	42.21738 (341.4)
140000.0	28.79888 (292.4)	31.09587 (357.20)	34.29752 (302.4)	36.11675 (292.4)	51.13134 (266.8)
120000.0	32.23611 (267.9)	31.38452 (264.9)	36.18892 (350.13)	40.12665 (332.15)	43.84525 (314.11)
100000.0	27.60806 (350.17)	30.95874 (260.19)	33.20037 (279.6)	41.30028 (309.11)	39.95249 (314.10)
80000.0	27.11452 (279.6)	31.70306 (352.14)	35.35715 (295.13)	35.48651 (307.13)	44.66514 (295.12)
60000.0	26.86500 (288.12)	30.17184 (294.13)	30.95875 (309.12)	37.54432 (295.12)	34.99872 (315.24)
40000.0	24.53071 (332.13)	24.36194 (309.12)	32.26101 (295.12)	28.51845 (264.13)	36.55541 (295.12)
20000.0	23.80557 (309.12)	24.21320 (295.12)	26.20062 (300.7)	25.02722 (306.11)	31.89521 (281.10)
0.0	25.18513 (295.12)	23.72229 (292.9)	26.91223 (351.16)	25.04150 (257.19)	25.91555 (321.17)

2ND HIGH
1-HR
GROUP# 1

*** SITE 1,150M STACK, MON. FALL, LARGE GRID ***

* SECOND HIGHEST 1-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTION GRID *

* MAXIMUM VALUE (EQUALS 122.23600 AND OCCURRED AT (160000.0, 180000.0) *

Y-AXIS (METERS)	100000.0	120000.0	X-AXIS (METERS) 140000.0	160000.0	180000.0
320000.0	27.25895 (351.20)	27.75130 (335.9)	32.74289 (332.15)	48.09947 (253.6)	32.25177 (340.16)
300000.0	30.37090 (307.14)	33.85568 (304.10)	32.76444 (249.7)	30.89937 (253.6)	31.51896 (357.4)
280000.0	34.13372 (250.10)	33.83724 (339.23)	34.21093 (314.7)	34.29285 (253.6)	36.12130 (357.11)
260000.0	36.40014 (306.15)	37.03317 (314.2)	38.74662 (304.10)	38.74662 (304.10)	34.51534 (326.12)
240000.0	39.44711 (306.15)	44.01687 (280.10)	46.63256 (308.3)	44.04392 (304.10)	55.58134 (326.12)
220000.0	46.78825 (314.10)	47.21781 (269.8)	49.26903 (339.20)	54.01267 (256.9)	65.37524 (330.17)
200000.0	47.24397 (258.10)	48.26145 (314.10)	63.01152 (302.13)	71.23367 (256.9)	53.98674 (287.5)
180000.0	47.43152 (346.20)	51.45417 (262.21)	120.40380 (314.10)	122.23600 (280.13)	105.41600 (275.7)
160000.0	46.24602 (283.9)	61.94489 (340.12)	114.51300 (351.15)	00000.0 (0.0)	11.36172 (267.13)
140000.0	63.68523 (280.12)	79.67786 (314.11)	79.10419 (352.14)	119.50210 (262.12)	97.52716 (346.14)
120000.0	53.29262 (293.13)	64.33241 (295.12)	75.02006 (301.13)	67.58691 (262.12)	54.75160 (312.17)
100000.0	54.07809 (285.12)	65.04516 (273.12)	59.84339 (331.16)	50.90401 (218.5)	51.09040 (251.10)
80000.0	46.48955 (309.10)	44.41140 (384.16)	48.48955 (249.20)	44.59310 (318.5)	45.62103 (264.11)
60000.0	41.83304 (281.10)	45.52051 (349.15)	36.12841 (266.19)	37.95140 (342.16)	38.47697 (304.7)
40000.0	32.81545 (321.13)	34.17342 (261.19)	35.78888 (256.18)	33.58588 (351.17)	33.34464 (306.4)
20000.0	30.36976 (307.16)	28.64264 (305.1)	27.71430 (280.11)	30.31299 (357.17)	31.33224 (346.23)
0.0	26.58374 (307.10)	26.70475 (276.6)	24.96103 (280.11)	27.60387 (357.17)	28.94256 (336.17)

2ND HIGH
HR
GROUP# 1

*** SITE 1,150M STACK, MON. FALL, LARGE GRID ***

* SECOND HIGHEST 1-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTION GRID *

* MAXIMUM VALUE (EQUALS 122.23600 AND OCCURRED AT (160000.0, 180000.0) *

Y-AXIS (METERS)	200000.0	220000.0	X-AXIS (METERS) 240000.0	260000.0	280000.0
320000.0	31.81026 (314.14)	28.00640 (266.21)	31.97621 (254.6)	26.78660 (245.1)	24.82614 (252.6)
300000.0	31.68676 (250.4)	31.07699 (355.16)	31.65360 (267.7)	31.54652 (324.13)	27.90455 (262.10)
280000.0	37.71702 (328.13)	39.48051 (256.8)	40.02171 (246.2)	32.24558 (248.0)	31.31279 (347.14)
260000.0	37.13818 (267.16)	38.85032 (356.25)	40.60791 (252.24)	36.47858 (347.14)	29.80045 (252.20)
240000.0	51.45846 (256.4)	42.37431 (256.10)	43.72676 (347.14)	33.67201 (334.7)	33.33379 (334.16)
220000.0	57.19487 (278.7)	54.34496 (347.14)	43.26926 (329.9)	38.37624 (338.13)	33.10347 (297.1)
200000.0	70.24450 (281.10)	57.48170 (342.21)	42.41160 (293.10)	35.55667 (326.16)	34.02347 (359.17)
180000.0	70.77763 (356.24)	59.90737 (254.6)	47.25932 (346.6)	37.54471 (323.23)	33.36237 (334.20)
160000.0	59.12933 (293.20)	51.87743 (293.20)	45.14126 (293.20)	39.67421 (293.20)	35.52607 (359.12)
140000.0	67.66132 (363.21)	46.29165 (353.4)	47.73276 (259.7)	33.17118 (295.17)	33.14075 (300.22)
120000.0	58.60323 (259.10)	52.72826 (293.17)	42.94341 (264.21)	34.44607 (355.20)	26.54531 (294.13)
100000.0	21.45920 (245.21)	40.68008 (347.16)	36.17431 (363.3)	29.51952 (256.22)	32.09530 (251.9)
80000.0	40.26537 (312.17)	38.40544 (363.6)	36.12503 (249.6)	33.30893 (249.4)	28.84645 (293.17)
60000.0	36.66650 (351.3)	34.22039 (357.1)	25.04625 (276.3)	20.77237 (297.18)	30.05018 (262.10)
40000.0	36.57481 (349.14)	31.10190 (357.4)	7.05909 (343.3)	21.61675 (312.6)	26.93444 (297.18)
20000.0	30.83777 (246.5)	29.56442 (346.22)	27.26392 (350.24)	21.74255 (317.10)	27.18909 (289.3)
0.0	28.08056 (329.7)	19.51486 (301.20)	25.54141 (357.4)	20.77932 (262.21)	28.06842 (363.4)

2ND HIGH
1-HR
GROUP# 1

*** SITE 1,150M STACK, MON. FALL, LARGE GRID ***

* SECOND HIGHEST 1-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTION GRID *

* MAXIMUM VALUE (EQUALS 122.23600 AND OCCURRED AT (160000.0, 180000.0) *

Y-AXIS (METERS)	300000.0	320000.0	X-AXIS (METERS) 340000.0	360000.0	380000.0
320000.0	24.79238 (289.10)	24.56403 (347.14)			
300000.0	27.49856 (347.14)	23.48039 (254.6)			
280000.0	28.81686 (267.5)	24.25374 (332.6)			
260000.0	27.57159 (261.5)	26.01353 (335.11)			
240000.0	32.43224 (354.12)	27.04693 (297.1)			
220000.0	38.19358 (304.5)	34.54128 (264.22)			
200000.0	32.07148 (237.16)	27.74255 (295.6)			
180000.0	29.83139 (293.19)	28.59384 (313.4)			
160000.0	30.76671 (257.7)	27.98772 (257.7)			
140000.0	30.84859 (314.4)	28.40602 (345.2)			
120000.0	26.22045 (257.24)	27.49425 (259.7)			
100000.0	33.24638 (210.11)	19.32957 (321.1)			
80000.0	16.77423 (265.19)	26.20791 (262.19)			
60000.0	27.41280 (249.7)	29.10543 (256.22)			
40000.0	21.72777 (320.22)	22.56786 (363.5)			
20000.0	24.01000 (297.18)	17.70490 (320.22)			
0.0	17.66545 (256.3)	21.61794 (297.16)			

*** SITE 1, 150M STACK, NON, FALL, LARGE GRID ***

HIGHEST 3-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER)
FROM ALL SOURCES
FOR THE RECEPTOR GRID

MAXIMUM VALUE EQUALS 82.36089 AND OCCURRED AT (160000.0, 140000.0)

T-AXIS / (METERS)	0	20000.0	X-AXIS (METERS) 10000.0	60000.0	80000.0
320000.0 /	13.32806 (244, 1)	8.77861 (281, 3)	8.95229 (335, 4)	13.53622 (363, 2)	16.86406 (346, 4)
300000.0 /	12.91218 (281, 6)	14.64631 (244, 1)	10.13867 (247, 2)	11.69446 (281, 8)	10.82151 (346, 2)
280000.0 /	15.86194 (249, 3)	15.89142 (361, 6)	16.73728 (244, 1)	13.15482 (247, 3)	18.73148 (301, 3)
260000.0 /	8.13491 (332, 1)	12.85191 (249, 3)	13.56426 (361, 8)	19.15271 (244, 1)	14.51145 (247, 3)
240000.0 /	14.20883 (353, 1)	12.45583 (303, 4)	17.26438 (332, 1)	16.72671 (249, 3)	22.33091 (246, 1)
220000.0 /	8.83788 (268, 1)	10.84768 (297, 3)	17.56894 (253, 1)	14.73497 (303, 4)	25.37158 (249, 3)
200000.0 /	8.88374 (300, 3)	13.17599 (300, 3)	14.51286 (363, 1)	13.24082 (358, 4)	23.07998 (253, 1)
180000.0 /	8.84787 (256, 7)	10.36530 (342, 1)	14.38407 (350, 5)	14.54820 (360, 8)	16.81672 (300, 3)
160000.0 /	9.43596 (293, 3)	10.41796 (283, 3)	11.56688 (281, 3)	12.87813 (283, 3)	14.27508 (293, 3)
140000.0 /	16.73393 (283, 3)	14.60213 (298, 5)	20.12344 (295, 5)	13.10466 (162, 3)	20.76085 (361, 2)
120000.0 /	18.31385 (361, 2)	18.44879 (257, 1)	24.52382 (244, 4)	25.24810 (332, 3)	21.81754 (243, 6)
100000.0 /	13.72953 (332, 3)	14.40179 (348, 2)	19.42788 (343, 6)	21.32981 (351, 2)	26.72686 (310, 5)
80000.0 /	11.72323 (343, 6)	14.43732 (306, 8)	17.58858 (352, 3)	20.17354 (307, 6)	22.41884 (289, 4)
60000.0 /	16.49646 (351, 2)	17.89641 (318, 7)	23.56142 (307, 1)	18.53974 (248, 4)	14.31873 (268, 2)
40000.0 /	14.51939 (318, 5)	13.95301 (307, 1)	15.78253 (249, 4)	13.09128 (315, 8)	20.24669 (307, 6)
20000.0 /	12.53504 (351, 1)	13.70628 (288, 4)	11.50017 (315, 8)	16.45425 (351, 6)	16.56175 (306, 8)
0 /	12.32534 (288, 4)	10.84804 (284, 7)	13.62205 (351, 6)	15.06437 (364, 5)	11.72457 (260, 6)

HIGH
3-HR
GROUP# 1

*** SITE 1, 150M STACK, NON, FALL, LARGE GRID ***

HIGHEST 3-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER)
FROM ALL SOURCES
FOR THE RECEPTOR GRID

MAXIMUM VALUE EQUALS 82.36089 AND OCCURRED AT (160000.0, 140000.0)

T-AXIS / (METERS)	100000.0	120000.0	X-AXIS (METERS) 140000.0	180000.0	160000.0
320000.0 /	11.97817 (351, 7)	17.75547 (235, 3)	19.23647 (260, 8)	10.61265 (252, 4)	20.52662 (340, 6)
300000.0 /	24.85625 (259, 8)	23.64510 (245, 3)	18.89808 (260, 8)	11.95541 (252, 4)	21.50848 (357, 3)
280000.0 /	20.92732 (346, 4)	15.44077 (324, 1)	11.99924 (275, 4)	13.71168 (193, 4)	24.28176 (285, 3)
260000.0 /	15.1924 (332, 5)	15.45311 (363, 7)	17.47394 (176, 4)	16.13888 (251, 4)	27.33583 (356, 7)
240000.0 /	15.86266 (335, 4)	21.15403 (346, 4)	27.81888 (312, 1)	19.88458 (253, 6)	26.44655 (313, 5)
220000.0 /	16.95528 (364, 5)	19.46727 (301, 3)	23.56712 (124, 1)	15.45883 (252, 4)	16.40628 (330, 4)
200000.0 /	26.63920 (332, 1)	32.80421 (244, 1)	16.21678 (346, 4)	26.58844 (253, 4)	37.72544 (344, 1)
180000.0 /	23.08957 (363, 1)	31.19190 (353, 1)	43.19571 (281, 4)	67.98559 (253, 4)	56.81346 (329, 5)
160000.0 /	16.08312 (341, 2)	21.54073 (351, 4)	41.40356 (351, 3)	20.00000 (0, 0)	47.85555 (246, 4)
140000.0 /	44.34686 (144, 4)	34.45818 (343, 6)	44.81897 (248, 4)	42.76045 (261, 4)	15.84617 (259, 6)
120000.0 /	27.44770 (332, 3)	27.12335 (289, 4)	30.19028 (308, 4)	43.01516 (261, 4)	15.46113 (312, 6)
100000.0 /	28.16087 (288, 4)	30.89111 (307, 6)	26.47702 (261, 6)	29.84015 (261, 6)	21.55402 (349, 5)
80000.0 /	24.73200 (351, 6)	21.11845 (260, 6)	25.48669 (267, 7)	24.05724 (261, 6)	18.35593 (339, 8)
60000.0 /	22.01184 (364, 5)	19.58555 (321, 4)	15.54541 (267, 7)	20.06847 (261, 4)	13.92132 (313, 5)
40000.0 /	15.25452 (260, 6)	15.22632 (261, 6)	13.64203 (299, 3)	17.23042 (261, 6)	11.35819 (343, 6)
20000.0 /	15.82284 (321, 6)	22.70052 (305, 2)	14.05433 (332, 5)	15.24450 (261, 6)	11.37182 (315, 6)
0 /	11.77843 (282, 5)	15.38547 (273, 7)	14.55994 (336, 6)	13.50347 (261, 6)	16.23722 (349, 8)

HIGH
3-HR
GROUP# 1

*** SITE 1, 150M STACK, NON, FALL, LARGE GRID ***

HIGHEST 3-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER)
FROM ALL SOURCES
FOR THE RECEPTOR GRID

MAXIMUM VALUE EQUALS 82.36089 AND OCCURRED AT (160000.0, 140000.0)

T-AXIS / (METERS)	200000.0	220000.0	X-AXIS (METERS) 240000.0	280000.0	260000.0
320000.0 /	19.73489 (297, 2)	15.14173 (330, 4)	18.27686 (344, 5)	15.73287 (298, 8)	16.34292 (252, 2)
300000.0 /	22.14818 (340, 1)	22.15356 (330, 4)	21.46781 (295, 7)	15.30578 (297, 2)	26.22195 (330, 5)
280000.0 /	17.19359 (256, 8)	23.38648 (344, 5)	26.56170 (297, 2)	20.05821 (330, 5)	16.30103 (347, 5)
260000.0 /	28.04726 (330, 4)	26.19458 (358, 4)	21.45120 (330, 5)	6.64660 (347, 5)	19.59558 (252, 7)
240000.0 /	30.24640 (285, 1)	26.22851 (252, 2)	22.51565 (347, 5)	18.70081 (332, 3)	20.30813 (363, 4)
220000.0 /	46.93138 (287, 2)	28.27645 (347, 5)	24.17245 (307, 2)	17.31732 (333, 8)	15.40728 (267, 3)
200000.0 /	37.80096 (339, 3)	16.81104 (383, 4)	21.27212 (267, 3)	16.81718 (344, 8)	15.27195 (264, 8)
180000.0 /	31.81539 (287, 3)	24.95685 (264, 8)	19.46265 (319, 2)	17.82963 (361, 7)	12.55138 (329, 4)
160000.0 /	30.32126 (281, 4)	21.28653 (287, 4)	16.18023 (359, 4)	13.62028 (359, 4)	11.88057 (283, 7)
140000.0 /	28.51079 (251, 3)	20.65745 (251, 5)	41.35004 (357, 8)	22.87097 (298, 3)	13.31258 (244, 7)
120000.0 /	19.45528 (264, 6)	25.24712 (248, 4)	15.84254 (265, 3)	13.35384 (321, 1)	11.32888 (281, 6)
100000.0 /	15.11110 (363, 3)	15.77733 (268, 8)	22.33895 (289, 3)	10.31081 (265, 7)	11.23278 (251, 5)
80000.0 /	14.10952 (293, 2)	12.56083 (352, 8)	12.12884 (288, 8)	13.89484 (302, 8)	14.02956 (281, 4)
60000.0 /	12.77833 (312, 5)	11.45232 (350, 8)	9.24687 (315, 2)	10.43957 (288, 2)	12.47550 (302, 8)
40000.0 /	12.37567 (261, 4)	11.00264 (293, 2)	10.34484 (363, 3)	9.83578 (178, 1)	9.20163 (285, 2)
20000.0 /	20.18080 (339, 8)	10.03699 (312, 6)	8.57225 (357, 1)	7.05687 (363, 2)	8.25724 (298, 1)
0 /	10.79339 (313, 5)	8.84273 (313, 2)	8.93255 (293, 2)	8.97408 (350, 8)	6.15780 (352, 6)

HIGH
3-HR
GROUP# 1

*** SITE 1, 150M STACK, NON, FALL, LARGE GRID ***

HIGHEST 3-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER)
FROM ALL SOURCES
FOR THE RECEPTOR GRID

MAXIMUM VALUE EQUALS 82.36089 AND OCCURRED AT (160000.0, 140000.0)

T-AXIS / (METERS)	300000.0	320000.0	X-AXIS (METERS)
320000.0 /	12.91147 (338, 5)	12.51295 (347, 7)	
300000.0 /	14.02571 (347, 5)	12.78013 (282, 7)	
280000.0 /	16.54844 (282, 7)	13.77224 (309, 2)	
260000.0 /	12.86367 (363, 4)	13.97052 (333, 6)	
240000.0 /	10.84047 (361, 9)	12.13609 (257, 3)	
220000.0 /	12.16583 (382, 6)	11.62495 (314, 6)	
200000.0 /	21.34021 (337, 6)	11.21178 (311, 2)	
180000.0 /	11.43944 (309, 4)	10.04582 (331, 6)	
160000.0 /	10.73078 (293, 7)	9.77498 (289, 7)	
140000.0 /	11.67542 (244, 7)	13.18510 (251, 5)	
120000.0 /	17.33815 (357, 8)	26.32065 (357, 8)	
100000.0 /	11.72879 (311, 5)	10.84204 (321, 1)	
80000.0 /	8.93735 (251, 3)	9.08462 (264, 7)	
60000.0 /	17.77833 (312, 7)	8.28584 (246, 1)	
40000.0 /	9.63067 (302, 5)	13.57837 (289, 3)	
20000.0 /	6.22379 (249, 2)	7.04574 (302, 6)	
0 /	7.87377 (249, 1)	7.43310 (288, 2)	

*** SITE 1, 150M STACK, NON-FALL, LARGE GRID ***

* SECOND HIGHEST 3-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTION GRID *

* MAXIMUM VALUE EQUALS 57.70270 AND OCCURRED AT (180000.0, 700000.0) *

Y-AXIS (METERS)	0	20000.0	X-AXIS (METERS) 40000.0	60000.0	80000.0
320000.0	11.62118 (328, 2)	8.85948 (272, 3)	8.21927 (254, 2)	10.94427 (301, 3)	11.59228 (323, 3)
300000.0	8.02436 (312, 4)	12.87328 (338, 2)	9.52129 (272, 3)	10.24307 (284, 2)	9.53376 (308, 6)
280000.0	6.67913 (287, 6)	10.70865 (312, 4)	14.85681 (338, 2)	11.39480 (272, 3)	15.60208 (285, 1)
260000.0	8.20831 (312, 3)	11.81214 (287, 6)	12.01621 (312, 4)	16.80476 (338, 2)	14.95026 (316, 2)
240000.0	12.28892 (351, 2)	9.41009 (323, 3)	12.13412 (264, 3)	11.78915 (312, 4)	18.62480 (336, 2)
220000.0	8.86273 (291, 8)	10.82794 (363, 1)	14.19761 (351, 2)	12.05795 (276, 1)	16.30379 (337, 6)
200000.0	9.47302 (306, 1)	13.88461 (298, 8)	11.22719 (321, 1)	11.48310 (354, 3)	17.63708 (351, 2)
180000.0	9.52276 (341, 1)	10.14205 (353, 8)	11.64824 (354, 2)	11.48972 (341, 2)	14.53376 (309, 1)
160000.0	9.14795 (341, 2)	10.04088 (341, 2)	12.11890 (341, 2)	12.43862 (341, 2)	14.07246 (341, 2)
140000.0	13.47310 (295, 5)	12.28523 (293, 2)	13.44759 (311, 2)	12.75387 (293, 2)	22.17077 (356, 8)
120000.0	14.90072 (386, 8)	18.33208 (354, 8)	19.55250 (217, 3)	19.67471 (349, 6)	18.03116 (332, 6)
100000.0	11.00013 (389, 7)	18.66757 (358, 7)	13.96959 (335, 6)	16.91571 (331, 8)	23.52604 (307, 5)
80000.0	10.72779 (335, 6)	12.06801 (351, 2)	15.20827 (284, 4)	16.67935 (307, 1)	16.47517 (316, 1)
60000.0	12.27032 (331, 8)	17.88436 (318, 8)	13.51395 (307, 5)	13.80528 (316, 2)	15.14241 (307, 2)
40000.0	13.21146 (354, 6)	12.60982 (351, 1)	12.28489 (338, 8)	10.52756 (264, 2)	20.05864 (336, 1)
20000.0	9.55539 (307, 1)	11.27492 (338, 8)	8.81681 (305, 4)	11.43832 (336, 1)	13.41463 (306, 1)
0	10.43236 (338, 8)	9.71513 (315, 8)	18.12756 (307, 2)	13.26083 (306, 1)	11.46616 (306, 4)

2ND HIGH
3-HR
15GROUP# 2

*** SITE 1, 150M STACK, NON-FALL, LARGE GRID ***

* SECOND HIGHEST 3-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTION GRID *

* MAXIMUM VALUE EQUALS 57.70270 AND OCCURRED AT (180000.0, 700000.0) *

Y-AXIS (METERS)	100000.0	120000.0	X-AXIS (METERS) 140000.0	160000.0	180000.0
320000.0	8.82836 (323, 3)	15.78267 (312, 1)	18.33666 (336, 1)	10.34940 (356, 5)	19.06951 (258, 1)
300000.0	19.65374 (383, 7)	19.42329 (358, 1)	14.68831 (336, 1)	11.66281 (356, 5)	20.16473 (340, 6)
280000.0	14.21808 (253, 2)	14.78350 (304, 4)	11.47688 (363, 1)	13.38757 (356, 5)	19.31345 (357, 4)
260000.0	14.01759 (289, 5)	14.86454 (351, 1)	15.71047 (312, 1)	15.75722 (354, 5)	13.53332 (367, 3)
240000.0	13.14964 (308, 5)	15.81804 (323, 3)	26.97663 (335, 3)	19.21519 (356, 5)	26.23279 (337, 4)
220000.0	23.42835 (318, 2)	23.75878 (285, 1)	23.28242 (304, 4)	24.66724 (346, 5)	24.61306 (356, 5)
200000.0	20.12775 (354, 3)	24.65556 (358, 2)	26.82793 (323, 3)	33.96540 (355, 5)	47.70270 (285, 1)
180000.0	16.36625 (323, 3)	23.44552 (248, 3)	40.24784 (314, 4)	14.35303 (303, 6)	19.41084 (363, 1)
160000.0	15.44888 (293, 3)	20.85121 (340, 4)	18.05064 (351, 5)	00000.0 (0, 0)	25.84706 (353, 5)
140000.0	29.58416 (277, 3)	20.85593 (335, 6)	18.05702 (280, 5)	50.67675 (347, 6)	32.55824 (346, 4)
120000.0	25.12944 (294, 4)	25.02517 (316, 1)	29.07600 (288, 6)	38.59877 (321, 6)	14.02163 (293, 2)
100000.0	26.02483 (316, 1)	20.16061 (273, 4)	24.82076 (301, 6)	29.22585 (328, 1)	17.33015 (281, 4)
80000.0	21.23804 (307, 2)	20.40477 (306, 4)	23.65364 (305, 2)	22.32291 (328, 4)	17.86723 (313, 5)
60000.0	25.17852 (306, 1)	16.20750 (307, 4)	12.74447 (259, 6)	18.93371 (308, 3)	12.42669 (304, 1)
40000.0	14.82290 (306, 4)	14.14817 (301, 6)	12.60670 (321, 5)	16.70259 (306, 3)	11.17642 (304, 2)
20000.0	10.45595 (307, 4)	16.70623 (340, 1)	12.91018 (288, 3)	14.91831 (308, 2)	12.81968 (345, 6)
0	10.91859 (301, 6)	13.40027 (305, 2)	13.74532 (331, 5)	13.46357 (306, 1)	11.85648 (291, 2)

2ND HIGH
3-HR
15GROUP# 1

*** SITE 1, 150M STACK, NON-FALL, LARGE GRID ***

* SECOND HIGHEST 3-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTION GRID *

* MAXIMUM VALUE EQUALS 57.70270 AND OCCURRED AT (180000.0, 700000.0) *

Y-AXIS (METERS)	200000.0	220000.0	X-AXIS (METERS) 240000.0	260000.0	280000.0
320000.0	15.54664 (317, 4)	14.46889 (357, 6)	18.14391 (285, 1)	13.05190 (356, 8)	10.38140 (334, 8)
300000.0	14.56287 (287, 5)	17.59481 (284, 4)	21.22728 (356, 8)	15.07375 (259, 1)	14.12715 (252, 8)
280000.0	15.90541 (253, 2)	23.31635 (285, 1)	20.09547 (312, 3)	17.04812 (252, 8)	15.54161 (309, 3)
260000.0	21.10845 (274, 2)	22.09144 (246, 8)	18.32178 (352, 8)	18.22640 (309, 3)	14.09156 (323, 2)
240000.0	32.56600 (344, 5)	18.88448 (318, 7)	22.11758 (309, 5)	19.63480 (252, 7)	16.34063 (321, 8)
220000.0	35.95320 (312, 3)	28.17383 (308, 3)	19.37384 (332, 3)	14.12847 (359, 4)	11.67867 (346, 1)
200000.0	37.48343 (329, 5)	28.10506 (331, 8)	16.91525 (346, 1)	13.67803 (287, 6)	15.16280 (337, 6)
180000.0	30.51840 (274, 7)	23.25951 (337, 6)	18.87548 (317, 5)	12.64824 (323, 8)	11.47284 (255, 7)
160000.0	22.47720 (359, 4)	19.40281 (359, 4)	16.05406 (287, 4)	13.29762 (292, 3)	11.67536 (358, 4)
140000.0	22.86484 (289, 5)	16.04905 (294, 5)	16.54123 (251, 5)	11.15603 (357, 4)	11.16625 (300, 8)
120000.0	19.53674 (289, 4)	21.24696 (291, 4)	14.31810 (264, 7)	12.10445 (311, 5)	10.55271 (251, 2)
100000.0	10.44840 (245, 7)	14.55383 (347, 6)	21.27746 (288, 4)	9.53327 (256, 5)	11.12341 (284, 7)
80000.0	13.93064 (312, 6)	12.85848 (363, 2)	12.05048 (289, 2)	12.45001 (281, 4)	13.21766 (291, 4)
60000.0	12.22230 (351, 1)	11.40880 (357, 1)	8.34875 (298, 1)	10.25746 (297, 4)	10.01870 (262, 7)
40000.0	12.30494 (348, 6)	10.85151 (312, 6)	9.89894 (352, 7)	11.27225 (312, 2)	8.93448 (287, 6)
20000.0	13.10534 (307, 5)	9.86223 (339, 9)	7.88797 (352, 8)	7.24752 (317, 4)	7.56236 (298, 1)
0	10.74740 (329, 8)	6.50495 (301, 7)	8.60738 (312, 4)	6.90970 (262, 7)	6.82214 (363, 2)

2ND HIGH
3-HR
15GROUP# 1

*** SITE 1, 150M STACK, NON-FALL, LARGE GRID ***

* SECOND HIGHEST 3-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTION GRID *

* MAXIMUM VALUE EQUALS 57.70270 AND OCCURRED AT (180000.0, 700000.0) *

Y-AXIS (METERS)	300000.0	320000.0	X-AXIS (METERS)
320000.0	11.51424 (282, 4)	12.25541 (251, 2)	
300000.0	12.83204 (291, 2)	10.29710 (337, 8)	
280000.0	12.16887 (295, 1)	11.41525 (323, 3)	
260000.0	12.64082 (323, 5)	13.66394 (321, 6)	
240000.0	10.81108 (354, 4)	9.04962 (257, 1)	
220000.0	12.99732 (348, 1)	9.15855 (315, 6)	
200000.0	14.83713 (285, 1)	10.44182 (311, 5)	
180000.0	10.59266 (307, 4)	9.76841 (355, 2)	
160000.0	10.25557 (287, 3)	8.33824 (287, 3)	
140000.0	10.38246 (318, 2)	8.63502 (343, 1)	
120000.0	11.21571 (281, 6)	8.15142 (259, 2)	
100000.0	11.08213 (310, 4)	9.22188 (257, 7)	
80000.0	8.64795 (312, 7)	8.89571 (251, 3)	
60000.0	16.79917 (288, 3)	7.37501 (281, 4)	
40000.0	7.24259 (320, 8)	11.64045 (278, 4)	
20000.0	8.00333 (297, 6)	5.90297 (320, 8)	
0	5.95818 (298, 1)	7.20598 (297, 6)	

*** SITE 1: 150M STACK MON.FALL.LARGE GRID ***

* HIGHEST 8-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTOR GRID *

* MAXIMUM VALUE EQUALS 48.62798 AND OCCURRED AT (180000.0, 80000.0) *

Y-AXIS / (METERS) /	0	20000.0	X-AXIS (METERS) 40000.0	60000.0	80000.0
320000.0 /	5.26087 (276.1)	4.18266 (338.1)	3.35708 (325.2)	6.30005 (244.1)	9.46701 (346.2)
300000.0 /	4.71456 (361.3)	5.83852 (276.1)	3.80088 (247.2)	4.84584 (244.2)	6.63876 (381.1)
280000.0 /	6.94831 (248.1)	5.20943 (361.3)	8.79134 (276.1)	4.63295 (247.2)	10.75196 (244.1)
260000.0 /	5.13201 (305.3)	7.09467 (248.1)	5.08685 (309.3)	7.89538 (276.2)	5.44179 (247.1)
240000.0 /	6.58446 (353.1)	4.67713 (338.2)	9.92096 (322.1)	6.26612 (249.1)	9.38298 (276.1)
220000.0 /	3.35129 (268.1)	6.28456 (287.2)	7.90986 (352.1)	6.71349 (302.3)	11.50828 (248.1)
200000.0 /	3.82140 (390.2)	4.94118 (308.2)	5.44238 (363.1)	5.48888 (354.3)	9.68730 (353.1)
180000.0 /	3.84447 (341.1)	4.58446 (341.1)	5.57525 (341.1)	7.53646 (341.1)	6.18108 (300.2)
160000.0 /	4.12685 (351.2)	4.89326 (351.2)	5.45611 (351.2)	6.50385 (351.2)	8.05411 (351.2)
140000.0 /	6.82787 (364.2)	4.88878 (285.2)	7.45426 (295.2)	6.13921 (346.2)	10.18202 (358.1)
120000.0 /	6.88762 (361.1)	10.05183 (357.1)	10.97824 (350.2)	12.04731 (332.1)	6.63817 (305.2)
100000.0 /	9.21947 (332.1)	7.05075 (349.1)	6.23007 (309.2)	10.11858 (331.1)	12.51618 (294.2)
80000.0 /	4.75406 (305.3)	9.69808 (305.3)	10.35410 (331.3)	8.24593 (294.2)	13.10585 (326.1)
60000.0 /	7.20983 (321.3)	8.38362 (294.2)	7.43898 (322.2)	11.78021 (328.1)	7.63348 (359.3)
40000.0 /	7.02476 (294.2)	7.02600 (274.1)	10.19112 (328.1)	6.23722 (359.1)	8.37296 (305.2)
20000.0 /	6.35640 (278.1)	4.94551 (328.1)	5.02655 (292.1)	7.46523 (351.2)	8.29745 (306.2)
0 /	4.03343 (328.1)	5.46000 (292.1)	7.65557 (327.1)	8.02017 (308.1)	5.40824 (306.2)

HIGH
8-HR
GROUP# 1

*** SITE 1: 150M STACK MON.FALL.LARGE GRID ***

* HIGHEST 8-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTOR GRID *

* MAXIMUM VALUE EQUALS 49.62798 AND OCCURRED AT (180000.0, 80000.0) *

Y-AXIS / (METERS) /	100000.0	120000.0	X-AXIS (METERS) 140000.0	160000.0	180000.0
320000.0 /	4.58886 (351.3)	9.25832 (245.1)	7.25118 (260.1)	4.63336 (165.3)	2.81352 (340.2)
300000.0 /	8.33755 (259.3)	11.13436 (245.1)	6.32679 (260.2)	4.88838 (165.3)	0.14454 (348.1)
280000.0 /	11.54289 (346.2)	7.67745 (319.1)	4.49571 (276.2)	4.0815 (156.2)	10.71443 (351.2)
260000.0 /	5.14843 (268.1)	9.04269 (193.2)	6.48655 (245.1)	9.34564 (256.2)	0.45195 (351.2)
240000.0 /	5.87350 (335.2)	5.04846 (346.2)	5.16166 (245.1)	11.14682 (258.2)	4.63307 (323.2)
220000.0 /	11.39325 (276.1)	16.52275 (244.1)	11.14441 (319.1)	14.73102 (256.2)	16.51162 (348.1)
200000.0 /	15.29381 (332.1)	14.25844 (276.1)	20.45160 (346.2)	22.44100 (301.3)	34.13356 (325.1)
180000.0 /	6.65607 (353.1)	3.42076 (380.2)	16.58028 (294.2)	17.40143 (307.3)	48.62798 (329.2)
160000.0 /	10.59242 (351.2)	15.54204 (351.2)	29.12485 (351.2)	20000.0 (0.0)	10.58067 (287.2)
140000.0 /	17.33334 (319.2)	13.38802 (320.2)	25.28908 (328.1)	10.92062 (262.2)	13.38732 (159.2)
120000.0 /	17.35477 (331.3)	21.36488 (326.1)	15.87643 (304.2)	7.86364 (308.1)	9.10325 (164.2)
100000.0 /	16.94118 (328.1)	13.48812 (305.2)	12.23372 (305.2)	5.06942 (306.1)	9.08276 (148.2)
80000.0 /	12.05912 (307.1)	10.55423 (304.2)	11.04001 (305.1)	12.94960 (306.1)	6.88347 (338.1)
60000.0 /	11.48999 (306.1)	8.64544 (307.2)	11.02299 (277.1)	11.29715 (306.1)	6.49264 (308.1)
40000.0 /	7.54606 (306.2)	6.75125 (305.2)	5.55144 (274.2)	9.49756 (308.1)	7.07706 (308.1)
20000.0 /	5.43374 (307.2)	12.24070 (305.1)	5.29812 (331.2)	8.95404 (306.1)	4.52208 (315.1)
0 /	4.41881 (282.2)	6.27001 (305.1)	6.42871 (283.2)	8.10223 (306.1)	6.04686 (348.1)

HIGH
8-HR
GROUP# 1

*** SITE 1: 150M STACK MON.FALL.LARGE GRID ***

* HIGHEST 8-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTOR GRID *

* MAXIMUM VALUE EQUALS 48.62798 AND OCCURRED AT (180000.0, 80000.0) *

Y-AXIS / (METERS) /	200000.0	220000.0	X-AXIS (METERS) 240000.0	260000.0	280000.0
320000.0 /	7.99942 (324.2)	6.17571 (262.2)	10.86994 (325.1)	9.12799 (295.1)	6.12660 (252.1)
300000.0 /	9.21228 (340.1)	12.05589 (247.2)	14.73066 (295.3)	7.40495 (1315.1)	7.03076 (330.2)
280000.0 /	9.27887 (340.2)	14.01617 (325.1)	9.94093 (297.1)	8.13585 (330.2)	12.62496 (329.2)
260000.0 /	11.38137 (320.2)	18.07782 (295.3)	8.31016 (330.2)	15.11785 (329.2)	7.25106 (252.1)
240000.0 /	18.37290 (325.1)	10.42957 (319.2)	18.46684 (329.2)	9.21141 (322.1)	0.38429 (362.2)
220000.0 /	16.33576 (315.1)	23.83596 (329.2)	13.20558 (329.2)	6.52891 (304.2)	7.10630 (354.1)
200000.0 /	32.42376 (329.2)	14.17140 (363.2)	10.82493 (335.1)	6.81575 (1214.2)	6.59062 (354.3)
180000.0 /	16.56777 (295.1)	11.04464 (294.2)	12.07716 (251.1)	6.15784 (212.2)	1.99253 (309.2)
160000.0 /	11.93560 (267.2)	6.14879 (267.2)	6.11454 (267.2)	5.10781 (355.2)	4.45522 (293.2)
140000.0 /	10.58304 (251.2)	7.75816 (251.2)	15.40183 (357.3)	5.41262 (248.2)	1.21277 (314.2)
120000.0 /	8.58492 (313.2)	9.05787 (281.2)	5.80485 (251.2)	5.00732 (321.1)	4.15331 (251.2)
100000.0 /	5.66666 (363.1)	6.75033 (313.2)	11.55597 (249.2)	3.44685 (265.2)	4.17503 (264.2)
80000.0 /	6.57294 (264.2)	6.86781 (312.2)	5.48622 (313.2)	7.36740 (249.1)	5.26110 (281.2)
60000.0 /	4.93719 (312.2)	4.57537 (357.1)	3.46713 (313.2)	4.57842 (333.2)	4.87719 (302.2)
40000.0 /	4.64088 (261.2)	4.18802 (357.2)	3.78557 (363.2)	3.72404 (298.2)	3.32387 (313.2)
20000.0 /	5.5783 (338.2)	7.1287 (312.2)	4.36433 (307.2)	2.49000 (363.1)	2.05447 (198.1)
0 /	4.64418 (353.3)	3.25640 (313.1)	3.37250 (293.1)	7.61632 (150.1)	3.05918 (139.2)

HIGH
8-HR
GROUP# 1

*** SITE 1: 150M STACK MON.FALL.LARGE GRID ***

* HIGHEST 8-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTOR GRID *

* MAXIMUM VALUE EQUALS 49.62798 AND OCCURRED AT (180000.0, 80000.0) *

Y-AXIS / (METERS) /	300000.0	320000.0	X-AXIS (METERS)
320000.0 /	5.88846 (330.2)	9.91342 (329.2)	
300000.0 /	11.17589 (329.2)	6.49151 (267.1)	
280000.0 /	7.21052 (287.1)	7.17549 (329.2)	
260000.0 /	6.27489 (245.2)	5.52674 (353.2)	
240000.0 /	4.98888 (322.1)	6.47901 (314.1)	
220000.0 /	7.19354 (314.2)	4.28286 (284.3)	
200000.0 /	8.82032 (345.1)	7.24853 (291.1)	
180000.0 /	6.44010 (309.2)	7.14518 (338.2)	
160000.0 /	4.02404 (273.3)	3.66750 (283.2)	
140000.0 /	5.61219 (318.1)	4.13324 (251.2)	
120000.0 /	6.58726 (337.3)	5.87142 (357.2)	
100000.0 /	5.70559 (286.1)	7.15517 (321.1)	
80000.0 /	3.24288 (312.2)	3.40675 (264.2)	
60000.0 /	6.32728 (249.1)	3.08973 (240.1)	
40000.0 /	3.61150 (302.2)	6.89367 (249.1)	
20000.0 /	3.18567 (313.3)	2.64215 (362.2)	
0 /	3.92158 (289.1)	2.99734 (289.1)	

*** SITE 1, 150M STACK, MON. FALL, LARGE GRID ***

* SECOND HIGHEST 8-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTION GRID *

* MAXIMUM VALUE EQUALS 31.73218 AND OCCURRED AT (160000.0, 160000.0) *

Y-AXIS (METERS)	X-AXIS (METERS)	0	20000.0	40000.0	60000.0	80000.0
320000.0	4.99403 (244. 1)	3.15584 (300. 2)	3.08273 (338. 1)	5.07608 (363. 2)	4.35646 (279. 1)	4.35646 (279. 1)
300000.0	3.01289 (312. 2)	5.56737 (244. 1)	3.77463 (338. 1)	4.36626 (358. 3)	4.06746 (304. 1)	4.06746 (304. 1)
280000.0	4.22621 (221. 2)	1.82748 (312. 2)	5.27652 (244. 1)	4.10893 (278. 2)	7.39928 (301. 1)	7.39928 (301. 1)
260000.0	4.38094 (232. 1)	6.12653 (332. 1)	4.52862 (212. 2)	7.18227 (244. 1)	5.26375 (354. 1)	5.26375 (354. 1)
240000.0	6.06246 (280. 1)	4.67994 (303. 2)	6.10283 (321. 2)	4.42093 (312. 2)	8.37411 (244. 1)	8.37411 (244. 1)
220000.0	3.31977 (291. 3)	6.19823 (354. 3)	7.49976 (240. 3)	6.36937 (338. 2)	7.92000 (321. 2)	7.92000 (321. 2)
200000.0	3.59238 (309. 1)	4.98673 (288. 1)	4.76217 (250. 1)	4.97295 (358. 2)	9.75132 (280. 2)	9.75132 (280. 2)
180000.0	3.59034 (286. 3)	4.95142 (340. 1)	8.98178 (350. 2)	5.88248 (257. 2)	5.47229 (305. 1)	5.47229 (305. 1)
160000.0	3.53448 (293. 2)	3.90591 (293. 2)	4.53758 (293. 2)	4.82931 (293. 2)	5.35240 (293. 2)	5.35240 (293. 2)
140000.0	6.37324 (283. 2)	6.31640 (364. 2)	7.55087 (322. 1)	5.81459 (295. 2)	10.59742 (381. 1)	10.59742 (381. 1)
120000.0	6.76218 (358. 1)	10.00829 (358. 3)	9.18636 (244. 2)	8.18995 (349. 2)	7.82040 (320. 2)	7.82040 (320. 2)
100000.0	5.76680 (350. 2)	7.00038 (354. 3)	5.59401 (320. 2)	9.86140 (307. 2)	10.02254 (314. 2)	10.02254 (314. 2)
80000.0	4.51760 (359. 2)	6.53954 (331. 3)	6.58461 (294. 2)	7.58926 (307. 2)	9.81709 (249. 2)	9.81709 (249. 2)
60000.0	6.18618 (351. 1)	6.94688 (321. 1)	8.97355 (278. 1)	8.11557 (289. 2)	7.24670 (307. 1)	7.24670 (307. 1)
40000.0	5.44477 (316. 2)	6.24158 (332. 2)	6.91247 (249. 2)	4.90524 (315. 3)	7.59250 (307. 2)	7.59250 (307. 2)
20000.0	4.89837 (332. 1)	6.01744 (288. 2)	4.51256 (315. 3)	5.18819 (300. 2)	7.87515 (306. 1)	7.87515 (306. 1)
0	5.43581 (294. 3)	4.76351 (284. 3)	5.82600 (351. 2)	9.58895 (364. 2)	5.14950 (336. 1)	5.14950 (336. 1)

2ND HIGH
8-HR
SCADUPP 1

*** SITE 1, 150M STACK, MON. FALL, LARGE GRID ***

* SECOND HIGHEST 8-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTION GRID *

* MAXIMUM VALUE EQUALS 31.73218 AND OCCURRED AT (160000.0, 160000.0) *

Y-AXIS (METERS)	X-AXIS (METERS)	100000.0	120000.0	140000.0	160000.0	180000.0
320000.0	4.39659 (291. 1)	5.58550 (312. 1)	6.87625 (336. 1)	6.01778 (254. 2)	6.67737 (344. 1)	6.67737 (344. 1)
300000.0	7.33747 (323. 1)	6.18731 (356. 1)	5.50812 (336. 1)	6.86877 (256. 2)	10.71753 (340. 2)	10.71753 (340. 2)
280000.0	5.55573 (278. 1)	5.79029 (324. 1)	4.30283 (363. 2)	7.88330 (265. 3)	10.20468 (344. 2)	10.20468 (344. 2)
260000.0	5.74943 (381. 1)	4.77052 (322. 1)	6.40212 (276. 2)	8.61038 (265. 3)	12.82183 (358. 1)	12.82183 (358. 1)
240000.0	4.93067 (326. 1)	7.39076 (279. 1)	10.43095 (312. 1)	10.46059 (245. 3)	14.53426 (291. 3)	14.53426 (291. 3)
220000.0	9.93288 (244. 1)	11.20022 (201. 1)	8.87817 (324. 1)	14.61055 (303. 3)	16.35773 (330. 3)	16.35773 (330. 3)
200000.0	11.18195 (321. 2)	12.22658 (244. 1)	10.66501 (278. 1)	20.11533 (256. 2)	26.94911 (324. 3)	26.94911 (324. 3)
180000.0	6.18598 (250. 1)	12.77075 (333. 1)	16.18772 (216. 1)	31.73218 (253. 2)	28.99738 (262. 2)	28.99738 (262. 2)
160000.0	6.15804 (326. 2)	9.86531 (326. 2)	20.53595 (376. 2)	20000.0 (0. 0)	16.48141 (287. 2)	16.48141 (287. 2)
140000.0	10.83007 (244. 2)	13.11831 (305. 3)	23.00130 (289. 2)	24.92118 (248. 2)	17.20973 (346. 2)	17.20973 (346. 2)
120000.0	14.47064 (284. 2)	16.48242 (249. 2)	12.98791 (384. 2)	10.36628 (342. 2)	7.61595 (357. 2)	7.61595 (357. 2)
100000.0	12.26555 (285. 2)	17.13857 (301. 2)	9.34528 (301. 3)	12.40526 (342. 2)	6.42340 (251. 2)	6.42340 (251. 2)
80000.0	9.96526 (251. 2)	8.49121 (336. 1)	9.54826 (277. 3)	9.99733 (342. 2)	6.70021 (312. 2)	6.70021 (312. 2)
60000.0	9.77328 (364. 2)	5.57016 (331. 2)	5.88877 (281. 2)	8.37338 (342. 2)	4.98455 (313. 2)	4.98455 (313. 2)
40000.0	6.43069 (336. 1)	5.30071 (381. 3)	5.20087 (286. 3)	7.19965 (342. 2)	4.48212 (274. 2)	4.48212 (274. 2)
20000.0	4.89474 (321. 2)	9.29210 (340. 1)	5.06757 (291. 2)	6.37007 (342. 2)	4.67191 (274. 2)	4.67191 (274. 2)
0	4.20113 (307. 2)	5.77105 (277. 3)	5.46125 (324. 2)	5.61263 (342. 2)	4.44614 (291. 2)	4.44614 (291. 2)

2ND HIGH
8-HR
SCADUPP 1

*** SITE 1, 150M STACK, MON. FALL, LARGE GRID ***

* SECOND HIGHEST 8-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTION GRID *

* MAXIMUM VALUE EQUALS 31.73218 AND OCCURRED AT (160000.0, 160000.0) *

Y-AXIS (METERS)	X-AXIS (METERS)	200000.0	220000.0	240000.0	260000.0	280000.0
320000.0	7.90078 (322. 2)	5.31615 (330. 2)	4.58840 (324. 3)	4.82459 (299. 3)	5.63556 (355. 1)	5.63556 (355. 1)
300000.0	8.80325 (315. 2)	9.42403 (330. 2)	8.29557 (253. 1)	6.97330 (314. 2)	6.44689 (252. 3)	6.44689 (252. 3)
280000.0	8.99804 (330. 3)	11.05017 (324. 3)	9.91854 (315. 3)	7.49996 (292. 3)	7.77042 (352. 1)	7.77042 (352. 1)
260000.0	11.33725 (287. 1)	12.94504 (271. 1)	7.99306 (329. 2)	8.36625 (382. 1)	7.76970 (317. 2)	7.76970 (317. 2)
240000.0	15.72675 (324. 3)	10.20469 (355. 1)	9.86845 (362. 2)	7.37344 (332. 1)	9.20983 (349. 2)	9.20983 (349. 2)
220000.0	15.35175 (297. 1)	12.44395 (340. 2)	12.33930 (323. 2)	6.42002 (332. 2)	7.84104 (257. 1)	7.84104 (257. 1)
200000.0	18.35206 (283. 2)	16.39437 (345. 2)	10.09561 (354. 2)	5.84154 (264. 2)	5.87588 (264. 2)	5.87588 (264. 2)
180000.0	13.31980 (257. 1)	9.35882 (284. 3)	10.49555 (311. 2)	5.64155 (209. 3)	8.57171 (301. 2)	8.57171 (301. 2)
160000.0	9.53373 (287. 2)	7.77605 (359. 2)	4.06759 (359. 2)	4.96474 (283. 1)	4.31825 (313. 2)	4.31825 (313. 2)
140000.0	8.58696 (249. 2)	6.01939 (294. 2)	7.86015 (290. 2)	4.42836 (314. 1)	5.21759 (244. 2)	5.21759 (244. 2)
120000.0	7.56423 (249. 1)	4.82129 (291. 2)	5.38029 (264. 3)	4.53817 (311. 2)	3.95558 (353. 1)	3.95558 (353. 1)
100000.0	4.99084 (342. 1)	6.10112 (249. 1)	7.97004 (241. 2)	3.64748 (256. 3)	4.11066 (425. 1)	4.11066 (425. 1)
80000.0	5.52552 (357. 1)	4.42569 (363. 1)	5.04157 (249. 1)	5.13556 (302. 2)	4.95682 (291. 2)	4.95682 (291. 2)
60000.0	4.58336 (351. 1)	4.50114 (307. 2)	3.33010 (294. 1)	4.23672 (288. 1)	4.53631 (249. 1)	4.53631 (249. 1)
40000.0	4.61425 (349. 2)	4.73647 (293. 1)	3.60435 (345. 1)	2.72709 (313. 1)	3.17725 (249. 1)	3.17725 (249. 1)
20000.0	4.81450 (307. 2)	3.68434 (330. 2)	6.07258 (357. 1)	2.80331 (345. 1)	2.90677 (289. 1)	2.90677 (289. 1)
0	4.04827 (313. 2)	2.46074 (254. 2)	3.35794 (357. 1)	2.59117 (282. 1)	3.00830 (369. 1)	3.00830 (369. 1)

2ND HIGH
8-HR
SCADUPP 1

*** SITE 1, 150M STACK, MON. FALL, LARGE GRID ***

* SECOND HIGHEST 8-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *
* FROM ALL SOURCES *
* FOR THE RECEPTION GRID *

* MAXIMUM VALUE EQUALS 31.73218 AND OCCURRED AT (160000.0, 160000.0) *

Y-AXIS (METERS)	X-AXIS (METERS)	300000.0	320000.0
320000.0	5.84442 (329. 2)	5.77390 (352. 1)	
300000.0	6.43289 (352. 1)	6.43409 (327. 3)	
280000.0	6.20763 (252. 3)	4.69216 (322. 1)	
260000.0	4.19387 (338. 2)	4.23895 (313. 3)	
240000.0	4.18671 (329. 1)	4.22090 (257. 1)	
220000.0	5.61340 (319. 1)	3.75759 (294. 3)	
200000.0	4.23545 (274. 2)	5.89777 (317. 2)	
180000.0	6.50886 (307. 7)	5.05861 (317. 2)	
160000.0	3.88857 (257. 1)	3.53065 (257. 1)	
140000.0	4.34878 (244. 3)	3.63113 (343. 1)	
120000.0	4.24382 (251. 2)	3.65435 (288. 2)	
100000.0	4.40204 (311. 2)	3.46797 (257. 3)	
80000.0	2.24429 (265. 3)	2.27599 (262. 3)	
60000.0	6.86725 (358. 3)	2.76568 (241. 2)	
40000.0	2.11581 (350. 3)	4.32167 (281. 1)	
20000.0	3.34321 (289. 1)	2.48810 (313. 3)	
0	2.23218 (258. 1)	2.97854 (313. 3)	

*** SITE 1, 150M STACK, NOX, FALL, LARGE GRID ***

* HIGHEST 24-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *

* FROM ALL SOURCES *

* FOR THE RECEPTION GRID *

* MAXIMUM VALUE EQUALS 23.07369 AND OCCURRED AT (160000.0, 140000.0) *

Y-AXIS / (METERS) /	0	20000.0	X-AXIS (METERS) 40000.0	60000.0	80000.0
320000.0 /	1.75362 (276.1)	1.45177 (244.1)	1.64446 (333.1)	2.30002 (244.1)	3.26484 (346.1)
300000.0 /	1.67146 (281.1)	1.57952 (276.1)	1.44968 (244.1)	1.58190 (333.1)	2.23636 (356.1)
280000.0 /	2.21610 (248.1)	1.78983 (341.1)	2.26219 (276.1)	1.64432 (247.1)	3.56399 (244.1)
260000.0 /	2.91404 (303.1)	2.55156 (249.1)	1.74085 (381.1)	2.52112 (278.1)	1.51421 (272.1)
240000.0 /	2.19834 (353.1)	2.77341 (303.1)	3.51032 (332.1)	2.08871 (248.1)	3.12089 (276.1)
220000.0 /	1.27376 (264.1)	2.09446 (287.1)	2.63672 (353.1)	4.19223 (303.1)	3.83613 (249.1)
200000.0 /	1.89569 (340.1)	1.84766 (300.1)	2.12095 (353.1)	2.80861 (264.1)	2.56022 (306.1)
180000.0 /	1.51087 (393.1)	1.52162 (341.1)	1.48478 (349.1)	2.51215 (341.1)	2.79952 (340.1)
160000.0 /	2.14913 (293.1)	2.41826 (283.1)	2.69134 (293.1)	3.01542 (293.1)	3.19094 (293.1)
140000.0 /	1.12100 (340.1)	2.75813 (283.1)	2.68138 (285.1)	2.40762 (248.1)	6.28000 (358.1)
120000.0 /	1.86275 (356.1)	3.97385 (356.1)	2.45943 (356.1)	4.25093 (332.1)	4.61774 (305.1)
100000.0 /	1.12956 (332.1)	2.61655 (298.1)	3.19806 (279.1)	3.96027 (305.1)	5.47559 (316.1)
80000.0 /	2.90766 (279.1)	4.13940 (305.1)	3.24844 (309.1)	4.51467 (267.1)	4.63822 (328.1)
60000.0 /	2.64936 (309.1)	4.44444 (318.1)	3.95398 (307.1)	3.92210 (328.1)	2.85662 (307.1)
40000.0 /	5.00953 (318.1)	2.88844 (307.1)	3.39704 (328.1)	2.07907 (359.1)	4.09554 (306.1)
20000.0 /	2.40059 (308.1)	9.86127 (318.1)	2.01431 (292.1)	3.44608 (351.1)	5.28148 (306.1)
0 /	2.67761 (328.1)	2.07787 (292.1)	2.55440 (307.1)	4.17492 (306.1)	2.99012 (306.1)

HIGH
24-HR
GROUP 1

*** SITE 1, 150M STACK, NOX, FALL, LARGE GRID ***

* HIGHEST 24-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *

* FROM ALL SOURCES *

* FOR THE RECEPTION GRID *

* MAXIMUM VALUE EQUALS 23.07369 AND OCCURRED AT (160000.0, 140000.0) *

Y-AXIS / (METERS) /	100000.0	120000.0	X-AXIS (METERS) 140000.0	160000.0	180000.0
320000.0 /	2.50946 (323.1)	3.22512 (245.1)	2.51230 (336.1)	2.49620 (253.1)	7.05299 (340.1)
300000.0 /	3.84702 (259.1)	3.74410 (245.1)	2.12226 (240.1)	3.30235 (253.1)	6.19345 (340.1)
280000.0 /	4.04308 (346.1)	3.31188 (304.1)	2.32227 (302.1)	3.82450 (253.1)	5.78563 (357.1)
260000.0 /	2.05335 (356.1)	3.98777 (323.1)	3.46282 (302.1)	4.62085 (293.1)	9.97559 (357.1)
240000.0 /	2.42162 (333.1)	5.27420 (346.1)	5.61703 (245.1)	5.17474 (303.1)	8.79480 (324.1)
220000.0 /	3.79735 (276.1)	5.50692 (244.1)	5.36479 (304.1)	8.21780 (303.1)	8.70122 (330.1)
200000.0 /	5.03194 (322.1)	4.75215 (276.1)	7.49104 (346.1)	12.94070 (302.1)	7.60492 (325.1)
180000.0 /	3.93009 (373.1)	5.95042 (306.1)	5.39946 (361.1)	19.29769 (302.1)	29.61019 (329.1)
160000.0 /	5.76114 (293.1)	5.22393 (351.1)	6.92438 (351.1)	30.0000 (3.0)	6.22764 (287.1)
140000.0 /	5.77778 (350.1)	7.14974 (305.1)	8.39994 (280.1)	10.32409 (281.1)	4.48077 (259.1)
120000.0 /	5.85616 (331.1)	7.12246 (329.1)	8.52812 (336.1)	8.84295 (306.1)	4.24707 (351.1)
100000.0 /	6.60726 (329.1)	0.1587 (330.1)	4.14806 (340.1)	5.53913 (308.1)	2.01424 (348.1)
80000.0 /	4.67021 (307.1)	5.53369 (305.1)	5.05610 (305.1)	4.68445 (306.1)	3.65247 (291.1)
60000.0 /	6.47781 (306.1)	3.38894 (321.1)	2.96036 (250.1)	4.04180 (306.1)	2.43086 (304.1)
40000.0 /	3.91961 (306.1)	7.49938 (340.1)	2.76566 (240.1)	3.54691 (304.1)	2.35902 (308.1)
20000.0 /	2.14362 (321.1)	4.82224 (305.1)	2.10611 (240.1)	1.56148 (306.1)	1.09902 (314.1)
0 /	1.74114 (292.1)	2.92900 (305.1)	2.34471 (283.1)	2.44051 (306.1)	2.02965 (349.1)

HIGH
24-HR
GROUP 1

*** SITE 1, 150M STACK, NOX, FALL, LARGE GRID ***

* HIGHEST 24-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *

* FROM ALL SOURCES *

* FOR THE RECEPTION GRID *

* MAXIMUM VALUE EQUALS 23.07369 AND OCCURRED AT (160000.0, 140000.0) *

Y-AXIS / (METERS) /	200000.0	220000.0	X-AXIS (METERS) 240000.0	260000.0	280000.0
320000.0 /	4.76382 (324.1)	3.80996 (330.1)	5.24518 (324.1)	3.39290 (271.1)	3.82715 (334.1)
300000.0 /	5.22699 (319.1)	5.41358 (287.1)	4.98641 (295.1)	3.88109 (315.1)	2.16750 (317.1)
280000.0 /	4.88235 (330.1)	6.76794 (324.1)	4.92289 (319.1)	3.84657 (317.1)	6.55016 (329.1)
260000.0 /	6.72740 (330.1)	3.16074 (325.1)	4.54702 (317.1)	7.65598 (328.1)	2.61497 (347.1)
240000.0 /	9.74906 (324.1)	6.67299 (334.1)	5.23008 (329.1)	3.33041 (355.1)	6.94137 (345.1)
220000.0 /	8.99281 (313.1)	11.70039 (328.1)	6.45096 (329.1)	3.01301 (295.1)	3.64361 (355.1)
200000.0 /	15.93950 (329.1)	11.60405 (345.1)	5.15612 (351.1)	3.04426 (254.1)	3.81492 (254.1)
180000.0 /	8.43371 (315.1)	6.91513 (284.1)	4.07091 (355.1)	2.31301 (328.1)	2.68440 (307.1)
160000.0 /	3.89044 (287.1)	3.02333 (303.1)	2.59504 (303.1)	2.29101 (305.1)	1.98757 (303.1)
140000.0 /	4.12643 (284.1)	2.58095 (281.1)	5.13394 (357.1)	3.93979 (270.1)	2.40426 (318.1)
120000.0 /	3.32701 (313.1)	3.28589 (281.1)	2.74172 (284.1)	2.05492 (321.1)	1.41777 (251.1)
100000.0 /	1.86889 (362.1)	2.16263 (313.1)	3.86062 (289.1)	1.24885 (245.1)	2.07561 (284.1)
80000.0 /	2.97496 (357.1)	1.62260 (352.1)	2.37633 (313.1)	2.45548 (289.1)	1.76261 (297.1)
60000.0 /	1.64737 (312.1)	1.61302 (357.1)	1.19571 (313.1)	2.07406 (313.1)	1.59108 (302.1)
40000.0 /	1.60706 (349.1)	2.19144 (357.1)	1.26186 (303.1)	1.24135 (289.1)	1.84183 (312.1)
20000.0 /	1.52261 (339.1)	1.40269 (284.1)	1.51310 (357.1)	9.0333 (343.1)	1.03218 (349.1)
0 /	2.31310 (291.1)	1.06547 (313.1)	1.71933 (357.1)	6721 (250.1)	1.01572 (352.1)

HIGH
24-HR
GROUP 1

*** SITE 1, 150M STACK, NOX, FALL, LARGE GRID ***

* HIGHEST 24-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) *

* FROM ALL SOURCES *

* FOR THE RECEPTION GRID *

* MAXIMUM VALUE EQUALS 23.07369 AND OCCURRED AT (160000.0, 140000.0) *

Y-AXIS / (METERS) /	300000.0	320000.0	X-AXIS (METERS)
320000.0 /	2.87817 (317.1)	5.10417 (329.1)	
300000.0 /	5.73356 (329.1)	3.86367 (287.1)	
280000.0 /	3.82296 (287.1)	3.92226 (329.1)	
260000.0 /	1.61820 (245.1)	2.56695 (245.1)	
240000.0 /	1.18192 (254.1)	2.60003 (355.1)	
220000.0 /	2.39785 (314.1)	2.14203 (254.1)	
200000.0 /	3.51409 (346.1)	2.41618 (251.1)	
180000.0 /	2.80337 (309.1)	2.44443 (309.1)	
160000.0 /	1.72957 (302.1)	1.59884 (303.1)	
140000.0 /	1.87106 (318.1)	1.81201 (251.1)	
120000.0 /	2.19575 (357.1)	3.29047 (357.1)	
100000.0 /	1.92186 (286.1)	1.32084 (321.1)	
80000.0 /	1.17116 (291.1)	9.16556 (264.1)	
60000.0 /	2.39041 (289.1)	1.05324 (240.1)	
40000.0 /	1.10383 (302.1)	2.30081 (249.1)	
20000.0 /	1.85812 (317.1)	1.80572 (382.1)	
0 /	1.80719 (289.1)	1.50914 (313.1)	

*** SITE 1, 150M STACK, NON-FALL, LARGE GRID ***

*** SECOND HIGHEST 24-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) ***
 *** FROM ALL SOURCES ***
 *** FOR THE RECEPTION GRID ***

*** MAXIMUM VALUE EQUALS 17.13816 AND OCCURRED AT (180000.0, 200000.0) ***

Y-AXIS (METERS)	0	20000.0	40000.0	60000.0	80000.0
320000.0	1.66601 (244.1)	1.39455 (336.1)	1.11505 (335.1)	1.70122 (339.1)	2.31504 (354.1)
300000.0	1.60430 (312.1)	1.35179 (244.1)	1.29154 (272.1)	1.81529 (244.1)	1.80571 (346.1)
280000.0	1.70881 (312.1)	1.21643 (312.1)	2.09217 (244.1)	1.52559 (272.1)	2.86643 (301.1)
260000.0	1.86031 (332.1)	2.04218 (332.1)	1.50964 (312.1)	2.39409 (244.1)	1.81393 (247.1)
240000.0	2.02115 (240.1)	1.84635 (330.1)	2.68042 (303.1)	1.64534 (313.1)	2.79137 (244.1)
220000.0	1.17156 (256.1)	2.05278 (354.1)	2.52259 (306.1)	2.22294 (339.1)	2.75956 (313.1)
200000.0	1.71047 (300.1)	1.63558 (216.1)	1.61412 (363.1)	1.88581 (354.1)	3.29636 (353.1)
180000.0	1.32816 (241.1)	1.51914 (342.1)	1.84418 (350.1)	1.88950 (357.1)	2.35235 (300.1)
160000.0	1.46276 (333.1)	1.60465 (333.1)	1.88937 (351.1)	2.21289 (351.1)	2.73384 (351.1)
140000.0	3.06446 (282.1)	2.75475 (285.1)	2.51728 (332.1)	1.59242 (361.1)	5.52626 (356.1)
120000.0	3.16311 (356.1)	3.61725 (357.1)	3.18755 (277.1)	3.73581 (349.1)	4.21126 (332.1)
100000.0	2.15781 (331.1)	3.81407 (349.1)	3.12050 (332.1)	3.36827 (307.1)	4.19360 (294.1)
80000.0	2.45143 (332.1)	2.29942 (307.1)	3.35206 (321.1)	2.35201 (303.1)	3.14623 (309.1)
60000.0	2.51446 (351.1)	2.78789 (294.1)	2.95071 (309.1)	2.86595 (305.1)	2.67116 (359.1)
40000.0	2.34776 (294.1)	2.78021 (309.1)	2.50896 (309.1)	2.02328 (307.1)	3.21695 (305.1)
20000.0	2.14130 (279.1)	2.23274 (309.1)	2.63474 (307.1)	2.67449 (307.1)	3.40710 (316.1)
0	2.31413 (309.1)	1.58784 (259.1)	2.52341 (351.1)	2.67856 (354.1)	1.97810 (336.1)

2ND HIGH
24-HR
56GROUP 1

*** SITE 1, 150M STACK, NON-FALL, LARGE GRID ***

*** SECOND HIGHEST 24-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) ***
 *** FROM ALL SOURCES ***
 *** FOR THE RECEPTION GRID ***

*** MAXIMUM VALUE EQUALS 17.13816 AND OCCURRED AT (180000.0, 200000.0) ***

Y-AXIS (METERS)	100000.0	120000.0	X-AXIS (METERS) 140000.0	160000.0	180000.0
320000.0	1.16769 (224.1)	2.98225 (381.1)	2.81726 (260.1)	2.86.43 (243.1)	4.44880 (194.1)
300000.0	2.39519 (323.1)	2.26159 (304.1)	1.59926 (321.1)	3.23500 (285.1)	4.52516 (348.1)
280000.0	2.88817 (318.1)	2.14629 (319.1)	2.29746 (321.1)	3.1.235 (243.1)	4.84581 (340.1)
260000.0	1.87161 (268.1)	3.64071 (259.1)	3.28070 (245.1)	4.41556 (255.1)	5.22266 (350.1)
240000.0	1.85783 (335.1)	1.79548 (358.1)	4.44347 (312.1)	7.622.3 (255.1)	7.53351 (308.1)
220000.0	3.33130 (244.1)	1.73341 (301.1)	4.03098 (339.1)	7.54951 (255.1)	8.42476 (348.1)
200000.0	4.58822 (339.1)	4.01553 (444.1)	5.29156 (259.1)	2.96444 (255.1)	17.13816 (324.1)
180000.0	2.88836 (263.1)	4.47259 (280.1)	5.39591 (275.1)	17.08892 (142.1)	13.18419 (288.1)
160000.0	3.18259 (351.1)	4.40862 (293.1)	7.50490 (378.1)	300000 (0.0)	5.40432 (287.1)
140000.0	5.54326 (244.1)	6.12477 (332.1)	8.36303 (378.1)	9.03174 (149.1)	4.08992 (346.1)
120000.0	5.92710 (311.1)	5.48447 (248.1)	5.39301 (264.1)	5.62405 (264.1)	7.70212 (284.1)
100000.0	4.12186 (289.1)	5.14417 (307.1)	4.02129 (325.1)	4.25955 (283.1)	2.14127 (251.1)
80000.0	4.33347 (351.1)	2.26416 (326.1)	3.30291 (277.1)	3.40214 (344.1)	2.57128 (349.1)
60000.0	4.72424 (364.1)	2.48202 (387.1)	2.88110 (274.1)	7.84079 (342.1)	1.80945 (274.1)
40000.0	2.50098 (336.1)	2.15524 (305.1)	2.47748 (307.1)	2.43646 (342.1)	1.44880 (274.1)
20000.0	2.39415 (282.1)	3.30766 (340.1)	2.50149 (299.1)	2.13241 (342.1)	1.50738 (315.1)
0	1.48989 (321.1)	2.96674 (277.1)	2.70591 (280.1)	1.59713 (342.1)	1.76693 (287.1)

2ND HIGH
24-HR
56GROUP 1

*** SITE 1, 150M STACK, NON-FALL, LARGE GRID ***

*** SECOND HIGHEST 24-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) ***
 *** FROM ALL SOURCES ***
 *** FOR THE RECEPTION GRID ***

*** MAXIMUM VALUE EQUALS 17.13816 AND OCCURRED AT (180000.0, 200000.0) ***

Y-AXIS (METERS)	200000.0	220000.0	240000.0	260000.0	280000.0
320000.0	4.04471 (306.1)	3.32688 (326.1)	4.35081 (325.1)	3.25162 (299.1)	2.43000 (338.1)
300000.0	4.09920 (324.1)	5.35941 (330.1)	4.01205 (271.1)	3.84758 (334.1)	2.15804 (338.1)
280000.0	4.52016 (348.1)	6.51312 (339.1)	4.18828 (319.1)	3.14401 (339.1)	2.53227 (344.1)
260000.0	6.27025 (226.1)	5.31856 (271.1)	3.74311 (284.1)	3.48816 (288.1)	2.58355 (355.1)
240000.0	9.58410 (325.1)	5.31942 (316.1)	4.42452 (288.1)	3.07525 (323.1)	5.11046 (363.1)
220000.0	7.12466 (319.1)	5.99915 (266.1)	5.86558 (345.1)	2.69409 (309.1)	3.37118 (257.1)
200000.0	6.51155 (264.1)	4.92579 (340.1)	4.48160 (257.1)	7.75044 (262.1)	2.09851 (316.1)
180000.0	6.71653 (274.1)	3.75746 (310.1)	4.02576 (251.1)	2.05261 (317.1)	2.86418 (308.1)
160000.0	3.52810 (240.1)	2.92636 (340.1)	2.45084 (340.1)	2.29618 (340.1)	1.82785 (340.1)
140000.0	3.57135 (251.1)	2.00613 (294.1)	2.84394 (279.1)	1.80421 (288.1)	1.79686 (329.1)
120000.0	2.52141 (269.1)	2.98684 (297.1)	1.98264 (261.1)	1.94137 (321.1)	2.31926 (353.1)
100000.0	1.86261 (243.1)	2.03671 (283.1)	2.65558 (281.1)	1.22916 (256.1)	1.53324 (316.1)
80000.0	1.83508 (264.1)	1.60456 (363.1)	1.68386 (288.1)	1.71395 (302.1)	1.75370 (281.1)
60000.0	1.52779 (351.1)	1.50036 (307.1)	1.04359 (298.1)	1.44557 (289.1)	1.51204 (289.1)
40000.0	1.54696 (281.1)	1.32536 (273.1)	1.20146 (333.1)	0.90503 (313.1)	1.25704 (289.1)
20000.0	2.40816 (349.1)	1.25463 (312.1)	1.45611 (307.1)	1.54444 (343.1)	1.68592 (285.1)
0	1.54493 (353.1)	45784 (254.1)	1.12419 (293.1)	863.2 (262.1)	1.00277 (363.1)

2ND HIGH
24-HR
56GROUP 1

*** SITE 1, 150M STACK, NON-FALL, LARGE GRID ***

*** SECOND HIGHEST 24-HOUR AVERAGE CONCENTRATION (MICROGRAMS/CUBIC METER) ***
 *** FROM ALL SOURCES ***
 *** FOR THE RECEPTION GRID ***

*** MAXIMUM VALUE EQUALS 17.13816 AND OCCURRED AT (180000.0, 200000.0) ***

Y-AXIS (METERS)	300000.0	320000.0	X-AXIS (METERS)
320000.0	2.48663 (339.1)	2.27937 (344.1)	
300000.0	2.35550 (344.1)	2.17079 (332.1)	
280000.0	2.19159 (259.1)	1.12492 (346.1)	
260000.0	4.53364 (329.1)	2.31732 (255.1)	
240000.0	1.86558 (309.1)	2.68571 (257.1)	
220000.0	2.33137 (374.1)	4.27562 (364.1)	
200000.0	1.54696 (281.1)	2.35447 (395.1)	
180000.0	2.40231 (307.1)	1.72994 (307.1)	
160000.0	1.81884 (340.1)	1.45190 (340.1)	
140000.0	1.56722 (251.1)	1.20438 (343.1)	
120000.0	1.81461 (251.1)	1.40987 (297.1)	
100000.0	1.49149 (246.1)	1.75599 (357.1)	
80000.0	1.04099 (312.1)	1.41960 (310.1)	
60000.0	2.22402 (219.1)	92128 (281.1)	
40000.0	90532 (320.1)	1.76474 (332.1)	
20000.0	1.11440 (249.1)	.82259 (313.1)	
0	1.74458 (294.1)	.99911 (289.1)	

APPENDIX C

CONTOUR MAPS SHOWING ANNUAL AVERAGE POLLUTANT CONCENTRATIONS

APPENDIX C

CONTOUR MAPS SHOWING ANNUAL AVERAGE POLLUTANT CONCENTRATIONS

This appendix contains contour maps of the four study sites showing the spatial variations in pollutant concentrations for the area within one hundred miles of each study site. Each plot shows the annual average air quality impacts for a combination of basic criteria pollutant, study site, study year, and resource alternatives. Contours are drawn over a background map of the study region using the 320-by-320-km expanded Cartesian grid. The study site, located at the center of the grid, is indicated by a cross (+). The contours are plotted using thick lines and the label numbers indicate annual average pollutant concentration in micrograms per m³. Roads, rivers, and urban boundaries are plotted using thin lines. In the lower right corner of the figure, we report the three highest pollutant concentrations recorded on the modeling grid and the distance from the study site at which these concentrations were computed.

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 1991
SITE: CENTRALIA

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
1.49	20.	40.
1.46	20.	20.
1.11	0.	20.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 1991
SITE: CENTRALIA

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
1.97	20.	40.
1.94	20.	20.
1.48	0.	20.

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 1991
SITE: CENTRALIA

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
.08	20.	40.
.08	20.	20.
.06	0.	20.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: CENTRALIA

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CONVENTIONAL COAL
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
3.22	20.	20.
3.08	20.	40.
2.81	0.	20.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: CENTRALIA

RESOURCE ALTERNATIVES

IMPORTS

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
3.69	20.	20.
3.51	20.	40.
3.25	0.	20.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: CENTRALIA

RESOURCE ALTERNATIVES

STATUS QUD
BASE CASE 4
CONSERVATION
CONVENTIONAL COAL
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
2.27	20.	40.
2.25	20.	20.
1.71	0.	20.

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: CENTRALIA

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CONVENTIONAL COAL
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION

THREE HIGHEST GRID CONC.	X(KM)	Y(KM)
.10	20.	20.
.10	20.	40.
.07	0.	20.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: CENTRALIA

RESOURCE ALTERNATIVES

IMPORTS

THREE HIGHEST GRID CONC.	X(KM)	Y(KM)
.12	20.	20.
.11	20.	40.
.09	0.	20.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CENTRALIA

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CONVENTIONAL COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
4.21	20.	20.
3.97	20.	40.
3.78	0.	20.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CENTRALIA

RESOURCE ALTERNATIVES

CLEAN COAL

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
3.34	20.	20.
3.19	20.	40.
2.90	0.	20.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CENTRALIA

RESOURCE ALTERNATIVES

IMPORTS

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
5.49	20.	20.
5.13	20.	40.
5.02	0.	20.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CENTRALIA

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CONVENTIONAL COAL
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
2.34	20.	40.
2.34	20.	20.
1.77	0.	20.

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CENTRALIA

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CONVENTIONAL COAL
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION

THREE HIGHEST GRID VALUES CONC.	X (KM)	Y (KM)
.11	20.	20.
.11	20.	40.
.09	0.	20.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CENTRALIA

RESOURCE ALTERNATIVES

IMPORTS

THREE HIGHEST GRID VALUES CONC.	X (KM)	Y (KM)
.14	20.	20.
.13	20.	40.
.11	0.	20.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: CRESTON

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CLEAN COAL
NUCLEAR
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
.54	20.	20.
.46	-20.	-20.
.46	20.	40.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: CRESTON

RESOURCE ALTERNATIVES

CONVENTIONAL COAL

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
.62	20.	20.
.56	-20.	-20.
.53	20.	40.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: CRESTON

RESOURCE ALTERNATIVES

COMBUSTION TURBINE

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
.65	20.	20.
.62	-20.	-20.
.55	0.	20.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: CRESTON

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
.21	20.	20.
.18	-20.	-20.
.18	20.	40.

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: CRESTON

RESOURCE ALTERNATIVES

CONVENTIONAL COAL

THREE HIGHEST GRID CONC.	X(KM)	Y(KM)
.25	20.	20.
.22	-20.	-20.
.21	20.	40.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: CRESTON

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID CONC.	X(KM)	Y(KM)
.03	20.	20.
.03	-20.	-20.
.03	20.	40.

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: CRESTON

RESOURCE ALTERNATIVES

CONVENTIONAL COAL
CLEAN COAL

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
.04	20.	20.
.03	-20.	-20.
.03	20.	40.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CRESTON

RESOURCE ALTERNATIVES

BASE CASE 4
CONSERVATION
NUCLEAR
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
.54	20.	20.
.47	-20.	-20.
.45	0.	20.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CRESTON

RESOURCE ALTERNATIVES

STATUS QUO
CONVENTIONAL COAL
COMBUSTION TURBINE

THREE HIGHEST GRID CONC.	X(KM)	Y(KM)
.73	20.	20.
.63	-20.	-20.
.62	0.	20.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CRESTON

RESOURCE ALTERNATIVES

CLEAN COAL

THREE HIGHEST GRID CONC.	X(KM)	Y(KM)
.62	20.	20.
.53	-20.	-20.
.53	0.	20.

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CRESTON

RESOURCE ALTERNATIVES

BASE CASE 4
CONSERVATION
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID CONC.	X(KM)	Y(KM)
.22	20.	20.
.19	-20.	-20.
.18	0.	20.

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CRESTON

RESOURCE ALTERNATIVES

STATUS QUO
CONVENTIONAL COAL

THREE HIGHEST GRID CONC.	X(KM)	Y(KM)
.29	20.	20.
.25	-20.	-20.
.25	0.	20.

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CRESTON

RESOURCE ALTERNATIVES

CLEAN COAL

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
.25	20.	20.
.22	-20.	-20.
.22	0.	20.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CRESTON

RESOURCE ALTERNATIVES

BASE CASE 4
CONSERVATION
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
.03	20.	20.
.03	-20.	-20.
.03	0.	20.

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CRESTON

RESOURCE ALTERNATIVES

STATUS QUO
CONVENTIONAL COAL

THREE HIGHEST GRID CONC.	X(KM)	Y(KM)
.04	20.	20.
.04	-20.	-20.
.04	0.	20.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: CRESTON

RESOURCE ALTERNATIVES

CLEAN COAL

THREE HIGHEST GRID CONC.	X(KM)	Y(KM)
.04	20.	20.
.03	-20.	-20.
.03	0.	20.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 1991
SITE: BOARDMAN

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
.46	20.	0.
.25	40.	0.
.24	20.	-20.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 1991
SITE: BOARDMAN

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
.61	20.	0.
.34	40.	0.
.31	20.	-20.

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 1991
SITE: BOARDMAN

THREE HIGHEST CONC.	X(KM)	Y(KM)
.02	20.	0.
.01	40.	0.
.01	20.	-20.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: BOARDMAN

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST CONC.	X(KM)	Y(KM)
1.12	20.	0.
.81	-20.	20.
.73	-20.	40.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: BOAROMAN

RESOURCE ALTERNATIVES

CONVENTIONAL COAL

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
1.43	20.	0.
.91	-20.	20.
.86	20.	-20.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: BOAROMAN

RESOURCE ALTERNATIVES

COGENERATION

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
1.43	20.	0.
1.36	-20.	20.
1.16	-20.	40.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: BOARDMAN

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CONVENTIONAL COAL
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
1.00	20.	0.
.54	40.	0.
.50	20.	-20.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: BOARDMAN

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CONVENTIONAL COAL
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
.04	20.	0.
.02	40.	0.
.02	20.	-20.

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: BOARDMAN

RESOURCE ALTERNATIVES

CONVENTIONAL COAL

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
.06	20.	0.
.03	40.	0.
.03	20.	-20.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: BOARDMAN

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
2.49	20.	0.
2.05	-20.	20.
1.79	-20.	40.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: BOARDMAN

RESOURCE ALTERNATIVES

CONVENTIONAL COAL
COGENERATION

THREE HIGHEST GRID CONC.	X(KM)	Y(KM)
2.90	20.	0.
2.15	-20.	20.
1.92	-20.	40.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: BOARDMAN

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID CONC.	X(KM)	Y(KM)
1.30	20.	0.
.70	40.	0.
.65	20.	-20.

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: BOARDMAN

RESOURCE ALTERNATIVES

CONVENTIONAL COAL

THREE HIGHEST CONC.	X(KM)	Y(KM)
1.47	20.	0.
.79	40.	0.
.74	20.	-20.

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: BOARDMAN

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST CONC.	X(KM)	Y(KM)
.09	20.	0.
.05	40.	0.
.05	20.	-20.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: BOARDMAN

RESOURCE ALTERNATIVES

CONVENTIONAL COAL

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
.11	20.	0.
.06	40.	0.
.06	20.	-20.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 1991
SITE: COLSTRIP

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
1.68	20.	-20.
1.40	-20.	40.
1.40	-20.	20.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 1991
SITE: COLSTRIP

THREE HIGHEST GRID CONC.	X (KM)	Y (KM)
2.23	20.	-20.
1.86	-20.	40.
1.86	-20.	20.

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 1991
SITE: COLSTRIP

THREE HIGHEST GRID CONC.	X (KM)	Y (KM)
.09	20.	-20
.07	-20.	40
.07	-20.	20

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: COLSTRIP

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID VALUES CONC.	X (KM)	Y (KM)
2.45	20.	-20.
2.11	-20.	20.
2.06	-20.	40.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: COLSTRIP

RESOURCE ALTERNATIVES

CONVENTIONAL COAL

THREE HIGHEST GRID VALUES CONC.	X (KM)	Y (KM)
2.86	20.	-20.
2.46	-20.	20.
2.39	-20.	40.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: COLSTRIP

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
2.72	20.	-20.
2.33	-20.	20.
2.28	-20.	40.

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: COLSTRIP

RESOURCE ALTERNATIVES

CONVENTIONAL COAL

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
2.89	20.	-20.
2.48	-20.	20.
2.42	-20.	40.

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: COLSTRIP

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID CONC.	X (KM)	Y (KM)
.13	20.	-20.
.11	-20.	20.
.11	-20.	40.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2000
SITE: COLSTRIP

RESOURCE ALTERNATIVES

CONVENTIONAL COAL

THREE HIGHEST GRID CONC.	X (KM)	Y (KM)
.16	20.	-20.
.13	-20.	20.
.13	-20.	40.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: COLSTRIP

RESOURCE ALTERNATIVES

BASE CASE 4
CONSERVATION
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
3.24	20.	-20.
2.79	-20.	20.
2.71	-20.	40.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: COLSTRIP

RESOURCE ALTERNATIVES

STATUS QUO
CONVENTIONAL COAL

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
3.64	20.	-20.
3.14	-20.	20.
3.05	-20.	40.

ANNUAL AVERAGE NITROGEN OXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: COLSTRIP

RESOURCE ALTERNATIVES

STATUS QUO
BASE CASE 4
CONSERVATION
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
3.20	20.	-20.
2.75	-20.	20.
2.68	-20.	40.

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: COLSTRIP

RESOURCE ALTERNATIVES

CONVENTIONAL COAL

THREE HIGHEST GRID VALUES CONC.	X(KM)	Y(KM)
3.24	20.	-20.
2.80	-20.	20.
2.71	-20.	40.

ANNUAL AVERAGE SULFUR DIOXIDE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: COLSTRIP

RESOURCE ALTERNATIVES

STATUS QUO
CONVENTIONAL COAL

THREE HIGHEST GRID CONC.	X (KM)	Y (KM)
.20	20.	-20.
.17	-20.	20.
.17	-20.	40.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

CONTOURS REPRESENT THE
POLLUTANT CONCENTRATION
IN UNITS OF:
MICROGRAMS / CUBIC METER

STUDY YEAR: 2010
SITE: COLSTRIP

RESOURCE ALTERNATIVES

BASE CASE 4
CONSERVATION
CLEAN COAL
NUCLEAR
COMBUSTION TURBINE
RENEWABLES
COGENERATION
FUEL SWITCHING
HIGH CONSERVATION
IMPORTS

THREE HIGHEST GRID CONC.	X (KM)	Y (KM)
.18	20.	-20.
.15	-20.	20.
.15	-20.	40.

ANNUAL AVERAGE PARTICULATE CONCENTRATIONS
FROM ALL POWER PLANT EMISSIONS

APPENDIX D

HIGHEST AVERAGE AND SHORT-TERM MAXIMUM BASIC CRITERIA POLLUTANT CONCENTRATIONS

APPENDIX D

HIGHEST AVERAGE AND SHORT-TERM MAXIMUM BASIC CRITERIA POLLUTANT CONCENTRATIONS

The series of tables presented in this appendix present the three highest pollutant concentrations reported anywhere on the ISCST model's close-in grid (i.e., the 32-km-wide Cartesian grid) for the indicated pollutant, averaging period, study year, release location, and resource alternative. In addition to presenting the three highest pollutant concentration values, the tables also present the east-west and north-south distance from the release location at which each reported value occurred. Values presented here are conservative in that they are computed assuming all pollutant releases occur at a single site; in reality, pollutant sources will be dispersed over a wider area producing lower maximum impacts.

SITE: CENTRALIA YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

<u>RESOURCE ALTERNATIVE</u>	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	36.1	-4, -2	36.0	2, 2	34.3	2, 16

SITE: CENTRALIA YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

<u>RESOURCE ALTERNATIVE</u>	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	43.7	2, 2	39.0	-4, -2	38.5	-2, -2
BASE CASE 4	43.0	2, 2	38.3	-4, -2	37.9	-2, -2
CONSERVATION	43.0	2, 2	38.3	-4, -2	37.9	-2, -2
CONVENTIONAL COAL	45.8	2, 2	40.8	-4, -2	40.4	-2, -2
CLEAN COAL	44.6	2, 2	39.8	-4, -2	39.3	-2, -2
NUCLEAR	41.8	2, 2	37.3	-4, -2	36.8	-2, -2
COMBUSTION TURBINE	43.0	2, 2	38.3	-4, -2	37.9	-2, -2
RENEWABLES	42.8	2, 2	38.2	-4, -2	37.8	-2, -2
COGENERATION	38.2	2, 2	37.0	-4, -2	35.2	2, 16
FUEL SWITCHING	43.7	2, 2	38.9	-4, -2	38.5	-2, -2
HIGH CONSERVATION	43.2	2, 2	38.5	-4, -2	38.1	-2, -2
IMPORTS	47.2	2, 2	42.0	-4, -2	41.6	-2, -2

SITE: CENTRALIA YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

<u>RESOURCE ALTERNATIVE</u>	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	48.7	2, 2	43.4	-4, -2	42.9	-2, -2
BASE CASE 4	48.7	2, 2	43.4	-4, -2	42.9	-2, -2
CONSERVATION	48.7	2, 2	43.4	-4, -2	42.9	-2, -2
CONVENTIONAL COAL	50.7	2, 2	45.1	-4, -2	44.6	-2, -2
CLEAN COAL	49.0	2, 2	43.7	-4, -2	43.2	-2, -2
NUCLEAR	48.7	2, 2	43.4	-4, -2	42.9	-2, -2
COMBUSTION TURBINE	48.7	2, 2	43.4	-4, -2	42.9	-2, -2
RENEWABLES	48.7	2, 2	43.4	-4, -2	42.9	-2, -2
COGENERATION	48.7	2, 2	43.4	-4, -2	42.9	-2, -2
FUEL SWITCHING	48.7	2, 2	43.4	-4, -2	42.9	-2, -2
HIGH CONSERVATION	48.7	2, 2	43.4	-4, -2	42.9	-2, -2
IMPORTS	48.7	2, 2	43.4	-4, -2	42.9	-2, -2

SITE: CENTRALIA YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
<u>RESOURCE ALTERNATIVE</u>	<u>(μg/m³)</u>	<u>(KM)</u>	<u>(μg/m³)</u>	<u>(KM)</u>	<u>(μg/m³)</u>	<u>(KM)</u>
ALL PROGRAMS	1.40	-4, -2	1.40	2, 2	1.33	2, 16

SITE: CENTRALIA YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
<u>RESOURCE ALTERNATIVE</u>	<u>(μg/m³)</u>	<u>(KM)</u>	<u>(μg/m³)</u>	<u>(KM)</u>	<u>(μg/m³)</u>	<u>(KM)</u>
STATUS QUO	1.83	2, 2	1.60	-2, -2	1.58	-4, -2
BASE CASE 4	1.80	2, 2	1.58	-2, -2	1.56	-4, -2
CONSERVATION	1.80	2, 2	1.58	-2, -2	1.56	-4, -2
CONVENTIONAL COAL	2.04	2, 2	1.79	-2, -2	1.78	-4, -2
CLEAN COAL	1.88	2, 2	1.65	-2, -2	1.63	-4, -2
NUCLEAR	1.74	2, 2	1.52	-2, -2	1.51	-4, -2
COMBUSTION TURBINE	1.84	2, 2	1.61	-2, -2	1.58	-4, -2
RENEWABLES	1.80	2, 2	1.58	-2, -2	1.57	-4, -2
COGENERATION	1.66	2, 2	1.56	-4, -2	1.50	2, 16
FUEL SWITCHING	1.86	2, 2	1.63	-4, -2	1.63	-2, -2
HIGH CONSERVATION	1.83	2, 2	1.61	-2, -2	1.60	-4, -2
IMPORTS	2.03	2, 2	1.86	2, 8	1.86	0, 4

SITE: CENTRALIA YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
<u>RESOURCE ALTERNATIVE</u>	<u>(μg/m³)</u>	<u>(KM)</u>	<u>(μg/m³)</u>	<u>(KM)</u>	<u>(μg/m³)</u>	<u>(KM)</u>
STATUS QUO	2.13	2, 2	1.87	-2, -2	1.82	-4, -2
BASE CASE 4	2.17	2, 2	1.90	-2, -2	1.84	-4, -2
CONSERVATION	2.17	2, 2	1.90	-2, -2	1.84	-4, -2
CONVENTIONAL COAL	2.39	2, 2	2.09	-2, -2	2.06	-4, -2
CLEAN COAL	2.14	2, 2	1.88	-2, -2	1.84	-4, -2
NUCLEAR	2.17	2, 2	1.90	-2, -2	1.84	-4, -2
COMBUSTION TURBINE	2.16	2, 2	1.88	-2, -2	1.83	-4, -2
RENEWABLES	2.16	2, 2	1.89	-2, -2	1.83	-4, -2
COGENERATION	2.13	2, 2	1.86	-2, -2	1.82	-4, -2
FUEL SWITCHING	2.13	2, 2	1.86	-2, -2	1.82	-4, -2
HIGH CONSERVATION	2.12	2, 2	1.85	-2, -2	1.81	-4, -2
IMPORTS	2.36	0, 4	2.33	2, 2	2.23	0, 6

SITE: CENTRALIA YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 3 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)
ALL PROGRAMS	186.7	2, 4	181.9	-4, -2	175.2	0, 4

SITE: CENTRALIA YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 3 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)
STATUS QUO	212.6	0, 4	198.9	0, 6	193.5	4, 6
BASE CASE 4	208.9	0, 4	195.5	0, 6	191.6	2, 4
CONSERVATION	208.9	0, 4	195.5	0, 6	191.6	2, 4
CONVENTIONAL COAL	222.6	0, 4	208.3	0, 6	202.7	4, 6
CLEAN COAL	216.9	0, 4	203.0	0, 6	197.5	4, 6
NUCLEAR	203.2	0, 4	191.4	2, 4	190.2	0, 6
COMBUSTION TURBINE	209.0	0, 4	195.6	0, 6	191.6	2, 4
RENEWABLES	208.3	0, 4	194.9	0, 6	191.7	2, 4
COGENERATION	191.5	2, 4	186.4	-4, -2	185.5	0, 4
FUEL SWITCHING	212.2	0, 4	198.6	0, 6	193.2	4, 6
HIGH CONSERVATION	209.9	0, 4	196.5	0, 6	191.7	2, 4
IMPORTS	229.3	0, 4	214.6	0, 6	208.7	4, 6

SITE: CENTRALIA YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 3 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)
STATUS QUO	236.6	0, 4	221.5	0, 6	215.5	4, 6
BASE CASE 4	236.7	0, 4	221.6	0, 6	215.6	4, 6
CONSERVATION	236.7	0, 4	221.6	0, 6	215.6	4, 6
CONVENTIONAL COAL	246.2	0, 4	230.4	0, 6	224.2	4, 6
CLEAN COAL	238.1	0, 4	222.9	0, 6	216.8	4, 6
NUCLEAR	236.8	0, 4	221.6	0, 6	215.6	4, 6
COMBUSTION TURBINE	236.7	0, 4	221.6	0, 6	215.5	4, 6
RENEWABLES	236.7	0, 4	221.6	0, 6	215.5	4, 6
COGENERATION	236.7	0, 4	221.6	0, 6	215.6	4, 6
FUEL SWITCHING	236.6	0, 4	221.5	0, 6	215.5	4, 6
HIGH CONSERVATION	236.6	0, 4	221.5	0, 6	215.5	4, 6
IMPORTS	236.7	0, 4	221.6	0, 6	215.6	4, 6

SITE: CENTRALIA YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 1 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	431.3	-4, -2	362.2	2, -8	334.7	2, 6

SITE: CENTRALIA YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 1 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	441.7	-4, -2	371.3	2, -8	360.1	0, 4
BASE CASE 4	441.7	-4, -2	371.3	2, -8	356.9	4, 4
CONSERVATION	441.7	-4, -2	371.3	2, -8	356.9	4, 4
CONVENTIONAL COAL	461.4	-4, -2	387.8	2, -8	377.1	0, 4
CLEAN COAL	441.8	-4, -2	371.3	2, -8	367.5	0, 4
NUCLEAR	441.5	-4, -2	371.1	2, -8	355.2	4, 4
COMBUSTION TURBINE	441.8	-4, -2	371.4	2, -8	357.1	4, 4
RENEWABLES	441.9	-4, -2	371.5	2, -8	356.9	4, 4
COGENERATION	441.4	-4, -2	371.1	2, -8	342.9	2, 6
FUEL SWITCHING	441.5	-4, -2	371.2	2, -8	359.5	0, 4
HIGH CONSERVATION	441.9	-4, -2	371.5	2, -8	360.1	4, 4
IMPORTS	441.7	-4, -2	388.4	0, 4	377.3	4, 4

SITE: CENTRALIA YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 1 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	442.2	-4, -2	400.8	0, 4	389.3	4, 4
BASE CASE 4	442.3	-4, -2	401.0	0, 4	389.5	4, 4
CONSERVATION	442.3	-4, -2	401.0	0, 4	389.5	4, 4
CONVENTIONAL COAL	461.8	-4, -2	417.0	0, 4	405.1	4, 4
CLEAN COAL	444.9	-4, -2	403.3	0, 4	391.8	4, 4
NUCLEAR	442.3	-4, -2	401.0	0, 4	389.5	4, 4
COMBUSTION TURBINE	442.1	-4, -2	400.9	0, 4	389.4	4, 4
RENEWABLES	442.3	-4, -2	400.9	0, 4	389.4	4, 4
COGENERATION	442.2	-4, -2	400.9	0, 4	389.4	4, 4
FUEL SWITCHING	442.2	-4, -2	400.8	0, 4	389.3	4, 4
HIGH CONSERVATION	442.1	-4, -2	400.8	0, 4	389.3	4, 4
IMPORTS	442.6	-4, -2	401.0	0, 4	389.5	4, 4

SITE: CENTRALIA YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	2.16	8, 16	2.10	8, 12	2.08	10, 14

SITE: CENTRALIA YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	6.54	4, 8	6.32	4, 6	6.18	6, 12
BASE CASE 4	6.78	4, 8	6.56	4, 6	6.37	6, 12
CONSERVATION	6.65	4, 8	6.42	4, 6	6.26	6, 12
CONVENTIONAL COAL	6.58	4, 8	6.32	4, 6	6.32	6, 12
CLEAN COAL	6.66	4, 8	6.43	4, 6	6.28	6, 12
NUCLEAR	5.73	4, 8	5.52	4, 6	5.50	6, 12
COMBUSTION TURBINE	7.54	4, 8	7.33	4, 6	7.00	6, 12
RENEWABLES	6.93	4, 8	6.69	4, 6	6.50	6, 12
COGENERATION	7.53	4, 8	7.32	4, 6	6.95	6, 12
FUEL SWITCHING	7.37	4, 8	7.13	4, 6	6.87	6, 12
HIGH CONSERVATION	7.30	4, 8	7.06	4, 6	6.81	6, 12
IMPORTS	6.45	4, 8	6.22	4, 6	6.12	6, 12

SITE: CENTRALIA YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	9.42	4, 8	9.19	4, 6	8.76	2, 4
BASE CASE 4	10.54	4, 8	10.32	4, 6	9.91	2, 4
CONSERVATION	10.54	4, 8	10.32	4, 6	9.91	2, 4
CONVENTIONAL COAL	9.04	4, 8	8.80	4, 6	8.37	6, 12
CLEAN COAL	8.81	4, 8	8.59	4, 6	8.13	2, 4
NUCLEAR	10.64	4, 8	10.43	4, 6	10.02	2, 4
COMBUSTION TURBINE	9.75	4, 8	9.55	4, 6	9.13	2, 4
RENEWABLES	10.09	4, 8	9.87	4, 6	9.45	2, 4
COGENERATION	10.13	4, 8	9.93	4, 6	9.51	2, 4
FUEL SWITCHING	9.45	4, 8	9.23	4, 6	8.79	2, 4
HIGH CONSERVATION	9.06	4, 8	8.85	4, 6	8.41	2, 4
IMPORTS	11.18	4, 8	10.95	4, 6	10.52	2, 4

SITE: CENTRALIA YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	2.87	8, 16	2.79	8, 12	2.76	10, 14

SITE: CENTRALIA YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	3.33	8, 16	3.26	8, 12	3.22	10, 14
BASE CASE 4	3.32	8, 16	3.24	8, 12	3.21	10, 14
CONSERVATION	3.32	8, 16	3.24	8, 12	3.21	10, 14
CONVENTIONAL COAL	3.50	8, 16	3.42	8, 12	3.39	10, 14
CLEAN COAL	3.38	8, 16	3.31	8, 12	3.27	10, 14
NUCLEAR	3.29	8, 16	3.22	8, 12	3.18	10, 14
COMBUSTION TURBINE	3.32	8, 16	3.25	8, 12	3.21	10, 14
RENEWABLES	3.33	8, 16	3.25	8, 12	3.22	10, 14
COGENERATION	3.14	8, 16	3.05	8, 12	3.02	10, 14
FUEL SWITCHING	3.35	8, 16	3.27	8, 12	3.24	10, 14
HIGH CONSERVATION	3.35	8, 16	3.28	8, 12	3.24	10, 14
IMPORTS	3.43	8, 16	3.36	8, 12	3.32	10, 14

SITE: CENTRALIA YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	3.44	8, 16	3.38	8, 12	3.34	10, 14
BASE CASE 4	3.45	8, 16	3.40	8, 12	3.35	10, 14
CONSERVATION	3.45	8, 16	3.40	8, 12	3.35	10, 14
CONVENTIONAL COAL	3.58	8, 16	3.52	8, 12	3.48	10, 14
CLEAN COAL	3.47	8, 16	3.42	8, 12	3.37	10, 14
NUCLEAR	3.45	8, 16	3.40	8, 12	3.35	10, 14
COMBUSTION TURBINE	3.45	8, 16	3.39	8, 12	3.35	10, 14
RENEWABLES	3.45	8, 16	3.40	8, 12	3.35	10, 14
COGENERATION	3.45	8, 16	3.39	8, 12	3.34	10, 14
FUEL SWITCHING	3.45	8, 16	3.40	8, 12	3.35	10, 14
HIGH CONSERVATION	3.45	8, 16	3.39	8, 12	3.35	10, 14
IMPORTS	3.51	8, 16	3.45	8, 12	3.40	10, 14

SITE: CENTRALIA YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

	Highest Maximum	Second Maximum	Third Maximum
	Conc. ₃ X,Y	Conc. ₃ X,Y	Conc. ₃ X,Y
<u>RESOURCE ALTERNATIVE</u>	<u>($\mu\text{g}/\text{m}^3$) (KM)</u>	<u>($\mu\text{g}/\text{m}^3$) (KM)</u>	<u>($\mu\text{g}/\text{m}^3$) (KM)</u>
ALL PROGRAMS	.111 8, 16	.108 8, 12	.107 10, 14

SITE: CENTRALIA YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

	Highest Maximum	Second Maximum	Third Maximum
	Conc. ₃ X,Y	Conc. ₃ X,Y	Conc. ₃ X,Y
<u>RESOURCE ALTERNATIVE</u>	<u>($\mu\text{g}/\text{m}^3$) (KM)</u>	<u>($\mu\text{g}/\text{m}^3$) (KM)</u>	<u>($\mu\text{g}/\text{m}^3$) (KM)</u>
STATUS QUO	.146 8, 16	.145 8, 12	.145 6, 12
BASE CASE 4	.147 8, 16	.146 6, 12	.146 8, 12
CONSERVATION	.146 8, 16	.145 8, 12	.145 6, 12
CONVENTIONAL COAL	.166 8, 16	.164 8, 12	.164 6, 12
CLEAN COAL	.153 8, 16	.153 6, 12	.152 8, 12
NUCLEAR	.142 8, 16	.141 8, 12	.141 6, 12
COMBUSTION TURBINE	.150 8, 16	.149 6, 12	.149 8, 12
RENEWABLES	.149 8, 16	.149 6, 12	.148 8, 12
COGENERATION	.144 6, 12	.144 8, 16	.143 8, 12
FUEL SWITCHING	.156 6, 12	.156 8, 16	.155 8, 12
HIGH CONSERVATION	.153 6, 12	.153 8, 16	.153 8, 12
IMPORTS	.183 6, 12	.180 8, 12	.178 8, 16

SITE: CENTRALIA YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

	Highest Maximum	Second Maximum	Third Maximum
	Conc. ₃ X,Y	Conc. ₃ X,Y	Conc. ₃ X,Y
<u>RESOURCE ALTERNATIVE</u>	<u>($\mu\text{g}/\text{m}^3$) (KM)</u>	<u>($\mu\text{g}/\text{m}^3$) (KM)</u>	<u>($\mu\text{g}/\text{m}^3$) (KM)</u>
STATUS QUO	.171 6, 12	.169 8, 12	.168 8, 16
BASE CASE 4	.176 6, 12	.174 8, 12	.172 8, 16
CONSERVATION	.176 6, 12	.174 8, 12	.172 8, 16
CONVENTIONAL COAL	.180 8, 16	.180 6, 12	.180 8, 12
CLEAN COAL	.163 6, 12	.163 8, 12	.163 8, 16
NUCLEAR	.177 6, 12	.175 8, 12	.173 8, 16
COMBUSTION TURBINE	.172 6, 12	.170 8, 12	.169 8, 16
RENEWABLES	.174 6, 12	.172 8, 12	.170 8, 16
COGENERATION	.166 6, 12	.165 8, 12	.164 8, 16
FUEL SWITCHING	.169 6, 12	.167 8, 12	.166 8, 16
HIGH CONSERVATION	.162 6, 12	.162 8, 12	.161 8, 16
IMPORTS	.224 6, 12	.221 4, 8	.218 8, 12

SITE: CRESTON YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 1 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	.0	0, 0	.0	0, 0	.0	0, 0

SITE: CRESTON YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 1 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	63.4	-2, 0	58.8	2, 4	57.7	0, 4
BASE CASE 4	62.6	-2, 0	58.8	2, 4	57.7	0, 4
CONSERVATION	62.6	-2, 0	58.8	2, 4	57.7	0, 4
CONVENTIONAL COAL	78.4	2, 4	73.5	4, 0	72.7	-2, -4
CLEAN COAL	71.2	-2, 0	68.4	2, 4	64.6	-2, -2
NUCLEAR	58.8	2, 4	57.7	0, 4	56.2	-2, 0
COMBUSTION TURBINE	62.6	-2, 0	59.0	2, 4	57.8	0, 4
RENEWABLES	61.5	-2, 0	58.8	2, 4	57.7	0, 4
COGENERATION	58.8	2, 4	57.7	0, 4	55.5	-4, 4
FUEL SWITCHING	63.4	-2, 0	58.8	2, 4	57.7	0, 4
HIGH CONSERVATION	61.5	-2, 0	58.8	2, 4	57.7	0, 4
IMPORTS	72.2	-2, 0	65.5	-2, -2	62.1	0, 2

SITE: CRESTON YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 1 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	104.3	-2, 0	94.7	-2, -2	89.7	0, 2
BASE CASE 4	78.3	-2, 0	71.1	-2, -2	67.3	0, 2
CONSERVATION	78.3	-2, 0	71.1	-2, -2	67.3	0, 2
CONVENTIONAL COAL	104.3	-2, 0	94.7	-2, -2	89.7	0, 2
CLEAN COAL	91.0	-2, 0	82.6	-2, -2	78.3	0, 2
NUCLEAR	78.3	-2, 0	71.1	-2, -2	67.3	0, 2
COMBUSTION TURBINE	78.4	-2, 0	71.1	-2, -2	67.4	0, 2
RENEWABLES	78.3	-2, 0	71.1	-2, -2	67.3	0, 2
COGENERATION	78.3	-2, 0	71.1	-2, -2	67.3	0, 2
FUEL SWITCHING	63.4	-2, 0	58.8	2, 4	57.7	0, 4
HIGH CONSERVATION	78.3	-2, 0	71.1	-2, -2	67.3	0, 2
IMPORTS	78.3	-2, 0	71.1	-2, -2	67.3	0, 2

SITE: CRESTON YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	.0	0, 0	.0	0, 0	.0	0, 0

SITE: CRESTON YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	16.7	-4, -2	15.8	-2, -2	14.4	-2, -4
BASE CASE 4	16.7	-4, -2	15.6	-2, -2	14.4	-2, -4
CONSERVATION	16.7	-4, -2	15.6	-2, -2	14.4	-2, -4
CONVENTIONAL COAL	19.2	-4, -2	19.2	-2, -4	18.1	-2, -2
CLEAN COAL	17.2	-2, -2	16.8	-4, -2	16.2	-2, -4
NUCLEAR	16.7	-4, -2	14.4	-2, -4	14.0	-2, -2
COMBUSTION TURBINE	19.8	-2, -4	19.5	-4, -2	18.4	-2, -6
RENEWABLES	16.7	-4, -2	15.4	-2, -2	14.4	-2, -4
COGENERATION	16.7	-4, -2	14.4	-2, -4	12.9	-2, -2
FUEL SWITCHING	16.7	-4, -2	15.8	-2, -2	14.4	-2, -4
HIGH CONSERVATION	16.7	-4, -2	15.4	-2, -2	14.4	-2, -4
IMPORTS	18.0	-2, -2	16.7	-4, -2	14.4	-2, -4

SITE: CRESTON YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	26.0	-2, -2	22.1	-4, -2	20.3	0, 4
BASE CASE 4	19.6	-2, -2	16.2	-4, -2	15.2	0, 4
CONSERVATION	19.6	-2, -2	16.2	-4, -2	15.2	0, 4
CONVENTIONAL COAL	26.0	-2, -2	22.3	-4, -2	20.3	0, 4
CLEAN COAL	22.1	-2, -2	18.9	-4, -2	17.2	0, 4
NUCLEAR	19.6	-2, -2	16.2	-4, -2	15.2	0, 4
COMBUSTION TURBINE	23.5	-2, -4	22.4	-2, -2	22.3	-2, -6
RENEWABLES	19.6	-2, -2	16.2	-4, -2	15.2	0, 4
COGENERATION	19.6	-2, -2	16.2	-4, -2	15.2	0, 4
FUEL SWITCHING	16.7	-4, -2	15.8	-2, -2	14.4	-2, -4
HIGH CONSERVATION	19.6	-2, -2	16.2	-4, -2	15.2	0, 4
IMPORTS	19.6	-2, -2	16.7	-4, -2	15.2	0, 4

SITE: CRESTON YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	.0	0, 0	.0	0, 0	.0	0, 0

SITE: CRESTON YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	6.7	-4, -2	6.3	-2, -2	5.8	-2, -4
BASE CASE 4	6.7	-4, -2	6.3	-2, -2	5.8	-2, -4
CONSERVATION	6.7	-4, -2	6.3	-2, -2	5.8	-2, -4
CONVENTIONAL COAL	7.7	-4, -2	7.7	-2, -4	7.3	-2, -2
CLEAN COAL	7.1	-2, -2	6.9	-4, -2	6.7	-2, -4
NUCLEAR	6.7	-4, -2	5.8	-2, -4	5.6	-2, -2
COMBUSTION TURBINE	6.7	-4, -2	6.3	-2, -2	5.8	-2, -4
RENEWABLES	6.7	-4, -2	6.1	-2, -2	5.8	-2, -4
COGENERATION	6.7	-4, -2	5.8	-2, -4	5.1	-2, -2
FUEL SWITCHING	6.7	-4, -2	6.3	-2, -2	5.8	-2, -4
HIGH CONSERVATION	6.7	-4, -2	6.1	-2, -2	5.8	-2, -4
IMPORTS	7.2	-2, -2	6.7	-4, -2	5.8	-2, -4

SITE: CRESTON YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	10.4	-2, -2	8.8	-4, -2	8.1	0, 4
BASE CASE 4	7.8	-2, -2	6.5	-4, -2	6.1	0, 4
CONSERVATION	7.8	-2, -2	6.5	-4, -2	6.1	0, 4
CONVENTIONAL COAL	10.4	-2, -2	8.9	-4, -2	8.1	0, 4
CLEAN COAL	9.1	-2, -2	7.8	-4, -2	7.1	0, 4
NUCLEAR	7.8	-2, -2	6.5	-4, -2	6.1	0, 4
COMBUSTION TURBINE	7.8	-2, -2	6.5	-4, -2	6.1	0, 4
RENEWABLES	7.8	-2, -2	6.5	-4, -2	6.1	0, 4
COGENERATION	7.8	-2, -2	6.5	-4, -2	6.1	0, 4
FUEL SWITCHING	6.7	-4, -2	6.3	-2, -2	5.8	-2, -4
HIGH CONSERVATION	7.8	-2, -2	6.5	-4, -2	6.1	0, 4
IMPORTS	7.8	-2, -2	6.7	-4, -2	6.1	0, 4

SITE: CRESTON YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	.00	0, 0	.00	0, 0	.00	0, 0

SITE: CRESTON YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	1.00	-4, -2	.95	-2, -2	.86	-2, -4
BASE CASE 4	1.00	-4, -2	.94	-2, -2	.86	-2, -4
CONSERVATION	1.00	-4, -2	.94	-2, -2	.86	-2, -4
CONVENTIONAL COAL	1.15	-4, -2	1.15	-2, -4	1.09	-2, -2
CLEAN COAL	1.10	-2, -2	1.07	-4, -2	1.03	-2, -4
NUCLEAR	1.00	-4, -2	.86	-2, -4	.84	-2, -2
COMBUSTION TURBINE	1.02	-4, -2	.94	-2, -2	.89	-2, -4
RENEWABLES	1.00	-4, -2	.92	-2, -2	.86	-2, -4
COGENERATION	1.00	-4, -2	.86	-2, -4	.77	-2, -2
FUEL SWITCHING	1.00	-4, -2	.95	-2, -2	.86	-2, -4
HIGH CONSERVATION	1.00	-4, -2	.92	-2, -2	.86	-2, -4
IMPORTS	1.08	-2, -2	1.00	-4, -2	.86	-2, -4

SITE: CRESTON YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	1.56	-2, -2	1.33	-4, -2	1.22	0, 4
BASE CASE 4	1.17	-2, -2	.97	-4, -2	.91	0, 4
CONSERVATION	1.17	-2, -2	.97	-4, -2	.91	0, 4
CONVENTIONAL COAL	1.56	-2, -2	1.34	-4, -2	1.22	0, 4
CLEAN COAL	1.40	-2, -2	1.20	-4, -2	1.09	0, 4
NUCLEAR	1.17	-2, -2	.97	-4, -2	.91	0, 4
COMBUSTION TURBINE	1.19	-2, -2	.99	-4, -2	.93	0, 4
RENEWABLES	1.17	-2, -2	.97	-4, -2	.91	0, 4
COGENERATION	1.17	-2, -2	.97	-4, -2	.91	0, 4
FUEL SWITCHING	1.00	-4, -2	.95	-2, -2	.86	-2, -4
HIGH CONSERVATION	1.17	-2, -2	.97	-4, -2	.91	0, 4
IMPORTS	1.17	-2, -2	1.00	-4, -2	.91	0, 4

SITE: CRESTON YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 CONCENTRATION IN MICROGRAMS PER CUBIC METER
 AVERAGING PERIOD: 3 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	.0	0, 0	.0	0, 0	.0	0, 0

SITE: CRESTON YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 3 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	35.5	4, 0	33.2	-6, -2	31.6	2, 4
BASE CASE 4	35.5	4, 0	33.2	-6, -2	31.6	2, 4
CONSERVATION	35.5	4, 0	33.2	-6, -2	31.6	2, 4
CONVENTIONAL COAL	47.3	4, 0	44.2	-6, -2	38.0	-2, -4
CLEAN COAL	41.2	4, 0	38.5	-6, -2	33.2	-2, -4
NUCLEAR	35.5	4, 0	33.2	-6, -2	31.6	2, 4
COMBUSTION TURBINE	35.6	4, 0	33.2	-6, -2	31.6	2, 4
RENEWABLES	35.5	4, 0	33.2	-6, -2	31.6	2, 4
COGENERATION	35.5	4, 0	33.2	-6, -2	31.6	2, 4
FUEL SWITCHING	35.5	4, 0	33.2	-6, -2	31.6	2, 4
HIGH CONSERVATION	35.5	4, 0	33.2	-6, -2	31.6	2, 4
IMPORTS	35.5	4, 0	33.2	-6, -2	31.6	2, 4

SITE: CRESTON YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 3 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	47.3	4, 0	44.2	-6, -2	42.0	2, 2
BASE CASE 4	35.5	4, 0	33.2	-6, -2	31.5	2, 2
CONSERVATION	35.5	4, 0	33.2	-6, -2	31.5	2, 2
CONVENTIONAL COAL	47.3	4, 0	44.2	-6, -2	42.0	2, 4
CLEAN COAL	41.2	4, 0	38.5	-6, -2	36.6	2, 4
NUCLEAR	35.5	4, 0	33.2	-6, -2	31.5	2, 2
COMBUSTION TURBINE	35.6	4, 0	33.3	-6, -2	31.6	2, 2
RENEWABLES	35.5	4, 0	33.2	-6, -2	31.5	2, 2
COGENERATION	35.5	4, 0	33.2	-6, -2	31.5	2, 2
FUEL SWITCHING	35.5	4, 0	33.2	-6, -2	31.6	2, 4
HIGH CONSERVATION	35.5	4, 0	33.2	-6, -2	31.5	2, 2
IMPORTS	35.5	4, 0	33.2	-6, -2	32.4	2, 2

SITE: CRESTON YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
<u>RESOURCE ALTERNATIVE</u>	Highest	Maximum	Second	Maximum	Third	Maximum
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)
ALL PROGRAMS	.00	0, 0	.00	0, 0	.00	0, 0

SITE: CRESTON YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
<u>RESOURCE ALTERNATIVE</u>	Highest	Maximum	Second	Maximum	Third	Maximum
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)
STATUS QUO	1.12	4, 6	1.08	4, 8	1.05	6, 10
BASE CASE 4	1.12	4, 6	1.07	4, 8	1.05	6, 10
CONSERVATION	1.12	4, 6	1.07	4, 8	1.05	6, 10
CONVENTIONAL COAL	1.29	4, 6	1.24	4, 8	1.22	6, 10
CLEAN COAL	1.15	4, 6	1.10	4, 8	1.08	6, 10
NUCLEAR	1.09	4, 6	1.05	4, 8	1.03	6, 10
COMBUSTION TURBINE	1.50	4, 6	1.46	2, 4	1.40	4, 8
RENEWABLES	1.13	4, 6	1.08	4, 8	1.06	6, 10
COGENERATION	1.07	4, 6	1.03	4, 8	1.01	6, 10
FUEL SWITCHING	1.14	4, 6	1.09	4, 8	1.07	6, 10
HIGH CONSERVATION	1.13	4, 6	1.08	4, 8	1.06	6, 10
IMPORTS	1.18	4, 6	1.13	4, 8	1.10	6, 10

SITE: CRESTON YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
<u>RESOURCE ALTERNATIVE</u>	Highest	Maximum	Second	Maximum	Third	Maximum
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)
STATUS QUO	1.54	4, 6	1.47	4, 8	1.43	6, 10
BASE CASE 4	1.14	4, 6	1.09	4, 8	1.06	6, 10
CONSERVATION	1.14	4, 6	1.09	4, 8	1.06	6, 10
CONVENTIONAL COAL	1.54	4, 6	1.47	4, 8	1.43	6, 10
CLEAN COAL	1.30	4, 6	1.24	4, 8	1.21	6, 10
NUCLEAR	1.15	4, 6	1.09	4, 8	1.06	6, 10
COMBUSTION TURBINE	1.78	2, 4	1.75	4, 6	1.60	4, 8
RENEWABLES	1.15	4, 6	1.09	4, 8	1.06	6, 10
COGENERATION	1.14	4, 6	1.08	4, 8	1.06	6, 10
FUEL SWITCHING	1.14	4, 6	1.09	4, 8	1.07	6, 10
HIGH CONSERVATION	1.14	4, 6	1.09	4, 8	1.06	6, 10
IMPORTS	1.24	4, 6	1.18	4, 8	1.15	6, 10

SITE: CRESTON YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	.00	0, 0	.00	0, 0	.00	0, 0

SITE: CRESTON YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	.45	4, 6	.43	4, 8	.42	6, 10
BASE CASE 4	.45	4, 6	.43	4, 8	.42	6, 10
CONSERVATION	.45	4, 6	.43	4, 8	.42	6, 10
CONVENTIONAL COAL	.52	4, 6	.50	4, 8	.49	6, 10
CLEAN COAL	.47	4, 6	.45	4, 8	.45	6, 10
NUCLEAR	.44	4, 6	.42	4, 8	.41	6, 10
COMBUSTION TURBINE	.45	4, 6	.43	4, 8	.42	6, 10
RENEWABLES	.45	4, 6	.43	4, 8	.42	6, 10
COGENERATION	.43	4, 6	.41	4, 8	.41	6, 10
FUEL SWITCHING	.46	4, 6	.44	4, 8	.43	6, 10
HIGH CONSERVATION	.45	4, 6	.43	4, 8	.42	6, 10
IMPORTS	.47	4, 6	.45	4, 8	.44	6, 10

SITE: CRESTON YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	.62	4, 6	.59	4, 8	.57	6, 10
BASE CASE 4	.46	4, 6	.43	4, 8	.42	6, 10
CONSERVATION	.46	4, 6	.43	4, 8	.42	6, 10
CONVENTIONAL COAL	.62	4, 6	.59	4, 8	.57	6, 10
CLEAN COAL	.54	4, 6	.51	4, 8	.50	6, 10
NUCLEAR	.46	4, 6	.44	4, 8	.43	6, 10
COMBUSTION TURBINE	.46	4, 6	.44	4, 8	.43	6, 10
RENEWABLES	.46	4, 6	.44	4, 8	.43	6, 10
COGENERATION	.46	4, 6	.43	4, 8	.42	6, 10
FUEL SWITCHING	.46	4, 6	.44	4, 8	.43	6, 10
HIGH CONSERVATION	.46	4, 6	.43	4, 8	.42	6, 10
IMPORTS	.50	4, 6	.47	4, 8	.46	6, 10

SITE: CRESTON YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	.000	0, 0	.000	0, 0	.000	0, 0

SITE: CRESTON YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	.067	4, 6	.065	4, 8	.063	6, 10
BASE CASE 4	.067	4, 6	.064	4, 8	.063	6, 10
CONSERVATION	.067	4, 6	.064	4, 8	.063	6, 10
CONVENTIONAL COAL	.077	4, 6	.075	4, 8	.073	6, 10
CLEAN COAL	.073	4, 6	.070	4, 8	.069	6, 10
NUCLEAR	.065	4, 6	.063	4, 8	.062	6, 10
COMBUSTION TURBINE	.070	4, 6	.066	4, 8	.065	6, 10
RENEWABLES	.068	4, 6	.065	4, 8	.063	6, 10
COGENERATION	.064	4, 6	.062	4, 8	.061	6, 10
FUEL SWITCHING	.068	4, 6	.065	4, 8	.064	6, 10
HIGH CONSERVATION	.068	4, 6	.065	4, 8	.064	6, 10
IMPORTS	.071	4, 6	.068	4, 8	.066	6, 10

SITE: CRESTON YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	.093	4, 6	.088	4, 8	.086	6, 10
BASE CASE 4	.068	4, 6	.065	4, 8	.064	6, 10
CONSERVATION	.068	4, 6	.065	4, 8	.064	6, 10
CONVENTIONAL COAL	.093	4, 6	.088	4, 8	.086	6, 10
CLEAN COAL	.083	4, 6	.079	4, 8	.077	6, 10
NUCLEAR	.069	4, 6	.065	4, 8	.064	6, 10
COMBUSTION TURBINE	.072	4, 6	.068	4, 8	.066	2, 4
RENEWABLES	.069	4, 6	.065	4, 8	.064	6, 10
COGENERATION	.068	4, 6	.065	4, 8	.063	6, 10
FUEL SWITCHING	.068	4, 6	.065	4, 8	.064	6, 10
HIGH CONSERVATION	.068	4, 6	.065	4, 8	.063	6, 10
IMPORTS	.075	4, 6	.071	4, 8	.069	6, 10

SITE: BOARDMAN YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 1 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	207.7	4, 2	190.9	2, -4	189.9	-2, 2

SITE: BOARDMAN YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 1 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	333.0	2, 0	271.5	0, 2	241.4	4, 2
BASE CASE 4	321.1	2, 0	261.8	0, 2	241.4	4, 2
CONSERVATION	321.1	2, 0	261.8	0, 2	241.4	4, 2
CONVENTIONAL COAL	324.5	2, 0	283.1	4, 2	264.6	0, 2
CLEAN COAL	317.5	2, 0	258.9	0, 2	248.2	4, 2
NUCLEAR	302.5	2, 0	246.7	0, 2	241.4	4, 2
COMBUSTION TURBINE	321.1	2, 0	261.8	0, 2	241.4	4, 2
RENEWABLES	305.9	2, 0	249.4	0, 2	241.4	4, 2
COGENERATION	268.5	2, 0	241.7	4, 2	222.1	2, -4
FUEL SWITCHING	329.7	2, 0	268.8	0, 2	241.4	4, 2
HIGH CONSERVATION	322.4	2, 0	262.9	0, 2	241.0	4, 2
IMPORTS	362.7	2, 0	295.7	0, 2	260.0	-4, 4

SITE: BOARDMAN YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 1 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	489.8	2, 0	399.6	0, 2	351.3	-4, 4
BASE CASE 4	493.8	2, 0	402.8	0, 2	354.1	-4, 4
CONSERVATION	493.8	2, 0	402.8	0, 2	354.1	-4, 4
CONVENTIONAL COAL	551.4	2, 0	449.8	0, 2	395.4	-4, 4
CLEAN COAL	498.2	2, 0	406.4	0, 2	357.3	-4, 4
NUCLEAR	494.5	2, 0	403.4	0, 2	354.6	-4, 4
COMBUSTION TURBINE	493.8	2, 0	402.8	0, 2	354.1	-4, 4
RENEWABLES	494.5	2, 0	403.3	0, 2	354.6	-4, 4
COGENERATION	490.1	2, 0	399.8	0, 2	351.5	-4, 4
FUEL SWITCHING	493.8	2, 0	402.8	0, 2	354.1	-4, 4
HIGH CONSERVATION	493.1	2, 0	402.2	0, 2	353.6	-4, 4
IMPORTS	493.7	2, 0	402.7	0, 2	354.0	-4, 4

SITE: BOARDMAN YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	16.6	4, -4	15.8	4, -2	14.9	6, -4

SITE: BOARDMAN YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	32.4	2, -2	28.8	4, -2	28.7	2, 0
BASE CASE 4	31.6	2, -2	28.7	2, 0	28.1	4, -2
CONSERVATION	31.6	2, -2	28.7	2, 0	28.1	4, -2
CONVENTIONAL COAL	39.4	2, -2	37.9	2, 0	35.1	4, -4
CLEAN COAL	31.9	2, -2	29.6	2, 0	28.3	4, -2
NUCLEAR	29.3	2, -2	27.3	2, 0	26.0	4, -2
COMBUSTION TURBINE	31.6	2, -2	28.7	2, 0	28.1	4, -2
RENEWABLES	30.5	2, -2	28.7	2, 0	27.2	4, -2
COGENERATION	40.9	4, 0	40.7	2, 0	35.8	2, -2
FUEL SWITCHING	32.2	2, -2	28.7	2, 0	28.6	4, -2
HIGH CONSERVATION	31.7	2, -2	28.6	2, 0	28.2	4, -2
IMPORTS	33.7	2, -2	29.4	4, -2	28.4	2, 0

SITE: BOARDMAN YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	75.2	2, -2	69.4	2, 0	68.1	4, -2
BASE CASE 4	75.5	2, -2	69.6	2, 0	68.3	4, -2
CONSERVATION	75.5	2, -2	69.6	2, 0	68.3	4, -2
CONVENTIONAL COAL	90.1	2, -2	79.6	4, -2	78.5	2, 0
CLEAN COAL	76.6	2, -2	69.1	2, 0	68.7	4, -2
NUCLEAR	76.2	2, -2	70.7	2, 0	69.1	4, -2
COMBUSTION TURBINE	75.5	2, -2	69.6	2, 0	68.3	4, -2
RENEWABLES	75.6	2, -2	69.7	2, 0	68.3	4, -2
COGENERATION	81.7	2, -2	79.7	2, 0	75.7	4, -2
FUEL SWITCHING	75.5	2, -2	69.6	2, 0	68.3	4, -2
HIGH CONSERVATION	75.5	2, -2	69.6	2, 0	68.3	4, -2
IMPORTS	73.7	2, -2	66.8	2, 0	66.2	4, -2

SITE: BOARDMAN YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	22.0	4, -4	21.0	4, -2	19.7	6, -4

SITE: BOARDMAN YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	32.1	2, -2	25.5	4, -4	25.4	4, -2
BASE CASE 4	30.9	2, -2	25.5	4, -4	24.5	4, -2
CONSERVATION	30.9	2, -2	25.5	4, -4	24.5	4, -2
CONVENTIONAL COAL	31.3	2, -2	30.0	4, -4	28.6	4, -2
CLEAN COAL	30.6	2, -2	26.3	4, -4	25.1	4, -2
NUCLEAR	29.1	2, -2	25.5	4, -4	24.4	4, -2
COMBUSTION TURBINE	30.9	2, -2	25.5	4, -4	24.5	4, -2
RENEWABLES	29.5	2, -2	25.5	4, -4	24.4	4, -2
COGENERATION	25.9	2, -2	25.6	4, -4	24.4	4, -2
FUEL SWITCHING	31.8	2, -2	25.5	4, -4	25.1	4, -2
HIGH CONSERVATION	31.1	2, -2	25.5	4, -4	24.6	4, -2
IMPORTS	34.9	2, -2	27.6	4, -2	25.5	4, -4

SITE: BOARDMAN YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	47.2	2, -2	37.3	4, -2	32.8	-2, -4
BASE CASE 4	47.6	2, -2	37.6	4, -2	33.1	-2, -4
CONSERVATION	47.6	2, -2	37.6	4, -2	33.1	-2, -4
CONVENTIONAL COAL	53.1	2, -2	42.0	4, -2	36.9	-2, -4
CLEAN COAL	48.0	2, -2	38.0	4, -2	33.4	4, -4
NUCLEAR	47.7	2, -2	37.7	4, -2	33.1	-2, -4
COMBUSTION TURBINE	47.6	2, -2	37.6	4, -2	33.1	-2, -4
RENEWABLES	47.7	2, -2	37.7	4, -2	33.1	-2, -4
COGENERATION	47.3	2, -2	37.4	4, -2	32.8	-2, -4
FUEL SWITCHING	47.6	2, -2	37.6	4, -2	33.1	-2, -4
HIGH CONSERVATION	47.5	2, -2	37.6	4, -2	33.0	-2, -4
IMPORTS	47.6	2, -2	37.6	4, -2	33.1	-2, -4

SITE: BOARDMAN YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	.85	4, -4	.81	4, -2	.77	6, -4

SITE: BOARDMAN YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	1.29	2, -2	1.04	4, -2	1.02	4, -4
BASE CASE 4	1.24	2, -2	1.02	4, -4	1.00	4, -2
CONSERVATION	1.24	2, -2	1.02	4, -4	1.00	4, -2
CONVENTIONAL COAL	1.74	2, -2	1.68	4, -4	1.60	4, -2
CLEAN COAL	1.32	2, -2	1.15	4, -4	1.10	4, -2
NUCLEAR	1.17	2, -2	1.01	4, -4	.97	4, -2
COMBUSTION TURBINE	1.24	2, -2	1.02	4, -4	1.00	4, -2
RENEWABLES	1.19	2, -2	1.02	4, -4	.98	4, -2
COGENERATION	1.09	2, -2	1.04	4, -4	1.01	4, -2
FUEL SWITCHING	1.28	2, -2	1.03	4, -2	1.02	4, -4
HIGH CONSERVATION	1.25	2, -2	1.02	4, -4	1.01	4, -2
IMPORTS	1.39	2, -2	1.12	4, -2	1.01	4, -4

SITE: BOARDMAN YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	3.03	2, -2	2.45	4, -2	2.09	-2, -4
BASE CASE 4	3.05	2, -2	2.46	4, -2	2.10	-2, -4
CONSERVATION	3.05	2, -2	2.46	4, -2	2.10	-2, -4
CONVENTIONAL COAL	3.96	2, -2	3.17	4, -2	2.73	-2, -4
CLEAN COAL	3.29	2, -2	2.64	4, -2	2.28	4, -4
NUCLEAR	3.06	2, -2	2.46	4, -2	2.11	-2, -4
COMBUSTION TURBINE	3.05	2, -2	2.46	4, -2	2.10	-2, -4
RENEWABLES	3.05	2, -2	2.46	4, -2	2.10	-2, -4
COGENERATION	3.07	2, -2	2.49	4, -2	2.12	2, 0
FUEL SWITCHING	3.05	2, -2	2.46	4, -2	2.10	-2, -4
HIGH CONSERVATION	3.05	2, -2	2.46	4, -2	2.10	-2, -4
IMPORTS	3.04	2, -2	2.45	4, -2	2.10	-2, -4

SITE: BOARDMAN YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 3 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	102.4	2, -2	102.2	2, -4	100.2	4, -4

SITE: BOARDMAN YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 3 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	139.4	2, -2	118.8	2, -4	116.4	4, -4
BASE CASE 4	134.4	2, -2	118.8	2, -4	116.4	4, -4
CONSERVATION	134.4	2, -2	118.8	2, -4	116.4	4, -4
CONVENTIONAL COAL	139.6	2, -2	139.3	2, -4	136.5	4, -4
CLEAN COAL	133.0	2, -2	122.1	2, -4	119.7	4, -4
NUCLEAR	126.7	2, -2	118.8	2, -4	116.4	4, -4
COMBUSTION TURBINE	134.4	2, -2	118.8	2, -4	116.4	4, -4
RENEWABLES	128.1	2, -2	118.8	2, -4	116.4	4, -4
COGENERATION	119.2	2, -2	118.9	2, -4	116.5	4, -4
FUEL SWITCHING	138.0	2, -2	118.8	2, -4	116.4	4, -4
HIGH CONSERVATION	135.0	2, -2	118.6	2, -4	116.2	4, -4
IMPORTS	151.8	2, -2	121.0	2, 0	119.1	-2, -2

SITE: BOARDMAN YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 3 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	205.1	2, -2	163.6	2, 0	160.9	-2, -2
BASE CASE 4	206.8	2, -2	164.9	2, 0	162.2	-2, -2
CONSERVATION	206.8	2, -2	164.9	2, 0	162.2	-2, -2
CONVENTIONAL COAL	230.9	2, -2	184.1	2, 0	181.1	-2, -2
CLEAN COAL	208.6	2, -2	166.4	2, 0	163.6	-2, -2
NUCLEAR	207.1	2, -2	165.2	2, 0	162.4	-2, -2
COMBUSTION TURBINE	206.8	2, -2	164.9	2, 0	162.2	-2, -2
RENEWABLES	207.1	2, -2	165.2	2, 0	162.4	-2, -2
COGENERATION	205.3	2, -2	163.8	2, 0	161.0	-2, -2
FUEL SWITCHING	206.8	2, -2	164.9	2, 0	162.2	-2, -2
HIGH CONSERVATION	206.5	2, -2	164.7	2, 0	162.0	-2, -2
IMPORTS	206.8	2, -2	164.9	2, 0	162.1	-2, -2

SITE: BOARDMAN YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	1.20	4, -2	1.14	2, -2	1.05	4, -4

SITE: BOARDMAN YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	3.15	4, -2	3.11	2, -2	3.06	4, 0
BASE CASE 4	3.11	4, -2	3.07	2, -2	3.03	4, 0
CONSERVATION	3.11	4, -2	3.07	2, -2	3.03	4, 0
CONVENTIONAL COAL	3.94	4, -2	3.85	2, -2	3.66	4, 0
CLEAN COAL	3.10	4, -2	3.06	2, -2	3.01	4, 0
NUCLEAR	2.94	4, -2	2.90	2, -2	2.83	4, 0
COMBUSTION TURBINE	3.11	4, -2	3.08	2, -2	3.03	4, 0
RENEWABLES	3.08	4, -2	3.04	2, -2	3.01	4, 0
COGENERATION	4.29	4, 0	3.99	2, -2	3.98	4, -2
FUEL SWITCHING	3.16	4, -2	3.12	2, -2	3.07	4, 0
HIGH CONSERVATION	3.14	4, -2	3.10	2, -2	3.05	4, 0
IMPORTS	3.14	4, -2	3.10	2, -2	2.99	4, 0

SITE: BOARDMAN YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	7.20	4, 0	7.09	4, -2	7.06	2, -2
BASE CASE 4	7.20	4, 0	7.08	4, -2	7.06	2, -2
CONSERVATION	7.20	4, 0	7.08	4, -2	7.06	2, -2
CONVENTIONAL COAL	8.26	4, -2	8.18	2, -2	8.07	4, 0
CLEAN COAL	7.15	4, 0	7.15	4, -2	7.11	2, -2
NUCLEAR	7.32	4, 0	7.18	4, -2	7.16	2, -2
COMBUSTION TURBINE	7.20	4, 0	7.08	4, -2	7.06	2, -2
RENEWABLES	7.21	4, 0	7.10	4, -2	7.08	2, -2
COGENERATION	8.30	4, 0	7.91	2, -2	7.88	4, -2
FUEL SWITCHING	7.23	4, 0	7.12	4, -2	7.10	2, -2
HIGH CONSERVATION	7.19	4, 0	7.07	4, -2	7.05	2, -2
IMPORTS	7.17	4, -2	7.16	4, 0	7.12	2, -2

SITE: BOARDMAN YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
<u>RESOURCE ALTERNATIVE</u>	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	1.60	4, -2	1.51	2, -2	1.39	4, -4

SITE: BOARDMAN YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
<u>RESOURCE ALTERNATIVE</u>	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	2.78	4, -2	2.66	2, -2	2.33	4, -4
BASE CASE 4	2.73	4, -2	2.61	2, -2	2.29	4, -4
CONSERVATION	2.73	4, -2	2.61	2, -2	2.29	4, -4
CONVENTIONAL COAL	2.85	4, -2	2.72	2, -2	2.42	4, -4
CLEAN COAL	2.64	4, -2	2.52	2, -2	2.23	4, -4
NUCLEAR	2.67	4, -2	2.54	2, -2	2.24	4, -4
COMBUSTION TURBINE	2.74	4, -2	2.61	2, -2	2.29	4, -4
RENEWABLES	2.70	4, -2	2.57	2, -2	2.26	4, -4
COGENERATION	2.53	4, -2	2.41	2, -2	2.15	4, -4
FUEL SWITCHING	2.80	4, -2	2.68	2, -2	2.34	4, -4
HIGH CONSERVATION	2.77	4, -2	2.64	2, -2	2.32	4, -4
IMPORTS	2.93	4, -2	2.80	2, -2	2.43	4, -4

SITE: BOARDMAN YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
<u>RESOURCE ALTERNATIVE</u>	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	3.72	4, -2	3.56	2, -2	3.09	4, -4
BASE CASE 4	3.72	4, -2	3.57	2, -2	3.09	4, -4
CONSERVATION	3.72	4, -2	3.57	2, -2	3.09	4, -4
CONVENTIONAL COAL	4.19	4, -2	4.01	2, -2	3.49	4, -4
CLEAN COAL	3.85	4, -2	3.69	2, -2	3.19	4, -4
NUCLEAR	3.74	4, -2	3.58	2, -2	3.10	4, -4
COMBUSTION TURBINE	3.72	4, -2	3.57	2, -2	3.09	4, -4
RENEWABLES	3.74	4, -2	3.58	2, -2	3.10	4, -4
COGENERATION	3.70	4, -2	3.55	2, -2	3.08	4, -4
FUEL SWITCHING	3.75	4, -2	3.60	2, -2	3.11	4, -4
HIGH CONSERVATION	3.71	4, -2	3.56	2, -2	3.08	4, -4
IMPORTS	3.98	4, -2	3.82	2, -2	3.28	4, -4

SITE: BOARDMAN YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	.062	4, -2	.058	2, -2	.054	4, -4

SITE: BOARDMAN YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	.114	4, -2	.109	2, -2	.095	4, -4
BASE CASE 4	.112	4, -2	.107	2, -2	.093	4, -4
CONSERVATION	.112	4, -2	.107	2, -2	.093	4, -4
CONVENTIONAL COAL	.163	4, -2	.156	2, -2	.139	4, -4
CLEAN COAL	.118	4, -2	.113	2, -2	.099	4, -4
NUCLEAR	.108	4, -2	.104	2, -2	.091	4, -4
COMBUSTION TURBINE	.112	4, -2	.107	2, -2	.093	4, -4
RENEWABLES	.110	4, -2	.106	2, -2	.092	4, -4
COGENERATION	.110	4, -2	.105	2, -2	.092	4, -4
FUEL SWITCHING	.114	4, -2	.110	2, -2	.095	4, -4
HIGH CONSERVATION	.113	4, -2	.109	2, -2	.094	4, -4
IMPORTS	.119	4, -2	.114	2, -2	.098	4, -4

SITE: BOARDMAN YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	.249	4, -2	.240	2, -2	.207	4, -4
BASE CASE 4	.249	4, -2	.240	2, -2	.206	4, -4
CONSERVATION	.249	4, -2	.240	2, -2	.206	4, -4
CONVENTIONAL COAL	.323	4, -2	.311	2, -2	.269	4, -4
CLEAN COAL	.269	4, -2	.259	2, -2	.224	4, -4
NUCLEAR	.250	4, -2	.241	2, -2	.207	4, -4
COMBUSTION TURBINE	.249	4, -2	.240	2, -2	.206	4, -4
RENEWABLES	.250	4, -2	.241	2, -2	.207	4, -4
COGENERATION	.252	4, -2	.243	2, -2	.209	4, -4
FUEL SWITCHING	.251	4, -2	.242	2, -2	.208	4, -4
HIGH CONSERVATION	.248	4, -2	.239	2, -2	.206	4, -4
IMPORTS	.265	4, -2	.255	2, -2	.218	4, -4

SITE: COLSTRIP YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 1 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	759.4	2, -2	652.1	-4, 4	608.1	4, -2

SITE: COLSTRIP YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 1 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	973.7	2, -2	836.1	-4, 4	749.1	-2, 2
BASE CASE 4	962.3	2, -2	826.3	-4, 4	740.3	-2, 2
CONSERVATION	962.3	2, -2	826.3	-4, 4	740.3	-2, 2
CONVENTIONAL COAL	1036.0	2, -2	889.6	-4, 4	797.0	-2, 2
CLEAN COAL	997.2	2, -2	856.3	-4, 4	767.2	-2, 2
NUCLEAR	940.6	2, -2	807.8	-4, 4	723.7	-2, 2
COMBUSTION TURBINE	962.3	2, -2	826.3	-4, 4	740.3	-2, 2
RENEWABLES	972.3	2, -2	834.9	-4, 4	748.0	-2, 2
COGENERATION	887.5	2, -2	762.1	-4, 4	682.8	-2, 2
FUEL SWITCHING	985.5	2, -2	846.3	-4, 4	758.2	-2, 2
HIGH CONSERVATION	975.4	2, -2	837.6	-4, 4	750.4	-2, 2
IMPORTS	982.4	2, -2	843.6	-4, 4	755.8	-2, 2

SITE: COLSTRIP YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 1 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	1151.8	2, -2	989.1	-4, 4	886.1	-2, 2
BASE CASE 4	1098.7	2, -2	943.4	-4, 4	845.2	-2, 2
CONSERVATION	1098.7	2, -2	943.4	-4, 4	845.2	-2, 2
CONVENTIONAL COAL	1151.8	2, -2	989.1	-4, 4	886.1	-2, 2
CLEAN COAL	1110.9	2, -2	953.9	-4, 4	854.7	-2, 2
NUCLEAR	1098.7	2, -2	943.4	-4, 4	845.2	-2, 2
COMBUSTION TURBINE	1098.7	2, -2	943.4	-4, 4	845.2	-2, 2
RENEWABLES	1098.7	2, -2	943.4	-4, 4	845.2	-2, 2
COGENERATION	1098.7	2, -2	943.4	-4, 4	845.2	-2, 2
FUEL SWITCHING	1091.8	2, -2	937.5	-4, 4	839.9	-2, 2
HIGH CONSERVATION	1098.7	2, -2	943.4	-4, 4	845.2	-2, 2
IMPORTS	1098.7	2, -2	943.4	-4, 4	845.2	-2, 2

SITE: COLSTRIP YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	58.5	-2, 2	57.5	2, -4	48.6	-4, 4

SITE: COLSTRIP YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	89.2	-2, 2	87.7	2, -4	74.1	-4, 4
BASE CASE 4	88.2	-2, 2	86.8	2, -4	73.4	-4, 4
CONSERVATION	88.2	-2, 2	86.8	2, -4	73.4	-4, 4
CONVENTIONAL COAL	103.4	-2, 2	101.8	2, -4	86.0	-4, 4
CLEAN COAL	92.5	-2, 2	91.0	2, -4	76.9	-4, 4
NUCLEAR	86.5	-2, 2	85.1	2, -4	71.9	-4, 4
COMBUSTION TURBINE	88.2	-2, 2	86.8	2, -4	73.4	-4, 4
RENEWABLES	89.1	-2, 2	87.6	2, -4	74.1	-4, 4
COGENERATION	82.0	-2, 2	80.6	2, -4	68.2	-4, 4
FUEL SWITCHING	90.1	-2, 2	88.6	2, -4	74.9	-4, 4
HIGH CONSERVATION	89.3	-2, 2	87.9	2, -4	74.3	-4, 4
IMPORTS	89.8	-2, 2	88.3	2, -4	74.7	-4, 4

SITE: COLSTRIP YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ₃ ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	131.3	-2, 2	129.2	2, -4	109.2	-4, 4
BASE CASE 4	117.7	-2, 2	115.8	2, -4	97.9	-4, 4
CONSERVATION	117.7	-2, 2	115.8	2, -4	97.9	-4, 4
CONVENTIONAL COAL	131.3	-2, 2	129.2	2, -4	109.2	-4, 4
CLEAN COAL	120.2	-2, 2	118.3	2, -4	100.0	-4, 4
NUCLEAR	117.7	-2, 2	115.8	2, -4	97.9	-4, 4
COMBUSTION TURBINE	117.7	-2, 2	115.8	2, -4	97.9	-4, 4
RENEWABLES	117.7	-2, 2	115.8	2, -4	97.9	-4, 4
COGENERATION	117.7	-2, 2	115.8	2, -4	97.9	-4, 4
FUEL SWITCHING	117.2	-2, 2	115.3	2, -4	97.5	-4, 4
HIGH CONSERVATION	117.7	-2, 2	115.8	2, -4	97.9	-4, 4
IMPORTS	117.7	-2, 2	115.8	2, -4	97.9	-4, 4

SITE: COLSTRIP YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest	Maximum	Second	Maximum	Third	Maximum
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	77.6	-2, 2	76.3	2, -4	64.5	-4, 4

SITE: COLSTRIP YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest	Maximum	Second	Maximum	Third	Maximum
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	99.5	-2, 2	97.8	2, -4	82.7	-4, 4
BASE CASE 4	98.3	-2, 2	96.7	2, -4	81.7	-4, 4
CONSERVATION	98.3	-2, 2	96.7	2, -4	81.7	-4, 4
CONVENTIONAL COAL	105.8	-2, 2	104.1	2, -4	88.0	-4, 4
CLEAN COAL	101.9	-2, 2	100.2	2, -4	84.7	-4, 4
NUCLEAR	96.1	-2, 2	94.5	2, -4	79.9	-4, 4
COMBUSTION TURBINE	98.3	-2, 2	96.7	2, -4	81.7	-4, 4
RENEWABLES	99.3	-2, 2	97.7	2, -4	82.6	-4, 4
COGENERATION	90.6	-2, 2	89.2	2, -4	75.4	-4, 4
FUEL SWITCHING	100.7	-2, 2	99.0	2, -4	83.7	-4, 4
HIGH CONSERVATION	99.6	-2, 2	98.0	2, -4	82.9	-4, 4
IMPORTS	100.3	-2, 2	98.7	2, -4	83.5	-4, 4

SITE: COLSTRIP YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest	Maximum	Second	Maximum	Third	Maximum
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	117.6	-2, 2	115.7	2, -4	97.8	-4, 4
BASE CASE 4	112.2	-2, 2	110.4	2, -4	93.3	-4, 4
CONSERVATION	112.2	-2, 2	110.4	2, -4	93.3	-4, 4
CONVENTIONAL COAL	117.6	-2, 2	115.7	2, -4	97.8	-4, 4
CLEAN COAL	113.5	-2, 2	111.6	2, -4	94.4	-4, 4
NUCLEAR	112.2	-2, 2	110.4	2, -4	93.3	-4, 4
COMBUSTION TURBINE	112.2	-2, 2	110.4	2, -4	93.3	-4, 4
RENEWABLES	112.2	-2, 2	110.4	2, -4	93.3	-4, 4
COGENERATION	112.2	-2, 2	110.4	2, -4	93.3	-4, 4
FUEL SWITCHING	111.5	-2, 2	109.7	2, -4	92.7	-4, 4
HIGH CONSERVATION	112.2	-2, 2	110.4	2, -4	93.3	-4, 4
IMPORTS	112.2	-2, 2	110.4	2, -4	93.3	-4, 4

SITE: COLSTRIP YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	3.01	-2, 2	2.96	2, -4	2.50	-4, 4

SITE: COLSTRIP YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	4.76	-2, 2	4.68	2, -4	3.96	-4, 4
BASE CASE 4	4.71	-2, 2	4.63	2, -4	3.92	-4, 4
CONSERVATION	4.71	-2, 2	4.63	2, -4	3.92	-4, 4
CONVENTIONAL COAL	5.61	-2, 2	5.52	2, -4	4.67	-4, 4
CLEAN COAL	5.03	-2, 2	4.95	2, -4	4.18	-4, 4
NUCLEAR	4.62	-2, 2	4.54	2, -4	3.84	-4, 4
COMBUSTION TURBINE	4.71	-2, 2	4.63	2, -4	3.92	-4, 4
RENEWABLES	4.76	-2, 2	4.68	2, -4	3.95	-4, 4
COGENERATION	4.38	-2, 2	4.31	2, -4	3.65	-4, 4
FUEL SWITCHING	4.81	-2, 2	4.73	2, -4	4.00	-4, 4
HIGH CONSERVATION	4.77	-2, 2	4.69	2, -4	3.97	-4, 4
IMPORTS	4.79	-2, 2	4.71	2, -4	3.98	-4, 4

SITE: COLSTRIP YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: 24H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	7.28	-2, 2	7.16	2, -4	6.05	-4, 4
BASE CASE 4	6.46	-2, 2	6.36	2, -4	5.38	-4, 4
CONSERVATION	6.46	-2, 2	6.36	2, -4	5.38	-4, 4
CONVENTIONAL COAL	7.28	-2, 2	7.16	2, -4	6.05	-4, 4
CLEAN COAL	6.69	-2, 2	6.58	2, -4	5.56	-4, 4
NUCLEAR	6.46	-2, 2	6.36	2, -4	5.38	-4, 4
COMBUSTION TURBINE	6.46	-2, 2	6.36	2, -4	5.38	-4, 4
RENEWABLES	6.46	-2, 2	6.36	2, -4	5.38	-4, 4
COGENERATION	6.46	-2, 2	6.36	2, -4	5.38	-4, 4
FUEL SWITCHING	6.44	-2, 2	6.33	2, -4	5.35	-4, 4
HIGH CONSERVATION	6.46	-2, 2	6.36	2, -4	5.38	-4, 4
IMPORTS	6.46	-2, 2	6.36	2, -4	5.38	-4, 4

SITE: COLSTRIP YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 3 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	382.0	-4, 4	369.0	-2, 2	353.2	2, -2

SITE: COLSTRIP YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 3 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	473.1	-2, 2	452.9	2, -2	449.1	2, 2
BASE CASE 4	467.5	-2, 2	447.6	2, -2	443.9	2, 2
CONSERVATION	467.5	-2, 2	447.6	2, -2	443.9	2, 2
CONVENTIONAL COAL	503.3	-2, 2	481.9	2, -2	477.9	2, 2
CLEAN COAL	484.5	-2, 2	463.8	2, -2	460.0	2, 2
NUCLEAR	457.0	-2, 2	437.5	2, -2	433.9	2, 2
COMBUSTION TURBINE	467.5	-2, 2	447.6	2, -2	443.9	2, 2
RENEWABLES	472.4	-2, 2	452.2	2, -2	448.5	2, 2
COGENERATION	431.2	-2, 2	417.1	-4, 4	412.8	2, -2
FUEL SWITCHING	478.8	-2, 2	458.4	2, -2	454.6	2, 2
HIGH CONSERVATION	473.9	-2, 2	453.7	2, -2	449.9	2, 2
IMPORTS	477.3	-2, 2	457.0	2, -2	453.2	2, 2

SITE: COLSTRIP YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: 3 H

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE

RESOURCE ALTERNATIVE	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	559.6	-2, 2	535.7	2, -2	531.3	2, 2
BASE CASE 4	533.8	-2, 2	511.0	2, -2	506.8	2, 2
CONSERVATION	533.8	-2, 2	511.0	2, -2	506.8	2, 2
CONVENTIONAL COAL	559.6	-2, 2	535.7	2, -2	531.3	2, 2
CLEAN COAL	539.7	-2, 2	516.7	2, -2	512.4	2, 2
NUCLEAR	533.8	-2, 2	511.0	2, -2	506.8	2, 2
COMBUSTION TURBINE	533.8	-2, 2	511.0	2, -2	506.8	2, 2
RENEWABLES	533.8	-2, 2	511.0	2, -2	506.8	2, 2
COGENERATION	533.8	-2, 2	511.0	2, -2	506.8	2, 2
FUEL SWITCHING	530.4	-2, 2	507.8	2, -2	503.6	2, 2
HIGH CONSERVATION	533.8	-2, 2	511.0	2, -2	506.8	2, 2
IMPORTS	533.8	-2, 2	511.0	2, -2	506.8	2, 2

SITE: COLSTRIP YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
RESOURCE ALTERNATIVE	Highest	Maximum	Second	Maximum	Third	Maximum
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)
ALL PROGRAMS	2.38	12, -8	2.35	8, -6	2.32	14, -10

SITE: COLSTRIP YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
RESOURCE ALTERNATIVE	Highest	Maximum	Second	Maximum	Third	Maximum
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)
STATUS QUO	3.48	12, -8	3.46	8, -6	3.39	14, -10
BASE CASE 4	3.47	12, -8	3.45	8, -6	3.38	14, -10
CONSERVATION	3.47	12, -8	3.45	8, -6	3.38	14, -10
CONVENTIONAL COAL	4.05	12, -8	4.03	8, -6	3.94	14, -10
CLEAN COAL	3.60	12, -8	3.58	8, -6	3.51	14, -10
NUCLEAR	3.46	12, -8	3.43	8, -6	3.37	14, -10
COMBUSTION TURBINE	3.48	12, -8	3.45	8, -6	3.38	14, -10
RENEWABLES	3.50	12, -8	3.48	8, -6	3.40	14, -10
COGENERATION	3.41	12, -8	3.38	8, -6	3.33	14, -10
FUEL SWITCHING	3.51	12, -8	3.49	8, -6	3.42	14, -10
HIGH CONSERVATION	3.50	12, -8	3.48	8, -6	3.41	14, -10
IMPORTS	3.50	12, -8	3.48	8, -6	3.41	14, -10

SITE: COLSTRIP YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: NOx AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
RESOURCE ALTERNATIVE	Highest	Maximum	Second	Maximum	Third	Maximum
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)
STATUS QUO	5.16	12, -8	5.13	8, -6	5.02	14, -10
BASE CASE 4	4.60	12, -8	4.57	8, -6	4.47	14, -10
CONSERVATION	4.60	12, -8	4.57	8, -6	4.47	14, -10
CONVENTIONAL COAL	5.22	12, -8	5.19	8, -6	5.07	14, -10
CLEAN COAL	4.76	12, -8	4.74	8, -6	4.63	14, -10
NUCLEAR	4.60	12, -8	4.57	8, -6	4.47	14, -10
COMBUSTION TURBINE	4.60	12, -8	4.57	8, -6	4.47	14, -10
RENEWABLES	4.60	12, -8	4.57	8, -6	4.47	14, -10
COGENERATION	4.59	12, -8	4.56	8, -6	4.46	14, -10
FUEL SWITCHING	4.60	12, -8	4.57	8, -6	4.47	14, -10
HIGH CONSERVATION	4.60	12, -8	4.57	8, -6	4.47	14, -10
IMPORTS	4.66	12, -8	4.64	8, -6	4.53	14, -10

SITE: COLSTRIP YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
<u>RESOURCE ALTERNATIVE</u>	Highest	Maximum	Second	Maximum	Third	Maximum
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)
ALL PROGRAMS	3.16	12, -8	3.12	8, -6	3.08	14, -10

SITE: COLSTRIP YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
<u>RESOURCE ALTERNATIVE</u>	Highest	Maximum	Second	Maximum	Third	Maximum
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)
STATUS QUO	3.86	12, -8	3.83	8, -6	3.76	14, -10
BASE CASE 4	3.85	12, -8	3.82	8, -6	3.75	14, -10
CONSERVATION	3.85	12, -8	3.82	8, -6	3.75	14, -10
CONVENTIONAL COAL	4.10	12, -8	4.08	8, -6	3.99	14, -10
CLEAN COAL	3.93	12, -8	3.91	8, -6	3.83	14, -10
NUCLEAR	3.83	12, -8	3.80	8, -6	3.73	14, -10
COMBUSTION TURBINE	3.85	12, -8	3.82	8, -6	3.75	14, -10
RENEWABLES	3.87	12, -8	3.85	8, -6	3.77	14, -10
COGENERATION	3.77	12, -8	3.73	8, -6	3.68	14, -10
FUEL SWITCHING	3.89	12, -8	3.87	8, -6	3.78	14, -10
HIGH CONSERVATION	3.88	12, -8	3.86	8, -6	3.77	14, -10
IMPORTS	3.88	12, -8	3.86	8, -6	3.78	14, -10

SITE: COLSTRIP YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: SO2 AVERAGING PERIOD: ANNUAL

THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE						
<u>RESOURCE ALTERNATIVE</u>	Highest	Maximum	Second	Maximum	Third	Maximum
	Conc. ₃	X,Y	Conc. ₃	X,Y	Conc. ₃	X,Y
	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)	($\mu\text{g}/\text{m}^3$)	(KM)
STATUS QUO	4.55	12, -8	4.52	8, -6	4.42	14, -10
BASE CASE 4	4.32	12, -8	4.30	8, -6	4.20	14, -10
CONSERVATION	4.32	12, -8	4.30	8, -6	4.20	14, -10
CONVENTIONAL COAL	4.59	12, -8	4.57	8, -6	4.46	14, -10
CLEAN COAL	4.42	12, -8	4.40	8, -6	4.30	14, -10
NUCLEAR	4.32	12, -8	4.30	8, -6	4.20	14, -10
COMBUSTION TURBINE	4.32	12, -8	4.30	8, -6	4.20	14, -10
RENEWABLES	4.32	12, -8	4.30	8, -6	4.20	14, -10
COGENERATION	4.31	12, -8	4.29	8, -6	4.20	14, -10
FUEL SWITCHING	4.32	12, -8	4.29	8, -6	4.20	14, -10
HIGH CONSERVATION	4.32	12, -8	4.30	8, -6	4.20	14, -10
IMPORTS	4.37	12, -8	4.35	8, -6	4.25	14, -10

SITE: COLSTRIP YEAR: 1991 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: ANNUAL

RESOURCE ALTERNATIVE	THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE					
	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
ALL PROGRAMS	.122	12, -8	.121	8, -6	.120	14, -10

SITE: COLSTRIP YEAR: 2000 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: ANNUAL

RESOURCE ALTERNATIVE	THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE					
	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	.186	12, -8	.185	8, -6	.181	14, -10
BASE CASE 4	.186	12, -8	.184	8, -6	.181	14, -10
CONSERVATION	.186	12, -8	.184	8, -6	.181	14, -10
CONVENTIONAL COAL	.220	12, -8	.219	8, -6	.214	14, -10
CLEAN COAL	.196	12, -8	.195	8, -6	.191	14, -10
NUCLEAR	.185	12, -8	.183	8, -6	.180	14, -10
COMBUSTION TURBINE	.186	12, -8	.184	8, -6	.181	14, -10
RENEWABLES	.187	12, -8	.186	8, -6	.182	14, -10
COGENERATION	.183	12, -8	.181	8, -6	.178	14, -10
FUEL SWITCHING	.188	12, -8	.187	8, -6	.183	14, -10
HIGH CONSERVATION	.187	12, -8	.186	8, -6	.182	14, -10
IMPORTS	.187	12, -8	.186	8, -6	.182	14, -10

SITE: COLSTRIP YEAR: 2010 GRID: Cartesian 32km
 POLLUTANT: TSP AVERAGING PERIOD: ANNUAL

RESOURCE ALTERNATIVE	THREE HIGHEST CONCENTRATION VALUES ON GRID AND THEIR DISTANCE FROM SOURCE					
	Highest Maximum		Second Maximum		Third Maximum	
	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)	Conc. ($\mu\text{g}/\text{m}^3$)	X,Y (KM)
STATUS QUO	.287	12, -8	.285	8, -6	.279	14, -10
BASE CASE 4	.253	12, -8	.251	8, -6	.246	14, -10
CONSERVATION	.253	12, -8	.251	8, -6	.246	14, -10
CONVENTIONAL COAL	.290	12, -8	.288	8, -6	.282	14, -10
CLEAN COAL	.266	12, -8	.264	8, -6	.258	14, -10
NUCLEAR	.253	12, -8	.252	8, -6	.246	14, -10
COMBUSTION TURBINE	.253	12, -8	.251	8, -6	.246	14, -10
RENEWABLES	.253	12, -8	.251	8, -6	.246	14, -10
COGENERATION	.252	12, -8	.251	8, -6	.245	14, -10
FUEL SWITCHING	.253	12, -8	.251	8, -6	.246	14, -10
HIGH CONSERVATION	.253	12, -8	.251	8, -6	.246	14, -10
IMPORTS	.256	12, -8	.255	8, -6	.249	14, -10

APPENDIX E

PLOTS OF THE AVERAGE pH OF PRECIPITATION

APPENDIX E

PLOTS OF THE AVERAGE pH OF PRECIPITATION

The plots in Appendix E represent estimates of the average pH of rainfall as a result of power plant emissions and the natural pH of rainfall (a pH of 5.7). The plots display every third data value for the MESOPUFF simulations generated on a 24-by-28 grid with a grid spacing of 25 km. The coordinate system is set up so that the source point is near the grid origin.

Each plot is labelled with the name of the release site and the designation "1991," "2010 HI," and "2010 LO." The "1991" designation presents results using the 1991 levels of pollutant emission, the "2010 HI" designation represents results using the highest level of pollutant emission for any resource alternative at the indicated site in the year 2010, and the "2010 LO" designation represents results using the lowest level of pollutant emission for any resource alternative at the indicated site in the year 2010.

Y, KM
E.10

BOARDMAN AVG pH: FALL (2010 HI)

BOARDMAN AVG pH: WINTER (1991)

E.14

BOARDMAN AVG pH: WINTER (2010 HI)

BOARDMAN AVG pH: WINTER (2010 LO)

E.17

E.19

COLSTRIP AVG pH: SPRING (2010 HI)

COLSTRIP AVG pH: SPRING (2010 LO)

APPENDIX F

MODEL SIMULATIONS OF HOURLY OZONE CONCENTRATIONS

APPENDIX F

MODEL SIMULATIONS OF HOURLY OZONE CONCENTRATIONS

In this appendix we present the results of our model simulations of hourly ozone concentrations. Simulations are made for different combinations of release site, study year, background atmosphere, and level of emissions (i.e., a resource alternative with a relatively "high" level of NO_x emissions and a resource alternative with a lower or "low" level of NO_x emissions). Results are reported on engineering worksheet paper. For each simulation, information is presented on the elapsed hour after the puff is released, the distance downwind the puff has traveled from its release location, and the concentration of ozone in the ambient atmosphere and in the plume. Ambient values do not change for a given combination of release site and background atmosphere; these values are therefore not repeated on the engineering worksheet.

Prepared By: L. A. Clements Date: 1/17/76 Project: EPA Study, Environmental Q₂
Title/Subject: Ozone Levels (from RPA Study)

O₂ concentrations in ppb
July 1, 4 mph meteorology; midnight start time

Elapsed time (hr.)	Distance (km)	Boardman Year 2000, low emiss. "Dry run" ambient (G4100)		Boardman Year 2000, high emiss. "Dry run" ambient (G4100)		Boardman Year 2000, low emiss. "Dry run" ambient (G4100)	
		Ambient (ppb)	Plane Avg (ppb)	Ambient (ppb)	Plane Avg (ppb)	Ambient (ppb)	Plane Avg (ppb)
10 AM 1	6.4	3.41	1.10 ⁻⁵				
2	12.8	3.41	1.10 ⁻⁵				
3	19.2	3.46	1.10 ⁻⁵				
4	25.7	3.46	1.10 ⁻⁵				
5	32.2	3.48	0.21				0.43
6	38.6	4.18	0.11				0.42
7	45.1	4.65	1.61				0.40
8	51.5	5.38	2.48				1.45
9	57.9	5.45	4.30				2.40
10	64.4	6.58	5.46				4.44
11	70.8	7.31	7.45				6.01
12 PM 12	77.2	8.61	8.75				7.38
13	83.7	9.74	9.77				8.54
14	90.1	9.81	10.4				9.54
15	96.6	9.71	10.8				10.3
16	103.0	9.75	11.1				10.8
17	109.4	10.1	11.2				11.2
18	115.9	10.3	11.3				11.3

Prepared By: L. A. Clements Date: 1/17/76 Project: EPA Study, Environmental Q₂
Title/Subject: Ozone Levels (from RPA Study)

O₂ concentrations in ppb
July 1, 4 mph meteorology; midnight start time

Elapsed time (hr.)	Distance (km)	Boardman Year 2000, high emiss. "Dry run" ambient (G4100)		Boardman Year 2000, low emiss. "Dry run" ambient (G4100)		Boardman Year 2000, high emiss. "Dry run" ambient (G4100)	
		Ambient (ppb)	Plane Avg (ppb)	Ambient (ppb)	Plane Avg (ppb)	Ambient (ppb)	Plane Avg (ppb)
10 AM 1	6.4	3.46	1.10 ⁻⁵	3.44	1.10 ⁻⁵		
2	12.8	3.46	1.10 ⁻⁵	3.51	1.10 ⁻⁵		
3	19.2	3.46	1.10 ⁻⁵	3.53	1.10 ⁻⁵		
4	25.7	3.46	1.10 ⁻⁵	3.54	1.10 ⁻⁵		
5	32.2	3.48	0.041	3.55	0.12		0.10
6	38.6	4.18	0.40	4.21	0.34		0.36
7	45.1	4.65	0.56	4.84	1.67		1.27
8	51.5	5.38	1.84	5.99	2.50		2.04
9	57.9	5.45	2.67	6.46	4.69		4.12
10	64.4	6.58	4.20	7.44	6.67		6.13
11	70.8	7.31	5.40	8.66	9.46		7.96
12 PM 12	77.2	8.61	7.05	9.80	10.0		9.57
13	83.7	9.74	9.78	10.6	11.2		10.4
14	90.1	9.81	9.28	11.3	12.1		11.4
15	96.6	9.71	10.0	11.8	12.6		12.3
16	103.0	9.75	10.6	12.1	12.9		12.7
17	109.4	10.1	11.0	12.3	13.1		13.1
18	115.9	10.3	11.2	12.3	13.1		13.2

FACILITY NAME AND LOCATION

ENGINEERING WORKSHEET

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Prepared By: L. A. MATTEN Date: 7/1/79 Project: BPA Site Evaluation - Q
 Title/Subject: Ground Levels (From EPA Study)

Q concentrations in ppbm
 July 1, 4 mph meteorology, midnight start time

Elapsed time (hr)	Distance (km)	Background		Background		Concentration	
		Year 2100, low emis.		Year 2100, high emis.		Year 2100, low emis.	
		Ambient (ppbm)	Plane Avg (ppbm)	Ambient (ppbm)	Plane Avg (ppbm)	Ambient (ppbm)	Plane Avg (ppbm)
18M 1	6.4	3.94	1×10^{-9}			3.94	1×10^{-9}
2	12.8	3.94	1×10^{-9}			3.94	1×10^{-9}
3	19.2	3.94	1×10^{-9}			3.94	1×10^{-9}
4	25.6	3.94	1×10^{-9}			3.94	1×10^{-9}
5	32.0	3.94	0.049	0.049	0.049	3.94	0.049
6	38.4	4.21	0.42	0.42	0.42	4.21	0.42
7	44.8	4.34	0.42	0.42	0.42	4.34	0.42
8	51.2	4.39	1.50	1.35	1.35	4.39	1.55
9	57.6	6.46	3.21	2.90	2.90	6.46	3.10
10	64.0	7.34	5.15	4.81	4.81	7.34	4.73
11	70.4	8.96	7.02	6.43	6.43	8.96	6.29
12M 12	77.2	9.80	9.67	9.25	9.07	9.80	7.64
13	83.7	10.4	10.1	9.91	9.74	10.4	9.36
14	90.1	11.3	11.2	10.9	10.71	11.3	9.79
15	96.5	11.9	12.0	11.8	11.71	11.9	10.5
16	103.0	12.1	12.4	12.4	12.4	12.1	11.0
17	109.4	12.3	12.9	12.7	12.7	12.3	11.3
18	115.9	12.3	13.1	12.9	12.9	12.3	11.4

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FACILITY NAME AND LOCATION

ENGINEERING WORKSHEET

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Prepared By: L. A. MATTEN Date: 7/1/79 Project: BPA Site Evaluation - Q
 Title/Subject: Ground Levels (From EPA Study)

Q concentrations in ppbm
 July 1, 4 mph meteorology, midnight start time

Elapsed time (hr)	Distance (km)	Background		Background		Concentration	
		Year 2100, low emis.		Year 2100, high emis.		Year 2100, low emis.	
		Ambient (ppbm)	Plane Avg (ppbm)	Ambient (ppbm)	Plane Avg (ppbm)	Ambient (ppbm)	Plane Avg (ppbm)
18M 1	6.4	3.94	1×10^{-9}			3.94	1×10^{-9}
2	12.8	3.94	1×10^{-9}			3.94	1×10^{-9}
3	19.2	3.94	1×10^{-9}			3.94	1×10^{-9}
4	25.6	3.94	1×10^{-9}			3.94	1×10^{-9}
5	32.0	3.94	0.049	0.049	0.049	3.94	0.049
6	38.4	4.21	0.42	0.42	0.42	4.21	0.42
7	44.8	4.34	0.42	0.42	0.42	4.34	0.42
8	51.2	4.39	1.46	1.34	1.34	4.39	1.63
9	57.6	6.46	2.45	2.33	2.33	6.46	3.38
10	64.0	6.58	4.54	4.29	4.29	6.58	5.29
11	70.4	7.31	6.03	5.74	5.74	7.31	7.49
12M 12	77.2	8.17	7.44	7.17	7.17	8.17	9.51
13	83.7	8.74	9.66	9.31	9.31	8.74	11.4
14	90.1	9.31	9.60	9.34	9.34	9.31	12.9
15	96.5	9.71	10.3	10.1	10.1	9.71	14.0
16	103.0	9.95	10.4	10.6	10.6	9.95	14.7
17	109.4	10.1	11.2	11.1	11.1	10.1	15.0
18	115.9	10.2	11.4	11.2	11.2	10.2	15.2

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50 1087-112 (7/79)

ENGINEERING WORKSHEET

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Prepared By: L. A. MATHIAS Date: 9/1/78 Project: RPA Siting Evaluation By: Q
 Title/Subject: Ozone Levels (from RPA Siting)

Q concentrations in ppb
 July 1, 4-ph meteorology; midnight start time

Elapsed time (hr)	Distance (km)	Control Year 2000, high emiss. "Dirty event" ambient (US100)		Control Year 2010, low emiss. "Dirty event" ambient (US100)		Catchup Year 2000, low emiss. "Dirty event" ambient (US100)	
		Ambient (ppb)	Plane Avg (ppb)	Ambient (ppb)	Plane Avg (ppb)	Ambient (ppb)	Plane Avg (ppb)
10 AM 1	6.4	5.67	1.0E-5			3.91	1.0E-5
2	12.8	5.67	1.0E-5			3.91	
3	19.2	3.66	1.0E-5			3.90	
4	25.7	3.65	1.0E-5			3.90	
5	32.2	3.79	0.10		0.06	3.48	0.042
6	38.6	4.10	0.45		0.43	4.18	0.41
7	45.1	4.70	0.97		0.90	4.05	0.84
8	51.5	5.65	1.54		1.45	5.30	1.28
9	57.9	7.01	3.21		2.49	5.93	2.97
10	64.4	8.55	5.14		4.44	6.58	3.90
11	70.8	10.1	7.31		7.04	7.31	5.90
12 PM 12	77.2	11.6	9.34		9.09	8.67	6.76
13	83.7	13.0	11.3		11.0	8.74	7.99
14	90.1	13.8	12.9		12.6	9.31	8.94
15	96.6	14.9	14.9		13.7	9.71	9.74
16	103.0	15.9	15.6		14.5	9.95	10.3
17	109.4	15.0	15.3		14.9	10.1	10.8
6 PM 18	115.9	15.0	15.1		15.0	10.2	10.9

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ENGINEERING WORKSHEET

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Prepared By: L. A. MATHIAS Date: 9/1/78 Project: RPA Siting Evaluation By: Q
 Title/Subject: Ozone Levels (from RPA Siting)

Q concentrations in ppb
 July 1, 4-ph meteorology; midnight start time

Elapsed time (hr)	Distance (km)	Control Year 2000, high emiss. "Dirty event" ambient (US100)		Control Year 2010, low emiss. "Dirty event" ambient (US100)		Catchup Year 2000, high emiss. "Dirty event" ambient (US100)	
		Ambient (ppb)	Plane Avg (ppb)	Ambient (ppb)	Plane Avg (ppb)	Ambient (ppb)	Plane Avg (ppb)
1 AM 1	6.4	3.91	1.0E-5				
2	12.8	3.91					
3	19.2	3.90					
4	25.7	3.90					
5	32.2	3.48	0.042		0.10		0.11
6	38.6	4.18	0.41		0.45		0.43
7	45.1	4.05	0.84		0.90		0.94
8	51.5	5.30	1.28		1.45		1.38
9	57.9	5.93	2.97		2.49		2.29
10	64.4	6.58	3.90		4.44		3.52
11	70.8	7.31	5.90		7.04		4.90
12 PM 12	77.2	8.67	6.76		9.09		6.20
13	83.7	8.74	7.99		11.0		7.42
14	90.1	9.31	8.94		12.6		9.19
15	96.6	9.71	9.74		13.7		9.16
16	103.0	9.95	10.3		14.5		9.71
17	109.4	10.1	10.8		14.9		10.2
6 PM 18	115.9	10.2	10.9		15.0		10.4

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501087-114 (11/78)

ENGINEERING WORKSHEET

Prepared By: L. A. Mankus Date: 7/1/79 Project: EPB S Fine Grained Soil
 Title/Subject: Creole Island (Lago RPA 8-61)

Q concentration in ppbm
 July 1, 4 mph meteorology, midday start time

Elapsed time (hr)	Distance (km)	Castrip Year 2000, low emiss. "Clean total" ambient (B1100)		Castrip Year 2000, high emiss. "Clean total" ambient (C1100)		Castrip Year 2010, low emiss. "Clean total" ambient (B1100)	
		Ambient (ppbm)	Plane Avg (ppbm)	Ambient (ppbm)	Plane Avg (ppbm)	Ambient (ppbm)	Plane Avg (ppbm)
1 AM 1	6.4	3.98	1 x 10 ⁻⁵		1 x 10 ⁻⁵		1 x 10 ⁻⁵
2	12.4	3.98					
3	15.3	3.98					
4	25.7	3.98					
5	32.2	3.97	0.095		0.094		0.10
6	38.6	3.98	0.85		0.81		0.92
7	45.1	3.98	0.76		0.80		0.88
8	51.5	3.96	1.06		1.10		1.15
9	57.9	3.93	1.72		1.71		1.73
10	64.4	3.91	2.14		2.31		2.32
11	70.3	3.81	2.57		2.84		2.84
12 PM 12	77.2	3.48	3.26		3.24		3.24
13	83.7	3.44	3.55		3.53		3.53
14	90.1	3.46	3.77		3.74		3.77
15	96.6	3.98	3.42		3.88		3.87
16	103.0	3.99	4.04		3.99		3.97
17	109.4	4.00	4.16		4.04		4.05
6 PM 18	115.9	4.00	4.10		4.02		3.97

6 PM 18
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ENGINEERING WORKSHEET

Prepared By: L. A. Mankus Date: 7/1/79 Project: EPB S Fine Grained Soil
 Title/Subject: Creole Island (Lago RPA 8-61)

Q concentration in ppbm
 July 1, 4 mph meteorology, midday start time

Elapsed time (hr)	Distance (km)	Castrip Year 2010, high emiss. "Clean total" ambient (C1100)		Castrip Year 2000, low emiss. "Clean total" ambient (B1100)		Castrip Year 2000, high emiss. "Clean total" ambient (C1100)	
		Ambient (ppbm)	Plane Avg (ppbm)	Ambient (ppbm)	Plane Avg (ppbm)	Ambient (ppbm)	Plane Avg (ppbm)
1 AM 1	6.4	3.98	1 x 10 ⁻⁵	3.91	1 x 10 ⁻⁵		1 x 10 ⁻⁵
2	12.4	3.98		3.91			
3	15.3	3.98		3.90			
4	25.7	3.98		3.90			
5	32.2	3.97	0.11	3.93	0.48		0.24
6	38.6	3.98	0.46	4.18	1.23		0.58
7	45.1	3.98	0.89	4.65	2.09		1.72
8	51.5	3.96	1.19	5.30	2.49		2.58
9	57.9	3.93	1.75	5.93	4.89		4.48
10	64.4	3.91	2.32	6.58	6.59		6.11
11	70.3	3.81	2.85	7.31	7.91		7.59
12 PM 12	77.2	3.48	3.28	8.07	9.08		8.88
13	83.7	3.44	2.53	9.74	9.57		9.82
14	90.1	3.46	3.13	9.81	10.4		10.9
15	96.6	3.98	3.87	9.71	10.6		10.8
16	103.0	3.99	3.94	9.95	10.9		11.0
17	109.4	4.00	3.98	10.1	11.0		11.2
6 PM 18	115.9	4.00	3.92	10.2	11.0		11.2

6 PM 18
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For the Department of the Interior

ENGINEERING WORKSHEET

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Prepared By: L. A. MAMMEN Date: 7/2/76 From: BPA Station Environment: O₃
Title/Subject: Clear Labels (from RPT 6-12)

O₃ concentrations in ppbm
July 1, 4-10 p.m. meteorology; mid-night start time

Elapsed time (hr)	Distance (km)	Creighton Year 2000, low emiss. "Typical rural" ambient (Q3100)		Creighton Year 2010, high emiss. "Typical rural" ambient (Q3100)		Creighton Year 2000, low emiss. "Typical rural" ambient (Q3100)	
		Ambient (ppbm)	Plane Avg (ppbm)	Ambient (ppbm)	Plane Avg (ppbm)	Ambient (ppbm)	Plane Avg (ppbm)
1 AM	6.4	3.4	1.0 x 10 ⁻⁵		1.0 x 10 ⁻⁵	4.80	1.0 x 10 ⁻⁵
2	12.4	3.90				3.99	
3	19.3	3.90				3.99	
4	25.7	5.90				3.99	
5	32.2	3.93	0.24		0.4	4.00	0.42
6	38.6	4.9	0.39		0.47	4.10	1.11
7	45.1	4.65	1.67		1.51	4.41	1.72
8	51.5	5.30	2.61		2.12	4.55	2.28
9	57.9	5.48	4.34		3.45	4.78	3.54
10	64.4	6.58	6.03		5.61	4.96	4.44
11	70.9	7.31	7.52		7.11	5.14	5.19
12 PM	77.2	8.01	8.30		8.47	5.32	5.90
13	83.7	8.74	9.80		9.58	5.46	6.23
14	90.1	9.21	10.4		10.3	5.57	6.47
15	96.6	9.71	10.8		10.8	5.65	6.60
16	103.0	9.95	11.1		11.2	5.68	6.71
17	109.4	10.1	11.3		11.3	5.70	6.75
6 PM	115.9	10.2	11.2		11.4	5.71	6.75

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56 1087 114 (1/82)

For the Department of the Interior

ENGINEERING WORKSHEET

Page 12 of 12

Prepared By: L. A. MAMMEN Date: 7/2/76 From: BPA Station Environment: O₃
Title/Subject: Clear Labels (from RPT 6-12)

O₃ concentrations in ppbm
July 1, 4-10 p.m. meteorology; mid-night start time

Elapsed time (hr)	Distance (km)	Creighton Year 2000, high emiss. "Typical rural" ambient (Q3100)		Creighton Year 2000, low emiss. "Typical rural" ambient (Q3100)		Creighton Year 2000, high emiss. "Typical rural" ambient (Q3100)	
		Ambient (ppbm)	Plane Avg (ppbm)	Ambient (ppbm)	Plane Avg (ppbm)	Ambient (ppbm)	Plane Avg (ppbm)
1 PM	6.4	4.75	1.0 x 10 ⁻⁵				
2	12.4	3.99					
3	19.3	3.99					
4	25.7	3.99					
5	32.2	4.10	0.24		0.21		0.14
6	38.6	4.10	0.32		0.38		0.59
7	45.1	4.41	1.69		1.39		1.13
8	51.5	4.55	1.97		1.70		1.63
9	57.9	4.78	3.44		3.14		2.95
10	64.4	4.96	4.15		4.04		3.81
11	70.9	5.14	4.90		4.84		4.58
12 PM	77.2	5.32	5.52		5.46		5.18
13	83.7	5.46	6.02		5.97		5.70
14	90.1	5.57	6.14		6.32		6.10
15	96.6	5.65	6.26		6.44		6.38
16	103.0	5.68	6.76		6.75		6.69
17	109.4	5.70	6.75		6.76		6.70
6 PM	115.9	5.71	6.75		6.79		6.78

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56 1087 114 (1/82)

ESCHLUC

Environmental Laboratory

ENGINEERING WORKSHEET

Prepared By: L. A. McIntosh Date: 9/1/91 Project: EPA Site Evaluation - O₃

Title/Subject: Ozone Intact (from EPA 8200)

O₃ concentrations in ppb
July 1, 4-ph meteorology; midnight start time

Elapsed time (hr)	Distance (km)	Centralia 1991 emissions Ambient area near big RD (EPA100)		Calverton 1991 emissions "Dirty rural" ambient (EPA100)		Calverton 1991 emissions "Clean rural" ambient (EPA100)	
		Ambient (ppb)	Plane Avg (ppb)	Ambient (ppb)	Plane Avg (ppb)	Ambient (ppb)	Plane Avg (ppb)
1 AM 1	6.4	3.61	1.00 ⁻⁵	3.41	1.00 ⁻⁵	3.58	1.00 ⁻⁵
2	12.4	3.67		3.41		3.58	
3	14.3	3.66		3.40		3.58	
4	25.7	3.67		3.41		3.58	
5	32.2	3.75	0.13	3.43	0.002	3.77	0.056
6	38.6	4.11	0.58	4.13	0.41	3.98	0.37
7	45.1	4.70	1.22	4.65	0.84	3.98	0.76
8	51.5	5.46	1.93	5.31	1.41	5.46	1.11
9	57.9	7.62	3.35	5.93	2.94	5.93	1.86
10	64.4	8.55	5.51	6.58	4.42	5.91	2.52
11	70.3	10.1	7.96	7.31	5.95	5.91	3.05
11 PM 12	77.2	11.6	9.94	8.67	7.32	5.95	3.43
13	92.7	12.8	11.8	9.74	9.53	5.94	5.10
14	98.1	13.8	13.2	9.31	9.49	5.94	5.91
15	98.6	14.8	14.2	9.11	10.2	3.93	4.05
16	103.0	14.8	14.8	9.55	10.8	2.94	4.22
17	109.4	15.0	15.1	10.1	11.2	4.00	4.32
6 PM 18	115.9	15.0	15.3	10.2	11.8	4.00	4.37

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Battelle

Environmental Laboratory

ENGINEERING WORKSHEET

Prepared By: L. A. McIntosh Date: 9/1/91 Project: EPA Site Evaluation - O₃

Title/Subject: Ozone Intact (from EPA 8200)

O₃ concentrations in ppb
July 1, 4-ph meteorology; midnight start time

Elapsed time (hr)	Distance (km)	Borden 1991 emissions "Dirty rural" ambient (EPA100)		Borden 1991 emissions Ambient area near RDs and road (EPA100)		Centralia 1991 emissions "Dirty rural" ambient (EPA100)	
		Ambient (ppb)	Plane Avg (ppb)	Ambient (ppb)	Plane Avg (ppb)	Ambient (ppb)	Plane Avg (ppb)
1 AM 1	6.4	3.41	1.00 ⁻⁵	3.84	1.00 ⁻⁵	3.91	1.00 ⁻⁵
2	12.4	3.91		3.84		3.91	
3	14.3	3.90		3.83		3.90	
4	25.7	3.90		3.84		3.90	
5	32.2	3.93	0.78	3.99	0.77	3.91	0.12
6	38.6	4.13	1.61	4.21	1.62	4.15	0.54
7	45.1	4.65	2.52	4.94	2.54	4.65	1.16
8	51.5	5.80	3.47	5.89	3.58	5.60	1.84
9	57.9	5.43	5.31	6.46	5.70	5.48	3.57
10	64.4	6.58	6.87	7.84	7.87	6.58	5.24
11	70.3	7.31	9.15	8.84	9.17	7.31	6.76
11 PM 12	77.2	8.67	9.13	9.80	10.4	8.07	8.13
13	92.7	9.74	9.80	10.6	11.4	9.74	9.12
14	98.1	9.31	10.2	11.3	12.0	9.31	10.2
15	98.6	9.31	10.5	11.8	12.4	9.71	10.7
16	103.0	9.55	10.7	12.1	12.4	9.95	11.2
17	109.4	10.1	10.8	12.3	12.8	10.1	11.4
6 PM 18	115.9	10.2	10.9	12.3	12.8	10.2	11.5

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F.7

ENGINEERING WORKSHEET

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Prepared By: L. A. MARCHET Date: 10/1/81 Project: BPA Siting Evaluation - Q₂
 Title/Subject: Ozone Impacts (from RPA runs)

O₃ concentrations in ppb
 July 1, 4 mph meteorology; 6 AM start time; 12 midnight end time

Elapsed Time (hr)	Distance (km)	Concentration Year 2000, high winds "Dirty road" ambient (TS100)		Concentration Year 2000, high winds Ambient and AD ₁₀ , mid road (TS100)		Concentration Year 2000, high winds Ambient high AD ₁₀ , mid road (TS100)	
		Ambient (ppb)	Plume Avg (ppb)	Ambient (ppb)	Plume Avg (ppb)	Ambient (ppb)	Plume Avg (ppb)
7 AM 1	6.4	4.68	0.78	4.85	0.28	4.70	0.29
2	12.4	5.84	0.68	5.78	0.71	5.50	0.72
3	14.4	4.04	1.78	4.84	1.98	6.64	1.92
4	25.8	6.75	2.48	7.47	4.02	7.41	3.84
5	32.8	7.45	5.84	8.96	6.24	9.52	6.76
12 noon 6	35.7	5.17	7.02	9.81	8.31	11.2	8.44
7	45.2	8.90	8.62	10.4	10.2	12.5	10.8
8	51.6	9.26	9.44	11.2	11.7	12.4	12.4
9	58.0	9.54	10.7	11.5	12.8	12.4	14.5
10	64.5	9.72	11.6	11.8	13.4	14.3	15.1
11	70.4	9.82	11.9	11.4	13.6	14.4	15.4
6 PM 12	77.8	9.95	12.0	11.4	13.7	14.5	15.6
13	82.8	9.85	11.9	11.4	13.7	14.5	15.6
14	90.2	9.82	11.9	11.4	13.6	14.5	15.6
7 PM 15	96.6	9.81	11.8	11.4	13.6	14.5	15.6
16	103	9.82	11.8	11.4	13.5	14.5	15.5
17	110	9.83	11.7	11.4	13.5	14.5	15.5
midnight 18	116	9.82	11.7	11.4	13.5	14.5	15.5
19							
20							
21							
22							
23							
24							

ENGINEERING WORKSHEET

Page 47 of 48

Prepared By: L. A. MARCHET Date: 10/1/81 Project: BPA Siting Evaluation - Q₂
 Title/Subject: Ozone Impacts (from RPA runs)

O₃ concentrations in ppb
 July 1, 4 mph meteorology; mid night start time

Elapsed Time (hr)	Distance (km)	Concentration Year 2000, high winds Ambient and AD ₁₀ , mid road (TS100)		Concentration Year 2000, high winds Ambient high AD ₁₀ , mid road (TS100)		Ambient (ppb)	Plume Avg (ppb)
		Ambient (ppb)	Plume Avg (ppb)	Ambient (ppb)	Plume Avg (ppb)		
1 AM 1	6.4	3.34	1 x 10 ⁻⁵		1 x 10 ⁻⁵		
2	12.4	9.54	1 x 10 ⁻⁵		1 x 10 ⁻⁵		
3	14.4	2.83	1 x 10 ⁻⁵		1 x 10 ⁻⁵		
4	25.7	5.84	1 x 10 ⁻⁵		1 x 10 ⁻⁵		
5	32.2	3.84	0.094		0.11		
6	38.6	4.21	0.42		0.48		
7	45.1	4.54	0.41		0.45		
8	51.5	5.54	1.45		1.35		
9	57.9	6.46	3.18		2.47		
10	64.4	7.44	5.06		4.00		
11	70.8	8.86	6.45		5.75		
12 PM 12	77.2	9.80	8.41		7.40		
13	82.2	10.6	10.1		8.48		
14	90.1	11.5	11.2		10.1		
15	96.6	11.8	12.0		11.1		
16	103.0	12.1	12.6		11.7		
17	109.4	12.5	12.7		12.2		
6 PM 18	115.4	12.8	13.1		12.4		

ENGINEERING WORKSHEET

Prepared By

L. A. MARSHALL

Date

10/1/75

Project

BPA Sulfur Evaluation - Qp

Title/Subject

Ozone Impact (from BPA work)

O₃ concentration in ppb

July 1, 4 up-midnight, midnight start time, midnight end time

Elapsed Time (hr)	Distance (km)	Centralia Year 2000, high-mist "Daily rural" ambient (TS400)		Centralia Year 2000, high-mist Ambient and up, mid-rural (TS400)		Centralia Year 2000, high-mist Ambient high-rural, mid-rural (TS400)	
		Ambient (ppb)	Plume Avg. (ppb)	Ambient (ppb)	Plume Avg. (ppb)	Ambient (ppb)	Plume Avg. (ppb)
1 AM	4.5	3.91	1.410 ⁻⁵	3.14	1.410 ⁻⁵	3.67	1.410 ⁻⁵
2	13.0	1.41	-	3.14	-	3.67	-
3	14.4	3.90	-	3.14	-	3.66	-
4	25.8	3.40	-	3.14	-	3.66	-
5	32.1	3.14	0.04	3.01	0.04	3.77	0.10
6 AM	39.7	4.18	0.42	4.21	0.43	4.12	0.45
7	45.2	4.44	0.41	4.55	0.44	4.70	0.57
8	51.6	5.00	1.40	5.90	1.53	5.65	1.54
9	58.0	5.43	2.45	6.54	3.26	7.00	5.21
10	64.5	6.58	4.54	7.43	5.21	8.57	5.20
11	70.9	7.21	6.78	8.34	7.08	10.1	7.31
12 PM	77.3	8.06	7.44	9.60	9.73	11.6	9.54
13	83.9	8.75	8.65	10.4	10.2	12.7	11.3
14	90.2	9.29	9.60	11.3	11.3	13.7	12.8
15	96.6	9.70	10.3	11.5	12.1	14.5	13.9
16	103	9.96	10.9	12.1	12.6	14.8	14.6
17	110	10.1	11.2	12.2	12.9	15.0	14.9
18	116	10.2	11.4	12.3	13.1	15.1	15.1
19	122	10.2	11.4	12.3	13.1	15.1	15.2
20	129	10.2	11.4	12.3	13.1	15.1	15.2
9 PM	21	155	11.1	12.5	13.1	15.1	15.2
22	147	10.1	11.1	12.5	13.1	15.1	15.2
23	143	10.1	11.1	12.5	13.1	15.1	15.2
24	154	10.1	11.1	12.5	13.0	15.1	15.2

BPA Sulfur

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34-1001 (11-17-75)

ENGINEERING WORKSHEET

Prepared By

L. A. MARSHALL

Date

10/1/75

Project

BPA Sulfur Evaluation - Qp

Title/Subject

Ozone Impact (from BPA work)

O₃ concentration in ppb

July 1, 3 up-midnight, midnight start time, midnight end time

Elapsed Time (hr)	Distance (km)	Centralia Year 2000, high-mist "Daily rural" ambient (TS400)		Centralia Year 2000, high-mist Ambient and up, mid-rural (TS400)		Centralia Year 2000, high-mist Ambient high-rural, mid-rural (TS400)	
		Ambient (ppb)	Plume Avg. (ppb)	Ambient (ppb)	Plume Avg. (ppb)	Ambient (ppb)	Plume Avg. (ppb)
1 AM	3.52	3.91	1.410 ⁻⁵	3.14	1.410 ⁻⁵	3.67	1.410 ⁻⁵
2	6.5	3.91	1.410 ⁻⁵	3.14	1.410 ⁻⁵	3.67	1.410 ⁻⁵
3	7.8	3.40	1.410 ⁻⁵	3.14	1.410 ⁻⁵	3.66	1.410 ⁻⁵
4	12.0	3.40	1.410 ⁻⁵	3.14	1.410 ⁻⁵	3.66	1.410 ⁻⁵
5	16.2	3.40	0.12	3.91	0.12	3.77	0.13
6 AM	17.4	4.20	0.54	4.23	0.54	4.12	0.55
7	22.4	4.44	1.05	4.55	1.06	4.70	1.06
8	25.8	5.30	1.40	5.90	1.43	5.65	1.43
9	29.1	5.43	2.20	6.44	2.76	7.00	2.34
10	32.1	6.58	3.25	7.43	3.65	8.57	3.68
11	35.6	7.21	4.48	8.34	5.19	10.1	5.42
12 PM	38.1	8.06	5.75	9.60	6.32	11.6	7.41
13	41.4	8.75	6.96	10.4	8.18	12.7	8.43
14	45.2	9.29	7.46	11.3	9.62	13.7	11.2
15	49.4	9.68	9.77	11.5	10.4	14.5	12.5
16	51.6	9.96	9.29	12.1	11.3	14.8	13.5
17	54.3	10.1	9.67	12.2	11.8	15.0	13.9
18	58.0	10.2	9.79	12.3	11.9	15.1	14.0
19	61.2	10.2	9.79	12.3	12.0	15.1	14.1
20	64.5	10.2	9.74	12.3	11.9	15.1	14.1
9 PM	21	67.7	10.1	9.75	12.3	15.1	14.1
22	70.9	10.1	9.76	12.3	11.9	15.1	14.1
23	74.1	10.1	9.77	12.3	12.0	15.1	14.2
24	77.3	10.1	9.77	12.3	12.0	15.1	14.2

BPA Sulfur

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34-1001 (11-17-75)

APPENDIX G

TESTS OF THE PLUVUE II MODEL

APPENDIX G

TESTS OF THE PLUVUE II MODEL

This appendix describes parameters used to run the PLUVUE II model and the results of our PLUVUE test simulations.

G.1 PARAMETERS USED IN MODEL TEST RUNS

In total 23 test runs of the PLUVUE II model were made prior to conducting our visibility analysis for the resource alternatives. These tests are named TESTA through TESTW. TESTA served as the base test case; all other test cases represented variations from TESTA.

Parameterizations Used in TESTA

The source term data used in TESTA are:

stack height: 330 ft
stack elevation: 600 ft msl
flue gas flow rate 830,000 cfm
Effluent Temp.: 170 °F (350 °K)
Gas oxygen content: 7 mole %
Emission Rate: 172.0 tons/day NO_x
 172.0 tons/day SO₂
 8.6 tons/day TSP

The meteorological data used in TESTA are:

Wind Speed: 3.0 mph
Stability Class: E
Potential Temp. Lapse rate: 0.02074 °K/M = 21 °C/KM
Ambient Temp.: 60 °F
Relative Humidity: 90%
Mixing Depth: 400 m
Pressure = 0.98 atm

The background air quality data for TESTA are:

NO _x conc.: 0.005 ppm	coarse mode conc.: 10 ug/m ³
NO ₂ conc.: 0.004 ppm	sulfate conc.: 2.1 ug/m ³
O ₃ conc.: 0.080 ppm	nitrate conc.: 0.0 ug/m ³
SO ₂ conc.: 0.020 ppm	

visual range: 60 km
SO₂ and NO_x deposition velocity: 1.0 cm/s
coarse and submicron deposition velocity: 0.1 cm/s

The geometry of the user-specified plume-observer sun orientations used in TESTA are:

wind direction: 270°
Date: 5/15
Time: 12:00
solar zenith angle: 30.1°
solar azimuth angle: 153°
Observer Positions: 20 km south of the release location

The following gives (1) the downwind distance from the stack (km) to the point at the center of the plume through which the observer's line of sight is focused and (2) the observer's observation angle from the stack to the indicated downwind point. Reductions in visual range are determined for lines of sight through these downwind points.

Downwind Distance (km)	Observation Angle
2.	5.7°
10.	26.6°
20.	45.0°
30.	56.3°
40.	63.4°
50.	68.2°
120.	80.5°

In this geometry, the observer is 20 km south of the release site and looking to the northeast through the eastward traveling plume. This a typical observer plume geometry that involves reduction in visibility over about 90° of arc. Other observer/plume geometry can cause higher reductions in visibility at some locations and lower reductions in visibility at others

Differences Between Test A and Subsequent Test Cases

The following lists the differences between subsequent test cases and TESTA.

TESTB - Involves meteorological conditions that will produce a higher, more "typical" rate of diffusion than seen in TESTA. This meteorology should produce lower reductions in visual range.

Wind Speed: 6.0 mph
Stability Class: D
Potential Temp. Lapse rate: -0.001137 °K/m = -1.137 °C/km
Ambient Temp.: 60 °F

Relative Humidity 30%
Mixing Depth: 1000 m

TESTC - Involves a lower rate of pollutant emissions. TESTA represents a high emission rate (characteristic of the level of emission for some resource alternatives at some sites during 2010); TESTC involves a low emissions rate (characteristic of the level of emission for some resource alternatives at some sites during 1991).

Emission Rate: 29.0 tons/day NOx
20.0 tons/day SO2
0.9 tons/day TSP

TESTD - Involves a lower background concentration of pollutants. TESTA represents a dirty rural atmosphere; TESTD a clean rural atmosphere.

NOx conc.: 0.000 ppm
NO2 conc.: 0.000 ppm
O3 conc.: 0.010 ppm
SO2 conc.: 0.000 ppm

TESTE - Involves an observer position that is 40 km south of the release location

The following gives (1) the downwind distance from the stack (km) to the point at the center of the plume through which the observer's line of sight is focused and (2) the observer's observation angle from the stack to the indicated downwind point. Reductions in visual range are determined for lines of sight through these downwind points.

Downwind Distance (km)	Observation Angle
2.	2.9°
10.	14.0°
20.	26.6°
30.	36.9°
40.	45.0°
50.	51.3°
120.	71.6°

TESTF - Involves a change in release date to January 15 from May 15. This produces a lower sun angle.

Date: 1/15
Time: 12:00
solar zenith angle: 69.6°
solar azimuth angle: 163.1°

TESTG - Involves a change in observation time from 12:00 to 16:00 for the May 15 study date. This also produces a lower sun angle.

Date: 5/15
Time: 16:00
solar zenith angle: 46.9°
solar azimuth angle: 249.6°

TESTH - Involves a reduction in relative humidity from 90% to 60%.

Relative Humidity 60%

TESTI - Involves a further reduction in relative humidity to 30%.

Relative Humidity 30%

TESTJ - Involves meteorological conditions that will produce a higher rate of diffusion than seen in TESTA or TESTB. This meteorology is "typical" of clear sky, daytime, warm season conditions. This meteorology should produce the lowest reductions in visual range.

Wind Speed: 6.0 mph
Stability Class: B
Potential Temp. Lapse rate: $-0.00843 \text{ }^{\circ}\text{K/m} = -8.42 \text{ }^{\circ}\text{C/km}$
Ambient Temp.: 60 °F
Relative Humidity: 30%
Mixing Depth: 3000 m

TESTK - Involves the meteorological conditions used in TESTB except the wind speed is doubled. This produces a more diffuse plume than presented in TESTB.

Wind Speed: 12.0 mph
Stability Class: D
Potential Temp. Lapse rate: $-0.001137 \text{ }^{\circ}\text{K/m} = -1.1137 \text{ }^{\circ}\text{C/km}$
Ambient Temp.: 60 °F
Relative Humidity: 30%
Mixing Depth: 1000 m

TESTL - Involves an observer position that is 20 km south and 10 km east of the release location

The following gives (1) the downwind distance from the stack (km) to the point at the center of the plume through which the observer's line of sight is focused and (2) the observer's observation angle from the stack to the indicated downwind point. Reductions in visual range are determined for lines of sight through these downwind points.

Downwind Distance (km)	Observation Angle
2.	338.2°
10.	0.0°
20.	26.6°
30.	45.0°
40.	56.3°
50.	63.4°
120.	79.7°

TESTM - Involves an observer position that is 20 km south and 10 km west of the release location

The following gives (1) the downwind distance from the stack (km) to the point at the center of the plume through which the observer's line of sight is focused and (2) the observer's observation angle from the stack to the indicated downwind point. Reductions in visual range are determined for lines of sight through these downwind points.

Downwind Distance (km)	Observation Angle
2.	31.0°
10.	45.0°
20.	56.3°
30.	63.4°
40.	68.2°
50.	71.6°
120.	81.3°

TESTN - Involves an observer position that is 20 km south and 30 km west of the release location

The following gives (1) the downwind distance from the stack (km) to the point at the center of the plume through which the observer's line of sight is focused and (2) the observer's observation angle from the stack to the indicated downwind point. Reductions in visual range are determined for lines of sight through these downwind points.

Downwind Distance (km)	Observation Angle
2.	58.0°
10.	63.4°
20.	68.2°
30.	71.6°
40.	74.1°
50.	76.0°
120.	82.4°

TESTO - Involves an observer position that is 20 km South and 30 km east of the release location

The following gives (1) the downwind distance from the stack (km) to the point at the center of the plume through which the observer's line of sight is focused and (2) the observer's observation angle from the stack to the indicated downwind point. Reductions in visual range are determined for lines of sight through these downwind points.

Downwind Distance (km)	Observation Angle
2.	305.5°
10.	315.0°
20.	333.4°
30.	0.0°
40.	26.6°
50.	45.0°
120.	77.5°

TESTP - Involves a negligible rate of pollutant emissions.

Emission Rate: 0.1 tons/day NOx
0.1 tons/day SO2
0.1 tons/day TSP

TESTQ - Involves an observer position that is 20 km north of the release location

The following gives (1) the downwind distance from the stack (km) to the point at the center of the plume through which the observer's line of sight is focused and (2) the observer's observation angle from the stack to the indicated downwind point. Reductions in visual range are determined for lines of sight through these downwind points.

Downwind Distance (km)	Observation Angle
2.	174.3°
10.	153.4°
20.	135.0°
30.	123.7°
40.	116.6°
50.	111.8°
60.	108.4°

TESTR - Involves a wind direction of 300°

The following gives (1) the downwind distance from the stack (km) to the point at the center of the plume through which the observer's line of sight is focused and (2) the observer's observation angle from the stack to the indicated downwind point. Reductions in visual range are determined for lines of sight through these downwind points.

Downwind Distance (km)	Observation Angle
2.	5.2°
10.	30.0°
20.	60.0°
30.	79.1°
40.	90.0°
50.	96.6°
60.	100.9°

TESTS - Involves a wind direction of 330°

The following gives (1) the downwind distance from the stack (km) to the point at the center of the plume through which the observer's line of sight is focused and (2) the observer's observation angle from the stack to the indicated downwind point. Reductions in visual range are determined for lines of sight through these downwind points.

Downwind Distance (km)	Observation Angle
2.	3.1°
10.	23.8°
20.	75.0°
30.	111.7°
40.	126.2°
50.	133.0°
60.	136.8°

TESTT - Involves a change in release time to 16:00 (May 15). This produces a lower sun angle.

solar zenith angle: 67.1°
solar azimuth angle: 273.7°

TESTU - Involves significant emissions of SO2 only.

Emission Rate: 0.1 tons/day NOx
172.0 tons/day SO2
0.1 tons/day TSP

TESTV - Involves significant emissions of NO2 only.

Emission Rate: 172.0 tons/day NOx
0.1 tons/day SO2
0.1 tons/day TSP

TESTW - Involves significant emissions of particulates only.

Emission Rate: 0.1 tons/day NOx
0.1 tons/day SO2
8.6 tons/day TSP

G.2 ANALYSIS OF TEST RESULTS

In the following section we will examine the results of our test simulations using the PLUVUE II model. Table G.1 presents a summary of test results.

Table G.1. Summary of Test Results.

TEST NAME	Description	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
		2	10	20	30	40	50	60
TESTA	Base Case	10.1	6.2	6.9	8.7	8.9	8.1	-
TESTB	Neutral Met.	3.7	2.5	2.9	3.5	3.2	3.5	-
TESTC	Reduced Emissions	1.1	1.1	1.5	2.2	2.2	3.5	-
TESTD	Lower Bkgrnd Conc.	9.9	5.3	5.3	6.0	5.7	5.8	-
TESTE	Obsrv 40 km South	10.9	6.2	5.8	6.2	4.0	0.6	-
TESTF	January-Noon Case	10.2	6.2	7.0	8.8	9.3	8.2	-
TESTG	May-Afternoon Case	10.2	6.2	7.0	8.8	9.3	8.1	-
TESTH	Base Case w 60% RH	10.1	6.2	6.9	8.6	10.8	8.0	-
TESTI	Base Case w 30% RH	10.1	6.2	6.9	8.6	10.7	7.9	-
TESTJ	Unstable Met.	1.6	0.9	0.8	1.1	1.3	1.2	-
TESTK	Neutral - High Wds	2.2	1.6	1.9	2.4	2.9	2.5	-
TESTL	Obsrv. 10 km East	11.0	5.4	5.2	6.6	8.7	11.2	-
TESTM	Obsrv. 10 km West	12.1	8.2	9.2	11.1	8.3	3.0	-
TESTN	Obsrv. 30 km West	20.6	13.7	9.0	2.0	0.0	0.0	-
TESTO	Obsrv. 30 km East	18.6	8.2	5.2	4.3	4.9	6.6	-
TESTP	Negligable Emis.	0.1	0.1	0.1	0.1	0.2	0.2	0.1
TESTQ	Obsrv. 20 km North	10.2	7.0	6.9	8.7	11.0	8.2	3.5
TESTR	Wind direct.: 300°	11.0	5.3	5.3	7.0	9.6	12.5	9.4
TESTS	Wind direct.: 330°	18.5	6.1	4.0	6.7	11.3	16.8	16.9
TESTT	May-Evening Case	10.2	6.3	7.1	9.2	11.9	8.6	3.7
TESTU	SO2 Emission only	0.1	0.3	3.0	8.8	17.1	12.7	7.2
TESTV	NOx Emission only	3.1	2.8	3.6	5.0	6.6	5.8	2.4
TESTW	TSP Emission only	7.0	3.4	3.3	3.7	4.3	3.9	-

PLUVUE II Sensitivity to Relative Humidity

Table G.2 shows the changes in reductions in visual range as a function of the relative humidity.

Table G.2. Testing the Impact of Relative Humidity on Reductions in Visible Range.

TEST NAME	Description	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
		2	10	20	30	40	50	120
TESTA	Base Case w 90% RH	10.1	6.2	6.9	8.7	8.9	8.1	0
TESTH	Base Case w 60% RH	10.1	6.2	6.9	8.6	10.8	8.0	0
TESTI	Base Case w 30% RH	10.1	6.2	6.9	8.6	10.7	7.9	0

For the range in relative humidities examined (from dry to near moist), relative humidity has little effect on reductions in visual range. At higher relative humidities (approaching saturation) there may be more of an effect, but under these conditions the background visual range will be reduced to such low values that further reductions of visual range due to power plant emissions will be insignificant.

PLUVUE II Sensitivity to Wind Speed

Table G.3 shows the changes in reductions in visual range as a function of doubling the wind speed.

Table G.3. Testing the Impact of Wind Speed on Reductions in Visual range.

TEST NAME	Description	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
		2	10	20	30	40	50	120
TESTB	Neutral - 6 mph	3.7	2.5	2.9	3.5	3.2	3.5	0
TESTK	Neutral - 12 mph	2.2	1.6	1.9	2.4	2.9	2.5	0

Wind speed can have a significant impact on reductions in visual range. A doubling of the wind speed in TESTK caused a significant decrease in the reductions in visual ranges from TESTB. Increasing the wind speed increases the dilution of pollutants as they are emitted to the atmosphere, this decreases pollutant concentrations in the plume and reduces reductions in visual range.

PLUVUE II Sensitivity to Atmospheric Stability and Related Meteorology

Table G.4 shows changes in reductions in visual range as a function of atmospheric stability and related meteorological conditions. Atmospheric stability is a measure of the rate of diffusion of pollutant material. Diffusion is dominated by thermally and mechanically-induced turbulence in the atmosphere. The more stable the atmosphere, the less turbulence is present, and the slower the rate of diffusion. Atmospheric stability depends on sun intensity, cloud cover, and wind speed and is therefore linked to these parameters. The atmosphere's mixing depth is a function of atmospheric stability.

Table G.4. Testing the Impact of Atmospheric Stability Conditions and Related Meteorology on Reductions in Visual range.

TEST NAME	Description	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
		2	10	20	30	40	50	120
TESTA	Base Case (stable)	10.1	6.2	6.9	8.7	8.9	8.1	0
TESTB	Neutral	3.7	2.5	2.9	3.5	3.2	3.5	0
TESTJ	Unstable	1.6	0.9	0.8	1.1	1.3	1.2	0.9

As the atmosphere becomes less stable, there is a higher rate of diffusion, the pollutant plume becomes more diffuse, and reductions in visual range decrease. Almost an order of magnitude difference in reductions in visual range are seen between the stable and unstable atmosphere cases (these cases have the same source term and observer/plume geometries).

PLUVUE II Sensitivity to Background Air Concentrations

Table G.5 shows changes in reductions in visual range as a function of the background air concentration.

Table G.5. Testing the Impact of Background Air Concentrations on Reductions in Visual range.

TEST NAME	Description	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
		2	10	20	30	40	50	120
TESTA	Base Case	10.1	6.2	6.9	8.7	8.9	8.1	0
TESTD	Lower Bkgrnd Conc.	9.9	5.3	5.3	6.0	5.7	5.8	0

The reductions in visual range at most distances downwind show a significant reduction for the test run with the "clean" background atmosphere (TESTD); however, this reduction is small compared to the reductions seen from varying other parameters such as wind speed or emission rates.

PLUVUE II Sensitivity to Season and Time of Day

Table G.6 shows changes in reductions in visual range as a function of the season and time of day.

Table G.6. Testing the Impact of Season and Time of Day on Reductions in Visual range.

TEST NAME	Description	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
		2	10	20	30	40	50	60
TESTA	Base Case (May-Noon)	10.1	6.2	6.9	8.7	8.9	8.1	-
TESTF	January-Noon Case	10.2	6.2	7.0	8.8	9.3	8.2	-
TESTG	May-Afternoon Case	10.2	6.2	7.0	8.8	9.3	8.1	-
TESTT	May-Evening Case	10.2	6.3	7.1	9.2	11.9	8.6	3.7

For the situations examined, with the observer looking north and northeast towards the plume (with the sun towards the south), there is little change in the reductions in visual range as a function of the season and time of day.

PLUVUE II Sensitivity to Observer/Plume Geometries

Table G.7 shows changes in reductions in visual range as a function of the observer/plume geometries.

Table G.7. Testing the Impact of Observer/plume Geometries on Reductions in Visual range.

TEST NAME	Observer Position	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
		2	10	20	30	40	50	60
TESTA	0 km E / 20 km S	10.1	6.2	6.9	8.7	8.9	8.1	-
TESTE	0 km E / 40 km S	10.9	6.2	5.8	6.2	4.0	0.6	-
TESTM	10 km W / 20 km S	12.1	8.2	9.2	11.1	8.3	3.0	-
TESTN	30 km W / 20 km S	13.7	9.0	2.0	0.0	0.0	0.0	-
TESTL	10 km E / 20 km S	11.0	5.4	5.2	6.6	8.7	11.2	-
TESTO	30 km E / 20 km S	18.6	8.2	5.2	4.3	4.9	6.6	-
TESTQ	0 km E / 20 km N	10.2	7.0	6.9	8.7	11.0	8.2	3.5

Table G.7 illustrates that the observer/plume geometry can have significant impacts on the reductions in visual range. Moving the observer further south (away from the release point) has little affect on reductions in visual range until the distance along the observer's line of sight through a point on the plume centerline approaches the background visual range.

Moving the observer to the west (upwind of the release site) increases reductions in visual range at distances within the background visual range

(however, as distances approach the background visual range, reductions in visual range rapidly drop toward zero). This increase in reductions in visual range occurs because the observer's lines of sight have to pass through more of the plume (to intersect a fixed point downwind of the release site) as the observer is positioned further upwind. In general, the closer the observer's line of sight is to being perpendicular to the plume centerline, the lower will be the reductions in visual range.

Moving the observer to the east (downwind of the release site) increases reductions in visual range at some locations and decreases reductions in visual range values at other locations. For the observation point 2 km downwind from the stack, reductions in visual range are larger than in the base case. These values also increase at far distances downwind (at points whose distances were close to the background visual range in the base case but are now well within the background visual range of the new observer positions).

Moving the observer to the north of the release site produces a similar result to having the observer to the south of the release site.

PLUVUE II Sensitivity to Wind Direction with Respect to the Observer

Table G.8 shows changes in reductions in visual range as a function of the wind direction (producing a change in the observer/plume geometry)

Table G.8. Testing the Impact of Different Wind Directions on Reductions in Visual range.

<u>TEST NAME</u>	<u>Description</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
		<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
TESTA	Wind direct.: 270°	10.1	6.2	6.9	8.7	8.9	8.1	-
TESTR	Wind direct.: 300°	11.0	5.3	5.3	7.0	9.6	12.5	9.4
TESTS	Wind direct.: 330°	18.5	6.1	4.0	6.7	11.3	16.8	16.9

Changing the wind direction so that it has a component toward the observer produces changes in reductions in visual range that are similar to what is seen when we move the observer to the east of the releasesite. The reductions in visual range increase near the stack because the observer's lines of sight have to pass through more of the plume (to intersect a fixed point downwind of the release site) as the observer is positioned further upwind. The reductions in visual range are slightly less at points 10, 20, and 30 km downwind of the stack. The reductions in visual range increase at 40 and 50 km downwind of the stack because the plume is closer to the observer for the given wind direction.

PLUVUE II Sensitivity to Emissions

Table G.9 shows changes in reductions in visual range as a function of pollutant emission rates.

Table G.9. Testing the Impact of Pollutant Emission Rates on Reductions in Visual range.

TEST NAME	Description	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
		2	10	20	30	40	50	60
TESTA	Max. Emissions	10.1	6.2	6.9	8.7	8.9	8.1	-
TESTP	Negligible Emis.	0.1	0.1	0.1	0.1	0.2	0.2	0.1
TESTU	SO ₂ Emission only	0.1	0.3	3.0	8.8	17.1	12.7	7.2
TESTV	NO _x Emission only	3.1	2.8	3.6	5.0	6.6	5.8	2.4
TESTW	TSP Emission only	7.0	3.4	3.3	3.7	4.3	3.9	-

Reductions in visual range vary greatly as function of pollutant emissions. In some cases pollutants that cause reductions in visual range may in some cases actually act to increase visibility by suppressing the atmospheric chemistry processes for another pollutant that may produce even greater reductions in visual range. This is illustrated by comparing results from TESTA and TESTU. In TESTU, the emission of SO₂ without NO_x or TSP caused greater reductions in visual range at distances greater than 30 km from the release location than observed in TESTA when the same level of emissions of SO₂ were coupled with a high level of NO_x and TSP emission.

APPENDIX H

PLUVUE II MODEL INPUT PARAMETERS

APPENDIX H

PLUVUE II MODEL INPUT PARAMETERS

This appendix provides information on the PLUVUE II model input parameters used in each of our model simulations.

Source Characterization

stack height: 330 ft stack elevation: 600 ft msl
flue gas flow rate 830,000 cfm effluent temp.: 170 °F (350 °K)
gas oxygen content: 7 mole %

Emission Rate: x tons/day NDx
 y tons/day SO₂
 z tons/day TSP

where: x, y, and z are the maximum seasonally-averaged emission rates for each resource alternative in the study year.
Emission rates are from all power plants that are active during the study year.

Meteorological Conditions

potential wind directions: 270°, 330°, and 210°

Meteorological Description	Pasquill-Gifford Stability Class	Wind Speed (m/s) (mph)		Mixing Depth (m)	Standard Lapse Rate (°C/M)	Potential Temp. Lapse Rate (°C/M)
1. Stable	E	1.3	3.0	400	10.9	20.7
2. Neutral	D	4.9	11.0	800	-10.0	-0.2
3. Unstable	B	1.8	4.0	1200	-18.2	-8.4

Ambient Temp.: 60 °F

Relative Humidity: 60%

Pressure = 0.98 atm

Background Air Quality

background visual range: 60 km

NO_x conc.: 0.005 ppm

coarse mode conc.: 10 ug/m³

NO₂ conc.: 0.004 ppm

sulfate conc.: 2.1 ug/m³

O₃ conc.: 0.080 ppm

nitrate conc.: 0.0 ug/m³

SO₂ conc.: 0.020 ppm

SO₂ and NO_x deposition velocity: 1.0 cm/s

coarse and submicron deposition velocity: 0.1 cm/s

Geometry of the User-Specified Plume-Observer Sun Orientations

Date: 5/15 Time: 12:00

solar zenith angle: 30.1°

solar azimuth angle: 153°

The following table gives the angle of the observer's line of sight to to the indicated downwind point. The reductions in visual range are determined for lines of sight through these downwind points.

Observer Position			Angle of Line of Sight from Observer to the Following						
E-W / N-S		Wind.	Downwind Distances in the Plume (° from North)						
(km)	(km)	Dir.	2	10	20	30	40	50	60
0	-20	270°	5.7°	26.6°	45.0°	56.3°	63.4°	68.2°	71.6°
0	-20	330°	3.1°	23.8°	75.0°	117.3°	126.2°	133.0°	136.8°
0	-20	210°	2.6°	9.9°	15.0°	18.1°	20.1°	21.6°	22.6°
40	-20	270°	297.8°	303.7°	315.0°	333.4°	0.0°	26.6°	45.0°
40	-20	330°	295.1°	288.0°	275.1°	256.5°	233.8°	212.8°	197.4°
40	-20	210°	299.1°	309.3°	321.2°	331.5°	339.9°	346.7°	352.1°

APPENDIX I

MODEL CALCULATIONS OF REDUCTIONS IN VISUAL RANGE

APPENDIX I

MODEL CALCULATIONS OF REDUCTIONS IN VISUAL RANGE

The series of tables presented in this appendix present PLUVUE II model calculations of the reduction in visual range (in percent) for each combination of observer location, wind direction, atmospheric stability, release site, study year, resource alternative, and line of site through each specified downwind distance within the plume. Data are available for all combinations of study year and resource alternative under stable atmospheric conditions, but for only selected combinations of study year and resource alternative for neutral and unstable atmospheric conditions. The data presented in this appendix represent instantaneous reductions in visible range for observations made under the conditions specified in Appendix H. These data were used in the computation of the estimates of annual average reductions in visual range that are presented in Section 6.

TABLE 1. Estimates of Reductions in Visual Range at Centralia for Stable Conditions with the Wind Blowing from 270° and the Observer 20 km Directly South of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	3.4	2.5	3.1	4.0	4.9	4.5	1.8

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	4.6	3.2	3.9	5.1	6.3	5.5	2.2
Base Case 4	4.6	3.2	3.9	5.1	6.3	5.5	2.2
Conservation	4.6	3.2	3.9	5.0	6.3	5.5	2.2
Conventional Coal	5.1	3.5	4.2	5.4	6.8	5.8	2.4
Clean Coal	4.6	3.2	3.9	5.1	6.3	5.5	2.2
Nuclear	4.3	3.0	3.7	4.8	6.0	5.3	2.1
Combustion Turbine	4.8	3.3	4.0	5.2	6.5	5.6	2.3
Renewables	4.6	3.2	3.9	5.1	6.3	5.5	2.2
Cogeneration	4.2	3.0	3.7	4.8	6.1	5.3	2.2
Fuel Switching	4.8	3.3	4.0	5.2	6.5	5.6	2.3
High Conservation	4.8	3.3	4.0	5.2	6.5	5.6	2.3
Imports	5.0	3.4	4.1	5.4	6.7	5.7	2.4

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	4.8	3.3	4.0	5.3	6.7	5.8	2.3
Base Case 4	5.1	3.5	4.2	5.5	6.9	6.0	2.4
Conservation	5.1	3.5	4.2	5.5	6.9	6.0	2.4
Conventional Coal	5.5	3.7	4.4	5.8	7.3	6.1	2.5
Clean Coal	4.8	3.3	4.0	5.2	6.5	5.6	2.3
Nuclear	5.1	3.5	4.2	5.5	6.9	6.0	2.4
Combustion Turbine	5.0	3.4	4.1	5.4	6.8	5.9	2.3
Renewables	5.1	3.5	4.2	5.5	6.9	6.0	2.4
Cogeneration	5.1	3.5	4.2	5.5	6.9	6.0	2.4
Fuel Switching	5.0	3.4	4.1	5.4	6.8	5.9	2.3
High Conservation	4.8	3.3	4.0	5.3	6.7	5.8	2.3
Imports	5.5	3.8	4.5	5.9	7.5	6.2	2.5

TABLE 2. Estimates of Reductions in Visual Range at Boardman for Stable Conditions with the Wind Blowing from 270° and the Observer 20 km Directly South of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	1.3	1.1	1.4	1.7	2.0	2.1	0.8

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	2.0	1.7	2.1	2.7	3.3	3.2	1.2
Base Case 4	2.0	1.7	2.1	2.7	3.3	3.1	1.2
Conservation	2.0	1.7	2.1	2.7	3.3	3.1	1.2
Conventional Coal	3.1	2.3	2.9	3.7	4.5	4.2	1.7
Clean Coal	2.0	1.7	2.1	2.7	3.3	3.1	1.2
Nuclear	2.0	1.7	2.1	2.7	3.3	3.1	1.2
Combustion Turbine	2.0	1.7	2.1	2.7	3.3	3.1	1.2
Renewables	2.0	1.7	2.1	2.7	3.3	3.1	1.2
Cogeneration	2.0	1.7	2.2	2.9	3.5	3.4	1.3
Fuel Switching	2.0	1.7	2.1	2.7	3.3	3.2	1.2
High Conservation	2.0	1.7	2.1	2.7	3.3	3.1	1.2
Imports	2.1	1.7	2.2	2.8	3.4	3.3	1.3

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	4.4	3.1	3.8	4.9	6.2	5.4	2.1
Base Case 4	4.4	3.1	3.8	4.9	6.2	5.4	2.1
Conservation	4.4	3.1	3.8	4.9	6.2	5.4	2.1
Conventional Coal	5.9	3.9	4.6	5.9	7.5	6.2	2.5
Clean Coal	4.5	3.1	3.8	4.9	6.0	5.2	2.1
Nuclear	4.4	3.1	3.8	4.9	6.2	5.4	2.1
Combustion Turbine	4.4	3.1	3.8	4.9	6.2	5.4	2.1
Renewables	4.4	3.1	3.8	4.9	6.2	5.4	2.1
Cogeneration	4.8	3.3	4.0	5.2	6.6	5.6	2.2
Fuel Switching	4.4	3.1	3.8	4.9	6.2	5.4	2.1
High Conservation	4.4	3.1	3.8	4.9	6.2	5.4	2.1
Imports	5.2	3.6	4.3	5.5	7.0	5.9	2.3

TABLE 3. Estimates of Reductions in Visual Range at Creston for Stable Conditions with the Wind Blowing from 270° and the Observer 20 km Directly South of the Pollutant Source.

Year: 1991 --- There are no emissions at this site during this year.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	1.9	1.5	1.8	2.2	2.7	2.6	1.0
Base Case 4	1.9	1.5	1.8	2.2	2.7	2.6	1.0
Conservation	1.9	1.5	1.8	2.2	2.7	2.6	1.0
Conventional Coal	2.3	1.8	2.2	2.7	3.2	3.0	1.2
Clean Coal	1.9	1.5	1.8	2.2	2.7	2.6	1.0
Nuclear	1.9	1.5	1.8	2.2	2.7	2.6	1.0
Combustion Turbine	2.0	1.6	1.9	2.4	2.8	2.8	1.1
Renewables	1.9	1.5	1.8	2.2	2.7	2.6	1.0
Cogeneration	1.9	1.5	1.8	2.2	2.7	2.6	1.0
Fuel Switching	1.9	1.5	1.8	2.2	2.7	2.6	1.0
High Conservation	1.9	1.5	1.8	2.2	2.7	2.6	1.0
Imports	2.0	1.6	1.9	2.4	2.8	2.8	1.1

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	2.6	2.0	2.4	3.0	3.6	3.4	1.3
Base Case 4	1.9	1.5	1.8	2.2	2.7	2.6	1.0
Conservation	1.9	1.5	1.8	2.2	2.7	2.6	1.0
Conventional Coal	2.6	2.0	2.4	3.0	3.6	3.4	1.3
Clean Coal	2.1	1.7	2.0	2.5	3.0	2.9	1.1
Nuclear	1.9	1.5	1.8	2.2	2.7	2.6	1.0
Combustion Turbine	1.9	1.5	1.9	2.4	2.9	2.8	1.2
Renewables	1.9	1.5	1.8	2.2	2.7	2.6	1.0
Cogeneration	1.9	1.5	1.8	2.2	2.7	2.6	1.0
Fuel Switching	1.9	1.5	1.8	2.2	2.7	2.6	1.0
High Conservation	1.9	1.5	1.8	2.2	2.7	2.6	1.0
Imports	2.1	1.7	2.0	2.5	2.9	2.8	1.1

TABLE 4. Estimates of Reductions in Visual Range at Colstrip for Stable Conditions with the Wind Blowing from 270° and the Observer 20 km Directly South of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	5.7	3.8	4.4	5.7	7.2	6.0	2.5

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	9.3	5.7	6.3	8.0	10.0	7.7	3.2
Base Case 4	9.3	5.7	6.3	8.0	10.0	7.7	3.2
Conservation	9.3	5.7	6.3	8.0	10.0	7.7	3.2
Conventional Coal	11.1	6.7	7.4	9.2	11.4	8.2	3.5
Clean Coal	9.7	5.9	6.6	8.3	10.4	7.8	3.2
Nuclear	9.3	5.7	6.3	8.0	10.0	7.7	3.2
Combustion Turbine	9.3	5.7	6.3	8.0	10.0	7.7	3.2
Renewables	9.4	5.8	6.4	8.1	10.1	7.7	3.2
Cogeneration	9.0	5.6	6.2	7.9	9.8	7.5	3.1
Fuel Switching	9.5	5.8	6.4	8.1	10.1	7.7	3.2
High Conservation	9.4	5.8	6.4	8.1	10.1	7.7	3.2
Imports	9.4	5.8	6.4	8.1	10.1	7.7	3.2

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	15.3	8.8	9.5	11.6	14.2	9.3	4.0
Base Case 4	12.6	7.5	8.1	10.0	12.4	8.6	3.7
Conservation	12.6	7.5	8.1	10.0	12.4	8.6	3.7
Conventional Coal	15.4	8.9	9.6	11.7	14.3	9.4	4.0
Clean Coal	13.3	7.9	8.5	10.4	12.9	8.8	3.8
Nuclear	12.6	7.5	8.1	10.0	12.4	8.6	3.7
Combustion Turbine	12.6	7.5	8.1	10.0	12.4	8.6	3.7
Renewables	12.6	7.5	8.1	10.0	12.4	8.6	3.7
Cogeneration	12.6	7.5	8.1	10.0	12.4	8.6	3.7
Fuel Switching	12.6	7.5	8.1	10.0	12.4	8.6	3.7
High Conservation	12.6	7.5	8.1	10.0	12.4	8.6	3.7
Imports	13.0	7.7	8.3	10.2	12.6	8.7	3.7

TABLE 5. Estimates of Reductions in Visual Range at Centralia for Neutral Stability with the Wind Blowing from 270° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	1.3	1.1	1.2	1.5	1.8	1.7	0.9

TABLE 6. Estimates of Reductions in Visual Range at Boardman for Neutral Stability with the Wind Blowing from 270° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	0.9	0.7	0.7	0.9	1.1	1.1	0.5

Year: 2010

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	1.5	1.2	1.3	1.6	2.0	1.8	0.9

TABLE 7. Estimates of Reductions in Visual Range at Creston for Neutral Stability with the Wind Blowing from 270° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	0.7	0.5	0.5	0.6	0.7	0.7	0.3

TABLE 8. Estimates of Reductions in Visual Range at Colstrip for Neutral Stability with the Wind Blowing from 270° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	2	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)					
		10	20	30	40	50	60
Conventional Coal	2.5	1.8	2.1	2.7	3.3	2.9	1.4

Year: 2010

RESOURCE ALTERNATIVE	2	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)					
		10	20	30	40	50	60
Conventional Coal	3.4	2.2	2.7	3.4	4.4	3.6	1.8

TABLE 9. Estimates of Reductions in Visual Range at Centralia for Unstable Stability with the Wind Blowing from 270° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	2	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)					
		10	20	30	40	50	60
Conventional Coal	1.3	1.1	1.6	2.2	2.7	2.4	2.0

TABLE 10. Estimates of Reductions in Visual Range at Boardman for Unstable Stability with the Wind Blowing from 270° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	2	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)					
		10	20	30	40	50	60
Conventional Coal	0.9	0.7	1.0	1.4	1.8	1.6	1.3

Year: 2010

RESOURCE ALTERNATIVE	2	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)					
		10	20	30	40	50	60
Conventional Coal	1.3	1.8	2.5	3.4	3.9	3.3	2.6

TABLE 11. Estimates of Reductions in Visual Range at Creston for Unstable Stability with the Wind Blowing from 270° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	0.7	0.5	0.6	0.9	1.1	1.0	0.8

TABLE 12. Estimates of Reductions in Visual Range at Colstrip for Unstable Stability with the Wind Blowing from 270° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	2.3	1.9	2.7	3.8	4.5	3.9	3.1

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	2.9	2.4	3.5	4.8	5.5	4.7	3.7

TABLE 13. Estimates of Reductions in Visual Range at Centralia for Stable Conditions with the Wind Blowing from 330° and the Observer 20 km Directly South of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	6.1	2.4	1.7	3.0	4.9	7.1	8.1

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	8.1	3.0	2.1	3.7	6.3	9.2	10.3
Base Case 4	8.2	3.0	2.1	3.7	6.3	9.2	10.3
Conservation	8.1	3.0	2.1	3.7	6.3	9.2	10.3
Conventional Coal	9.2	3.3	2.3	4.0	6.9	10.0	11.1
Clean Coal	8.2	3.0	2.1	3.7	6.3	9.2	10.3
Nuclear	7.7	2.9	2.0	3.5	6.0	8.8	9.9
Combustion Turbine	8.6	3.1	2.2	3.8	6.5	9.5	10.6
Renewables	9.3	3.1	2.1	3.7	6.4	9.3	10.4
Cogeneration	7.6	2.8	2.0	3.5	6.1	8.9	10.0
Fuel Switching	8.6	3.1	2.2	3.8	6.5	9.5	10.6
High Conservation	8.6	3.1	2.2	3.8	6.5	9.5	10.6
Imports	9.0	3.2	2.3	3.9	6.8	9.8	10.9

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	8.7	3.2	2.2	3.9	6.8	9.9	11.0
Base Case 4	9.1	3.3	2.3	4.0	6.9	10.1	11.2
Conservation	9.1	3.3	2.3	4.0	6.9	10.1	11.2
Conventional Coal	10.0	3.6	2.4	4.3	7.4	10.8	11.8
Clean Coal	8.9	3.1	2.2	3.8	6.7	9.6	10.7
Nuclear	9.1	3.3	2.3	4.0	6.9	10.1	11.2
Combustion Turbine	8.8	3.3	2.2	3.9	6.8	9.9	11.0
Renewables	8.9	3.3	2.3	4.0	6.9	10.0	11.1
Cogeneration	8.9	3.3	2.3	4.0	6.9	10.0	11.1
Fuel Switching	8.7	3.2	2.2	3.9	6.8	9.9	11.0
High Conservation	8.6	3.2	2.2	3.9	6.7	9.8	10.9
Imports	10.0	3.6	2.4	4.3	7.5	11.0	12.1

TABLE 14. Estimates of Reductions in Visual Range at Boardman for Stable Conditions with the Wind Blowing from 330° and the Observer 20 km Directly South of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	2.3	1.0	0.7	1.2	2.0	3.0	3.6

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	3.6	1.6	1.1	2.0	3.4	4.8	5.6
Base Case 4	3.6	1.6	1.1	2.0	3.4	4.8	5.6
Conservation	3.6	1.6	1.1	2.0	3.4	4.8	5.6
Conventional Coal	5.6	2.2	1.6	2.7	4.6	6.5	7.4
Clean Coal	3.6	1.6	1.1	2.0	3.4	4.8	5.6
Nuclear	3.6	1.6	1.1	1.9	3.3	4.7	5.5
Combustion Turbine	3.6	1.6	1.1	2.0	3.4	4.8	5.6
Renewables	3.6	1.6	1.1	2.0	3.4	4.8	5.6
Cogeneration	3.7	1.6	1.2	2.1	3.5	5.0	5.9
Fuel Switching	3.6	1.6	1.1	2.0	3.4	4.8	5.6
High Conservation	3.6	1.6	1.1	2.0	3.4	4.8	5.6
Imports	3.8	1.6	1.2	2.0	3.4	4.9	5.7

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	8.2	3.0	2.1	3.6	6.1	8.7	9.7
Base Case 4	8.2	3.0	2.1	3.6	6.1	8.7	9.7
Conservation	8.2	3.0	2.1	3.6	6.1	8.7	9.7
Conventional Coal	10.8	3.8	2.6	4.4	7.6	11.0	12.0
Clean Coal	8.0	3.0	2.1	3.6	6.2	8.9	10.0
Nuclear	8.2	3.0	2.1	3.6	6.1	8.7	9.7
Combustion Turbine	8.2	3.0	2.1	3.6	6.1	8.7	9.7
Renewables	8.2	3.0	2.1	3.6	6.1	8.7	9.7
Cogeneration	8.8	3.3	2.3	3.9	6.6	9.5	10.5
Fuel Switching	8.2	3.0	2.1	3.6	6.1	8.7	9.7
High Conservation	8.2	3.0	2.1	3.6	6.1	8.7	9.7
Imports	9.2	3.5	2.4	4.1	7.0	10.1	11.1

TABLE 15. Estimates of Reductions in Visual Range at Creston for Stable Conditions with the Wind Blowing from 330° and the Observer 20 km Directly South of the Pollutant Source.

Year: 1991 --- There are no emissions at this site during this year.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	3.5	1.5	1.0	1.7	2.8	3.9	4.5
Base Case 4	3.5	1.5	1.0	1.7	2.8	3.9	4.5
Conservation	3.5	1.5	1.0	1.7	2.8	3.9	4.5
Conventional Coal	4.1	1.7	1.2	2.0	3.2	4.5	5.2
Clean Coal	3.8	1.6	1.1	1.8	3.0	4.2	4.8
Nuclear	3.4	1.4	1.0	1.6	2.7	3.7	4.4
Combustion Turbine	3.7	1.6	1.1	1.7	2.9	4.1	4.7
Renewables	3.5	1.5	1.0	1.7	2.8	3.9	4.5
Cogeneration	3.4	1.4	1.0	1.6	2.7	3.7	4.4
Fuel Switching	3.5	1.5	1.0	1.7	2.8	3.9	4.5
High Conservation	3.5	1.5	1.0	1.7	2.8	3.9	4.5
Imports	3.8	1.6	1.1	1.8	3.0	4.2	4.8

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	4.7	1.9	1.3	2.2	3.6	5.1	5.9
Base Case 4	3.5	1.5	1.0	1.7	2.8	3.9	4.5
Conservation	3.5	1.5	1.0	1.7	2.8	3.9	4.5
Conventional Coal	4.7	1.9	1.3	2.2	3.6	5.1	5.9
Clean Coal	4.0	1.7	1.2	1.9	3.1	4.4	5.0
Nuclear	3.5	1.5	1.0	1.7	2.8	3.9	4.5
Combustion Turbine	3.6	1.5	1.0	1.7	2.9	4.0	4.6
Renewables	3.5	1.5	1.0	1.7	2.8	3.9	4.5
Cogeneration	3.5	1.5	1.0	1.7	2.8	3.9	4.5
Fuel Switching	3.5	1.5	1.0	1.7	2.8	3.9	4.5
High Conservation	3.5	1.5	1.0	1.7	2.8	3.9	4.5
Imports	3.8	1.6	1.1	1.8	3.0	4.2	4.8

TABLE 16. Estimates of Reductions in Visual Range at Colstrip for Stable Conditions with the Wind Blowing from 330° and the Observer 20 km Directly South of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	10.3	3.6	2.5	4.3	7.3	10.5	11.6

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	16.8	5.5	3.7	6.1	10.2	14.8	15.1
Base Case 4	16.8	5.5	3.7	6.1	10.2	14.8	15.1
Conservation	16.8	5.5	3.7	6.1	10.2	14.8	15.1
Conventional Coal	20.3	6.5	4.2	7.0	11.8	16.9	16.6
Clean Coal	17.7	5.8	3.8	6.3	10.6	15.3	15.5
Nuclear	16.7	5.4	3.7	6.1	10.2	14.7	15.0
Combustion Turbine	16.8	5.5	3.7	6.1	10.2	14.8	15.1
Renewables	17.1	5.6	3.7	6.1	10.3	14.9	15.2
Cogeneration	16.4	5.4	3.6	6.0	10.1	14.6	14.9
Fuel Switching	17.1	5.6	3.7	6.1	10.3	14.9	15.2
High Conservation	17.1	5.6	3.7	6.1	10.3	14.9	15.2
Imports	17.1	5.6	3.7	6.1	10.3	14.9	15.2

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	28.2	8.8	5.6	9.1	14.9	21.3	19.2
Base Case 4	23.1	7.4	4.7	7.8	12.8	18.4	17.5
Conservation	23.1	7.4	4.7	7.8	12.8	18.4	17.5
Conventional Coal	28.2	8.8	5.6	9.1	14.9	21.3	19.2
Clean Coal	24.5	7.8	4.9	8.1	13.4	19.2	18.0
Nuclear	23.1	7.4	4.7	7.8	12.8	18.4	17.5
Combustion Turbine	23.1	7.4	4.7	7.8	12.8	18.4	17.5
Renewables	23.1	7.4	4.7	7.8	12.8	18.4	17.5
Cogeneration	23.1	7.4	4.7	7.8	12.8	18.4	17.5
Fuel Switching	23.1	7.4	4.7	7.8	12.8	18.4	17.5
High Conservation	23.1	7.4	4.7	7.8	12.8	18.4	17.5
Imports	23.3	7.5	4.7	7.9	12.9	18.5	17.6

TABLE 17. Estimates of Reductions in Visual Range at Centralia for Neutral Stability with the Wind Blowing from 330° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	2.3	1.0	0.6	1.1	1.8	2.7	3.0

TABLE 18. Estimates of Reductions in Visual Range at Boardman for Neutral Stability with the Wind Blowing from 330° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	1.6	0.6	0.4	0.7	1.1	1.6	1.9

Year: 2010

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	2.7	1.1	0.7	1.2	2.0	2.8	3.2

TABLE 19. Estimates of Reductions in Visual Range at Creston for Neutral Stability with the Wind Blowing from 330° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	1.2	0.4	0.3	0.4	0.7	1.0	1.2

TABLE 20. Estimates of Reductions in Visual Range at Colstrip for Neutral Stability with the Wind Blowing from 330° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	4.6	1.7	1.1	2.0	3.3	4.6	5.1

Year: 2010

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	6.1	2.1	1.4	2.5	4.2	5.9	6.4

TABLE 21. Estimates of Reductions in Visual Range at Centralia for Unstable Stability with the Wind Blowing from 330° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	2.3	0.8	0.8	1.6	3.0	4.2	4.3

TABLE 22. Estimates of Reductions in Visual Range at Boardman for Unstable Stability with the Wind Blowing from 330° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	1.6	0.6	0.5	1.0	1.9	2.7	2.8

Year: 2010

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	2.3	1.6	1.3	2.5	4.4	5.8	5.7

TABLE 23. Estimates of Reductions in Visual Range at Creston for Unstable Stability with the Wind Blowing from 330° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	1.2	0.4	0.3	0.7	1.2	1.6	1.7

TABLE 24. Estimates of Reductions in Visual Range at Colstrip for Unstable Stability with the Wind Blowing from 330° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	4.4	1.8	1.5	2.8	5.1	6.8	6.7

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	5.2	2.2	1.9	3.5	6.3	8.3	8.0

TABLE 25. Estimates of Reductions in Visual Range at Centralia for Stable Conditions with the Wind Blowing from 210° and the Observer 20 km Directly South of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	7.4	6.9	8.9	9.4	5.6	3.1	2.2

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	10.0	8.7	11.1	11.2	6.8	3.8	2.8
Base Case 4	10.1	8.8	11.2	11.3	6.8	3.8	2.8
Conservation	10.0	8.7	11.1	11.2	6.8	3.8	2.8
Conventional Coal	11.3	9.6	12.1	11.9	7.1	4.1	3.0
Clean Coal	10.2	8.8	11.3	11.3	6.8	3.9	2.8
Nuclear	9.4	8.3	10.7	10.9	6.6	3.7	2.7
Combustion Turbine	10.5	9.1	11.5	11.5	6.9	3.9	2.9
Renewables	10.2	8.8	11.3	11.3	6.8	3.9	2.8
Cogeneration	9.2	8.3	10.7	11.0	6.6	3.8	2.7
Fuel Switching	10.5	9.1	11.5	11.5	6.9	3.9	2.9
High Conservation	10.5	9.1	11.5	11.5	6.9	3.9	2.9
Imports	11.1	9.4	11.9	11.8	7.0	4.0	3.0

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	10.8	9.5	11.9	11.8	7.1	4.1	3.0
Base Case 4	11.7	10.0	12.5	12.2	7.3	4.2	3.1
Conservation	11.7	10.0	12.5	12.2	7.3	4.2	3.1
Conventional Coal	12.2	10.4	12.9	12.4	7.5	4.3	3.2
Clean Coal	10.5	9.2	11.6	11.6	7.0	4.0	3.0
Nuclear	11.7	10.1	12.6	12.2	7.4	4.2	3.1
Combustion Turbine	11.0	9.6	12.1	11.9	7.2	4.2	3.1
Renewables	11.3	9.8	12.3	12.0	7.2	4.2	3.1
Cogeneration	11.3	9.8	12.3	12.0	7.2	4.2	3.1
Fuel Switching	10.8	9.5	11.9	11.8	7.1	4.1	3.0
High Conservation	10.5	9.3	11.7	11.7	7.0	4.1	3.0
Imports	12.3	10.5	13.1	12.5	7.6	4.4	3.3

TABLE 26. Estimates of Reductions in Visual Range at Boardman for Stable Conditions with the Wind Blowing from 210° and the Observer 20 km Directly South of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	2.8	3.2	3.9	4.3	2.7	1.5	1.0

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	4.4	4.7	6.3	6.9	4.2	2.3	1.5
Base Case 4	4.4	4.7	6.3	6.9	4.2	2.3	1.5
Conservation	4.4	4.7	6.3	6.9	4.2	2.3	1.5
Conventional Coal	6.8	6.4	8.4	8.9	5.3	2.9	2.0
Clean Coal	4.4	4.7	6.3	6.9	4.2	2.3	1.5
Nuclear	4.4	4.6	6.2	6.7	4.1	2.2	1.5
Combustion Turbine	4.4	4.7	6.3	6.9	4.2	2.3	1.5
Renewables	4.4	4.7	6.3	6.9	4.2	2.3	1.5
Cogeneration	4.6	4.8	6.4	6.9	4.2	2.3	1.6
Fuel Switching	4.4	4.7	6.3	6.9	4.2	2.3	1.5
High Conservation	4.4	4.7	6.3	6.9	4.2	2.3	1.5
Imports	4.5	4.8	6.5	7.1	4.4	2.4	1.6

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	9.8	8.5	10.9	11.1	6.6	3.8	2.7
Base Case 4	9.8	8.5	10.9	11.1	6.6	3.8	2.7
Conservation	9.8	8.5	10.9	11.1	6.6	3.8	2.7
Conventional Coal	13.1	10.8	13.3	12.6	7.6	4.4	3.3
Clean Coal	10.0	8.6	10.9	11.0	6.5	3.7	2.7
Nuclear	9.8	8.5	10.9	11.1	6.6	3.8	2.7
Combustion Turbine	9.8	8.5	10.9	11.1	6.6	3.8	2.7
Renewables	9.8	8.5	10.9	11.1	6.6	3.8	2.7
Cogeneration	9.8	8.5	10.9	11.1	6.6	3.8	2.7
Fuel Switching	9.8	8.5	10.9	11.1	6.6	3.8	2.7
High Conservation	9.8	8.5	10.9	11.1	6.6	3.8	2.7
Imports	9.8	8.5	10.9	11.1	6.6	3.8	2.7

TABLE 27. Estimates of Reductions in Visual Range at Creston for Stable Conditions with the Wind Blowing from 210° and the Observer 20 km Directly South of the Pollutant Source.

Year: 1991 --- There are no emissions at this site during this year.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	4.3	4.3	5.5	5.9	3.5	1.9	1.2
Base Case 4	4.3	4.3	5.4	5.9	3.5	1.9	1.2
Conservation	4.3	4.3	5.4	5.9	3.5	1.9	1.2
Conventional Coal	5.0	4.9	6.3	6.6	4.0	2.1	1.4
Clean Coal	4.5	4.5	5.7	6.1	3.7	1.9	1.2
Nuclear	4.3	4.3	5.4	5.8	3.5	1.8	1.2
Combustion Turbine	4.2	4.2	5.3	5.7	3.4	1.8	1.2
Renewables	4.3	4.3	5.4	5.9	3.5	1.9	1.2
Cogeneration	4.2	4.2	5.3	5.7	3.4	1.8	1.2
Fuel Switching	4.3	4.3	5.4	5.9	3.5	1.9	1.2
High Conservation	4.3	4.3	5.4	5.9	3.5	1.9	1.2
Imports	4.5	4.5	5.7	6.1	3.7	1.9	1.2

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	5.6	5.4	7.0	7.4	4.4	2.4	1.6
Base Case 4	4.3	4.3	5.4	5.9	3.5	1.9	1.2
Conservation	4.3	4.3	5.4	5.9	3.5	1.9	1.2
Conventional Coal	5.6	5.4	7.0	7.4	4.4	2.4	1.6
Clean Coal	4.6	4.5	5.7	6.2	3.7	2.0	1.3
Nuclear	4.3	4.3	5.4	5.9	3.5	1.9	1.2
Combustion Turbine	4.4	4.4	5.5	6.0	3.6	2.0	1.2
Renewables	4.3	4.3	5.4	5.9	3.5	1.9	1.2
Cogeneration	4.3	4.3	5.4	5.9	3.5	1.9	1.2
Fuel Switching	4.3	4.3	5.4	5.9	3.5	1.9	1.2
High Conservation	4.3	4.3	5.4	5.9	3.5	1.9	1.2
Imports	4.6	4.6	5.9	6.2	3.8	2.0	1.3

TABLE 28. Estimates of Reductions in Visual Range at Colstrip for Stable Conditions with the Wind Blowing from 210° and the Observer 20 km Directly South of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	12.5	10.4	12.8	12.3	7.4	4.3	3.2

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	20.4	15.6	18.2	15.0	9.1	5.4	4.3
Base Case 4	20.4	15.6	18.2	15.0	9.1	5.4	4.3
Conservation	20.4	15.6	18.2	15.0	9.1	5.4	4.3
Conventional Coal	24.8	18.4	21.2	16.1	9.8	5.9	4.7
Clean Coal	21.5	16.3	19.0	15.3	9.2	5.5	4.4
Nuclear	20.4	15.6	18.2	15.0	9.1	5.4	4.3
Combustion Turbine	20.4	15.6	18.2	15.0	9.1	5.4	4.3
Renewables	20.6	15.8	18.4	15.1	9.1	5.4	4.3
Cogeneration	19.9	15.3	17.9	14.9	9.0	5.3	4.2
Fuel Switching	20.6	15.8	18.4	15.1	9.1	5.4	4.3
High Conservation	20.6	15.8	18.4	15.1	9.1	5.4	4.3
Imports	20.6	15.8	18.4	15.1	9.1	5.4	4.3

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	33.8	24.1	26.0	18.0	11.0	6.9	5.5
Base Case 4	28.2	20.6	23.3	16.8	10.2	6.3	5.0
Conservation	28.2	20.6	23.3	16.8	10.2	6.3	5.0
Conventional Coal	34.4	24.7	26.3	18.1	11.1	7.0	5.6
Clean Coal	29.9	21.7	24.1	17.2	10.4	6.5	5.2
Nuclear	28.2	20.6	23.3	16.8	10.2	6.3	5.0
Combustion Turbine	28.2	20.6	23.3	16.8	10.2	6.3	5.0
Renewables	28.2	20.6	23.3	16.8	10.2	6.3	5.0
Cogeneration	28.2	20.6	23.3	16.8	10.2	6.3	5.0
Fuel Switching	28.2	20.6	23.3	16.8	10.2	6.3	5.0
High Conservation	28.2	20.6	23.3	16.8	10.2	6.3	5.0
Imports	28.8	21.2	23.6	16.9	10.3	6.4	5.1

TABLE 29. Estimates of Reductions in Visual Range at Centralia for Neutral Stability with the Wind Blowing from 210° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	2.9	3.0	3.5	3.7	2.5	1.6	1.2

TABLE 30. Estimates of Reductions in Visual Range at Boardman for Neutral Stability with the Wind Blowing from 210° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	2.0	1.9	2.2	2.3	1.6	1.0	0.8

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	3.3	3.3	3.9	4.0	2.7	1.8	1.3

TABLE 31. Estimates of Reductions in Visual Range at Creston for Neutral Stability with the Wind Blowing from 210° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	1.5	1.3	1.5	1.6	1.1	0.7	0.5

TABLE 32. Estimates of Reductions in Visual Range at Colstrip for Neutral Stability with the Wind Blowing from 210° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	5.6	5.0	6.2	6.3	4.1	2.7	2.0

Year: 2010

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	7.4	6.2	7.8	7.9	5.1	3.4	2.5

TABLE 33. Estimates of Reductions in Visual Range at Centralia for Unstable Stability with the Wind Blowing from 210° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	2.8	3.1	4.5	4.4	3.9	3.7	3.4

TABLE 34. Estimates of Reductions in Visual Range at Boardman for Unstable Stability with the Wind Blowing from 210° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	2.0	1.9	2.8	2.8	2.6	2.5	2.2

Year: 2010

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	2.8	4.9	7.0	6.4	5.5	5.1	4.5

TABLE 35. Estimates of Reductions in Visual Range at Creston for Unstable Stability with the Wind Blowing from 210° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	1.5	1.3	1.9	1.8	1.6	1.5	1.3

TABLE 36. Estimates of Reductions in Visual Range at Colstrip for Unstable Stability with the Wind Blowing from 210° and the Observer 20 km Directly South of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	5.0	5.4	7.7	7.1	6.2	5.9	5.3

Year: 201

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	6.5	6.8	9.6	8.7	7.6	7.1	6.3

TABLE 37. Estimates of Reductions in Visual Range at Centralia for Stable Conditions with the Wind Blowing from 270° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	7.8	4.4	3.1	2.2	1.9	2.1	2.8

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	10.5	5.5	3.9	2.8	2.4	2.7	3.6
Base Case 4	10.6	5.6	3.9	2.8	2.4	2.7	3.6
Conservation	10.5	5.5	3.9	2.8	2.4	2.7	3.6
Conventional Coal	11.8	6.1	4.2	3.0	2.6	2.9	3.9
Clean Coal	10.7	5.6	3.9	2.8	2.4	2.7	3.6
Nuclear	9.9	5.3	3.7	2.7	2.3	2.6	3.4
Combustion Turbine	11.0	5.8	4.0	2.9	2.5	2.8	3.7
Renewables	10.7	5.6	3.9	2.8	2.4	2.7	3.6
Cogeneration	9.8	5.3	3.7	2.7	2.3	2.6	3.5
Fuel Switching	11.0	5.8	4.0	2.9	2.5	2.8	3.7
High Conservation	11.0	5.8	4.0	2.9	2.5	2.8	3.7
Imports	11.6	6.0	4.1	3.0	2.6	2.9	3.8

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	11.5	6.0	4.0	3.0	2.6	3.0	3.9
Base Case 4	12.4	6.4	4.3	3.1	2.7	3.1	4.1
Conservation	12.4	6.4	4.3	3.1	2.7	3.1	4.1
Conventional Coal	12.9	6.6	4.4	3.2	2.8	3.2	4.2
Clean Coal	11.0	5.8	4.0	2.9	2.5	2.8	3.7
Nuclear	12.4	6.4	4.3	3.1	2.7	3.1	4.1
Combustion Turbine	11.7	6.1	4.1	3.0	2.6	3.0	3.9
Renewables	12.0	6.2	4.2	3.0	2.6	3.0	4.0
Cogeneration	12.0	6.2	4.2	3.0	2.6	3.0	4.0
Fuel Switching	11.5	6.0	4.0	3.0	2.6	3.0	3.9
High Conservation	11.2	5.9	4.0	2.9	2.5	2.9	3.8
Imports	13.0	6.7	4.5	3.3	2.8	3.2	4.3

TABLE 38. Estimates of Reductions in Visual Range at Boardman for Stable Conditions with the Wind Blowing from 270° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	3.0	2.0	1.3	0.9	0.8	0.9	1.2

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	4.7	3.1	2.2	1.5	1.2	1.4	1.8
Base Case 4	4.7	3.1	2.2	1.5	1.2	1.4	1.8
Conservation	4.7	3.1	2.2	1.5	1.2	1.4	1.8
Conventional Coal	7.1	4.1	2.9	2.1	1.7	1.9	2.5
Clean Coal	4.7	3.1	2.2	1.5	1.2	1.4	1.8
Nuclear	4.6	3.0	2.1	1.5	1.2	1.4	1.8
Combustion Turbine	4.7	3.1	2.2	1.5	1.2	1.4	1.8
Renewables	4.7	3.1	2.2	1.5	1.2	1.4	1.8
Cogeneration	4.8	3.1	2.2	1.6	1.3	1.5	1.9
Fuel Switching	4.7	3.1	2.2	1.5	1.2	1.4	1.8
High Conservation	4.7	3.1	2.2	1.5	1.2	1.4	1.8
Imports	4.8	3.1	2.2	1.5	1.3	1.4	1.9

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	10.3	5.5	3.8	2.7	2.3	2.6	3.5
Base Case 4	10.3	5.5	3.8	2.7	2.3	2.6	3.5
Conservation	10.3	5.5	3.8	2.7	2.3	2.6	3.5
Conventional Coal	13.8	6.9	4.6	3.3	2.8	3.2	4.3
Clean Coal	10.5	5.5	3.8	2.7	2.3	2.6	3.4
Nuclear	10.3	5.5	3.8	2.7	2.3	2.6	3.5
Combustion Turbine	10.3	5.5	3.8	2.7	2.3	2.6	3.5
Renewables	10.3	5.5	3.8	2.7	2.3	2.6	3.5
Cogeneration	11.1	5.8	4.0	2.8	2.4	2.7	3.7
Fuel Switching	10.3	5.5	3.8	2.7	2.3	2.6	3.5
High Conservation	10.3	5.5	3.8	2.7	2.3	2.6	3.5
Imports	12.1	6.2	4.2	3.0	2.6	2.9	3.9

TABLE 39. Estimates of Reductions in Visual Range at Creston for Stable Conditions with the Wind Blowing from 270° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 1991 --- There are no emissions at this site during this year.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	4.5	2.8	1.9	1.3	1.0	1.1	1.5
Base Case 4	4.5	2.8	1.9	1.3	1.0	1.1	1.5
Conservation	4.5	2.8	1.9	1.3	1.0	1.1	1.5
Conventional Coal	5.2	3.1	2.2	1.5	1.2	1.3	1.7
Clean Coal	4.8	2.9	2.0	1.4	1.1	1.2	1.6
Nuclear	4.4	2.7	1.8	1.2	1.0	1.1	1.4
Combustion Turbine	4.7	2.9	2.0	1.4	1.1	1.2	1.8
Renewables	4.5	2.8	1.9	1.3	1.0	1.1	1.5
Cogeneration	4.3	2.7	1.8	1.2	1.0	1.1	1.4
Fuel Switching	4.5	2.8	1.9	1.3	1.0	1.1	1.5
High Conservation	4.5	2.8	1.9	1.3	1.0	1.1	1.5
Imports	4.6	2.8	1.9	1.9	1.1	1.2	1.6

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	5.9	3.5	2.4	1.7	1.4	1.5	2.0
Base Case 4	4.5	2.8	1.9	1.3	1.0	1.1	1.5
Conservation	4.5	2.8	1.9	1.3	1.0	1.1	1.5
Conventional Coal	5.9	3.5	2.4	1.7	1.4	1.5	2.0
Clean Coal	5.1	3.1	2.1	1.5	1.2	1.3	1.7
Nuclear	4.5	2.8	1.9	1.3	1.0	1.1	1.5
Combustion Turbine	5.0	3.0	2.1	1.4	1.1	1.2	1.7
Renewables	4.5	2.8	1.9	1.3	1.0	1.1	1.5
Cogeneration	4.5	2.8	1.9	1.3	1.0	1.1	1.5
Fuel Switching	4.5	2.8	1.9	1.3	1.0	1.1	1.5
High Conservation	4.5	2.8	1.9	1.3	1.0	1.1	1.5
Imports	4.8	2.9	2.0	1.4	1.1	1.2	1.6

TABLE 40. Estimates of Reductions in Visual Range at Colstrip for Stable Conditions with the Wind Blowing from 270° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	13.1	6.6	4.4	3.2	2.7	3.1	4.1

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	21.3	9.9	6.3	4.5	3.9	4.4	5.8
Base Case 4	21.3	9.9	6.3	4.5	3.9	4.4	5.8
Conservation	21.3	9.9	6.3	4.5	3.9	4.4	5.8
Conventional Coal	25.8	11.6	7.4	5.2	4.4	5.0	6.7
Clean Coal	22.4	10.3	6.6	4.7	4.0	4.5	6.0
Nuclear	21.3	9.9	6.3	4.5	3.9	4.4	5.8
Combustion Turbine	21.3	9.9	6.3	4.5	3.9	4.4	5.8
Renewables	21.5	10.0	6.4	4.5	3.9	4.4	5.8
Cogeneration	20.8	9.7	6.2	4.4	3.8	4.3	5.7
Fuel Switching	21.5	10.0	6.4	4.5	3.9	4.4	5.8
High Conservation	21.5	10.0	6.4	4.5	3.9	4.4	5.8
Imports	21.5	10.0	6.4	4.5	3.9	4.4	5.8

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	28.0	15.3	9.5	6.6	5.5	6.2	8.3
Base Case 4	27.8	13.0	8.1	5.7	4.8	5.5	7.2
Conservation	27.8	13.0	8.1	5.7	4.8	5.5	7.2
Conventional Coal	28.1	15.5	9.6	6.7	5.6	6.3	8.4
Clean Coal	27.9	13.7	8.5	6.0	5.0	5.7	7.5
Nuclear	27.8	13.0	8.1	5.7	4.8	5.5	7.2
Combustion Turbine	27.8	13.0	8.1	5.7	4.8	5.5	7.2
Renewables	27.8	13.0	8.1	5.7	4.8	5.5	7.2
Cogeneration	27.8	13.0	8.1	5.7	4.8	5.5	7.2
Fuel Switching	27.8	13.0	8.1	5.7	4.8	5.5	7.2
High Conservation	27.8	13.0	8.1	5.7	4.8	5.5	7.2
Imports	27.8	13.3	8.3	5.8	4.9	5.6	7.3

TABLE 41. Estimates of Reductions in Visual Range at Centralia for Neutral Stability with the Wind Blowing from 270° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	3.1	1.9	1.2	0.8	0.7	0.8	1.0

TABLE 42. Estimates of Reductions in Visual Range at Boardman for Neutral Stability with the Wind Blowing from 270° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	2.1	1.2	0.7	0.5	0.4	0.5	0.6

TABLE 43. Estimates of Reductions in Visual Range at Creston for Neutral Stability with the Wind Blowing from 270° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	1.7	0.9	0.5	0.3	0.3	0.3	0.4

TABLE 44. Estimates of Reductions in Visual Range at Colstrip for Neutral Stability with the Wind Blowing from 270° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

<u>RESOURCE ALTERNATIVE</u>	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	<u>2</u>	<u>10</u>	<u>20</u>	<u>30</u>	<u>40</u>	<u>50</u>	<u>60</u>
Conventional Coal	6.0	3.2	2.1	1.5	1.2	1.4	1.8

TABLE 45. Estimates of Reductions in Visual Range at Centralia for Unstable Stability with the Wind Blowing from 270° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	3.1	2.0	1.6	1.2	1.1	1.4	2.0

TABLE 46. Estimates of Reductions in Visual Range at Boardman for Unstable Stability with the Wind Blowing from 270° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	2.2	1.2	1.0	0.8	0.7	0.9	1.3

TABLE 47. Estimates of Reductions in Visual Range at Creston for Unstable Stability with the Wind Blowing from 270° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	1.7	0.8	0.6	0.5	0.5	0.5	0.7

TABLE 48. Estimates of Reductions in Visual Range at Colstrip for Unstable Stability with the Wind Blowing from 270° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	5.4	3.5	2.7	2.1	1.9	2.3	3.2

TABLE 49. Estimates of Reductions in Visual Range at Centralia for Stable Conditions with the Wind Blowing from 330° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	6.3	3.6	2.7	2.1	2.0	2.2	2.8

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	8.5	4.6	3.3	2.7	2.5	2.9	3.6
Base Case 4	8.6	4.7	3.4	2.7	2.6	2.9	3.6
Conservation	8.5	4.6	3.3	2.7	2.5	2.9	3.6
Conventional Coal	9.6	5.1	3.6	2.9	2.8	3.1	3.9
Clean Coal	8.7	4.7	3.4	2.7	2.6	2.9	3.6
Nuclear	8.0	4.4	3.2	2.6	2.4	2.8	3.4
Combustion Turbine	8.9	4.8	3.4	2.8	2.6	3.0	3.7
Renewables	8.7	4.7	3.4	2.7	2.6	2.9	3.6
Cogeneration	7.9	4.4	3.2	2.6	2.5	2.8	3.4
Fuel Switching	8.9	4.8	3.4	2.8	2.6	3.0	3.7
High Conservation	8.9	4.8	3.4	2.8	2.6	3.0	3.7
Imports	9.4	5.0	3.5	2.9	2.7	3.1	3.8

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	9.3	5.0	3.6	2.9	2.7	3.1	3.9
Base Case 4	10.1	5.3	3.8	3.0	2.9	3.3	4.1
Conservation	10.1	5.3	3.8	3.0	2.9	3.3	4.1
Conventional Coal	10.5	5.5	3.9	3.1	3.0	3.4	4.2
Clean Coal	8.9	4.8	3.4	2.8	2.6	3.0	3.7
Nuclear	10.1	5.3	3.8	3.0	2.9	3.3	4.1
Combustion Turbine	9.5	5.1	3.6	3.0	2.8	3.2	4.0
Renewables	9.8	5.2	3.7	3.0	2.8	3.2	4.0
Cogeneration	9.8	5.2	3.7	3.0	2.8	3.2	4.0
Fuel Switching	9.3	5.0	3.6	2.9	2.8	3.2	3.9
High Conservation	9.1	4.9	3.5	2.9	2.7	3.1	3.8
Imports	10.6	5.5	3.9	3.2	3.0	3.4	4.3

TABLE 50. Estimates of Reductions in Visual Range at Boardman for Stable Conditions with the Wind Blowing from 330° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	2.4	1.7	1.2	0.9	0.8	0.9	1.2

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	4.5	2.9	2.2	1.7	1.5	1.7	2.1
Base Case 4	4.5	2.9	2.2	1.7	1.5	1.7	2.1
Conservation	4.5	2.9	2.2	1.7	1.5	1.7	2.1
Conventional Coal	5.8	3.4	2.5	2.0	1.8	2.0	2.5
Clean Coal	4.5	2.9	2.2	1.7	1.5	1.7	2.1
Nuclear	3.7	2.5	1.9	1.4	1.3	1.5	1.8
Combustion Turbine	4.5	2.9	2.2	1.7	1.5	1.7	2.1
Renewables	4.5	2.9	2.2	1.7	1.5	1.7	2.1
Cogeneration	3.9	2.6	2.0	1.5	1.4	1.6	1.9
Fuel Switching	4.5	2.9	2.2	1.7	1.5	1.7	2.1
High Conservation	4.5	2.9	2.2	1.7	1.5	1.7	2.1
Imports	3.9	2.6	1.9	1.5	1.4	1.5	1.9

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	8.4	4.5	3.3	2.7	2.5	2.8	3.4
Base Case 4	8.4	4.5	3.3	2.7	2.5	2.8	3.4
Conservation	8.4	4.5	3.3	2.7	2.5	2.8	3.4
Conventional Coal	11.2	5.7	4.0	3.2	3.0	3.4	4.2
Clean Coal	8.5	4.5	3.3	2.7	2.5	2.8	3.4
Nuclear	8.4	4.5	3.3	2.7	2.5	2.8	3.4
Combustion Turbine	8.4	4.5	3.3	2.7	2.5	2.8	3.4
Renewables	8.4	4.5	3.3	2.7	2.5	2.8	3.4
Cogeneration	8.8	4.8	3.5	2.8	2.6	2.9	3.6
Fuel Switching	8.4	4.5	3.3	2.7	2.5	2.8	3.4
High Conservation	8.4	4.5	3.3	2.7	2.5	2.8	3.4
Imports	9.3	5.1	3.7	3.0	2.8	3.1	3.8

TABLE 51. Estimates of Reductions in Visual Range at Creston for Stable Conditions with the Wind Blowing from 330° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 1991 --- There are no emissions at this site during this year.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	3.6	2.3	1.7	1.2	1.1	1.2	1.5
Base Case 4	3.6	2.3	1.7	1.2	1.1	1.2	1.5
Conservation	3.6	2.3	1.7	1.2	1.1	1.2	1.5
Conventional Coal	4.2	2.6	1.9	1.4	1.3	1.4	1.7
Clean Coal	3.8	2.4	1.9	1.3	1.2	1.3	1.7
Nuclear	3.5	2.3	1.6	1.2	1.1	1.2	1.4
Combustion Turbine	3.7	2.4	1.8	1.3	1.2	1.3	1.6
Renewables	3.6	2.3	1.7	1.2	1.1	1.2	1.5
Cogeneration	3.5	2.3	1.6	1.2	1.1	1.2	1.4
Fuel Switching	3.6	2.3	1.7	1.2	1.1	1.2	1.5
High Conservation	3.6	2.3	1.7	1.2	1.1	1.2	1.5
Imports	3.7	2.4	1.8	1.3	1.2	1.3	1.6

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	4.8	2.9	2.1	1.6	1.5	1.6	1.9
Base Case 4	3.6	2.3	1.7	1.2	1.1	1.2	1.5
Conservation	3.6	2.3	1.7	1.2	1.1	1.2	1.5
Conventional Coal	4.8	2.9	2.1	1.6	1.5	1.6	1.9
Clean Coal	3.9	2.5	1.8	1.3	1.2	1.3	1.6
Nuclear	3.6	2.3	1.7	1.2	1.1	1.2	1.5
Combustion Turbine	3.8	2.4	1.8	1.3	1.2	1.3	1.6
Renewables	3.6	2.3	1.7	1.2	1.1	1.2	1.5
Cogeneration	3.6	2.3	1.7	1.2	1.1	1.2	1.5
Fuel Switching	3.6	2.3	1.7	1.2	1.1	1.2	1.5
High Conservation	3.6	2.3	1.7	1.2	1.1	1.2	1.5
Imports	3.9	2.4	1.8	1.3	1.2	1.3	1.6

TABLE 52. Estimates of Reductions in Visual Range at Colstrip for Stable Conditions with the Wind Blowing from 330° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	10.6	5.5	3.9	3.1	2.9	3.3	4.1

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	17.3	8.2	5.5	4.4	4.1	4.7	5.8
Base Case 4	17.3	8.2	5.5	4.4	4.1	4.7	5.8
Conservation	17.3	8.2	5.5	4.4	4.1	4.7	5.8
Conventional Coal	21.0	9.7	6.4	5.0	4.7	5.3	6.6
Clean Coal	18.2	8.5	5.8	4.5	4.2	4.8	6.0
Nuclear	17.3	8.2	5.5	4.4	4.1	4.7	5.8
Combustion Turbine	17.3	8.2	5.5	4.4	4.1	4.7	5.8
Renewables	17.5	8.2	5.6	4.4	4.1	4.7	5.8
Cogeneration	16.9	8.0	5.4	4.3	4.0	4.6	5.7
Fuel Switching	17.5	8.2	5.6	4.4	4.1	4.7	5.8
High Conservation	17.5	8.2	5.6	4.4	4.1	4.7	5.8
Imports	17.5	8.2	5.6	4.4	4.1	4.7	5.8

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	27.7	12.9	8.4	6.4	5.9	6.7	8.3
Base Case 4	27.7	10.7	7.1	5.5	5.1	5.8	7.2
Conservation	27.7	10.7	7.1	5.5	5.1	5.8	7.2
Conventional Coal	27.7	12.9	8.4	6.4	5.9	6.7	8.3
Clean Coal	27.7	11.3	7.5	5.8	5.3	6.0	7.5
Nuclear	27.7	10.7	7.1	5.5	5.1	5.8	7.2
Combustion Turbine	27.7	10.7	7.1	5.5	5.1	5.8	7.2
Renewables	27.7	10.7	7.1	5.5	5.1	5.8	7.2
Cogeneration	27.7	10.7	7.1	5.5	5.1	5.8	7.2
Fuel Switching	27.7	10.7	7.1	5.5	5.1	5.8	7.2
High Conservation	27.7	10.7	7.1	5.5	5.1	5.8	7.2
Imports	27.7	10.9	7.2	5.6	5.7	5.9	7.3

TABLE 53. Estimates of Reductions in Visual Range at Centralia for Neutral Stability with the Wind Blowing from 330° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	2.5	1.6	1.1	0.8	0.7	0.8	1.0

TABLE 54. Estimates of Reductions in Visual Range at Boardman for Neutral Stability with the Wind Blowing from 330° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	1.7	1.0	0.7	0.5	0.5	0.5	0.6

TABLE 55. Estimates of Reductions in Visual Range at Creston for Neutral Stability with the Wind Blowing from 330° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	1.4	0.7	0.4	0.3	0.3	0.3	0.4

TABLE 56. Estimates of Reductions in Visual Range at Colstrip for Neutral Stability with the Wind Blowing from 330° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	4.8	2.7	1.9	1.4	1.3	1.5	1.8

TABLE 57. Estimates of Reductions in Visual Range at Centralia for Unstable Stability with the Wind Blowing from 330° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	2.5	1.7	1.4	1.2	1.2	1.5	2.0

TABLE 58. Estimates of Reductions in Visual Range at Boardman for Unstable Stability with the Wind Blowing from 330° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	1.8	1.0	0.9	0.8	0.8	1.0	1.3

TABLE 59. Estimates of Reductions in Visual Range at Creston for Unstable Stability with the Wind Blowing from 330° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	1.4	0.7	0.6	0.5	0.5	0.6	0.7

TABLE 60. Estimates of Reductions in Visual Range at Colstrip for Unstable Stability with the Wind Blowing from 330° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	4.4	2.9	2.4	2.0	2.0	2.4	3.2

TABLE 61. Estimates of Reductions in Visual Range at Centralia for Stable Conditions with the Wind Blowing from 210° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	3.6	2.5	2.5	2.7	1.9	0.1	0.0

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	4.9	3.2	3.1	3.4	2.3	0.1	0.0
Base Case 4	4.9	3.2	3.1	3.4	2.3	0.1	0.0
Conservation	4.9	3.2	3.1	3.4	2.3	0.1	0.0
Conventional Coal	5.5	3.5	3.4	3.7	2.4	0.1	0.0
Clean Coal	5.0	3.3	3.2	3.2	2.3	0.1	0.0
Nuclear	4.6	3.1	3.0	3.3	2.2	0.1	0.0
Combustion Turbine	5.0	3.3	3.2	3.5	2.4	0.1	0.0
Renewables	5.0	3.3	3.2	3.2	2.3	0.1	0.0
Cogeneration	4.5	3.1	3.0	3.3	2.2	0.1	0.0
Fuel Switching	5.0	3.3	3.2	3.5	2.4	0.1	0.0
High Conservation	5.0	3.3	3.2	3.5	2.4	0.1	0.0
Imports	5.3	3.4	3.3	3.6	2.5	0.1	0.0

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	5.3	3.5	3.3	3.6	2.3	0.1	0.0
Base Case 4	5.8	3.7	3.5	3.8	2.4	0.1	0.0
Conservation	5.8	3.7	3.5	3.8	2.4	0.1	0.0
Conventional Coal	6.0	3.8	3.6	3.9	2.5	0.1	0.0
Clean Coal	5.2	3.4	3.3	3.6	2.3	0.1	0.0
Nuclear	5.8	3.7	3.5	3.8	2.4	0.1	0.0
Combustion Turbine	5.5	3.6	3.4	3.7	2.4	0.1	0.0
Renewables	5.6	3.6	3.4	3.7	2.4	0.1	0.0
Cogeneration	5.6	3.6	3.4	3.7	2.4	0.1	0.0
Fuel Switching	5.3	3.5	3.3	3.6	2.3	0.1	0.0
High Conservation	5.2	3.4	3.3	3.6	2.3	0.1	0.0
Imports	6.1	3.8	3.7	4.0	2.5	0.1	0.0

TABLE 62. Estimates of Reductions in Visual Range at Boardman for Stable Conditions with the Wind Blowing from 210° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	1.4	1.2	1.1	1.1	0.9	0.0	0.0

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	2.2	1.7	1.8	1.8	1.3	0.0	0.0
Base Case 4	2.2	1.7	1.8	1.8	1.3	0.0	0.0
Conservation	2.2	1.7	1.8	1.8	1.3	0.0	0.0
Conventional Coal	3.3	2.3	2.4	2.5	1.8	0.0	0.0
Clean Coal	2.2	1.7	1.8	1.8	1.3	0.0	0.0
Nuclear	2.1	1.7	1.8	1.8	1.3	0.0	0.0
Combustion Turbine	2.2	1.7	1.8	1.8	1.3	0.0	0.0
Renewables	2.2	1.7	1.8	1.8	1.3	0.0	0.0
Cogeneration	2.2	1.8	1.9	2.0	1.4	0.0	0.0
Fuel Switching	2.2	1.7	1.8	1.8	1.3	0.0	0.0
High Conservation	2.2	1.7	1.8	1.8	1.3	0.0	0.0
Imports	2.3	1.8	1.8	1.9	1.4	0.0	0.0

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	4.8	3.1	3.1	3.3	2.2	0.0	0.0
Base Case 4	4.8	3.1	3.1	3.3	2.2	0.0	0.0
Conservation	4.8	3.1	3.1	3.3	2.2	0.0	0.0
Conventional Coal	6.4	3.9	3.8	4.0	2.5	0.0	0.0
Clean Coal	4.9	3.1	3.1	3.3	2.2	0.0	0.0
Nuclear	4.8	3.1	3.1	3.3	2.2	0.0	0.0
Combustion Turbine	4.8	3.1	3.1	3.3	2.2	0.0	0.0
Renewables	4.8	3.1	3.1	3.3	2.2	0.0	0.0
Cogeneration	5.2	3.3	3.3	3.5	2.3	0.0	0.0
Fuel Switching	4.8	3.1	3.1	3.3	2.2	0.0	0.0
High Conservation	4.8	3.1	3.1	3.3	2.2	0.0	0.0
Imports	5.6	3.5	3.5	3.8	2.4	0.0	0.0

TABLE 63. Estimates of Reductions in Visual Range at Creston for Stable Conditions with the Wind Blowing from 210° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 1991 --- There are no emissions at this site during this year.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	2.0	1.6	1.5	1.5	1.1	0.0	0.0
Base Case 4	2.0	1.6	1.5	1.5	1.1	0.0	0.0
Conservation	2.0	1.6	1.5	1.5	1.1	0.0	0.0
Conventional Coal	2.4	1.8	1.8	1.8	1.3	0.0	0.0
Clean Coal	2.1	1.7	1.6	1.6	1.2	0.0	0.0
Nuclear	2.0	1.6	1.5	1.5	1.1	0.0	0.0
Combustion Turbine	2.2	1.7	1.7	1.7	1.2	0.0	0.0
Renewables	2.0	1.6	1.5	1.5	1.1	0.0	0.0
Cogeneration	2.0	1.6	1.5	1.5	1.1	0.0	0.0
Fuel Switching	2.0	1.6	1.5	1.5	1.1	0.0	0.0
High Conservation	2.0	1.6	1.5	1.5	1.1	0.0	0.0
Imports	2.1	1.7	1.6	1.6	1.2	0.0	0.0

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo							
Base Case 4	2.0	1.6	1.5	1.5	1.1	0.0	0.0
Conservation	2.0	1.6	1.5	1.5	1.1	0.0	0.0
Conventional Coal	2.7	2.0	2.0	2.0	1.5	0.0	0.0
Clean Coal	2.2	1.7	1.6	1.6	1.2	0.0	0.0
Nuclear	2.0	1.6	1.5	1.5	1.1	0.0	0.0
Combustion Turbine	2.1	1.7	1.6	1.6	1.2	0.0	0.0
Renewables	2.0	1.6	1.5	1.5	1.1	0.0	0.0
Cogeneration	2.0	1.6	1.5	1.5	1.1	0.0	0.0
Fuel Switching	2.0	1.6	1.5	1.5	1.1	0.0	0.0
High Conservation	2.0	1.6	1.5	1.5	1.1	0.0	0.0
Imports	2.2	1.7	1.7	1.7	1.2	0.0	0.0

TABLE 64. Estimates of Reductions in Visual Range at Colstrip for Stable Conditions with the Wind Blowing from 210° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 1991

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
All Alternatives	6.1	3.8	3.6	3.9	2.4	0.1	0.0

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	9.9	5.6	5.1	5.4	3.1	0.1	0.0
Base Case 4	9.9	5.6	5.1	5.4	3.1	0.1	0.0
Conservation	9.9	5.6	5.1	5.4	3.1	0.1	0.0
Conventional Coal	12.0	6.7	5.9	6.2	3.2	0.1	0.0
Clean Coal	10.4	5.9	5.3	5.6	3.1	0.1	0.0
Nuclear	9.9	5.6	5.1	5.4	3.1	0.1	0.0
Combustion Turbine	9.9	5.6	5.1	5.4	3.1	0.1	0.0
Renewables	10.2	5.8	5.2	5.5	3.1	0.1	0.0
Cogeneration	9.7	5.5	5.0	5.3	3.0	0.1	0.0
Fuel Switching	10.2	5.8	5.2	5.5	3.1	0.1	0.0
High Conservation	10.2	5.8	5.2	5.5	3.1	0.1	0.0
Imports	10.2	5.8	5.2	5.5	3.1	0.1	0.0

Year: 2010

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Status Quo	16.6	8.9	7.7	7.9	3.6	0.1	0.0
Base Case 4	13.6	7.4	6.5	6.7	3.4	0.1	0.0
Conservation	13.6	7.4	6.5	6.7	3.4	0.1	0.0
Conventional Coal	16.6	8.9	7.7	7.9	3.6	0.1	0.0
Clean Coal	14.4	7.8	6.8	7.0	3.5	0.1	0.0
Nuclear	13.6	7.4	6.5	6.7	3.4	0.1	0.0
Combustion Turbine	13.6	7.4	6.5	6.7	3.4	0.1	0.0
Renewables	13.6	7.4	6.5	6.7	3.4	0.1	0.0
Cogeneration	13.6	7.4	6.5	6.7	3.4	0.1	0.0
Fuel Switching	13.6	7.4	6.5	6.7	3.4	0.1	0.0
High Conservation	13.6	7.4	6.5	6.7	3.4	0.1	0.0
Imports	13.9	7.6	6.6	6.8	3.5	0.1	0.0

TABLE 65. Estimates of Reductions in Visual Range at Centralia for Neutral Stability with the Wind Blowing from 210° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	1.5	1.1	1.0	1.0	0.8	0.1	0.0

TABLE 66. Estimates of Reductions in Visual Range at Boardman for Neutral Stability with the Wind Blowing from 210° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	1.0	0.7	0.6	0.6	0.5	0.1	0.0

TABLE 67. Estimates of Reductions in Visual Range at Creston for Neutral Stability with the Wind Blowing from 210° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	0.8	0.5	0.4	0.4	0.3	0.0	0.0

TABLE 68. Estimates of Reductions in Visual Range at Colstrip for Neutral Stability with the Wind Blowing from 210° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	2.8	1.8	1.8	1.8	1.3	0.2	0.0

TABLE 69. Estimates of Reductions in Visual Range at Centralia for Unstable Stability with the Wind Blowing from 210° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	1.5	1.2	1.3	1.4	1.0	0.5	0.3

TABLE 70. Estimates of Reductions in Visual Range at Boardman for Unstable Stability with the Wind Blowing from 210° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	1.0	0.7	0.8	0.9	0.7	0.3	0.2

TABLE 71. Estimates of Reductions in Visual Range at Creston for Unstable Stability with the Wind Blowing from 210° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	0.8	0.5	0.5	0.6	0.4	0.2	0.1

TABLE 72. Estimates of Reductions in Visual Range at Colstrip for Unstable Stability with the Wind Blowing from 210° and the Observer 20 km Directly South and 40 km East of the Pollutant Source.

Year: 2000

RESOURCE ALTERNATIVE	REDUCTION IN VISUAL RANGE (%) AT THE FOLLOWING DISTANCES (km)						
	2	10	20	30	40	50	60
Conventional Coal	2.5	2.0	2.3	2.4	1.7	0.8	0.4

APPENDIX J

DETAILED ESTIMATES OF IMPACTS TO WILDLIFE FROM EXPOSURE TO SULFUR OXIDES AND TOTAL SUSPENDED PARTICULATES

APPENDIX J

DETAILED ESTIMATES OF IMPACTS TO WILDLIFE FROM EXPOSURE TO SULFUR OXIDES AND TOTAL SUSPENDED PARTICULATES

This appendix provides detailed estimates of annual wildlife mortalities from exposure to sulfur oxides (SO_x) and total suspended particulates (TSP). The estimates were calculated for the three study periods (1991, 2000, and 2010) at the four representative locations (Centralia, Washington; Creston, Washington; Boardman, Oregon; and Colstrip, Montana) and are shown in the tables below.

TABLE J.1.

Estimated Annual Wildlife Mortalities from Exposure to 1991 Annual Average Concentration of Sulfur Oxides (SO_x) and Total Suspended Particulates (TSP) within 32 km of Centralia, Washington, Power Facilities

CENTRALIA			
YEAR 1991			
Species	No./mi ²	1.5 µg SOX/m ³	214.5µg TSP/m ³
Small rodent*	103600	8235	2194
Beaver**	6	0	0
Mink**	2	0	0
Black tailed deer***	20	2	0
Elk**	1	0	0
Avian spp.****	2560	203	54

*Taitt et al 1981

**Eberhardt 1991

***Ralph Johnson, 1991

**** Udvardy 1957

TABLE J.2. Estimated Annual Wildlife Mortalities from Exposure to 1991 Annual Average Concentration of Sulfur Oxides (SO_x) and Total Suspended Particulates (TSP) within 32 km of Creston, Washington, Power Facilities (no facilities present)

CRESTON			
YEAR 1991			
Species	No./mi ²	0 µg SOX/m ³	0 µg TSP/m ³
Small Rodent*	103600	0	0
Beaver**	6	0	0
Ground squirrel**	30	0	0
Mule deer and White-tailed deer***	8	0	0
Elk**	1	0	0
Avian spp****	1024	0	0

*Taitt et al 1981

**Eberhardt 1991

***Kreine 1991

****Udvardy 1957

TABLE J.3. Estimated Annual Wildlife Mortalities from Exposure to 1991 Annual Average Concentration of Sulfur Oxides (SO_x) and Total Suspended Particulates (TSP) within 32 km of Boardman, Oregon, Power Facilities

BOARDMAN YEAR 1991			
Species	No./mi ²	1.5 µg SOX/m ³	0.08µg TSP/m ³
Small Rodent.*	103600	7720	10
Beaver**	6	0	0
Ground squirrel**	30	2	0
Mink**	2	0	0
Mule deer arid lands	12	1	0
Mule deer other***	20	1	0
Elk**	1	0	0
Avian spp.****	1024	76	0

*Taitt et al 1981

**Eberhardt 1991

***Kreine 1991

****Udvardy 1957

TABLE J.4. Estimated Annual Wildlife Mortalities from Exposure to 1991 Annual Average Concentration of Sulfur Oxides (SO_x) and Total Suspended Particulates (TSP) within 32 km of Colstrip Montana, Power Facilities

COLSTRIP			
YEAR 1991			
Species	No./mi ²	2.8 µg SOX/m ³	274.0 µg TSP/m ³
Small Rodent*	103600	14411	4904
Ground squirrel**	30	4	1
Mink**	2	0	0
Mule deer***	2	0	0
Avian spp.****	1024	142	48

*Taitt et al 1981

**Eberhardt 1991

***Waage 1991

****Udvardy 1957

TABLE J.5. Estimated Annual Wildlife Mortalities from Exposure to 2000 Annual Average Concentration of Sulfur Oxides (SO_x) within 32 km of Centralia, Washington, Power Facilities

		CENTRALIA YEAR 2000											
		Maximum Annual Average $\mu\text{g SO}_x/\text{m}^3$ at site by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
		2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
		Mortality per Year Associated with SO _x Exposure by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²	11838	11838	11838	11838	11838	11838	11838	11838	11838	11838	11838	11838
Small rodent*	103600												
Beaver**	6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Mink**	2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Black tailed deer***	20	2.5	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Elk**	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Avian spp.****	2560	318.0	305.2	292.5	292.5	292.5	292.5	292.5	292.5	292.5	292.5	292.5	292.5

*Taft et al 1981

**Eberhardt 1991

***Ralph Johnson, 1991

**** Udvardy 1957

TABLE J.6. Estimated Annual Wildlife Mortalities from Exposure to 2000 Annual Average Concentration of Sulfur Oxides (SO_x) within 32 km of Creston, Washington, Power Facilities

		CRESTON YEAR 2000											
		Maximum Annual Average µg SO _x /m ³ at site by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
		0.23	0.23	0.23	0.25	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
		Mortality per Year Associated with SO _x Exposure by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²	1184	1183.8	1184	1287	1184	1184	1184	1184	1184	1184	7206	7206
Small Rodent*	103600												
Beaver**	6	0.4	0.4	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Ground squirrel**	30	1.9	1.9	2.8	2.2	1.9	1.9	1.9	1.9	1.9	1.9	2.1	2.1
Mule deer and White-tailed deer***	8	0.5	0.5	0.8	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6
Elk**	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Avian spp****	1024	66.1	66.1	96.7	76.3	66.1	66.1	66.1	66.1	66.1	66.1	71.2	71.2

*Taitt et al 1981

**Eberhardt 1991

***Kreine 1991

****Udvardy 1957

TABLE J.7. Estimated Annual Wildlife Mortalities from Exposure to 2000 Annual Average Concentration of Sulfur Oxides (SO_x) within 32 km of Boardman, Oregon, Power Facilities

		BOARDMAN YEAR 2000											
		Maximum Annual Average $\mu\text{g SO}_x/\text{m}^3$ at site by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
		0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94

		Mortality per Year Associated with SO _x Exposure by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²	4838	4838	4838	4838	4838	4838	4838	4838	4838	4838	4838	4838
Small Rodent.*	103600	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Beaver**	6	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Ground squirrel**	30	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Mink**	2	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Mule deer arid lands	12	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Mule deer other***	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Elk**	1	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8	47.8
Avian spp.****	1024												

*Taft et al 1981

**Eberhardt 1991

***Kreine 1991

****Udvardy 1957

TABLE J.8. Estimated Annual Wildlife Mortalities from Exposure to 2000 Annual Average Concentration of Sulfur Oxides (SO_x) within 32 km of Colstrip, Montana, Power Facilities

		COLSTRIP YEAR 2000											
		Maximum Annual Average $\mu\text{g SO}_x/\text{m}^3$ at site by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
		2.7	2.7	2.7	2.9	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
		Mortality per Year Associated with SO _x Exposure by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²	13896	13896	13896	14926	13896	13896	13896	13896	13896	13896	13896	13896
Small Rodent*	103600												
Ground squirrel**	30	4.0	4.0	4.0	4.3	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Mink**	2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Mule deer***	2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Avian spp.****	1024	137.4	137.4	137.4	147.5	137.4	137.4	137.4	137.4	137.4	137.4	137.4	137.4

*Taitt et al 1981

**Eberhardt 1991

***Waage 1991

****Udvardy 1957

TABLE J.9. Estimated Annual Wildlife Mortalities from Exposure to 2000 Annual Average Concentration of Total Suspended Particulates (TSP) within 32 km of Centralia, Washington, Power Facilities

		CENTRALIA YEAR 2000											
		Maximum Annual Average $\mu\text{g TSP}/\text{m}^3$ at site by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.12
		Mortality per Year Associated with TSP Exposure by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²												
Small rodent*	103600	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	46.3
Beaver**	6	0	0	0	0	0	0	0	0	0	0	0	0
Mink**	2	0	0	0	0	0	0	0	0	0	0	0	0
Black tailed deer***	20	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Elk**	1	0	0	0	0	0	0	0	0	0	0	0	0
Avian spp.****	2560	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	1.14

*Taitt et al 1981

**Eberhardt 1991

***Ralph Johnson, 1991

**** Udvardy 1957

TABLE J.10. Estimated Annual Wildlife Mortalities from Exposure to 2000 Annual Average Concentration of Total Suspended Particulates (TSP) within 32 km of Creston, Washington, Power Facilities

		CRESTON YEAR 2000 µg TSP/m ³ at site by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
		0.03	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03

		Mortality per Year Associated with TSP Exposure by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²	11.6	11.6	11.6	15.4	15.4	11.6	11.6	11.6	11.6	11.6	11.6	11.6
Small Rodent*	103600												
Beaver**	6	0	0	0	0	0	0	0	0	0	0	0	0
Ground squirrel**	30	0	0	0	0	0	0	0	0	0	0	0	0
Mule deer and		0	0	0	0	0	0	0	0	0	0	0	0
White-tailed deer***	8	0	0	0	0	0	0	0	0	0	0	0	0
Elk**	1	0	0	0	0	0	0	0	0	0	0	0	0
Avian spp****	1024	0.11	0.11	0.11	0.15	0.15	0.11	0.11	0.11	0.11	0.11	0.11	0.11

*Taitt et al 1981

**Eberhardt 1991

***Kreine 1991

****Udvardy 1957

TABLE J.11. Estimated Annual Wildlife Mortalities from Exposure to 2000 Annual Average Concentration of Total Suspended Particulates (TSP) within 32 km of Boardman, Oregon, Power Facilities

		BOARDMAN YEAR 2000											
		Maximum Annual Average $\mu\text{g TSP}/\text{m}^3$ at site by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
		0.04	0.04	0.04	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
		Mortality per Year Associated with TSP Exposure by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²	15.4	15.4	15.4	23.2	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4
Small Rodent.*	103600	15.4	15.4	15.4	23.2	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4
Beaver**	6	0	0	0	0	0	0	0	0	0	0	0	0
Ground squirrel**	30	0	0	0	0.01	0	0	0	0	0	0	0	0
Mink**	2	0	0	0	0	0	0	0	0	0	0	0	0
Mule deer arid lands	12	0	0	0	0	0	0	0	0	0	0	0	0
Mule deer other***	20	0	0	0	0	0	0	0	0	0	0	0	0
Elk**	1	0	0	0	0	0	0	0	0	0	0	0	0
Avian spp.****	1024	0.15	0.15	0.15	0.23	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

*Taitt et al 1981

**Eberhardt 1991

***Kreine 1991

****Udvardy 1957

TABLE J.12. Estimated Annual Wildlife Mortalities from Exposure to 2000 Annual Average Concentration of Total Suspended Particulates (TSP) within 32 km of Colstrip, Montana, Power Facilities

		COLSTRIP YEAR 2000											
		Maximum Annual Average $\mu\text{g TSP/m}^3$ by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
		.13	0.13	0.13	0.16	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13

		Mortality per Year Associated with TSP Exposure by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²	50.2	50.2	50.2	61.8	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
Small Rodent*	103600	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ground squirrel**	30	0	0	0	0	0	0	0	0	0	0	0	0
Mink**	2	0	0	0	0	0	0	0	0	0	0	0	0
Mule deer***	2	0	0	0	0	0	0	0	0	0	0	0	0
Avian spp.****	1024	0.5	0.5	0.5	0.61	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

*Taitt et al 1981

**Eberhardt 1991

***Waage 1991

****Udvardy 1957

TABLE J.13. Estimated Annual Wildlife Mortalities from Exposure to 2010 Annual Average Concentration of Sulfur Oxides (SO_x) within 32 km of Centralia, Washington, Power Facilities

		CENTRALIA YEAR 2010											
		Maximum Annual Average $\mu\text{g SO}_x/\text{m}^3$ at site by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
		2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
		Mortality per Year Associated with SO _x Exposure by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²	12352	12352	12352	12352	12352	12352	12352	12352	12352	12352	12352	12352
Small rodent*	103600												
Beaver**	6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Mink**	2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Black tailed deer***	20	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Elk**	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Avian spp.****	2560	305.2	305.2	305.2	305.2	305.2	305.2	305.2	305.2	305.2	305.2	305.2	305.2

*Taitt et al 1981

**Eberhardt 1991

***Ralph Johnson, 1991

**** Udvardy 1957

TABLE J.14. Estimated Annual Wildlife Mortalities from Exposure to 2010 Annual Average Concentration of Sulfur Oxides (SO_x) within 32 km of Creston, Washington, Power Facilities

		CRESTON YEAR 2010											
		Maximum Annual Average $\mu\text{g SO}_x/\text{m}^3$ at site by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
		0.29	0.23	0.234	0.29	0.26	0.23	0.23	0.23	0.23	0.23	0.23	0.23
		Mortality per Year Associated with SO _x Exposure by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²	1493	1184	1184	1493	1338	1184	1184	1184	1184	1184	1184	1184
Small Rodent*	103600												
Beaver**	6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Ground squirrel**	30	0.4	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Mule deer and		0	0	0	0	0	0	0	0	0	0	0	0
White-tailed deer***	8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Elk**	1	0	0	0	0	0	0	0	0	0	0	0	0
Avian spp****	1024	14.8	11.7	11.7	14.8	13.2	11.7	11.7	11.7	11.7	11.7	11.7	11.7

*Taitt et al 1981

**Eberhardt 1991

***Kreine 1991

****Udvardy 1957

TABLE J.15. Estimated Annual Wildlife Mortalities from Exposure to 2010 Annual Average Concentration of Sulfur Oxides (SO_x) within 32 km of Boardman, Oregon, Power Facilities

BOARDMAN
YEAR 2010

Maximum Annual Average $\mu\text{g SO}_x/\text{m}^3$ at site by Primary Number											
1	2	3	4	5	6	7	8	9	10	11	12
1.3	1.3	1.3	1.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3

		Mortality per Year Associated with SO _x Exposure by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²												
Small Rodent.*	103600	6690.9	6691	6691	7720	6691	6691	6691	6691	6691	6691	6691	6691
Beaver**	6	0.3875	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Ground squirrel**	30	1.9375	1.9	1.9	2.2	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Mink**	2	0.1292	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Mule deer arid lands	12	0.775	0.8	0.8	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Mule deer other***	20	1.2917	1.3	1.3	1.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Elk**	1	0.0646	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Avian spp.****	1024	66.134	66.1	66.1	76.3	66.1	66.1	66.1	66.1	66.1	66.1	66.1	66.1

*Taitt et al 1981

**Eberhardt 1991

***Kreine 1991

****Udvardy 1957

TABLE J.16. Estimated Annual Wildlife Mortalities from Exposure to 20100 Annual Average Concentration of Sulfur Oxides (SO_x) within 32 km of Colstrip, Montana, Power Facilities

COLSTRIP
YEAR 2010

Maximum Annual Average $\mu\text{g SO}_x/\text{m}^3$ at site by Primary Number											
1	2	3	4	5	6	7	8	9	10	11	12
3	3	3	3.2	3	3	3	3	3	3	3	3

Mortality per Year Associated with SO _x Exposure by Primary Number											
1	2	3	4	5	6	7	8	9	10	11	12
15441	15441	15441	16470	15441	15441	15441	15441	15441	15441	15441	15441
4.5	4.5	4.5	4.8	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
152.6	152.6	152.6	162.8	152.6	152.6	152.6	152.6	152.6	152.6	152.6	152.6

Species	No./mi ²
Small Rodent*	103600
Ground squirrel**	30
Mink**	2
Mule deer***	2
Avian spp.****	1024

*Taitt et al 1981

**Eberhardt 1991

***Waage 1991

****Udvardy 1957

TABLE J.17. Estimated Annual Wildlife Mortalities from Exposure to 2010 Annual Average Concentration of Total Suspended Particulates (TSP) within 32 km of Centralia, Washington, Power Facilities

		CENTRALIA											
		YEAR 2010											
		Maximum Annual Average $\mu\text{g TSP}/\text{m}^3$ at site by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
		0.11	0.11	0.11	0.11	0.11	0.11	0	0.11	0.11	0.11	0.11	0.14

		Mortality per Year Associated with TSP Exposure by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	42.5	54
Small rodent*	103600												
Beaver**	6	0.0	0	0	0	0	0	0	0	0	0	0	0
Mink**	2	0.0	0	0	0	0	0	0	0	0	0	0	0
Black tailed deer***	20	0.0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Elk**	1	0.0	0	0	0	0	0	0	0	0	0	0	0
Avian spp.****	2560	1.0	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.34

*Taft et al 1981

**Eberhardt 1991

***Ralph Johnson, 1991

**** Udvardy 1957

TABLE J.18. Estimated Annual Wildlife Mortalities from Exposure to 2010 Annual Average Concentration of Total Suspended Particulates (TSP) within 32 km of Creston, Washington, Power Facilities

		CRESTON											
		YEAR 2010											
		Maximum Annual Average $\mu\text{g TSP}/\text{m}^3$											
		by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
		0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

		Mortality per Year Associated with TSP Exposure											
		by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²	15.4	15.4	15.4	0.04	15.4	15.4	15.4	15.4	15.4	15.4	15.4	15.4
Small Rodent*	103600												
Beaver**	6	0	0	0	0.04	0	0	0	0	0	0	0	0
Ground squirrel**	30	0	0	0	0.04	0	0	0	0	0	0	0	0
Mule deer and													
White-tailed deer***	8	0	0	0	0.04	0	0	0	0	0	0	0	0
Elk**	1	0	0	0	0.04	0	0	0	0	0	0	0	0
Avian spp****	1024	0.15	0.15	0.15	0.04	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

*Taft et al 1981

**Eberhardt 1991

***Kreine 1991

****Udvardy 1957

TABLE J.19. Estimated Annual Wildlife Mortalities from Exposure to 2010 Annual Average Concentration of Total Suspended Particulates (TSP) within 32 km of Boardman, Oregon, Power Facilities

		BOARDMAN YEAR 2010											
		Maximum Annual Average $\mu\text{g TSP}/\text{m}^3$ at site by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
		0.09	0.09	0.09	0.11	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
		Mortality per Year Associated with TSP Exposure by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²	34.7	34.7	34.7	42.5	34.7	34.7	34.7	34.7	34.7	34.7	34.7	34.7
Small Rodent.*	103600												
Beaver**	6	0	0	0	0	0	0	0	0	0	0	0	0
Ground squirrel**	30	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mink**	2	0	0	0	0	0	0	0	0	0	0	0	0
Mule deer arid lands	12	0	0	0	0	0	0	0	0	0	0	0	0
Mule deer other***	20	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Elk**	1	0	0	0	0	0	0	0	0	0	0	0	0
Avian spp.****	1024	0.34	0.34	0.34	0.42	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34

*Taft et al 1981

**Eberhardt 1991

***Kreine 1991

****Udvardy 1957

TABLE J.20. Estimated Annual Wildlife Mortalities from Exposure to 2010 Annual Average Concentration of Total Suspended Particulates (TSP) within 32 km of Colstrip, Montana, Power Facilities

		COLSTRIP YEAR 2010											
		Maximum Annual Average $\mu\text{g TSP}/\text{m}^3$ at site by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
		0.2	0.18	0.18	0.2	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18

		Mortality per Year Associated with TSP Exposure by Primary Number											
		1	2	3	4	5	6	7	8	9	10	11	12
Species	No./mi ²	77.2	69.5	69.5	77.2	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5
Small Rodent*	103600	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Ground squirrel**	30	0	0	0	0	0	0	0	0	0	0	0	0
Mink**	2	0	0	0	0	0	0	0	0	0	0	0	0
Mule deer***	2	0	0	0	0	0	0	0	0	0	0	0	0
Avian spp.****	1024	0.76	0.69	0.69	0.76	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69

*Taitt et al 1981

**Eberhardt 1991

***Waage 1991

****Udvardy 1957

KEY FOR TABLES J.2 THROUGH J.20

<u>Column Number</u>		<u>Resource Alternative</u>
1	=	Status Quo
2	=	Base Case
3	=	Fuel Switching
4	=	Nuclear
5	=	Imports
6	=	Cogeneration
7	=	Combustion Turbines
8	=	Pulverized Coal
9	=	Clean Coal
10	=	High Conservation
11	=	Conservation
12	=	Renewables