HEALTH IMPLICATIONS OF SNOWMOBILE USE IN YELLOWSTONE NATIONAL PARK

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EXECUTIVE SUMMARY

The National Park Service recently announced a major change in how it plans to manage winter visitation in Yellowstone and Grand Teton National Parks. Instead of phasing out the use of snowmobiles, the agency said it intends to restrict the numbers and types of snowmobiles permitted within the parks, protecting environmental and human health through careful limits.

The agency noted that its plan to continue snowmobile use would provide less protection for air quality and human health than an earlier decision to replace snowmobile use with a transportation system of snowcoaches.

The agency also reported that its plan would reduce snowmobile emissions significantly but not enough to remove a likelihood of adverse health effects for employees and visitors susceptible to respiratory and other health problems.

These two acknowledgements seemed at odds with Yellowstone's designation by Congress as a Class 1 airshed, a place intended to have the cleanest air in the nation.

This report grew out of a strong interest on the part of organizations concerned about public health to better understand the human health implications of this change in policy.

Specifically, the report was undertaken to assess:

- The pollution levels predicted by the National Park Service;
- Peer-reviewed literature on the health effects of pollutants prevalent in snowmobile emissions; and
- Assumptions used by the National Park Service in modeling snowmobile emissions and the agency's resulting conclusions about the effects on air quality and human health.

The assessment highlights significant omissions and discrepancies in the National Park Service's analysis. It appears that risks to human health under the Preferred Alternative would likely be greater than the National Park Service has acknowledged, particularly for children, pregnant women, seniors, asthmatics, and people with other respiratory and cardiovascular diseases. Some of these risks are not accurately described in the National Park Service's analysis. Others are overlooked entirely.

This report details concerns about data both used and not incorporated by the National Park Service in development of its plans to change winter use in Yellowstone. At present, the agency is using flawed analysis to make a decision, which, as a result, is unlikely to be fully protective of employee or public health:

- The National Park Service has predicted pollution levels with a continuation of snowmobile use that would clearly pose health risks for particular populations. Individuals with asthma and other respiratory and cardiovascular diseases, pregnant

women, children, and the elderly would face a higher level of risk than under a snowmobile phase-out. These groups comprise a large percentage of the general public. Yet the National Park Service did not analyze their elevated risk.

- Many employees and visitors in Yellowstone are exposed to concentrations of snowmobile emissions that are much higher than those measurable as ambient pollution. Examples include employees working in areas of concentrated snowmobile traffic, snowmobilers trailing large groups of machines, or children riding on the backs of snowmobiles. Studies have demonstrated that in these circumstances exposure to harmful pollutants can increase dramatically. The National Park Service's most recent analysis did not model for these circumstances. As a result there would likely be frequent discrepancies between predicted pollution levels and actual exposure to air contaminants.

- Recent health studies have identified airborne particulate matter less than 2.5 microns in size (PM2.5) as causing many of the health effects attributed to particulate matter, including respiratory disease, lung damage, cancer, and premature death. Even modest levels of PM2.5 have been associated with adverse health effects. Virtually all particulate matter emissions from snowmobile engines are PM2.5 or smaller yet the National Park Service did not model specifically for PM2.5 in its most recent analysis. Nor did the agency discuss potential health effects of acute and chronic exposure to PM2.5 in its analysis.

- Visitors not acclimated to Yellowstone's high elevation are likely to be more susceptible than local residents to adverse health effects from carbon monoxide exposure. CO enters the bloodstream from the lungs, binds to hemoglobin in red blood cells, and forms carboxyhemoglobin (COHb). COHb impairs oxygen delivery throughout the body. For individuals who travel from low elevation to Yellowstone's average elevation of more than 7,000 feet, the resultant decrease in oxygen delivery to tissues and organs could be highly significant. People who already suffer from compromised oxygen delivery are especially sensitive to changes in elevation and CO exposure. Individuals with cardiac disease are more likely to experience arrhythmia or angina when exposed to CO at high elevations than when exposed to the same concentration of CO at lower elevations. These factors are likely to apply to many of Yellowstone's winter visitors. However, the National Park Service analysis does not discuss this potential health consequence of permitting higher levels of carbon monoxide than are achievable through a snowmobile phaseout.

- The National Park Service has overstated benefits to air quality from its plan to cap numbers of snowmobiles and require that all machines be "Best Available Technology" (BAT). In predicting total snowmobile emissions, the agency used data from a snowmobile that is significantly less polluting than the new definition of BAT. The Park Service defines BAT as snowmobiles that emit 90 percent fewer hydrocarbons (HC) than a standard 2-stroke snowmobile and 70 percent less carbon monoxide (CO). The agency's modeling of future air quality used emissions data from a snowmobile with 95 to 98 percent less HC and 85 percent less CO.

- The National Park Service has stated that its plan to allow continued snowmobile use is one that assures dramatic reductions in snowmobile emissions. But the agency has failed to make clear that cutting emissions is not the same as cutting pollution. During the winter, Yellowstone frequently experiences stable air masses and/or inversions that limit dispersion of emissions. When emissions accumulate, pollution levels rise. Pollution levels can remain high hours after peak snowmobile traffic has subsided. This is a critical distinction because pollution levels, not emissions from individual snowmobiles, are the relevant factor for human health. By not making this distinction clear, the National Park Service analysis reflects a distorted view of air quality and health benefits associated with its plan to continue snowmobile use. For example, carbon monoxide emissions would be reduced by some 70 percent per snowmobile. But modeling indicates that peak carbon monoxide pollution levels would drop by just 51 percent at Old Faithful, and only 26 percent at the West Entrance where fresh air is piped into work booths and employees still experience symptoms of CO toxicity, including headaches, dizziness, and nausea.

- The National Park Service plan for continued snowmobile use hinges upon several disputed assumptions regarding "Best Available Technology" (BAT). These include whether the agency has the authority to require emissions reduction more stringent than the Environmental Protection Agency and whether snowmobiles meeting these requirements would be readily available and affordable to the public. It is also unclear how the National Park Service would ensure that all private snowmobiles would be BAT when the machines are not clearly labeled as such by the manufacturers and can be modified, resulting in higher emissions and more noise.

In summary, the evidence presented here demonstrates that serious public health risks from pollution would remain under the National Park Service plan to continue snowmobile use in Yellowstone and Grand Teton national parks. The agency did not use the best available data in its most recent analysis. Air pollution and health effects from snowmobiles have been underestimated, poorly depicted, and, in some cases, not analyzed at all. For these reasons, actual exposure and health risks for park employees and potentially tens of thousands of winter visitors would be greater than the National Park Service has reported. The aim of this report is to convey these concerns, and the large body of peer-reviewed science upon which they are based, to the National Park Service and the public so that more informed decisions can be made. More than 60 published studies referred to throughout this report are listed on pages 26-29.

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INTRODUCTION

In February 2003, the National Park Service (NPS) released its Winter Use Plan, Final Supplemental Environmental Impact Statement for Yellowstone and Grand Teton National Parks (FSEIS). In the document, NPS analyzed the environmental impacts predicted under four possible winter use management alternatives for these parks. The FSEIS identifies Alternative 4 as the "Preferred Alternative." Alternative 4 would allow snowmobiles with reduced emissions into the park and limit total numbers of machines. If implemented, this alternative would reverse an earlier decision to replace snowmobiles with snowcoaches. The FSEIS analyzes a new range of alternatives and confirms that the earlier decision to phase out snowmobiles (now referred to as Alternative 1b) continues to be the "Environmentally Preferred Alternative," with fewer impacts to park resources and human health.

This report analyzes data from the FSEIS regarding individual pollutants found in snowmobile emissions. The report assesses the health implications associated with exposure to current levels of these pollutants. It then examines how health risks would change with pollution levels predicted for the agency's Preferred Alternative and for the Environmentally Preferred Alternative. Particular attention is focused on individuals disproportionately exposed to those pollutants and to susceptible sub-populations at greater risk.

Finally, after analyzing the health effects of the two management alternatives, this report reviews the methods and assumptions used by NPS to predict how these alternatives will affect levels of pollution and their impacts on human health.

This report was written by Sarah Janssen, M.D., Ph.D. and Ted Schettler, M.D., MPH, Science Director, Science and Environmental Health Network. The authors are grateful to Jefferson Dickey, M.D., and Deborah Shprentz for their comments and suggestions on an earlier draft of this report. Any errors are the responsibility of the authors.

BACKGROUND

During the winter, the city of West Yellowstone, Montana becomes a popular staging area for some of the nation's most concentrated snowmobiling. Between December and March, tens of thousands of snowmobiles travel from the town into Yellowstone National Park and nearby national forest lands.

Over the past several years, an average of 65,000 snowmobiles have entered Yellowstone National Park during its winter season, more than 700 snowmobiles per day. Four entrances to the park are open to snowmobiles. On peak days, up to 2,000 snowmobiles enter the park, 80 percent converging at Old Faithful. The West Entrance, near the community of West Yellowstone, is the busiest park gate. On holidays and weekends, more than 1,000 snowmobiles a day often pass through this single entrance.

These levels of snowmobile use developed rapidly during the late 1980s and early 1990s, raising concerns about impacts to Yellowstone's air quality, tranquility, wildlife, and the health and safety of employees and visitors.

By the late 1990s, the concerns extended to neighboring Grand Teton National Park and John D. Rockefeller Jr. Memorial Parkway. On November 22, 2000, after a decade of scientific study and three years of public involvement, the National Park Service decided that protecting the three park units required eliminating snowmobile use and developing a winter transportation system of multi-passenger snowcoaches. By the time the decision was finalized, 80 percent of citizen comment to the National Park Service favored the phaseout of snowmobile use.

The agency said in its decision that if it allowed snowmobile use to continue: "the impact on people who may visit the three parks once or twice in a lifetime, and who seek the resources and values for which the parks were created, may be adversely and irretrievably affected." (Record of Decision, Winter Use Plans, 2000)

On December 6, 2000, a lawsuit brought by the International Snowmobile Manufacturers Association challenged the National Park Service decision. In a procedural settlement, the U.S. Department of Interior agreed to reconsider whether protecting the parks necessitated banning snowmobiles. This supplemental study has brought increased attention to the serious health risks from exposure to snowmobile emissions.

Park personnel exposed to snowmobile emissions have reported nausea, headaches, dizziness, hearing loss, burning eyes, sore throats, and fatigue. At Yellowstone's West Entrance, fresh air piped into work booths has not eliminated these symptoms. In the winter of 2001-2002, the National Park Service equipped these workers with respirator masks. In the winter of 2002-2003, the agency also made respiratory protection available to rangers on snowmobile patrol, purchasing paper masks lined with layers of charcoal. These masks are less effective than respirators, inefficient in filtering some pollutants, and unable to filter others. The National Park Service said it chose the paper masks because they are less cumbersome for rangers who must also wear helmets.

Yellowstone employees exposed to snowmobile noise have also experienced ringing in their ears and partial hearing loss. In the winter of 2002-2003, the National Park Service purchased high-tech hearing protection. At the urging of the Occupational Safety and Health Administration, the National Park Service also instituted a "Hearing Conservation Program" to educate employees about the risks from snowmobile noise and the protective measures available.

On February 10, 2003, the American Cancer Society, the Science and Environmental Health Network, Women's Voices for the Earth, Physicians For Social Responsibility, Institute For Children's Environmental Health, and Idaho Women's Network wrote to the superintendent of Yellowstone National Park:

> *"We are concerned that park employees and visitors, especially vulnerable populations such as children, pregnant women, the elderly, people with respiratory disease, and those with cardiovascular disease are being exposed to dangerous levels of pollutants. Because the public has a right to know about potential hazards they may face in Yellowstone, we urge you to issue a health advisory to all park visitors during the remainder of the winter months."*

The health organizations cited Yellowstone's high levels of carbon monoxide, particulate matter, and carcinogens such as benzene and formaldehyde. The organizations noted that the National Park Service's Air Resources Division concluded in its own analysis of snowmobile pollution in Yellowstone that visitors are at risk from snowmobile emissions. The Air Resources Division wrote:

> *"It is important that employee exposure to exhaust gasses be minimized. It would seem that visitors would likewise want to minimize their exposure to what are likely unhealthy levels of air pollution."* [19]

The National Park Service has not issued a health advisory.

On February 20, 2003, the agency issued its Winter Use Plans, Final Supplemental Environmental Impact Statement (FSEIS), identifying as the **"**Preferred Alternative" (Alternative 4) continued snowmobile use with restrictions on the numbers and types of snowmobiles permitted. The number of snowmobiles entering Yellowstone each day would be capped at 950. Over a phase-in period, machines would be required to have "best available technology," to reduce emissions of hydrocarbons and carbon monoxide by 90 and 70 percent, respectively.

The FSEIS noted that the National Park Service's November 22, 2000 decision to replace snowmobiles with snowcoaches remains the "Environmentally Preferred Alternative" (Alternative 1b) and would yield the lowest impacts to Yellowstone's air quality, natural soundscapes, wildlife, and employee and visitor health.

Limiting snowmobile use would unquestionably improve air quality and reduce risks to human health. But the agency is choosing a lower level of protection than its Environmentally Preferred Alternative would provide. Using the most current scientific evidence on the health effects of air pollution, this report describes the public and employee health impacts of this choice

NATIONAL PARK SERVICE RESPONSIBILITIES

A large body of public law, regulations and Executive Orders define the mission of the National Park Service (NPS).

Under the Clean Air Act, Yellowstone is designated a Class 1 airshed—intended to have the cleanest air in the country. Congress directed that Class 1 airsheds be afforded the greatest degree of air quality protection. The National Park Service Organic Act established the NPS to manage parks "in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

Reflecting these mandates NPS management policies define an affirmative duty to pursue the best possible protection for air quality and human health within the national park system:

"NPS managers must always seek ways to avoid, or to minimize to the greatest degree practicable, adverse impacts on park resources and values…" (NPS Policies at 1.4.3)

"…the Service will seek to perpetuate the best possible air quality in the parks to (1) preserve natural resources and systems; (2) preserve cultural resources; and (3) sustain visitor enjoyment, human health, and scenic vistas… The Service will assume an aggressive role in promoting and pursuing measures to protect values from the adverse impact of air pollution. In cases of doubt as to the impacts of existing or potential air pollution on park resources, the Service will err on the side of protecting air quality and related values for future generations." (NPS Policies at 4.7.1)

AIR POLLUTION HEALTH EFFECTS LITERATURE REVIEW

This section summarizes an extensive collection of peer-reviewed scientific literature that addresses air pollutants prevalent in Yellowstone during the winter and their known health effects.

A full bibliography of sources cited in this report can be found on page 26, including a number of recently published reviews [1-5]. The American Lung Association publishes annotated bibliographies and summaries of recent findings on air pollution, available at: www.lungusa.org/air/ [6, 7]. The United States Environmental Protection Agency also has on-line resources at: www.epa.gov/air/.

A large body of scientific research demonstrates that air pollution causes premature death, chronic heart and lung disease exacerbation, respiratory irritation, and lung cancer. This has been shown in cross sectional, case control, time series, and prospective cohort studies. These conclusions have withstood all academic challenges.

Air pollution causes chest pain, shortness of breath, coughing, wheezing, headache, eye irritation, asthma exacerbations, increased asthma medication use, days lost from school and work due to chest illness, impaired growth of lungs in children living in high air pollution areas, and other severe morbidity including heart attacks, strokes, cardiac arrhythmias, angina, arterial spasm, and sudden death [2, 3, 8-17]. These effects are found at air pollution levels seen in many U.S. cities. Life span can be shortened by months or years [3, 18]. Sensitive individuals may experience symptoms at levels well below accepted standards.

The U.S. EPA has adopted standards for some air pollutants that are of particular concern from a health perspective. These include particulate matter (PM), sulfur dioxide (SOx), nitrogen oxide (NOx), carbon monoxide (CO), ozone (O_3), and lead (Pb). National Ambient Air Quality Standards (NAAQS) define maximum concentrations of these air pollutants allowed in the air, (www.epa.gov/airs/criteria.html). NAAQS are intended to protect the general public from harmful effects of air contaminants and do not apply in the workplace.

In Yellowstone, air monitoring projects show that employees and visitors are frequently exposed to levels of air pollution that exceed NAAQS, at least in the short term. Although fixed site NPS monitors have recorded air pollutant levels within NAAQS, monitoring projects examining individual exposure have shown that in certain situations levels of air pollution do exceed these standards [19-21].

The Occupational Safety and Health Act of 1970 created two distinct agencies, the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH), both agencies with the mission of protecting worker safety and health.

OSHA, in the U.S. Department of Labor, is responsible for creating and enforcing workplace safety and health regulations. OSHA has established Permissible Exposure Limits (PELs) for some toxic compounds in an attempt to offer some worker protection. PELs are not intended to be as protective as NAAQS.

NIOSH, in the U.S. Department of Health and Human Services, is a research agency that has established Recommended Exposure Levels (RELs) for some workplace exposures as well. RELs have been established for pollutants for which OSHA has no standards or for which existing OSHA standards may not be protective for all workers.

NIOSH RELs have been exceeded at Yellowstone's West Entrance. Studies have shown park workers to be excessively exposed to benzene, formaldehyde, carbon monoxide and noise

Snowmobiles emit high levels of the air pollutants CO and PM. Hydrocarbon (HC) emissions from the incomplete combustion of fuel can also be significant and contribute to the organic carbon fraction of fine particles and visibility impairment. In Yellowstone National Park (YNP), snowmobile HC emissions can exceed 600 tons/year and CO emissions exceed 1900 tons/year. On an average day with more than 700 snowmobiles in the park, approximately 7 tons of HC and 19 tons of CO are produced. In comparison, on an average July day with 9,214 automobiles in YNP, 2.5 tons of HC and 17.9 tons of CO are produced [19]. One study found that snowmobiles over the 90-day season contribute 77% of annual HC emissions in YNP [20]. In fact, snowmobiles contribute more of the annual HC emissions than automobiles, RV's and buses combined. Snowcoaches currently are estimated to contribute < 1% of annual CO and HC emissions in YNP.

Snowmobile riders are exposed to high levels of toxic air pollutants not only from their own machine but also from others around them. Snowmobile riders are often in groups and in a single line along trails or while waiting to enter the park. Due to these riding patterns, riders breathe exhaust emissions from their own vehicle as well as the vehicle directly in front of them, and others farther ahead. Exposure to high levels of CO, PM, HC and polycyclic aromatic hydrocarbons (PAHs) can last for hours at a time. In addition, large numbers of snowmobiles gather in small areas: parking lots, entrance stations, and particularly at Old Faithful.

There is a strong correlation between snowmobile numbers and pollution levels. Weather patterns also play an important role when stable atmospheric conditions with low wind

speeds prevent dispersion of air pollutants, allowing accumulation and causing poor air quality. These conditions can result in relatively high personal exposure levels of harmful pollutants from one day of snowmobiling.

In response to employee complaints, NPS commissioned reports to investigate exposure of park employees to air pollutants from snowmobile exhaust [19, 21]. *Environmental and Occupational Exposure to Toxic Air Pollutants from Winter Snowmobile Use in Yellowstone National Park* measured exposure to CO, PM, benzene and other volatile organic compounds (VOCs) and aldehydes. Four locations were evaluated: a residential neighborhood in West Yellowstone, MT, downtown West Yellowstone, the West Entrance gate to Yellowstone Park, and Old Faithful. The West Entrance, near the community of West Yellowstone, is the busiest and most popular entrance to the park with the majority of snowmobiles entering through this gate. *Air Quality Concerns Related to Snowmobile Usage in National Parks* measured exposure levels for snowmobile riders. These studies will be referred to extensively as they are the most recent and comprehensive assessments of employee and visitor exposure in YNP.

Specific Pollutants Found in Yellowstone and their Health Effects

Carbon Monoxide (CO)

Health effects of CO Carbon monoxide is an odorless, tasteless, non-irritating gas. CO enters the bloodstream from the lungs and binds to hemoglobin in red blood cells to form carboxyhemoglobin (COHb). COHb impairs oxygen delivery throughout the body but has the most profound impact on organs with high oxygen requirements such as the brain and heart.

Nonsmokers typically have COHb concentrations <1%. Elevated blood levels of COHb (~5%) can result in decreased cognitive function, impaired learning, decreased manual dexterity, difficulty performing complex tasks, reduced visual perception and shortness of breath with exertion. At higher levels of COHb (10%) nausea, dizziness and headaches can occur. At 50-70% COHb, seizures, coma and death result.

Mathematical modeling is used to predict COHb levels from known CO exposure [22]. At sea level, a non-smoking adult exposed to 25-50 ppm (parts per million) CO for 1h with light exercise is predicted to have 2-3% COHb levels. After 8h of continued exposure predicted COHb levels reach 4-7%.

High altitude can impair oxygen delivery to tissues because of both decreased oxygen tension and COHb formation. At high elevations, the lower partial pressure of oxygen results in less saturation of hemoglobin with oxygen than at sea level. For individuals unacclimated to high altitudes, the resultant decrease in oxygen delivery to tissues and organs can be highly significant. Also at high elevations, compensatory physiological changes can favor COHb formation. Breathing 9 ppm CO at rest in high altitudes produces higher COHb levels than at sea level [22, 23]. Animal studies show that endogenous CO production results in increased levels of COHb at higher altitude than at sea level, without any additional CO in the respired air [23].

Adding CO to the inspired air at higher elevation, such as from snowmobile emission, will predictably result in even higher levels of COHb and further reductions in oxygen delivery to sensitive tissues and organs. Therefore, visitors unacclimated to high altitudes are more susceptible to CO effects that local residents. People with compromised oxygen delivery are especially sensitive to these changes in elevation and CO exposure.

Although healthy people can exhibit mild symptoms from CO exposure, people with anemia, cardiovascular disease, respiratory disease, pregnant women, infants and children, and the elderly are particularly susceptible to the more serious effects of CO toxicity. Controlled clinical exercise studies have demonstrated an increased risk for angina, coronary ischemia, and arrhythmias in people with coronary artery disease at relatively low levels of CO. One large multi-center trial found earlier onset myocardial ischemia during exercise when exposed to ambient CO resulting in COHb levels of 2-3% [24]. Ambient urban CO levels (<9-ppm/8h average) have been associated with angina, cardiac arrhythmia, and cardiac arrest [24-28]. COHb also impairs delivery of oxygen to the fetus and can interfere with pregnancy and fetal growth. CO at ambient levels (2-6 ppm) has been associated with low birth weight and cardiac malformations [29-32].

Analysis of CO in Yellowstone and Grand Teton
Snowmobile emissions contain non-combusted fuel and have a high carbon monoxide content. This can be accentuated in Yellowstone where cold air hampers engine performance, leading to less complete combustion. In YNP, current CO emissions due to snowmobiles are 1900 tons/yr. with an average daily production of 19 tons.

Table 1. One hour maximum carbon monoxide (CO) concentrations, West Entrance

Existing conditions	12.20 (ppm, w/bkgd)
Alternative 1b, snowcoaches only (predicted)	4.20 (ppm, w/bkgd)
Alternative 4, cont. snowmobile use (predicted)	9.00 (ppm, w/bkgd)

Current levels of CO in the park due to snowmobile emissions are putting both employees and visitors at risk. Recreational snowmobile riding patterns can result in dangerously high exposure to CO. In a study at Grand Teton National Park, snowmobile riders at distances 25 to 125 feet behind another snowmobile, traveling speeds at 10 to 40 mph, were exposed to average CO levels of 0.5 to 23 ppm, depending on speed and distance [33].

The highest CO level measured was 45 ppm, well above the current 1h NAAQS for CO of 35 ppm. A study of YNP employees in Feb. 1999 found the 8h average CO concentration at the West gate was 8.86 ppm [21]. This is similar to NPS reported CO levels and is very close to the 8h NAAQS for CO of 9 ppm. An OSHA industrial survey in Feb. 2000 reported a peak CO exposure of 268 ppm for a YNP employee [57]. OSHA does not have a short-term exposure limit for CO but the NIOSH REL for a 15-minute peak exposure is 200 ppm. In comparison, typical ambient levels of CO in outdoor settings are less than 1ppm, while peak commuter traffic CO levels are ~50 ppm. A table comparing these values is on the next page.

Table 2. Comparative CO exposure levels

	8h NAAQS	8h avg. West Entrance	1h NAAQS	1h Snowmobile rider YNP	NIOSH REL (15 min)	YNP employee peak exposure	commuter traffic
CO (ppm)	9	8.86	35	0.5-45	200	268	50

Several employees have been exposed to CO levels above allowable limits. Park employees have complained of symptoms of CO toxicity, including headaches, dizziness and decreased cognitive function. These symptoms increase the risk of injuries on the job or accidents. Furthermore, respirators and paper masks issued to the park rangers do not filter CO and will not alleviate symptoms of CO toxicity.

Current levels of CO in YNP place pregnant women, children, and people with anemia, chronic lung or heart diseases at an increased risk of toxicity. Furthermore, sensitivity to CO exposure increases with cold and altitude, especially in unacclimated individuals. Increased sensitivity to CO at high altitudes in a person with cardiac disease is likely to exacerbate the effects of coronary artery disease resulting in an increased incidence of ectopy (abnormal heart rhythm), angina and ischemia at relatively low CO concentrations [27, 34]. For pregnant women exposed to CO during critical periods of pregnancy, fetal growth can be impaired. This is especially concerning for pregnant employees and YNP area residents chronically exposed to elevated CO levels over the winter season.

Particulate Matter (PM)

Health Effects of PM

Particulate air pollution refers to air suspended mixture of solid and liquid particles varying in size, composition, and origin. The size distribution of total suspended particles (TSP) includes particles that are both larger and smaller than 10 μm in aerodynamic diameter. Particulate matter equal to or less than 10 μm in aerodynamic diameter is called PM10, but this includes particulate matter <2.5 μm (PM 2.5), and ultrafine particulate matter (<0.1 μm). Particulate matter (PM) is derived from: 1) biological sources such as pollens and other microscopic organic materials; 2) geologic sources including soil, volcanic activity and other crustal materials; and 3) man-made sources including industrial operations and combustion processes.

Particulate airway distribution and health effects are dependent on the size and compositions of particles and characteristics of the airway. Particles that are 10 μm and larger tend to be trapped in the upper airways where they are cleared by mucociliary mechanisms. Smaller particles tend to penetrate more deeply, and PM2.5 reaches well into the lower respiratory tract and smaller airways. Recent health studies have identified the smaller particulates as causing many of the health effects attributed to PM.

Acute exposure to particulate air pollution results in an increased occurrence of respiratory symptoms, cough, exacerbation of asthma, and increased mortality and hospitalizations due to respiratory and cardiovascular causes. Small increases in ambient

PM2.5 levels exacerbate asthma in children and adults [17, 35-37]. Acute exposure to particulate air pollution (PM10) is strongly associated with daily mortality due to respiratory and cardiovascular causes [2, 3, 15, 38]. Increases in daily mortality are typically estimated at 0.5-1.5% per 10 μg/m^3 increase in PM10 concentrations [9, 15]. Infant mortality is also associated with PM10 particulate exposure [3, 39, 40].

Chronic exposure to particulate pollution is associated with bronchitis, chronic cough, respiratory illness, chronic obstructive pulmonary disease (COPD), premature death, and lung cancer. Several studies have shown school children and adolescents exposed chronically to PM and other air pollutants at ambient levels in southern California have impaired lung development and function [41-43]. Prolonged exposure to fine particulate air pollution also significantly increases the risk of dying from lung cancer and cardiopulmonary causes [44].

Individuals with respiratory disease (COPD, asthma, acute bronchitis, and infections such as pneumonia or influenza) and cardiovascular disease (arrhythmias, coronary artery disease, congestive heart failure), children and the elderly are particularly susceptible to PM effects [45]. In both short and long term studies, particulate air pollution has an effect on cardiac-related deaths and hospital admissions. Particulate air pollution is associated with decreased heart rate variability, increased heart rate, arrhythmias, stroke, and myocardial infarction [1, 3, 11, 25, 46-49]. Some studies suggest that diabetics may be at an increased risk for cardiovascular damage due to PM [50, 51].

Numerous studies have shown that even healthy populations are at an increased risk of premature death due to current ambient PM 2.5 levels in the U.S. NAAQS mandate a 24h average PM 10 of 150 μg/m^3 with an annual average not to exceed 50 μg/m^3 and a 24h average PM2.5 NAAQS of 65μg/m^3 with an annual average less than 15 μg/m^3. The World Health Organization (WHO) has not proposed guidelines for particulate matter arguing it is not possible to define a threshold below which no adverse effects are expected. A recent study of mortality rates and PM2.5 levels found an association between an increase in death rates and PM2.5 concentrations [52]. There was no evidence of a threshold, or "safe level" found. These associations were linear to the lowest levels studied, 2 μg/m^3, well below the threshold set by the US EPA of 15 μg/m^3 annually. For each 10 μg/m^3 increase in PM2.5 a 1.5% increase in death rate was observed [52]. Therefore, current EPA standards for PM may not be fully protective of human health, especially for sensitive populations.

Analysis of PM in Yellowstone and Grand Teton

Table 3. One hour maximum particulate matter (PM) concentrations, West Entrance

Existing conditions ..... 78.00 (μg/m^3, w/o bkgd)
Alternative1b, snowcoaches only (predicted) ..... 1.0 (μg /m^3, w/o bkgd)
Alternative 4, (cont. snowmobile use (predicted)..... 11.00 (μg /m^3, w/o bkgd)

Snowmobiles contribute 10-12 tons/yr. of PM, or about 39% of annual PM emissions seen in the park [19]. In a study of YNP employees, particulate matter was measured as PM10, PM 2.5 and TSP [21]. In this study, concentrations of PM10 and TSP were virtually identical to PM2.5 concentrations collected at the same location. This is

consistent with other studies describing particulate matter from snowmobile engines as sub-micrometer or < 1 micron in size and suggests fine particulate matter accounts for essentially all PM measured in YNP. These smaller particles pose a particular health concern as they are breathed deeply into smaller airways of lung. Control of combustion sources would be expected to directly lower PM concentrations. In turn, given a linear relation between air pollution and morbidity and mortality, lower particulate matter concentrations would be expected to result in fewer health effects.

Measures of PM in YNP found the highest exposures occurred to employees working outside in booths or at the express lane, West Entrance [21]. Using fixed site samplers, the 8h average of PM 2.5 was 62.1 $\mu g/m^3$ at the West Entrance, and 24.7 $\mu g/m^3$ at Old Faithful. A maximum exposure of 116 $\mu g/m^3$ was measured at the West Entrance express lane over a 4h period (8:30AM-12: 30 PM), coincident with the time of day when most snowmobiles enter the park. The morning measures were consistently 3 to 5 times higher than afternoon samples. Similar levels were found in personal respirable PM (PerPM, PM4) samples of employees.

The most alarming level of PerPM was found in a mechanic working indoors with a concentration of 500 $\mu g/m^3$ over a 4h sampling period. Mobile park rangers had PerPM exposures 40 to 100 $\mu g/m^3$ and employee exposure at Old Faithful was 10 to 60 $\mu g/m^3$. Visitors are exposed to similar levels of PM when traveling in the busiest corridors of the park or when visiting Old Faithful. PM10 concentration in a residential area of West Yellowstone, MT was ~3 $\mu g/m^3$ and in west downtown ~ 15 $\mu g/m^3$. A comparison of morning-time PM exposure in a non-smoking mechanic, PM concentrations at the West Entrance, at Old Faithful, on a busy LA highway, and NAAQS are shown below.

Table 4. Comparative PM exposure levels

	Mechanic YNP	West Entrance, express lane	Old Faithful	Los Angeles Highway	NAAQS PM 2.5 1 hour
PM level $\mu g/m^3$	60-500 (PerPM)	60-116 (PM2.5) 50-160 (PerPM)	17-60 (PM 2.5) 10-60 (PerPM)	32-64 (PM2.5)	65

Employees of and visitors to YNP are exposed to PM2.5 levels that exceed those found on a Los Angeles highway commute and often surpass the one-hour NAAQS of 65 $\mu g/m^3$.

In healthy people, acute exposure to PM at this level could cause respiratory irritation and cough. For visitors with existing respiratory or cardiac conditions, exposure to current PM levels in YNP places them at an increased risk for cardiac arrhythmias, ischemia and an exacerbation of lung disease, possibly resulting in hospitalization or death. Children with asthma risk shortness of breath, decreased lung function and could require physician treatment. Chronic exposure to current levels of PM puts YNP employees, recreational

tour guides, snowcoach operators and others who work in the park at a higher risk for premature death, chronic lung disease, cardiac instability and possibly lung cancer.

Hydrocarbons (HC)
(Volatile Organic Compounds including uncombusted hydrocarbons found in gasoline - including benzene, toluene, ethylbenzene and xylenes)

Table 5. Comparative HC emission levels

Existing conditions	674 (tons/year)
Alternative 1b, snowcoaches only (predicted)	44 (tons/year)
Alternative 4, cont snowmobile use (predicted)	67 (tons/year)

In the 3-month winter season, snowmobiles produce an estimated 674 tons of hydrocarbons (HC), or an estimated 77% of annual HC emissions in the park [20]. HC emissions from snowmobiles in YNP exceeded those of automobiles, RV's and buses combined in 1998 [19]. Exposure to volatile organic compounds (VOCs) including uncombusted hydrocarbons found in gasoline - benzene, toluene, ethyl benzene and xylenes were measured in YNP employees [21].

- ***Benzene***

Health effects: Benzene is an aromatic hydrocarbon present in both exhaust and evaporative emissions from motor vehicles. Information from the EPA Air Toxics Website describes the health effects of benzene [53]. Acute inhalation of benzene may cause drowsiness, dizziness, and headaches, as well as eye, skin and respiratory tract irritation and at high levels can cause a loss of consciousness. Chronic inhalation causes bone marrow suppression. Reproductive effects have been reported in women occupationally exposed to high levels of benzene by inhalation and adverse effects on the developing fetus have been observed in animal studies [54]. A recently published study found an association between maternal ambient VOC exposure and altered T-cell profiles in umbilical cord blood [55]. The clinical relevance is unknown, but the immune status of the newborn child may be affected.

EPA has identified benzene as a known human carcinogen and an increased incidence of leukemia has been observed in humans occupationally exposed to benzene.

Gender differences in benzene metabolism have been reported. One study reports that women metabolize 23 -26% more benzene than men do, when subjected to the same exposure [56]. The most serious benzene related adverse health effects are caused by benzene metabolites. Current standards for occupational exposure are based on male workers, and therefore may not be protective of female health. Thus, women may be at a higher risk for benzene exposure than men.

Analysis of Benzene in Yellowstone and Grand Teton: Snowmobiles presently contribute 8 tons/yr. to annual benzene emissions inside YNP. Benzene exposure for some employees and visitors currently exceeds recommended exposure levels [19, 57].

In addition to NIOSH and OSHA recommended exposure limits, the Agency for Toxic Substances and Disease Registry (ATSDR) has set Minimal Risk Levels (MRLs) for

hazardous substances based on acute, intermediate or chronic exposures. MRLs are not regulatory but rather estimates of a specified period of exposure to a hazardous chemical likely to be without appreciable risk of adverse non-cancer health effects. Visitors and employees in YNP fall in acute (1-14 days) or intermediate (15-364 days) categories. Benzene MRLs for acute (0.162 mg/m^3) and intermediate (0.013 mg/m^3) exposure are set for immunological and neurological effects, respectively.

Benzene exposure has been measured both in YNP employees and visitors [19, 21, 57]. Exposure in employees has been found to range from 0.067 to 0.600 mg/m^3. Workers at the West Entrance and mechanics have the highest exposures measured. Benzene levels at Old Faithful range from 0.042 to 0.048 mg/m^3. The range of exposure for riders behind other snowmobiles is estimated to be 0.120 to 1.400 mg/m^3. Riders at the end of a line of six snowmobiles have the highest predicted exposure, especially at lower speeds. In comparison, benzene levels measured inside an automobile on a Los Angeles highway commute range from 0.01 to 0.022 mg/m^3 [21]. The table below compares current benzene exposures in the park with OSHA 8h time weighted average (TWA) permissible exposure limit (PEL), the NIOSH 8h TWA recommended exposure limit (REL) and ATSDR intermediate MRL for neurological effects.

Table 6. Comparative benzene exposure levels

	OSHA 8h TWA PEL	NIOSH 8h TWA REL	ATSDR Intermed. MRL	YNP employee	Rider behind one snow-mobile GTNP	Old Faithful	Inside car - LA highway
Benzene (mg/m^3)	3.26	0.326	0.013	0.067-0.60	0.120-1.40	0.042-0.048	0.01-0.02

Depending on location, benzene levels are currently 2 to 30 times higher in YNP than on a Los Angeles commute. Employees and visitors riding behind other snowmobiles often exceed the ATSDR intermediate MRL and NIOSH 8h REL for benzene exposure. Overall, 5 employees at the West Entrance, one mobile patrol employee and a mechanic were found to exceed the ATSDR MRLs for non-cancer effects of benzene at both the acute and intermediate exposure levels [21].

Acute and chronic exposure to elevated benzene levels by park visitors and employees could result in neurological and immunological adverse effects. Because women metabolize more benzene than men do, females may be more sensitive to the adverse effects of benzene exposure. Finally, chronic benzene exposure at these elevated levels could increase the risk of cancer in employees.

- ***Ethylbenzene, toluene and xylenes***

Health effects: Information from the EPA Air Toxics Website describes the health effects of each of these volatile organic compounds. [53]. Exposure to many of these pollutants can result in respiratory effects such as throat irritation, chest constriction, eye irritation and neurological effects such as dizziness and headache.

Analysis in Yellowstone and Grand Teton: A recent study of VOC exposure in snowmobile riders demonstrated the highest exposures occur to passengers on the back of the snowmobile [58]. Therefore, VOC exposure in children, who often ride as passengers, could be higher than adult driver exposure. Results of VOC exposure in YNP employees is shown in the table below[21]. Ambient urban levels are presented as comparison [53].

Table 7. Comparative VOC exposure levels

	ATSDR MRL	West Entrance YNP	Mobile Patrol YNP	Mechanic working YNP	Reported ambient urban levels
Ethylbenzene (mg/m^3)	intermediate 0.868	0.068-0.257	0.092-0.159	0.109-0.870	0.0027
Toluene (mg/m^3)	chronic 1.50	0.406-1.483	0.511-0.863	0.609-2.526	0.011
Xylenes (mg/m^3)	chronic 0.434	0.156-0.611	0.209-0.356	0.248-1.926	0.003-0.38

Exposure to VOCs in YNP employees is often much higher than exposure in urban environments. In one day, a mechanic exposed to elevated levels of PM was also exposed to high levels of benzene, toluene, xylenes and ethylbenzene exceeding intermediate and chronic MRL for these substances [21]. Chronic exposure to these VOC levels in YNP mechanics could cause both respiratory irritation and neurological symptoms.

- ***Aldehydes***

Analysis of aldehydes in Yellowstone and Grand Teton: Under existing conditions, snowmobiles account for 2.43 tons per year of formaldehyde and 0.54 tons per year of acetaldehyde in YNP. Acetaldehyde levels are higher and formaldehyde levels are lower in engines using gasoline with ethanol. There is currently a combination of both MTBE and ethanol gasoline use in the park. At low concentrations formaldehyde and acetaldehyde have been shown to cause eye irritation, and irritation of mucous membranes. Both are classified as probable human carcinogens with long-term exposure at higher concentrations [53].

Some employees have been tested for exposure to aldehydes [21]. All employees studied were exposed to formaldehyde and acetaldehyde. The highest concentrations were found in workers in the express lane of the West Entrance. Formaldehyde levels ranged from 26 to 73 $\mu g/m^3$ with a maximum long-term concentration of 88 $\mu g/m^3$. Acetaldehyde levels ranged from 17 to 42 $\mu g/m^3$ with a maximum concentration of 52 $\mu g/m^3$ after longer exposure. Visitors in areas of high use could expect similar exposure levels.

The ATSDR acute MRL for formaldehyde is 62 $\mu m/m^3$ and the intermediate MRL is 12.4 $\mu m/m^3$. Employees working at the West Entrance exceed both the acute MRL and intermediate MRLs for formaldehyde, placing them at increased risk of mild respiratory effects. Those who have asthma may be more susceptible to formaldehyde and may suffer from wheezing, coughing and shortness of breath.

- ***Polycyclic Aromatic Hydrocarbons (PAHs)***

Health effects of PAHs: Although not regulated by federal clean air standards, PAHs have important public health impacts, as they are carcinogenic. There is little information regarding the acute effects of PAHs. PAHs are known to cross the placenta, exposing the fetus to possible toxic effects [60, 61]. Cancer is a major concern from chronic exposure. Epidemiological studies have reported increased lung cancer in humans exposed to emissions containing PAHs [62].

Analysis of PAHs in Yellowstone and Grand Teton: Snowmobiles are reported to emit PAHs in both the particle (61%) and vapor (39%) phase [19]. Eighteen PAHs have been identified in snowmobile exhaust, 22% in the form of pyrene. A report commissioned by NPS recommends that exposure to these compounds be measured "to assess personal and environmental exposure to these potent carcinogens" [21]. Risks of exposure to visitors and employees are unknown at this time.

Noise

Noise restrictions under the NPS Preferred Alternative may not be sufficient to protect employee hearing. Several park rangers have suffered hearing loss and tinnitus (ringing in the ears) due to snowmobile noise. Snowmobiles with 2 stroke engines currently operate between 70 and 80 dB(A), depending on speed and manufacturer [63]. When traveling in groups, noise levels can reach over 90 dB(A). An OSHA survey found a patrol ranger exposed to noise at a level of 93dB(A). As a comparison, normal conversation takes place at 60 dB, a bulldozer idling is ~ 85 dB, and an operating gas mower or hair dryer is ~95 dB. To prevent hearing loss, NIOSH recommends noise exposure no greater than 85 dB(A) for 8 hours (www.cdc.gov/niosh/noise.html). However, sensitive individuals may experience hearing loss at slightly lower levels. Under the NPS Preferred Alternative, only snowmobiles with noise levels of 73 dB(A) or less will be allowed into the park. This may not be protective enough to prevent continued hearing problems. For a group of 20 snowmobiles operating at 73 dB(A) each, the resulting noise level would be ~85 dB(A), just at the upper limit of exposure by NIOSH standards.

TWO NPS ALTERNATIVES FOR WINTER USE IN YELLOWSTONE

At the time of this analysis, the two management alternatives under consideration are Alternative 1b, implementation of the NPS original decision to replace snowmobiles with snowcoaches and Alternative 4, to allow snowmobile use to continue, restricting the numbers and types of machines allowed within the parks. The FSEIS analyzes the impacts of each alternative on air quality, and employee and public health.

This section of the report analyzes the health implications of those two management scenarios and the methods used by the NPS to predict the resulting emissions and possible health risks.

The proposed alternatives are briefly described below.

- **Alternative 1b** would implement the decision to phase out snowmobile use and provide motorized winter access to the park with snowcoaches. This

alternative is referred to as the Environmentally Preferred Alternative and is acknowledged by the agency as the best alternative to protect park resources and human health.

- **Alternative 4** would require the use of best available technology (BAT) to reduce snowmobile emissions. Eighty percent of snowmobiles would be commercially guided. The remaining 20% would be non-commercially guided. Five hundred-fifty snowmobiles per day would be allowed through the West Entrance with a total of 950 snowmobiles per day at full implementation, pending further analysis. This is the agency's Preferred Alternative and is based on a projected reduction in emissions and noise from new technology resulting in "cleaner and quieter" snowmobiles.

Regarding the health and safety effects that may occur in YNP with implementation of the Preferred Alternative, the NPS writes:

> *"Where high levels of NAAQS pollutants occur, employees and visitors who are susceptible to respiratory problems would likely be adversely and moderately affected… ATSDR MRLs could be approached in staging areas and occasionally exceeded."* (p. 78, FSEIS)

> *"On days with poor atmospheric and weather conditions, employees working in staging areas may need to use respirators to protect their health."* (p. 194, FSEIS)

> *"…vehicular emissions would cause local, perceptible visibility impacts in the areas around the Old Faithful."* (p. 185, FSEIS)

Regarding the health and safety effects that may occur in YNP with implementation of the Environmentally Preferred Alternative, the NPS writes that Alternative 1b provides the best protection for the park and human health.

> *"Alternative 1b best preserves the unique historic, cultural, and natural resources associated with Yellowstone and Grand Teton National Parks. This alternative yields the lowest levels of impacts to air quality, water quality, natural soundscapes, and wildlife, because it relies on mass transit snowcoaches to provide oversnow access to the parks."* (p. 72, FSEIS)

PREDICTED SNOWMOBILE EMISSIONS AND POLLUTION LEVELS

The tables below present NPS data on existing and predicted maximum concentrations of CO and PM pollution at the West Entrance and Old Faithful. CO levels were modeled with and without ambient background pollution. Only the values for CO with background are presented here. Maximum 1h PM10 without background and 24h PM10 with background are presented. Percent reductions in overall pollution for both CO and PM in each alternative are shown. For comparison, NAAQS of the pollutants are included. Because snowmobile emissions are virtually all PM2.5 or smaller, the NAAQS for PM2.5 is also included.

Table 8. Comparative CO and PM10 exposure levels, West Entrance

Alternative	1h CO (ppm)	8h CO (ppm)	% reduction CO relative to existing conditions	1h PM10 ($\mu g/m^3$) (w/o bkgd)	% reduction 1h PM10 relative to existing conditions	24h PM10 ($\mu g/m^3$) (w/bkgd)
Existing Conditions	12.2	8.54	N/A	78.00	N/A	54.2
1b	4.2	2.94	- 66%	1.0	-99%	23.4
4	9.0	6.3	- 26%	11.00	-86%	27.4
NAAQS	35	9				150 (PM10)
NAAQS PM2.5						65 (PM 2.5)

Table 9. Comparative CO and PM10 exposure levels, Old Faithful

Alternative	1h CO (ppm)	8h CO (ppm)	% reduction 8h CO relative to existing conditions	24h PM10 ($\mu g/m^3$)	% reduction 24h PM10 relative to existing conditions	Visibility Impairment
Existing Conditions	29.13	5.2		20.42		YES
1b	7.57	1.61	-69%	5.04	-75%	NO
4	13.27	2.56	-51%	7.47	-63%	YES
NAAQS	35	9		150		

Under Alternative 4, NPS would require as Best Available Technology (BAT) a 90% reduction in PM and a 70% reduction in CO emissions. However, even if these reduced emissions are achieved, reduction in maximum CO pollution would be only 26% at the West Entrance and 51% at Old Faithful. This is due to the high number of snowmobiles entering the park over a short time period and stagnant weather patterns that prevent dispersion of CO. CO levels can remain elevated for hours after peak snowmobile traffic has subsided. Therefore, although BAT requires significant emission reductions, there will not be similar 70-90% reductions in ambient pollution levels at the West Entrance, Old Faithful, or on highly traveled routes. This is a critical distinction because ambient pollution levels, not emissions from individual machines, are the relevant factor for human health.

In summary, Alternative 4 results in ambient pollution levels of CO two times greater and 1h PM10 levels eleven times greater than Alternative 1b. For this reason, Alternative 4, while clearly better than existing conditions, will continue to pose health risks. Even with BAT requirements and limited numbers of snowmobiles, employees, tour guides, and

visitors would continue to be exposed to significant concentrations of CO, PM and other pollutants, increasing their risk of adverse health outcomes.

CRITICAL REVIEW OF THE PROPOSED ALTERNATIVES AND NPS METHODS

This section examines how NPS identified and assessed health risks, including the modeling assumptions used to analyze the alternatives and identifies health issues not addressed in the FSEIS.

Health Risks Associated with the NPS Preferred Alternative

NPS acknowledges that under its Preferred Alternative visitors and employees with respiratory illness would continue to be adversely affected by air pollution. However, the FSEIS does not clearly identify these susceptible populations or the potential health effects associated with the Preferred Alternative, including these factors:

1. **Pollution levels under the Preferred Alternative would pose health risks for susceptible populations.** These populations include a large portion of the general public: children, pregnant women, people with cardiovascular and respiratory disease and the elderly. These individuals include both visitors and employees who would be at risk for mucous membrane and respiratory irritation, asthma attacks, adverse fetal effects, heart arrhythmias, cardiac ischemia, and angina.

2. **Individuals with cardiac disease are more likely to experience arrhythmias or angina because of high altitude and CO levels.** The Yellowstone Plateau has an average elevation of more than 7000 feet.

3. **Levels of PM would remain elevated in areas of high snowmobile traffic.** Although these levels would likely remain within federal standards, it has been determined that exposure to PM at levels below these standards still causes health effects.

4. **Park employees, recreational tour guides, snowcoach operators and others who live near the park face chronic exposure to air pollutants.** Compared to the general public these individuals face greater risk of bronchitis, chronic cough, respiratory illness, chronic lung disease, cardiac instability, chronic obstructive pulmonary disease, lung cancer and premature death.

5. **Visitors and employees would be exposed to a mixture of pollution rather than individual pollutants.** While there is considerable information about the health effects of each air contaminant, we have less understanding about the consequences of exposure to a mixture of pollutants.

Deficiencies in the FSEIS analysis

- **The FSEIS overestimates reduction of pollution levels under the NPS Preferred Alternative**. NPS has predicted air pollution levels at various locations in the park including the West Entrance, Old Faithful and highly traveled routes based upon best available technology (BAT) emission factors. BAT as required by the NPS Preferred Alternative would require a 90% reduction in HC emissions and a 70% reduction in CO emissions. However, the emission factors used by the NPS in its modeling were based on a 4-stroke snowmobile engine with a measured 95-98% reduction in HC emissions and an 85% reduction in CO emissions. In the FSEIS, NPS acknowledges this inconsistency and how it likely distorts air quality predictions for Alternative 4:

  > *"...the modeling for these alternatives could underestimate the amount of air quality emissions resulting from BAT because emission factors used in the modeling are cleaner than the BAT threshold of 90/70. The difference between these emission factors is approximately double."* (p. 167)

  In light of this error, actual pollution levels of CO and HC at the West Entrance and Old Faithful would almost certainly be higher than predicted by NPS modeling.

- **Many important health risks from CO exposure are not analyzed in the FSEIS.** These include increased sensitivity to CO for people traveling from lower elevations to Yellowstone's higher altitude. For example, individuals with cardiac disease are more likely to experience arrhythmias or angina when exposed to CO at high elevations [24, 27, 34].

  Patients with coronary artery disease and angina are at risk for early onset of angina both because of lower oxygen concentrations at high altitude and because of CO exposure from snowmobile emissions. Although a one-hour exposure to CO at 9-13 ppm is within NAAQS guidelines, it is not known whether or not that level is health protective of individuals with angina at high altitudes. The time to onset of angina and cardiac ischemia is significantly decreased with carboxyhemoglobin levels as low as 2.0% at sea level [24]. Studies of patients with cardiovascular disease have shown the effects of high altitude and CO on decreased time to onset of angina are additive [27, 34]. Consequently, it is entirely possible that individuals from lower altitudes with coronary artery disease and angina would experience chest pain and arrhythmias as a direct result of CO exposures projected under the NPS Preferred Alternative.

- **The FSEIS does not account for exposure to site-specific pollution that frequently exceeds ambient pollution levels.** For example, the FSEIS does not assess health risks for employees working in areas of concentrated snowmobile use, riders trailing groups of snowmobiles, or children riding on the backs of snowmobiles. These are common circumstances in which measurements of ambient pollution levels are not good predictors of actual exposure. The FSEIS thus omits identification of high exposure groups and the associated potential health risks that may result from these exposures in the Preferred Alternative.

- **Analysis was not done for PM2.5.** Modeling for PM2.5 was not done by NPS nor are the potential health effects of acute and chronic exposure discussed in the FSEIS. PM2.5 is a regulated air pollutant and as such should be included in any assessment of snowmobile emissions. Particulate matter from snowmobile engines is less than PM2.5 in size. NAAQS for PM2.5 are 65 $\mu g/m^3$ for 24h, not to exceed a 15 $\mu g/m^3$ annual average. Under existing conditions PM2.5 levels have been found to exceed federal standards [21]. Furthermore, in many epidemiological studies, even low levels of PM2.5 have been associated with adverse health effects, suggesting current NAAQS are not protective of public health.

- **NPS modeling overlooked the influence of elevation on emissions.** Modeling was done with data obtained from 4-stroke snowmobiles in a laboratory at lower elevations and higher temperatures than exist in Yellowstone's operating conditions. Emissions are known to increase with elevation and cold because engine performance is reduced and fuel combustion is less complete. Thus, NPS modeling may underestimate actual emissions.

- **Flaws in the FSEIS.** A number of mistakes have been identified in the FSEIS and are listed here. In table 56, page 177, the 24-hour PM10 value for existing conditions at West Entrance is listed as 54.2 $\mu g/m^3$ and on table 39, p. 165 it is listed as 30.2 $\mu g/m^3$. Depending on which number is used to calculate the percent change, the reduction in PM10 at the West Entrance is either 9% or 49%. These are significantly different values and the implications of each are very different. Adding to the confusion, in table 39 the West Entrance is labeled as West Yellowstone.

  Table 2, p. C-13 shows emission factors for pollutants in each alternative. Emission factors at 15 mph were used to calculate pollution levels at the West Entrance. In the CO column at 15 mph, the emission factor for alternative 4, in 2002-2003, is 120.3 g/mi whereas in 2003-2004, it is listed as 138.9 g/mi. With the Preferred Alternative emissions of CO are supposed to decrease in 2003-2004 with the use of BAT, not increase. If this emission factor was used in the NPS modeling, the predicted reduction in CO levels at the West Entrance would not be possible. The actual emission factor used in modeling CO pollution levels at the West Entrance cannot be discerned.

  On pages 185-187, NPS concludes that at Old Faithful there would be localized visibility impacts but notes that these impacts would not be sufficient to result in an *impairment* of park resources or values. NPS is legally required to prevent impairment to park resources. The conclusion about visibility impacts at Old Faithful is inconsistent with the conclusions in Appendix C, visibility modeling. On p. C-50 under Alternative 4, NPS states that "under this alternative for the full implementation year, vehicular emissions would cause local, perceptible, visibility *impairment* in the areas around Old Faithful." (emphasis added)

Concerns regarding Best Available Technology (BAT)

There are many concerns regarding the feasibility and implementation of BAT, including whether "cleaner and quieter" snowmobiles will become readily available and affordable to the public.

The majority of the snowmobile market is comprised of high performance machines with high-powered engines that provide good acceleration, speed and handling. Touring snowmobiles are the second major style of snowmobile in production and are the type used most often in YNP. Touring snowmobiles have lower horsepower engines and emphasize comfort and convenience over speed. Currently, touring snowmobiles are only 10% of the snowmobile market, spread over 4 major manufacturers. Thus, there is a very small market for low horsepower 4-stroke touring snowmobiles.

Four-stroke snowmobiles currently in production also cost more – roughly $2,000 - $5,000 more than a standard 2-stroke machine. Given the small market for 4-stroke models it remains to be seen whether the market would sustain production of these machines.

Meanwhile, 4-stroke technology by itself does not guarantee low emissions or quiet operation. It is possible to produce an engine that is "cleaner" but not "quiet" and vice versa.

EPA has set a standard for a 50% reduction in HC and CO but these reductions will not be fully implemented until 2012. The NPS is relying on the snowmobile industry to do the research and investment in producing cleaner and quieter machines many years earlier than required. Also, NPS is requiring emission reductions more stringent than those required by EPA in the next 9 years. Whether or not the NPS has the authority to enforce emission reductions on the public that are more stringent than those set by EPA is disputed. If the NPS is not able to regulate emissions in privately owned snowmobiles, under the Preferred Alternative, 20% of snowmobiles would continue to emit levels of pollutants seen under existing conditions, compromising the predicted improvement in overall air quality. Also in regard to privately owned snowmobiles, it is unclear how NPS would enforce a requirement that only BAT snowmobiles enter the park when these models are not clearly labeled by the manufacturers and can be modified, resulting in higher emissions and more noise.

The Preferred Alternative would not require BAT of the non-commercially guided snowmobiles until 2004-2005. Thus, levels of air pollutants would remain elevated next season, placing employees and visitors at risk of adverse health effects. In addition, under full implementation the average total number of snowmobiles allowed in the park would actually increase under the Preferred Alternative's proposed "limits." This is shown in the table below. Approximately 80% of these snowmobiles travel to Old Faithful, where NPS acknowledges the Preferred Alternative would result in poor air quality even with BAT.

Table 10. Comparative daily numbers of snowmobiles by entrance*

	N. entrance	S. entrance	W. entrance	E. entrance	TOTAL
Current averages	16	176	538	35	765
Alternative 1b	0	0	0	0	0
Alternative 4	50	250	550	100	950

*Current daily averages compiled by NPS, January-February only, 1992-2000

Even if air pollution levels were consistent with modeling predictions, NPS says susceptible populations would remain at risk and park rangers might continue to need respirators on high use days. In the worst case, if BAT was not feasible or the park could not enforce emission reductions more stringent than EPA standards, air quality improvements would be minimal.

Alternative 1b, the Environmentally Preferred Alternative identified by NPS, remains the best and surest alternative for protecting air quality and human health, while maintaining motorized and non-motorized access to the park.

CONCLUSION

Serious public health risks from snowmobile pollution would remain under the National Park Service plan to continue snowmobile use in Yellowstone and Grand Teton national parks. The agency did not use the best available data in its most recent analysis. Air pollution and health effects have been underestimated, poorly depicted, and, in some cases, not analyzed at all. For these reasons, actual exposure and health risks for park employees and potentially tens of thousands of winter visitors would be greater than the National Park Service has reported. The agency's analysis particularly overlooks populations more susceptible to air pollution than the general public, including asthmatics, individuals with other respiratory and cardiovascular diseases, seniors, pregnant women, and children. An informed decision that would protect employee and public health and uphold the National Park Service responsibility to maintain the nation's best air quality in these two national parks depends upon a more thorough consideration of these concerns.

ABBREVIATIONS

ATSDR - Agency for Toxic Substances and Disease Registry
BAT - Best available technology
CO - Carbon monoxide
COHb - Carboxyhemoglobin
COPD - Chronic obstructive pulmonary disease
dB - decibel
EPA - Environmental Protection Agency FSEIS - Final Supplemental Environmental Impact Statement
HC - Hydrocarbons
GTNP – Grand Teton National Park
MRL - Minimum Risk Level
NAAQS - National Ambient Air Quality Standards
NIOSH - National Institute of Occupational Health and Safety
NPS - National Park Service
NOx - Nitrogen oxide
OSHA - Occupational Safety and Health Administration
PM - Particulate matter
PEL - Permissible Exposure Limit
PerPM - Personal particulate matter
ppm – Parts per million
PAH - Polycyclic aromatic hydrocarbons
REL - Recommended Exposure Limit
TWA - Time Weighted Average
VOC - Volatile organic compounds
WHO - World Health Organization
YNP - Yellowstone National Park

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