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Environmental Assessment

Aspen Free-Air Carbon Dioxide and Ozone Enrichment Facility Infrastructure Upgrades

Harshaw, Wisconsin

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SUMMARY

The North Central Research Station of the U.S. Department of Agriculture Forest Service (USFS) has prepared this Environmental Assessment (EA) for upgrades to the Aspen Free-Air Carbon Dioxide and Ozone Enrichment Facility in compliance with the National Environmental Policy Act (NEPA) and other relevant Federal and state laws and regulations. The proposed action would involve continued site operation, installation of taller vertical carbon dioxide and ozone fumigation pipes and support poles for the vertical fumigation pipes, and raising the walkways in the experimental rings to facilitate researcher access to the tree canopies. Carbon dioxide and ozone fumigation levels would increase by about ten percent annually under the proposed action. Under the no action alternative, proposed infrastructure modifications would not be made, but research would continue at the facility.

Although there are some minor and temporary adverse impacts associated with construction at the site, these impacts would not be significant. Ozone emissions from site operations would not cause exceedance of air quality standards. Infrequent elevated ozone concentrations (due largely to elevated background ozone concentrations that are unrelated to site-operations) could cause leaf damage to some plants, but decreased crop yields are not expected. If an individual with particular sensitivity to ozone spent several hours near the site fence line on one of the infrequent days with an elevated ozone level, that person could experience some respiratory discomfort. From 84% to 96% of these possible occurrences of ozone effects on human health would be due solely to background, non-site sources. Site emissions contribute less than 5% to the exceedance when an exceedance occurs due to a combination of background and site emissions. The incidence of such an adverse health impact on an individual is expected to be very low, if it occurs at all. No adverse health impacts due to site emissions would be seen at actual residential locations under either the proposed action or no action alternatives.

This EA concludes the proposed action and no action alternative for the FACE site would result in minimal or no adverse impacts to air quality, noise, ecology, human health and safety, socioeconomics, environmental justice, and visual resources.

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NOTATION

The following is a list of acronyms and abbreviations, chemical names, and units of measure used in this document. Some acronyms used only in tables may be defined only in those tables.

ACRONYMS AND ABBREVIATIONS

AERMET	AERMOD meteorological data preprocessor
AERMOD	AMS/EPA Regulatory Model
AQI	air quality index
BLM	Bureau of Land Management
CEQ	Council on Environmental Quality
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FACE	Free-Air Carbon Dioxide and Ozone Enrichment
FONSI	Finding of No Significant Impact
FWS	U.S. Fish and Wildlife Service
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NWS	National Weather Service
OSHA	Occupational Safety and Health Administration
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 µm or less
PM_{10}	particulate matter with an aerodynamic diameter of 10 µm or less
PVC	polyvinyl chloride
ROI	region of influence
SAAQS	State Ambient Air Quality Standards
STEL	short-term exposure limit
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
VOC	volatile organic compound
WDNR	Wisconsin Department of Natural Resources

CHEMICALS

CO_2	carbon dioxide
NO_x	oxides of nitrogen (or nitrogen oxides)
O_3	ozone

UNITS OF MEASURE

°C	degree(s) Celsius
cm	centimeter(s)
d	day
dB	decibel(s)
dBA	A-weighted decibel(s)
DNL	day-night average sound level (same as L_{dn})
°F	degree(s) Fahrenheit
ft	foot (feet)
ft^2	square foot (feet)
hp	horsepower(s)
hr	hour(s)
in.	inch(es)
kg	kilogram(s)
km	kilometer(s)
lb	pound(s)
L_{dn}	day-night average sound level (same as DNL)
L_{eq}	equivalent-continuous sound level
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
mg	milligram(s)
mi	mile(s)
µg	microgram(s)
µm	micrometer(s)
MT	metric ton(s)
ppb	part(s) per billion by volume
ppm	part(s) per million by volume
s	second(s)
yr	year(s)

1 INTRODUCTION

The North Central Research Station of the U.S. Department of Agriculture Forest Service (USFS) has prepared this Environmental Assessment (EA) in compliance with the National Environmental Policy Act (NEPA) and other relevant Federal and state laws and regulations.

The EA addresses the direct, indirect, and cumulative impacts that would result from implementing the proposed action and the no action alternative. The EA also includes the necessary supporting information for a management decision to prepare either an Environmental Impact Statement (EIS) or Finding of No Significant Impact (FONSI). The key areas of potential concern that are addressed are impacts to air quality, human health, ecology, noise and visual impacts, and socioeconomics in the region of interest.

1.1 Description of the Proposed Action

In 1996, the Michigan Technological University received approvals from the U.S. Department of Energy (DOE) and the Forest Service to construct and operate a research facility near Harshaw, Wisconsin, that could evaluate the effects of elevated levels of carbon dioxide (CO_2) and ozone (O_3) on native tree species common in the upper Midwest. The experimental facility, known as the Aspen Free-Air Carbon Dioxide and Ozone Enrichment User Facility (Aspen FACE), was constructed in 1996 and became operational in 1998. The main features of the site include 12 experimental rings, a main laboratory and computer building and various equipment buildings and sheds, and liquid CO_2 and oxygen storage tanks (see Figure 1.1-1). As part of its Program for Ecosystem Research, the DOE Office of Science has approved continued funding for the Aspen FACE project from April 1, 2005 to March 31, 2008 (Amthor 2005).

The original experimental design allowed researchers to analyze the effects of elevated CO_2 and O_3 on trembling aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), and sugar maple (*Acer saccharum*), by fumigating the trees with measured amounts of CO_2 and O_3. The DOE approved a categorical exclusion for the FACE project in 1996, indicating that the project would not have a significant effect on the human environment (Flannigan 1996). During the nine years of experiments since that time, trees in some rings have grown to the top of the vertical fumigation pipes, making it difficult if not impossible to continue experiments in the tree canopies without infrastructure upgrades.

The proposed action would involve continued site operation, installation of taller vertical fumigation pipes and support poles for the vertical fumigation pipes, and raising the walkways in the experimental rings to facilitate researcher access to the tree canopies. Currently experiments are carried out in twelve 30-m (98-ft) diameter rings. New vertical fumigation pipes would be installed to adjust the fumigation height as necessary due to tree growth. First, an additional 5-m (16-ft) extension of the vertical fumigation pipes would be erected that would allow experiments to continue for an additional 5 to 6 years. A second 5-m (16-ft) extension of the fumigation pipes would be needed after that time to allow continuation and completion of the experiments during the planned life of the research facility. The current height of support poles is 10 m (33 ft); the

FIGURE 1.1-1 Features of FACE Site (Sources: Aerial photo from USGS et al. 2005; site infrastructure from DOE et al. 2005)

fumigation pipes extend to about 11 m (36 ft). The new installed vertical support poles would be long enough to allow the full extension of 10 m (33 ft). A detailed description of the experimental rings and the proposed action is provided in Chapter 2. Appendix A provides a description of the ongoing operation of the Aspen FACE User Facility.

1.2 Purpose and Need

The purpose of the proposed action would be to implement infrastructure upgrades needed for continuation of research on CO_2 and O_3 enrichment on trees in 12 experimental rings that comprise the Aspen FACE User Facility. The Aspen FACE project is part of the North Central Research Station's mission of evaluating the potential effects of global atmospheric change on forest ecosystems and the DOE mission of evaluating climate change as part of its Program for Ecosystem Research (Karnosky et al. 2004).

The North Central Research Station is of one of seven research and development units of the USFS. Forest Service research and development scientists carry out basic applied research to study biological, physical, and social sciences related to diverse forests and rangelands. The North Central Research Station participates in research that is part of national programs such as the ongoing Forest Inventory and Analysis as well as specialized research (Karnosky et al. 2004).

The Aspen FACE experiments are multidisciplinary studies that assess the effects of increasing CO_2 and O_3 concentrations on forest ecosystems. The research is collaborative and multinational involving scientists from the United States, Canada, Slovakia, Finland, and Estonia.

Current experiments are under way that focus on the following areas:

- Tree physiology effects – the study of plant productivity, carbon balance and allocation, and photosynthesis responses to elevated CO_2 and O_3;

- Effects on insects and microbes – how the change in nutrient quality of tree leaves grown in the presence of elevated CO_2 and O_3 will impact organisms that feed on and decompose those leaves;

- Effects on soil processes and nutrient cycling;

- Meteorology effects – the characterization of the microclimate both within and outside the 12 rings; and

- Ecosystem effects – how changes in plant productivity affect water and nutrient cycles.

Of particular concern for this EA are the potential impacts of chemical releases to air from the FACE facility, and particularly O_3 releases. O_3 is an oxidizing molecule that, above certain concentrations, causes damage to human health (respiratory system damage) and to vegetation (photosynthesis and metabolic function disruption). O_3 occurs naturally in the stratosphere, and is occasionally transported downward into the troposphere (lower atmosphere, near ground level). It is naturally produced in the troposphere by lightning. O_3 is also produced in the troposphere by reactions between oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight, and its peak concentrations normally occur during summer months characterized by high temperatures and intense solar radiation. NO_x comes primarily from the combustion of fossil fuels, such as oil, coal, and natural gas. By far the largest source of NO_x is motor vehicle exhaust and secondarily fuel combustion (e.g., electric power plants). Major sources of VOCs are motor vehicle exhaust, solvents and paints, petrochemical industries, and agriculture.

Ground-level O_3 is considered to be air pollution; O_3 is regulated as a criteria pollutant (that is, one that all regions of the country must keep below regulatory levels) by the U.S. Environmental Protection Agency (EPA). Of key importance in this EA will be an examination of whether, under the proposed action, O_3 emitted from the FACE facility would travel beyond the site boundary at concentrations higher than concentrations of concern for adverse impacts to human health or vegetation. Although emissions of CO_2 are not of such high concern because it is far less hazardous than O_3, CO_2 emissions are also addressed.

1.3 Scope of the Environmental Assessment

The EA assesses the proposed action and the no action alternative. The analysis of potential impacts of these alternatives on air quality, human health, ecological resources and several other resources was based on project description information provided by Michigan Technological University and the Forest Service, a review of relevant published information, and information obtained from Federal and state agencies on natural resources in the project vicinity. Issues raised during the public meetings that were considered within the scope of the EA are addressed in the impact analysis.

1.4 Related Documents and NEPA Projects

The North Central Research Station prepared an EA and a FONSI in 2005 on a proposed laboratory facility at the Aspen FACE site (USFS 2005b). The EA evaluated impacts of constructing a 232 m^2 (2,500 ft^2) laboratory building suitable for use by 20 to 30 field researchers participating the Aspen FACE experiments. No other projects related to the proposed action have been identified.

1.5 Public Scoping Comments and Issues

Public scoping meetings and tours of the existing Aspen FACE Project Facility took place on June 15, 2005. Notices of the public meetings were published in the *Rhinelander Daily News*, the *Vilas County News Review*, and the *Lakeland Times*. In the newspaper notices and at the public meetings, the Forest Service informed the public of the various ways to submit comments, and that comments would be received until July 12, 2005.

Approximately 90 people attended the afternoon and evening public meetings. Researchers from Michigan Technological University and the Forest Service Forest Sciences Laboratory in Rhinelander, Wisconsin, attended the meetings to discuss the proposed upgrades to the Aspen FACE User Facility and to describe past and ongoing experiments.

The main concerns raised at the public meetings and in written comments were about the human health effects from exposure to elevated O_3 levels that may be transported beyond the Aspen FACE site. Other concerns involved O_3 effects beyond the fence line on agricultural crops, particularly potatoes; noise; and safety issues related to storing and unloading gases at the site. A complete summary of comments received during public scoping can be found in the Scoping Summary Report (Appendix B).

1.6 Decisions to be Made

The Forest Service will determine whether or not to proceed with the proposed action and, if so, whether any measures would be required to mitigate impacts associated with implementing the proposed action. The decision will include a determination of the significance of impacts and a statement regarding consistency of the proposed action with standards, guidelines, goals, and objectives of the North Central Research Station, and with environmental laws and regulations.

2 ALTERNATIVES

This chapter describes the alternatives considered in this EA related to infrastructure upgrades at the Aspen FACE User Facility. As a minimum for compliance with the Council on Environmental Quality Guidelines for Implementing requirements of the NEPA (CEQ 1986), all federal agencies must address the proposed action and a no action alternative when preparing an EA or EIS. The Forest Service has decided that no additional alternatives are reasonable to include in the EA.

2.1 Alternatives Analyzed in the Environmental Assessment

2.1.1 Proposed Action

The proposed action involves modifications to the infrastructure of the Aspen FACE User Facility that are needed for continuation of the CO_2 and O_3 enrichment experiments. Upgrades to the infrastructure are necessary in the twelve 30-m (98-ft) diameter rings because the aspen and birch trees in some rings have grown to heights that are even with the tops of the vertical fumigation pipes and the center pole used to support instrumentation that is needed to regulate dispersion of the gases during the growing season. The trees are the tallest in the CO_2-only rings, which require the infrastructure modifications most immediately. A schematic diagram of the locations of the 12 rings within the FACE site is shown in Figure 1.1-1.

This EA addresses the impacts of raising the poles and vertical fumigation (vent) pipes approximately 10 m (33 ft) above the current height of 10 m (33 ft). The extensions would take place in two phases to approximately match tree growth. First the fumigation system will be raised 5 m (16 ft) during a six-month period from approximately November 2006 through April 2007, then it will be raised another 5 m (16 ft) about 5 to 6 years later.

Continued operation of the facility is also addressed with an emphasis on the potential for air quality, vegetation, and human health impacts from O_3 released during the experiments. The description of the proposed action was obtained from site documents and personal communications with site staff (Karnosky et al. 2004; Nelson 2005; Kubiske 2005). The evaluation period considered in this EA extends from the current time to 10 years in the future.

The first part of the proposed action is the extension of the fumigation system by 5 m (16 ft), a height needed to support experiments in the canopy for an additional 5 to 6 years. The sequence of the infrastructure modifications would consist of the following steps:

- Removal of center poles and support poles and replacement with new longer poles – either galvanized metal poles or wooden poles;

- Preparation of new vertical vent pipes by an internal work crew. Preparation would include cutting the polyvinyl chloride (PVC) pipes to the desired length and installation of new baffles adjacent to the slots in each pipe used for fumigation;

- Installation of new vertical vent pipes; and

- Raising the height of the elevated canopy-access walkways in each ring.

The first task of the first extension will be to replace the wooden center poles with longer poles to increase the height of sensors to a level that is at the top of the canopy. The center poles support wind-speed and wind-direction monitoring equipment and canopy air monitoring lines. At this time, it is not certain whether metal or wooden poles will be used. If metal poles are used, then the center pole extension will be in two 5-m (16-ft) increments, one in the near term and the second after about five years. If wooden poles are used, the poles would be long enough to support the entire 10-m (33-ft) extension of the fumigation system (i.e., the first 5-m [16-ft] extension to be done in the winter of 2006-2007, and the second extension done 5 to 6 years later). The extension of the center poles could be completed in about one week by two workers. Pole removal and replacement would be conducted by a Forest Service contractor. Although a contractor has not been selected, it is expected that a crane would be required to set the new center poles.

The second task would involve extension of the vertical vent pipes to accommodate dispensing gases at various heights from the forest floor upward through the tree canopy. For this task, the existing vent pipes would first be removed. Then the wooden vertical vent pipe support poles would be replaced, requiring a crew of four people working for one month. A total of 16 support poles would be replaced around the perimeter of each ring. As for the center poles discussed above, it is not yet known whether the support poles will be metal or wooden and whether the extensions will be done in one 10-m (33-ft) increment or two 5-m (16-ft) increments. The support poles would likely be put in place by a pole-setting truck similar to that used by Wisconsin Power and Light Company when the original poles were placed in each ring.

Preparation of the vertical vent pipes (32 per ring) and modifications to the baffles would be done by three site staff inside an existing onsite building. These modifications would likely occur during a two to three month period in the winter months prior to the time of work on pole removal and replacement (Nelson 2005).

A third infrastructure change required for the first extension would increase the height of the existing walkways used by researchers to allow continued access to the tree canopy. The original walkway system was designed to allow manual lifting of the walkways. Walkways are supported by metal scaffolding. The walkway modifications are expected to require a four-person crew about two to three weeks to complete.

The construction workforce would make the infrastructure modifications during a six-month period from the fall of 2006 to the winter and early spring of 2007 (Nelson 2005). Work would proceed during this time as weather conditions permit. This time period would not conflict with any experiments under way and would allow completion of the infrastructure modifications before start of the 2007 growing season. The construction crew is expected to work eight-hour shifts, five days per week. New wood or galvanized metal poles, vertical PVC vent pipes, and walkway materials would be transported to the site by trucks and stored on a grass-covered mowed area adjacent to the Quonset hut near the entrance to the User Facility (see Figure 1.1-1). This same area will also be used to store the existing wooden center and support poles once they are removed from the 12 rings. Equipment and worker vehicles would be parked in mowed areas adjacent to each ring during construction work.

Minor tree pruning and removal would be needed around the periphery of each ring to allow placement of the longer vertical vent pipes and support poles. Pruned branches and trees that were removed could be chipped and used as mulch in landscaped areas elsewhere on the User Facility. A decision will be made by the Forest Service on what to do with cleared and pruned vegetation prior to Michigan Technological University letting a contract for the infrastructure modifications.

Removal and replacement of the center poles and support poles would disturb a small area around the base of each pole. The soil removed during extraction of the poles would be used as backfill or spread evenly over the disturbed area (an area, 2 m [6.6 ft] in diameter).

A water truck would be used, if necessary, to control dust generated during construction. During dry periods when vehicles create fugitive dust while traveling along site roads, water would be applied as needed.

The increased height of the vertical vent pipes would require more liquid CO_2 and O_3 than is currently used to maintain the desired concentration of these gases (CO_2 gas is maintained at about 570 parts per million by volume [ppm]; O_3 is kept to about 1.5 times the ambient level). In recent years, about two 18-MT (20-ton) CO_2 tanker trucks per day were required during the period from approximately May 15 to October 1, when the fumigation experiments were in progress (Nelson 2005). It is estimated that each growing season the amount of CO_2 and O_3 emitted will need to be increased by 10% to maintain these concentrations in the center of each ring. For CO_2, by the end of the evaluation period considered (i.e., after about 10 years), about three additional tanker truck deliveries of liquid CO_2 per day above the current shipments of two per day would be required. The need for increased O_3 would require a minimal increase in liquid oxygen shipments (currently receive two shipments per growing season), but would require the replacement of the O_3 generator. The current generator has a capacity of 23 kg (50 lb) O_3 per day; the new generator would have a capacity of 36 kg (80 lb) O_3 per day. Installation of the new O_3 generator into the O_3 generation building would also require increased ventilation in the building to dissipate heat. A new roof-top ventilation fan would accommodate this need.

Currently no modifications are planned for the placement or operation of existing O_3 and CO_2 monitors located around the site boundary. With the exception of increased CO_2 and O_3 emission rates, the User Facility would continue to operate as it has since 1998 when experiments were first conducted for a full growing season. A description of the operation of the User Facility is included in Appendix A. A more thorough treatment of the experiments and functioning of the User Facility is included in Dickson et al. (2000).

The second part of the proposed action would occur about 5 to 6 years after the first extension, and would extend the vertical vent pipes another 5 m (16 ft). This phase would also extend the center poles and support poles by 5 m (16 ft) if metal poles that could accommodate extensions were used initially. The construction work required for this second phase would not be as extensive as for the first phase, because either the center poles and vent pipe support poles will not require replacing at all, or these poles will be extended without being replaced. However, at about this same time the vertical walkways will either need to be raised, or will need to be replaced if raising is not feasible.

2.1.2 No Action Alternative

Under the no action alternative, proposed infrastructure modifications would not be made, but research would continue at the facility. In order to accomplish this, there would be two possibilities: (1) continue to operate even though the vent heights would not allow optimal fumigation, especially in the CO_2 rings where the trees are the tallest; or (2) remove the existing trees in the rings and replant (with the same species or with other species for which research data on the effects of CO_2 and O_3 are needed). This latter possibility would require disposal of the wood from the current trees in the rings and modification of the heights of the vents in the vertical vent pipes. It also would mean that the amount of CO_2 and O_3 emitted would be maintained at levels similar to current levels or less. For this assessment, it is assumed that emissions would remain at current levels under the no action alternative, and that the current trees in the rings will not be removed.

2.2 Alternatives Not Considered for Further Analysis

The Forest Service considered another alternative but concluded it was not consistent with its research mission, and chose not to include it for analysis in the EA. This alternative would be to stop all research now and not implement the infrastructure modifications. This alternative would include removal of the existing infrastructure associated with each of the 12 rings and would constitute a full decommissioning. If implemented, this alternative would not allow researchers to complete experiments that are under way on the effects of CO_2 and O_3 exposure on northern hardwood ecosystems.

2.3 Comparison of Alternatives

Table 2.3-1 provides a summary of the impacts under the proposed action and no action alternative for the assessment areas of interest in this EA. Although there are some minor and temporary adverse impacts associated with construction at the site, these impacts would not be significant. O_3 emissions from the site would not cause exceedance of air quality standards.

Infrequent elevated O_3 concentrations could cause leaf damage to some plants, but decreased crop yields are not expected. Most of the leaf damage, if any occurs, would be due to background, non-site ozone sources. If an individual with particular sensitivity to ozone spent several hours near the site fence line on one of the infrequent days with an elevated ozone level, that person could experience some respiratory discomfort. From 84% to 96% of these possible occurrences of ozone effects on human health would be solely due to background, non-site sources. Site emissions contribute less than 5% to the exceedance when an exceedance occurs due to a combination of background and site emissions. The incidence of such an adverse health impact on an individual is expected to be very low, if it occurs at all. No adverse health impacts due to site emissions would be seen at actual residential locations under either the proposed action or no action alternatives.

This EA concludes the proposed action and no action alternative for the FACE site would result in minimal or no adverse impacts to air quality, noise, ecology, human health and safety, socioeconomics, environmental justice, and visual resources.

TABLE 2.3-1 Comparison of the Proposed Action and No Action Alternatives at Aspen FACE Site

Impact Area	Impacts of Proposed Action	Impacts of No Action (Continued Site Operations)
Air Quality	Construction: Insignificant and temporary increase in engine exhaust and fugitive dust emissions. Operations: Increase in emissions of O_3, but no exceedance of 1-hour or 8-hour standards. Increase in emissions of CO_2, but negligible impact on global warming.	Construction: Not applicable. Operations: CO_2 and O_3 emissions unchanged from current levels. No exceedance of standards.
Noise	Construction: Temporary minor impact near the fence line; negligible impact at nearest residences. Operations: Below EPA guidelines for residential zones at the site fence lines; negligible impact at nearest residences.	Construction: Not applicable. Operations: No increase above current levels.
Ecology	Construction: Minimal and non-measurable impacts. Operations: No or minimal impacts to animal populations. Possible minimal damage to plant leaves from a low incidence of O_3 levels exceeding the damage threshold at adjacent offsite areas (70% of the O_3 exceedances are due solely to background, non-site sources); damage insufficient to cause decreased crop yields. No impacts to threatened and endangered species or species of concern. No impacts to wetlands or floodplains.	Construction: Not applicable. Operations: No or minimal impacts to animal populations. Possible minimal damage to plant leaves from a low incidence of O_3 levels exceeding the damage threshold at adjacent offsite areas (87% of the O_3 exceedances are due solely to background, non-site sources); damage insufficient to cause decreased crop yields. No impacts to threatened and endangered species or species of concern. No impacts to wetlands or floodplains.
Human Health	Construction: Minimal impacts. Operations: Possible infrequent days that a hypothetical sensitive individual located at the fence line would experience respiratory discomfort (84% of O_3 exceedances are due solely to background, non-site sources). No impacts at existing residential locations.	Construction: Not applicable. Operations: Possible infrequent days that a hypothetical sensitive individual located at the fence line would experience respiratory discomfort (96% of the O_3 exceedances are due solely to background, non-site sources). No impacts at existing residential locations.
Socioeconomics	Construction: Create 4 temporary jobs, about $0.3 million in income. Operations: Sustain 7 direct jobs, 5 indirect jobs, about $0.3 million income annually.	Construction: Not applicable. Operations: Sustain 7 direct jobs, 5 indirect jobs, about $0.3 million income annually.
Environmental Justice	No high and adverse impacts to minority or low income populations.	No high and adverse impacts to minority or low income populations.
Visual Resources	Increased visibility of structures from roads adjacent to the site. Appearance consistent with existing conditions. Minimal impacts.	No change from existing conditions.
Cumulative Impacts	Minimal impacts.	Minimal impacts.

3 ENVIRONMENTAL SETTING

3.1 Hydrology

No surface water is present on or in close proximity to the FACE site (Oneida County 2005). The nearest surface water bodies are two small lakes located approximately 1 km (0.6 mi) to the northeast of the site, a small pond located approximately 0.8 km (0.5 mi) to the east, and Bearskin Creek (a tributary of the Tomahawk River) located about 1.6 km (1 mi) to the west. The FACE site is relatively flat, and elevations range from 488 to 491 m (1,600 to 1,612 ft) above mean sea level. Surface water drains generally towards the west, and the FACE site is located entirely within the Middle Tomahawk River watershed (Oneida County 2005).

A geotechnical investigation of the site determined that groundwater was present in underlying alluvial deposits at depths of 2.3 to 2.7 m (7.5 to 9 ft) (USFS 2005b). The facilities onsite are served by an existing septic system and a 32-m (104-ft) deep well. A planned upgrade in association with the new laboratory facility will include installation of a new septic system and a new potable well (USFS 2005b).

3.2 Soils and Geology

Soils of the site are well-drained Padus loam, with 0 to 6% slopes, underlain by glacial outwash of stratified sand and gravel (Oneida County 2005; USFS 2005b). These soils are suitable for agriculture, and the site was used to grow potatoes until it was developed as a research facility in the mid-1970s, when it was used for testing hybrid poplar and other short rotation species, and then in 1996 as the FACE facility. Soil borings taken as part of a geotechnical investigation of the site determined that 20 to 30 cm (8 to 12 in.) of topsoil was underlain by alluvial deposits that consisted primarily of layers of sands, sands with silt, and gravel. The alluvium continued to the full boring depth of 6.4 m (21 ft) below the ground surface. Groundwater was encountered in all the borings at depths of 2.3 to 2.7 m (7.5 to 9 ft).

3.3 Land Use and Cultural Resources

The entire FACE site is used as a research facility. It is fenced and not accessible to the public. The site is served by two paved roads (Horsehead Lake Road 400 m [1,300 ft] east of the site and Harshaw Road about 800 m [2,600 ft] south of the site) and two entirely or partially-gravel roads (Webster Road at the north site boundary and Grace Lane at the west site boundary) that connect with paved local roads and highways (County Road K). Parts of Horsehead Lake Road were repaved in 2005. Research and maintenance vehicles and delivery vehicles, including heavy trucks, access the site regularly.

Figure 3.3-1 is an aerial photo of the site showing nearest residences and farm buildings. The FACE site is surrounded by land classified as cropland and pasture, mixed forest land, and evergreen forest land (Oneida County 2005). The land is federally owned (Forest Service) and privately owned. Privately owned lands are used for residential and agricultural purposes, especially hay production and pasture land. The nearest residences are located 0.8 km

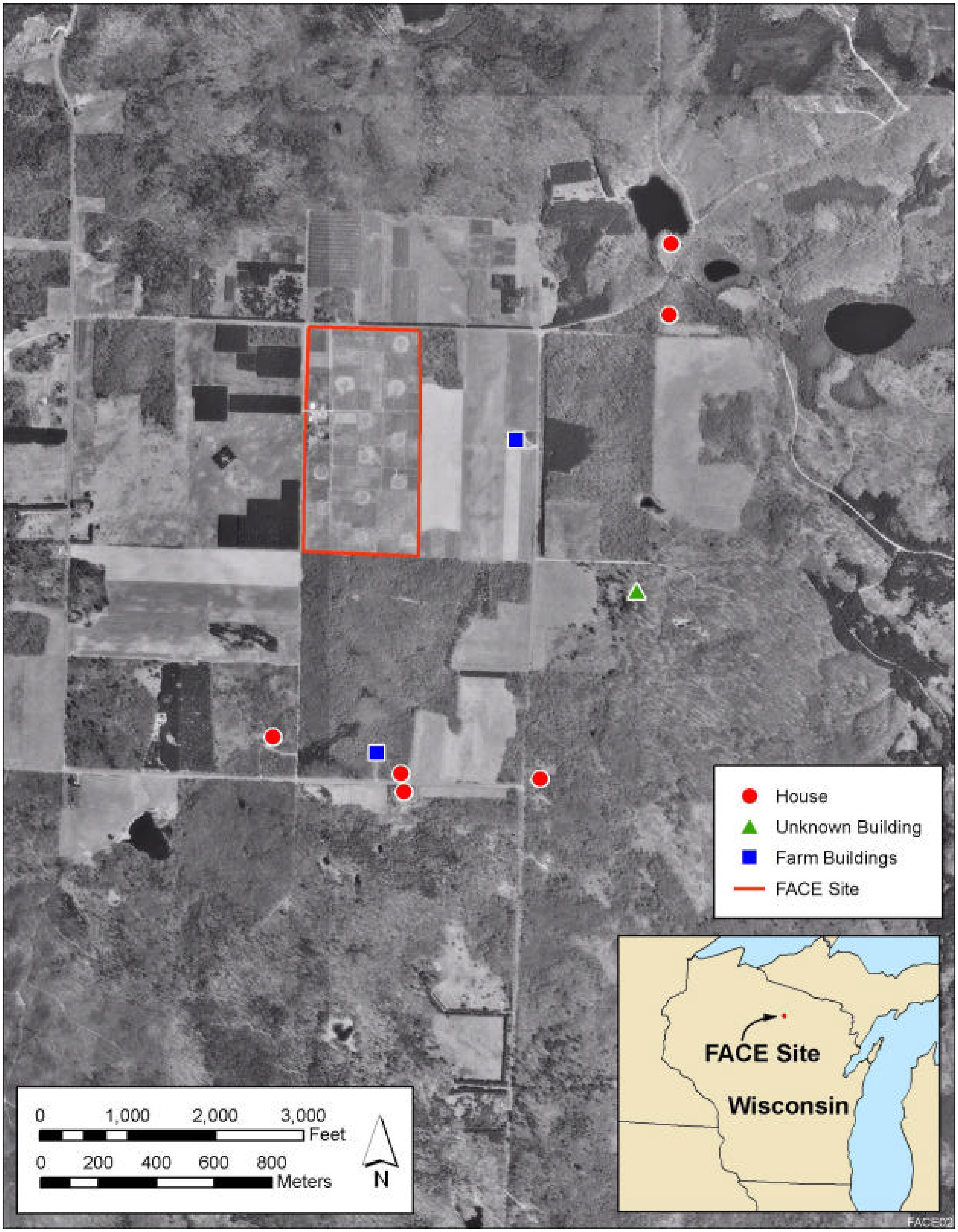

FIGURE 3.3-1 Aerial Photo of FACE Site and Surrounding Area (Source: USGS et al. 2005).

(0.5 mi) to the south and northeast of the site. Snowmobiling and hunting are popular recreational activities in the area (USFS 2005b).

The occurrence of intact archaeological remains at the FACE site is considered unlikely because the soils of the site have been extensively disturbed. From the 1920s until the mid-1970s when the Forest Service purchased the property, the site was used as a potato farm (USFS 2005b). Construction of the FACE facility further disturbed the soils of the site. The buildings on the site are less than 50 years old and not of historic interest, and do not meet criteria for listing on the National Register of Historic Places.

In preparing the Environmental Assessment (EA) for the proposed Harshaw Field Laboratory building on the FACE site, the Forest Service consulted the National Register to determine if any nearby Federally or state-listed historic sites or districts would be impacted by the proposed project (USFS 2005b). The nearest listing was more than 16 km (10 mi) away.

3.4 Ecology

Using the Bailey ecoregion system, the FACE site is located in the Laurentian Mixed Forest Province of the Warm Continental Division (Bailey 1995). Most of this province has low relief, but rolling hills occur in many places. Lakes, poorly drained depressions, and a variety of glacial features are typical of the area. Winters are moderately long and can be severe. Average annual temperatures range from 2 to 10^{o}C (35 to 50^{o}F). A short growing season imposes severe restrictions on agriculture; the frost-free season lasts from 100 to 140 days. Average annual precipitation is moderate, and ranges from 61 to 115 cm (24 to 45 in.), with most precipitation occurring in summer.

The Laurentian Mixed Forest Province lies between the boreal forest and the broadleaf deciduous forest zones (Bailey 1995). Part of the province is composed of mixed stands of coniferous (pine—*Pinus* sp.) and deciduous species (mainly yellow birch—*Betula alleghaniensis,* sugar maple—*Acer saccharum*, and American beech—*Fagus grandifolia*); the remainder is a mosaic of pure deciduous forest in favorable habitats with good soils and pure coniferous forest in less favorable habitats with relatively poor soils. Soils of the province include peat, muck, marl, clay, silt, sand, gravel, and boulders in various combinations (Bailey 1995).

The FACE facility is located on land that had been farmed for potatoes from the 1920s through the 1970s. The site consists of patches of planted nine-year-old aspen, paper birch, and sugar maple within each of the experimental ring structures, with old field (mowed periodically to control woody species), regularly mowed grasses, and patches of immature trees interspersed across the remainder of the site. The area near the western entrance to the site has been developed to support research on the site. According to Oneida County (2005), no wetlands, floodplains, or surface waters exist on or adjacent to the FACE facility; however, a small depression north of the FACE facility entrance has saturated soil during wetter periods of the year.

The Forest Service contacted the U.S. Fish and Wildlife Service (FWS) in July 2005 to request a list of threatened and endangered species that could occur on and in the vicinity of the FACE site. FWS responded with a list of species known from Oneida County (bald eagle, [*Haliaeetus leucocephalus*], threatened; gray wolf, [*Canis lupus*], endangered; and Canada lynx, [*Lynx canadensis*], threatened), and stated that no Federally listed threatened or endangered species or designated critical habitat are known to exist on the site (Smith 2005). A biological evaluation of the FACE site was performed by the Forest Service for the Harshaw Field Laboratory EA to determine the occurrence of any Federally or state-protected threatened or endangered plant species or suitable habitat on the site (USFS 2005b). That evaluation determined that potentially suitable habitat for 5 plant, 3 invertebrate, 12 bird, and 5 mammal species was present within 0.8 km (0.5 mi) of the site (Table 3.4-1). None of these species or their habitats are known to occur on the FACE site.

3.5 Meteorology, Air Quality, and Noise

3.5.1 Meteorology

The climate around the Aspen FACE site is continental and is largely determined by the movement and interaction of large air masses (Burley 1960). Winters are usually long and cold, while summers are warm and pleasant. Temperatures fluctuate considerably from season to season and from year to year.

Wind data from the onsite meteorological station, which is located near the north boundary of the Aspen FACE site, have been measured at five levels (2, 5, 10, 15, and 20 m [7, 16, 33, 49, and 66 ft]). The annual wind rose at the 10-m (33-ft) level for the five-year period 2000 through 2004 is shown in Figure 3.5-1 (USFS 2005a). Predominant wind directions are from the west, ranging from south-southwest to west-northwest. These winds also have higher directional wind speeds than those for any other direction. During the 2000-2004 period, the average wind speed measured at the 10-m (33-ft) level was about 1.9 m/s (4.3 mi/hr), which is about 60% of that at Rhinelander Airport. This seems to be due to the fact that the Aspen FACE site is surrounded by tall trees. Note that the area experiences calm winds at the relatively high frequency of about 18%, especially a higher frequency of about 41% during nighttime hours in summer.

The historical (1951-1980) annual average temperature at Rhinelander, Wisconsin, is 5.1°C (41.2°F) (Ruffner 1985). January is the coldest month, averaging –11.9°C (10.5°F), and July is the warmest month, averaging 19.9°C (67.9°F). During the same period, the highest temperatures reached 36.7°C (98°F) and the lowest, –40°C (–40°F).

The average annual precipitation is approximately 78.0 cm (30.72 in.) (Ruffner 1985). Precipitation is light in winter, increasing in spring and summer. Annually, the area experiences about 30 thunderstorms. Snowfall is quite variable (ranging from 56-254 cm [22-100 in.]) from year to year, and the annual average snowfall in the area is about 130 cm (51.2 in.).

Tornadoes are relatively frequent in the area surrounding the Aspen FACE site, though less frequent than in "tornado alley," which stretches from Texas to Nebraska and Iowa. From 1950 to May 2005, 1,100 tornadoes were reported in Wisconsin, with a tornado event frequency of

TABLE 3.4-1 Federally and State-Listed Threatened and Endangered Species, State Species of Special Concern, and Regional Forester Sensitive Species that Could Occur on or in the Vicinity of the FACE Site

Common Name	Scientific Name	Federal Status[1]	State Status[1]	USFS Status[1]	Habitat
<u>Plants</u>					
Dwarf huckleberry	*Vaccinium cespitosum*	NL	LE	SS	Openings in aspen or hardwood forests, sandy fields, and rocky streambanks
Large-flowered ground-cherry	*Leucophysalis grandiflora*	NL	SC	SS	Dry, rocky sandy openings
Pale beardtongue	*Penstemon pallidus*	NL	SC	NL	Dry open rocky woods, bluff ledges, prairies
Rocky mountain sedge	*Carex backii*	NL	SC	SS	Dry rocky and sandy ground
Ternate grape fern	*Botrychium rugulosum*	NL	NL	SS	Fields, clearings, and young forests
<u>Invertebrates</u>					
Red-disked alpine	*Erebia discoidalis*	NL	SC	NL	Large, open, grassy bogs; other areas with acidic soils
Tawny crescent	*Phyciodes batesii*	NL	SC	SS	Moist meadows and pastures
West Virginia white	*Pieris virginiensis*	NL	NL	SS	Moist deciduous woodlands or mixed woods
<u>Birds</u>					
Bald eagle	*Haliaeetus leucocephalus*	LT	NL	NL	Breeds in wooded areas along large rivers and lakes
Evening grosbeak	*Coccothraustes vespertinus*	NL	SC	NL	Breeds in woodland habitat
Gray jay	*Perisoreus canadensis*	NL	SC	NL	Breeds in woodland habitat
Henslow's sparrow	*Ammodramus henslowii*	NL	NL	SS	Breeds in undisturbed pastures and meadows
Merlin	*Falco columbarius*	NL	SC	NL	Breeds in coniferous forests near open areas

TABLE 3.4-1 (cont.)

Common Name	Scientific Name	Federal Status[1]	State Status[1]	USFS Status[1]	Habitat
Northern goshawk	*Accipiter gentilis*	NL	NL	SS	Breeds in boreal and temperate forests
Northern harrier	*Circus cyaneus*	NL	SC	NL	Breeds in open fields and marshes
Red-shouldered hawk	*Buteo lineatus*	NL	LT	SS	Breeds in bottomland hardwoods, mesic deciduous or mixed deciduous-conifer forests
Swainson's thrush	*Catharus ustulatus*	NL	NL	SS	Breeds in coniferous or mixed forest
Upland sandpiper	*Bartramia longicauda*	NL	NL	SS	Breeds in grasslands, meadows, and pastures
Black-backed woodpecker	*Picoides arcticus*	NL	NL	SS	Breeds in coniferous and mixed forest
Sharp-tailed grouse	*Tympanuchus phasianellus*	NL	NL	SS	Resident in open grassland
Mammals					
Arctic shrew	*Sorex arcticus*	NL	SC	NL	Tamarack and spruce swamps
Gray wolf	*Canis lupus*	LE	LT	NL	Northern and central forests
Pygmy shrew	*Sorex hoyi*	NL	SC	NL	Wooded and open areas
Water shrew	*Sorex palustris*	NL	SC	NL	Bogs and along cold streams
Woodland jumping mouse	*Napaeozapus insignis*	NL	SC	NL	Forested or brushy areas near water, bogs, stream borders

[1] LE = listed as endangered, LT = listed as threatened, NL = not listed, SC = state species of special concern, SS = Regional Forester sensitive species.

Source: USFS (2005b).

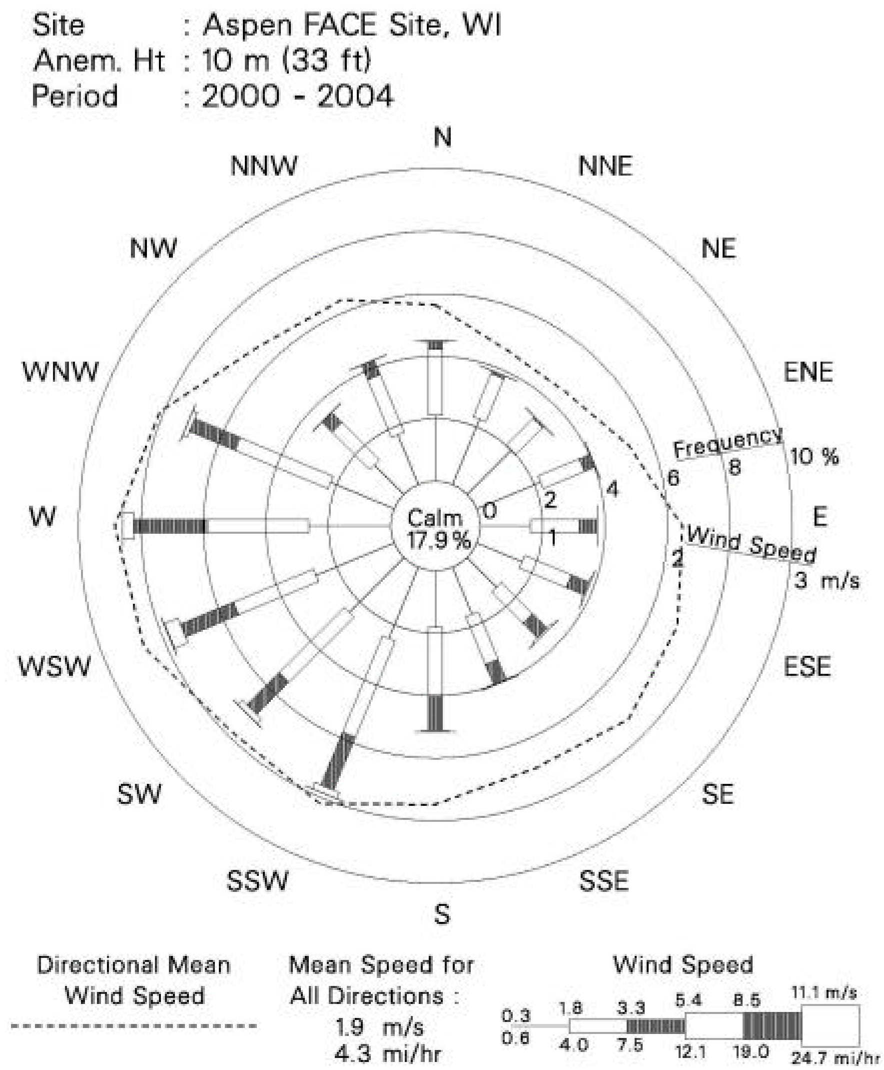

FIGURE 3.5-1 Wind Rose at the 10-m (33-ft) Level for the Aspen FACE Meteorological Station, Wisconsin, 2000–2004 (Source: USFS 2005a)

3.7×10^{-4} per year per square mile and an average of 20 tornadoes per year (National Climatic Data Center 2005). For the same period, 20 tornadoes were reported in Oneida County, with a tornado event frequency of 3.2×10^{-4} per year per square mile. Over the 55-year period, most tornadoes that occurred in Oneida County were relatively weak (except for one F4 in 1950 and two F3s in 1984 and 1985, on the Fujita tornado scale).[1] During the past 55 years, the area near the Aspen FACE site was struck by one tornado (in the mildest class of tornado of F0[1]) on July 11, 2004.

[1] Fujita scale F0, F3, and F4 are classified as gale, severe, and devastating tornados with wind speeds of 18-32 m/s (40-72 mi/hr), 71-92 m/s (158-206 mi/hr), and 93-116 m/s (207-260 mi/hr), respectively.

3.5.2 Existing Emissions

The Aspen FACE site was exempted from permitting requirements by the Wisconsin Department of Natural Resources (WDNR) under the provision that sources will not violate or exacerbate a violation of the air quality standard or ambient air increment (Baudhuin 2005), so the site does not have an air quality permit. Currently the site has neither a heating unit (e.g., boiler) nor emergency diesel generator; therefore, no stationary emission sources exist at the site. Minor sources are exhaust emissions from mowers, tractors, commuting cars, and delivery trucks (two CO_2 trucks per day). Most of the site is covered with grasses and tall trees, so fugitive dust emissions caused by wind erosion and mobile equipment are minimal.

In association with current site operations, O_3 fumigated to trees from O_3 gas-emitter tubes at the six rings is the only emission source of criteria pollutants. Based on 2000-2004 monitoring data, the annual average mass of O_3 being fumigated was 423 kg (932 lb) with 117 days and 940 hours of operations per year (Nagy 2005), as shown in Table 3.5-1. Daily emissions vary depending on meteorological conditions such as wind speed, rainfall, and presence of dew in the mornings. Annual emissions during the period 2000-2004 have varied, from a minimum of about 400 kg (875 lb) in 2002 to a maximum of 454 kg (1,000 lb) in 2000.

3.5.3 Air Quality

The Wisconsin State Ambient Air Quality Standards (SAAQS) for six criteria pollutants — sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), particulate matter (PM_{10} and $PM_{2.5}$),[2] and lead (Pb) — are identical to the National Ambient Air Quality Standards (NAAQS) with a few exceptions (WDNR 2005), as shown in Table 3.5-2. The only criteria air pollutant of potential concern for the FACE site is O_3.

TABLE 3.5-1 O_3 Fumigation Rates Associated with Site Operations at the Aspen FACE Site, Harshaw, Wisconsin, for Years 2000-2004

	Duration of Operation		O_3 Fumigated Mass		
Year	Days	Hours	(g)	(lb)	(lb/day)
2000	121	911	454,297	1,001.5	8.3
2001	124	958	417,853	921.2	7.4
2002	107	902	396,695	874.5	8.2
2003	117	992	441,965	974.3	8.3
2004	115	938	402,260	886.8	7.7
Total	584	4,701	2,113,070	4,658	-
Annual average	117	940	422,614	931.7	8.0

Source: Nagy (2005).

2 PM_{10} and $PM_{2.5}$ are particulate matter with an aerodynamic diameter ≤ 10 μm and ≤ 2.5 μm, respectively.

TABLE 3.5-2 National Ambient Air Quality Standards (NAAQS), Wisconsin State Ambient Air Quality Standards (SAAQS), and Highest Background Levels (2000-2004) Representative of the Aspen FACE Site, Harshaw, Wisconsin

		NAAQS[c]/Wisconsin SAAQS			Highest Background Levels	
Pollutant[a]	Averaging Time[b]	Standard Value		Standard Type[d]	Concentration[e]	Location (Year)[f]
SO_2	3 hours	0.5 ppm	(1,300 µg/m³)	S	0.227 ppm (45%)	Rhinelander (2000)
	24 hours	0.14 ppm	(365 µg/m³)	P	0.098 ppm (70%)	Rhinelander (2004)
	Annual	0.030 ppm	(80 µg/m³)	P	0.006 ppm (20%)	Rhinelander (2002)
NO_2	Annual	0.053 ppm	(100 µg/m³)	P, S	0.021 ppm (40%)	Milwaukee (2001)
CO	1 hour	35 ppm	(40 mg/m³)	P[g]	7.4 ppm (21%)	Milwaukee (2004)
	8 hours	9 ppm	(10 mg/m³)	P[g]	3.7 ppm (41%)	Milwaukee (2003)
O_3	1 hour[h]	0.12 ppm	(235 µg/m³)	P, S	0.087 ppm (73%)	Harshaw (2001)
	8 hours	0.08 ppm	(157 µg/m³)	P, S	0.073 ppm (91%)[i]	Harshaw (2001)
TSP	24 hours	150 µg/m³		S	N/A[j]	N/A
PM_{10}	24 hours	150 µg/m³		P, S	27 µg/m³ (18%)[i]	Crandon, Forest Co. (2003)
	Annual	50 µg/m³		P, S	16 µg/m³ (32%)	Crandon, Forest Co. (2002)
$PM_{2.5}$[k]	24 hours	65 µg/m³		P, S	22 µg/m³ (34%)[l]	Boulder Junction, Vilas Co. (2003)
	Annual	15.0 µg/m³		P, S	8 µg/m³ (53%)	Boulder Junction, Vilas Co. (2003)
Pb	Calendar quarter	1.5 µg/m³		P, S	0.0 µg/m³ (0%)	Boulder Junction, Vilas Co. (2002)

[a] Notation: CO = carbon monoxide; NO_2 = nitrogen dioxide; O_3 = ozone; Pb =lead; $PM_{2.5}$ = particulate matter ≤ 2.5 µm; PM_{10} = particulate matter ≤ 10 µm; SO_2 = sulfur dioxide; and TSP = total suspended particulates.

[b] Time period over which concentrations are averaged for comparison to the standard.

[c] Refer to 40 CFR Part 50 for detailed information on attainment determination and reference method for monitoring.

[d] P=Primary Standards, which set limits to protect public health; S =Secondary Standards, which set limits to protect welfare.

[e] Values in parentheses are monitored concentrations as a percentage of NAAQS.

[f] For each pollutant, the location shown is the closest monitoring station tothe FACE site. For some pollutants, values for Milwaukee are shown because these are the highest monitored values in Wisconsin but are still well below the standard .

[g] Wisconsin has a secondary standard having the same value as the primary standard.

[h] EPA's revised O_3 standards will replace the current 1-hour standard. However, the 1-hour standard will continue to apply to areas not attaining it for an interim period to ensure an effective transition to the new 8-hour standard.

[i] The 4th highest.

[j] Not available.

[k] Wisconsin has not adopted $PM_{2.5}$ standards at the time of this writing.

[l] The 98th percentile.

Sources: *Code of Federal Regulations*, Title 40, Part 50 (40 CFR 50); WDNR 2005; U.S. EPA 2005.

The Aspen FACE site in Oneida County, Wisconsin is located in the North Central Wisconsin Intrastate Air Quality Control Region (AQCR 238), which covers central and north central Wisconsin. Oneida County is currently an attainment area for all criteria pollutants (indicating it meets the standards; Title 40, Part 81, Section 350 of the *Code of Federal Regulations* [40 CFR 81.350]).

Currently, O_3 is the only criteria pollutant that is regularly monitored at the Aspen FACE site, as part of a state-wide monitoring program. Ambient air quality data representative of the site for the five-year period (2000-2004) are summarized in Table 3.5-2. Based on the monitoring data, concentration levels for all criteria pollutants around the Aspen FACE site are less than 91% of their respective NAAQS. The concentration of O_3, whose formation and transport is a regional issue, is close to its standard.

Since the site is not a major air emissions source, prevention of significant deterioration (PSD) regulations (40 CFR 52.21) are not applicable.

3.5.4 Noise

The Noise Control Act of 1972, along with its subsequent amendments (Quiet Communities Act of 1978, *United States Code*, Title 42, Parts 4901-4918), delegates to the states the authority to regulate environmental noise and directs government agencies to comply with local community noise statutes and regulations. The State of Wisconsin and Oneida County where the Aspen FACE site is located have no quantitative noise-limit regulations.

The EPA guideline recommends a day-night average sound level (L_{dn}[3] or DNL) of 55 dBA[4], which is sufficient to protect the public from the effect of broadband environmental noise in typically quiet outdoor and residential areas (EPA 1974). These levels are not regulatory levels, but are "intentionally conservative to protect the most sensitive portion of the American population" with "an adequate margin of safety." For protection against hearing loss in the general population from nonimpulsive noise, the EPA guideline recommends an L_{eq}[5] of 70 dBA or less over a 40-year period.

As shown in Figure 3.3-1, the Aspen FACE site is located in a rural area, surrounded by private agricultural property and Forest Service-owned property covered with managed wooded plots. The major noise sources around the Aspen FACE site are heavy equipment from logging and agricultural activities and infrequent cars and trucks along the nearby roads.

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3 L_{dn} is the day-night A-weighted average sound level, averaged over a 24-hour period, after the addition of 10 dB to sound levels from 10 p.m. to 7 a.m. to account for increased annoyance from nighttime noise.

4 dBA is a unit of weighted sound-pressure level, measured by the use of the metering characteristics and the A-weighting specified in the *American National Standard Specification for Sound Level Meters ANSI S1.4-1983* and *Amendment S1.4A-1985* (Acoustical Society of America 1983, 1985).

5 L_{eq} is the equivalent-continuous sound level that, if continuous during a specific time period, would represent the same A-weighted sound energy as the actual time-varying sound. For example, L_{eq}(1-h) is the 1-hour equivalent-continuous sound level.

Currently, major noise-generating sources from site operations are 12 fans with 7.5 hp motors, running only during daytime hours, and high-pitched noise from pressure-reducing valves. Other noise sources are infrequent vehicular traffic from commuters and delivery trucks, and miscellaneous activities, such as mowers. The CO_2 trucks emit a high-pitched loud noise that lasts 10 to 20 seconds when venting after unloading. The O_3 generator and auxiliary compressors are in enclosures. No offsite sensitive noise receptors (e.g., hospitals, schools) are located around the site. The nearest residences are located about 0.8 km (0.5 mi) south and northeast of the site.

Daytime and nighttime ambient sound level measurements were performed by Argonne National Laboratory staff at the Aspen FACE site fence lines and on Horsehead Lake Road to the east side of the property (near the barn on that property, shown in Figure 3.3-1) in late September 2005. During the daytime when all rings were in operation, measured noise levels ranged from 45 dBA at the north fence line to 53 dBA at the east fence line. On Horsehead Lake Road, the noise level was recorded at about 45 dBA. During nighttime hours with no site operations, noise levels were about 30 dBA or less at the north fence line and 38 dBA at the west gate (somewhat higher than other fence lines due to phase converters, consisting of a one-phase motor and a three-phase generator, with noise levels similar to a 10-kilowatt electric motor).

3.6 Socioeconomics

In this section, two key measures of economic development, employment and personal income, are described for a region of influence (ROI) for the FACE facility. The ROI is defined as Oneida County, which is the area in which staff, researchers, and students at the site spend their wages and salaries during the operating season. Other local community impact measures, such as population, housing, public services, and education, are not included in the description of the ROI, as they are not expected to be impacted, with no non-resident labor force likely to reside in the county for either construction or operation of the facility.

Employment. In 2003, total employment in the county was 15,166, and it is expected to reach 16,000 in 2005 (Table 3.6-1). County employment grew at an annual average rate of 3% over the period 1993 through 2003. The economy of the county is dominated by wholesale and retail trade and service industries, with employment in these activities currently contributing almost 73% of all employment in the county. The manufacturing sector (10% of county employment) is also a significant employer in the county. Michigan Technological University employment at FACE currently stands at 2 full-time equivalents (Karnosky 2005b).

Income. Personal income in the state totaled $1.1 billion in 2003, and is expected to reach $1.2 billion in 2005 (Table 3.6-2). Personal income grew at an annual average rate of 2.7% over the period 1993 through 2003. County personal income per capita also rose over the period 1993 through 2003, and is expected to reach $29,200 in 2005, compared to $19,318 in 1993.

TABLE 3.6-1 County Employment by Industry

Sector	2003	% of County Total
Agriculture[a]	418	2.8
Mining	0	0.0
Utilities	175	1.2
Construction	903	6.0
Manufacturing	1,485	9.8
Transportation and warehousing	568	3.7
Wholesale and retail trade	4,033	26.6
Finance, insurance, and real estate	586	3.9
Services	6,988	46.1
Total[b]	15,166	100

[a] Data from 2002 shown.
[b] Includes 10 jobs classified as "other."

Source: Agriculture data USDA (2005), otherwise U.S. Bureau of the Census (2005a).

TABLE 3.6-2 County Personal Income (2004 dollars)

Parameter	1993	2003	Average Annual Growth Rate 1993-2003
Total personal income ($ millions)	640	1,068	2.7%
Personal income per capita ($)	19,318	27,770	1.2%

Source: U.S. Department of Commerce (2005)

3.7 Environmental Justice

Executive Order 12898, (February 16, 1994) formally requires federal agencies to incorporate environmental justice as part of their missions. Specifically, it directs them to address, as appropriate, any disproportionately high and adverse human health or environmental effects of their actions, programs or policies on minority and low-income populations.

The analysis of the impacts of the FACE facility on environmental justice issues follows guidelines described in the CEQ's *Environmental Justice Guidance Under the National Environmental Policy Act* (CEQ 1997). The analysis method has three parts: (1) a description of the geographic distribution of low-income and minority populations in the affected area; (2) an assessment of whether construction and operations would produce impacts that are high and adverse; and (3) if impacts are high and adverse, a determination as to whether there are disproportionate impacts to minority and low-income populations.

A description of the geographic distribution of minority and low-income groups was based on demographic data from the 2000 Census (U.S. Bureau of the Census 2005b) to describe the minority and low-income composition in the affected area, in this case Oneida County. The following definitions were used to define minority and low-income population groups:

- **Minority.** Persons are included in the minority category if they identify themselves as belonging to any of the following racial groups: (1) Hispanic, (2) Black (not of Hispanic origin) or African American, (3) American Indian or Alaska Native, (4) Asian, or (5) Native Hawaiian or Other Pacific Islander.

- **Low-Income.** Individuals who fall below the poverty line. The poverty line takes into account family size and age of individuals in the family. In 1999, for example, the poverty line for a family of five with three children below the age of 18 was $19,882. For any given family below the poverty line, all family members are considered as being below the poverty line for the purposes of analysis (U.S. Bureau of Census 2005a).

The CEQ guidance suggests that there is a potential for environmental justice impacts where minority and low-income populations in the affected area either (1) exceed 50%, or (2) the minority and low-income population percentage of the affected area is meaningfully greater than the minority and low-income population percentage in the reference geographic unit. This EA applies both criteria in using the Census Bureau data for Oneida County, wherein consideration is given to the minority and low-income population that is both over 50% of the total county population, and 20 percentage points higher than in the state (the reference geographic unit).

Data in Table 3.7-1 show the minority and low-income composition of Oneida County on the basis of 2000 Census data and CEQ guidelines. Individuals identifying themselves as Hispanic are included in the table as a separate entry. However, as Hispanics can be of any race, this number also includes individuals identifying themselves as being a part of one or more of the other population groups listed in the table. Less than 3% of the population in the county can be classified as minority, with 7.4% of the county population classified as low-income. Neither the minority nor the low-income population in Oneida County exceed 50% of the total population, and neither population exceeds the state minority and low-income average by more than 20 percentage points.

3.8 Visual Resources

The assessment of visual resources for the FACE site follows the guidelines of the Bureau of Land Management (BLM 2003), which consist of assessing the visual quality of the affected area, then assessing the impacts of the proposed action based on a contrast of the changes with the existing landscape.

TABLE 3.7-1 Minority and Low-Income Population Characteristics in Oneida County, Wisconsin

Parameter	Number of Individuals
MINORITY POPULATION	
Total Population	36,776
White	35,794
Total Minority	982
Hispanic or Latino	244
Not Hispanic or Latino	36,532
One Race	36,278
Black or African American	114
American Indian or Alaska Native	233
Asian	109
Native Hawaiian or Other Pacific Islander	14
Other Race	14
Two or More Races	254
LOW-INCOME POPULATION	2,721
Percent Minority	2.7%
Percent Low-Income	7.4%
Wisconsin Percent Minority	12.7%
Wisconsin Percent Low-Income	8.7%

Source: U.S. Bureau of Census (2005a).

The FACE site is in a rural setting, immediately bordered by land used for agriculture (cropland and pasture) and small wooded plots. Residences exist about 0.8 km (0.5 mi) or more to the south and to the northeast (Figure 3.3-1). Recreational use of surrounding areas is for hunting and snowmobiling.

The site is surrounded by a 3.6-m (12-ft) high deer fence; trees that screen the site are found in a limited number of locations at the fence line (see aerial photo in Figure 3.8-1). Vertical structures that can be seen from offsite locations include the approximately 8-m (26-ft) tall liquid oxygen storage tank, which can be seen from the western access gate, and the ring structures, which are currently about 11 m (36 ft) in height (the support poles are 10 m [33 ft] and the vertical vent pipes extend about 1 m [3.3 ft] above them). Most of the ring structures are partially shielded from view at offsite locations by surrounding stands of trees. However, the experimental trees and ring structures are generally taller than the surrounding trees at this time. Currently, the rings are most easily seen from offsite at the agricultural property and on Horsehead Lake Road to the east of the site. (Figure 3.8-1)

FIGURE 3.8-1 Top: Aerial View of the FACE Site and Surrounding Area; Bottom: View from Horsehead Lake Road, With Two Rings Visible

The scenic quality of the site was rated according to the BLM Visual Resource Management (VRM) inventory guidelines, which consider the following factors: landform, vegetation, water, color, influence of adjacent scenery, scarcity, and cultural modifications. The area of the FACE site is flat, with no landforms such as hills or relief in the vicinity. Vegetation and coloration are typical of the wooded plots in the surrounding area. There are no water bodies on the site. There are no items of particular visual interest or cultural modifications on the site or in the immediate area. According to this rating, the FACE site and surrounding area can be rated as Class C, indicating lands of minimal diversity or interest.

4 ENVIRONMENTAL IMPACTS

4.1 Air Quality and Noise

4.1.1 Air Quality Impacts during Construction

Proposed Action. As discussed in detail in Section 2.1.1, the proposed action involves the modifications to the infrastructure of the Aspen FACE User Facility that are needed for continuation of the CO_2 and O_3 fumigation experiments. The key modification is to raise the poles and vertical vent pipes approximately 10 m (33 ft) above the current height of approximately 10 m (33 ft). The extensions would take place in two phases. The first phase of the proposed action would consist of: (1) replacement of center poles and support poles with new longer poles, (2) preparation and installation of new vertical vent pipes, and (3) raising the height of the elevated canopy-access walkways in each ring. The second phase of the proposed action is another extension that would occur about 5 to 6 years after the first extension. The construction work required for this second phase would not be as extensive as for the first phase, because either the center poles and vent pipe support poles will not require replacing at all, or these poles will be extended without being replaced. However, replacement of the vertical vent pipes would be needed.

Potential air emission sources during construction activities at the facility would include fugitive dust and engine exhaust from heavy equipment and vehicular traffic, such as commuter and visitor vehicles and trucks for hauling, delivery, and dust control. However, these upgrades at the Aspen FACE site would be relatively small-scale activities without typical earthmoving activities. Associated with proposed construction activities, removal and replacement of the center poles and support poles would disturb a small area (about 2 m [6.6 ft] in diameter) around the base of each pole. Other emission sources would include some heavy equipment, such as a crane or pole-setting truck, operating for short periods of time (e.g., intermittently for about 2 weeks). The number of commuting vehicles and delivery trucks in and out of the site would be anticipated to increase slightly during the construction period. Small crews would be required from time to time during the late fall, winter, and spring months.

Currently, Oneida County, where the Aspen FACE site is located, is in attainment for all criteria pollutants (40 CFR 81.350). Considering the scale of construction activities, anticipated construction emissions would neither trigger violations of national or state ambient air quality standards at offsite locations nor become an air pollution concern. In particular, construction activities would be conducted so as to minimize potential impacts on ambient air quality. For example, where appropriate, fugitive dust would be controlled by established standard dust control practices for construction, primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles. The total length of construction would be about six months during late fall, winter, and spring. Construction activities would occur only during daytime hours when air dispersion is most favorable. As a result, potential impacts of construction activities on ambient air quality are expected to be insignificant and temporary in nature.

No Action Alternative. The Forest Service has identified the no action alternative as not implementing the infrastructure modifications, but continuing to conduct research at the facility. Under the no action alternative, no upgrades would occur; thus, there would be no fugitive dust or engine exhaust emissions from additional vehicles and heavy equipment onsite. Therefore, construction-related impacts on ambient air quality would not occur.

4.1.2 Air Quality Impacts during Operations

Ozone is the only criteria pollutant emitted at the site, and no additional emission sources or other criteria pollutants will be emitted over the next 10 years, which is the evaluation period considered in this EA. Truck traffic for CO_2 and O_3 deliveries is expected to increase somewhat, but the impact from fugitive dust and engine exhaust emissions would be negligible and not likely to become a concern. Therefore, potential impacts on ambient air quality from CO_2 and O_3 fumigation under the proposed action and no action alternatives were the focus of the EA analysis and will be discussed in detail in this section.

The air quality modeling analysis for O_3 performed by Argonne National Laboratory consisted of estimating emission rates and calculating concentration levels at receptor locations under varying meteorological conditions. For the proposed action and no action alternative, air emissions from O_3 fumigation were estimated on the basis of site-specific emissions data. These estimates were used to model air concentrations that might occur at potential offsite receptor locations where the general public could have access (i.e., at the fence line locations and beyond). The analysis was done for three scenarios: (1) base case (no action alternative, or current operations); (2) 5 years in the future; and (3) 10 years in the future (the end of the evaluation period considered in this EA). The method for estimating O_3 emissions associated with operation of the Aspen FACE site is provided in Section 4.1.2.1, and the air dispersion model used, model input data, and assumptions are discussed in Section 4.1.2.2. Modeling results and discussion are presented in Section 4.1.2.3. Potential impacts from CO_2 emissions at the site are discussed in Section 4.1.2.4.

4.1.2.1 O_3 Emission Estimates

For the base case, average O_3 emissions for the years 2000 to 2004 were used (Nagy 2005). For the purpose of this analysis, O_3 fumigation rates were assumed to increase at 10% per year over the next ten years, based on operational experience in the project with CO_2 fumigation in relation to expected crown development, which so far has shown a requirement for higher fumigation levels at higher release heights in order to achieve the target experimental center ring concentrations. This may be due to increased turbulence at higher release heights. Assuming this phenomenon also applies for O_3 fumigation, the O_3 fumigation rates would be 161% and 259% of the current level for 5 and 10 years in the future, respectively. Based on 2000 to 2004 data, O_3 emissions for the base case were estimated to be 423 kg/yr (932 lb/yr), more specifically, 3.6 kg/d (8.0 lb/d) over 117 days per growing season (Table 3.5-1). Assuming a 10% increase per year, O_3 emissions were estimated to be 681 kg/yr (1,500 lb/yr) and 1,096 kg/yr (2,417 lb/yr) for 5 and 10 years in the future, respectively. Average daily emission rates would be about 5.8 kg (12.8 lb) and 9.4 kg (20.7 lb) for 5 and 10 years in the future, respectively.

4.1.2.2 Air Dispersion Model, Model Input Data, and Assumptions Used in Air Quality Impact Analysis

Air Quality Model. For the analysis, the EPA's AERMOD (AMS/EPA Regulatory MODel) (Version 04300) (EPA 2002) was used to estimate increments in O_3 concentrations at offsite receptors as a result of O_3 fumigation emissions from the Aspen FACE site. AERMOD is a steady-state plume dispersion model for assessing pollutant concentrations from a variety of sources. In October 2005, the EPA promulgated AERMOD as the preferred air dispersion model in place of ISC3 (Industrial Source Complex Dispersion Model 3), which prior to that time had been EPA's preferred air dispersion model to support regulatory modeling. AERMOD simulates transport and dispersion from flat and complex terrain, surface and elevated releases, and multiple sources, including point, volume, and area sources. AERMOD can be applied to rural and urban areas. It is based on an up-to-date characterization of the atmospheric boundary layer and accounts for building wake effects and plume downwash. The model uses hourly sequential preprocessed meteorological data to estimate concentrations for averaging times from one hour to one year. It is a modeling system with three separate components: AERMOD (air dispersion model), AERMET (meteorological data preprocessor), and AERMAP (terrain data preprocessor).

Meteorological Data. The meteorological data preprocessor (AERMET) requires three types of data: National Weather Service (NWS) hourly surface observations; NWS twice-daily upper air soundings; and data collected from an onsite measurement program such as from an instrumented tower, if available. For this assessment, onsite meteorological data were used from a meteorological tower with five heights (2, 5, 10, 15, and 20 m [7, 16, 33, 49, and 66 ft]) located at the north end of the Aspen FACE site. Hourly surface meteorological data for Rhinelander Airport (10-m [33-ft] measurement height) and upper air sounding data (e.g., temperature, pressure) for Green Bay, Wisconsin, were also used for the analysis. These data were obtained from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center. Using the AERMET preprocessor, the most recent five years of meteorological data (2000 to 2004) were processed for input to the AERMOD model.

Receptor Location Data. For the analysis, a modeling domain of 10 km × 10 km (6.2 mi × 6.2 mi) centered on the Aspen FACE site was developed. In doing so, two sets of Cartesian[6] receptor locations were generated: (1) site fence line receptors and (2) regularly spaced receptor grids. Ninety-four fence line receptors were set 25 m (82 ft) apart along the Aspen FACE site boundaries. A total of 4,721 regularly spaced receptor grids were placed at 25-m, 50-m, 100-m, 250-m, and 500-m increments, beginning at the center of the Aspen FACE site and moving outward. The nearest offsite building (a barn on the farm located (340 m [1,120 ft]) to the east of the site) was also assumed to be a potential receptor location.

Other Assumptions. For modeling potential air quality impacts during the 10-year evaluation period, the following assumptions were made:

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6 A three-dimensional coordinate system in which the coordinates of a point are its distances from each of three intersecting, often mutually perpendicular planes along lines parallel to the intersection of the other two.

- No data on the uptake, binding, or deactivation of fumigated O_3 by plants are available at this time. All of the fumigated O_3 was conservatively assumed to drift out of the O_3 rings without plant uptake.

- Currently, O_3 release points are placed between 3 and 7 m (10 and 23 ft) above ground level. O_3 release points were assumed to increase 1 m (3.3 ft) per year over the next 10 years. Therefore, release points would be placed at heights of 8 to 12 m (26 to 39 ft) and 13 to 17 m (43 to 56 ft) for 5 and 10 years in the future, respectively.

- The O_3 fumigation source is assumed to be an elevated rectangular volume source with a length of 26.6 m (87.3 ft) (equivalent to a ring with a diameter of 30 m [98 ft]) and a height of 4 m (13 ft). The release height input to the AERMOD model is defined as the center of the O_3 release points, currently at 5 m (16 ft), and assumed to be at 15 m (49 ft) for 10 years in the future.

- The modeling domain is 10 km $\times$ 10 km (6.2 mi $\times$ 6.2 mi) centered on the Aspen FACE site, and terrain data for the sources and receptor locations are included to account for the effects of terrain features.

- For the last 11 years, monitored O_3 concentrations for Oneida County have tended to decrease slightly while fluctuating from year to year. It is assumed that background concentrations remain the same over the 10-year modeling period.

- For the 5 and 10 years in the future scenarios, hours of O_3 fumigation were assumed to be the same as in the base case data set.

AERMOD estimates 1-hour average O_3 concentrations for the operational period. Eight-hour O_3 moving averages were calculated based on these 1-hour concentrations.

Fence Line O_3 Levels. Fence line O_3 data at three site fence lines (north, east, and south) have been collected since 1998. There are some limitations in interpreting these data, due to limitations in the sampling and analysis protocols, as discussed in Appendix C. Therefore, data for these three fence line monitors have not been used for the analyses in this EA.

Background O_3 Levels. For this assessment, hourly and 8-hour average O_3 concentrations at the site west monitor are used as background levels. This monitor is part of the WDNR and U.S. EPA monitoring network, and hourly and 8-hour average O_3 data are available through these sources (EPA 2005; Dinsmore 2005).

The O_3 concentration at the site west monitor may contain a component from site emissions when winds blew from the site O_3 rings toward the monitor (i.e., when winds are from any direction between the northeast and south, clockwise) and fumigation is occurring. About one-third of the time, monitored concentrations at this location include some contribution from site operations. Analyses presented in Appendix C indicate that the O_3 levels at the site west monitor are impacted by site emissions when winds are from the northeast to south and fumigation is occurring, but that the site contribution does not increase the monitored O_3 level by a significant amount.

A 50th percentile (median; levels would exceed this value 50% of the time) 1-hour background level of O_3 for the site was estimated to be about 40 parts per billion by volume (ppb), on the basis of monitoring data from the site west monitor, using only hourly values when fumigation was occurring (see Appendix C, Table C-2). The 90th percentile level for the 1-hour background O_3 levels was estimated as 58 ppb (hourly O_3 levels would only exceed this value 10% of the time). The 100th percentile (maximum) 1-hour O_3 background value was 80 ppb.

Similarly, a 50th percentile (median) daily maximum 8-hour background level of O_3 concentrations for the site was estimated to be about 41 ppb, including only daily maximum values for days that included 1 or more fumigation hours (Appendix C, Table C-3). The 90th percentile level for the daily maximum 8-hour background O_3 concentration was estimated as 59 ppb. The 100th percentile (maximum) daily maximum 8-hour O_3 concentration was 77 ppb.

4.1.2.3 Modeling Results and Discussion

Incremental O_3 Concentrations from Fumigation. Increments in 1- and 8-hour O_3 concentrations over the background O_3 level due to drift of the fumigated O_3 at the site were estimated for the receptor locations discussed in Section 4.1.2.2. Modeling results for 1-hour O_3 are only for hours when at least one of six O_3 rings was in operation. For 8-hour O_3, daily maximum 8-hour averages are presented only for days when at least one of six O_3 rings are in operation.[7] The statistical distributions of predicted 1- and 8-hour O_3 concentrations for three scenarios (base case, 5 years, and 10 years in the future) are presented in Tables 4.1-1 and 4.1-2, contour, or isopleth,[8] plots for the base-case and 10-years-in-the-future scenarios are presented in Figures 4.1-1 through 4.1-4. Modeling results for the 5-years-in-the-future scenario are not presented because they show mostly intermediate patterns between the base-case and 10-years-in-the-future scenarios. The statistical distributions indicate projected O_3 concentrations while the contour plots indicate where those concentrations would occur.

Note that when multiple locations exist within a category (e.g., at 25-m [82-ft] intervals for fence lines and various intervals for offsite locations), concentrations presented in the tables were summarized from the highest in each receptor group each hour for 1-hour O_3, and each day for the maximum 8-hour O_3. Therefore, the tables present the highest values in each receptor group for each hour or day for each percentile, and percentiles may be for different locations in that category. Note also that there are currently no residences at offsite locations adjacent to the site.

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[7] The 8-hour running average adopts "forward averaging," e.g., the 8-hour average at 1 p.m. is based on concentrations from 1 p.m. to 8 p.m. If the site operates for 8 hours in any day, then 15 hours of non-zero 8-hour running averages associated with site operations can exist, and many 8-hour averages, in fact, contain hours not in operation. When discussing 8-hour O_3 contributions from site operations, daily maximum 8-hour averages are used.

[8] Lines connecting points of equal concentration levels, to illustrate the distributions of concentrations over the geographical areas.

TABLE 4.1-1 Cumulative Distributions of Predicted 1-Hour O_3 Concentration Increments (ppb) above the Background Concentrations[1]

Cumulative Freq. (%)	Offsite[2]			North Fence Line			East Fence Line			South Fence Line			West Fence Line			Barn to East		
	Base case (current)	Five years in the future	Ten years in the future	Base case (current)	Five years in the future	Ten years in the future	Base case (current)	Five years in the future	Ten years in the future	Base case (current)	Five years in the future	Ten years in the future	Base case (current)	Five years in the future	Ten years in the future	Base case (current)	Five years in the future	Ten years in the future
Lowest	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.06	0.08	0.11	0	0	0.01	0.02	0.02	0.02	0	0	0	0	0	0.01	0	0	0
5	0.26	0.39	0.57	0.01	0.02	0.03	0.11	0.14	0.15	0.03	0.03	0.04	0.01	0.02	0.03	0	0	0.01
10	0.43	0.63	0.92	0.02	0.03	0.05	0.17	0.23	0.25	0.06	0.08	0.08	0.02	0.03	0.04	0.01	0.01	0.01
25	0.87	1.28	1.80	0.04	0.06	0.09	0.33	0.46	0.57	0.23	0.26	0.21	0.04	0.06	0.08	0.01	0.01	0.02
50	1.96	2.83	3.57	0.07	0.11	0.18	1.08	1.49	2.00	0.44	0.56	0.55	0.07	0.11	0.16	0.02	0.03	0.04
75	3.54	5.07	6.00	0.24	0.43	0.73	2.46	3.48	4.35	1.37	2.19	2.97	0.22	0.34	0.52	0.11	0.17	0.24
90	5.01	7.23	8.69	0.49	0.81	1.35	3.88	5.49	6.67	4.00	6.01	6.69	0.79	1.18	1.75	0.20	0.30	0.46
95	6.15	9.12	10.81	0.66	1.07	1.74	4.68	6.72	8.10	5.50	8.12	9.31	1.20	1.77	2.63	0.25	0.38	0.58
99	9.51	13.89	16.77	1.03	1.68	2.70	6.58	9.69	12.09	9.32	13.76	15.79	1.84	2.72	3.98	0.38	0.54	0.83
100	20.54	27.70	33.84	4.17	4.48	6.34	11.49	15.27	19.78	20.54	27.70	33.84	11.26	5.45	8.54	2.11	1.55	2.32
Max of Avg[3]	1.15	1.51	1.66	0.12	0.21	0.34	1.15	1.51	1.66	0.92	1.27	1.27	0.16	0.24	0.34	0.07	0.10	0.15

1 O_3 concentrations are estimated only for hours when any one of the O_3 rings is in operation. The base case uses emission and meteorological data for 2000 to 2004. Estimates for five and ten years in the future assume a 10% annual increase in emissions and an increased height of emissions (see text).

2 "Offsite" receptors are those at or beyond the Aspen FACE site fence lines.

3 "Maximum of Average" denotes the highest among the averages at each receptor in a given receptor group (e.g., each east fence line receptor location at 25-m [82-ft] intervals).

TABLE 4.1-2 Cumulative Distributions of Predicted Daily Maximum 8-Hour O_3 Concentration Increments (ppb) above the Background Concentrations[1]

Cumulative Freq. (%)	Offsite[2]			North Fence Line			East Fence Line			South Fence Line			West Fence Line			Barn to East		
	Base case (current)	Five years in the future	Ten years in the future	Base case (current)	Five years in the future	Ten years in the future	Base case (current)	Five years in the future	Ten years in the future	Base case (current)	Five years in the future	Ten years in the future	Base case (current)	Five years in the future	Ten years in the future	Base case (current)	Five years in the future	Ten years in the future
Lowest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.01	0.02	0.03	0	0	0	0	0.01	0.01	0	0	0	0	0	0	0	0	0
5	0.20	0.29	0.42	0.02	0.02	0.04	0.10	0.12	0.16	0.02	0.03	0.04	0.01	0.02	0.03	0	0.01	0.01
10	0.38	0.56	0.81	0.02	0.04	0.06	0.18	0.23	0.26	0.07	0.08	0.09	0.02	0.03	0.05	0.01	0.01	0.01
25	0.78	1.09	1.47	0.04	0.07	0.11	0.40	0.55	0.69	0.23	0.26	0.20	0.04	0.06	0.08	0.01	0.02	0.03
50	1.63	2.33	2.90	0.09	0.14	0.23	1.03	1.42	1.83	0.44	0.53	0.60	0.08	0.12	0.17	0.04	0.05	0.07
75	2.80	4.02	4.68	0.22	0.40	0.66	2.06	2.85	3.51	1.41	2.22	2.71	0.26	0.37	0.57	0.11	0.16	0.23
90	3.82	5.59	6.39	0.37	0.63	1.03	3.11	4.31	4.95	3.30	4.82	5.16	0.58	0.88	1.30	0.17	0.25	0.38
95	4.58	6.67	7.74	0.44	0.75	1.25	3.64	5.07	6.04	4.25	6.19	7.01	0.87	1.28	1.86	0.21	0.32	0.49
99	6.64	9.17	9.99	0.79	1.29	2.07	4.66	6.55	7.98	6.64	9.17	9.81	1.48	2.28	3.33	0.28	0.42	0.67
100	8.70	13.73	16.48	1.16	1.67	2.57	5.90	8.82	11.24	8.70	13.73	16.48	1.84	2.75	4.08	0.36	0.54	0.84
Max of Avg[3]	1.08	1.42	1.56	0.12	0.20	0.32	1.08	1.42	1.56	0.86	1.19	1.21	0.15	0.22	0.31	0.07	0.10	0.14

1 O_3 concentrations are estimated only for days when any one of the O_3 rings is in operation. The base case uses emission and meteorological data for 2000 to 2004. Estimates for five and ten years in the future assume a 10% annual increase in emissions and an increased height of emissions (see text).

2 "Offsite" receptors are those at or beyond the Aspen FACE site fence lines.

3 "Maximum of Average" denotes the highest among the averages of daily maximum 8-hour concentrations at each receptor in a given receptor group (e.g., each east fence line receptor location at 25-m [82-ft] intervals).

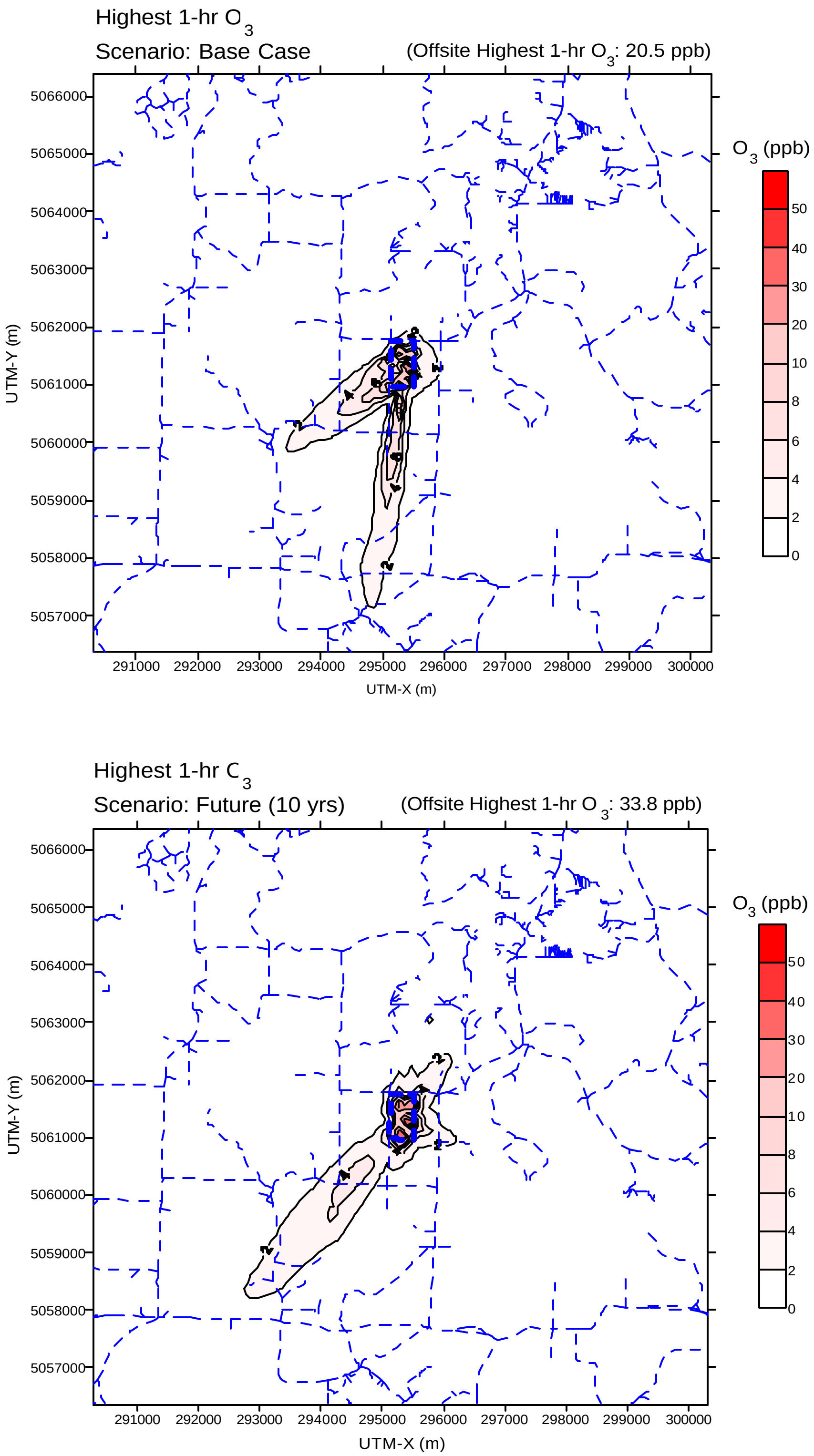


FIGURE 4.1-1 Predicted Maximum 1-Hour O_3 Concentration Increments above Background for the Base Case and 10 Years in the Future (Dotted rectangle represents Aspen FACE site.)

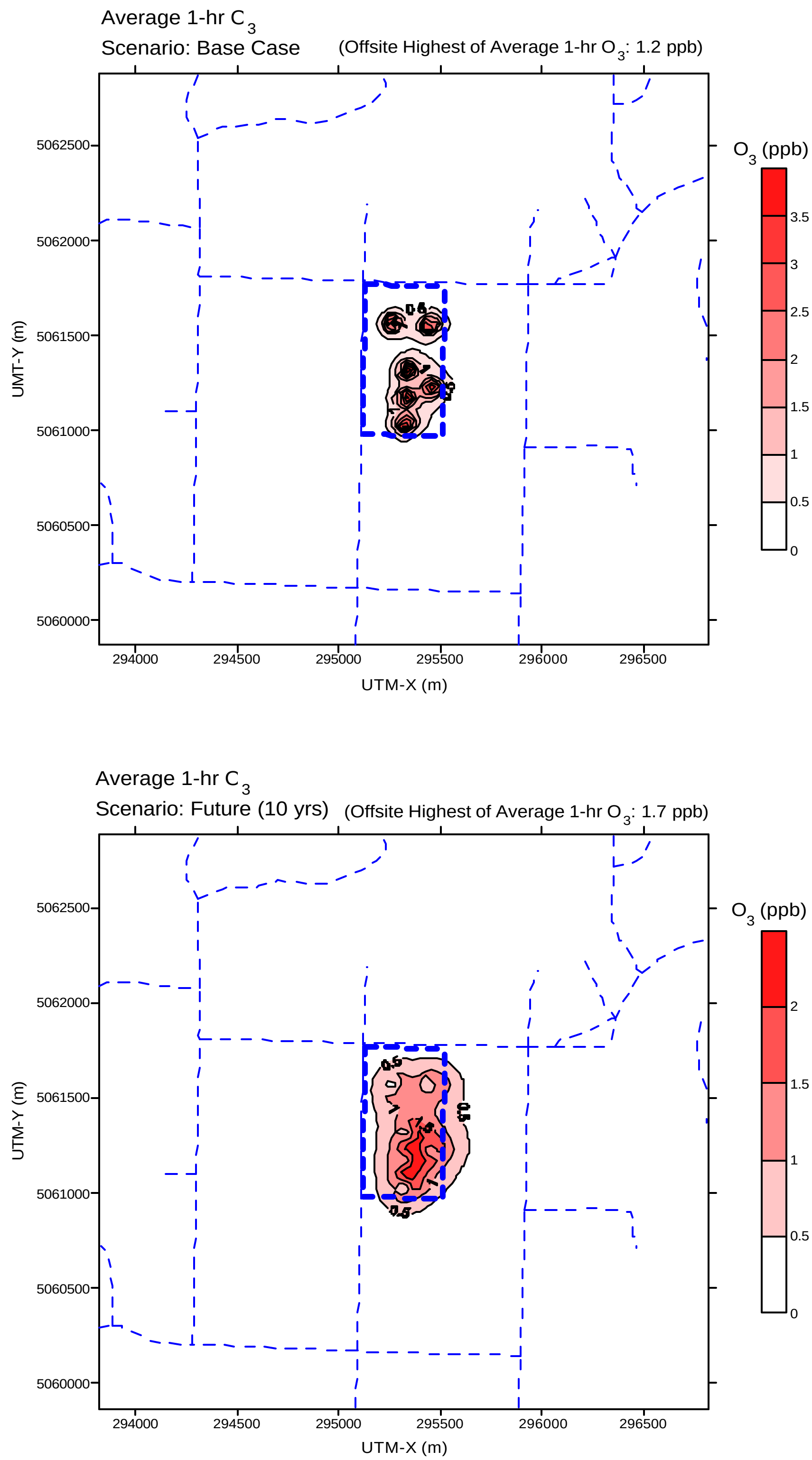


FIGURE 4.1-2 Predicted Average 1-Hour O_3 Concentration Increments above Background for the Base Case and 10 Years in the Future (Dotted rectangle represents Aspen FACE site.)

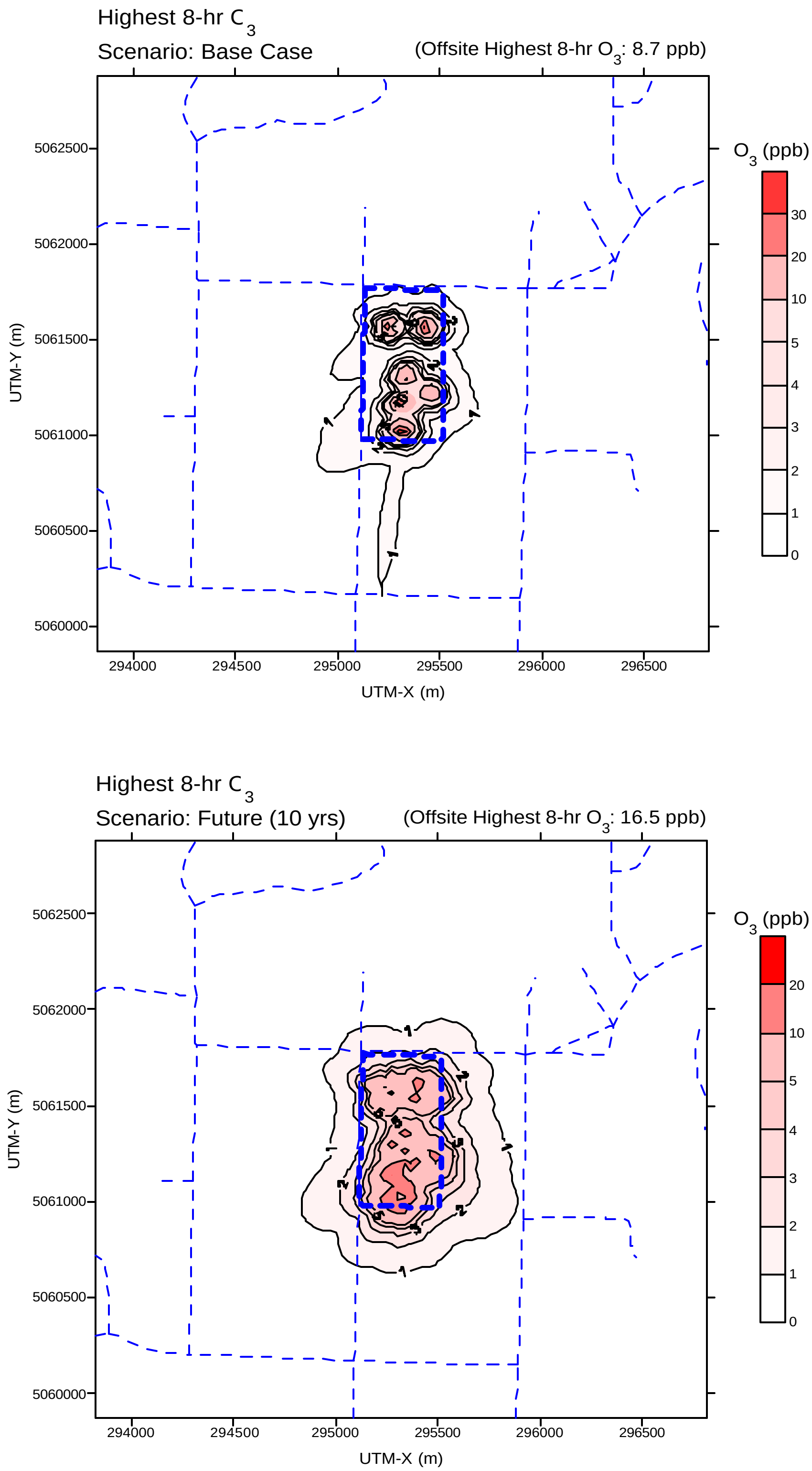
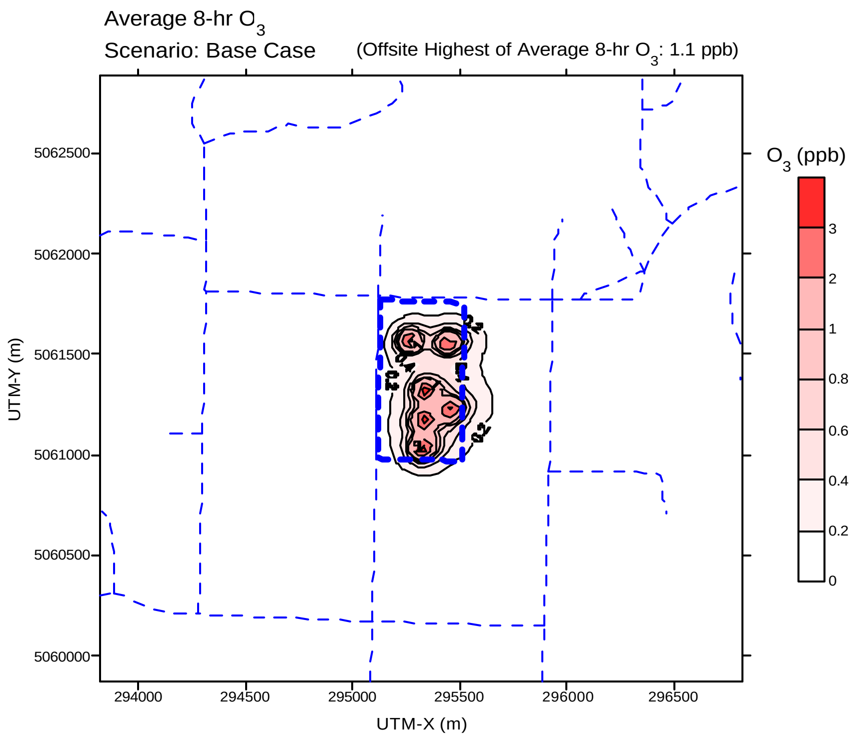


FIGURE 4.1-3 Predicted Maximum of Daily Maximum 8-Hour O_3 Concentration Increments above Background for the Base Case and 10 Years in the Future (Dotted rectangle represents Aspen FACE site.)



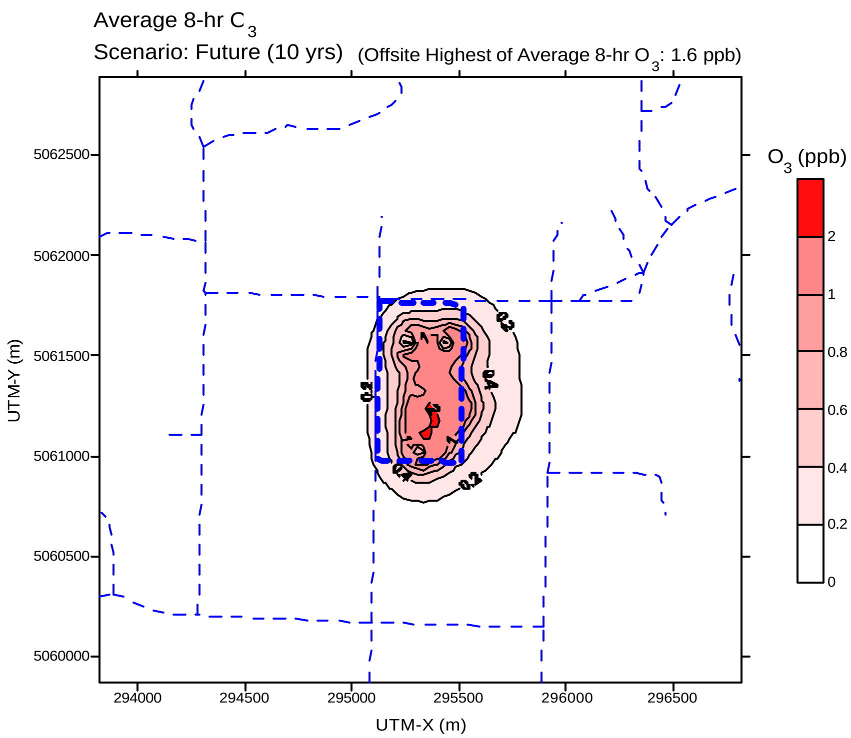


FIGURE 4.1-4 Predicted Average of Daily Maximum 8-Hour O_3 Concentration Increments above Background for the Base Case and 10 Years in the Future (Dotted rectangle represents Aspen FACE site.)

Modeling results indicate that maximum offsite concentrations each hour are predicted mainly at the site fence lines or infrequently slightly beyond the fence line. For the base case, most of the time (about 99.8%), modeled highest 1-hour O_3 concentrations would occur at the site fence lines. However, for 10 years in the future, about 10% of the time highest concentrations would occur slightly beyond the fence line, due to the elevated emission source height to be discussed below.

For the base case (current emission levels), maximum 1-hour incremental (above background) O_3 concentrations at offsite receptor locations are predicted to be about 21 ppb at the middle of the south fence line (Figure 4.1-1). For 10 years in the future, maximum 1-hour incremental O_3 concentrations are predicted to be 34 ppb, again in the middle of the south fence line. These maximums are predicted to occur when wind speed is low (~0.5 m/s [1.1 mi/hr]) and the wind blows from the north, corresponding to an alignment of multiple O_3 rings with the wind direction (see Figure 1.1-1). The isopleth plots of the modeling results (Figure 4.1-1) show that the maximum concentrations are confined to very near the site fence line; 1-hour O_3 incremental concentration offsite drops to less than 8 ppb within 0.8 km (0.5 mi) from the fence line. Many of the higher O_3 incremental concentrations (e.g., >10 ppb) would take place when the wind speed is low (~1.4 m/s [3.1 mi/hr]) and/or when winds blow mostly from the north or secondarily from the west. Under these wind conditions, higher concentrations would occur at the south and east fence lines where O_3 rings are closer to the fence line and sometimes more than one ring is lined up with the wind direction, which causes more site-generated O_3 to move to the fence line. At lower wind speeds, fumigated O_3 stays in the ring longer and has a better chance of being taken up, bound, or deactivated by the plants, although these processes are not considered in the modeling. Modeled O_3 incremental concentrations tend to be higher when wind speeds are low because of limited air dispersion. During these times, monitoring data indicate that background levels tend to be lower, because transport of regional O_3 and O_3 precursors into the area seems to be limited. For example, higher modeled increments from site emissions (e.g., >5 ppb) are predicted to occur at lower average wind speeds of 2 m/s (4.5 mi/hr) or less, along with winds from the north or the west. At these times, average background concentrations are recorded at about 35 ppb.

At higher average wind speeds (3 m/s [6.7 mi/hr] or higher) and when winds are from the south and southwest, higher background concentrations (e.g., >60 ppb) are recorded. At these times, average increments from site emissions are about 1.1 ppb. Accordingly, wind patterns conducive to higher modeled site O_3 increments and to higher background concentrations are different, so this interrelationship of O_3 levels and wind patterns tends to keep offsite levels of O_3 lower.

Figure 4.1-2 shows average 1-hour O_3 concentrations for the base case and 10 years in the future. In either case, the offsite highest average concentrations would occur at the east fence line, due to prevailing westerly winds. Offsite highest average concentrations increase from 1.2 ppb for the base case to 1.7 ppb for 10 years in the future. Also, O_3 contours would spread outward for the 10-years-in-the-future scenario due to increased emission rates and increased height of O_3 release points in the future. The isopleth of average offsite O_3 concentrations shows O_3 increments of 0.5 ppb or less beyond the fence line, about 60 m (200 ft) and 120 m (400 ft) from the fence line for the base case and 10 years in the future, respectively.

At the barn to the east of the site, the maximum 1-hour incremental O_3 concentration is predicted to be about 2.1 ppb for the base case. For 10 years in the future, the maximum 1-hour incremental O_3 concentration is predicted to be 2.3 ppb. A small change in O_3 concentration is seen in spite of increased O_3 emissions, due to the increased O_3 release height, as explained below. The average 1-hour concentration is projected to increase less than 0.1 ppb (from 0.07 to 0.15 ppb).

In general, wind direction changes from hour to hour, i.e., winds do not blow persistently in one direction. Accordingly, 8-hour average O_3 concentrations are lower than 1-hour O_3 concentrations and have smoother contours. For daily maximum 8-hour O_3 concentrations, general patterns are somewhat different from those for maximum 1-hour O_3 concentrations. As shown in Figure 4.1-3, offsite maximum incremental 8-hour O_3 concentrations were estimated to double from about 9 ppb for the base case to 17 ppb for 10 years in the future. However, the offsite highest average of daily maximum incremental 8-hour O_3 concentrations increase only from 1.1 ppb for the base case to 1.6 ppb for 10 years in the future (see Table 4.1-2 and Figure 4.1-4); these values are similar to the highest 1-hour average O_3 concentrations (i.e., 1.2 ppb for the base case; 1.7 ppb for 10 years in the future; Table 4.1-1). As for the 1-hour O_3, the maximum 8-hour O_3 concentrations were predicted to occur at the south fence line, while the highest average of daily maximum 8-hour concentrations were at the east fence line. For the 10-years-in-the-future scenario, maximum and average O_3 contours would spread outward, due to increased emission rates and higher release heights.

Overall, the north and west fence lines and beyond are least impacted from site O_3 emissions in terms of maximum and average 1-hour O_3 concentrations, due to infrequent wind in those directions and farther distances to the O_3 rings.

Modeling results show that ground-level O_3 concentrations would not increase in proportion to increases in future O_3 emissions. For example, maximum and average 1-hour concentrations would increase by about 65% and 44%, respectively, over the next 10 years, although O_3 emissions are assumed to increase by about 159% for 10 years in the future. This is because increased O_3 emissions are, to some extent, offset by raising the O_3 release height. In general, when the release height is raised, ground-level concentrations are lower and lower peak concentrations occur farther downwind from the source than with a lower release height (because a plume with a higher release height has a longer time to be airborne, and thus would be more dispersed in the atmosphere).

As mentioned above, it was conservatively assumed that all fumigated O_3 could escape the O_3 ring without uptake, binding, or deactivation by plants. Accordingly, actual fence line and offsite concentrations are expected to be somewhat lower than those discussed above.

Comparison with O_3 Standards. To assess whether the modeled O_3 increments from site emissions could cause exceedance of the old 1-hour standard of 120 ppb (standard retained for some applications) at offsite locations, modeling results were added to monitored 1-hour background levels. Highest total (modeled plus background) 1-hour O_3 concentrations are 80.2 and 80.6 ppb for the base case and 10 years in the future, respectively. These levels are still well below the 1-hour standard. For this case, modeled concentrations from site operations added about 0.2 and 1.6 ppb to the background concentrations of 80 and 79 ppb, respectively. For these specific hours, the wind blew from the southwest (purely background contribution to the west site monitor, i.e., no contribution from the site) at a wind speed of 3.2 m/s (7.2 mi/hr). For the hours when the modeled site increments from emissions were the highest, i.e., 21 ppb for the base case and 34 ppb for 10 years in the future, total (modeled plus background) concentrations were 71 and 67 ppb, respectively. Winds blew from the north at a wind speed of about 0.5 m/s (1.1 mi/hr). As discussed above, wind patterns that cause higher modeled concentrations are different than those that cause higher background concentrations. As a consequence, site emissions under the no action and proposed action alternatives would not cause exceedance of the 1-hour standard.

To assess whether the modeled O_3 increments from site emissions could cause exceedance of the 8-hour standard of 80 ppb, modeling results were added to monitored 8-hour background levels. For the base case and 10 years in the future, the results showed maximum 8-hr concentrations of about 77.5 and 77.9 ppb, with 77 and 75 ppb from background and 0.5 and 2.9 ppb contributed from site emissions, respectively. For the hours when the modeled increments from site emissions were the highest, total concentrations are estimated to be as follows: for the base case and 10 years in the future, maximum concentrations of about 38.7 and 46.5 ppb, with 30 ppb from background and 8.7 ppb and 16.5 ppb contributed from site emissions, respectively. For these hours, winds blew persistently from the north with an 8-hour average speed of 1.6 m/s (3.6 mi/hr). Therefore, the 8-hour O_3 standard is not expected to be exceeded as a result of site emissions under either the proposed action or the no action alternative.

To summarize, the maximum modeled O_3 levels due to site emissions occur at the south fence line, due to the alignment of O_3 rings when winds are from the north. The maximum occurs at infrequent low wind speeds (e.g., ~ 0.5 m/s [1.1 mi/hr]). The highest average O_3 levels occur at the east fence line, due to the prevalence of westerly winds. Generally, O_3 impacts from site operations are limited to the immediate vicinity of the site fence line. For example, the average 1-hour O_3 increment of 0.5 ppb (Figure 4.1-2) from site operations is estimated at receptor locations ranging from 60 m (200 ft) beyond the fence line for the base case to 120 m (400 ft) beyond the fence line for 10 years in the future.

4.1.2.4 CO_2 Emissions

The major air quality concern with respect to emissions of CO_2 is that it is a greenhouse gas, which traps solar radiation reflected from the earth, keeping it in the atmosphere. Although some other gases (e.g., methane) are more efficient than CO_2 as greenhouse gases, the combustion of fossil fuels makes CO_2 the greenhouse gas most widely emitted worldwide. Water vapor is the most abundant greenhouse gas in the atmosphere, and it is natural in origin. The second most abundant greenhouse gas is CO_2, which is both natural and anthropogenic. However, CO_2 concentrations in the atmosphere have continuously increased from approximately 280 ppm in preindustrial times to 373 ppm in 2002, a 33% increase, and most of this increase has occurred in the last 100 years.

There is no federal regulatory guidance on CO_2 emissions. Because CO_2 is stable in the atmosphere and essentially uniformly mixed, climatic impact does not depend on the geographic location of sources; that is, the global total is the important factor with respect to global warming. Therefore, a comparison between U.S. and global emissions and the total emissions from the rings is useful in understanding whether CO_2 emissions from the FACE site are significant with respect to global warming. Experiments at the FACE facility target CO_2 emissions to reach a concentration of 570 ppm at the center of the rings, although the target is not achieved over the entire growing season (Karnosky et al. 2004). The annual amount of CO_2 emission at the site is dependent on meteorological conditions; in 2004, about 6,400 metric tons (MT) (7,000 tons) of CO_2 were used (Karnosky et al. 2004). This amount would remain about the same under the no action alternative; under the proposed action, the emissions would be about 16,600 MT/yr (18,200 tons/yr) after 10 years (assuming a 10% annual increase). The annual CO_2 emissions in the United States in 2003 were 1.56 billion MT in carbon equivalents (5.73 billion MT CO_2). Worldwide 2003 CO_2 emissions were 6.86 billion MT in carbon equivalents (25.14 billion MT CO_2) (EIA 2005). Since CO_2 emissions from the FACE site under both the no action and proposed action alternatives are 0.0003% or less of U.S. emissions (even assuming no rise in U.S. emissions over the next ten years), the expected impacts to U.S. and global climate change from these emissions are negligible.

4.1.3 Noise Impacts during Construction

Proposed Action. In general, the dominant noise source from most construction equipment is diesel engines continuously operating around a fixed location or with limited movement (especially without muffling). In addition, vehicular traffic around a construction site and on nearby roads generates intermittent noise. However, the contribution to noise from these intermittent sources is limited to the immediate vicinity of the traffic route and is minor in comparison with the contribution from continuous noise sources (e.g., backhoe/loader) during construction.

During the construction period, sound levels would be elevated around the site, due to noise from heavy equipment, cars, and trucks. Noise from these sources would be sporadic and brief in duration. Based on U.S. census data for Oneida County, the day-night average sound level (DNL) was estimated to be 37 dBA (Miller 2002). Simple noise propagation calculations (considering geometric divergence only) indicate that the noise level at the nearest residences (about 0.8 km [0.5 mi] from the site) would be about 44 dBA, which is below the EPA guideline of 55 dBA as the DNL for residential zones. The EPA guideline was established to protect against interference and annoyance due to outdoor activity (EPA 1974). Sound levels would be much lower when including other types of attenuation, such as air absorption and ground effects due to terrain and vegetation. For example, there is a tall, dense growth of trees between the site and the nearest residences that would attenuate noise propagation. Accordingly, noise from the site would be barely discernable or completely inaudible at the nearest residences.

Most construction activities would occur during the day, when noise is better tolerated than at night, because of the masking effects of background noise. Nighttime noise levels would drop to the background levels of a rural environment because construction activities would not occur at night. Noise emitted from construction activities is also expected to be temporary (occurring intermittently over a period of about 6 months) and local in nature. No unusual or significant noise impact (e.g., impulsive noise) is expected from Aspen FACE construction activities.

No Action Alternative. The Forest Service has identified the no action alternative as not implementing the infrastructure modifications, but continuing to conduct research at the facility. Under the no action alternative, no upgrades would occur; thus, there would be no operation of noise sources such as vehicles and heavy equipment. Therefore, impacts of construction on ambient noise levels would not occur.

4.1.4 Noise Impacts during Operation

As detailed in Section 3.5.4, major noise-generating sources from site operations currently are 12 fans with 7.5 hp motors running only during daytime hours and high-pitched noise from pressure-reducing valves. Other noise sources are infrequent vehicular traffic from commuters and delivery trucks and miscellaneous activities, such as mowers, and a high-pitched loud noise from CO_2 trucks during venting for about 20-30 seconds after unloading. The O_3 generator and auxiliary compressors are in enclosures.

Proposed Action. For this assessment, CO_2 and O_3 fumigation rates are assumed to increase by 10% per year over the next 10 years. Accordingly, by the end of the evaluation period 10 years in the future, the number of truckloads would increase from two trucks to five trucks per day for CO_2 and from two trucks to five trucks per season for O_3. These increases would result in only a minimal increase in noise levels in terms of DNL. However, the truck noise may be an annoyance to individuals near the roads for short periods of time each day.

For fumigation, the number of operating hours for the fans would stay the same as current levels. The only change would be that computer-operated proportional valves would be opened wider to allow for a higher fumigation rate (Sober 2005), and this would not affect noise levels. Therefore, no increases in noise levels are expected for the proposed action.

During current site operations, the day-night average sound levels (DNL) at the site fence lines were estimated to range from 43 dBA to 50 dBA, on the basis of measurements in September 2005 (see Section 3.5.4). These noise levels at site fence lines are below the EPA guideline of 55 dBA as the DNL for residential zones, which was established to protect against interference and annoyance due to outdoor activity (EPA 1974). Under the proposed action, sound levels would be almost the same as the current level except for infrequent small increases from the increased number of truck deliveries. Noise levels at the nearest residences (0.8 km [0.5 mi] from the site fence line) would be well below the EPA guideline limit of 55 dBA as the DNL for residential zones.

Most operational activities would occur during the day, when noise is better tolerated than at night, because of the masking effects of background noise. Nighttime noise levels would drop to the background levels of a rural environment because activities would not occur at night. In summary, noise emitted from operational activities at the site under the proposed action is expected to be continuous only during daytime hours, and potential impacts of such noise would be minor.

No Action Alternative. Under the no action alternative, noise-generating activities would not change from current activities. The impacts of current operations on noise levels are minor, as discussed above.

4.2 Ecology

Construction activities associated with the proposed action would have minimal or no impacts on ecology, including Federally and state-listed threatened and endangered species, state species of special concern, Regional Forester sensitive species, and wetlands. Construction activities would be limited to areas in and around the existing ring structures when poles and other ring infrastructure are replaced and the height of the rings is raised. Minimal ground disturbance is expected and would be limited to the immediate vicinity of individual holes. Limiting disturbance during construction is important to prevent inadvertent impacts on experimental trees.

Impacts to ecological resources would be further reduced because construction activities would occur during the winter when impacts to vegetation and the ground surface are less likely. During this period, the number of animal species using the site would be low, as most species do not occur in the area during the winter or are not active then. No listed or protected animal species are known to occur on the site.

Continued operation of the FACE facility is also not expected to have significant impacts on ecological resources. CO_2 emissions during site operations are expected to have negligible effects on ecological resources of the area. In general, the amounts of CO_2 released during operations are well below levels that could have important effects. Some very slight benefits to vegetation could occur because CO_2 enrichment could increase primary productivity.

O_3 emissions during site operations are not expected to significantly affect animal populations in the area. Values within the rings would be highest and comparable to O_3 concentrations in urban areas. In addition, more mobile vertebrate species such as birds and mammals would likely move from higher concentration areas to avoid the discomfort associated with prolonged exposure.

O_3 emissions during site operations could result in vegetation damage within the rings, and this effect is one of the primary subjects of FACE research. However, the impact of this damage is not considered significant, because the area within the rings is minor, common species are present within the rings, and the vegetation was planted for the experiment.

To determine the potential for site operations to affect vegetation (including crops) in areas adjacent to the FACE facility, a guideline threshold of 60 ppb for a 1-hour concentration of O_3 was used to assess leaf damage (based on EPA O_3 Criteria Documents; see Appendix D). One-hour values greater than 60 ppb were conservatively considered potentially damaging to plant leaves, although experimental findings show that this level would need to be exceeded for several hours per day for more than 16 days to cause damage (Jacobson 1977; see Appendix D for details).

For the base case, about 9.2% of the hours when O_3 rings are in operation, total 1-hour O_3 levels (modeled increment due to site emissions plus background) exceed 60 ppb. For 87% of these exceedance hours, the background concentration alone is greater than 60 ppb. Ten years after infrastructure upgrades are made, exceedances are expected to increase by 2.1% to about 11.3% of the hours; for 70% of these exceedances, background concentrations alone would be greater than 60 ppb.

In all cases, when total concentrations exceed 60 ppb, background concentrations are already close to 60 ppb and contributions from site operations are relatively small (4 ppb at most for the base case). Site operations seldom play a major role in triggering exceedances. Ten years after infrastructure upgrades are made, contributions from site operations would continue to be a relatively small increment to total O_3 concentration, but could add a maximum increment of about 20 ppb on a few days.

The guideline threshold used in this EA to assess crop damage is an average of daily maximum 8-hour O_3 concentration over a 3-month growing period of greater than 50 ppb (based on discussions in EPA O_3 criteria documents, as described in Appendix D, Section D.2). Estimated 3-month average concentrations (total of modeled increment due to site emissions plus background) range from 40.2 to 46.9 ppb for the base case and from 41.9 to 48.0 ppb for 10 years in the future. These 3-month average concentrations are below the threshold value, accordingly no decrease in crop yield would be expected in association with 8-hour O_3 concentrations anticipated under both the no action and proposed action alternatives.

4.3 Human Health and Safety

This EA evaluates human health and safety considerations of the proposed action and no action alternatives in two main areas: the potential for injury to site personnel and contractors during work activities, and exposures of workers and the general public to hazardous substances.

4.3.1 General Considerations

Under the proposed action, operations would continue at the site through approximately 2015. The site would continue to emit O_3 and CO_2 at the rings, and fumigation levels would increase by about 10% annually throughout this period. Workers and researchers would continue to conduct experiments at the site, measuring tree growth and other variables in the rings and modifying the height of fumigation emissions, as necessary.

A comprehensive safety program to protect site staff and researchers from hazards has been developed for the experimental program at the FACE site. The safety program includes written guidance, video presentations, and oral instructions that cover all areas of concern on the use of power tools and electrical systems, farm equipment use, storm warnings, lightning, wind protection, and Occupational Safety and Health Administration (OSHA) safety data for O_3 and cryogenic gas exposures. The program also includes safety requirements for work conducted at an elevation of 1.8 m (6 ft) or higher; workers must use fall-protection devices when working at these heights (e.g., when working on the elevated walkways). Recently, the site safety officer has had a series of signs installed at the main control building and each ring, specifying hazards and safety precautions that site workers should take (see Figure 4.3-1).

Few chemicals other than O_3 and CO_2 are used at the site. Roundup herbicide is used to control weeds in some areas; it is used according to packaging directions. The site water supply comes from a well at the site. There are no known chemical releases to groundwater or soil from the site.

4.3.2 CO_2 Exposures

CO_2 is a natural component of air; air is roughly composed of 78% nitrogen, 21% oxygen, 1% argon, and 0.033% CO_2 (330 ppm). In humans, the inhaled concentration of CO_2 is used to regulate the respiration level, with elevated concentrations of CO_2 causing increased respiration. At concentrations of about 2% CO_2 (20,000 ppm), lung ventilation increases by 50% and headaches may occur after several hours of exposure.

OSHA has set the 8-hour average limit for CO_2 in air at 5,000 ppm. The National Institute for Occupational Safety and Health (NIOSH) has also set a short-term exposure limit (STEL) of 30,000 ppm (NIOSH 1996)—STELs are values not to be exceeded for more than 15 minutes. The level of 560 ppm reached at the middle of the rings by fumigation is well below this level. For both the proposed action and the no action alternative, CO_2 exposures are not of concern with respect to adverse health effects for workers or the general public.

The greenhouse gas effects of CO_2 are discussed in Section 4.1.2.4. Climate change can have implications for human health and can alter ecosystems. Some possible outcomes include changing the distribution of airborne allergens and increasing the levels of other air pollutants due to increased use of fossil fuels to cool living spaces (Bernard et al. 2001). However, it was concluded in Section 4.1.2.4 that site CO_2 emissions are negligible with respect to global climate change.

4.3.3 O_3 Exposures

O_3 is an oxidative gas that reacts with many types of molecules, causing damage to cells at certain exposure levels. Inhalation of O_3 causes respiratory irritation and damage in animals and humans; O_3 can also damage plant tissues. The types of injury caused by O_3 and the levels of exposure at which injury occurs are discussed in detail in Appendix D. Under the proposed action, O_3 would continue to be emitted from vertical vent pipes at six of the rings at the site, and emissions would increase annually (see Section 4.1.2).

There are two concerns about these O_3 emissions: exposures of onsite workers and exposure of the general public offsite. Because O_3 injury mainly occurs at higher air concentrations (organisms have some ability to compensate for lower-level exposures without incurring injury), O_3 exposures are considered to have a threshold for adverse health effects, that is, a level below which adverse effects do not occur. In this assessment, the threshold for risk from O_3 exposures for the general public (including sensitive subpopulations) is considered to be an exposure to an 8-hour average level of 65 ppb or greater, based on the EPA’s Air Quality Index (AQI).

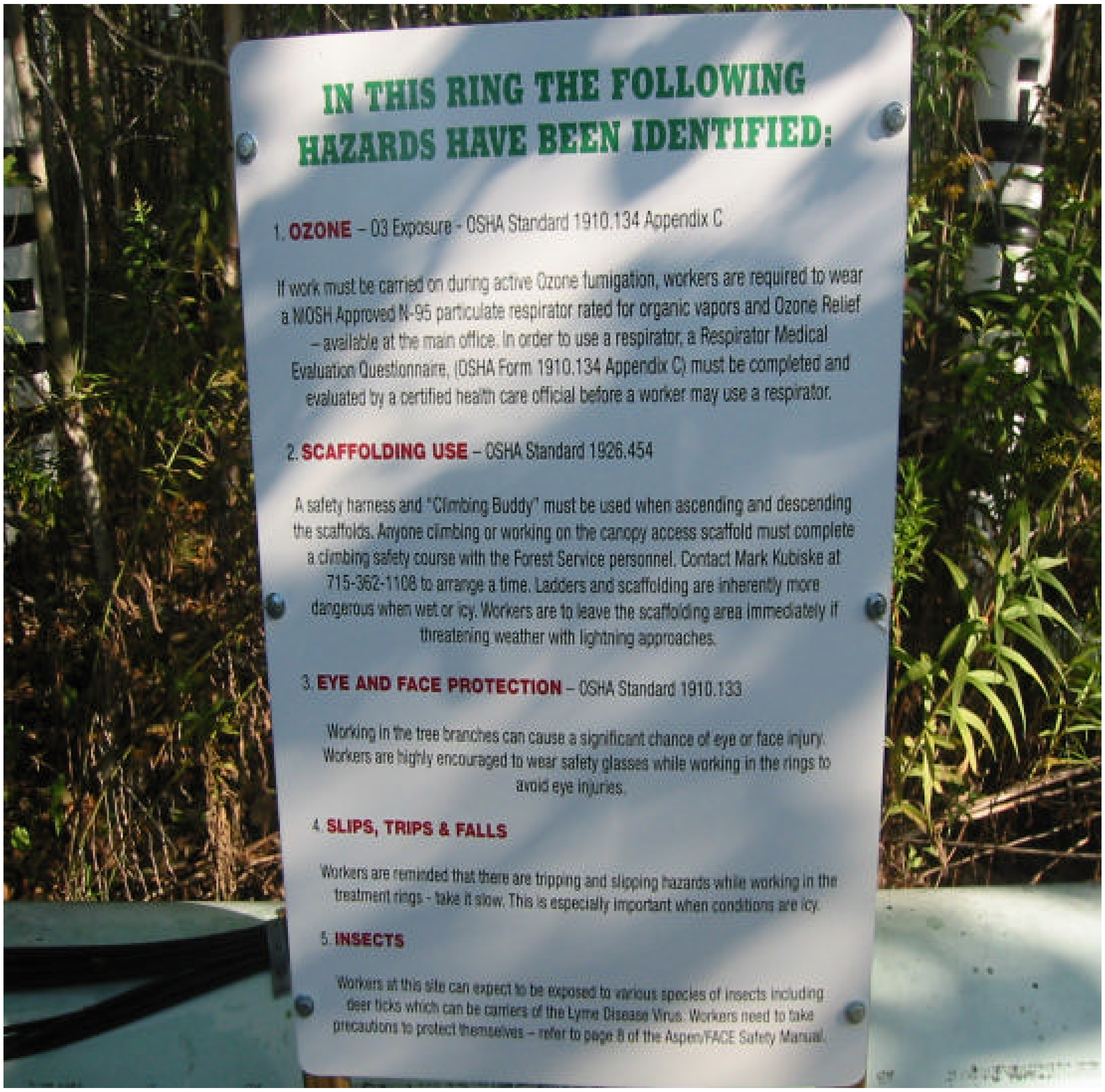


FIGURE 4.3-1 Hazard Warning Sign at All Rings

According to the AQI, 8-hour average O_3 levels between 65 and 84 ppb indicate a moderate risk, during which sensitive groups should consider limiting prolonged outdoor exertion. The EPA 8-hour O_3 standard for determining nonattainment areas in the United States is 80 ppb. For workers, OSHA has set the allowable level for O_3 exposures at an 8-hour average of 100 ppb or less. OSHA does not currently provide a STEL value for O_3, but the 1989 version of OSHA regulations provided a STEL value of 300 ppb (NIOSH 1996).

Worker Exposures. Based on site operating data contained in Dickson et al. (2000), the O_3 supply lines leading to the rings contain about 4% O_3 (40,000 ppm) in the oxygen carrier gas. O_3 concentrations just outside the vents in the vertical pipes used for fumigation vary from 150 to 250 ppb. Levels decrease in the center of each treatment ring to a concentration of 60 to 100 ppb. O_3 is emitted only during daylight hours during the growing season, if wind and moisture conditions allow.

Researchers and site operators are generally not in any one ring for more than two hours per day while conducting research. The maximum amount of time that either researchers (including students) or site operators would be in the rings is 15 hours per week during a growing season (Kubiske 2005). Although the average O_3 level in the rings when operating can approach the OSHA standard and exceed the standard in some locations, worker exposures would not exceed the regulatory levels because they are not in the rings for 8 hours. Nonetheless, management of the Aspen FACE experiment expects researchers to use respiratory equipment when they are in the O_3 rings when the O_3 emission equipment is in operation, and the safety protocol for the project requires it. However, there is no legal or official regulatory requirement for researchers to use respirators or other protection while they are in the rings.

General Public Exposures. To address the question of whether O_3 levels at the site fence line and beyond can adversely impact human health under either the no action or proposed action alternatives, this assessment compares offsite O_3 concentration data (including modeled levels attributable to site emissions and background levels) with levels known to adversely affect human health. The threshold for adverse effects is considered to be an 8-hour level of 65 ppb (see text above and Appendix D, Section D.1). Background O_3 concentrations for the site and for rural northern Wisconsin are discussed in Appendix C.

Air dispersion modeling (Section 4.1.2) predicts that the number of exceedance days of daily maximum 8-hour O_3 over the threshold of 65 ppb increases from 22 for the base case to 24 for 10 years in the future, and ranges from 3.9% to 4.5% of O_3 fumigation days for the base case and 10 years in the future, respectively, when the O_3 rings are in operation. Of these exceedance days, about 96% (for the base case) and 84% (for 10 years in the future) are due only to background concentrations at or near the site boundaries. Site emissions contribute less than 5% to the exceedance when an exceedance occurs due to a combination of background and site emissions. Total (modeled plus background) concentrations averaged over exceedance days are about 70.2 and 69.3 ppb, and site contributions to these concentrations are predicted to be about 0.6 and 1.1 ppb, for the base case and 10 years in the future, respectively. Incidences of exceeding the 65 ppb threshold at residences near the site would be always purely due to background (i.e., there would be no contribution from site emissions).

These modeled incidences of exceedance of the 65 ppb threshold can be compared with the recorded times over the past 10 years, by using EPA summaries of monitoring data for the west site monitor (EPA 2005). According to these data, the 8-hour average background level exceeds 65 ppb on average about 5 or 6 days per growing season. EPA summary reports give the 1st through 4th highest 8-hour O_3 concentrations for the years 1995 through 2004 for the west site O_3 monitor. For four of the ten years, the 4th highest concentration was 65 ppb or less; for 5 other years, the 4th highest concentration ranged from 66 to 73 ppb; data for 1999 showed an unusually high 4th highest level of 82 ppb.

Although occasionally 8-hour O_3 levels near the site could exceed the 65 ppb threshold level, these occurrences are very unlikely to cause adverse human health effects, under either the proposed action or the no action alternative. If sensitive persons (e.g., individuals with asthma) did spend several hours at a location close to the site fence line during a time when O_3 levels exceed 65 ppb, they could experience some respiratory discomfort, especially if they were exercising during the exposure. The incidence of such an adverse health impact on an individual is expected to be very low, if it occurs at all. No adverse health impacts due to site emissions would be seen at actual residential locations under either the proposed action or no action alternatives. Therefore, the impact of operations on human health due to O_3 emissions is considered to be negligible for both the proposed action and no action alternatives.

4.4 Socioeconomic Impacts

The socioeconomic impacts of constructing and operating the FACE facility were assessed for a region of influence corresponding to Oneida County, which is the area in which staff, researchers, and students at the site spend their wages and salaries during the operating season. Impacts were measured in terms of employment and income. Impacts on population, housing, public services, and education were not assessed, as no nonresident labor force is expected for either construction or operation of the facility. A brief discussion of the expected impact of the FACE facility on property values is also included.

To calculate impacts, the assessment used preliminary project construction and cost data (Karnosky 2005a, 2005b). These data included material and labor cost and employment for project construction and operation, which were used to calculate the direct economic impacts of the project. IMPLAN economic data (Minnesota IMPLAN Group Inc. 2004) were then used to calculate the indirect impacts occurring in the county economy associated with project material procurement and wage and salary spending.

The potential socioeconomic impacts from construction and operation of the FACE facility would be small (Table 4.4-1).

Proposed Action. Construction and operations activities would create direct employment of 11 jobs in the first year and an additional eight indirect jobs in the state. First-year activities would increase the employment growth rate in the county by less than 0.001 of a percentage point in the first year. Facility employment and related wages and salaries would also produce about $0.7 million in income in the first year.

Operational activities after the first year would sustain seven direct jobs annually and an additional 5 indirect jobs in the county. Facility employment and related wages and salaries would also produce about $0.4 million in income.

No Action Alternative. There would be no new construction activities associated with the no action alternative. Operational activities in the first year would sustain seven direct jobs annually and an additional six indirect jobs in the county. Facility employment and related wages and salaries would also produce about $0.4 million in income.

Property Value. There is concern that the FACE facility might affect property values in the surrounding communities, particularly for those properties located close to the facility. As is discussed below, evidence from the literature suggests that while there may be a small negative

TABLE 4.4-1 Socioeconomic Impacts of the FACE Facility[a]

Parameter	Proposed Action		No Action
	2006	2007-2015	2006-2015
Employment (number of jobs)			
Direct	11	7	7
Indirect	8	5	5
Total	19	12	12
Income ($ million 2004)			
Direct	0.5	0.2	0.2
Indirect	0.2	0.1	0.1
Total	0.7	0.3	0.3

[a] For the proposed action, values for 2006 include construction and operation effects; values from 2007 through 2015 are annual values for operations only. For no action, values from 2006 to 2015 are annual values for operations only. Years are approximate.

effect on property values in the immediate vicinity of potentially hazardous facilities (i.e., less than 1.6 km [1 mi]), this effect is often temporary and is usually associated with specific project phases, such as the siting announcement and start of construction and operations, etc. With projects involving relatively minor changes in site facility configuration, as would be the case with the FACE facility, no significant enduring negative property value effects have been found over longer durations and at larger distances from the facility.

In general, potentially hazardous facilities have the potential to affect property values in two ways (Clark et. al. 1997). First, negative imagery associated with these facilities may reduce property values if potential buyers believe that a given facility poses a potential health risk. Negative imagery may be based on individual perceptions of risk associated with proximity to these facilities, and also on perceptions at the community level that the presence of such a facility may adversely affect prospects for local economic development. Even though a potential buyer may not personally fear a potentially hazardous facility, they may be willing to offer less for a property in the vicinity of a facility if there is a fear that the facility will reduce the rate of appreciation of housing in the area. Second, there may be a positive influence on property values associated with accessibility to the workplace for workers at the facility, with workers offering more for property close to the facility to minimize commuting times. Workers directly associated with the facility are likely to have considerably less fear of the technology and operations at the facility than the population as a whole. The importance of this influence on property values will vary with the size of the workforce involved.

While there are no studies specifically about the impact of O_3 research facilities on local property values, a large number of studies have assessed the impact of other potentially hazardous facilities, such as nuclear power plants and waste facilities (Clark and Nieves 1994; Clark et al. 1997), hazardous material and municipal waste incinerators, and landfills (Kohlhase 1991; Kiel and McClain 1995), on local property markets. Many of these studies use a modeling approach that takes into account a wide range of spatial influences on property values, including hazardous facilities, crime (Thaler 1978), fiscal factors (Stull and Stull 1991), and noise and air quality (Nelson 1979).

4.5 Environmental Justice

The potential for environmental justice impacts is most likely to arise from changes in air quality due to increases in O_3 emissions during operation of the FACE facility. Exposure to elevated levels of O_3 can cause respiratory irritation in sensitive individuals, with the severity depending on concentration and length of exposure. The analysis of human health impacts (Section 4.3) from O_3 fumigation concluded that the threshold levels for plant leaf damage and for human lung irritation would be exceeded on a few days per year for both the proposed action and no action alternatives. However, most of these exceedances would be due to background O_3 alone, and only 1 to 5 ppb is contributed from site emissions whenever exceedances occur due to a combination of both site emissions and background concentration.

As construction and operation of the FACE facility would not have any high and adverse impacts on the general population in Oneida County, the facility would not impact minority and low-income populations in the county, and would therefore have no impact on environmental justice.

4.6 Visual Impacts

Proposed Action. Under the proposed action, the ring structures at the FACE site would be raised in two increments of 5 m (16 ft), to a total height of about 20 to 21 m (66 to 69 ft) at the tops of the vertical vent pipes. The support and center poles would either be galvanized metal that initially would only be 15 m (49 ft) in length and would be extended to 20 m (66 ft) after five to six years, or they would be wooden poles installed at 20 m (66 ft) with the initial installation. Although the wooden poles would extend 5 m (16 ft) higher at an earlier date, the wood might be expected to blend in better with the surrounding of the FACE site than the metal poles.

The increased height of the rings would be visible on the east from the agricultural property bordering the site and from Horsehead Lake Road, on the north from Webster Road, and on the west from Grace Lane and the U.S. Forest Service property across Grace Lane from the site. The area to the north of the site is owned by the USDA and is currently unused; it also has a stand of trees at the southern edge that restricts vision of the FACE site.

After the pole extensions are completed under the proposed action, the ring structures will be more visible from the roads surrounding the site, and from the agricultural properties to the east and west. The ring structures will not be visible from the residential properties to the south and northeast, due to both the distance of about 0.8 km (0.5 mi) and to wooded areas to the south of the site and at the northeast corner of the site. Also, the ring structures will be in place only temporarily, until the research project is ended.

As stated in Section 3.8, the FACE site and its surrounding area are rated as Class C under the BLM visual resources guidelines (BLM 2003), indicating lands of minimal diversity or interest.

Because changes to the visual landscape of the site under the proposed action would be minimal (but visible from the site boundaries), temporary, and not visible from nearby residential areas, adverse impacts to visual resources are considered to be minimal under the proposed action.

No Action Alternative. Under current site conditions (the no action alternative), some of the experimental rings are visible from the roads surrounding the site. The experimental rings are not visible from the residential properties near the site. Since the height of the ring structures would not be increased under the no action alternative, there would be no adverse impacts.

5 CUMULATIVE IMPACTS

The Council on Environmental Quality guidelines for implementing NEPA define cumulative effects as the impacts on the environment resulting from the incremental impacts of an action when added to other past, present, and reasonably foreseeable future actions (40 CFR 1508.7). For this EA, the actions considered in addition to the proposed action and no action alternatives were (1) the planned construction of a 232 m^2 (2,500 ft^2) laboratory facility at the Aspen FACE site, to begin in June 2006 (as detailed in USFS 2005b); and (2) the predicted regional air quality trends for O_3, as discussed in EPA documentation (EPA 2004). The impact areas considered are those considered most important for the system upgrades that are the subject of this EA, specifically air quality, noise, ecology, human health and safety, socio economics, environmental justice, and visual resources.

Air Quality. The EA for the new laboratory at the FACE site found that the air quality impacts from construction equipment would be minimal and temporary. The laboratory would not emit air pollutants, and there would not be significant new traffic, and thus exhaust and fugitive emissions associated with the facility would be minimal (USFS 2005b).

EPA air quality trend data for the fourth highest daily maximum 8-hour O_3 concentration for the Upper Midwest shows that the value decreased by 11% between 1980 and 2003 (from 96 to 85 ppb) (EPA 2004). Continued implementation of state plans to decrease emissions of O_3 precursors (NO_x and VOCs) should result in lower background levels of O_3 over the next ten years. For example, EPA estimates that regulations for mobile and stationary sources will cut NO_x emissions by 6.4 million MT (7 million tons) annually in 2015 from 2001 levels (EPA 2004).

Site emissions of O_3 could contribute a very small amount to infrequent exceedance of the 8-hour 80 ppb NAAQS. The 80 ppb level is not the actual standard; the 3-year average of the annual 4^{th} highest daily maximum 8-hour O_3 concentration level must exceed 80 ppb (numerically equivalent to 85 ppb) in order for the area in which the air quality monitor is located to be classified as “nonattainment” by EPA. This has not occurred in previous years of operations at the FACE site, and modeling shows that site emissions add only less than 3 ppb to the maximum 8-hour background level under either the proposed action or no action alternative (see Section 4.1). EPA predicts that background levels of O_3 will be decreasing through 2015. The site emissions will not result in exceedance of the air quality standard for O_3, either under the proposed action or the no action alternative. Therefore, cumulative impacts of the proposed action and the no action alternative, when considering other related actions, would not adversely affect air quality.

Noise. The EA for the new laboratory states that noise impacts from construction would be minimal and temporary (USFS 2005b). This EA for system upgrades at the FACE site also shows minimal and temporary noise impacts for construction (Section 4.1.3). The construction activities would not take place at the same time (system upgrades are planned to take place after laboratory building construction, and therefore noise impacts would not occur simultaneously).

Operations at the new laboratory building would not generate noise, other than a few additional commuter vehicles entering and leaving the site daily. Operations for the system upgrades that are the subject of this EA would not generate noise levels in excess of EPA guidelines for residential zones beyond the site fence line. Therefore, there are no significant cumulative noise impacts to be considered.

Ecology. The area where the new laboratory building is to be located is about 33 m (100 ft) south of the existing CO_2 storage tanks. The area is in the footprint of an old barn demolished in 2001. This land is currently a mowed area covered with low grasses. For the construction of the new laboratory building at the FACE site, turf and groundcover would be impacted, but no trees would be removed. Except for the area of the building itself, disturbed areas would be reseeded, so impacts to vegetation would be temporary (USFS 2005b). The analysis in the EA for the new laboratory building project shows no impacts of the project to listed plant or animal species. Similarly, this EA shows no impacts from construction on listed plant or animal species. Section 4.2 of this EA also concludes that operation of the FACE facility under proposed action and no action conditions would not adversely impact animals. O_3 damage to trees within the rings could occur, but this is not an adverse impact to vegetation, because these trees were specifically planted for research and the affected area is small. Offsite decreased crop yields would not occur in association with site O_3 emissions. Therefore, there are no significant cumulative impacts to ecology at or near the site.

Human Health and Safety. With adherence to safety rules, no adverse human health impacts would be associated with the construction and operation of the new laboratory building. For the proposed action and no action alternatives considered in this EA, worker health and safety are adequately addressed through the existing site health and safety plan, assuming continued worker and researcher training and clear expectations that safety rules be adhered to. With respect to O_3 exposures, workers will not be adversely affected if they use respiratory protection equipment when operating O_3 rings.

Occasional exceedance of the O_3 8-hour 65 ppb threshold for adverse respiratory effects in sensitive individuals (see Appendix D; Section D.1) occurs currently and would also occur under the proposed action (about 4 and 5% of O_3 fumigation days for the base case and 10 years in the future, respectively) at the site fence line, primarily due to background O_3 levels. Section 4.3 provides details of this analysis, showing that for incidences of exceedance of the 65 ppb threshold, modeled site emissions would contribute about 1.6% of the O_3 under the proposed action alternative and about 0.8% of the O_3 under the no action alternative. With background levels of O_3 expected to decrease over the time period covered by the proposed action (EPA 2004), site O_3 emissions would not cause any measurable increase in adverse human health effects. There are no other important emission sources in the vicinity of the site, so there are no significant cumulative impacts.

Socioeconomics. Socioeconomics were not addressed in the EA for the new laboratory (USFS 2005b), but it is a relatively small project of limited duration, and would bring only a small number of temporary construction workers to the site. It is also not anticipated to result in new permanent jobs in the area, because the laboratory users would be existing researchers and their students. The socioeconomic impacts of the proposed system upgrades at the FACE site would also be small, but positive, impacts (19 direct and indirect temporary construction jobs generated; 12 direct and indirect operations jobs created, with about $0.4 million in income generated annually) (see Section 4.4). Property values in the near vicinity (e.g., within 1.6 km [1 mi]) of the site are not expected to be adversely affected by the proposed action or no action alternatives, although temporary adverse impacts may occur. The cumulative socioeconomic impacts from the new laboratory building and the system upgrades are expected to be small and positive.

Environmental Justice. Environmental justice was not addressed in the EA for the new laboratory (USFS 2005b), but since that project predicted no high and adverse impacts to human health, no adverse environmental justice impacts would be expected. Since there are also no adverse impacts expected under the proposed action or no action alternatives addressed in this EA, there are no cumulative environmental justice impacts expected.

Visual Resources. The new laboratory building will be set back about 100 m (330 ft) from the road, and will be a part of a cluster of existing site buildings. It is not expected to have any impact on existing visual quality of the landscape. Under current site conditions (the no action alternative), some of the experimental rings are visible from the properties and roads surrounding the site. The experimental rings are not visible from the residential properties located about 0.8 km (0.5 mi) to the south of the site.

After the pole extensions are completed under the proposed action, the ring structures will be more visible from the roads surrounding the site and from the agricultural properties to the east and west. The ring structures will still not be visible from the residential properties near the site, both due to the distance and to a wooded area to the south of the site. Section 4.6 concluded that the proposed action will have minimal impacts on visual resources. It is also concluded that cumulative visual impacts (from the proposed action and the construction and operation of the new laboratory building) will be minimal.

6 REFERENCES

Acoustical Society of America, 1983, *American National Standard Specification for Sound Level Meters, ANSI S1.4-1983*, New York, N.Y., Feb.

Acoustical Society of America, 1985, *American National Standard Specification for Sound Level Meters, ANSI S1.4A-1985, Amendment to ANSI S1.4-1983*, New York, N.Y., June.

Amthor, J.S., 2005, Letter from J.S. Amthor (Office of Science, U.S. Department of Energy, Washington, D.C.) to D.F. Karnosky (Michigan Technological University, Houghton, Mich.), Jan. 4.

Bailey, R.G., 1995, *Description of the Ecoregions of the United States*, Misc. Publ. 1391, U.S. Department of Agriculture, Forest Service, Washington, D.C.

Baudhuin, N., 2005, Personal communication from N. Baudhuin (Wisconsin Department of Natural Resources, Rhinelander, Wis.) to Y.-S. Chang (Argonne National Laboratory, Argonne, Ill.), Oct. 5.

Bernard, S.M., J.M. Samet, A. Grambsch, K.L. Ebi, and I. Romieu, 2001, "The Potential Impacts of Climate Variability and Change on Air Pollution-Related Health Effects in the United States," *Environmental Health Perspectives* 109(Suppl. 2):199–209.

BLM (Bureau of Land Management), 2003, *Visual Resource Management: Inventory* (BLM Handbook H-8410-1) and *Contrast Rating* (BLM Handbook H-8431-1), Washington, D.C., March. Available at http://www.blm.gov/nstc/VRM/vrmsys.html.

Burley, M.W., 1960, *Climatological Summary 1930-1959 — Rhinelander, Wisconsin*, U.S. Weather Bureau.

CEQ (Council on Environmental Quality), 1986, *Guidelines for Implementing the Requirements of the National Environmental Policy Act*, Washington, D.C.

CEQ (Council on Environmental Quality), 1997, *Environmental Justice Guidance Under the National Environmental Policy Act*, Executive Office of the President, Washington, D.C.

Clark, D.E., L. Michaelbrink, T. Allison, and W.C. Metz, 1997, "Nuclear Power Plants and Residential Housing Prices," *Growth and Change* 28:496–519.

Clark, D.E., and L.A. Nieves, 1994, "An Interregional Hedonic Analysis of Noxious Facility Impacts on Local Wages and Property Values," *Journal of Environmental Economics and Management* 27:235–253.

Dickson, R.E., K.F. Lewin, J.G. Isebrands, M.D. Coleman, W.E. Heilman, D.E. Riemenschneider, J. Sober, G.E. Host, D.R. Zak, G.R. Hendrey, K.S. Pregitzer, and D.F. Karnosky, 2000, *Forest Atmosphere Carbon Transfer and Storage (FACTS-II) The Aspen Free-Air CO_2 and O_3 Enrichment (FACE) Project: An Overview*, Gen. Tech. Rep. NC–214, U.S. Department of Agriculture, Forest Service, North Central Research Station, St. Paul, Minn.

Dinsmore, D., 2005, Personal communication from D. Dinsmore (WDNR, Madison, Wis.), to H. Hartmann and Y.-S. Chang (Argonne National Laboratory, Argonne, Ill.), Oct. 13–14.

DOE (U.S. Department of Energy), National Science Foundation, U.S. Forest Service, and Michigan Technological University, 2005, "FACTS II: The Aspen FACE Experiment." Available at http://aspenface.mtu.edu, last updated Oct. 2005.

EIA (Energy Information Administration), 2005, *International Energy Annual 2003*. Available at http://www.eia.doe.gov/pub/international/iealf/tableh1.xls.

EPA (U.S. Environmental Protection Agency), 1974, *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*, EPA-550/9-74-004, Washington, D.C.

EPA (U.S. Environmental Protection Agency), 2002, *Revised Draft, User's Guide for the AMS/EPA Regulatory Model – AERMOD*, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., Aug. Available at http://www.epa.gov/scram001/7thconf/aermod/aermodugb.pdf. Accessed Aug. 3, 2005.

EPA (U.S. Environmental Protection Agency), 2004, *The Ozone Report – Measuring Progress through 2003*, EPA 454/K-04-001, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., April. Available at http://www.epa.gov/airtrends/aqtrnd04/ozone.html. Accessed Oct. 4, 2005.

EPA (U.S. Environmental Protection Agency), 2005, *AirData: Monitor Values Report – Criteria Air Pollutants*. Available at http://www.epa.gov/air/data. Accessed Oct. 1, 2005.

Flannigan, M.J., 1996, "National Environmental Policy Act (NEPA) Determination for Michigan Technological University," Letter from M.J. Flannigan (Department of Energy, Argonne, Ill.) to J.D. Greenwood (Department of Energy, Argonne, Ill.), June 6.

Jacobson, J.S., 1977, "The Effects of Photochemical Oxidants on Vegetation." In: *Ozon und Begleitsubstanzen im photochemische Smog*, VDI Colloquium, 1976, Düsseldorf, Germany, VDI-Berichte 270, pp. 163–173.

Karnosky, D.F., K. Pregitzer, K. Percy, N. Nelson, G. Hendrey, J. Nagy, M. Kubiske, R. Lindroth, and D. Zak, 2004, *Impacts of Elevated CO_2 and O_3, Alone and in Combination, on the Structure and Functioning of a Northern Forest Ecosystem: Operating the Aspen FACE User Facility*, Grant Renewal Application, dated Sept. 27, 2004, submitted to the Office of Science, U.S. Department of Energy, Washington, D.C.

Karnosky, D., 2005a, Budget Proposal, unpublished information, Sept.

Karnosky, D., 2005b, Personal communication from D. Karnosky (Michigan Technological University, Houghton, Mich.) with H. Hartmann (Argonne National Laboratory, Argonne, Ill.), Sept.

Kiel, K.A., and K.T. McClain, 1995, "House Prices during Siting Decision Stages: The Case of an Incinerator from Rumor through Operation," *Journal of Environmental Economics and Management* 28:241–255.

Kohlhase, J., 1991, "The Impact of Toxic Waste Sites on Housing Values," *Journal of Urban Economics* 30:1–26.

Kubiske, M., 2005, Personal communication from M. Kubiske (U.S. Forest Service, Rhinelander, Wis.) to H. Hartmann (Argonne National Laboratory, Argonne, Ill.), Sept. 20.

Miller, S.P., 2002, "Transportation Noise and Recreational Lands," *Proceedings* of *Inter-Noise 2002*, Dearborn, Mich., Aug. 19–21.

Minnesota IMPLAN Group Inc., 2004, *IMPLAN Data Files*, Stillwater, Minn.

Nagy, J., 2005, Personal communication from J. Nagy (Brookhaven National Laboratory, Upton, N.Y.) to Y.-S. Chang (Argonne National Laboratory, Argonne, Ill.), Sept. 5.

National Climatic Data Center, 2005, *Storm Events*. Available at http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms. Accessed Aug. 30, 2005.

NIOSH (National Institute for Occupational Safety and Health), 1996, *IDLH Documentation for Carbon Dioxide and Ozone*. Available at http://www.cdc.gov/niosh/idlh/124389.html and http://www.cdc.gov/niosh/idlh/10028156.html.

Nelson, J.P., 1979, "Airport Noise, Location Rent, and the Market for Residential Amenities," *Journal of Environmental Economics and Management* 6:320–331.

Nelson, N.D., 2005, Email message to J. Krummel (Argonne National Laboratory, Argonne, Ill.) from N.D. Nelson (Forestry Sciences Laboratory, Rhinelander, Wis.), Aug. 19.

Oneida County, 2005, *Oneida County GIS Mapping*. Located at http://ocgis.co.oneida.wi.us/oneida/index.htm. Accessed Oct. 3, 2005.

Ruffner, J.A., 1985, *Climates of the States*, 3rd Ed., Gale Research Company, Detroit, Mich.

Smith, J.M., 2005, Letter from J.M. Smith (FWS, New Franken, Wis.) to R. Sindt (USFS, St. Paul, Minn.), Subject: "Species List Request, Upgrade of Existing FACE Facility, Harshaw Field Laboratory, Oneida County, Wisconsin," Aug. 15.

Sober, J., 2005, Personal communication from J. Sober (Michigan Technological University, Harshaw, Wis.) to Y.-S. Chang (Argonne National Laboratory, Argonne, Ill.), Oct. 3.

Stull W.J., and J.C. Stull, 1991, "Capitalization of Local Income Taxes," *Journal of Urban Economics* 29:182–190.

Thaler, R., 1978, "A Note on the Value of Crime Control: Evidence from the Property Market," *Journal of Urban Economics* 5:137–145.

U.S. Bureau of the Census, 2005a, *County Business Patterns, 2003*, Washington, D.C. Available at http://www.census.gov/ftp/pub/epcd/cbp/view/cbpview.html. Accessed Sept. 2005.

U.S. Bureau of the Census, 2005b. *U.S. Census American FactFinder*. Available at http://factfinder.census.gov.

USDA (U.S. Department of Agriculture), 2005, *Census of Agriculture – County Data, 2002*, National Agricultural Statistics Service, Washington, D.C. Available at http://www.nass.usda.gov/census/census97/volume1/vol1pubs.htm. Accessed Sept. 2005.

U.S. Department of Commerce, 2005, *Regional Accounts Data – Local Area Personal Income*, Bureau of Economic Analysis, Washington, D.C. Available at http://www.bea.doc.gov/bea/regional/reis. Accessed Sept. 2005.

USFS (U.S. Forest Service), 2005a, *AspenFACE Micromet Tower Data*. Available at http://www.fs.fed.us/nc/face/. Accessed Aug. 1, 2005.

USFS (U.S. Forest Service), 2005b, *Environmental Assessment, Harshaw Field Laboratory, Harshaw Research Farm, Harshaw, Wisconsin*, U.S. Department of Agriculture Forest Service, St. Paul, Minn., Feb.

USGS (U.S. Geological Survey), MSN Visual Earth, and Microsoft Research, 2005, *Terra-Server USA*. Available at http://teraserver-usa.com. Accessed Sept. 2005.

WDNR (Wisconsin Department of Natural Resources), 2005, *Chapter NR 404, Ambient Air Quality*, May. Available at http://www.legis.state.wi.us/rsb/code/nr/nr404.pdf#search='NR%20404.04'. Accessed Aug. 30, 2005.

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Appendix A: DESIGN AND OPERATION OF THE ASPEN FREE-AIR CARBON DIOXIDE AND OZONE ENRICHMENT (FACE) FACILITY

Background

The Free-Air Carbon Dioxide and Ozone Enrichment (FACE) systems have been developed to conduct experiments in various vegetation types in the United States, including agricultural crops, tall-grass prairie, desert scrub and grasses, southern pine, southern hardwoods, and northern hardwoods. The major research goal at these facilities is to study the effects of CO_2 and other trace gases such as O_3 on different representative ecosystems and to minimize duplication between sites to control costs associated with the experimental systems. The Aspen FACE User Facility, located near Rhinelander, Wisconsin, is designed to evaluate the effects of CO_2 and O_3 on three tree species (trembling aspen, *Populus tremuloides*; paper birch, *Betula papyrifera*; and sugar maple, *Acer saccharum*) from the seedling stage to maturity. Experiments conducted in twelve 30-m (98-ft) diameter rings evaluate the effects of CO_2 and O_3 singly and in combination on these tree species and other species typical of the northern hardwood region.

Site Description

The Aspen FACE site is a 32-ha (80-ac) site located in northern Wisconsin near Rhinelander on the Harshaw Experimental Farm managed by the U.S. Forest Service. The legal site description is SW 80, Section 21, T37N, R7E, Cassian Township, Oneida County, Wisconsin (Dickson et al. 2000).

The Forest Service purchased the Aspen FACE site in 1972 for use as an experimental facility to conduct genetics research on forest plant species. About 80 percent of the site was planted with different hybrid poplar clones and larch seedlings during the period of 1976-1990. In 1996 and 1997, all poplar and larch stands were cleared and the area was disked in preparation for the tree plantings used in the Aspen FACE experiments. A total of 7,920 trembling aspen (representing six clones), paper birch, and sugar maple seedlings were planted in the twelve rings in 1997 (Dickson et al. 2000).

Study Design

The twelve rings were spaced 100 m (330 ft) apart to minimize drift of CO_2 and O_3 from one ring to another. The experimental design consists of three control rings (i.e., no CO_2 or O_3 added), three CO_2, three O_3, and three combination rings of CO_2 and O_3 (Dickson et al. 2000). The three treatments are replicated in each of the three blocks from north to south across the site (Figure A-1).

Each ring is divided into east and west halves, and the west half is divided into north and south quadrants. The eastern half of each ring contains six different aspen clones that are subjected to elevated CO_2 concentrations from the time of rooting until planting. Seedlings were planted at 1-m (3.3-ft) spacing in randomized pairs. The northwest quadrant was planted at 1-m × 1-m (3.3-ft × 3.3-ft) intervals, with alternating sugar maple and aspen. The southwest quadrant was planted, also at 1-m × 1-m (3.3-ft × 3.3-ft) intervals with paper birch and aspen. Each tree

FIGURE A-1 Location of Treatment Rings and Facilities Within the Aspen FACE Site

seedling was coded with numbers and letters to denote unique coordinates within the ring. This coding enabled researchers to track the responses of individual trees to experimental treatment and control conditions within a growing season and in subsequent years.

Fumigation Procedures

The fumigation experiments use vertical polyvinyl chloride (PVC) pipes to expose the seedlings to the CO_2 and O_3 through five slots in the pipes located around the periphery of each ring. Fumigation experiments have started each year when the aspen trees show signs of bud break (i.e., leaves are visible but curled) and continue until about 50% leaf drop has occurred. During the six years from 1998 to 2003, the CO_2 fumigation period has ranged from 139 to 166 days starting in about mid-May and continuing until early to mid-October (Karnosky et al. 2004). For CO_2, fumigation starts about 30 min before sunrise and continues until 30 min before sundown. O_3 fumigation times are more restricted (see following paragraph).

Fumigation does not occur under certain meteorological conditions. Neither CO_2 nor O_3 fumigation occurs when wind speeds are <0.4 m/sec (0.9 mi/hr) and >4 m/sec (8.9 mi/hr). O_3 fumigation does not occur at times when the predicted maximum air temperature is <15^oC (59^oF), whereas CO_2 fumigation is not done when temperatures are below 3^oC (37^oF). O_3 is also not released when dew is present on the leaves and when it is raining.

The target average seasonal concentration for CO_2 fumigation in the rings has been increased from 560 ppm to 570 ppm (Karnosky et al. 2004). This increase was necessary to keep experimental levels at concentrations that are about 200 ppm above ambient (background) concentrations, to be consistent with experiments in the FACE system at other sites in the United States. The target concentration for O_3 within the experimental rings is 1.5 times ambient. Growth season concentrations in the rings during fumigation averaged 48.8-53.6 ppb during the period from 1998 to 2003 (Karnosky et al. 2004).

Delivery and Monitoring Systems

Liquid CO_2 is delivered to the site each day during the fumigation period. Two trucks per day are required to deliver the CO_2 during the growing season. Each truck weighs about 18 MT (20 tons) and carries about 16.3 MT (18 tons) of liquid CO_2. CO_2 is stored at the Aspen FACE site in two insulated receiving tanks that hold a total of 98 MT (108 tons) (Figure A-2). Eight ambient air heat exchangers vaporize the CO_2 before it is piped to the rings through a 5-cm (2-in) diameter copper pipe (Karnosky et al. 2004).

Liquid oxygen is brought to the site in a tanker truck and stored in a 22 m^3 (6,000 gal) tank (Karnosky et al. 2004). It is then routed to an O_3 generator before being piped to the rings through stainless steel tubing.

At each experimental ring, CO_2 and O_3 are piped into a 38-cm (15-in) diameter PVC pipe attached to a radial fan. At each ring control shed, there is a back-pressure relief regulator that excess O_3 is shunted through; the excess is piped to an O_3-destruct unit consisting of a stainless

FIGURE A-2. Central Control Systems for CO_2, Liquid O_2, O_3 Production, and Gas Distribution (from Dickson et al. 2000) A. Liquid CO_2 storage tank. B. Ambient air heat exchangers. C. Liquid O_2 storage tank. D. O_3 generation building. E. CO_2 and O_3 gas distribution lines. F. Main computer control building and shops.

steel canister filled with the catalyst manganese dioxide, that converts O_3 into O_2 (Karnosky et al. 2004).

The CO_2 and O_3 gases are released upwind of the ring's vegetation through slots in 12 vertical vent pipes that are open at one time and that extend over a 135^o arc in each ring. Up to five slots are open in the vertical vent pipes between the ground and the top of the canopy during the fumigation periods. Baffles situated above the slots on the vertical pipes deflect the gases downward along the pipes where the gases can flow horizontally through the canopy and sub-canopy layers.

The gas delivery control systems consist of: (1) wind velocity and direction sensors; (2) gas concentration detectors, as a part of a central data recording and control system; and (3) a gas enrichment control system. Data acquisition and control system equipment are housed in a shed adjacent to each ring. The three control systems are run on personal computers that link the control computers and sheds at each ring. A more detailed description of the control systems is found in Dickson et al. (2000).

Operations Workforce

Two full-time operators are present at the Aspen FACE User Facility during the growing season. One remains during the non-fumigation period (Nelson 2005). An estimated 15 to 40 researchers per month are present at the site during the growing season. The maximum amount of time that either researchers (including students) or site operators would be in the rings is 15 hours per week during a growing season (Kubiske 2005). Actual exposure duration is estimated to be closer to one to five hours per week during a growing season (Nelson 2005). Based on 2000 to 2004 monitoring data, the annual average mass of O_3 being fumigated was 423 kg (932 lb) with 117 days and 940 hours of operations per year (Nagy 2005). This is about 3.6 kg (8 lb) of O_3 emitted per day. The annual amount of CO_2 emission at the FACE site is dependent on meteorological conditions; in 2004, about 6,400 MT (7,000 tons) of CO_2 were used (Karnosky et al. 2004).

Site Safety

A site-specific health and safety plan to protect site staff and researchers from hazards has been developed for the experimental program at the FACE site (Karnosky et al. 2002). The safety program includes written guidance, video presentations, and oral instructions that cover all areas of concern on use of power tools, electrical systems, farm equipment use, storm warnings, lightning, wind protection, and Occupational Safety and Health Administration (OSHA) safety data for O_3 and cryogenic gas exposure. The program also includes safety requirements for work conducted at an elevation of 1.8 m (6 ft) or higher; workers must use fall protection devices when working at these heights (e.g., when working on the elevated walkways). Recently the site safety officer has had a series of signs installed at the main control building and each ring, specifying hazards and safety precautions for site workers.

O_3 Monitoring

Monitors to continuously record O_3 concentrations during the growing season are located at the six O_3 rings and along the north, east, and south site fence boundaries. Additionally, the monitor at the control building is in operation from late March through mid-October and its levels are reported to the statewide air quality monitoring network (WDNR 2005).

Passive O_3 samplers are also used to measure O_3. Four passive samplers are distributed along each fence line at about 2 m (6.6 ft) height; 27 samplers are dispersed throughout each O_3 treatment ring at three different heights (12 at 1 m [3 ft], 12 at 4 m [13 ft], and 3 at 6 m [20 ft]); and 1 sampler is installed at 2 m (6.6 ft) at the center of each control ring. These samplers are changed every month during the growing season. The sample results for 2004 are quite uniform, ranging from about 25 to 30 ppm-hour (Karnosky et al. 2004). These levels correspond to average O_3 concentrations of approximately 35 to 42 ppb.

Noise Generated during Operation

Noise is generated by the CO_2 tanker trucks entering and leaving the site and while unloading at the storage tanks. Noise is also produced by the 7.5 hp motors on the 12 fans at each of the 12 rings, operating during fumigation. Other noise sources are infrequent vehicular traffic from commuters and delivery trucks, and miscellaneous activities, such as mowers.

References for Appendix A

Dickson, R.E., K.F. Lewin, J.G. Isebrands, M.D. Coleman, W.E. Heilman, D.E. Riemenschneider, J. Sober, G.E. Host, D.R. Zak, G.R. Hendrey, K.S. Pregitzer, and D.F. Karnosky, 2000, *Forest Atmosphere Carbon Transfer and Storage (FACTS-II) The Aspen Free-Air CO_2 and O_3 Enrichment (FACE) Project: An Overview*, Gen. Tech. Rep. NC–214, U.S. Department of Agriculture, Forest Service, North Central Research Station, St. Paul, Minn.

Karnosky, D. et al., 2002, *FACTS II (Aspen FACE) Facility and Harshaw Forest Experimental Farm Facility Site-Specific Health and Safety Plan*, June. Available at http://aspenface.mtu.edu.

Karnosky, D.F., K. Pregitzer, K. Percy, N. Nelson, G. Hendrey, J. Nagy, M. Kubiske, R. Lindroth, and D. Zak, 2004, *Impacts of Elevated CO_2 and O_3, Alone and in Combination, on the Structure and Functioning of a Northern Forest Ecosystem: Operating the Aspen FACE User Facility*, Grant Renewal Application, dated Sept. 27, 2004, submitted to the Office of Science, U.S. Department of Energy, Washington, D.C.

Kubiske, M., 2005, Personal communication from M. Kubiske (U.S. Forest Service, Rhinelander, Wis.) to H. Hartmann (Argonne National Laboratory, Argonne, Ill.), Sept.

Nagy, J., 2005, Personal communication from J. Nagy (Brookhaven National Laboratory, Upton, N.Y.) to Y.-S. Chang (Argonne National Laboratory, Argonne, Ill.), Sept. 5.

Nelson, N.D., 2005, Email message to J. Krummel (Argonne National Laboratory, Argonne, Ill.) from N.D. Nelson (Forestry Sciences Laboratory, Rhinelander, Wis.), Aug. 19.

WDNR (Wisconsin Department of Natural Resources), 2005, *Wisconsin Department of Natural Resources Air Monitoring Network*. Available at http://apps.dnr.state.wi.us/wisards/webreports/advancedReports.do.

APPENDIX B: SCOPING SUMMARY REPORT

SCOPING REPORT FOR AN ENVIRONMENTAL ASSESSMENT OF INFRASTRUCTURE UPGRADES TO THE ASPEN FREE-AIR CARBON DIOXIDE AND OZONE ENRICHMENT USER FACILITY

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For

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U.S. Department of Agriculture Forest Service

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INTRODUCTION

The Aspen Free-Air Carbon Dioxide and Ozone Enrichment (FACE) User Facility is located near Harshaw, Oneida County, Wisconsin on an 80-acre site managed by the North Central Research Station of the U.S. Department of Agriculture Forest Service (USFS). The facility was constructed in 1996 and began full operation in 1998 to evaluate the effects of increased atmospheric concentrations of carbon dioxide (CO_2) and ozone (O_3), alone and in combination, on trees and other ecosystem components typical of northern hardwood forests.

The FACE facility uses a series of 12, 30-m diameter experimental ring structures that surround representative northern hardwood tree species (aspen, sugar maple, and paper birch). Carbon dioxide and/or ozone are released from the ring structures to achieve elevated concentrations within the rings. Since original construction, trees in some of the experimental rings have grown to the full height of the existing structures. The upgrade proposed by the USFS is a 10-m increase in the height of these ring structures to accommodate the additional growth of the trees over the next ten years. The upgrade consists of a replacement of existing components, and no ground disturbance is anticipated outside of the original footprint of the structures.

The USFS will prepare an Environmental Assessment (EA) in compliance with the National Environmental Policy Act (NEPA) to evaluate the potential impacts associated with construction of infrastructure upgrades, as well as continued operation of the facility.

SCOPING PROCESS

To support preparation of the EA, the USFS solicited input from the public to help identify concerns and issues that should be addressed in the EA. As part of this scoping process, the USFS held site tours and public meetings at the facility to provide members of the public with information on the facility and the proposed action and to solicit comments on issues related to the EA. More than 90 people participated in the scoping process through attendance at the public meetings or by providing written comments. Also, during the scoping period, a total of

205 visits were made by individuals accessing the Aspen FACE Experiment project web site (http://www.ncrs.fs.fed.us/projects/face_ea/).

Public notices of the scoping process and opportunities to participate were provided through two advertisements in *The Rhinelander Daily News*, one advertisement in the weekly *Vilas County News*, and one advertisement in the *Lakeland Times*. These advertisements invited all interested individuals and organizations to participate in site tours and public meetings on June 15, 2005 at the Aspen FACE User Facility. Similar announcements were posted on the project web site, and letters of invitation to participate were mailed to interested parties and nearby land owners.

During the scoping period, the public was invited to submit comments to the USFS. Public comments were provided to the USFS in several ways:

- Verbal comments during the open house and public meetings held on June 15, 2005 at the facility;
- Postal mail delivery;
- Toll-free facsimile transmission;
- Electronic mail; and
- Electronic submittal using a form available on the project internet web site.

Regardless of how they were submitted, all public comments were given equal consideration.

In addition to comments from the public, the Wisconsin Department of Natural Resources (WDNR) provided comments during the scoping period. These comments also are considered in this scoping report.

SUMMARY OF SCOPING COMMENTS

Each comment received during the scoping period was sorted into issue areas that captured key concerns, questions, and information. Comment summaries were then developed for each issue area, and are included in this report. The order in which the issues are presented in this document does not reflect relative importance or significance in terms of preparing the EA or USFS policies and procedures. Also, the comment summaries presented here report what was provided to the USFS during the scoping period; the summaries do not provide an evaluation of the comments or attempt to depict any major opinions or trends.

Air Quality

A number of individuals expressed concern about ozone transport from the Aspen FACE experimental rings to off-site locations. It was suggested by some members of the public that ozone emitted at the facility could lead to elevated levels outside the boundaries of the facility. It was stated that an analysis of ozone transport and associated concentration levels beyond the facility boundary should be conducted for the EA. It was also suggested that air quality modeling should be conducted to evaluate the transport and fate of ozone emitted from the experimental facility rings. Individuals requested a more thorough explanation of how state and federal air regulatory agencies oversee the facility. The WDNR recommended that monitoring done to assess dissipation of ozone off of the study site should be continued, and that data from monitoring should continue to be shared with the WDNR and be made available to the public online.

Questions raised by the public on air quality issues included:

- What are the carbon dioxide and ozone levels within and outside the rings?
- What are key components of ozone chemistry and transport behavior?
- What are the characteristics of long-distance transport of air pollutants from metropolitan locations to the facility?
- What is the persistence of ozone in the atmosphere?
- What are typical background ozone levels for urban and rural locations?
- What levels of carbon dioxide and ozone could lead to shutdown of the facility?
- How were fumigation levels of ozone and carbon dioxide determined for the facility experimental rings?

Human Health

Several individuals expressed concern about the concentrations of ozone that may be drifting beyond the facility boundaries and whether this drift could affect the health of nearby residents. Local residents requested that an analysis of offsite ozone levels and their effects on human health be included in the EA. A suggestion was made that a human health survey of local residents should be conducted for the EA. Some individuals indicated that they had respiratory problems and wanted to know if emissions from the facility could be a contributing factor.

Monitoring

Some individuals questioned the adequacy of ozone monitoring at the facility and surrounding areas. Concerns were raised about the location of the monitors and the quality of the information collected by the monitors at the facility. Some individuals requested that an independent group verify current monitoring and set up off-site ozone monitors to measure ozone levels in areas adjacent to the facility. Individuals asked if the USFS was considering installing additional off-site ozone monitoring stations. Off-site monitoring was recommended to ensure that residents were not being exposed to emissions originating from the facility. One individual provided an analysis of monitoring results that he had developed using publicly available monitoring data.

NEPA Process

Individuals wanted to know the difference between an EA and an Environmental Impact Statement (EIS), and when they would have opportunities for public involvement after the scoping period. Comments addressed the USFS decision-making process, including questions as to who in the USFS would approve or disapprove the proposed infrastructure upgrades. An individual asked why Argonne National Laboratory was chosen to prepare the EA. A request was made to see an outline for the EA and an individual inquired as to whether the EA would be more extensive than the checklist used in the evaluation of the original construction. Another individual expressed their opinion that the USFS should produce an EIS, rather than an EA.

Operation of the Aspen FACE User Facility

Comments on facility operations pertained to time of day that fumigation was conducted, the volume and concentrations of carbon dioxide and ozone released by the vertical fumigation pipes, size of the rings, the length of a typical growing season, facility operation during periods of wind and rain, and tree species used in the experiments.

Ozone Effects on Vegetation

Several comments addressed the potential effects of ozone to off-site vegetation. Local residents expressed concern about ozone effects on potato crops, including crop yield reductions in a portion of a field near the facility boundary. One individual submitted data from a study by a local school student on the effects of ozone on milkweed near the facility. Another individual stated that agricultural crops, such as potatoes and tomatoes are sensitive to ozone, and asked if crop sensitivity would be addressed in the EA.

One person wanted to know why evergreen trees were not used in the experimental plots and another was interested in the sensitivity of oak trees to carbon dioxide and ozone. Individuals were also interested in why trees north of the facility were dead. Aspen FACE researchers were asked how the effects of carbon dioxide and ozone on trees could be separated from other stresses, such as disease and drought that occur during the experimental period.

Roads

A comment was raised about truck deliveries and truck weights during periods of weight restrictions on local roads. Some individuals believed that tanker trucks delivering supplies to the facility had damaged local road surfaces. Several individuals requested that funds be made available to assist in paying for re-surfacing of the township road that serves the facility. It was noted by several individuals that Federal payments in lieu of taxes would not be satisfactory as compensation for damaged roads. It was recommended that the EA evaluate noise generated by trucks serving the facility, as well as by on-site compressor engines.

Safety

Concerns were raised about safety during routine operations of the facility. These concerns included:

- The potential rupture of carbon dioxide or oxygen storage tanks,
- Potential areas affected by a tank rupture,
- A lack of buffers around the facility,
- Other chemicals used at the facility that may be potentially hazardous, and
- Existing site security measures and the need for additional security.

Ecology

An individual asked if the EA would evaluate the potential effects of the facility on threatened and endangered species in the area. A question was raised about the effects of the experiments on birds and if birds avoided the rings. The WDNR indicated that the EA should include a description of the plant species or communities that will be included with the experimental rings, as well as a list of invasive species that may be present in the area and plans to prevent their spread. In addition, the WDNR mentioned that the area has been identified as habitat for two State-listed species of special concern (large roundleaf orchid and large-flowered ground cherry).

SCOPE OF THE ENVIRONMENTAL ASSESSMENT

The EA will examine the effects of the proposed action on key environmental attributes as presented in the EA outline provided in the Appendix. Topics included in the outline are those that arose during the scoping process, and are limited to those attributes that are potentially affected by the proposed action. Although there is not a one-to-one correspondence between issue areas identified by the public and the topical headings in the EA outline, those issues will receive full consideration in the EA. Topics to be evaluated in the EA include (1) air quality and noise, (2) ecology (including threatened and endangered species, wildlife, vegetation, and agricultural crops); (3) human health (including worker safety); (4) visual resources; and (5) socioeconomics (including effects on tourism, property values, and transportation). Alternatives to be considered in the EA will be limited to a no-action alternative that would consider the environmental consequences of not making the proposed infrastructure upgrade.

APPENDIX

Draft Outline

Environmental Assessment for Infrastructure Upgrades to the Aspen Free-Air Carbon Dioxide and Ozone Enrichment User Facility

Summary

1. Introduction
   1.1. Purpose and Need
   1.2. Description of Proposed Action
   1.3. Public Scoping, Identification of Key Issues, and Scope of Analysis
   1.4. Public Review and Comments on the Draft EA

2. Alternatives
   2.1. Alternatives Analyzed in the EA
   2.2. Alternatives not Considered for Further Analysis
   2.3. Comparison of Alternatives

3. Environmental Setting
   3.1. Hydrology
   3.2. Soils and Geology
   3.3. Land Use and Cultural Resources
   3.4. Ecology
   3.5. Air Quality and Noise
   3.6. Socioeconomics

4. Environmental Impacts
   4.1. Air Quality and Noise
   4.2. Ecology

4.3. Human Health

4.4. Visual Resources

4.5. Socioeconomics

5. Cumulative Impacts

Appendices of Supporting Information

APPENDIX C: OZONE MONITORING AND BACKGROUND LEVELS AT THE FACE SITE

Discussion of Regional and Site Ozone Monitoring Data

The impact assessment for FACE site upgrades focuses on ozone (O_3) levels associated with site emissions, but data on background O_3 levels are required to estimate total potential impacts. Background O_3 data are available from two sources: the Wisconsin Department of Natural Resources (WDNR) O_3 monitor at the west side of the FACE site (especially when winds are from the southwest to the north direction so that site emissions cannot contribute to the measured levels); and from the next closest WDNR O_3 monitors to the site (these provide data on regional O_3 levels in rural northern Wisconsin). Additionally, data are available for the north, east, and south fence line monitors. These data are not background, because they are likely affected by site emissions. However, they provide a useful indication of O_3 levels around the site, and are also discussed in this section.

O_3 is produced in the atmosphere by photochemical reaction of nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight. These reactions occur only during the day when sunlight is present. This means that there is a diurnal cycle for O_3 concentrations; that is, the level increases from morning into late afternoon. O_3 is also decomposed in the atmosphere, again by reaction with nitrogen oxides; the decomposition reactions are not necessarily dependent on the presence of sunlight, but do require nitrogen oxides, which are present in greater quantities in urban areas due to automobile combustion products and other sources. In urban areas, O_3 levels are completely depleted at nighttime by reactions of fresh nitrogen oxides emitted from mobile sources. There are fewer nitrogen oxide sources in rural areas, so nighttime reactions of O_3 are less prevalent. Therefore, it has been found that O_3 levels decrease almost to zero at night in urban areas, but do not decrease so drastically in rural areas (Fuentes and Dann 1994). Nighttime average 1-hour O_3 concentration levels were about 20-30 ppb at the FACE site based on 2000-2004 monitoring data (Dinsmore 2005).

FACE Site O_3 Monitoring – Methods and Data.

North, South, and East Fence Line Data. The north, south, and east fence line monitors at the site have been in place since site operations began in 1998. Hourly fence line data for these monitors are provided on the FACE website (DOE et al. 2005). The fence line sampling inlets are installed at a height of approximately 2 m (7 ft), with glass funnels used to protect the inlets from drawing in precipitation. The inlets are equipped with 70 micron filters. Samples at the fence line locations travel through 1.3 cm (0.5 in) Teflon tubes to the measurement instruments (UV absorption TECO 49C O_3 sensors) located at the nearest O_3 ring sheds. The distance to the nearest ring shed varies for the three fence lines, from approximately 67 to 100 m (220 to 330). This results in a tube volume of approximately 2.2 to 3.3 L (0.6 to 0.9 gal), and thus a delay time from inlet to O_3 sensor of approximately 2.2 to 3.3 minutes.

The filters at the sampling inlets remove very large particles, allowing fine particles, which make up probably 90% of the total particle count, to enter the inlet tube. These fine particles, particularly soot from vehicles, etc., will collect on the wall and in the pores of the Teflon tubing. This contamination can reduce the concentration of O_3 that is measured because of O_3's high reactivity with most materials, especially carbon-containing compounds. Therefore, the reported O_3 concentrations for the fence line monitors are likely to be underestimates of the true O_3 concentrations at the sample locations, due to loss of O_3 in the tubes during travel to the measurement instruments.

In September 2005, Argonne National Laboratory conducted calibration measurements through the north fence line Teflon tubing to obtain an estimate of O_3 loss in the tubing (Cook 2005). The calibration measurements found losses of about 7% at reported O_3 concentrations of 35 ppb or less, losses of about 22% at O_3 concentrations between 36 and 76 ppb, and losses of about 47% at O_3 concentrations of greater than 76 ppb. When this algorithm was applied to the entire north fence line data set for 2004, it indicated that the uncorrected data underestimated the overall mean O_3 concentration by about 15%. It should also be noted; however, that the O_3 loss estimate was somewhat inflated because the calibration was done at the end of the growing season when particles had been accumulating in the tubing for the whole season.

These calibration data cannot be used to make accurate estimates of O_3 losses through the tubing at the east and south fence line locations, because the length of tubing is different, and it is not known if contamination levels in the tubing are similar to those at the north fence line. However, it is likely that O_3 losses at these two locations are similar to those at the north fence line.

Recommendations to limit and measure O_3 losses at the site fence line monitoring locations have been given to FACE site staff. The existing O_3 monitoring data can still be used to look at O_3 level trends over the past several years, bearing in mind that the levels are likely somewhat underestimated, as described above. These fence line data were not used in the impact assessment conducted for this EA.

Background Data. The west monitor at the FACE site is part of the WDNR and EPA O_3 monitoring network, and is referred to as the Harshaw Farm monitor. The measurement methods used for this monitor are those required by WDNR. A 5-m (16-ft) tube connects the sampling inlet positioned at a height of about 3 m (10 ft) to the measurement instrument (a UV absorption API 400A ozone sensor). Minimal loss of O_3 in the short tube length would be expected (Cook 2005). Hourly data for the west site monitor were obtained for the years 2000-2004 through WDNR (Dinsmore 2005).

Data Summary. Table C-1 shows means, standard deviations, maximums, and minimums for the west monitor and the other fence line monitors for May through October of 2002 through 2004, by month; separate values are given for daytime and nighttime measurements. Figure C-1 is a graph of the daytime value data. The data show good correlation between values for all four monitoring locations. The 2002 data showed wide monthly variations, with daytime means ranging from about 20 to 55 ppb. The 2003 and 2004 data showed less variability, with means ranging from about 30 to 50 ppb. The daytime data are roughly correlated to times of O_3 emissions at the site, but include all days, whereas the rings do not emit O_3 when wind speeds are lower than 0.4 m/s (0.9 mi/hr) or higher than 4 m/s (8.9 mi/hr), or when conditions are wet.

TABLE C-1 Daytime and Nighttime O_3 Data by Month for 2002 through 2004[a]

			Ozone Concentration (ppb)															
			Mean				Standard Deviation				Minimum				Maximum			
Year	Month	Time of Day	North	East	South	West	North	East	South	West	North	East	South	West	North	East	South	West
2002	5	night	--	42	32	47	--	10.9	10.8	11.6	--	25	14	27	--	63	55	68
2002	6	night	--	29	21	31	--	15.7	11.6	16.5	--	5	6	3	--	68	54	74
2002	7	night	19	19	14	21	10.7	12.0	7.5	13.0	5	5	6	3	52	53	46	50
2002	8	night	19	21	16	19	12.7	13.0	7.9	14.5	5	5	6	3	57	58	40	59
2002	9	night	20	21	14	21	12.7	12.6	8.1	13.6	5	5	6	3	55	55	51	57
2002	10	night	18	18	15	18	7.1	6.8	6.3	7.1	5	5	6	3	44	43	37	43
2003	5	night	26	26	19	30	9.6	8.8	8.5	9.8	8	8	6	10	44	43	43	49
2003	6	night	27	26	20	31	12.5	12.7	11.5	13.3	6	6	6	6	62	62	55	66
2003	7	night	21	20	18	22	11.3	10.7	9.3	12.3	5	5	6	2	52	47	45	52
2003	8	night	20	20	16	21	14.6	13.5	10.8	15.5	5	5	6	2	67	62	54	67
2003	9	night	29	27	25	30	18.2	17.1	17.6	18.3	5	5	7	2	86	81	87	84
2003	10	night	29	26	24	30	13.9	13.1	11.3	13.8	6	5	8	7	61	57	55	63
2004	5	night	33	31	33	34	9.8	9.3	12.0	9.3	8	10	3	10	53	48	57	54
2004	6	night	26	24	21	27	10.6	10.7	12.0	11.1	6	2	2	2	52	49	44	49
2004	7	night	24	21	18	23	12.3	12.2	14.0	13.2	3	1	2	2	66	61	73	62
2004	8	night	19	17	12	19	9.7	9.6	8.9	10.0	4	2	1	2	48	43	40	43
2004	9	night	30	29	24	31	17.2	17.1	17.1	17.3	3	1	1	2	71	70	77	68
2004	10	night	26	24	21	24	11.7	11.5	11.5	11.9	4	5	3	2	59	59	53	58
2002	5	day	--	53	48	55	--	10.2	10.8	10.8	--	28	20	29	--	67	64	72
2002	6	day	--	36	31	39	--	12.8	10.8	13.0	--	7	6	6	--	71	63	75
2002	7	day	31	30	26	34	11.3	12.6	10.3	12.5	6	5	6	3	58	59	54	63
2002	8	day	30	30	25	32	12.2	12.6	10.6	13.3	6	5	6	3	65	68	54	69
2002	9	day	30	30	24	31	12.8	12.9	10.5	13.5	5	6	6	3	64	66	51	68
2002	10	day	24	24	21	24	8.5	8.5	8.5	8.8	7	9	6	7	52	52	48	52
2003	5	day	42	41	43	44	10.3	9.7	13.2	10.5	9	7	6	9	62	60	68	66
2003	6	day	40	38	39	43	12.0	11.8	15.0	12.2	7	6	7	2	78	75	77	79
2003	7	day	34	32	34	36	11.9	10.7	12.3	12.1	5	5	6	2	64	60	73	67
2003	8	day	35	32	33	36	13.1	12.1	13.2	13.4	6	5	6	2	69	66	67	70
2003	9	day	37	34	35	37	17.1	16.0	18.2	16.8	6	5	7	2	87	81	85	83
2003	10	day	38	35	38	38	13.2	12.0	15.5	12.6	11	13	9	14	68	62	80	67

TABLE C-1 (cont.)

			Ozone Concentration (ppb)															
			Mean				Standard Deviation				Minimum				Maximum			
Year	Month	Time of Day	North	East	South	West	North	East	South	West	North	East	South	West	North	East	South	West
2004	5	day	37	33	40	38	8.3	7.6	12.6	8.1	7	16	3	9	53	56	74	54
2004	6	day	35	33	37	36	10.9	10.6	15.2	10.2	9	5	4	9	64	59	78	63
2004	7	day	36	33	38	35	12.3	11.7	16.3	11.7	4	1	2	2	67	64	76	67
2004	8	day	30	28	32	30	9.2	9.3	14.4	9.1	3	1	1	2	54	48	65	50
2004	9	day	42	40	42	41	16.1	15.8	19.3	15.5	4	3	2	2	82	80	80	78
2004	10	day	35	33	35	34	11.0	10.9	13.9	11.4	6	4	3	2	63	60	70	62

[a] Daytime and nighttime hours were identified on the basis of sunrise and sunset data for each day.

Source: DOE et al. 2005 (data for north, east, and south monitors); Dinsmore 2005 (data for west monitor).

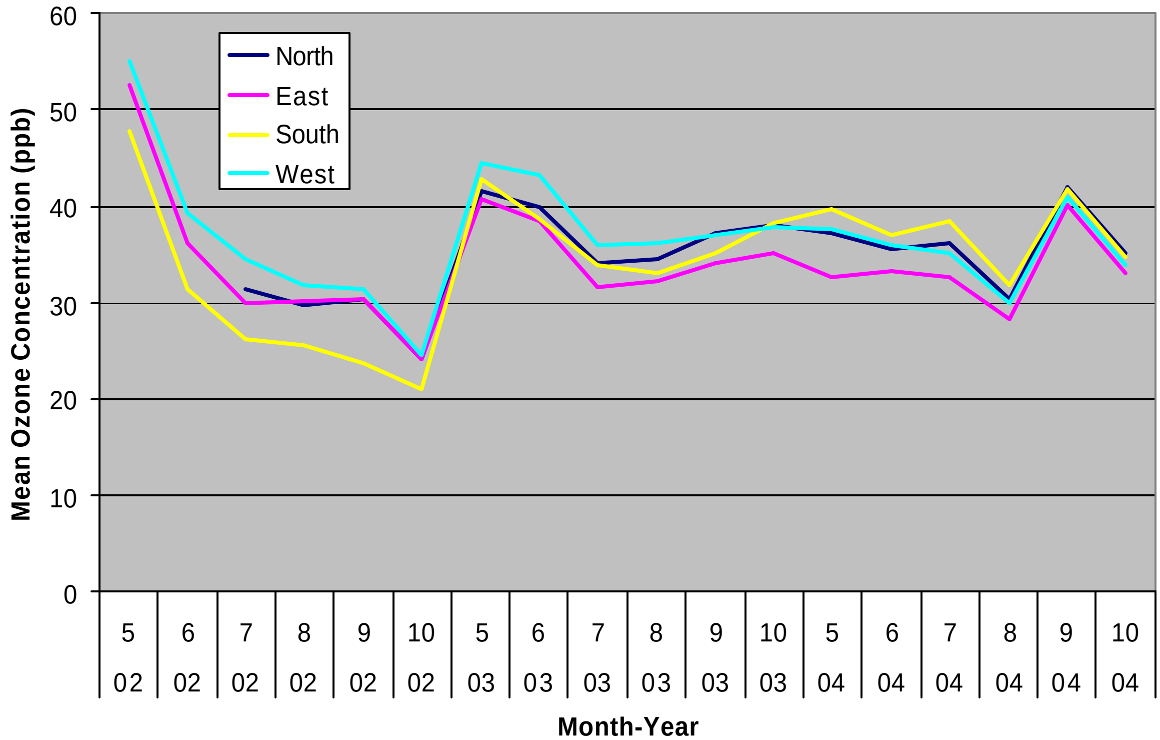

FIGURE C-1 Mean O_3 Concentrations by Month for the FACE Site Monitoring Locations

A comparison of monitoring data for days of fumigation vs. days of no fumigation was also conducted. This assessment indicated that mean O_3 concentrations during the daytime hours when fumigation operations are occurring are relatively low (means range among monitors from 33.5 to 35.0 ppb). Mean O_3 concentrations are lower when fumigation operations are not occurring (means range from 27.4 to 29.3 ppb), but the differences between values with and without fumigation are not necessarily attributable to the effects of site operations, since fumigation does not occur during certain environmental conditions that would naturally result in lower O_3 levels (e.g., rain events).

An analysis was conducted to determine whether all west monitor data would be representative of background levels (i.e., whether all data are similar to data when winds with a contribution from the site are excluded). To determine this, all the west monitor hourly data for 2000-2004 were compared with west monitor data for when winds have only a westerly component (are from any direction between the southwest and north, clockwise). When winds are from these directions, site emissions from the rings do not affect the west monitor location O_3 levels. Table C-2 presents this analysis, giving the distribution of O_3 levels for all west monitor 2000 to 2004 hourly measurements, and for when winds have only the westerly components described above. The 50th percentile for all data and times of west winds are the same, 40 ppb; the 90th percentile values are 58 ppb for all winds and 56 ppb for west winds only. The values for all 2000 to 2004 data are similar, indicating that use of all west monitor data as background data for the FACE site provides a good estimate of the actual background levels (i.e., levels are not significantly elevated due to the contribution from site emissions).

TABLE C-2 Cumulative Distributions of Monitored 1-Hour O_3 Concentrations (ppb) at the FACE Site West Monitor[a]

Cumulative Frequency (%)	All Winds	West Winds
0	2	2
1	18	20
5	25	26
10	27	28
25	32	33
50	40	40
75	49	48
90	58	56
95	63	61
99	72	68
100	80	80
Number of hours sampled	4,422	2,435
Mean (ppb)	41.2	41.2

[a] Monitored O_3 concentrations are based on data for 2000-2004, using only data for hours when any one of the O_3 rings is in operation.

[b] West winds denote when winds blow from southwest to north, clockwise. Under these wind conditions, the west monitor at the Aspen FACE site represents background O_3 levels, i.e., free from contributions of O_3 from the site operations.

Source: Dinsmore 2005.

Table C-3 summarizes the distribution of daily maximum 8-hour average O_3 concentrations at the west monitor for comparison with the O_3 standard and with human health guideline levels.

Summary data for the west monitor were also available through U.S. EPA going back to 1995 (EPA 2005b). These data are frequencies that the 1-hour averages exceeded the 120 ppb standard and frequencies that the 8-hour average exceeded the 80 ppb standard. Between 1995 and 2004, the 1-hour average for this monitor never exceeded the 120 ppb standard. The 8-hour average exceeded the 80 ppb standard three times, once in 1998 and twice in 1999. The maximum 8-hour average recorded for this monitor was 90 ppb in 1999.

TABLE C-3 Cumulative Distribution of Monitored Daily Maximum 8-Hour O_3 Concentrations (ppb) at the FACE Site West Monitor[a]

Cumulative Frequency (%)	All Winds
0	12
1	22
5	27
10	30
25	34
50	41
75	50
90	59
95	63
99	72
100	77
Number of days sampled	558
Mean (ppb)	42.8

[a] Monitored O_3 concentrations are based on data for 2000-2004, using only daily maximum data for days when any one of the O_3 rings is in operation.

Source: Dinsmore 2005.

Ozone in Wisconsin and Oneida County. The WDNR operates air quality monitoring locations throughout the state. The west monitor at the FACE site (called the Harshaw Farm monitor in the WDNR network) is one of these monitors. The next closest monitors to the FACE site are the Trout Lake station, located in Vilas County about 40 km (25 mi) north of the site, and the Popple River station, located in Florence County about 96 km (60 mi) east and slightly north of the site. O_3 data from these monitoring stations are representative for rural northern Wisconsin; the monitors are located in remote locations far from industrial areas. O_3 data from these three monitors are collected from approximately the end of March through mid-October annually. Data from 2005 for the daily 1-hour concentrations of O_3 at these three stations through August 16, 2005, are presented in Table C-4. The average, maximum, and minimum of the daily maximum 1-hour O_3 concentrations at these three sites were very similar. The highest maximum 1-hour concentration was 91 ppb at the Trout Lake location; the maximum at both the FACE and Popple River sites was 80 ppb. For the FACE site, Trout Lake site, and Popple River site, there were 8, 10, and 7 days, respectively, that had 1-hour O_3 concentrations of 60 ppb or greater (60 ppb is used in this assessment as a threshold for adverse impacts to vegetation; see Appendix C). These data show that the O_3 concentrations and days with elevated 1-hour concentrations in the northern part of Wisconsin, including at the FACE site, are well below those in urban areas such as Milwaukee (see Table C-4).

In the State of Wisconsin, all of the counties bordering Lake Michigan except those on the western side of Green Bay were designated as nonattainment areas for O_3 as of April 2005 (EPA 2005a). All other counties (including Oneida) were attainment areas, indicating that the 3-year average of the annual 4th highest daily maximum 8-hour O_3 concentration was less than 80 ppb. The 3-year average and the 4th highest daily maximum are used to avoid having areas flip-flop in and out of compliance with the standard due to variability in meteorological conditions.

Historically, Wisconsin O_3 levels were decreasing from the late 1980s through 1999, as shown by decreased numbers of days annually exceeding the 1-hour standard (Daggett et al. 2000). The peak was almost 30 exceedance days in 1988 because of the anomalous summer heat wave, but always five or fewer exceedance days from 1996 through 1999. In the U.S. as a whole, O_3 levels generally decreased between 1998 and 2003, although there was a spike in 2002. In 1998, there were 387 counties with a total population of 146 million that exceeded the standard; in 2003, there were 209 counties with a total population of 100 million that exceeded the standard (EPA 2004). However, these trends must be interpreted cautiously because the weather in any given year can greatly affect O_3 production in the atmosphere. Currently for the U.S. as a whole, mainly large metropolitan areas are nonattainment areas, as shown in Figure C-2.

TABLE C-4 Summary of One-Hour O_3 Monitoring Data for FACE Site, Background Locations, and an Urban Location[a]

Wisconsin DNR Monitoring Station	Number of Days for Which Data Were Available 3/29/05 to 8/16/05	Maximum Daily 1-hour O_3 Conc.: Average for 3/29/05 to 8/16/05 (ppb)	Maximum Daily 1-hour O_3 Conc.: Maximum for 3/29/05 to 8/16/05 (ppb)	Maximum Daily 1-hour O_3 Conc.: Minimum for 3/29/05 to 8/16/05 (ppb)	Number of Days with Daily 1-hour O_3 Conc. of 60 ppb or Higher
Harshaw County (FACE site; western boundary)	140	50	80	22	8
Trout Lake, Vilas County	141	53	91	30	10
Popple River, Florence County	124	48	80	23	7
Bayside, Milwaukee	127	64	108	25	25

[a] Data obtained from Wisconsin DNR Air Monitoring Network, Wisards reports (WDNR 2005). Start date chosen because this was the first date available for the Harshaw County site.

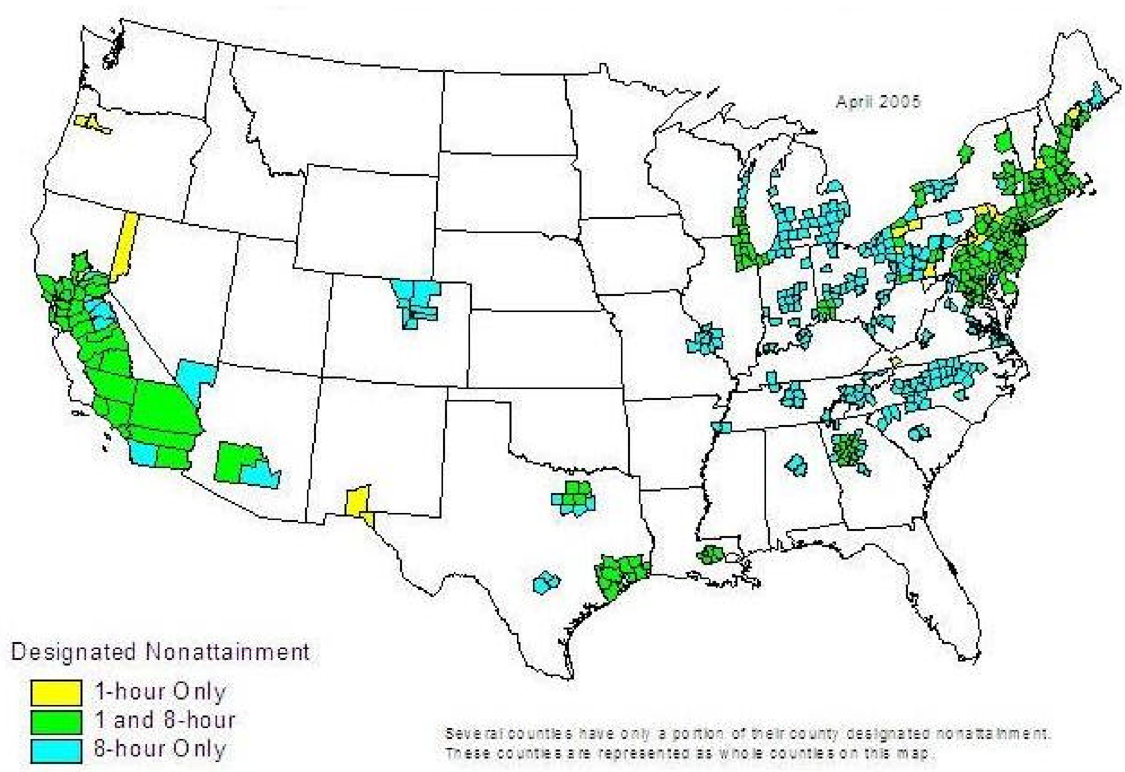

FIGURE C-2 Counties Designated Nonattainment for the 1- and/or 8-hour O_3 Standard as of April 2005 (adapted from EPA 2005a)

References for Appendix C

Cook, D., 2005, "Calibration Measurements for FACE Site North Fence line Ozone Monitor," unpublished data, personal communication from D. Cook (Argonne National Laboratory, Argonne, Ill.), to H. Hartmann (Argonne National Laboratory, Argonne, Ill.), Sept. 28.

Daggett, D.A., J.D. Myers, and H.A. Anderson, 2000, "Ozone and Particulate Matter Air Pollution in Wisconsin: Trends and Estimates of Health Effects," *Wisconsin Medical Journal*, Nov.

Dinsmore, D., 2005, Personal communication from D. Dinsmore (WDNR, Madison, Wis.) to H. Hartmann and Y.-S. Chang (Argonne National Laboratory, Argonne, Ill.), Oct. 13-14.

DOE (U.S. Department of Energy), National Science Foundation, U.S. Forest Service, and Michigan Technological University, 2005, "FACTS II: The Aspen FACE Experiment." Available at http://aspenface.mtu.edu, last updated Oct. 2005.

EPA (U.S. Environmental Protection Agency), 2004, *The Ozone Report – Measuring Progress through 2003*, EPA 454/K-04-001, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., April. Available at http://www.epa.gov/airtrends/aqtrnd04/ozone.html. Accessed Oct. 4, 2005.

EPA (U.S. Environmental Protection Agency), 2005a, *Green Book: EPA Ozone Nonattainment Areas*, Office of Air Quality Planning and Standards. Available at http://www.epa.gov/oar/oaqps/greenbk/o8index.html, Last updated April 21, 2005.

EPA (U.S. Environmental Protection Agency), 2005b, *Air Data: Monitoring Values for Oneida County, Wisconsin*. Available at http://www.epa.gov/air/data/monvals.html. Accessed Oct. 2005.

Fuentes, J.D., and T.F. Dann, 1994, "Ground-level Ozone in Eastern Canada: Seasonal Variations, Trends, and Occurrences of High Concentrations," *J. Air & Waste Manage. Assoc.* 44:1019–1026.

WDNR (Wisconsin Department of Natural Resources), 2005, *Wisconsin Department of Natural Resources Air Monitoring Network*. Available at http://apps.dnr.state.wi.us/wisards/webreports/advancedReports.do.

APPENDIX D: IMPACTS OF OZONE EXPOSURES ON HUMAN HEALTH AND CROPS

D.1 Human Health Impacts from Ozone Inhalation

Background. Ozone (O_3) is a lung irritant that causes coughing and difficulty breathing, especially in individuals that already have respiratory problems. Persons who participate in vigorous exercise activities, including active children and adults, are at increased risk when ambient O_3 levels are high. O_3 can also aggravate asthma and other chronic respiratory diseases like emphysema. Repeated exposures can cause permanent lung damage.

O_3 is regulated as a criteria air pollutant under the Clean Air Act. The National Ambient Air Quality Standard for O_3 is 80 ppb (8-hour average). This standard was proposed in 1997, and finalized in 2004 after standards for implementation were revised by EPA as the result of hearings before the U.S. Court of Appeals. This standard is replacing the previous 1-hour standard of 120 ppb.[1] In the workplace, the permissible exposure limit for O_3 is an 8-hour average of 100 ppb (OSHA 2005). OSHA does not currently provide an short-term exposure limit (STEL) value for O_3, but the 1989 version of the OSHA regulations provided a STEL value of 300 ppb (NIOSH 1996).

Decreased lung function has been observed at levels lower than the ambient air quality standard, especially for children that already have respiratory problems. A recent study of asthmatic children found that for the group of children with more severe asthma (that is, those using maintenance medication for their asthma), 1-hour average O_3 levels greater than 59 ppb were significantly associated with wheezing and chest tightness. Average 1-hour O_3 levels greater than 73 ppb were significantly associated with shortness of breath and rescue medication use (Gent et al. 2003). A summary of studies conducted by Thurston and Ito (1999) documents an approximate 18% increase in the incidence of respiratory-related hospital admissions for each 100-ppb increase in the airborne O_3 concentration.

The EPA uses an "Air Quality Index," or AQI, to advise the public about the hazards associated with O_3 on specific days in specific locations, especially for sensitive groups (i.e., children and people with respiratory disease such as asthma are sensitive groups for O_3 exposures) (EPA 1999). Eight-hour average O_3 levels between 65 and 84 ppb indicate a moderate risk, during which sensitive groups should consider limiting prolonged outdoor exertion. Eight-hour averages between 85 and 104 ppb indicate conditions that are unhealthy for sensitive groups, during which they should limit prolonged outdoor exertion; 8-hour averages between 105 and 124 ppb indicate unhealthy conditions, during which sensitive groups should avoid prolonged outdoor exertion and others should limit prolonged outdoor exertion. Eight-hour average levels greater than 125 ppb are ranked as very unhealthy, indicating that sensitive groups should avoid all outdoor exertion and others should limit outdoor exertion; levels of 375 ppb or higher are ranked hazardous, indicating that severe respiratory effects and impaired breathing are likely in active

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1 The 120 ppb 1-hour standard will not be revoked in a given area until that area has achieved three consecutive years of air quality data meeting the 1-hour standard. The purpose of retaining the current 1-hour standard is to ensure a smooth, legal, and practical transition to the new standard.

children and adults and people with respiratory disease, and that effects in the general population are increasingly likely (EPA 1999). EPA ranks these conditions with an AQI corresponding to 51-100 (yellow), 101-150 (orange), 150-200 (red), 201-300 (purple), and greater than 300 (maroon).

In this EA, the threshold for risk from O_3 exposures for the general public (including sensitive subpopulations) is considered to be an 8-hr average exposure to 65 ppb, based on the U.S. EPA's AQI threshold for sensitive individuals to experience adverse effects.

O_3-Related Health Effects in Wisconsin and Oneida County. Asthma is the adverse health outcome most readily correlated with elevated O_3 concentrations, because its effects can be severe, and therefore substantial information on prevalence, emergency department (ED) visits, hospitalization rates, and asthma mortality is available throughout the U.S. However, there are many other contributing risk factors for asthma that must be taken into consideration. For example, exposures to irritants such as smoke, cockroach dung, pesticides, and herbicides in the first year of life are risk factors for childhood asthma (Salam et al. 2004). The risk factors for childhood asthma appear to be more prevalent in urban areas, regardless of the socioeconomic status of the children (Aligne et al. 2000).

About 9% of Wisconsin residents reported current asthma symptoms in 2002 (WDHFS 2004). Asthma prevalence is similar in Wisconsin to that of the general U.S. population (WDHFS 2004; NCHS 2005). In Oneida County, asthma-related 2002 ED visits and long-term (1990-2001) mortality rates were substantially lower than those for the state as a whole, although hospitalization rates were similar (see Table D-1). The U.S. asthma-related mortality rate for 2002 was 15 per million (NCHS 2005). These data indicate that the residents of the State of Wisconsin have asthma-related health problems similar to those of the U.S. population as a whole in terms of numbers of cases and severity of cases. Oneida County has a somewhat lower rate of serious asthma cases than average Wisconsin residents, although there are similar numbers of hospitalizations.

TABLE D-1 Comparison of Asthma-Related Adverse Effects – Oneida County and Wisconsin Overall (Adapted from WDHFS 2004, Table 20)

Area	ED Visit Rate (per 10,000), 2002	Age-Adjusted Asthma Hospitalization Rate (per 10,000) 2000-2002	Age-Adjusted Asthma Mortality Rate (per million) 1990-2001
Oneida County	22.0	10.2	12.0
State of Wisconsin	42.0	10.1	18.5

D.2 O_3 Effects on Vegetation

The adverse effect of O_3 on vegetation has been observed for many years, but O_3 was first identified as the causative agent in the late 1950s (Feder 1973). Some of the effects include leaf damage, increased disease susceptibility, reduced root growth, and premature vine death. Of economic importance is the effect of decreased yield in crops, in the form of fewer and smaller fruits and vegetables. Important types of plants susceptible to O_3 include agricultural crops, especially alfalfa, beans, cotton, corn, grape, onion, peanut, potato, radish, soybean, spinach, tobacco, tomato, watermelon, and wheat; barley is less susceptible (Texas A&M Univ. 1996; EPA 2005; WHO 2000).

The mechanism of O_3's damage to vegetation is by uptake of O_3 through stomata, which causes nonspecific oxidative injury (EPA 2005). Research has shown that O_3 damage to vegetation does not occur at air concentrations below a threshold value (EPA 2005). O_3 exerts phytotoxic effects only if a sufficient amount of O_3 reaches sensitive sites within the leaf. O_3 injury will not occur if the rate of O_3 uptake is low enough that the plant can detoxify or metabolize O_3 or its metabolites or if the plant is able to repair the damage (EPA 1986). Once leaf damage does occur, photosynthesis is disrupted, leading to decreases in crop yields.

Environmental factors also can modify the effects of O_3 on vegetation. Temperature is one of the factors, but the relationship between O_3 exposure, temperature, and damage is complex, being dependent on whether the change in temperature moves the plant to an optimal level of photosynthesis or pushes it over a threshold into a harmful region (EPA 2005). O_3 is known to decrease the cold-hardiness of herbaceous species (EPA 2005). Other environmental factors that have been shown to impact O_3 damage to plants include humidity, surface wetness, salinity, drought conditions, and interactions with other pollutants. For example, increased levels of carbon dioxide (CO_2), a greenhouse gas associated with global warming, have been shown to decrease damage to vegetation caused by O_3. This of course makes sense because atmospheric CO_2 is required by plants in the photosynthetic process, and CO_2 increases lead to closing of stomas.

It is interesting that the protective effect of CO_2 has been shown to be influenced by climate. Wolf and Van Oijen (2003; as cited in EPA 2005) studied the effects of climate factors, O_3, and CO_2 in potatoes from northern to southern Europe. They noted that although increased CO_2, O_3, and light intensity were predominant controlling factors, increased temperature also influenced potential yields substantially, with increased yields in northern latitudes (attributed to a longer growing season) but decreased yields in southern latitudes (attributed to decreased assimilate production).

D.2.1 Guidelines for Plant O_3 Exposures

For certain crops, the visible damage O_3 causes in leaves has a direct adverse economic impact, because the leaves are the product (e.g., spinach, petunias). Jacobson (1977; as cited in EPA 2005) developed limiting values used in the literature to identify the lowest exposure concentration/duration reported to cause foliar symptoms in a variety of plant species. The results indicated that the threshold for foliar symptoms was an exposure to 50 ppb for several hours per day for more than 16 days. Decreasing the exposure period to 10 days increased the concentration required to cause symptoms to 100 ppb; and a short, 6-day exposure further increased the concentration to cause symptoms to 300 ppb. These limiting values established in 1978 were still deemed appropriate in the 1986, 1996, and 2005 O_3 criteria documents (EPA 2005). The 1978 and 1986 EPA O_3 criteria documents indicated that the limiting value for foliar symptoms on trees and shrubs was 60 to 100 ppb for 4 hr (as cited in EPA 2005).

Efforts have been made to develop exposure guidelines for decreased yield in crops based on a cumulative dose each season, rather than based on an air concentration. These guidelines also consider only exposures above a certain level; they are therefore called “peak-weighted” guidelines (EPA 2005). The cumulative dose-based guidelines include 3-month (May-July) exposures to concentrations above the threshold level. In the U.S., 60 ppb is used as the threshold and the guideline is termed SUM06; in Europe, 40 ppb is used as the threshold and the guideline is termed AOT40. These dose-based guidelines have units of ppm-hour. For comparison, from 1989 to 1995, mean 12-hour 3-month SUM06 values (in ppm-hour) at rural sites in the Clean Air Status and Trends Network were 31.5 for the Midwest and 18.9 for the Upper Midwest (EPA 2005). The Upper Midwest value is representative of the region of the FACE site.

It is difficult to compare studies that report O_3 exposure using different indices, such as AOT40, SUM06, or 7-hour or 12-hour mean values. However, a correspondence between the SUM06 exposure index and 7-hour mean O_3 air concentrations has been identified. A summary of earlier literature concluded that a 7-hour, 3-month mean of 49 ppb corresponds to a SUM06 exposure of 26 ppm-hour. Further, this 7-hour, 3-month exposure level would cause 10% loss in 50% of 49 experimental cases (Tingey et al. 1991, as cited in EPA 2005). In 1986, the EPA (1986) established that 7 hour per day growing season mean exposures to O_3 concentrations above 50 ppb were likely to cause measurable yield loss in agricultural crops. This conclusion was not changed in the 1996 or 2005 criteria documents (although the 2005 document is not final at this time).

Based on the data discussed above, in this EA average daily maximum 8-hour mean O_3 concentrations over a 3-month growing period (June-August) greater than 50 ppb are considered likely to cause decreased crop yields. One-hour O_3 levels are also discussed in the main text. One-hour levels greater than 60 ppb are considered to potentially cause foliar damage.

D.2.2 O_3 Effects on Potatoes

O_3 has been observed to decrease yield of potatoes. In a 1989 study exposing field-grown potatoes in outdoor fumigation systems to O_3 at levels of 1.33, 1.66, and 1.99 times ambient levels, O_3 caused an increasing yield reduction with each increased dose level, shown in decreases in both the number and weight of tubers (Pell et al. 1989). Although ambient levels vary by location, they are approximately 35-40 ppb in northern Wisconsin (Karnosky et al. 2004) suggesting that average O_3 levels greater than 50 ppb over the growing season could cause decreased yields.

The interactive effects of elevated O_3 and CO_2 additions on potato yield were studied in open-top containers (OTCs) at six sites in northern Europe as part of the CHIP (Changing Climate and

Potential Impacts on Potato Yield and Quality) program (Craigon et al. 2002). O_3 was added to a target daily average value of 60 ppb, and AOT40 values across all years and experiments ranged from approximately 6 to 27 ppm-hour. The O_3 treatment reduced total tuber yield an average of 4.8% with elevated O_3 treatment across all experiments (Craigon et al., 2002, as cited in EPA 2005).

References for Appendix D

Aligne, C.A., P. Auinger, R.S. Byrd, and M. Weitzman, 2000, "Risk Factors for Pediatric Asthma, Contributions of Poverty, Race, and Urban Residence," *Am. J. Respir. Crit. Care Med.* 162:873–877.

Craigon, J., A. Fangmeier, M. Jones, A. Donnelly, M. Bindi, L. De Temmerman, K. Persson, and K. Ojanpera, 2002, "Growth and marketable-yield responses of potato to increased CO_2 and ozone," *Eur. J. Agron.* 17: 273–289.

EPA (U.S. Environmental Protection Agency), 1986, *Air Quality Criteria for Ozone and Other Photochemical Oxidants*, EPA-600/8-84-020aF-eF, Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, N.C.

EPA (U.S. Environmental Protection Agency), 1999, *Guideline for Reporting of Daily Air Quality – Air Quality Index (AQI)*, EPA-454/R-99/010, Office of Air Quality Planning and Standards, Research Triangle Park, N.C., July.

EPA (U.S. Environmental Protection Agency), 2005, *Air Quality Criteria for Ozone and Related Photochemical Oxidants (First External Review Draft), Volume III*, EPA/600/R-05/004cA, National Center for Environmental Assessment-RTP Office, Office of Research and Development, Research Triangle Park, N.C., Jan.

Feder, W.A., 1973, "Cumulative Effects of Chronic Exposure of Plants to Low Levels of Air Pollutants," in: *Air Pollution Damage to Vegetation*, J.A. Naegele (ed.), a symposium sponsored by the Division of Agricultural and Food Chemistry at the 161st Meeting of the American Chemical Society, Los Angeles, Calif., March 31-April 1, 1971, Advances in Chemistry Series, American Chemical Society, Washington, D.C.

Gent, J.F., et al., 2003, "Association of Low-Level Ozone and Fine Particles with Respiratory Symptoms in Children with Asthma," *JAMA* 290(14):1859–1867.

Jacobson, J.S., 1977, "The Effects of Photochemical Oxidants on Vegetation." In: *Ozon und Begleitsubstanzen im photochemische Smog*, VDI Colloquium, 1976, Düsseldorf, Germany, VDI-Berichte 270, pp. 163–173.

Karnosky, D.F., K. Pregitzer, K. Percy, N. Nelson, G. Hendrey, J. Nagy, M. Kubiske, R. Lindroth, and D. Zak, 2004, *Impacts of Elevated CO_2 and O_3, Alone and in Combination, on the Structure and Functioning of a Northern Forest Ecosystem: Operating the Aspen FACE User Facility*, grant renewal application, Sept. 27, 2004, submitted to the Office of Science, U.S. Department of Energy, Washington, D.C.

NCHS (National Center for Health Statistics), 2005, *FastStats A to Z: Asthma*. U.S. Dept. of Health and Human Services, Centers for Disease Control. Available at http://www.cdc.gov/nchs/fastats/asthma.htm, last updated Aug. 21, 2005.

NIOSH (National Institute for Occupational Safety and Health), 1996, *IDLH Documentation for Carbon Dioxide and Ozone*. Available at http://www.cdc.gov/niosh/idlh/124389.html.

OSHA (Occupational Safety and Health Administration), 2005, *Regulation 1910.1000, Table Z-1, Limits for Air Contaminants*. Available at http://www.osha.gov/pls/oshaweb/owadisp. show_document?p_table=STANDARDS&p_id=9992. Accessed Oct. 4, 2005.

Pell, E.J., N.S. Pearson, C. Vinten-Johansen, G. McGruer, and Y. Yang, 1989, *Effects of Sulfur Dioxide and Ozone on Yield and Quality of Potatoes: Final Report*, EPRI-EA-6164, Electrical Power Research Inst., Palo Alto, Calif. and Pennsylvania State University, University Park, Penn., Jan.

Salam, M.T., Y.-F. Li, B. Langholz, and F.D. Gilliland, 2004, "Early-Life Environmental Risk Factors for Asthma: Findings from the Children's Health Study," *Environmental Health Perspectives* 112(6):760–765.

Texas A&M Univ., 1996, *Air Pollution Injury, Texas Plant Disease Handbook*, Nov. Available at http://plantpathology.tamu.edu/Texlab/Multicrop/airpollution.html.

Thurston, G.D., and K. Ito, 1999, "Epidemiological Studies of Ozone Exposure Effects," in *Air Pollution and Health*, S.T. Holgate, et al. (eds.), Academic Press, London, United Kingdom.

Tingey, D.T., W.E. Hogsett, E.H. Lee, A.A. Herstrom, and S.H. Azevedo, 1991, "An Evaluation of Various Alternative Ambient Ozone Standards Based on Crop Yield Loss Data," pp. 272-288, in R.L Berglund, D.R. Lawson, and D.J. McKee (eds.), *Tropospheric Ozone and the Environment: Papers from an International Conference*, March 1990, Los Angeles, Calif.

WDHFS (Wisconsin Dept. of Health and Family Services), 2004, *Burden of Asthma in Wisconsin 2004*, Division of Public Health, Bureau of Environmental Health, Madison, Wis. Available at http://dhfs.wisconsin.gov/eh/asthma/pdf/boawi04.pdf.

Wolf, J., and M. Van Oijen, 2003, "Model Simulation of Effects of Changes in Climate and Atmospheric CO_2 and O_3 on Tuber Yield Potential of Potato (cv. Bintje) in the European Union," *Agric. Ecosyst. Environ*. 94:141–157.

WHO (World Health Organization), 2000, "Effects of ozone on vegetation: critical levels," Chapter 12 in *Air Quality Guidelines for Europe*, 2nd Ed., WHO Regional Publications, European Series, No. 91, Regional Office for Europe, Copenhagen, Denmark. Available at http://www.euro.who.int/document/e71922.pdf.