

Originally Processed With FOIA(s):
2001-1865-F; 2001-1978-F

FOIA Number:
2001-1865-F

FOIA MARKER

**This is not a textual record. This is used as an
administrative marker by the George Bush Presidential
Library Staff.**

Record Group/Collection: George H.W. Bush Presidential Records
Collection/Office of Origin: Counsels Office, White House
Series: Holmstead, Jeffrey, Files
Subseries: Miscellaneous Subject Files

OA/ID Number: 45145
Folder ID Number: 45145-002

Folder Title:
Environmental Protection Agency/Clean Air Act/Grand Canyon Visibility [1]

Stack:	Row:	Section:	Shelf:	Position:
G	12	8	5	2

GEORGE BUSH



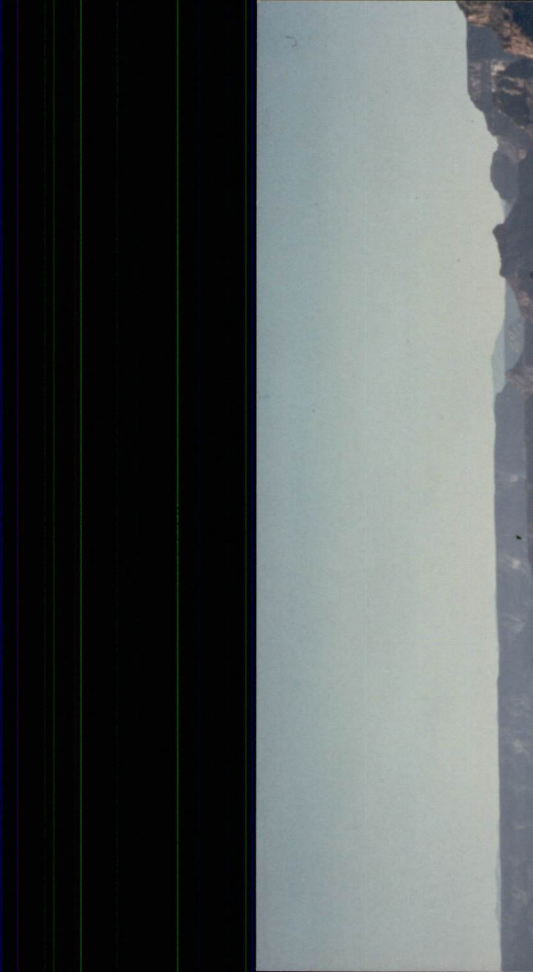
Presidential Library
and Museum

Post Office Box 10410
College Station, Texas 77842





2/17



Visibility Protection at the Grand Canyon

Why Action is Needed

- The Grand Canyon is a crown jewel of our National Parks; It is one of the world's greatest natural treasures
- Protecting visibility in our National Parks has been established as one of the goals of the Clean Air Act
- Apart from our statutory obligation, we jointly have the obligation of protecting a resource as valuable as the Grand Canyon from impairment which can be prevented
- EPA, NAS, SRP, studies all show NGS is a significant contributor to impairment and that pollution controls can help remedy the problem
- And, the benefits of applying the controls exceed the costs of applying those controls

Grand Canyon is A National Treasure

Because of its size, unique rock formations, and sheer beauty, the Grand Canyon is one of our Nation's most prized national parks

It is located in the cleanest region of the Country

Millions of people visit the Grand Canyon every year

- Almost one million visitors every winter

Visual air quality is important to visitors and the Nation

President Bush has indicated his concern for protecting such treasures as the Grand Canyon;

"Behind all the studies, the figures, and the debates, the environment is a moral issue. . . For it is unjust to allow the natural splendor bestowed to us to be compromised. . . Recovery, Restoration, and Renewal -- that is our moral imperative."

June 8, 1989

Clean Air Act

Section 169A "Congress hereby declares as a national goal the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from man-made air pollution."

Impairment in the Grand Canyon was a major reason for establishment of the national goal.

Section 169A requires best available retrofit technology (BART) for any source that " . . . may reasonably be anticipated to cause or contribute to any impairment of visibility. . . " in any Class I area

Navajo Generating Station

Three 750,000 KW Units = 2,250,000 KW Total

Uses 2.4 Million Lbs of Coal Each Hour
0.9 Lbs/MMBtu Sulfur
0.5% Ash

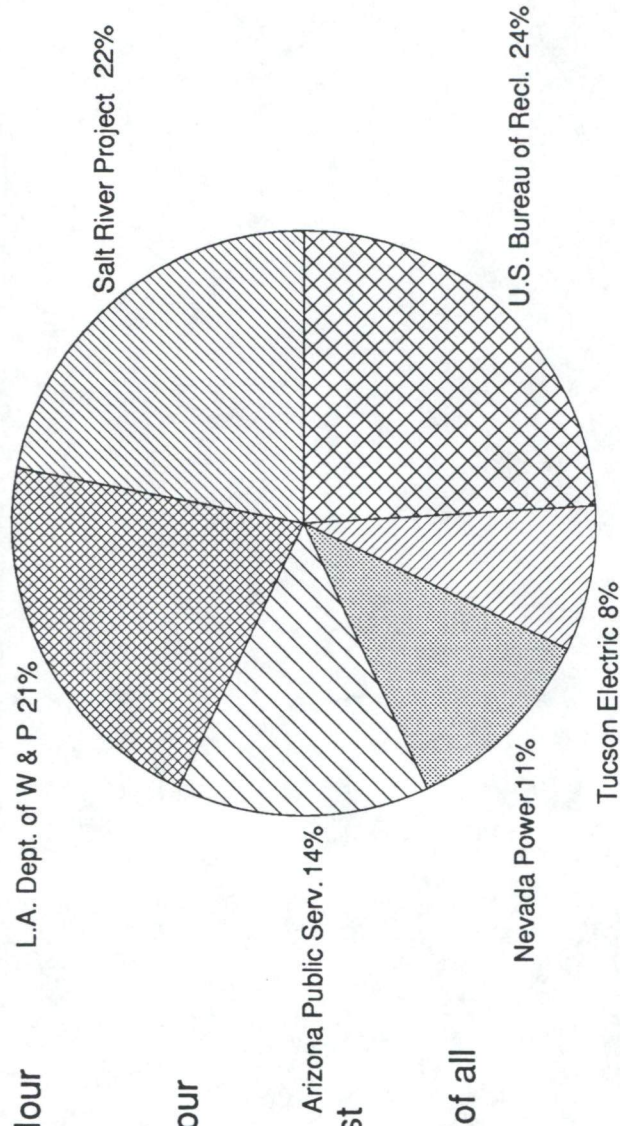
Produces 12-13 Tons of SO₂ per Hour

Second Largest SO₂ Source in West

Navajo is approximately 10 percent of all western utility SO₂ emissions

Located in the heart of area with highest natural visibility,
15 miles from the Grand Canyon National Park

Ownership



History of NGS Plans For Controlling SO₂ Emissions

Planned to Incorporate Scrubbers

In 1971, NGS, stated, "the plant will be designed so that additional control equipment, including devices for removal of oxides of sulfur, can be added when developed."

Final environmental statement, Feb., 1972:

"the participants have committed themselves to installing sulfur dioxide removal systems on all three units at NGS. . . It is planned that an SO₂ removal system will be installed and operative before. . . May, 1975."

Clear Case of Impairment by NGS

NPS, NAS, SRP Studies All Show NGS is Significant Contributor

NPS

NGS contributes 60-70% of extinction during winter haze episodes

NGS contributes 40% of extinction during winter period based on mass balance analysis

Summer haze contribution not studied

Contribution based on WHITEX and additional in-Canyon data from 1988

NAS

NGS is significant contributor to haze

WHITEX data analysis does not supply enough data to quantify NGS contribution (lack of multiple monitors in GCNP and missing data points)

NGS could be the major contributor to extinction during episodes

Did not look at data outside of WHITEX

SRP

NGS contributes 50% of sulfate during winter haze episodes

NGS contributes to haze only 4 to 7% of the time based on plant plume tracking

No general winter component was calculated based on mass balance analysis

Analysis of 1990 Study is incomplete. Only one data point was analyzed

No in-canyon data was released

Tracer data inconclusive for WHITEX data point

EPA Must Determine What is Best Available Retrofit Technology (BART)

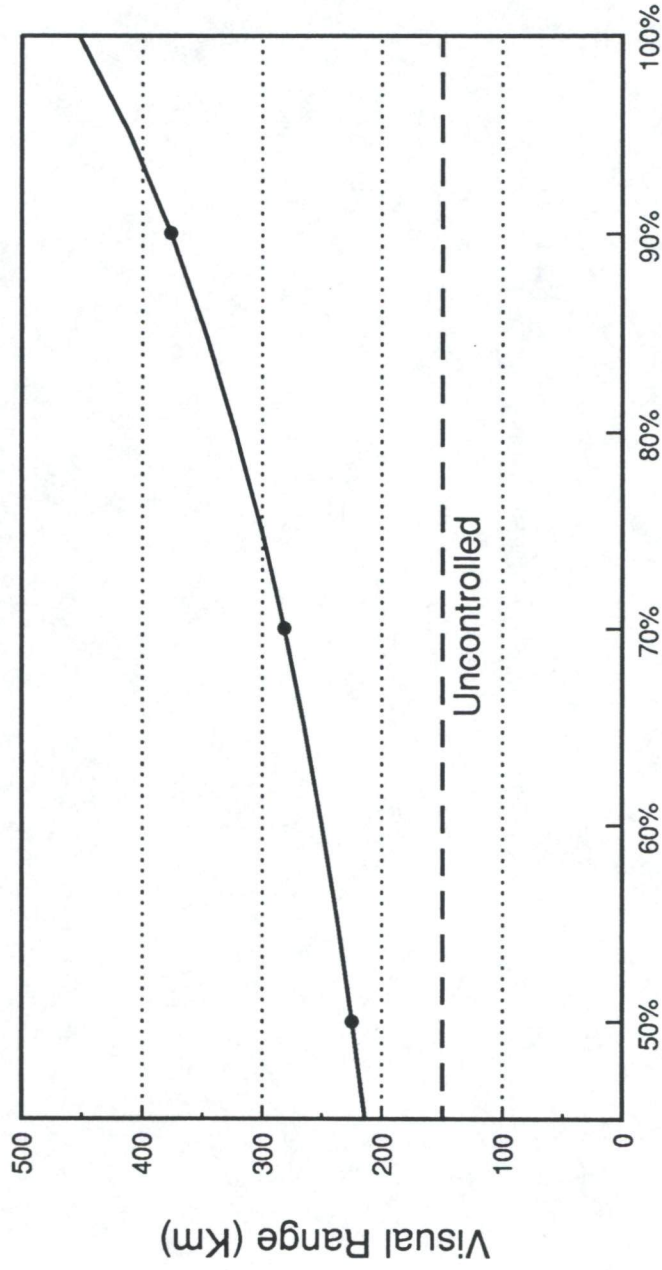
BART PROCESS

1. Impairment attributed to source
2. Requires use of BART Guideline required
 - NSPS controls are starting point
 - Adjust based on
 - source - impairment relationship
 - cost
 - benefits
3. Requires "best system of continuous emissions reductions"
4. Requires compliance in 5 years

Relationship of Pollution Control at NGS to Visibility

GRAND CANYON VISIBILITY IMPROVEMENTS

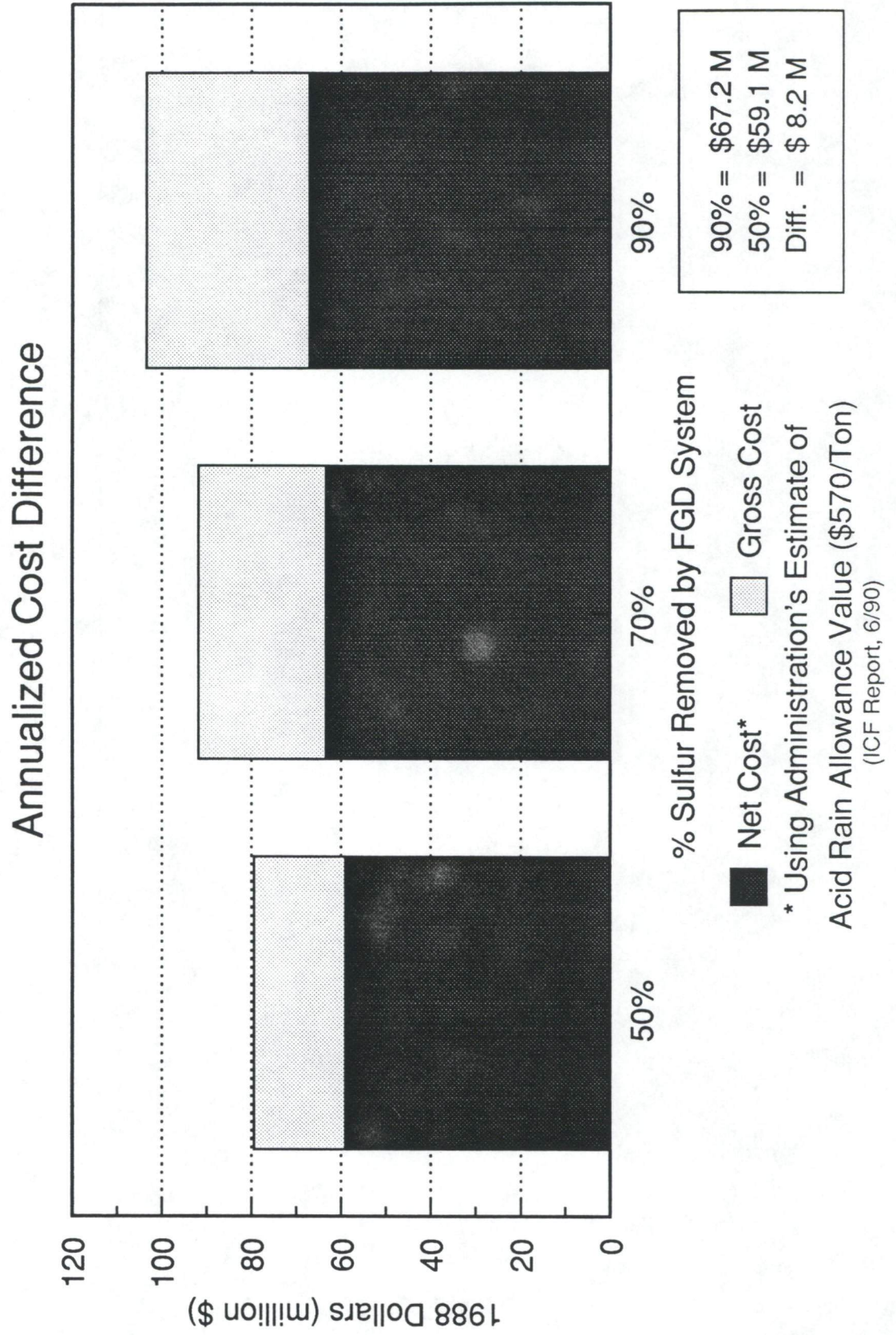
Visual Range on Worst* Episode Days



% Sulfur Reduction at NGS

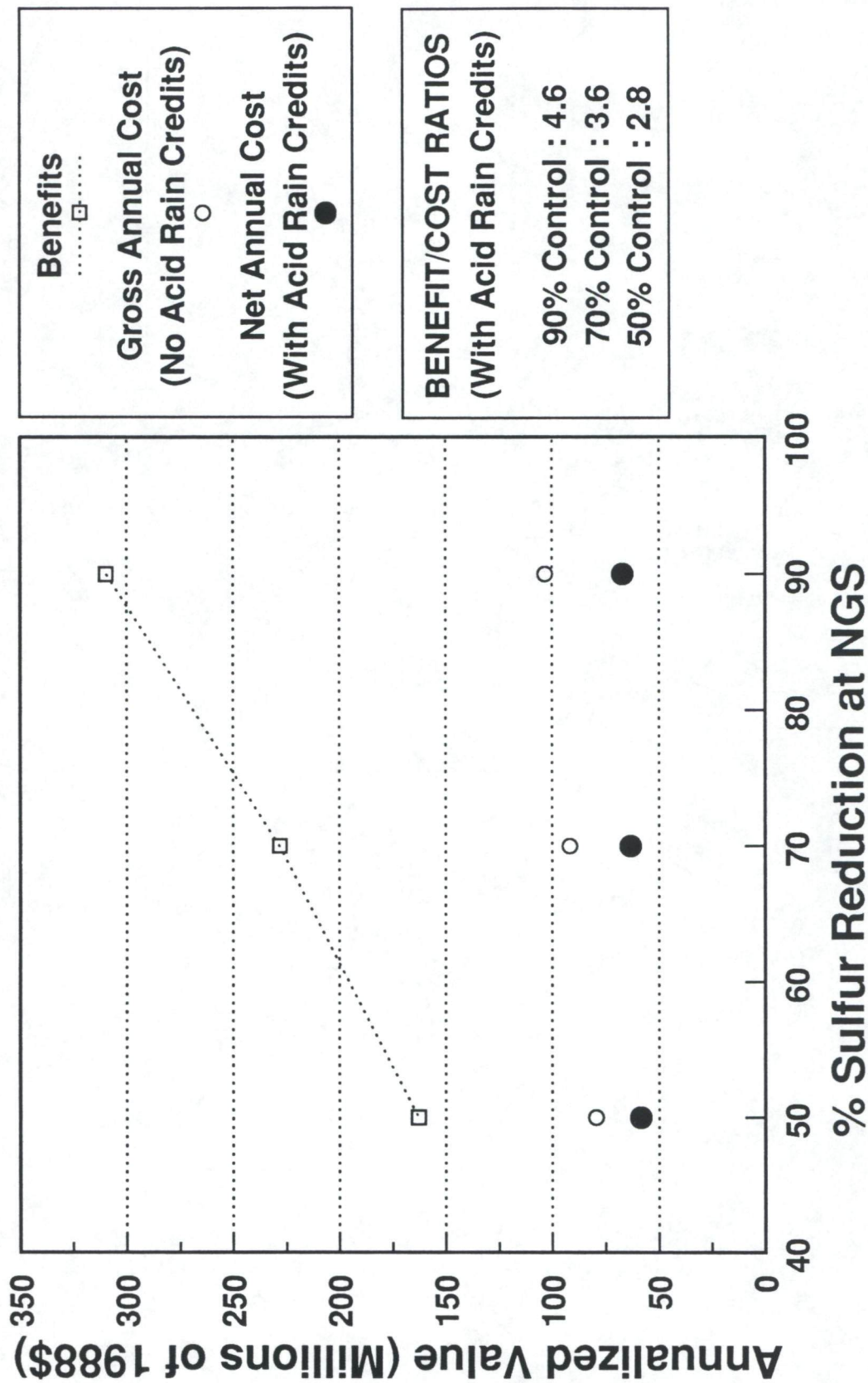
* visibility improvements also increase exponentially on average and best days

Cost Difference Between BART Options is Negligible



Benefits Substantially Exceed Costs

Year 2005, Acid Rain Credits of \$570 / ton



Summary of Draft EPA Regulation

Emission Limitations

Limit SO₂ Emissions to 0.10 Lbs/MMBtu

Option A: 3-hour Average

Exception for Start-up, Shut-down, Malfunction

Exception for 7 hours per month

Option B: 24-hour Average

Exception for Start-up, Shut-down, Malfunction

Option C: 30-day average

Limit NO₂ Emissions to 0.50 Lbs/MMBtu
30 Day Average

Opacity Limit (Particulate Matter) 20 Percent

6 Minute Average

Exception: 6 Minutes per Hour, Max 27 Percent

Other Requirements

CEMS Required

Compliance Date January 1, 1995

Justification

Sulfates reduce Grand Canyon visibility
Based on WHITEX and other data.

Existing NO₂ emission rate of 0.40 Lbs/MMBtu.
Increased NO_x emissions could affect visibility in
Grand Canyon due to nitrate formation.
NSPS limits used.

Existing opacity is 12-13 percent. (Limit is 40 percent)
NSPS limits used.

Enforcement consistent with State Requirements
3 Years for Construction

Broad-Based Support for Action

Congress

EPA Testimony, March 9, 1990, House Subcommittee:

"EPA has proposed to conclude that the Navajo Generating Station in Page, Arizona was an identifiable source of visibility impairment in the Grand Canyon. We are now proceeding with the rulemaking proposal to determine best available retrofit technology (BART) for this plant."

National Park Service

State of Arizona

Current Governor Supports Control
Department of Environmental Quality Supports WHITEX Conclusions

News Media

General Support in West

City of Los Angeles

Mayor's Office Directs Dept. of Water and Power to investigate control

Environmental Groups

High Level of Attention Focused on Decision

Congress

New Hearings Likely

Environmental Groups Aware of Data and Prepared
to Capitalize on Issue

Public Aware of Issue

Summary of EPA's Position

- Grand Canyon region requires protection as a National Treasure
- NGS contributes to visibility impairment at Grand Canyon
- 90% SO₂ reduction is the most defensible position based on technical, cost, benefit, and legal analyses

NGS, SO₂ CONTROL OPTIONS

	TOTAL LIFETIME COSTS (20 YRS.) <u>MILLION \$'s</u>
▪ EPA-90% 3 HR FGD	3,400
▪ 70% ANNUAL FGD	1,800
▪ 70% TRIMEX SEASONAL	1,000 <u>1,800</u>

ESTIMATED VISIBILITY BENEFITS

MEDIAN DATA	ANNUAL VALUE (MILLION\$/YEAR)
EPA's "ANNUAL AVERAGE"	\$100 - 200
GCVB STUDY	0
MEAN DATA	
EPA's "ANNUAL AVERAGE"	\$300 - 400
GCVB STUDY	\$1 - 16*

* THIS ESTIMATE OF ANNUAL VISIBILITY BENEFITS IS LESS THAN THE ANNUAL COSTS OF ALL THREE CONTROL OPTIONS.

Withdrawal/Redaction Sheet

(George Bush Library)

Document No. and Type	Subject/Title of Document	Date	Restriction	Class.
01. Redaction	From William E. Balson to Bob Bedell RE: Salt River Project Final Draft Report. [Redaction of home phone number.] (1 pp.)	01/11/91	P-6, (b)(6)	

Collection:

Record Group: Bush Presidential Records
Office: Counsel to the President, Office of
Series: Holmstead, Jeffrey
Subseries: Miscellaneous Subject Files
WHORM Cat.:
File Location: Environmental Protection Agency/Clean Air Act/Grand Canyon Visibility [1]

Date Closed: 8/7/2002	OA/ID Number: 45145-002
FOIA/SYS Case #: 2001-1865-F	
Re-review Case #:	
P-2/P-5 Review Case #:	
MR Case #:	Appeal Case #:
MR Disposition:	Appeal Disposition:
Disposition Date:	Disposition Date:

RESTRICTION CODES

Presidential Records Act - [44 U.S.C. 2204(a)]

P-1 National Security Classified Information [(a)(1) of the PRA]
P-2 Relating to the appointment to Federal office [(a)(2) of the PRA]
P-3 Release would violate a Federal statute [(a)(3) of the PRA]
P-4 Release would disclose trade secrets or confidential commercial or financial information [(a)(4) of the PRA]
P-5 Release would disclose confidential advice between the President and his advisors, or between such advisors [(a)(5) of the PRA]
P-6 Release would constitute a clearly unwarranted invasion of personal privacy [(a)(6) of the PRA]

C. Closed in accordance with restrictions contained in donor's deed of gift.

PRM. Removed as a personal record misfile.

Freedom of Information Act - [5 U.S.C. 552(b)]

(b)(1) National security classified information [(b)(1) of the FOIA]
(b)(2) Release would disclose internal personnel rules and practices of an agency [(b)(2) of the FOIA]
(b)(3) Release would violate a Federal statute [(b)(3) of the FOIA]
(b)(4) Release would disclose trade secrets or confidential or financial information [(b)(4) of the FOIA]
(b)(6) Release would constitute a clearly unwarranted invasion of personal privacy [(b)(6) of the FOIA]
(b)(7) Release would disclose information compiled for law enforcement purposes [(b)(7) of the FOIA]
(b)(8) Release would disclose information concerning the regulation of financial institutions [(b)(8) of the FOIA]
(b)(9) Release would disclose geological or geophysical information

DECISION
FOCUS
INCORPORATED

4984 El Camino Real
Los Altos, California 94022
415 960 3450

4 more sets of photos

January 11, 1991

Bob Bedell
10001 Pennsylvania Avenue, NW
Suite 275 North
Washington, DC 20004

sent via Federal Express

Re: Salt River Project Final Draft Report

Dear Mr. Bedell:

Greg Witherspoon asked me to send you some photographs illustrating the magnitude of visibility improvements that might occur due to a BART action at Navajo Generating Station and a copy of the photographs used by Chestnut and Rowe in their value study for the NPS.

I have enclosed 2 photographs to illustrate the likely improvement and 2 photographs out of the Chestnut and Rowe set. All four photographs are labeled on the back.

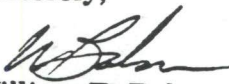
The Chestnut and Rowe (C&R) photographs are labeled A and C, corresponding to the labeling they adopted for their report. As you can see there is a dramatic difference. C&R claims the visibility difference is 155 km for photo C and 250 km for photo A for a 61% improvement. The main features that changes, however is the manner in which the canyon cliffs are lighted. In photo A they are colorful and vibrant, while in photo C they are dull. That color change has mainly to do with the fact that in January the sun is lower in the sky more clearly illuminating the cliffs.

notes To illustrate the visibility changes that might follow a BART action, I looked at the photographs taken by the NPS during the WHITEX study. I selected two photographs from February 13 and 17, 1987 at 1:00pm. These represent visual ranges of about 45 and 135 inches respectively for a percentage change of 195%. The maximum changes calculated in the EPA BART Analysis was 154% (Table 12).

I hope these are useful. Please call if you need clarification. My home number is

[REDACTED] (b)(6)

Sincerely,


William E. Balson
Director, Environmental Risk
Management Services

WEB:dlm
Enclosures

HUNTON & WILLIAMS

ATLANTA, GEORGIA
BRUSSELS, BELGIUM
FAIRFAX, VIRGINIA
KNOXVILLE, TENNESSEE

P. O. BOX 19230
2000 PENNSYLVANIA AVENUE, N.W.
WASHINGTON, D.C. 20006
TELEPHONE (202) 955-1500
FAX (202) 778-2201

NEW YORK, NEW YORK
NORFOLK, VIRGINIA
RALEIGH, NORTH CAROLINA
RICHMOND, VIRGINIA

January 14, 1991

BY HAND

Mr. Michael Shapiro
Deputy Assistant Administrator
for Air and Radiation
United States Environmental
Protection Agency
Room 937, West Tower
401 M Street, S.W.
Washington, D.C. 20460

Paper on Seasonal Emission Controls

Dear Mr. Shapiro:

Enclosed is a position paper on seasonal emission controls that Henry Nickel discussed with you last week. Henry is out of town this week, but will be calling in frequently and would be glad to discuss any comments or questions that you may have about the paper.

Sincerely,



Norman W. Fichthorn

Enclosure

cc: Gregory B. Foote, Esq.

HUNTON & WILLIAMS

EPA's Authority to Adopt a Seasonal Control Strategy in Implementing BART

Statutory Setting

Section 169A of the Clean Air Act calls for best available retrofit technology (BART) emission limitations to address "reasonably attributable" visibility impairments in Class I areas. Any BART limit must require continuous emission controls on a source during any and all periods that the source's emissions are "reasonably attributable" to impairments in the Class I area. These controls are required for the purpose of making "reasonable progress" toward the goal of eliminating visibility impairments.

Section 123 of the Act prohibits noncontinuous controls based upon a program to reduce emissions on a temporary basis in response to changing meteorological conditions. While section 123 prohibits such "interim" or "supplemental" control strategies, it nowhere prohibits "seasonal" control strategies under which one continuous limit applies for certain months and another applies for the remaining months.

Factual Setting

EPA's proposed attribution finding is based exclusively on a finding that emissions from the Navajo Generating Station

HUNTON & WILLIAMS

- 2 -

contribute to haze in the Grand Canyon National Park during winter months (December through February). There is no evidence in the rulemaking record that emissions are contributing to summer haze in the Park. To the contrary, evidence in the record demonstrates that summer hazes are not attributable to emissions from Navajo. Emissions from sources in southern California are the main cause of the summertime visibility impairments.

Discussion

BART limitations are to reflect a balance of visibility benefits and costs for the purpose of making "reasonable progress." Assuming, for the purposes of this paper, that the wintertime visibility improvements resulting from reducing current emissions at Navajo outweigh the costs, a continuous reduction in emissions at Navajo during winter months would be justified under section 169A of the Act. On the other hand, costly emission reductions at Navajo in the summer, when haze in the Park cannot be attributed to Navajo emissions, would not improve visibility. Such summertime reductions could not be justified as BART because they would not contribute to "reasonable progress."

The legal standard governing BART would allow EPA to impose a more stringent limitation only during winter months and would require EPA to recognize the current limitation as BART for the

HUNTON & WILLIAMS

- 3 -

summer months. In other words, BART would be a more stringent continuous emission limitation during December, January, and February and would be the current continuous emission limitation for the remaining months.

BART limits, like limits to meet ambient standards, are result-oriented. They must be tailored to meet the statutory objective: achieving air quality of a specific level during those periods that air quality may exceed the regulatory standards. The Agency has long recognized that, where these ambient objectives can be achieved using a seasonal control strategy, such a strategy is authorized.

In 1977, EPA approved a revision to the Massachusetts state implementation plan establishing "a seasonal control strategy" for certain sources subject to SO₂ emission limitations.^{1/} Under that control strategy, sources were allowed to burn a higher-sulfur oil in the summer than in the winter. The Agency approved this summertime relaxation in the SIP emission limits on the grounds that "none of the sources being approved to burn the higher sulfur content fuel [in the summer] is predicted to cause or contribute to violations of the primary or secondary NAAQS for SO₂."^{2/}

^{1/} 42 Fed. Reg. 25730 col. 3 (1977); see also 44 Fed. Reg. 41179 col. 1 (1979).

^{2/} 42 Fed. Reg. at 25731 col. 1 (1977).

HUNTON & WILLIAMS

- 4 -

In the case of SIP emission limitations to attain the ozone standards, the Agency on July 29, 1976, issued a policy statement authorizing a seasonal control strategy for certain sources using natural gas-fired afterburners to reduce hydrocarbon emissions. Under that policy, SIPs could allow the shutdown of such afterburners (and an increase in hydrocarbon emissions) during months in which the mean temperature was 50 degrees Fahrenheit or less. The policy was based on the scientific fact that ozone does not readily form at temperatures below 59 degrees Fahrenheit and the conclusion that the additional hydrocarbon emissions would not impair attainment of the air quality objective. This seasonal control strategy was reaffirmed in a December 19, 1978, memorandum extending it to another source category of hydrocarbon emissions.

Again, the ozone seasonal control strategy, which EPA reaffirmed after enactment of section 123 as part of the 1977 Amendments to the Act, recognizes that different continuous controls can be established on a defined seasonal basis where annual controls are not required to achieve the statutorily mandated end -- in this case, attainment of the ozone ambient air quality standard. This is the case because such seasonal controls are not "intermittent" or "supplemental" controls regulated under section 123.

HUNTON & WILLIAMS

- 5 -

These contemporaneous interpretations of the 1977 Amendments recognize that seasonal controls are not "intermittent" controls as defined in section 123. Accordingly, seasonal controls at Navajo are fully consistent with these precedents. Unless EPA can establish that summertime controls at Navajo are needed to abate "reasonably attributable" impairments in the summer by showing that such controls will make "reasonable progress" in improving visual air quality in a class I area, a seasonal limitation is the only kind of limitation that the Agency can lawfully impose as BART.

Conclusion

Seasonal control strategies are not proscribed by section 123 of the Clean Air Act. They are a cost-effective approach to achieving the Act's ambient air quality objectives where it is demonstrated that more stringent controls are needed only during certain months of the year.

Any reversal of the Agency's position on the legal validity of "seasonal" control strategies in the Navajo proceeding could have major implications for other Clean Air Act programs. For example, such a reversal would undermine the basis for EPA's summertime-only controls on gasoline volatility, which the Agency designed to help achieve the national ambient air quality

HUNTON & WILLIAMS

- 6 -

standard for ozone.^{1/} Such a reversal also would undermine the basis for EPA's approval of SIP revisions imposing seasonal gasoline volatility controls more stringent than federal controls.^{2/}

A seasonal emission limitation to implement section 169A of the Act is authorized by existing law. It is the only kind of limitation authorized in the case of Navajo because the only impairments that can be abated under the proposed attribution finding for the Grand Canyon National Park are impairments that are alleged to occur in winter months and are known not to occur in summer months.

^{1/} See 40 C.F.R. § 80.27 (1989); 54 Fed. Reg. 11868 (1989).

^{2/} See, e.g., 54 Fed. Reg. 26030 (1989) (approval of New York SIP revision); *id.* at 25572 (approval of New Jersey SIP revision); *id.* at 23650 (approval of Connecticut and Rhode Island SIP revisions); *id.* at 19173 (approval of Massachusetts SIP revision).

The proposed changes to the manual, which EPA Administrator William Reilly has called for "good science," would remove a large number of swamps from wetlands regulatory protection, the regional comments state. Moreover, the new manual is more confusing to use than the previous 1989 version, the staff say. The staff warn that EPA's public image will be tarnished because the agency will be seen as "retreating from wetlands protection." Similarly, EPA's Region X predicted that proposed changes could result in hundreds of thousands of wetlands in Region X being eliminated.

EPA sources caution that changes to the manual are undergoing extensive revisions almost daily and therefore any comments submitted by regions may refer to earlier drafts no longer being promoted. One regional agency source says that as a policy matter the agency wants to narrow the range of areas defined as wetlands, responding to the outrage farmers and developers expressed because they felt the wetlands manual brought dry lands and areas with no wetlands functions into the regulatory net. But the "pure science" does not support the agency's policy goal because many areas EPA officials would want to exclude from regulation are from a purely scientific perspective genuine wetlands even if they are dry much of the time, the source says.

EPA officials fear that Congress will revamp wetlands regulations -- cutting EPA out of its current role under the Clean Water Act -- unless the agency can address concerns of developers and farmers about regulatory overkill by changing the wetlands manual, say EPA sources. But regional staff insist that the manual must have "integrity" and not become subject to political pressures that would distort scientific principles.

One regional source expresses disappointment in the headquarters' briefing, commenting that the Water Office is "deluded into thinking it can sell the manual" by "repackaging" it. The source fears that more confusion will be created under the new manual. Another regional source, however, says it appears from the headquarters' briefing that the manual "will be technically sound." The outcry from the regions produced "thoughtful considerations" by the Water Office, the source says.

Jeff Hirstead

ENVIRONMENTALISTS URGE EPA TO HALT PLANT PERMITS PENDING OVERALL IMPACT STUDY

Several major environmental organizations are urging EPA to suspend a state's permitting action on proposed power plants until the agency has conducted an environmental impact statement on the combined impact of all pollution sources on a nearby national park and the Chesapeake Bay. The case is particularly important as it is expected to set a precedent for EPA's prevention of significant deterioration (PSD) program under the Clean Air Act, which requires any new source proposing to be permitted in a Class I (pristine wilderness) area to prove that its emissions will not exacerbate air quality.

At issue are 17 power plants that have been proposed for construction in Virginia (*Inside EPA*, Feb. 8, p11). The National Park Service issued a precedent-setting "adverse impact" finding last year in an effort to block the permitting of some of these new sources, which are located near Shenandoah National Park (*Inside EPA*, Nov. 9, 1990, p5). NPS argued the proposed utilities would harm both the park's visibility and natural resources. EPA concluded, however, that the impact of the new sources cannot be quantified, and that therefore no adverse finding is justified.

Under the leadership of the Southern Environmental Law Center, 15 state and national environmental groups -- in an April 17 letter to EPA administrator William Reilly -- request that a single EIS be completed on the total impact of pollution sources in the area on Shenandoah National Park. Although an individual EIS is required for every proposed source, the groups argue that the more important question is what the total impact of all sources would be on the park -- particularly since more plants are up for permitting in Virginia than anywhere else in the U.S. The groups point out that the pending power plants "would constitute a 12% increase in stationary source emissions of SO₂ and a 40% increase in NO_x emissions."

Disappointed with action taken by EPA Region III and the state of Virginia, the environmentalists say they are appealing to Reilly for being "uniquely situated to undertake, in conjunction with other federal agencies including the Department of the Interior, a comprehensive review of the likely cumulative effects of new sources of air pollution on Class I areas, the Chesapeake Bay and regional ozone concentrations, and alternative control strategies, including alternatives to new source construction." Such a review would occur through the EIS process under the National Environmental Policy Act, the environmentalists write.

The Clean Air Act does not require this type of EIS to be completed, an EPA source says, adding nonetheless that the proposal is "interesting." An NPS source praises the concept of a single EIS, arguing that natural resources are hit by cumulative pollution from a variety of sources, not from a single power plant.

Environmental groups signing the letter include the Sierra Club, Environmental Defense Fund, Natural Resources Defense Council, National Parks & Conservation Assn.

In this case, EPA has conducted a thorough analysis of the statutory BART factors, and therefore does not need to rely on any presumption regarding the advisability of using NSPS-level controls as BART. [Of course, this approach is consistent with the existing Guidelines.]

The agency believes that any future BART analyses should also carefully balance the various statutory factors to ensure that the costs of any proposed requirement are outweighed by ^{it} the environmental benefits.

in that the careful study

6560-50

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 52

[AD-FRL-]

Approval and Promulgation of Implementation Plans:
Revision of the Visibility FIP for Arizona

AGENCY: U.S. Environmental Protection Agency (EPA).

ACTION: Final rule.

SUMMARY: This notice revises the Federal implementation plan (FIP) for the State of Arizona to include a sulfur dioxide (SO₂) emission limit of 42 nanograms per Joule (ng/J) [0.10 pounds per million British thermal units (lbs/MMBtu)], heat input for the Navajo Generating Station (NGS) to remedy ~~wintertime~~ visibility impairment in the Grand Canyon National Park (GCNP). Compliance with this emission limit will be phased-in by unit in 1997, 1998, and 1999 and determined on a plant-wide annual rolling average basis. In addition, NGS will be required to reschedule its maintenance such that 6 unit-weeks of maintenance will be performed during the winter months.

This action is taken pursuant to sections 169A and 110(c) of the Clean Air Act (Act), 42 U.S.C. sections 7491 and 7410(c), which require EPA, upon default by a State, to take appropriate measures to remedy certified visibility impairments in mandatory Class I areas where the impairment

is reasonably attributed to a specific source. On September 5, 1989, EPA preliminarily attributed a significant portion of wintertime impairment in GCNP to the NGS (54 FR 36948). On February 8, 1991, EPA proposed to require NGS to meet new emission limits to address that impairment (56 FR 5173), reopened the comment period on EPA's September 5, 1989 preliminary attribution finding and provided an opportunity for public comment on all other issues relevant to the rulemaking proposal. Over 380 comments were received during this initial comment period. In addition to soliciting written comments during the comment period, EPA held a public hearing on March 18 and 19, 1991, in Phoenix, Arizona. A copy of the transcript of the hearing is in Docket A-89-02A. After the close of the comment period on April 19, 1991, many meetings took place among representatives of the Salt River Project (SRP) acting on behalf of the NGS participants, and representatives of the Grand Canyon Trust (GCT) and the Environmental Defense Fund (EDF) acting on behalf of their organizations. In August 1991, representatives of the NGS participants and the environmental groups agreed on an SO₂ control strategy for NGS and recommended that it be adopted by EPA. They entered into a memorandum of understanding (MOU) memorializing their agreement which was submitted (together with associated documents) to EPA. Therefore, EPA reopened the comment period on its February 1991 proposal to request comments on

the regulatory strategy option and legal rationale presented in the MOU and associated documents [56 FR 38399 (August 13, 1991)]. During the supplemental comment period SRP and several ~~work environmental~~ groups ~~conditional~~ withdrew all their prior comments which were inconsistent with a rule which is consistent with the MOU and associated recommendations to EPA.

The timing of today's action is in accordance with the revised settlement agreement between EPA and EDF in EDF v. Reilly, No. C82-6850 RPA (N. D. Cal.).

EFFECTIVE DATE: This action will be effective on [30 days from date of publication].

Docket: Pursuant to section 307(d)(1)(B) of the Act, 42 U.S.C. 7607(d)(1)(B), this action is subject to the procedural requirements of section 307(d). Therefore, EPA established Docket A-89-02A for this action. Materials related to the development of this notice have been placed in this docket. Materials related to EPA's preliminary attribution determination [54 FR 36948 (September 5, 1989)] have been placed in Docket A-89-02. For background information, materials related to the development of the visibility protection program (40 CFR 51.300 et seq.) are available in Docket A-79-40. Also, materials related to the development of the visibility new source review (NSR) and visibility monitoring strategies are available in Docket

A-84-32. Materials related to the visibility long-term strategy, implementation of control strategy, and integral vista program are available in Docket A-85-26. All dockets are available for public inspection and copying between 8:30 a.m. to 12:00 noon and 1:30 p.m. to 3:30 p.m., Monday through Friday, at EPA's Central Docket Section, Office of the General Counsel, Room 1500, 401 M Street, S.W., Washington, DC 20460. A reasonable fee may be charged for copies.

FOR FURTHER INFORMATION CONTACT: Mr. David H. Stonefield, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards (MD-15), Research Triangle Park, North Carolina 27711, (919) 541-5350 or FTS 629-5350.

SUPPLEMENTARY INFORMATION:

Background

A. Regulatory Requirements

Section 169A of the Act, 42 U.S.C. 7491, sets as a national goal "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas which impairment results from manmade air pollution." Mandatory Class I Federal areas are certain national parks, wildernesses, and international parks as described in section 162(a) of the Act, 42 U.S.C. 7472(a). Section 169A requires that EPA promulgate regulations to assure reasonable progress toward meeting the national goal for mandatory Class I Federal

areas where EPA has determined that visibility is an important value. On November 30, 1979, EPA identified 156 such areas, including the GCNP in Arizona, where visibility is an important air quality-related value (44 FR 69122). Section 169A specifically requires EPA to promulgate regulations requiring States to amend their State implementation plans (SIP's) to provide reasonable progress toward meeting the national goal for the 156 areas. On December 2, 1980, EPA promulgated the required visibility regulations (45 FR 80084, codified at 40 CFR 51.300 et seq.). Specifically, the visibility regulations require the 36 States listed in section 51.300(b), including Arizona, to: (1) coordinate SIP development with the appropriate Federal land managers (FLM's), (2) develop a program to assess and remedy visibility impairment from new and existing sources, (3) develop a long-term (10 to 15 years) strategy to assure reasonable progress toward the national goal, (4) develop a visibility monitoring strategy to collect information on visibility conditions, and (5) consider in all aspects of visibility protection any "integral vistas" (important views of landmarks or panoramas that extend outside of the boundaries of the Class I area) identified by the FLM's as critical to the visitors' enjoyment of the Class I areas. The affected States were required to submit revised SIP's satisfying these provisions

by September 2, 1981 [see 45 FR 80091, codified at 40 CFR 51.302(a)(1)].¹

The second and third requirements listed above are of particular relevance to today's action. Pursuant to 40 CFR 51.302(c)(2), each affected State is required to include in its SIP such emission limitations, schedules of compliance, and other measures as may be necessary to make reasonable progress toward the national visibility goal. Under 40 CFR 51.302(c)(1), an FLM may certify to a State that there exists impairment of visibility in any mandatory Class I Federal area. Such impairment must be addressed in accordance with 40 CFR 51.302(c) which sets forth measures for achieving reasonable progress, including best available retrofit technology (BART) and a long-term strategy (see 40 CFR 51.302(c)(1) and (2), section 169A(b)(2)(A) and (B)). Pursuant to 40 CFR 51.302(c)(4)(i), where impairment is

¹The EPA's 1980 regulations implementing the statutory requirements of section 169A address visibility impairment that is reasonably attributable to a single source or small group of sources [see generally 45 FR 80084 (December 2, 1980)]. Recognizing certain scientific and technical limitations, EPA, in promulgating the 1980 regulations, deferred regulatory action on more "complex problems such as regional haze and urban plumes." *Id.* at 80086. Today, in accordance with the 1980 regulations, EPA is taking regulatory action to remedy visibility impairment that is reasonably attributable to NGS. The EPA is in the process of establishing the Grand Canyon Visibility Transport Commission as required by section 169B of the Act. The duties of that commission include making recommendations on "promulgation of regulations under section 169A to address long-range strategies for addressing regional haze which impairs visibility in . . ." the GCNP [section 169B(d)(2)(C)].

certified at least 6 months prior to plan submission, an affected State must identify each existing stationary facility which may "reasonably be anticipated to cause or contribute" to any such impairment which is "reasonably attributable to that existing stationary facility," and analyze for BART any facility so identified. "Reasonably attributable" impairment is impairment "attributable by visual observation or any other technique the State deems appropriate" [40 CFR 51.301(s)]. Where a State defaults on its obligations under the visibility regulations, EPA may act in place of the State pursuant to a FIP under section 110(c) of the Act, 42 U.S.C. 7410(c)², and promulgate such

²Section 110(c) requires EPA to promulgate FIP's whenever a State fails to submit an implementation plan (or portion thereof) which meets the requirements of section 110; the Administrator determines that a plan (or portion) is not in accordance with the requirements of section 110; or the State fails to revise its plan within 60 days after notification by the Administrator in accordance with section 110(a)(2)(H).

During the House of Representatives consideration of the Conference Report on the 1977 Amendments to the Clean Air Act, Congressman Rogers reiterated that the conferees had agreed that EPA was to act where States failed to carry out their duties in implementing the requirements of section 169A. Congressman Rogers statement, in pertinent part, is as follows:

The conferees . . . rejected a motion to delete EPA's supervisory role under section 110 to assure that the required progress towards that goal [the national visibility goal] will be achieved by the revised State plan. If a State visibility protection plan is not adequate to assure such progress, the Administrator must disapprove that portion of the SIP and promulgate a visibility protection plan under section 110(c). Thus, visibility protection in mandatory federal class I areas remains a national commitment, which is

limitation and measures as are required to achieve reasonable progress. In such cases, all of the rights and duties that would otherwise fall to the State accrue instead to EPA. Thus, EPA may utilize attribution techniques it deems appropriate; identify "reasonably attributable" sources of impairment, develop and implement the elements of a long-term strategy, conduct BART analyses, adopt BART requirements, where appropriate; and may promulgate such other control strategies that EPA, in its discretion, deems necessary to make reasonable progress toward the national visibility goal.

The visibility regulations promulgated at 40 CFR 51.302(c)(4)(i) require that once ^{a plan I} impairment has been certified, a State (or EPA if the State's visibility protection program addressing BART has not been approved and EPA is acting in its place) must analyze for BART any specific existing stationary facility it identifies as a "reasonably attributable" source of the impairment.

Pursuant to section 169A(b) of the Act [42 U.S.C. 7491(b)] and 40 CFR 51.302(c)(4)(iii), the emission limitation representing BART for fossil fuel-fired power plants with a generating capacity in excess of 750 megawatts (MW) must be

nationally enforceable.

See Senate Comm. on Environment and Public Works, 95th Cong. 2d Sess. A Legislative History of the Clean Air Act Amendment of 1977 No. 16, vol. 3 at 311, 320-21 (Comm. Print 1978).

determined pursuant to guidelines promulgated by the Administrator. This statutorily-required procedure for conducting a BART analysis is found in "Guidelines for Determining Best Available Retrofit Technology Analysis for Coal-Fired Power Plants and Other Stationary Facilities" (EPA-450/3-80-009b) (BART Guidelines). A copy of this document may be found in Docket A-89-02A.

In December 1982, environmental groups, including EDF, filed a citizens' suit in the United States District Court for the Northern District of California alleging that EPA had failed to perform a nondiscretionary duty under section 110(c) of the Act, 42 U.S.C. 7410(c), to promulgate visibility FIP's for the 35 States³ that, at that time, had failed to submit SIP's to EPA as called for by the 1980 visibility regulations, EDF v. Reilly, No. C82-6850 RPA (N. D. Cal.). The State of Arizona was one of the 35 States that failed to submit a revised SIP to EPA.

The EPA and the plaintiffs negotiated a settlement agreement for the remaining States which the court approved by order on April 20, 1984. For more information on details of the provisions of the original settlement, including a schedule of actions by EPA, see EPA's announcement of the agreement at 49 FR 20647 (May 16, 1984).

³The State of Alaska had submitted a SIP which was approved on July 5, 1983 at 48 FR 30623.

B. Settlement Agreement

To remedy the States' failure to submit the necessary SIP revisions during the time specified by the regulations, the settlement agreement replaced the original regulatory deadlines for visibility SIP provisions with a rulemaking schedule agreed to by the parties and approved by the court. This schedule required EPA to review the existing SIP's to determine any deficiencies, allow the States to cure those deficiencies, and to promulgate FIP's on a specified schedule for those States that still did not submit visibility SIP revisions to EPA. Specifically, the first part of the agreement required EPA to promulgate FIP's which cover the monitoring and NSR provisions of 40 CFR 51.305 and 51.307. The EPA promulgated its monitoring strategy for 23 States and its NSR provisions for 21 States, including Arizona, at 50 FR 28544 (July 12, 1985), 51 FR 5504 (February 1, 1986), and 51 FR 22937 (June 1986). In separate notices, EPA approved the SIP's of the other States with respect to monitoring and NSR.

The second part of the settlement agreement required EPA to determine the adequacy of the SIP's to meet the remaining provisions of the visibility regulations and gave the States until December 1986 to submit additional measures that would avoid the need for a FIP. These provisions are the general plan provisions for achieving reasonable progress toward the national visibility goal, including BART

and other implementation control strategies (section 51.302), integral vista protection (section 51.302-307), and long-term strategies (section 51.306). The settlement agreement required EPA to promulgate FIP's to remedy any deficiencies on a specified schedule.

Pursuant to 40 CFR 51.302(c)(1), on November 14, 1985, the Department of the Interior (DOI) certified the existence of visibility impairment in all Class I areas within its jurisdiction in the lower 48 States.

On January 23, 1986, EPA determined that the SIP's of 32 States (including Arizona) were deficient with respect to the remaining visibility provisions (51 FR 3046) and offered the States an opportunity to submit corrective SIP revisions. Thereafter, EPA and the plaintiffs negotiated revisions to the settlement agreement which extended the deadlines for State action or, if the States failed to respond, Federal action proposing FIP's to remedy these deficiencies. The court approved these revisions by its order of September 9, 1986.⁴

On March 24, 1986, the DOI sent a letter to EPA which supplemented its earlier certification of visibility impairment. The letter addressed the GCNP and identified the NGS, a coal-fired power plant located near Page,

⁴A copy of the settlement agreement and revisions is available in docket A-85-26 at the address given at the beginning of this notice.

Arizona, as a probable source of impairment in this Class I area. A copy of this letter may be found in Docket A-89-02.

Thirty-two affected States failed to submit visibility SIP revisions in response to the notice of deficiency. Consequently, in accordance with the revised settlement agreement, on March 12, 1987 (52 FR 7802), EPA proposed to disapprove the SIP's of 32 States, including Arizona, for failing to meet the remaining provisions of the visibility regulations, including general plan requirements to achieve reasonable progress toward the national visibility goal (which in turn includes BART, long-term strategies, and other control strategies). Also in accordance with the agreement, on November 24, 1987 (52 FR 45132), EPA took final action disapproving the affected SIP's, again including Arizona. In that action, EPA also promulgated, as FIP measures under section 110(c), general plan requirements for these States. The EPA also determined that BART was unnecessary in 28 States because it could not reasonably attribute the visibility impairment of mandatory Class I Federal areas in these States to specific sources or small groups of sources. In addition, under the revised agreement, EPA deferred until August 31, 1988 a decision regarding the need for BART or other control measures in the FIP's for the States of Arizona, Maine, Minnesota, and Utah to address certified visibility impairments in seven Class I areas in these States which potentially could be reasonably

attributed to a specific source, pending acquisition and evaluation of additional technical information regarding the potential sources of impairment.

The EPA needed additional information to determine whether the impairment in any of these Class I areas was "reasonably attributable" to an existing stationary facility, and to enable a BART analysis for any source so identified as causing or contributing to visibility impairment [40 CFR 51.302(c)(4)(i)].

Because all of the additional information needed by EPA was forthcoming but still not available by August 1988, the Agency sought and received a second extension, until August 31, 1989, of the deadline for issuing a rulemaking proposal regarding the need for BART or other control measures to remedy visibility impairments in three of the remaining Class I areas (Moosehorn Wilderness, GCNP, and Canyonlands National Park). With regard to the impairment in the GCNP, EPA delayed action in order to allow the National Park Service (NPS) time to analyze the data from a 1987 winter visibility attribution study, termed the Winter Haze Intensive Tracer Experiment (WHITEX), conducted in the Colorado Plateau where the GCNP is located. In the meantime, on May 19, 1989 (54 FR 21904), in accordance with the second revision to the settlement agreement, EPA promulgated final decisions concerning certified visibility impairments in four of the seven Class I areas. Based on monitoring conducted in these areas, EPA found that the

visibility impairments were not reasonably attributable to any specific source at that time. Therefore, EPA determined that it was not necessary at that time to revise the FIP's for the States of Maine, Minnesota, and Arizona to include BART or other control strategies to remedy impairments in Roosevelt Campobello International Park (Canada), Voyageurs National Park (Minnesota), Saguaro Wilderness (Arizona), and Petrified Forest National Park (Arizona).

In April 1989, EPA received a draft report on WHITEX from the NPS.⁵ Because of the delay in receiving this report, EPA believed that it lacked sufficient time to complete ~~all actions in determining whether impairment in the GCNP was reasonably attributable to a specific source, conduct a BART analysis, and issue a proposal regarding BART or other control strategies by the August 31, 1989 deadline.~~ ^{its analysis & issue its proposal re} Accordingly, EPA and EDF filed a joint motion to revise the settlement agreement for a third time, which was approved by order of the court dated July 6, 1989. Under this revision, there was no change in the deadlines for proposed action regarding Canyonlands National Park or Moosehorn Wilderness. As to GCNP, the third revision to the settlement agreement divided EPA's duty into two parts. The EPA would proceed, on a preliminary basis, to issue a finding on reasonably attributable impairment by the August 31, 1989 deadline.

⁵Malm, et al., "The National Park Service Report on WHITEX Draft Final Report" (April 7, 1989).

However, if EPA did provisionally identify a specific source of impairment, it would solicit comments on that finding and would have additional time to conduct a BART analysis. The EPA was to issue a rulemaking proposal on the need for BART by February 1, 1990 unless, in response to comments, EPA rejected its proposed identification and instead determined that BART was unnecessary.

In accordance with the third revision to the settlement agreement, EPA published a notice of proposed rulemaking on September 5, 1989 (54 FR 36948). Regarding Moosehorn Wilderness, EPA identified a source of the certified impairment, but proposed that BART was unnecessary at ~~this~~ that time because the impairment would be adequately remedied by the retirement of certain existing emission units and the addition of pollution controls on other units pursuant to a permit issued under the Act's prevention of significant deterioration (PSD) provisions. As to Canyonlands National Park, EPA could not reasonably attribute the certified impairment to a specific source at that time and so proposed that BART was unnecessary. On June 13, 1990 (55 FR 24060), EPA issued final decisions that BART was not necessary at that time to address impairment in either the Moosehorn Wilderness or the Canyonlands National Park.

Regarding the GCNP, in the September 5, 1989 notice, EPA preliminarily attributed a ~~significant portion of~~

*several sources of ~~total~~
residual impairment*

in the regard

wintertime visibility impairment to emissions from the NGS. The EPA reviewed the draft NPS report on WHITEX and concurred with the findings of the NPS that NGS is a ~~substantial contributor to the~~ wintertime visibility impairment. The EPA solicited comments on the merits of its preliminary attribution finding.

On November 28, 1989, the SRP, et al., and Alabama Power Company, et al., intervenors in EDF v. Reilly, filed a motion requesting a 1-year delay in the rulemaking schedule so that, among other things, the intervenors could conduct their own studies of the visibility impairment in the GCNP. By order dated January 9, 1990, the court granted the intervenors' motion to extend the deadlines. This order set February 1, 1991, as the new deadline for EPA to propose whether or not to require BART emission limits for the NGS to remedy winter visibility impairment. The order also extended the deadline for final action on any proposal regarding BART until October 1991 (6 months after the close of the comment period).⁶

C. Navajo Generating Station

⁶The EDF has appealed the extension of rulemaking deadlines in this case EDF v. Reilly, No. 90-15264 (9th Cir.). That appeal is pending. In a memorandum of understanding discussed below, parties to this litigation have agreed, in light of today's action, to petition (a) the Ninth Circuit to vacate the judgment below and remand the matter to the court below with instructions to dismiss and (b) the District Court for the Northern District of California to dismiss EDF v. Reilly, No. C82-6850.

The NGS is a 2250 MW coal-fired power plant located near Page, Arizona, approximately 20 kilometers from the northern boundary of the GCNP. The NGS is a baseload generating station consisting of three 750 MW units which became operational between 1974 and 1976. The SRP is the operating agent for NGS which is jointly owned by the SRP,⁷ the Los Angeles Department of Water and Power, the Arizona Public Service Company, the Nevada Power Company, and the Tucson Gas and Electric Company. Existing pollution control equipment at NGS includes electrostatic precipitators for particulate matter (PM) removal and specific burner design for nitrogen oxides (NO_x) control.

D. February 8, 1991 Proposal

On February 8, 1991, EPA proposed to revise the FIP for Arizona to include emission limits to address the visibility impairment observed in GCNP. The following is a summary of the main issues discussed in the proposal notice:

1. Emission limitation

The EPA proposed to adopt a continuous SO₂ emission limitation of 0.30 lbs/MMBtu. Compliance would be determined on a 30-day rolling average and would be phased

⁷The Salt River project owns 21.7 percent of the project for its own use and benefit, and 24.3 percent for the use and benefit of the United States in accordance with the project agreements. The term "NGS participants" is used in this notice to refer to the parties which have rights and responsibilities associated with the operation of NGS and includes the owners, operators and U.S. Bureau of Reclamation (for the United States).

in between 1995 and 1999. Because of the uncertainty in determining the improvement in visibility expected as a result of reducing emissions at the NGS, EPA solicited comments on three ~~specific~~ alternative ~~emission limitations~~ ~~at~~ control strategies for NGS:

a. A continuous SO₂ emission limitation of 0.50 lbs/MMBtu. Compliance would be determined on a 30-day rolling average and would be phased in between 1995 and 1999.

b. A continuous SO₂ emission limitation of 0.10 lbs/MMBtu. Compliance would be determined on a 30-day rolling average and would be phased in between 1995 and 1999.

c. A January 10, 1991, proposal submitted by SRP under which it would test alternative control technologies and if one of the technologies met a minimum removal efficiency at a set cost the NGS would install that technology and operate it in the wintertime. If none of the technologies met the test criteria, NGS would reduce its emissions by 70 percent (0.30 lbs/MMBtu emission limit) measured on an annual basis by the year 2000.

In addition, EPA requested comment on whether another emission limitation or a different averaging period may be more appropriate.

2. Attribution

several
episodes
-L

As part of the February 8, 1991 proposal, EPA reopened the comment period on its September 5, 1989, preliminary finding that ~~a significant portion~~ of wintertime impairment in the GCNP was reasonably attributable to NGS. The EPA noted both in the September 1989 and the February 1991 notices that the finding was not based on any single analytical technique in the NPS report on WHITEX, but rather on the collection of techniques performed by the NPS using WHITEX and other data. In detail, EPA explained that all of the techniques used by the NPS support the conclusion that NGS is a ^{source} ~~significant contributor to~~ ^{of} visibility impairment in the Grand Canyon during ~~the winter months~~ ^{certain episodes}. Also, in some detail, EPA discussed the National Academy of Science's (NAS') review of the WHITEX study and discussed other visibility studies performed subsequent to WHITEX.

The National Research Council of the NAS reviewed and reported on the scientific methods used in the WHITEX report. The NAS report, entitled "Haze in the Grand Canyon: An Evaluation of the Winter Haze Intensive Tracer Experiment" (October 1990), contained a qualitative assessment of WHITEX which supported EPA's finding that, on some days, NGS ^{is the source of visibility impairment} ~~contributes significantly to haze~~ in the GCNP.⁸ Further, the NAS found that the "rate of SO₂

⁸The report found, for example, that the detection at Hopi Point (GCNP) of the unique tracer released from NGS in the WHITEX study "is an unambiguous indicator that air

emissions from NGS is easily large enough to serve as the source of the sulfur measured in the GCNP."⁹ However, the report also found that the data base and data analyses techniques in the WHITEX report ~~reviewed by NAS,~~ were not, standing alone, sufficient to ascertain the quantitative NGS contribution to haze at any given time. The NAS report has been placed in the rulemaking docket.¹⁰ ~~The report also found that the data base and data analyses techniques in the WHITEX report reviewed by NAS, were not, standing alone, sufficient to ascertain the quantitative NGS contribution to haze at any given time.~~

The SRP has conducted another study known as the Navajo Generating Station Visibility Study (NGSVS). That study attempted to measure the degree of contribution by the NGS to visibility impairment in the GCNP during the 1989-1990 winter season and to assess the level of improvement expected as a result of reducing the SO₂ emissions at NGS. The SRP submitted a draft report describing that study and its results¹¹ during the public comment period on EPA's February 8, 1991 proposal. The NSVS concluded that NGS

parcels containing NGS emissions did impinge on the GCNP on several occasions." Executive Summary at p. 3.

⁹ NAS Report at 33 (emphasis added).

¹⁰ Additional copies of this report are available from the National Academy Press, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

¹¹ Sonoma Technology Inc. "Navajo Generating Station Visibility Study", Draft Number 2, April 16, 1991.

emissions were present at Hopi Point less frequently than during the WHITEX period. In addition, the NGSVS concluded that on days when NGS emissions were present, visibility impairment at Hopi Point associated with those emissions was substantially less than the amount calculated in the NPS report on WHITEX.

3. BART Analysis

In light of its attribution finding, EPA conducted an analysis in accordance with the BART Guidelines (EPA-450/3-80-009b) and 40 CFR 51.301(c)(4)(iii).¹² That analysis included consideration of the following: the costs of compliance, the energy and non-air quality environmental impacts, any existing pollution control technology in use at the facility, the remaining useful life of the source, and the degree of improvement in visibility anticipated to result from application of controls.

Considering the requirements found in the BART Guidelines, EPA divided its analysis into two major parts. In the first part, EPA identified the SO₂ emission controls that are readily available to the source, the costs of such controls, and other impacts of installing and operating the controls. In the second part of the analysis, EPA attempted to define the source-impairment relationship which was then

¹²U.S. EPA, "Draft Report on Best Available Retrofit Technology (BART) Analysis for the Navajo Generating Station in Page, Arizona," January 1990. A copy this document has been placed in Docket A-89-02A.

used to predict the improvements in visual air quality that can reasonably be expected to occur as a result of installing and operating the controls defined in the control technology analysis. Because EPA was faced with some uncertainties in each of the parts of the analysis, EPA bounded its results by giving low and high estimates. A detailed discussion of this analysis for NGS was provided in EPA's February 8, 1991 proposal.

To estimate the cost of controlling the SO₂ emissions at NGS, EPA used the Integrated Air Pollution Control System (IAPCS) cost model to predict the capital and operating cost estimates for 0.10, 0.30, and 0.50 lbs/MMBtu control levels.¹³ The results from IAPCS indicated that wet flue gas desulfurization (FGD) achieving a 0.30 lbs/MMBtu emission limit for all three units, the control level that was proposed by EPA, was estimated to have total capital cost requirements of between \$245.9 million and \$402 million with total levelized annual costs (including amortized capital, interest, operating, and maintenance costs) estimated to be between \$91.9 million and \$128.3 million.¹⁴

~~Although not a required inquiry in the BART analysis, in its February 8, 1991 proposal, EPA also estimated the potential costs to residential electricity customers~~

¹³Integrated Air Pollution Control System Costing Program, Version 3.0, copyright PEI and Associates, Inc., 1989.

¹⁴All dollar amounts were measured in 1988 dollars.

served by the NGS participants as well as the potential costs to Central Arizona Project customers.

One of the more complicated tasks in the BART analysis was defining the relationship between the SO₂ emissions at NGS and the visibility impairing sulfate in the GCNP. This relationship had to be addressed in order to estimate the degree of improvement in visibility that could be anticipated to result from the use of the alternative SO₂ control systems. Because of the complex terrain in and around the GCNP, EPA defined the source/impairment relationship using the ratio of SO₂ emissions at NGS to sulfate in the GCNP attributable to NGS as found in the final WHITEX report. Using this ratio, EPA then applied a linear rollback model. However, in light of the uncertainties surrounding these analyses EPA considered a broad range of source-impairment relationships. In addition, EPA developed and applied a nonlinearity factor to the rollback model to estimate the improvements in visibility that would result from reductions in SO₂.

Because no single standard method exists for measuring improvements in visibility, the EPA employed two of the most widely used techniques to define the improvements in visibility expected to occur in the GCNP.

One of the methods used to estimate the visibility improvements in the GCNP was analyzing the changes in contrast expected to occur as a result of reducing SO₂

emissions at NGS. The EPA stated in the proposal that this method is particularly relevant because human observers use contrast to make judgments of how atmospheric clarity changes with pollutant concentration. The contrast is defined as the percent difference between the brightness of a scenic element and its background.

Using the information obtained during the WHITEX study and extrapolating it to a period from November 1 through March 31 based on historic particle composition data (and applying the nonlinearity factor), EPA estimated the number of days with a "perceptible" change in the visibility conditions (4 percent change in contrast), a "quite noticeable" change in visibility conditions (10 percent change in contrast), and a "very apparent" change in visibility conditions (20 percent change in contrast) which would occur if NGS SO₂ emissions were reduced to 0.30 and 0.10 lbs/MMBtu.

In addition to analyzing the changes in contrast in order to describe the improvement in seasonal average visibility expected to occur as a result of controlling SO₂ emissions at NGS, the EPA also estimated the improvements in visual range expected to occur at 0.10 and 0.30 lbs/MMBtu SO₂ emission limits. In its proposal, EPA estimated that ~~the average~~ wintertime visual range would improve 11 percent if NGS had to meet a 0.30 lbs/MMBtu emission limitation and

certain
episodic

impairments

would improve 14 percent if NGS had to meet a 0.10 lbs/MMBtu emission limit.

Although not specifically addressed in the BART analysis, the proposal noted that EPA and NPS suspected that NGS emissions may contribute to visibility impairment in the GCNP during other seasons of the year and in other Class I areas in the region. Thus, EPA sought comment on other potential visibility impairment caused by NGS.

The EPA also noted in the proposal that it was not required as a part of its analysis to estimate monetary benefits associated with improving visibility in the GCNP. However, EPA evaluated the monetary benefits in developing a part of the preliminary Regulatory Impact Analysis (RIA) (as required by Executive Order 12291) for the proposed rule.

4. Control of Particulate Matter and Nitrogen Oxides

In the February 8, 1991 proposal, EPA noted that two other pollutants emitted by NGS, NO_x and PM, are known to contribute to visibility impairment in some circumstances.¹⁵ The current emissions of NO_x and PM from NGS were not identified as significantly contributing to the visibility impairment in the Grand Canyon. However, EPA expressed concern based upon its technical judgment regarding the behavior of the pollutants as potential contributors to visibility impairment as a general matter, upon the amount of the pollutants emitted by NGS, upon the

¹⁵See, e.g., BART Guidelines at 12-13.

proximity of NGS to the GCNP and upon the characteristics of the NGS plume shown by WHITEX and other studies, that increased emissions of these pollutants could result in impairment in the GCNP. The EPA noted that although the NGS is not subject to any NO_x emission limitations, SRP has stated that NGS currently emits NO_x at a rate of 0.4 to 0.5 lbs/MMBtu. Therefore, EPA proposed an NO_x emission limit consistent with NGS's existing emission rate, as well as the rate at other similar plants, of 0.5 lbs/MMBtu.

The EPA noted that PM emissions for the NGS are currently limited in two ways. The Arizona SIP has both an emission rate limitation of 0.06 lbs/MMBtu and an opacity limit of 40 percent for NGS. The SRP has stated that NGS currently emits PM at a rate of 0.03 lbs/MMBtu with an opacity of between 10 and 15 percent. Thus, the opacity limit of 40 percent is well above the NGS existing emissions. Therefore, EPA proposed a 20 percent opacity limitation consistent with current NGS emissions in order to preclude any visibility deterioration that would be caused by an increase in PM emissions.

The EPA requested comments on whether NO_x and PM emission limits would be appropriate for NGS.

5. Compliance Schedule

The EPA proposed to require that the emission limitation be achieved in three phases. Specifically, EPA proposed that the final emission limitation would need to be

met on one unit by January 1, 1995; on two units by January 1, 1997; and on all three units by January 1, 1999. The EPA solicited comments on whether the phased-in compliance schedule proposed was appropriate as a matter of law or policy, and, as noted, requested comment on the January 1991 SRP proposal that a final emission limitation not become effective before January 1, 2000.

6. Use of Seasonal Controls

Part of the SRP proposal called for the use of seasonal controls. Therefore, EPA solicited comment on the use of seasonal controls. In the February 8, 1991 notice, EPA noted that such controls would have to be both technically and legally justified before they could be used.

7. Other Issues

In the February 8, 1991 proposal, EPA also specifically solicited comments on the following:

- Use of continuous emission monitoring systems for compliance determinations,
- Plant-wide averaging of the emission limitations, and
- Other available technologies which can reduce SO₂ emissions at NGS to achieve the proposed or alternative limits and which may require less capital investment and/or operating expenses than those technologies evaluated in the BART analysis.

In addition to soliciting written comments during the comment period, EPA held a public hearing on March 18 and

19, 1991 in Phoenix, Arizona. A copy of the transcript of the hearing is in Docket A-89-02A. As a result of the comment period and public hearing EPA received over 400 comments on its proposal. All the comments have been placed in Docket A-89-02A.

Because of the differences in technical opinions expressed and data analyses submitted to EPA during the comment period, EPA sponsored a technical review meeting on April 25 and 26, 1991. The EPA invited the NGS participants and the environmental groups who submitted technical information to EPA to send technical representatives to the meeting to discuss the interpretation of the available data. The meeting was open to the public and a summary of it is included in Docket A-89-02A.

E. New Information After the Close of the
Initial Comment Period

After the comment period closed on April 19, 1991, at the recommendation of EPA, representatives of SRP, GCT, and EDF met to discuss alternative approaches to EPA's February 8, 1991 proposal. In August 1991, the outside parties reached agreement and together recommended that EPA adopt an alternative control for NGS consisting of a 0.10 lb/MMBtu SO₂ emission limitation (approximate to a 90 percent control level) based on a rolling annual average and phased in by unit in November 1997, November 1998, and August 1999. In addition, under the agreement, NGS would

shift its maintenance schedule such that six unit-weeks of planned maintenance would occur between November 1 and March 15 each year. Under specific conditions, the Administrator of EPA may allow NGS to shift the maintenance schedule outside of that period or not to conduct scheduled maintenance in a given year.

Representatives of EPA participated in many of the meetings with the parties and provided technical assistance. Representatives of the State of Arizona also attended several of the meetings and provided additional technical support. New technical materials and cost information, including adjustments of the potential control costs were exchanged between the parties and EPA. Summaries of the meetings and significant conversations in which EPA was involved and copies of the new material and information which were submitted to or developed by EPA have been included in Docket A-89-02A.

The outside parties memorialized their agreement in an MOU which they submitted to EPA along with recommended regulatory requirements for EPA's final rulemaking action. The SRP estimated (in 1992 dollars) a capital cost of \$430 million and a total levelized annual cost of \$89.6 million for the parties' recommended alternative. In comparison, The SRP also estimated a capital cost of \$510 million and total levelized annual cost of \$106 million to meet the alternative EPA proposed in February 1991.

Noting that the alternative incorporated in the MOU would provide more visibility protection for the GCNP at a lower cost for NGS and its customers, EPA, on August 8, 1991, reopened the comment period on its February 8, 1991 proposed action (56 FR 38399, August 13, 1991). In the notice EPA stated that it was giving serious consideration to the control option recommended by the outside parties and incorporated in an appendix to the notice a memorandum from EPA's Office of General Counsel concluding that the outside parties' legal rationale in support of their recommended control option was meritorious.

The EPA reopened the comment period until September 9, 1991. Where addresses were available, commenters on the February 8, 1991 proposal were notified by mail of the reopened comment period in order to facilitate their ability to comment.

The EPA received 13 comments during the supplement comment period. Twelve of the commenters supported the alternative incorporated in the MOU and one opposed it. The SRP, GCT, EDF, the Wilderness Society, the National Wildlife Federation, and the Sierra Club conditionally withdrew their prior the previous comments which were inconsistent with a rule which is consistent with the MOU and associated documents.

TODAY'S ACTION

In today's action EPA is promulgating its final determination on the attribution to NGS of visibility impairment in GCNP and is promulgating Federal revisions to the visibility implementation plan for Arizona to address that impairment. As discussed below, EPA has concluded that visibility impairment of GCNP is "reasonably attributable" to NGS and that NGS is a significant contributor to certain visibility episodes. The EPA also finds today that a 0.10 lbs/MMBtu SO₂ emission limitation (approximately a 90 percent emission reduction) based on a rolling annual average and phased in by unit in November 1997, November 1998 and August 1999, in addition to scheduled winter maintenance at NGS affords greater visibility improvement than the alternative advanced in EPA's February 1991 proposal. In particular, it will reduce by two-thirds the amount of pollution allowed under the proposed rule. In addition, EPA finds that the final rule will be significantly less costly than the proposal. Consequently, EPA further concludes that today's final action will provide a greater degree of "reasonable progress" toward the national goal of remedying such impairment than would be provided by the February 1991 proposal [see section 169A(b)(2) of the Clean Air Act, 42 U.S.C. §7491(b)(2)].

In EPA's August 1991 supplemental notice requesting comment on the rulemaking alternative largely adopted in

final form today, the Agency noted that SRP, GCT, and EDF had recommended that the legal rationale in support of this alternative be the requirement in section 169A(b)(2) of the Act that implementation plan revisions addressing visibility impairment achieve "reasonable progress" toward the national visibility goal. The supplemental notice also indicated that EPA's Office of General Counsel had reviewed the matter and concluded, subject to any significant points that may be raised in the reopened comment period, that EPA could rely on the reasonable progress provisions as the basis for this alternative. No significant adverse comments addressing the legal basis were received ~~on this issue~~. Accordingly, EPA is adopting this rationale as discussed in the supplemental notice.

Today's action is based upon the material in the docket including EPA's review and consideration of all comments received during the comment periods and at the public hearing. The agreement between GCT, EDF, and SRP and associated recommendations to EPA, largely adopted in final form today, also are in the docket. The EPA has responded to all of the significant comments received. Some responses are provided later in today's notice. Additionally, EPA has prepared a document accompanying today's action, "Response to Public Comments: Proposed Revisions to Arizona Visibility FIP for Navajo Generating Station," which

responds to comments. This document has been placed in Docket A-89-02A.

A. Attribution

The EPA regulations promulgated on December 2, 1980 "[r]equire the control of impairment that can be traced to a single existing stationary facility or small group of existing stationary facilities . . . " (45 FR 80085). Accordingly, EPA's regulations currently cover existing sources "which may reasonably be anticipated to cause or contribute to impairment of visibility in any mandatory Class I Federal area" where the impairment is "reasonably attributable" to that source by visual observation or other techniques deemed appropriate by the State. The EPA, acting for the State under section 110(c) of the Act, deems the techniques in the WHITEX report, the NGSVS report and other data and analyses in the docket appropriate techniques for determining reasonable attribution in this case for the following reasons:

1. The unique tracers, deuterated methane (CD_4) used in the WHITEX study and perfluorocarbons used in the NGSVS, injected into the emissions of NGS were observed in substantial quantities at Hopi Point during periods of episodic visibility impairment;
2. The NGS is the predominate source of SO_2 in the region;

3. SO₂ released by a power plant converts into sulfates through chemical transformation in the atmosphere;
4. Meteorological data shows that the NGS plume easily can, and frequently does, travel to GCNP; and
5. The data and analyses in the docket show that sulfates are the major contributor to visibility impairment in GCNP.

The EPA recognizes that NGS is not the only source of visibility impairment at GCNP. Under the applicable statutory provisions and regulations, however, this is not determinative.¹⁶ (see generally section 169A of the Act and 40 CFR 51.300-307). Moreover, even though WHITEX and NGSVS contain some scientific uncertainty, they are technically

¹⁶ For example, under section 169A(b)(2) of the Act EPA is authorized to require visibility implementation plans containing "emission limits, schedules of compliance and other measures" necessary to make reasonable progress toward meeting the national visibility goal [see also 40 CFR 51.302(c)]. The national visibility goal, in turn, calls for the remedying of "any" manmade visibility impairment in Class I areas [see section 169A(a)(1) and 40 CFR 51.300(a)]. As noted, EPA's regulations implementing section 169A address visibility impairment that is reasonably attributable to a single source or small group of sources and deferred action on complex problems such as regional haze [see generally, 45 FR 80084 (December 2, 1980)]. Accordingly, as provided in the 1980 regulations, EPA may remedy through emission limits, schedules of compliance, or other measures "any" visibility impairment that is reasonably attributable to an existing stationary source or small group of sources [see also section 169A(c) of the Act and 50 CFR 51.303 (authorizing an exemption from control requirements only where a plant does not "by itself or in combination with other sources" emit pollution "which may reasonably be anticipated to cause or contribute to significant impairment of visibility" in any Class I area and affirms, by negative inference, EPA's broad rulemaking authority)] (emphasis added).

adequate for the regulatory purposes at hand, as they both showed that at certain times a significant portion of the visibility impairment in the GCNP can be reasonably attributed to NGS. Accordingly, EPA concludes today that visibility impairment of the GCNP is "reasonably attributable" to NGS and NGS is a significant contributor to certain visibility episodes. Notwithstanding that other sources also may contribute to the impairment of GCNP, EPA concludes that the addition of emissions controls at NGS alone will result in a significant improvement in visibility at GCNP and will make "reasonable progress" toward meeting the national visibility goal.

B. Control Technology

As part of the BART analysis¹⁷ for the February 1991 proposal, EPA reviewed the available control technologies as well as the environmental impact of the use of such technologies and the estimated costs of installing and operating such equipment. In today's action EPA is not requiring the use of any particular control technology. Rather, EPA is establishing an emission limitation and NGS has the discretion to select and install the type of control system which best meets its needs. The available information in the docket indicates that a wet FGD system

¹⁷U.S. EPA "Draft Report on Best Available Retrofit Technology (BART) Analysis for the Navajo Generating Station in Page, Arizona" January 1990.

will be the economical proven control technology for meeting the 0.10 lbs/MMBtu emission limitation at NGS.

As a result of new information provided by SRP, EPA has revised and updated its cost estimates for the installation and operation of a wet FGD system. The revised estimated capital cost and total levelized annual cost to meet the emission limitation EPA proposed in February 1991, in 1992 dollars, are \$510 million and \$106 million, respectively. The estimated capital cost and that the total levelized annual cost, in 1992 dollars, to meet the emission limitation promulgated today, are \$430 million and \$89.6 million, respectively. Although not considered in these cost estimates, EPA expects that NGS will be able to recoup a portion of the control costs by the sale of ~~excess~~ marketable allowances which it will receive as part of the allowance trading program that EPA is establishing under Title IV of the Act.

Based on the information submitted during the comment period by SRP and Nevada Power Company (NPC) and the above cost figures, EPA has estimated that the average SRP and NPC customers electric bills will increase approximately \$1.72 and \$1.57 per month, respectfully. The customers of the other utilities will have smaller increases in their electric bills. Commenters representing Central Arizona Project (CAP) customers submitted information showing that water cost would increase between \$4.10 and \$4.50 per acre-

foot based on EPA February 1991 proposal. Since the cost figures for the final action are lower than figures used for these estimates, the increase in water costs for the CAP customers is expected to be less than \$4.10 to \$4.50 per acre-foot.

C. Control Strategy

The EPA has adopted the combination of a higher level of control, compliance phased in by unit in 1997, 1998 and 1999, an annual averaging period, and scheduled winter maintenance as a control strategy for NGS--the alternative recommended to the EPA by GCT, EDF and SRP and identified in EPA's August 1991 supplemental notice--because it better addresses the ~~two~~ visibility effects of concern at a lower cost than the proposal in EPA's February 1991 notice. As highlighted here and elsewhere the control strategy for NGS must be viewed as a whole and not as severable parts. The EPA carefully has weighed the relevant statutory and regulatory considerations and concluded that, taken in its entirety, today's control strategy for NGS will provide a greater degree of reasonable progress toward the national goal at a lower cost than EPA's February proposal.

Essentially, the SO₂ emissions from NGS can contribute to two types of visibility impairment. The major impact of NGS is its dominant impact during certain episodic visibility impairment events, usually during the winter. This impact has been observed in winter studies (WHITEX and

NGSVS) as well as intense aerosol monitoring within the canyon since 1988.¹⁸ The other concern addressed by the control strategy in today's action is the less intense impairments which (1) occur at the GCNP during seasons other than winter, and (2) occur at other nearby mandatory Class I Federal areas.¹⁹

The lower level of NGS SO₂ emissions required by the 0.10 lbs/MMBtu emission limitation adopted today will afford GCNP greater protection from episodic events than an emission limitation which allows significantly more SO₂ emissions but is averaged over a shorter period, such as the 0.30 lbs/MMBtu emission limitation proposed by EPA in its February 1991 notice. The probability of high NGS contribution to severe episodic sulfate impairment events is limited by the known design reliability of current technologies which will achieve the required 0.10 lbs/MMBtu emission limitation as well as the scheduled winter maintenance requirement. Thus, EPA believes that despite the use of an annual averaging time, the significant increase in control level, expected reliability of the control technology, and winter maintenance, taken together, will for the most part prevent continuation of severe winter

¹⁸~~The NPS in canyon data.~~ See Docket A-89-02A, item IV-D-164.

¹⁹ See, e.g., Latimer, Douglas, "Haze Impacts on the Golden Circle of National Parks of Sulfur Dioxide Emission from Navajo Generating Station: Haze Puff Model Calculations for 1986-90."

episodes caused by NGS. At the same time, the annual average lowers the costs of compliance.

With respect to long-term visibility impacts on the Golden Circle area (the other Class I areas in the Colorado Plateau) there is little doubt that the lower emission rate over a year's average will reduce NGS's contribution to sulfate formula and thus to sulfate-caused impairment more than the control level proposed by EPA in February 1991. Given NGS's central location in relation to many Class I areas, no matter what meteorological events occur over a multi-year period, it is likely that the sulfates originating from NGS and transported to surrounding Class I areas will be reduced in proportion to the difference in emission limitations, i.e., to one-third of the levels in the February 1991 proposal.

Further, during the comment period on the February 1991 proposal, EPA received technical information ^{suggesting} ~~demonstrating~~ that NGS contributes to visibility impairment at GCNP in non-winter seasons.²⁰ For the reasons just discussed, the significantly lower emission rate required today ~~must~~ inevitably will, over the long-term, curb NGS's contribution to visibility impairment in the GCNP during seasons other than winter to a greater degree than EPA proposed option.

²⁰See Docket A-89-02A item IV-D-171 and seasonal control discussion below.

Accordingly, the control scheme adopted today for NGS is appropriate for addressing the winter episodic visibility impairment observed at the GCNP and will also reduce ~~the~~ ^{any} long-term, long-range impairment that NGS emissions may contribute to during other seasons at GCNP and at other nearby Class I areas.²¹

D. Emission Limitation

After reviewing the option recommended by SRP, EDF, and GCT in their MOU, EPA has determined that such a control strategy will provide a substantially greater degree of emissions reduction, and a correspondingly greater degree of visibility improvement, at a substantially lower cost than

²¹ As noted, section 169A of the Act establishes a national visibility goal, not an air quality standard or a specific emission standard. While the objective is to attain the goal, EPA's mandate from Congress only is to make reasonable progress toward the goal. For these reasons, EPA has more flexibility in selecting a control strategy to meet the visibility reasonable progress requirements than it does when a health-based air quality standard or specific emission standard must be met. Thus, in determining reasonable progress, EPA by law must consider the costs of compliance, the time necessary for compliance, and the energy and non-air quality environmental impacts of compliance [see section 169A(g)(1) of the Act]. Consideration of the pertinent statutory scheme and these specific factors has informed several aspects of today's action. Thus, for the policy and legal reasons stated, an annual rolling average emission limitation is acceptable for this case. ~~However, use of an annual average today and is not intended to be a precedent for its use in other circumstances such as for attaining a health-based standard, protecting against short-term health exposure.~~ Moreover, while this emission limitation is not expected to interfere with attainment of any other requirement of the Act, its adoption does not relieve NGS of any responsibility for meeting any air quality standard, emission standard, or other requirement of the Act.

*The agency recognizes that some of approx
is setting standards to
protect*

the alternative proposed in February 1991.²² For these reasons, EPA also concludes that this option will make additional reasonable progress towards attainment of the national visibility goal in comparison to the February 1991 proposal. Thus, in today's action EPA is promulgating an SO₂ emission limitation of 42 ng/J (0.10 lbs/MMBtu) heat input, to be phased in by unit in November 1997, November 1998, and August 1999, with compliance determined on a rolling annual average basis.

Under today's final action, compliance with the annual rolling average will be determined by computing a weighted plant-wide average of the SO₂ emission rate based on the daily SO₂ emission rate and the electric energy generated for the previous 365 "boiler operating days" for each unit.²³ The EPA was concerned that the plant-wide average reflect the actual release of emissions at the plant.

²²In the August 1991 supplemental notice, EPA published and requested comment on the parties' August 8, 1991 MOU and associated documents. During the public comment period, the parties further clarified their agreement and submitted a revised version of their MOU and recommended regulatory requirements to EPA, both documents dated August 22, 1991.

²³A "boiler operating day" is specific for each steam generating unit at NGS and is defined as a 24-hour calendar day (the period of time between 12:01 AM and 12:00 midnight in Page, Arizona) during which coal is combusted at that NGS unit for the entire 24 hours. This definition is consistent with the definition for "boiler operating day" in 40 CFR 60.41a: "a 24-hour period during which fossil fuel is combusted in a steam generating unit for the entire 24 hours." The EPA notes that the set of previous 365 boiler operating days for each unit will be unique to that unit and thus the same set of calendar days probably will not be used for all three units in determining compliance.

Therefore, after ~~consultation~~ discussion with representatives of SRP GCT and EDF, EPA settled on a methodology that appropriately weights the emissions from each unit before calculation of the plant-wide average. The EPA has used the daily electric energy generated as a weighting factor because that information is readily available for each unit and in this case is proportional to the heat input to the boilers. Specifically, compliance will be determined as follows:

1. For each unit that has accumulated at least 365 boiler operating days since the passage of the starting date applicable to it, the plant must measure and record the SO₂ emission rate and the electric energy generated on each boiler operating day. The SO₂ emission rate will be computed using the data from the required continuous emission monitoring system (CEMS) for the unit and using method 19, Appendix A, 40 CFR 60. The electric energy generated, in megawatt-hours, will be recorded from the megawatt-hour meter for the unit.

2. For each unit the previous 365 boiler operating days will be identified.

3. For each such day the product of the SO₂ emission rate and the electric energy generated will be computed.

4. The 365 products for each unit will be added.

5. The electric energy generated for ~~same~~ the 365 boiler operating days for each unit will be added.

6. The sums of the product of the SO₂ emission rate and the electric energy generated will be divided by the sum of the electric energy generated to produce a plant-wide weighted annual average SO₂ emission rate for comparison with the emission limitation to determine compliance.

Recording and computation of the daily electric energy generated and SO₂ emission rates will commence on:

- November 19, 1997 for the first unit,
- November 19, 1998 for the second unit, and
- August 19, 1999 for the third unit.

The NGS has the discretion to determine which of its three units will be controlled first and second.

In the discussion below, EPA has recognized that certain difficulties encountered during the first year of operation of a control system or the catastrophic failure of a control system may, based on EPA's judgment warrant a limited exclusion from compliance with the emission limitation. However, as discussion below indicates, the control system, as a general matter, must be optimally operated consistent with good engineering practices to keep emissions at or below the emission limitation.

For each unit, in determining compliance with the annual average emission limitation during the first year of operation of the control equipment installed to comply with this emission limitation, periods during which one of the following conditions are met will be excluded:

1. Equipment or systems do not meet designer's or manufacturer's performance expectations.
2. Field installation including engineering or construction precludes equipment or systems from performing as designed.

The periods during the first year to be excluded will be determined by the Administrator based on periodic reports of compliance with this emission limitation which must identify the times proposed for exclusion and provide the reasons for the exclusion, including the reasons for the outage of the control system. The report also must describe the actions taken to avoid the outage, to minimize its duration, and to reduce SO₂ emissions at the plant to the extent practicable while the control system was not fully operational. Whenever the time to be excluded exceeds a cumulative total of 30 days for any control system, the NGS owner or operator must file a report within 15 days addressing the history of and prognosis for the performance of the control equipment.

In addition to the foregoing, the Administrator will exclude from the compliance determination for a unit any periods of emissions from a unit for which the Administrator finds that the control equipment is out of service because of catastrophic failure of any control system which occurred for reasons beyond the control of the NGS participants and operators and could not have been prevented by good

engineering practice. The Administrator will not exclude the period if the equipment failure was a consequence of a lack of appropriate maintenance, of intentional or negligent conduct or omissions of the NGS participants or operators or the control system design, construction, or operating contractors.

The final regulation requires that all equipment needed to comply with this regulation to be optimally operated consistent with good engineering practice to keep emissions at or below the emission limitation. The regulation also requires that following any control system outages, the system must be returned to full operation as expeditiously as practicable.

The final regulation provides that continuous emission monitors must be installed to determine compliance with the emission limitation. This equipment must meet the specifications listed in Appendix B of 40 CFR Part 60, the quality assurance procedures in Appendix F of 40 CFR Part 60, and the requirements for estimating emission rate in ng/J (or lbs/MMBtu) set out in method 19 Appendix A, 40 CFR Part 60.²⁴ The NGS is required to report emissions and

²⁴For certain requirements in today's action (e.g., monitoring, reporting, recordkeeping, etc.), EPA has relied on its regulations governing standards for performance for new stationary sources. Those regulations have been relied on because they contain standardized procedures and requirements which apply to coal-fired steam generating units. In addition, EPA has provided that the NGS owners or operators must comply with the requirements relied on in 40 CFR Part 60 as in effect today. This approach was agreed to

maintain records in accordance with the procedures in 40 CFR 60.7. In addition, EPA is establishing special notification procedures when an outage of a control system occurs. The NGS must notify the Administrator by telephone or by writing within one business day of any outage of the control system needed for compliance with the emission limitation and must submit a follow-up written report within 30 days of the repairs stating how the repairs were accomplished and justifying the amount of time taken for the repairs.

~~In the February 1991 notice, EPA proposed new NO_x and opacity limits on NGS emissions. The EPA does not have any guidance at this time that NO_x or PM (which are limited by opacity limitations) emissions from NGS contribute significantly to visibility impairment in the GCNP. Although, as noted previously, this regulation does not require the use of any particular control technology to meet the emission limitation, the proven readily available technology that will achieve the required SO₂ reduction will not increase existing PM or NO_x hourly emission rates from NGS. In addition, NGS is a baseload plant already operated at a high capacity factor and EPA has determined that the installation of control equipment will not cause operations~~

and recommended to EPA by SRP, GCT, and EDF in their August 22, 1991 MOU and associated documents. At this time, EPA believes that reliance on the regulations as they currently exist is reasonable in that they appear to provide adequate technical methods and procedures for determining and monitoring compliance with the SO₂ emission limitation established today.

~~at NGS to increase. Accordingly, EPA has determined that compliance with today's SO₂ emission limitation will not result in an increase in overall emissions of NO_x or PM at NGS. Thus, EPA finds no need to include additional emission limitations for these pollutants at this time in order to prevent increased emissions of these pollutants.~~

In the February 1991 notice, EPA proposed new NO_x and opacity limits on NGS emissions consistent with current emission levels. These were proposed due a concern that certain SO₂ emission control equipment would cause increases in NO_x and PM (which are limited by opacity limitations) emissions at NGS which could affect visibility in GCNP. However, EPA does not have any evidence at this time that NO_x or PM emissions from NGS contribute significantly to visibility impairment in the GCNP. Further, EPA does not expect that the proven readily available technology that will achieve the required SO₂ reduction will increase NO_x or PM hourly emission rates from NGS. In addition, NGS is a baseload plant already operated at a high capacity factor and EPA has determined that the installation of control equipment will not cause operations at NGS to increase. Accordingly, EPA has determined that compliance with today's SO₂ emission limitation will not result in an increase in overall emissions of NO_x or PM at NGS. Thus, EPA finds no need to include additional emission limitations for these

pollutants at this time in order to prevent increased emissions of those pollutants.²⁵

E. Source/Impairment Relationship

~~As noted in the February 8, 1991 proposal, EPA provided calculations of the relationship between reductions in SO₂ emissions from NGS and the visibility at the GCNP. The calculations were based on the overall findings of the WHITEX report which used several techniques to apportion NGS's contribution to sulfates and the resulting haze at GCNP. The EPA's calculations used to estimate the distribution of days when the reduction in SO₂ emissions from NGS would result in perceptible, quite noticeable, and very apparent change in visibility conditions in GCNP were in error because the final contrast assessment did not take into account natural (Rayleigh) atmospheric scattering of light. The seasonal visual range changes i~~ In the February 1991 proposal, EPA estimated seasonal visual range changes which were based on a simple rollback model applied to average NGS contribution during the entire WHITEX study period. Based on this model, a 0.10 lbs/MMBtu SO₂ emission limitation on NGS should result in an approximate 14 percent

²⁵ Under EPA's current interpretation of its PSD regulations as well as its proposed "WEPCO" rule (56 FR 27630, June 14, 1991), a pollution control project that does not increase actual emissions would not be considered a "modification" and therefore would not subject the unit to new source review.

improvement in seasonal average standard visual range at Hopi Point.

~~The major change in the seasonal average visibility results from more dramatic improvements expected to occur as a result of reducing emissions from NGS during certain meteorological conditions. Recent measurements of peak winter sulfate levels in the canyon approach four times the average winter levels. For certain periods analyzed in WHITEX and in NGSVS, NGS was shown to be the dominant contributor (more than 50 percent) to sulfates measured at Hopi Point. If certain humidity and wind conditions occur during the period when these episodes are formed, reducing NGS emissions could result in increases in standard visual range up to 300 percent. Given the variability in meteorological conditions throughout the winter and from one winter to the next, it is impossible to exactly quantify the peak episodic expected improvement for any given period.~~

During the comment period on EPA's February 1991 proposal, SRP submitted the results and analyses of the NGSVS which included estimates of NGS' contribution to seasonal average visibility impairment in GCNP, specifically focused on Hopi Point. ~~The general conclusion of The NGSVS data indicate that controlling~~ was that a SO₂ emissions from NGS would result in at most ~~limitation of 0.10 lbs/MMBtu~~

would result in approximately a 2 percent improvement in the seasonal average standard visual range.²⁶

Another study²⁷ submitted during the comment period, which was based on modelling of NGS' emission over a long time period, indicated average wintertime improvements in the range of 4 to 8 percent if NGS emissions are reduced. This study is not based on any specific monitoring period nor was it based on an EPA-approved model.

The two intensive studies, WHITEX and NGSVS, included detailed aerosol, wind flow, and tracer analyses. They represent snapshots of NGS's impacts for their respective study periods. Based solely on wind flow analysis during these periods, these studies varied significantly in concluding how often NGS emissions would be transported directly to the Hopi Point, the common GCNP monitoring site for both studies.

The major change in the seasonal average visibility results from more dramatic improvements expected to occur as a result of reducing emissions from NGS during certain meteorological conditions. Recent measurements of peak winter sulfate levels in the canyon approach four times the average winter levels. For certain periods analyzed in

²⁶Average of the total light scattering to that part apportioned to NGS over the entire study period as found in Appendix G of the NGSVS, Final Report, Draft Number 2, Sonoma Technology, Inc., April 16, 1991.

²⁷See Docket A-89-02A item IV-D-171.

WHITEX and in NGSVS, NGS was shown to be the dominant contributor (more than 50 percent) to sulfates measured at Hopi Point. If certain humidity and wind conditions occur during the period when very high sulfate episodes are formed, reducing NGS emissions could result in increases in standard visual range up to 300 percent. Given the variability in meteorological conditions throughout the winter and from one winter to the next, it is impossible to exactly quantify the peak episodic expected improvement for any given period.

Photographic data taken during WHITEX indicated that airflow below the rim of the canyon could result in higher visibility impairment due to trapping of pollution. As a result, a new aerosol monitoring site at Indian Gardens (4000 feet below the rim of the canyon) was established after the WHITEX study. This site has provided information since 1988 which indicates confirms that the transport and conversion processes below the rim of the canyon are sometimes decoupled from the processes above the rim. ~~which were represented by~~ Both NGSVS and the NPS report on WHITEX used the Hopi Point site, which is above the rim of the Canyon, as the basis for determining the NGS impact on GCNP. ~~used for analyses in WHITEX and NGSVS.~~ Data submitted during the comment period show that visibility below the rim

is impaired more often and to a greater degree than is the visibility above the rim at Hopi Point.²⁸

Taking into account the conclusions from both studies as well as other monitoring information at GCNP from long-term monitoring, EPA expects that reducing SO₂ emissions from NGS to 0.10 lbs/MMBtu should improve the winter seasonal average visibility above the rim of the canyon approximately 7 percent. Analyses of peak in-canyon sulfate levels during winter inversion episodes also lead EPA to conclude that reductions in NGS SO₂ emissions may well contribute to greater than a 7 percent improvement in the seasonal average visibility below the rim of the canyon. However, EPA did not quantify the expected visibility improvement below the rim of the canyon due to the limited amount of data and understanding of the air transport mechanisms below the rim of the canyon.

F. Schedule of Compliance

As noted above, compliance with the emission limitation will be phased-in by unit on the following schedule:

- One unit by November 19, 1997
- Two units by November 19, 1998
- All units by August 19, 1999.

The phasing in of the emission limitation will allow NGS to initiate operation of the control systems one at a time.

²⁸See Docket A-89-02A, Items IV-D-164, IV-D-346, and IV-G-3.

To ensure that NGS complies with the emission limitation by the dates specified, EPA has established a schedule of compliance containing interim deadlines as follow:

Date of binding contract for Architectural/ Engineering firm to design and procure the control system needed for compliance.	6/92
Start of on-site construction of the control system for the first unit.	1/95
Initiation of start-up testing	
first unit	5/97
second unit	5/98
third unit	2/99

The Administrator may extend the interim deadlines if NGS can demonstrate that compliance with the final deadlines for compliance, stated above, will not be affected.

G. Maintenance Schedule

The final regulation provides that by March 16, 1993, and every March 16th thereafter, the NGS owner or operator will prepare a long-term maintenance plan for NGS that maximizes winter down-time while accommodating the maintenance requirements for the other generating facilities on the NGS grid. The plan will cover the period from March 16 to March 15 of the next year and must provide at least a full six unit-weeks of maintenance for NGS in the November 1 to March 15 period, except as provided below, to further

reduce SO₂ emissions during the winter. The plan will be developed consistent with the criteria established by the Western States Coordinating Council of the North American Electric Reliability Council to ensure adequate reserve margin. The full six unit-weeks of winter maintenance need not occur if any of the following circumstances arise:

1. There is no need for six unit-weeks of scheduled periodic maintenance in the March 16 - March 15 year covered by the plan.

2. The reserve margin on any electrical system served by NGS would fall to an inadequate level, as defined by the criteria referenced above. In such case, the scheduled maintenance may be moved out of the November 1 to March 15 period.

3. The cost of compliance with this provision would be excessive. Costs of compliance would be considered excessive when the economic savings to the participants of moving NGS' maintenance out of the November 1 to March 15 period exceeds \$50,000 per unit-day of maintenance moved.

4. A major forced outage at a unit occurs outside the winter months, and necessary periodic maintenance occurs during the period of forced outage.

The NGS owner or operator must demonstrate to the satisfaction of the Administrator that one or more of the events listed above render unnecessary or unreasonable a full six-unit weeks of scheduled maintenance during the

specified winter period. Where six unit-weeks of scheduled maintenance is unnecessary or unreasonable, the NGS owner or operator must nevertheless make best efforts to conduct as much scheduled maintenance as practicable during the winter period. If NGS does not conduct its scheduled winter maintenance (up to 6 unit-weeks) it must report to EPA why it did not do so.

When maintenance is being conducted on a unit, the unit will not be in operation and therefore not emitting SO₂. Thus, the shifting of NGS maintenance to the wintertime period will further reduce NGS SO₂ emissions during the period when NGS is suspected to have its greatest impact on the GCNP. Further, because the scheduled winter maintenance requirement will be implemented in the winter of 1993-1994 it will have the effect of making a degree of reasonable progress toward the national visibility goal before final compliance with the emission limitation is required. Because NGS must, for normal operation, conduct this maintenance, rescheduling it in the wintertime period should have little economic impact on NGS.

H. Air Quality Review

The installation and operation of a wet FGD control system at NGS (the proven available technology that EPA anticipates will be used) will lower the exhaust gas temperature from the stacks and could reduce the plume rise above the NGS stacks. The EPA and the Arizona Department of

Environmental Quality reviewed the need to reheat the exhaust gases to ensure appropriate plume rise with the lower gas exit temperatures associated with meeting a 0.10 lbs/MMBtu emission limitation using wet FGD and found that reheating of the exhaust gas will not be necessary to prevent a violation of any national ambient air quality standard. If the exhaust gas is not reheated the control cost will be reduced significantly.

If NGS were to select a wet FGD SO₂ control system, the water content of the plume would increase. Under certain conditions, a white steam plume will occur as the water vapors condenses before it dissipates. This steam plume may be visible near the stack. However, it will not cause any visibility impairment in GCNP or surrounding mandatory Class I Federal areas and will not interfere with the attainment of any national ambient air quality standards. Such steam plumes are not subject to any State or Federal visual emission standards or regulations.

RESPONSE TO COMMENTS

The September 5, 1989, February 8, 1991, and August 13, 1991 notices requested comment on a variety of issues relating to attribution of impairment, cost of controls, and the benefit expected from the controls. In addition, EPA held a public hearing on March 18 and 19, 1991 during which EPA received comments on its February 1991 proposal.

Under section 307(d) of the Act, today's action must be accompanied by a response to each of the significant comments, criticisms, and new data submitted in written or oral presentations during the comment period. The EPA has carried out this duty. Moreover, modifications to the proposed rule have been made in response to public comments. The EPA's final control strategy for NGS largely embodies public comments received from representatives of GCT, EDF and SRP which, in turn, were subject to public comment [see, e.g., 56 FR 38399 (August 13, 1991)]. Further, in its February 1991 proposal EPA requested comment on several control options including but not limited to the following rule elements and specific regulatory alternatives: (1) emission limitations, including limitations ranging between 0.50 and 0.10 lbs/MMBtu, (2) averaging times, including a 3-hour, 30-day, and annual averaging period, and (3) implementation schedules, including one providing for plant-wide compliance by the year 2000. As noted below, EPA received many comments in response to the February 1991 proposal supporting, in part, the control elements adopted by EPA, in total, today. For example, many citizens and representatives of environmental organizations submitted comments commented supporting a 0.10 lbs/MMBtu emission limitation, ~~that~~ the emission limitation adopted today. Many representatives of industry and business submitted

comments supporting an annual averaging period and a long compliance schedule.

During the initial public comment period EPA received over 400 comments, including the public hearing transcript. A summary of the significant comments, criticisms, and new data submitted in written or verbal presentations during the public comment period, and EPA's responses are provided below ~~and in supporting documents which Documents containing a more thorough listing of the comments, along with EPA's responses,~~ have been placed in Docket A-89-02A.^{29, 30}

During the supplemental comment period EPA received 13 additional comments. One commenter objected to requiring any additional pollution controls on NGS based on the information provided in the NGSVS. The other 12 commenters generally supported the adoption of a control strategy consistent with the MOU. One of these commenters expressed a concern about the exemptions from the winter scheduling of maintenance and a desire that the schedule for the installation and operation of controls be expedited.

The SRP, GCT, EDF, The Wilderness Society, National Wildlife Federation, and Sierra Club, have conditionally

²⁹JCM Environmental, "Summary of Public Comments, Proposed Revision to Arizona Visibility FIP for Navajo Generating Station" July 1991.

³⁰ See "Response to Public Comments, Proposed Revisions to Arizona Visibility FIP," U.S. EPA, September 1991.

withdrawn prior comments that are inconsistent with the August MOU entered by representatives of SRP, GCT and EDF and associated recommendations to the Agency. In light of this withdrawal, some of the comments discussed here and in the supplementary response to comments documents placed in the rulemaking docket are no longer pending before the Agency and, clearly, no longer "significant" within the meaning of section 307(d) of the Act. ~~Nevertheless,~~ The EPA has discussed them in order to help the public better understand today's action.

A. ~~Attribution and Source Impairment Relationship~~

The EPA received a large number of comments on its attribution of a portion of the visibility impairment in the GCNP to NGS. These comments expressed a variety of opinions including statements that EPA had already made an attribution decision and that EPA should not revisit that decision, that more than adequate information was available to make such a decision and that it is clear from the record that a portion of the visibility impairment in GCNP is attributable to NGS, that EPA should not make a decision to attribute the impairment to NGS until it developed a strong source-impairment relationship, and that EPA should not attribute the impairment to NGS since it is not the sole cause of the impairment in the GCNP. In its February 1991 proposal, EPA reopened its comment period on and explicitly requested public comment on its preliminary attribution

decision. Therefore, EPA's proposed attribution decision was subject to public comment. As explained earlier, EPA has reviewed the available technical data and analyses and has concluded that a portion of the visibility impairment in GCNP is reasonably attributable to NGS.

B. Source-Impairment Relationship

Once EPA attributed a portion of the impairment to NGS, it then had to develop a source-impairment relationship in order to estimate the expected improvements in visibility resulting from the installation of the controls. ~~The EPA has balanced the available information to establish a reasonable source impairment relationship for effects at Hopi Point. As explained earlier, NGS does not have to be the sole contributor to the impairment in order for EPA to take action under section 169A or the 1980 visibility regulations implementing section 169A.~~

In the February 1991 proposal, EPA provided calculations of the relationship between reductions in SO₂ emissions from NGS and the visibility at the GCNP. The calculations were based on the overall findings of the WHITEX report which used several techniques to apportion NGS's contribution to sulfates and the resulting haze at GCNP. The EPA calculated two measures of visibility improvements, one seasonal average change in standard visual range and the other a distribution of days where control of NGS would result in several levels of contrast changes. The

EPA received several comments that its calculations used to estimate the distribution of days when the reduction in SO₂ emissions from NGS would result in perceptible, quite noticeable, and very apparent change in contrast in GCNP were in error because the final contrast assessment did not take into account natural (Rayleigh) atmospheric scattering of light. The EPA agrees that these calculations did not take into account Rayleigh scattering. However, EPA's seasonal visual range estimates in the February 1991 proposal, did not include error as some commenters had alleged and is relied on in today's action.

The EPA has received new information during the comment period which has improved its understanding of the source-impairment relationship. Based on this and other available information EPA has refined the source-impairment relationship and concluded that it is as described in the Source-Impairment discussion in "Today's Action" above.

C. Emission Limitation

Individuals and groups that commented on the emission limitation generally requested that EPA adopt a requirement for the maximum level of control or no controls at all. No commenters supported the 50 percent control level. Some commenters supported an SRP proposal, now withdrawn, which called for a 70 percent level. Most commenters on the emission limitation supported a 90 or 95 percent control level. The commenters that did not support controls did so

because of the cost of the controls and/or the alleged lack of a strong demonstrated source-impairment relationship. As discussed ~~earlier~~, EPA believes that an adequate source-impairment relationship does exist for EPA to require NGS to control its emissions. The control strategy that EPA is promulgating today will provide a 90 percent reduction in the SO₂ emissions from NGS at a cost below that which would have been necessary to meet the control strategy EPA proposed in February 1991. Thus, the control strategy adopted by EPA satisfies both groups of commenters in that it will result in a greater emission reduction at a lower cost. Further, as noted previously, EPA must balance a number of factors in taking action today under section 169A. Such action must be balanced in light of EPA's statutory mandate set out in section 169A to make "reasonable progress" toward the national goal of "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory class I Federal areas which impairment results from manmade air pollution." EPA carefully has weighed, for example, the estimated cost of compliance with today's emission limitation and the visibility benefits expected to be realized and concluded that today's control strategy, taken together, is a reasonable exercise of its delegated rulemaking authority under section 169A.

D. Averaging Time

Several commenters supported a short (3 hour) averaging time stating that it would ensure that maximum visibility protection. Some of these comments have been withdrawn. Other commenters supported a longer (30 days to annual) averaging time stating that it would eliminate the need for expensive backup control equipment. The EPA adoption of the control strategy which includes an annual rolling average emission limitation will eliminate the need for the backup equipment. However, the control strategy also includes a stringent emission limitation and winter maintenance scheduling to ensure maximum visibility protection.

E. Compliance Schedule

Several commenters noted that section 169A of the Act requires that BART emission limitations be met within 5 years. Some of the commenters have since withdrawn these comments. Others commented that it was legally permissible for compliance with a BART emission limitation to extend beyond 5 years. In EPA's August 1991 notice reopening the comment period, EPA also published a memorandum from its Office of General Counsel that described the legal basis for the 1997, 1998, and 1999 compliance schedule adopted today. No adverse comments addressing the legal basis were received during the supplemental comment period. ~~In essence,~~ Therefore, as discussed in the August 1991 notice, EPA is relying principally on the reasonable progress requirements

of section 169A(b)(2). The requirements of that section, which encompasses both the long-term strategy and BART provisions, are met by today's action.

F. BART Guidelines

In the February 1991 proposal (56 FR 5178 col. 1) EPA requested comments on two potential revisions to the BART Guidelines. First, EPA requested comment on the continued use of the New Source Performance Standards as a base for the BART analysis. Second, EPA requested comment on whether it should include the consideration of the value of marketable allowances when estimating the cost of control systems. The EPA received several comments on both issues. However, in making its final determination on today's action neither of these issues were significant. Therefore, EPA is not making a final decision on whether to revise the BART Guideline at this time.

G. Cost of Controls

Several commenters alleged that EPA may have overestimated the economic impact of the controls. They also noted that costs are quite small when divided up among the various consumers. Other commenters alleged that the increase cost will have a significant impact on the consumers. The EPA has recalculated the cost of the controls of today's final action based upon the new information provided by SRP. Those numbers may be overestimates of the actual cost of control. Even if the

actual controls costs are consistent with SRP and EPA estimates, as noted, EPA has concluded that today's action achieves greater visibility benefit at less cost than EPA's February 1991 proposed option and, moreover, balancing the estimated costs, expected visibility improvement and other relevant factors EPA has concluded that the expected improvements in the visibility in the GCNP justify the estimated costs.

Several commenters noted that the recipients of Central Arizona Project (CAP) water face a greater price increase than electricity customers or will otherwise bear a significant economic hardship as a result of the control costs of today's action. As discussed in the Regulatory Flexibility Act (RFA) section below, EPA cannot estimate every potential indirect cost of today's action. Nevertheless, EPA carefully has considered the potential impacts of today's action on recipients of CAP water, including farmers receiving such water. The Central Arizona Water Conservation District submitted an estimate of a 7 percent to 10 percent increase in agricultural water rates, resulting in an increased water cost of nearly \$10,000 per year for a typical family farmer. The EPA estimates such an increase would be less than a 2 percent increase in the total variable costs of a typical farm. At the present time agricultural water in Arizona receives a substantial Federal subsidy. Current Federal policy calls for phasing out the

water subsidy. When the subsidy is eliminated, the impact of the increased cost at NGS will be an even smaller percentage of both total variable cost and total water cost. ~~As discussed elsewhere,~~ EPA has weighed and balanced the costs of today's action, the expected visibility improvement, and other requisite considerations and concluded that today's control strategy, taken together, constitutes a reasonable exercise of EPA's delegated rulemaking authority under section 169A of the Act. ~~In addition, a steam plume is not regulated under either State or Federal air pollution regulations.~~

H. Impacts on Other Class I Areas

Several commenters noted the impact of NGS on the other Class I areas in the region known as the "Golden Circle." Two of the commenters provided photographs and modeling to support their statements. The EPA agrees that NGS ~~could~~ ^{conU} contribute to the visibility impairment in those other areas, but, the data and modeling that was presented was not adequate for EPA to use in making a definitive determination on attribution of the impairment in those areas to NGS. However, the controls that are being required today will significantly reduce if not eliminate NGS's contribution to the visibility impairment in those areas.

I. Seasonal Controls

In the February 1991 proposal EPA requested comment on whether, as a policy matter, it should allow seasonal

controls at NGS and whether, if technically justified, seasonal controls would be legally permissible. Several commenters recommended that EPA adopt a control strategy for NGS that include seasonal controls and/or commented that seasonal controls could lawfully constitute an emission limitation representing BART under section 169A. The principal comments supporting seasonal controls were submitted by SRP and have been withdrawn. Several others commented that the technical record did not support seasonal controls and/or commented that as a legal matter seasonal controls could not constitute an emission limitation under section 169A. During the comment period the GCT and its consultants presented analyses, which are in the rulemaking docket, demonstrating that NGS's emissions may significantly impair visibility year-round at the GCNP as well as other class I areas in the region. For example, a simple transport and transformation model of NGS emissions over a five-year period indicated impacts at GCNP in seasons other than winter. While the degree of visibility impairment during these impacts is less than those documented by other studies during the winter period, the impacts are nevertheless strongly suggestive of attributable impairment in non-winter seasons. ~~Although the analyses were based on limited modeling, they demonstrated, for example,~~ Further, the analyses demonstrated that NGS emissions could impair visibility in surrounding class I areas between 60 and 80

suggested

percent of the time year-round. In light of NGS's impacts on GCNP in seasons other than winter, its potential year-round impacts on surrounding class I areas and other policy benefits associated with year-round controls, EPA has concluded that seasonal controls would not be appropriate in this case. Therefore, EPA need not determine whether such controls would be legally permissible.

J. Monetary Benefits

In the February 1991 proposal, EPA noted that it was not legally required to estimate the monetary benefits associated with improving visibility in the GCNP. However, as a check of the reasonableness of its approach, EPA evaluated and considered the benefit analysis developed as a part of the draft Regulatory Impact Analysis (RIA) for the proposed rule. The EPA requested comment on its monetary benefits analysis and a monetary benefits analysis conducted by SRP. Some commenters stated that EPA and SRP had underestimated the monetary benefits while others indicated that EPA's benefits were overstated. Considering all of the relevant information, including the comments received, EPA estimates that the monetary benefits of today's action will exceed the costs.

EDF v. Reilly

Today's action regarding NGS completes EPA's obligations under the settlement agreement in EDF v. Reilly,

No. C82-6850 (N.D. Cal.), and under the first round of SIP/FIP planning called for in the visibility regulations.

NONPRECEDENTIAL EFFECT OF THIS ACTION

Today's promulgation is limited to the rulemaking requiring an SO₂ emission limitation for NGS in order to remedy visibility impairment in the GCNP that is reasonably attributable to NGS. As such, it has no direct precedential effect on any other rulemaking action EPA might undertake in the future regarding other existing sources or Class I areas. This is so because the outcome of this rulemaking has been highly dependent upon facts and circumstances that are unique to this proceeding and thus may not be decisive for other cases. For example, the tracer studies and other analyses contained in the WHITEX and NGSVS reports that are keyed to a showing that impairment at GCNP is reasonably attributable to NGS are not necessarily determinative in any other rulemaking addressing other potential sources of visibility impairment. Should EPA or State agencies conduct visibility rulemakings regarding other Class I areas and other existing sources of pollution in the future, they will need to rely on attribution techniques appropriate for those other areas and sources in order to make reasoned regulatory decisions. They will not be able to rely solely on WHITEX or NGSVS findings that specifically address the GCNP and NGS to determine the existence of impairment that is reasonably attributable to any such other source. Likewise, neither

the methodology used for establishing the expected improvement in visibility that could be anticipated to result from use of alternative SO₂ control systems nor the final emission limit being promulgating today will ~~not~~ have direct precedential effect elsewhere. The statutory requirement that EPA weigh various factors before reaching a decision is by nature a case-specific process.

Classification

Executive Order No. 12291 requires each Federal agency to determine if a regulation is a "major" rule as defined by the order and "to the extent permitted by law," to prepare and consider an RIA in connection with every major rule.

Major rules are defined as those likely to result in:

1. an annual effect on the economy of \$100 million or more; or
2. a major increase in costs or prices for consumers or individual industries; Federal, State, or local government agencies; or geographic region; or
3. significant adverse effects on competition, employment, investment, productivity, innovation, or the ability of the United States-based enterprises to compete with foreign-based enterprises in domestic or export markets.

The EPA judged the February 1991 proposed regulation for NGS to be a major rule based on projected annualized costs potentially in excess of \$100 million. The EPA then

prepared a preliminary RIA that included estimates of costs, benefits, and net benefits for three control options. The preliminary analysis, titled "Regulatory Impact Analysis of a Revision of the Federal Implementation Plan for the State of Arizona to Include SO₂ Controls for the Navajo Generating Station," and an addendum, titled "Addendum to the Regulatory Impact Analysis of a Revision of the Federal Implementation Plan for the State of Arizona to Include SO₂ Controls for the Navajo Generating Station" are available in Docket A-89-02A.

In light of the reduced estimated cost of this rule, the Office of Management and Budget (OMB) has exempted this action from the RIA requirements. Therefore, EPA did not finalize the preliminary RIA.

Paperwork Reduction Act

This rule will impose a modest reporting burden on the participants of the NGS to enable EPA to ensure compliance with the emission limits. Because the reporting burden affects only a single source, it is not subject to OMB review under the Paperwork Reduction Act.

Section 317(c) Economic Impact Assessment

This action is taken pursuant to sections 169A and 110(c) of the Act, and a section 317(c) economic impact assessment may not be required. However, all of the analytical requirements of section 317(c) have been met. The section 317(c)(1) analysis of alternative regulations,

and the impact of varying the effective date, are essential considerations in promulgating this revision to the FIP for Arizona. Each of the section 317(c) requirements are included in the BART analysis prepared by EPA. Portions of the economic impact assessment are revised in this notice based on additional information and comments provided to EPA.

Regulatory Flexibility Act

Under the RFA, 5 U.S.C. §§601-612, EPA must prepare for rules subject to notice and comment rulemaking initial and final regulatory flexibility analyses describing the impact on small entities, which include small businesses, small not-for-profit enterprises, and governmental entities with jurisdiction over populations of less than 50,000. The requirement of preparing such ~~an analysis is waived~~ is inapplicable, however, if the Administrator certifies that the rule will not have a significant economic impact on a substantial number of small entities [see 5 U.S.C. §605(b)].

In the February 1991 proposal, the Administrator certified that the proposed rule would not have a significant impact on a substantial number of small entities because none of the participants of NGS are classified as small according to the guidelines developed by the Small Business Administration. Moreover, EPA estimated that for all of the electric utilities using NGS power, the impact on

electric utility rates would be substantially less than 5 percent.

Similarly, the emission limitation being established today does not have a direct impact on and will not apply to a substantial number of small entities because none of the participants of NGS subject to today's action are classified as small according to the guidelines developed by the Small Business Administration. Further, during the comment period on the February 1991 proposal and the August 1991 supplemental notice, SRP, NPC and the Central Arizona Water Conservation District (CAWCD) submitted comments indicating that the potential indirect costs that may be passed on to customers of the NGS participants were less than those estimated by EPA.

The comments on potential indirect costs incurred by rate payers submitted by SRP, NPC, CAWCD, and others do not address the costs incurred directly by the NGS participants, the entities that are subject to and directly impacted by today's action and that do not qualify as "small." Further, except for the general comments submitted by the Bureau of Reclamation, the comments do not address EPA's conclusion under the RFA that the proposed rule would not have a significant economic impact on a substantial number of small entities. Before discussing the comments, EPA notes that it cannot and is not legally required to foresee all of the indirect impacts associated with today's action. The EPA

cannot anticipate how the NGS participants will seek to pay for the costs associated with today's action, the decisions that public utility commissions will confront and make, etc. Nevertheless, EPA has considered and attempted to respond to those comments addressing indirect costs impacting potential small entities in order to explain more fully for the public the Administrator's finding under the RFA that today's final rule will not have a significant impact on a substantial number of small entities.

In the draft RIA, EPA estimated a \$92 million per year control cost would increase SRP's and NPC's electric rates by a maximum of 3.1 percent and 4.4 percent, respectively.³¹ The EPA estimated that of the six utilities receiving power from NGS, these two would experience the greatest electric rate increases if power generation costs were passed through completely to consumers because both SRP and NPC rely on 25 percent of Navajo NGS electricity for their total sales and each has a low average cost/kWh relative to the other four participants. Further, EPA estimated that these percentage estimates likely were overestimates due to various dampening effects omitted from the calculation.

³¹ See generally Draft Regulatory Impact Analysis of a Revision of the Federal Implementation Plan for the State of Arizona to Include SO₂ Controls for the Navajo Generating Station.

The NPC submitted comments on EPA's February 1991 proposal in which it estimated that the control costs would result in a 2.27 percent increase for its residential customers. The SRP also submitted comments on the February 1991 proposal in which it estimated that a control strategy costing \$90 million would result in a 2.1 percent to 2.5 percent increase to its rate payers. These estimated increases are less than the 5 percent impact estimated in EPA's February 1991 proposal. Further, these costs may be overestimated in that, for example, today's control option is cheaper than that advanced in the February 1991 proposal. In addition, the sale of SO₂ allowances under the SO₂ allowance trading program established by EPA under Title IV of the Act may mitigate costs.

In the draft RIA for the February 1991 proposal, EPA also estimated the economic impact on CAP water users. The EPA estimated an 18 percent increase in water costs for farmers receiving agricultural water from the CAP. This estimate translated into a \$11/acre-foot increase (3 cents per 1000 gallons of water), raising total annual variable costs for a 800-900 acre farm (the size of the average farm served by CAP) by 3-4 percent per year (\$22,000/year). The EPA further explained why these costs were anticipated to be overestimates and how the costs compared with unsubsidized non-CAP water.

At the public hearing on the February 1991 proposal, a member of the Board of Directors of the CAWCD testified that their analysis concluded the NGS control costs would result in a \$4.50 per acre-foot increase in CAP water, less than EPA's \$11 estimate. The CAWCD further testified that the \$4.50/acre-foot would translate into an annual cost increase of \$7200 for the average farmer irrigating 800 acres. In comments dated September 6, 1991, addressing the proposal identified in EPA's August 1991 supplemental notice, CAWCD generally commented that the control costs will add 7 percent to 10 percent to the annual costs of its water delivery and, in turn, additional costs of nearly \$10,000 per year for CAP water for a typical farmer, costs of approximately \$3 million annually on all of its municipal water suppliers taken together, and a \$1.5 million annual increase on Indian Tribes.

As evident, the CAWCD cost figures are inconsistent in that testimony at the public hearing and the written text accompanying that testimony estimated an annual impact of \$7200 on the average farmer and comments dated September 6, 1991 estimated that costs would be "nearly \$10,000 per year." The inconsistency is further perplexing in that the option advanced in the August 1991 notice was less expensive than that identified in the February 1991 proposal. Because CAWCD's comments on costs are general and undocumented, EPA cannot check their derivation. In any case, both cost

figures are less than half of that identified in EPA's draft RIA. The EPA estimates that the \$7200 and \$10,000 cost figures submitted by CAWCD would translate into a 1 percent to 2 percent increase in total variable costs for the average farmer. The EPA has no reason to believe that the percentage increase in costs of water for municipal suppliers or Indian Tribes will be substantially different from the economic impact on farmers purchasing CAP water. Further, as noted above, the owner of NGS may substantially mitigate the costs of today's action by selling SO₂ allowances. This, in turn, should curb any indirect costs incurred.

Finally, in commenting on EPA's February 1991 proposal, the Bureau of Reclamation (the Bureau) generally commented on EPA's conclusion that an initial RFA was unnecessary by noting that testimony at the public hearing provided evidence of adverse impacts on small businesses, farmers, governmental entities and Indian Tribes. In its only example of cost impacts, the Bureau commented that the agricultural customers of the CAWCD could experience increases in their water rates of approximately \$10 per acre-foot which, they commented, would result in a 16 percent increase in annual costs for CAWCD's large customers.

The Bureau's comments that agricultural customers of CAWCD could experience increases in water rates of

approximately \$10 per acre-foot are inconsistent with CAWCD's own comments which suggested an impact of approximately \$4.50 per acre-foot and, further, were not substantiated. In addition, the Bureau's \$10 per acre-foot estimate is lower than EPA's more conservative estimate. ~~DOE's~~ The Bureau's comments also were based on the February 1991 option which, as noted, is more costly than today's final action. Based on the CAWCD comments, EPA estimates that today's action will result in less than a 2 percent increase in the total variable costs for the average CAWCD farmer.

As noted, EPA has estimated the cost impacts on the residential customers of SRP and NPC. Residential customers are usually the category of consumers bearing the greatest impact in cost increases because most utility rate structures typically charge incrementally less for the more power that is consumed. Further, as noted, EPA expects the impacts on the residential customers of NPC to be higher than any other customers of the NGS participants. Thus, EPA's estimate of the impact on NPC residential customers serves as a worst-case check on the potential electricity rate impacts on other potential customers. The impact on all potential small entities, including school districts, local governments, business establishments, not-for-profit enterprises, etc., should be similar or smaller. Thus, not only were the Bureau's general claims about potential

impacts on small entities undocumented, EPA believes its consideration of the impacts on residential rate payers affords a reasonable check of the potential impacts on other NGS electricity customers.

Accordingly, for all of the reasons stated, I hereby certify that the regulation being promulgated today will not have a significant economic impact on a substantial number of small entities.

Interagency Review

This final rule was submitted to the Office of Management and Budget (OMB) for review. Drafts submitted to OMB for review, written comments on these drafts by OMB or other agencies and EPA's written responses to such comments have been placed in the rulemaking docket.

List of Subjects in 40 CFR Part 52

Air pollution control, Nitrogen dioxide, Particulate matter, Carbon monoxide, Ozone, Lead, Sulfur oxides, Reporting and recordkeeping requirements.

Date

Administrator

1. The authority for Part 52 continues to read as follows: Authority: 42 U.S.C. 7401-7642.

2. Section 52.145 is amended by adding paragraph (d) to read as follows:

Section 52.145 Visibility Protection

* * * * *

"(d) This paragraph is applicable to the fossil fuel-fired, steam-generating equipment designated as Units 1, 2, and 3 at the Navajo Generating Station in the Northern Arizona Intrastate Air Quality Control Region (§81.270 of this chapter).

(1) Definitions

"Affected Unit(s)" means the steam generating unit(s) at the Navajo Generating Station, all of which are subject to the emission limitation in paragraph (d)(2) below, that has accumulated at least 365 boiler operating days since the passage of the date defined in paragraph (d)(6) below applicable to it.

"Administrator" means the Administrator of EPA or his/her designee.

"Boiler Operating Day" for each of the boiler units at the Navajo Generating Station is as defined as a 24-hour calendar day (the period of time between 12:01 AM and 12:00 midnight in Page, Arizona) during which coal is combusted in that unit for the entire 24 hours.

"Owner or Operator" means the owner, participant in, or operator of the Navajo Generating Station to which this paragraph is applicable.

"Unit-Week of Maintenance" means a period of 7 days during which a fossil fuel-fired steam generating unit is under repair and no coal is combusted in the unit.

(2) Emission Limitation. No owner or operator shall discharge or cause the discharge of sulfur oxides into the atmosphere in excess of 42 ng/J [0.10 pounds per million British thermal units (lbs/MMBtu)] heat input.

(3) Compliance Determination. Until at least one unit qualifies as an affected unit no compliance determination is appropriate. As each unit qualifies for treatment as an affected unit it shall be included in the compliance determination. Compliance with this emission limit shall be determined daily on a plant-wide rolling annual basis as follows:

(i) For each boiler operating day at each steam generating unit subject to the emission limitation in paragraph (d)(2) above, the owner or operator shall record the unit's hourly SO₂ emissions using the data from the continuous emission monitoring systems, (required in paragraph (d)(4) below) and the daily electric energy generated by the unit (in megawatt-hours) as measured by the megawatt-hour meter for the unit.

(ii) Compute the average daily SO₂ emission rate in ng/J (lbs/MMBtu) following the procedures set out in method 19, Appendix A, 40 CFR Part 60 in effect on [date of publication].

(iii) For each boiler operating day for each affected unit calculate the product of the daily SO₂ emission rate (computed according to ii above) and the daily electric energy generated (recorded according to i above) for each unit.

(iv) For each affected unit identify the previous 365 boiler operating days to be used in the compliance determination. Except as provided in paragraphs (d)(9) and (d)(10) below, all of the immediately preceding 365 boiler operating days will be used for compliance determinations.

(v) Sum, for all affected units, the products of the daily SO₂ emission rate-electric energy generated (as calculated according to ii above) for the boiler operating days identified in iii above.

(vi) Sum, for all affected units, the daily electric energy generated (recorded according to i above) for the boiler operating days identified in iii above.

(vii) Calculate the weighted plant-wide annual average SO₂ emission rate by dividing the sum of the products determined according to iv above by the sum of the electric energy generated determined according to v above.

(viii) The weighted plant-wide annual average SO₂ emission rate shall be used to determine compliance with the emission limitation in paragraph (d)(2) above.

(4) Continuous Emission Monitoring. The owner or operator shall install, maintain, and operate continuous emission monitoring systems to determine compliance with the emission limitation in paragraph (d)(2) as calculated in paragraph (d)(3) above. This equipment shall meet the specifications in Appendix B of 40 CFR Part 60 in effect on [date of publication]. The owner or operator shall comply with the quality assurance procedures for continuous emission monitoring systems found in Appendix F of 40 CFR Part 60 in effect on [date of publication].

(5) Reporting Requirements. For each steam generating unit subject to the emission limitation in paragraph (d)(2) above, the owner or operator:

(i) shall furnish the Administrator written notification of the SO₂, oxygen and carbon dioxide emissions according to the procedures found in 40 CFR §60.7 in effect on [date of publication].

(ii) shall furnish the Administrator written notification of the daily electric energy generated in megawatt-hours.

(iii) shall maintain records according to the procedures in 40 CFR §60.7 in effect on [date of publication].

(iv) shall notify the Administrator by telephone or in writing within one business day of any outage of the control system needed for compliance with the emission limitation in paragraph (d)(2) above and shall submit a follow-up written report within 30 days of the repairs stating how the repairs were accomplished and justifying the amount of time taken for the repairs.

(6) Compliance Dates. The requirements of this paragraph shall be applicable to one unit at the Navajo Generating Station beginning November 19, 1997, to two units beginning November 19, 1998, and to all units beginning on August 19, 1999.

(7) Schedule of Compliance. The owner or operator shall take the following actions by the dates specified:

(i) By June 1, 1992, award binding contracts to an architectural and engineering firm to design and procure the control system needed for compliance with the emission limitation in paragraph (D)(2) above.

(ii) By January 1, 1995, initiate on-site construction or installation of control system for the first unit.

(iii) By May 1, 1997 initiate start-up testing of the control system for the first unit.

(iv) By May 1, 1998 initiate start-up testing of the control system for the second unit.

(v) By February 1, 1999 initiate start-up testing of the control system for the third unit.

The interim deadlines will be extended if the ~~participants~~ ~~owner~~ or operators can demonstrate to the Administrator that compliance with the deadlines in paragraph (D)(6) above will not be affected.

(8) Reporting on Compliance Schedule. Within 30 days after the specified date for each deadline in the schedule of compliance (paragraph (D)(7) above), the owner or operator shall in writing notify the Administrator whether the deadline was met. If it was not met the notice shall include an explanation why it was not met and the steps which shall be taken to ensure future deadlines will be met.

(9) Exclusion for Equipment Failure during Initial Operation. For each unit, in determining compliance for the first year that such unit is required to meet the emission limitation in paragraph (D)(2) above, periods during which one of the following conditions are met shall be excluded:

(i) Equipment or systems do not meet designer's or manufacturer's performance expectations.

(ii) Field installation including engineering or construction precludes equipment or systems from performing as designed.

The periods to be excluded shall be determined by the Administrator based on the periodic reports of compliance with the emission limitation in paragraph (d)(2) above which shall identify the times proposed for exclusion and provide the reasons for the exclusion, including the reasons for the

control system outage. The report also shall describe the actions taken to avoid the outage, to minimize its duration, and to reduce SO₂ emissions at the plant to the extent practicable while the control system was not fully operational. Whenever the time to be excluded exceeds a cumulative total of 30 days for any control system for any affected unit, the owner or operators shall submit a report within 15 days addressing the history of and prognosis for the performance of the control system.

(10) Exclusion for Catastrophic Failure. In addition to the exclusion of periods allowed in paragraph (d)(9) above, any periods of emissions from an affected unit for which the Administrator finds that the control equipment or system for such unit is out of service because of catastrophic failure of the control system which occurred for reasons beyond the control of the owner or operators and could not have been prevented by good engineering practices will be excluded from the compliance determination. Events which are the consequence of lack of appropriate maintenance or of intentional or negligent conduct or omissions of the owner or operators or the control system design, construction, or operating contractors do not constitute catastrophic failure.

(11) Equipment Operation. The owner or operator shall optimally operate all equipment or systems needed to comply with the requirements of this paragraph consistent with good

engineering practices to keep emissions at or below the emission limitation in paragraph (d)(2) above; and following outages of any control equipment or systems the control equipment or system will be returned to full operation as expeditiously as practicable.

(12) Maintenance Scheduling. On March 16 each year starting in 1993, the owner or operator shall prepare and submit to the Administrator a long-term maintenance plan for the Navajo Generating Station, which accommodates the maintenance requirements for the other generating facilities on the Navajo Generating Station grid, covering the period from March 16 to March 15 of the next year and showing at least 6 unit-weeks of maintenance for the Navajo Generating Station during the November 1 to March 15 period, except as provided in paragraph (d)(13) below. This plan shall be developed consistent with the criteria established by the Western States Coordinating Council of the North American Electric Reliability Council to ensure an adequate reserve margin of electric generating capacity. At the time that a plan is transmitted to the Administrator, the owner or operator shall notify, in writing, the Administrator if less than the full scheduled unit-weeks of maintenance were conducted for the period covered by the previous plan and shall furnish a written reporting stating how that year qualified for one of the exceptions identified in paragraph (d)(13) below.

(13) Exceptions for Maintenance Scheduling. The owner or operator shall conduct a full 6 unit-weeks of maintenance in accordance with the plan required in paragraph (d)(12) above unless the owner or operator can demonstrate to the satisfaction of the Administrator that a full 6 unit-weeks of maintenance during the November 1 to March 15 period should not be required because of the following:

(i) There is no need for 6 unit-weeks of scheduled periodic maintenance in the year covered by the plan;

(ii) The reserve margin on any electrical system served by the Navajo Generating Station would fall to an inadequate level, as defined by the criteria referred to in paragraph (d)(12) above;

(iii) The cost of compliance with this requirement would be excessive. The cost of compliance would be excessive when the economic savings to the owner or operator of moving maintenance out of the November 1 to March 15 period exceeds \$50,000 per unit-day of maintenance moved; or

(vi) A major forced outage at a unit occurs outside of the November 1 to March 15 period, and necessary periodic maintenance occurs during the period of forced outage.

If the Administrator determines that a full 6 unit-weeks of maintenance during the November 1 to March 15 period should not be required, the owner or operator shall nevertheless conduct that amount of scheduled maintenance that is not precluded by the Administrator. Generally, the

owner or operator shall make best efforts to conduct as much scheduled maintenance as practicable during the November 1 to March 15 period.

Board on Atmospheric Sciences and Climate

JOHN A. DUTTON, *Chairman*, Pennsylvania State University, University
Park

JON F. BARTHOLIC, Michigan State University, East Lansing

RAFAEL L. BRAS, Massachusetts Institute of Technology, Cambridge

MOUSTAFA T. CHAHINE, California Institute of Technology, Pasadena

ROBERT A. DUCE, University of Rhode Island, Narragansett

MICHAEL H. GLANTZ, National Center for Atmospheric Research, Boulder

THOMAS E. GRAEDEL, AT&T Bell Laboratories, Murray Hill, NJ

DAVID D. HOUGHTON, University of Wisconsin, Madison

RICHARD G. JOHNSON, Los Altos, CA

EUGENIA KALNAY, National Meteorological Center, Washington, D.C.

SYUKURO MANABE, Princeton University, Princeton

GERALD R. NORTH, Texas A&M University, College Station

JAMES J. O'BRIEN, Florida State University, Tallahassee

Ex-Officio Members

ROBERT DICKINSON, National Center for Atmospheric Research, Boulder

ROBERT E. SIEVERS, University of Colorado, Boulder

PETER S. RAY, Florida State University, Tallahassee

DONALD J. WILLIAMS, John Hopkins University, Laurel, MD

Commission on Geosciences, Environment, and Resources*

M. GORDON WOLMAN (*Chairman*), The Johns Hopkins University
ROBERT C. BEARDSLEY, Woods Hole Oceanographic Institution
B. CLARK BURCHFIEL, Massachusetts Institute of Technology, Cambridge
RALPH J. CICERONE, University of California, Irvine
PETER S. EAGLESON, Massachusetts Institute of Technology, Cambridge
GENE E. LIKENS, New York Botanical Gardens, Millbrook
SCOTT M. MATHESON, Parsons, Behle & Latimer, Salt Lake City
JACK E. OLIVER, Cornell University, Ithaca
PHILIP A. PALMER, E.I. du Pont de Nemours & Co., Newark, DE
FRANK L. PARKER, Vanderbilt University, Nashville
DUNCAN T. PATTEN, Arizona State University, Tempe
MAXINE L. SAVITZ, Allied Signal Aerospace, Torrance, CA
LARRY L. SMARR, University of Illinois at Urbana-Champaign, Champaign
STEVEN M. STANLEY, Case Western Reserve University, Cleveland
SIR CRISPIN TICKELL, United Kingdom Mission to the United Nations
KARL K. TUREKIAN, Yale University, New Haven
IRVIN L. WHITE, New York State Energy Research and Development
Authority, Albany
JAMES H. ZUMBERGE, University of Southern California, Los Angeles

Staff

STEPHEN RATTIEN, Executive Director
STEPHEN D. PARKER, Associate Executive Director
JANICE E. GREENE, Assistant Executive Director
JEANETTE A. SPOON, Financial Officer

* This study was begun under the Commission on Physical Sciences, Mathematics, and Resources, whose members are listed in Appendix 4, and completed under the successor Commission on Geosciences, Environment, and Resources.

Board on Environmental Studies and Toxicology

GILBERT S. OMENN (*Chairman*), University of Washington, Seattle
FREDERICK R. ANDERSON, Washington School of Law, American University
JOHN C. BAILAR, III, McGill University School of Medicine, Montreal
LAWRENCE W. BARNHOUSE, Oak Ridge National Laboratory, Oak Ridge
GARRY D. BREWER, Yale University, New Haven
JOANNA BURGER, Nelson Laboratory, Rutgers University, Piscataway, NJ
YORAM COHEN, University of California, Los Angeles
JOHN L. EMMERSON, Lilly Research Laboratories, Greenfield, IN
ROBERT L. HARNESS, Monsanto Agricultural Company, St. Louis
ALFRED G. KNUDSON, Fox Chase Cancer Center, Philadelphia
GENE E. LIKENS, The New York Botanical Garden, Millbrook
PAUL J. LIOY, UMDNJ-Robert Wood Johnson Medical School, Piscataway
JANE LUBCHENCO, Oregon State University, Corvallis
DONALD MATTISON, University of Pittsburgh, Pittsburgh
NATHANIEL REED, Hobe Sound, FL
F. SHERWOOD ROWLAND, University of California, Irvine
MILTON RUSSELL, University of Tennessee, Knoxville
MARGARET M. SEMINARIO, AFL/CIO, Washington, DC
I. GLENN SIPES, University of Arizona, Tucson
WALTER J. WEBER, JR., University of Michigan, Ann Arbor

Staff

JAMES J. REISA, Director
DAVID J. POLICANSKY, Program Director for Natural Resources
and Applied Ecology
ROBERT B. SMYTHE, Program Director for Exposure Assessment
and Risk Reduction
RICHARD D. THOMAS, Program Director for Human Toxicology
and Risk Assessment
LEE R. PAULSON, Manager, Toxicology Information Center

Preface

Many delightful experiences can be enjoyed in our nation's numerous national parks and wilderness areas, but among the finest are the beautiful views of nature found in these locations. Particularly spectacular are the often distant and majestic scenes of mountains, deserts, plains, and ocean. Our concern for maintaining the clarity of views in these areas is reflected in the Clean Air Act, which specifically addresses the protection of visibility in our national parks and wilderness areas. Early in 1990, the National Research Council (NRC) established the Committee on Haze in National Parks and Wilderness Areas to address issues related to visibility degradation in these protected regions. In particular, the committee was asked to consider the relative importance of human-derived and natural emissions that contribute to visibility reduction in these locations and to evaluate possible source-control approaches. As part of its charge, the committee was also asked to evaluate a recent scientific study by the National Park Service (NPS) of visibility degradation and its causes in one of our most beautiful national parks, Grand Canyon. This publication is the committee's evaluation of the NPS report on the Winter Haze Intensive Tracer Experiment (WHITEX) and its conclusion that the Navajo Generating Station (NGS) contributed to wintertime visibility impairment in Grand Canyon National Park during the study.

The committee's task was not an easy one. Source apportionment is a rather inexact but very complex component of the atmospheric sciences. New techniques and approaches are constantly being designed and tested, and personal judgment and experience often play significant roles in evaluation processes. However, I have never worked with a committee more dedicated to the development of a fair, objective, and honest evaluation of what has become a controversial issue. Everyone involved in this NRC project, including the sponsoring organizations, cooperated in every way possible.

The committee met at Grand Canyon National Park from March 28-31, 1990. We were provided with extensive written and oral information by feder-

al personnel and other project sponsors, including the National Park Service, the Bureau of Reclamation, the Department of the Interior's Office of Environmental Quality, the Department of Energy, the Environmental Protection Agency, the Forest Service, and the Arizona Salt River Project (operators of NGS) and their consultants. We were also given an extensive tour of the NGS and of the atmospheric monitoring station at Hopi Point in Grand Canyon National Park. After this meeting, the federal liaison group—representing the sponsoring agencies—and the Arizona Salt River Project continued to provide the committee with information promptly whenever it was requested. This was greatly appreciated. In addition to the committee's formal meetings, committee members and NRC staff spent many hours in conference calls and in individual conversations.

The committee's heartfelt thanks must go to the NRC staff who devoted themselves so thoroughly to this report. Dr. James J. Reisa, the director of the Board on Environmental Studies and Toxicology, and Dr. Robert Smythe, the program director, provided us with guidance, perspective, and oversight. The project director, Kathleen J. Daniel, worked closely with committee members through all phases of the report preparation. Her enthusiasm, knowledge of the field, sense of humor, commitment to a quality report, and true concern about the issues being addressed played a major role in the committee's efforts, and in particular, in our development of a consensus on this controversial issue. We also thank staff member Raymond Wassel, who contributed significantly to the committee's efforts, and Felita Buckner, Boyce Agnew, and Sandi Fitzpatrick, who worked closely and effectively with the committee throughout report preparation and production. Finally, Lee Paulson took our often-tangled prose and provided clear renditions and editorial revisions.

The committee hopes this report will provide useful suggestions and guidance as the nation continues efforts to protect and preserve the natural visibility in our national parks and wilderness areas for ourselves and future generations.

Robert A. Duce
Chairman
October 3, 1990

Contents

EXECUTIVE SUMMARY	1
BACKGROUND	9
THE NRC COMMITTEE STUDY	15
The Committee, Its Charge, and Its Approach, 15	
The Committee's Specific Interpretation of Its Charge, 16	
EVALUATION OF WHITEX	16
WHITEX Overview, 16	
WHITEX Source-Attribution Models, 18	
Critical Aspects of WHITEX Techniques and Design, 19	
Qualitative Assessment, 19	
Quantitative Assessment, 23	
Limitations of the WHITEX Study, 24	
Weaknesses in the Data Base, 24	
Departures from Statistical Assumptions, 25	
Formulation of Statistical Models, 26	
Simplifications in the DMB Model, 31	
Potential Covariance of NGS and Other Source Contributions, 32	
Estimates of the Range of Possible Impacts of NGS Emissions at Hopi Point, 33	
THE COMMITTEE'S CONCLUSIONS IN PERSPECTIVE	37
CONCLUSIONS	37
REFERENCES	39

x ■ CONTENTS

APPENDIX 1: NATURE OF THE VISIBILITY PROBLEM	43
APPENDIX 2: SELECTED PAGES FROM THE NPS- WHITEX REPORT	45
APPENDIX 3: CD₄ AS AN AIR-MASS TRACER	95
APPENDIX 4: COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND RESOURCES	97

Executive Summary

BACKGROUND

The Grand Canyon is one of the most spectacular natural sights on earth. Approximately 4 million visitors travel to Grand Canyon National Park (GCNP) each year to enjoy its majestic geological formations and intensely colored views. However, visibility in GCNP can be impaired by small increases in concentrations of fine suspended particles that scatter and absorb light; the resulting visibility degradation is perceived as haze. Sulfate (SO_4^{2-}) particles—largely the result of the atmospheric transformation of sulfur dioxide (SO_2) emissions from anthropogenic sources—are a major factor in visibility impairment at Grand Canyon in summer and winter.

Many wintertime hazes at GCNP are believed to result from the accumulation of emissions from local sources during conditions of air stagnation, which occur more frequently in winter than in summer. In January and February 1987, the National Park Service (NPS)—the managing agency for the GCNP—carried out a large-scale experiment known as the Winter Haze Intensive Tracer Experiment (WHITEX) to investigate the causes of wintertime haze in the region of GCNP and Canyonlands National Park. The overall objective of WHITEX was to assess the feasibility of attributing visibility impairment in specific geographic regions to emissions from a single point source. The experiment called for the injection of a tracer, deuterated methane (CD_4), into one of the stacks of the Navajo Generating Station (NGS), a major coal-fired power plant located 25 km from the GCNP boundary and 110 km northeast of Grand Canyon Village. A network of field stations was established in the vicinity—mostly to the northeast of GCNP and NGS—to measure CD_4 concentrations, atmospheric aerosol and optical properties, and other chemical and physical attributes.

During some haze episodes, significant concentrations of CD_4 were detected at the Hopi Point sampling station on the south rim of the Grand Canyon

near Grand Canyon Village to the southwest of NGS. The NPS analyzed data from WHITEX and recently issued a final report concluding that NGS contributed to wintertime visibility impairment in the GCNP during the study period. The report asserted that NGS was responsible for approximately 70% of the mean particulate SO_4^{2-} and approximately 40% of the mean aerosol-related light extinction for selected wintertime periods of haze at the Hopi Point sampling station. In response to the NPS-WHITEX report, the U.S. Environmental Protection Agency (EPA) published a proposal to attribute visibility impairment in the GCNP to NGS and took steps to propose that the level of allowable SO_2 emissions from NGS be reduced by 90%.

THE NATIONAL RESEARCH COUNCIL STUDY

This evaluation of WHITEX was prepared by the Committee on Haze in National Parks and Wilderness Areas, which was convened in February 1990 by the National Research Council's Board on Environmental Studies and Toxicology in collaboration with the Board on Atmospheric Sciences and Climate of the Commission on Geosciences, Environment, and Resources. The committee comprises members appointed for their expertise in meteorology, atmospheric chemistry, atmospheric aerosols, air pollution monitoring and modeling, statistics, environmental engineering, control technology, and environmental law and public policy.

The committee's overall charge is (1) to develop working principles for assessing the relative importance of anthropogenic emission sources that contribute to haze in Class I areas (which include many national parks and wilderness areas) and for assessing alternative source control measures and (2) to recommend strategies for improving scientific understanding and technical information on relative source contributions to haze formation, regional and seasonal factors affecting haze, relevant air quality models, and various emission control measures. The committee's work is sponsored by the U.S. Department of the Interior (National Park Service, Bureau of Reclamation, and Office of Environmental Quality), the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Arizona Salt River Project (SRP). The committee's final report, which will address this charge, will be issued in 1991.

In addition to the final report, the committee was also asked to provide this special report evaluating WHITEX, the recent site-specific study conducted by NPS. This report evaluates the scientific evidence relevant to EPA's recently proposed finding that NGS contributes to "impairment of visibility" in GCNP. Specifically, the committee was asked to review NPS data and analyses upon

which the EPA determination was based and other data and analyses related to source attribution for Grand Canyon haze. It was also asked to evaluate the contribution of the WHITEX study toward the science of source apportionment. The committee reviewed the December 1989 NPS-WHITEX report, other relevant published materials, and some unpublished information. In March 1990, the committee conducted site visits to the GCNP and NGS near Page, Arizona, and heard technical presentations from NPS, SRP, and their scientific consultants. This information was used as part of the basis for the committee's evaluation.

The committee based its evaluation solely on the scientific aspects of WHITEX. It did not consider whether or how EPA should regulate NGS.

QUALITATIVE ASSESSMENT

On the basis of the data presented in the NPS-WHITEX report, the committee concludes that, at some times during the study period, NGS contributed significantly to haze in GCNP. The committee bases this assessment on evaluations of meteorological, photographic, chemical, and other physical evidence. The committee's conclusion is supported by the following qualitative evidence: (1) the haze episodes (periods when visibility was particularly poor) observed during WHITEX occurred under conditions of air stagnation, when sulfur from local sources would be expected to accumulate; (2) SO_4^{2-} aerosol was a significant contributor to haze at Hopi Point during periods when visibility was particularly poor and when CD_4 was detected; (3) NGS is a large source of SO_2 emissions near GCNP and it could potentially account for the total sulfur (SO_2 and SO_4^{2-}) observed at Hopi Point during some haze episodes; (4) meteorological analyses and photography indicate air movement from NGS to GCNP during some haze episodes; (5) significant quantities of CD_4 released from NGS were observed at Hopi Point; and (6) the presence of clouds and fog in the vicinity of GCNP and NGS during haze episodes would accelerate the conversion of NGS SO_2 to form SO_4^{2-} aerosol.

The detection of CD_4 at Hopi Point is an unambiguous indicator that air parcels containing NGS emissions did impinge on the GCNP on several occasions. The use of CD_4 in WHITEX was an innovative and important step forward in the field of source attribution, and NPS and the WHITEX team are to be commended for including this tracer in WHITEX.

QUANTITATIVE ASSESSMENT

The NPS-WHITEX report based its quantification of the NGS contribution to SO_4^{2-} aerosol at Hopi Point on two empirical models—Tracer Mass Balance Regression (TMBR) and Differential Mass Balance (DMB)—both of which are based on multiple linear regression techniques. Although multiple linear regression has been used before to apportion primary (directly emitted as particles) source contributions to ambient aerosol mass, there has been little verification of its applicability in the case of a predominantly secondary (particles formed in the atmosphere) species, such as SO_4^{2-} . Moreover, the committee identifies problems in the implementation and interpretation of multiple linear regression in the WHITEX analysis: (1) satisfactory tracers were not available for all major sources; (2) the interpretation did not adequately account for the possible covariance between NGS contributions and those from other coal-fired power plants in the region; and (3) both models employ inadequate treatment of sulfur conversion, which is an important controlling factor in the formation of haze at GCNP.

Therefore, the committee concludes that WHITEX did not quantitatively determine the fraction of SO_4^{2-} aerosol and resultant haze in GCNP that is attributable to NGS emissions. The report did not adequately quantify the sensitivity of the analyses to departures from model assumptions, nor did it establish an objective and quantitative rationale for selecting among various statistical models. The conceptual framework for DMB involved physically unrealistic simplifications, the effect of which on quantitative assessments was not addressed. The data base contained weaknesses; especially damaging were the absence of measurements below the rim of the Grand Canyon and the paucity of background measurements. In addition, the background measurements that were made were not adequately incorporated into the data analyses.

ESTIMATES OF THE RANGE OF POSSIBLE IMPACTS FROM NGS

The committee used the WHITEX data obtained during a haze episode in GCNP to estimate the ranges of possible impacts from NGS. These estimates consist of a series of mass-balance calculations made on the basis of simple, but reasonable, assumptions. These calculations were made for illustrative purposes; they cannot, in themselves, be used to quantify the impacts of NGS on visibility in GCNP, in part because measurements needed to confirm some of the assumptions were not made during WHITEX. The committee's analysis

indicates that NGS sulfur emissions are sufficiently large to account for even more than the total sulfur concentration measured in GCNP. However, the actual impact of NGS emissions on haze in GCNP depends on the rate of conversion of SO_2 to SO_4^{2-} . The extent of conversion is extremely sensitive to meteorological conditions and the availability of oxidants; the extent could range from a very small percentage to nearly 100%. Conversion rates would tend to be high during cloudy and foggy conditions, such as those observed during WHITEX haze episodes. Under these conditions, NGS emissions could produce SO_4^{2-} concentrations similar to those measured in GCNP. However, the WHITEX data also show that there are important sulfur sources in addition to NGS that appear to contribute to regional background SO_4^{2-} aerosol levels. These additional sources evidently account for a significant fraction of the haze observed in GCNP. Thus, if NGS emissions were controlled, then wintertime haze at GCNP would most likely be reduced, but not eliminated.

THE COMMITTEE'S CONCLUSIONS IN PERSPECTIVE

The committee cautions that its conclusions do not resolve whether EPA should require NGS to install the best available retrofit technology (BART). First, the committee's conclusions are not binding on EPA or any other government agency. Second, even if accepted by EPA, the committee's conclusions would not dictate a particular result to EPA's rule making. Section 169A of the Clean Air Act generally requires the installation of BART on any "major stationary source" built after 1962 if that source "emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility" in a listed Class I area, such as GCNP. The phrase "may reasonably be anticipated" suggests that Congress did not intend to require EPA to show a precise relationship between a source's emissions and all or a specific fraction of the visibility impairment within a Class I area. Rather, EPA is to assess the risk in light of policy considerations regarding the respective risks of overprotection and underprotection. These considerations transcend scientific issues and are, therefore, outside this committee's purview.

Haze in the Grand Canyon

*An Evaluation of the Winter Haze
Intensive Tracer Experiment*

Haze in the Grand Canyon: An Evaluation of the Winter Haze Intensive Tracer Experiment

BACKGROUND

The Grand Canyon is one of the most spectacular natural sights on earth. The diversity and color of the geological formations are extraordinary, and the geographical scales are immense. In some places the canyon is 1.6 km deep and 30 km wide, and panoramic views typically extend to over 100 km. The aesthetic effect of the canyon depends on many aspects of visibility in addition to distance: the luminous quality of the air; the interplay of color, light, and shadow; the colossal scale; and the clarity of the view. These magnificent and unique qualities attract approximately 4 million visitors to Grand Canyon National Park (GCNP) each year.

The atmosphere in the Grand Canyon is generally very clear, and under ideal "blue-sky" conditions (particle-free, also known as Rayleigh, conditions), visibility approaches the ultimate value of 400 km. However, even small increases in aerosol¹ concentrations can change the appearance of views—dulling the colors, shifting the color spectrum, reducing the contrasts, and decreasing the visual range (see Appendix 1).

When visibility is impaired in the Grand Canyon, suspended fine particles in the air are usually the major cause. Fine particles, which typically are 0.1- to 1.0- μm diam., scatter and absorb light, and the viewer perceives haze. In the Grand Canyon region, sulfates (SO_4^{2-}) account for approximately one-third to one-half of the fine-particle-mass concentration in the air. SO_4^{2-} plays a major role in visibility degradation in summer and winter (NPS, 1988; Trijonis et al., 1989); SO_4^{2-} in this area is predominantly the result of atmo-

¹An aerosol is strictly defined as suspension of particles in a gas. In this report, "aerosol" is used synonymously with "particle," in conformity with common usage in the atmospheric chemistry literature (e.g., see Buat-Ménard et al., 1989, p. 252).

spheric transformation of sulfur dioxide (SO_2) emissions from anthropogenic sources. Wintertime hazes are believed to result from the accumulation of emissions from local sources during conditions of air stagnation; such conditions occur more frequently in winter than in summer.

The National Park Service (NPS)—the managing agency for the GCNP—believes that the Navajo Generating Station (NGS) is an important source of SO_4^{2-} aerosols that cause wintertime haze in GCNP. NGS is a coal-fired power plant placed in operation in stages between 1974 and 1976. It is owned jointly by the U.S. Department of the Interior's Bureau of Reclamation, the Salt River Project (SRP),² and several electric utilities. NGS is located approximately 25 km from the GCNP border at its closest point and about 110 km northeast of the Grand Canyon Village tourist area near Hopi Point (Fig. 1). NGS has a generating capacity of 2,400 MW gross (2,250 MW net), which makes it one of the largest power plants in the United States west of the 100th meridian.

In January and February 1987, a large-scale experiment was carried out by NPS to investigate the causes of wintertime haze in the region between Grand Canyon and Canyonlands National Park. The Winter Haze Intensive Tracer Experiment (WHITEX) was a research project sponsored by a consortium of utilities and governmental agencies called SCENES (Subregional Cooperative Electric Utility, Department of Defense, National Park Service, and Environmental Protection Agency Study). The original objectives of WHITEX were (1) to evaluate an empirical approach for assessing the relative contribution of an isolated source to aerosols at specified locations and (2) to determine the relative contributions of individual aerosol constituents to haze at these locations (SCENES, 1987). The initial plan was for "a scoping study to investigate the feasibility of more extensive source attribution studies in future years" (SCENES, 1987). The original experimental design focused on the area between NGS and Canyonlands National Park, because this region was believed to be most susceptible to effects from NGS emissions due to the presumed prevailing wind flow toward the east. NPS added additional sampling sites in northeastern Arizona and southeastern Utah, including one at Hopi Point on the south canyon rim near Grand Canyon Village to the southwest of NGS.

Except for the Hopi Point site, all of the NPS sampling sites were north and east of GCNP (Figs. 1 and 2). Measurements included atmospheric optical properties, particle concentrations and composition, SO_2 concentrations,

²The SRP, a political subdivision of Arizona (akin to a special district), supplies consumers with water and electrical power. The project is the operating agent of the NGS.

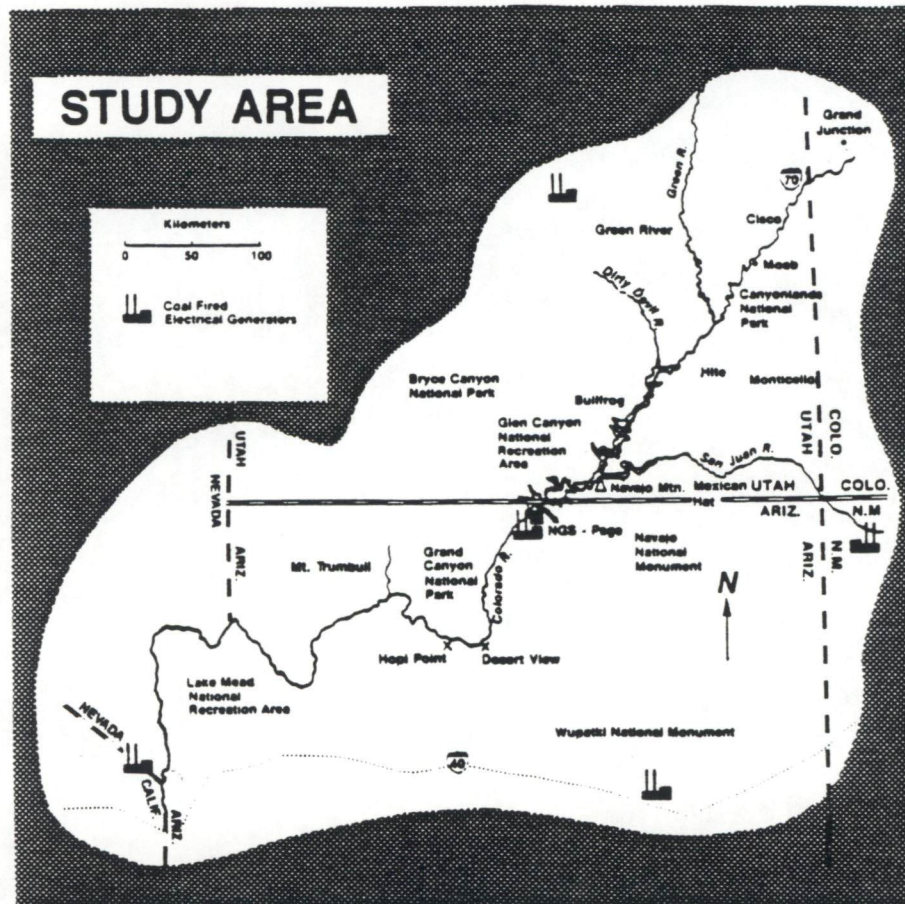


FIGURE 1 SCENES WHITEX study area. Source: Adapted from NPS, 1989.

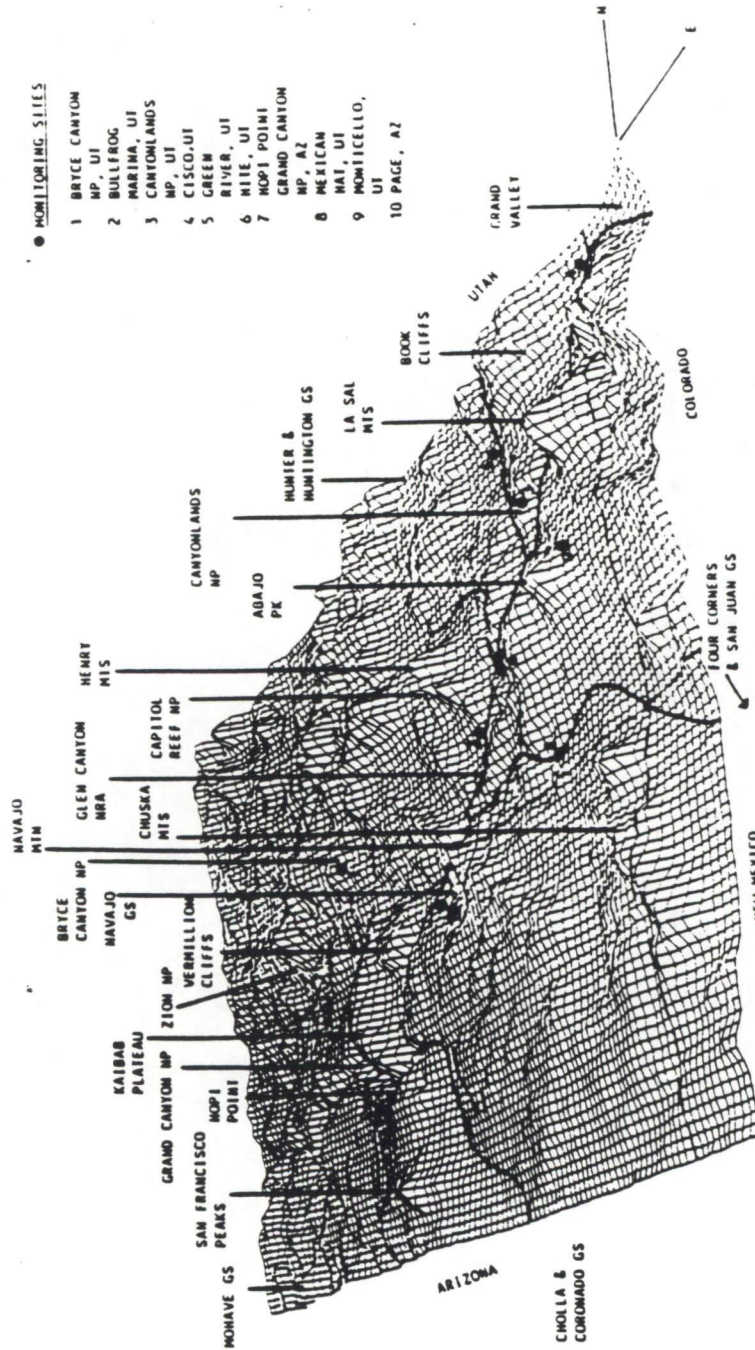


FIGURE 2 Topographical map of WHITEX study area showing location of sampling sites. The boundaries of the figure are as follows: northern boundary, 39° 21' N. latitude; eastern boundary, 108° 30' W. longitude; southern boundary, 35° N. latitude; and western boundary 115° W. longitude. Each grid block is 3' x 3', or approximately 5,228 meters x 4,435 meters at this location. Source: NPS, 1989.

meteorological variables, and trace elements. Source tracers included particulate selenium (Se), assumed to be a generic tracer for coal-fired power plants; particulate arsenic (As), assumed to be a generic tracer for copper smelters; and deuterated methane (CD_4), which was injected into the NGS stacks to serve as a unique tracer for NGS emissions. NPS analyzed the data from WHITEX to evaluate the effects of NGS emissions on visibility in GCNP. NPS recently issued a final report on the WHITEX study (NPS, 1989), subsequently referred to as the NPS-WHITEX report.

WHITEX focused on NGS because it has large sulfur emissions. NGS is one of the largest single sources of SO_2 in the United States west of the 100th meridian. It emits more SO_2 than is emitted in the Los Angeles basin but less than is emitted in the area of California south of Point Conception.³ NGS emits approximately the same amount of SO_2 as the combined output of two power plants at Four Corners and San Juan, New Mexico (Appendix 2, p. 80)⁴ (EIA, 1987). However, NGS emits less than half the total SO_2 of the group of copper smelters in southeast Arizona and Mexico. During WHITEX, NGS emitted less SO_2 than two or three individual copper smelters whose emissions have since been reduced.⁵

NGS has no technological controls on its SO_2 emissions, although the plant was designed so that flue-gas desulfurization could be incorporated later (SRP, 1971).⁶ NGS limits its SO_2 emissions by burning low-sulfur coal, typically 0.45%-0.55% sulfur, which allows NGS to meet Arizona's emission limit of 1.0 lb SO_2 /million btu for the plant. Nevertheless, at full operation, NGS emits more than 200 tons SO_2 /day through three 236-m tall stacks.⁷ These emissions qualify NGS as a major stationary source, defined by Section

³About 120 tons SO_2 /day were emitted in 1987 in the Los Angeles Basin and about 300 tons SO_2 /day were emitted for all of southern California in 1987 (California Air Resources Board, 1990).

⁴Appendix 2 consists of selected pages from the NPS-WHITEX report.

⁵According to the Arizona Department of Environmental Quality (1989), the three Arizona copper smelters currently emit a total of 170 tons SO_2 /day, and the two Mexican smelters a total of 300 tons SO_2 /day. During WHITEX, the estimates by ADEQ were 450 tons SO_2 /day total from the Arizona smelters and 620 tons SO_2 /day total from the Mexican smelters.

⁶NGS is equipped with electrostatic precipitators that limit primary particle emissions to approximately 6.4 tons/day under typical conditions (Appendix 2, p. 82).

⁷During WHITEX, the average emission rate was reported to be 163 tons SO_2 /day (Appendix 2, p. 78). This emission rate is reasonably consistent with coal consumption records for January and February 1987: 648,000 and 488,000 short tons, respectively, with sulfur contents of 0.47% and 0.46% (EIA, 1987).

169A(g)(7) of the Clean Air Act⁸ as a source that emits over 250 tons of a regulated pollutant in a year (i.e., 0.68 ton/day).

In an innovative step forward in the field of source attribution, WHITEX injected CD₄ as a tracer into the NGS stacks (Appendix 3). Significant concentrations of CD₄ later were detected at Hopi Point during some haze episodes (periods during which visibility was particularly poor). WHITEX investigators focused their analyses on these episodes. Receptor modeling and statistical techniques were used to estimate quantitatively the fraction of particulate SO₄²⁻ at Hopi Point that could be attributed to NGS. As is often the case when new techniques and approaches are being used, however, unexpected problems arose that made quantitative evaluations of the experimental data difficult. These are discussed in detail in this report.

The NPS-WHITEX report concluded that NGS causes wintertime haze in GCNP (Appendix 2, p. 74). The report claimed that during the days CD₄ measurements were made at Hopi Point, NGS was responsible for about 70% of the mean particulate SO₄²⁻ and about 40% of the mean aerosol-related light extinction. During some wintertime haze episodes,⁹ the report claimed that NGS contributed as much as 60% of the aerosol-related light extinction.

On the basis of the WHITEX results, the U.S. Environmental Protection Agency (EPA) initiated regulatory action under Section 169A of the Clean Air Act (U.S. EPA, 1989). This section requires the installation of the best available retrofit technology (BART) on any "major stationary source" placed in operation after August 7, 1962, that "emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility" in a Class I area¹⁰ for which EPA has determined that visibility is an important value (Section 169A(b)(2)(A)). EPA has chosen to take a phased approach to the implementation of Section 169A. Consequently the agency's regulations

⁸References are to the Clean Air Act as amended, 42 USC § 7401-7626.

⁹CD₄ was released for 43 days, from January 7 to February 18, 1987, and was sampled continuously throughout this period. Based on examination of meteorological and other available data, a minority of the CD₄ samples was selected for analysis. At Hopi Point, the selected samples covered 36 half-day periods. The selection process and criteria are not documented in the NPS-WHITEX report, but had the effect of emphasizing periods of higher than average SO₄²⁻ concentrations.

¹⁰Class I areas are those areas subject to the most restrictive limits on growth in air-pollution concentrations under the Clean Air Act's Prevention of Significant Deterioration program. Section 162(a) of the act classifies 158 national parks, international parks, and wilderness areas as Class I areas whose designation may not be altered. Section 164(a) allows states and Indian tribes to designate additional areas as Class I; to date, this authority has been little used.

currently require BART only when visibility impairment is "reasonably attributable" to an existing major stationary source (U.S. EPA, 1980).

EPA preliminarily attributed haze in the GCNP to NGS (U.S. EPA, 1989). This is the first attempt by EPA to regulate an existing source under Section 169A. The agency is in the process of deciding whether to make its attribution final and, if so, determining what level of control of air pollution from NGS would constitute BART, as defined in Section 169A(g) of the act. The agency placed in the public docket (EPA Docket No. A-89-02-A) a draft notice of proposed rule making pursuant to Section 110(c) of the Clean Air Act. The proposal would require that NGS reduce emissions to 0.1 lb SO₂/million btu, which would reduce the level of allowable emissions by 90%. EPA believes that an approximately 90% reduction in emissions would be required to meet the emission limit reliably.

THE NRC COMMITTEE STUDY

The Committee, Its Charge, and Its Approach

This evaluation of WHITEX was prepared by the Committee on Haze in National Parks and Wilderness Areas, which was convened in February 1990 by the National Research Council's Board on Environmental Studies and Toxicology in collaboration with the Board on Atmospheric Sciences and Climate of the Commission on Geosciences, Environment, and Resources. The committee comprises members appointed for expertise in meteorology, atmospheric chemistry, atmospheric aerosols, air pollution monitoring and modeling, statistics, environmental engineering, control technology, and environmental law and public policy.

The committee's overall charge is:

to develop working principles for assessing the relative importance of anthropogenic emission sources that contribute to haze in Class I areas and for assessing alternative source control measures; and

to recommend strategies for improving scientific understanding and technical information on relative source contributions to haze formation, regional and seasonal factors affecting haze, relevant air quality models, and various emission control measures.

The committee's work is sponsored by the U.S. Department of the Interior (National Park Service, Bureau of Reclamation, and Office of Environmental

Quality), the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the Arizona Salt River Project. The committee's final report, which will address this charge, will be issued in 1991.

In addition to the final report, the committee was also asked to provide this special report evaluating WHITEX, the recent site-specific study conducted by NPS. This report evaluates the scientific evidence relevant to EPA's recently proposed finding that NGS contributes to impairment of visibility in GCNP. Specifically, the committee was asked to review NPS data and analyses upon which the EPA determination was based and other data and analyses related to source apportionment for Grand Canyon haze. It was also asked to evaluate the contribution of the WHITEX study toward the science of source apportionment. The committee reviewed the December 1989 NPS-WHITEX report, other relevant published materials, and some unpublished information. In March 1990, the committee conducted site visits to the GCNP and NGS near Page, Arizona, and it heard technical presentations from NPS, SRP, and their scientific consultants. This information was used as part of the basis for the committee's evaluation.

The Committee's Specific Interpretation of Its Charge

The committee focused on assessing the methodology and design of WHITEX and the validity of the conclusions. The committee based its evaluation solely on the scientific aspects of WHITEX.

The committee is aware that its assessment is relevant to the regulatory matters currently before EPA. The committee wishes to emphasize that it has not considered regulatory issues relating to NGS and expresses no opinion on them. Such issues involve policy considerations; these matters lie outside the committee's purview.

This review of WHITEX will be considered by the committee in the preparation of its final report. WHITEX is an example of approaches to source attribution in Class I areas. Because WHITEX is one of the most recent studies of this type, it will provide useful insight for the final report.

EVALUATION OF WHITEX

WHITEX Overview

WHITEX was conducted on the Colorado Plateau in Northern Arizona and Southern Utah between January 7 and February 18, 1987 (days 7-49 in 1987).

The objective of the WHITEX research program was to evaluate the suitability of various receptor modeling methods for attributing haze in specific Class I areas (i.e., Grand Canyon and Canyonlands) to emissions from an isolated point source (i.e., NGS). Previous investigations demonstrated that wintertime regional hazes occur during periods of air stagnation and that these hazes are largely attributable to submicrometer particles composed primarily of SO_4^{2-} , organic carbon compounds, and black carbon (soot) (Malm and Walther, 1979; Walther and Malm, 1979; Chinkin et al., 1986). A significant part of WHITEX focused on SO_4^{2-} , because it is the dominant light-scattering species during the most severe haze episodes. NGS emissions include primary SO_4^{2-} particles, as well as gaseous SO_2 which is converted to SO_4^{2-} in the atmosphere.

The NPS-WHITEX report contains the following major elements:

- A discussion of the experimental setting, including a review of regional emissions and climatology;
- A description of the optical, particle, SO_2 , and tracer measurements, as well as discussions of data quality;
- A description of some preliminary prognostic transport modeling for one 2-day period; and
- Various analyses supporting the attribution of SO_4^{2-} concentrations and haze to NGS.

A distinctive and novel feature of the WHITEX experiment was the use of CD_4 . CD_4 is nearly inert; its concentration during WHITEX would not have been significantly affected by chemical reactions, precipitation scavenging, or dry deposition to the surface. The concentration of CD_4 in an air parcel can be reduced only through dilution with air that does not contain CD_4 . WHITEX used CD_4 as a tracer to identify air parcels that contained NGS emissions, to estimate the dilution that had occurred during transit, and to estimate the amount of sulfur species that were originally injected into the air parcel by NGS. Knowing the ratio of SO_2 : CD_4 in the stack emissions at NGS and knowing the concentration of CD_4 at GCNP, the concentration of NGS SO_2 that would have been present in the air parcel in the absence of deposition or conversion can be calculated, assuming the CD_4 and sulfur species from NGS travelled by the same trajectory. This calculated upper limit on NGS-derived sulfur is referred to as $\text{S}(\text{CD}_4)$.

The analyses in the NPS-WHITEX report focused on data acquired at Hopi Point, because higher CD_4 concentrations were found there than at the other sampling stations (except for Page, which is immediately adjacent to NGS). NPS estimates of NGS effects on haze at GCNP depended on the

measurements of CD_4 at Hopi Point. However, measurements of CD_4 by themselves could not provide information on the fraction of SO_2 that was converted to SO_4^{2-} in transit, nor could they account for the quantities of these species that were deposited during transit. Thus, $\text{S}(\text{CD}_4)$ yielded only an upper-limit estimate of possible effects of NGS SO_2 emissions at GCNP. For this reason, statistical and modeling tools were needed to make quantitative estimates of NGS impacts.

The attribution analysis of the NPS-WHITEX report was carried out in two stages: (1) the observed light extinction first was apportioned to fine-particle SO_4^{2-} and other atmospheric species, and (2) the observed SO_4^{2-} concentrations then were attributed to NGS and other sources. The apportionment of extinction among chemical species (extinction budgeting) was largely based on literature and statistical values for the extinction : mass ratios (extinction efficiencies) of the various species. The quantitative attribution of SO_4^{2-} to specific sources rested primarily on semi-empirical statistical models, highly simplified physical models fit to the data through least-squares procedures.

WHITEX Source-Attribution Models

The quantitative attribution of SO_4^{2-} to NGS rested on two empirical models: Tracer Mass Balance Regression (TMBR) and Differential Mass Balance (DMB). TMBR employs multiple linear regression (MLR) of the SO_4^{2-} concentration on selected source-tracer concentrations to estimate the ambient SO_4^{2-} : tracer ratios attributable to individual sources. MLR has been used since the mid-1970's to apportion primary (directly emitted as particles) source contributions to ambient aerosol mass, although it has been subjected only to limited testing and verification. The literature does not contain convincing evidence that MLR applications can successfully apportion a predominantly secondary (particles formed in the atmosphere) species, such as SO_4^{2-} , among several source types.

In the NPS-WHITEX report, some of the tracer concentrations are multiplied by relative humidity (RH) in an attempt to account for the increased rate at which SO_2 is converted to SO_4^{2-} in liquid-phase reactions in clouds or fogs. RH scaling as used in the NPS-WHITEX report appears to be previously untested.

DMB is an elaboration of TMBR in which the regression variable for the target source is adjusted to reflect the varying ages of emissions at the receptor. The expected proportion of SO_4^{2-} : tracer is calculated based on the following factors: 1) assumed and constant values of SO_2 and SO_4^{2-} deposition rates, 2) an SO_2 conversion rate assumed to be in constant proportion to

RH, and 3) plume ages estimated from wind data. Because these factors were not measured during WHITEX, NPS selected them from within a range that they believed to be physically reasonable to maximize the correlation coefficient of the multiple linear regression relating SO_4^{2-} to the NGS tracer term and other source tracer terms. The net effect is one of nonlinear multiple regression.

The use of DMB appears to be unprecedented in the source-apportionment literature. Because it ultimately relies on MLR, its statistical assumptions are similar to those of TMBR. As with TMBR, DMB requires that SO_4^{2-} from untraced sources be only negligibly correlated with the source-tracer terms used in the regressions. The statistical assumptions used in the NPS-WHITEX report are accurately identified in the report (Appendix 2).

Critical Aspects of WHITEX Techniques and Design

The committee assessed the qualitative and quantitative aspects of the NPS-WHITEX conclusions; these two aspects are addressed separately.

Qualitative Assessment

The committee concludes that a properly executed experiment using a methodology and design similar to those used in WHITEX could provide qualitative information as to whether NGS emissions contribute to SO_4^{2-} aerosol and resultant haze in GCNP.

The WHITEX protocol included measurements of ambient optical properties, concentrations of key gaseous and particulate species, tracers for contributing SO_4^{2-} sources (including CD_4), wind-flow patterns and other meteorological data, and time-lapse photography. WHITEX analyses included dynamic meteorological modeling of air movements, tracer mass-balance calculations, and multiple-regression analyses for apportioning SO_4^{2-} among sources. Such information should be adequate to support a qualitative assessment of whether NGS emissions reach GCNP and whether these emissions contribute to haze in GCNP.

The use of CD_4 in NGS emissions could provide definitive evidence of the transport of NGS emissions to the GCNP. Dynamic meteorological modeling could provide supplemental information that could be used to help evaluate the extent to which the emissions are transported into and distributed throughout the Grand Canyon. For any particular site, the contributions of the various aerosol species to optical extinction could be reasonably estimated.

Multiple-regression techniques, such as those used in TMBR and DMB, have a long history of success in many areas of science; they are widely accepted in epidemiology, econometrics, and other disciplines for which cause-effect relationships are complex and for which extraneous factors cannot be controlled. Such techniques clearly could be used in a WHITEX-type experiment if 1) satisfactory tracers were available for all major sources that might affect GCNP, and 2) there were a strong correlation between the NGS tracer and the fraction of haze-forming aerosol (i.e., SO_4^{2-}) that was not accounted for by the tracers for all other sources. Under these conditions, the results of multiple-regression analyses would constitute persuasive qualitative evidence that NGS emissions had a detectable effect on haze at GCNP. However, the literature does not demonstrate that previous MLR applications can successfully apportion a predominantly secondary species, such as SO_4^{2-} , among several source types. Therefore, it would not seem advisable to rely solely on such models for the success of a major field experiment.

The committee concludes that WHITEX qualitatively showed that, at some times during the study period, NGS emissions significantly contributed to SO_4^{2-} aerosol and resultant haze at Hopi Point in GCNP.

This conclusion is based on the data presented in the NPS-WHITEX report. The conclusion is not based on the results of the TMBR and DMB analyses, which contained various shortcomings that are discussed in more detail later in this report. Instead, the committee's qualitative assessment is based on the following observations and measurements made during WHITEX.

Meteorological Evidence. Meteorological analyses support the NPS conclusion that NGS emissions can be transported to GCNP during the wintertime when the air stagnates. The NPS-WHITEX report focused on February 11-14, 1987 (days 42-45 in 1987), for its intensive analyses of the NGS contribution to haze in GCNP. During this time, the region was dominated by a polar high-pressure system that resulted in low-speed surface winds. Under such conditions, surface winds at Page usually alternate between northeasterly during the day and southwesterly during the night (Balling and Sutherland, 1988), and observations at Page during the study period showed this pattern. Furthermore, the upper-air winds measured at Page confirmed the NPS conclusion that winds at the expected plume height flowed from the northeast during much of this period. Deterministic meteorological modeling performed in WHITEX also indicated that winds at the height of NGS stacks could have

carried emissions to the GCNP area; however, these simulations did not reproduce the diurnal fluctuations in wind flow observed at the surface at Page.

The meteorological data and the deterministic meteorological modeling do not allow quantification of the contribution that NGS might have made to haze at GCNP. The deterministic meteorological modeling cannot pinpoint the location of the NGS plume nor its entrainment into the canyon. The model uses a grid size of 5 km; hence, it cannot reproduce the complex topography of GCNP (Fig. 2) nor the associated small-scale meteorological effects, such as gravity flows. (For example, the model could not be expected to quantify the mass of sulfur entering the Grand Canyon from the rim versus that transported directly down the Grand Canyon.) Thus, the meteorological studies provide only qualitative evidence of transport.

Photographic Evidence. The wind-field analyses are supported by time-lapse photography and still photographs of cloud, fog, and haze conditions. Photographic evidence was obtained on the rim of the Grand Canyon and elsewhere in the region. The time-lapse images provided particularly striking evidence of the complex meteorological conditions that are due in part to the complicated topography (Fig. 2). Time-lapse video sequences taken on the east end of the south rim during the early part of the period showed well-developed wind flow into the Grand Canyon from the east; in contrast, aloft and at relatively low altitudes, winds flowed strongly from the west.

Still photographs provided additional information on the meteorological context of February 11-14. Photographs from Echo Cliffs looking northeast toward NGS—about 24 km away—showed noticeable haze on February 8 that dissipated on February 9. On the 9th, a brown plume was seen moving in a westerly direction from NGS. On February 10-12, the plume was embedded in fog; when the fog rose, the plume appeared to move to the west. On the afternoon of February 12, skies were clear and visibility was improved, except in the Lake Powell valley, where a haze was obvious. These photographs are evidence that the NGS plume was entrained into a cloudy environment with winds traveling toward the GCNP most of the time during February 11-14. The presence of cloud water within the plume has important implications regarding the conversion rate of SO_2 to SO_4^{2-} , because the heterogeneous conversion rate in cloud droplets can be much faster than that for homogeneous gas-phase conversion.

Chemical and Physical Evidence. The chemical and physical evidence are summarized by the following statements, most of which are based on data obtained during WHITEX.

1. Averaged over the WHITEX study period, SO_4^{2-} aerosol was a significant contributor to non-Rayleigh light extinction at Hopi Point in GCNP. During certain episodes, SO_4^{2-} was the predominant contributor to non-Rayleigh light extinction. These conclusions regarding the contribution of SO_4^{2-} aerosol to haze at Hopi Point are not sensitive to uncertainties in the WHITEX data (including substantial uncertainties regarding the carbon data). These conclusions are based on visibility and aerosol data taken during WHITEX and on literature values for sulfate light extinction efficiencies and are consistent with prior studies linking SO_4^{2-} to haze in the Southwest (Trjonis et al., 1989).

2. NGS is one of the largest single SO_2 sources in the United States west of the 100th meridian, and during WHITEX, it was also among the largest. Although other large SO_2 sources could affect Hopi Point (e.g., the smelters in southeast Arizona and Mexico, other power plants, and urban areas), NGS is the source closest to Grand Canyon—25 km from the GCNP boundary and 110 km northeast of Grand Canyon Village—while the other major sources are 300–500 km distant. Mass-balance considerations suggest that the rate of SO_2 emissions from NGS during WHITEX was large enough to produce sulfur concentrations at GCNP much greater than those measured at Hopi Point.

3. The SO_4^{2-} measured at Hopi Point during haze episodes probably included contributions from sources within the region. These episodes tended to occur during stagnant wind conditions, which could lead to the accumulation of emissions from sources in the region, as evidenced by the significant spatial inhomogeneities in SO_4^{2-} concentrations. The modeling studies of transport winds during the major stagnation episodes showed that NGS emissions could affect GCNP. However, these findings do not preclude the possibility of significant contributions from other local and regional sources, such as copper smelters, urban areas, and other power plants.

4. During the periods selected for tracer analysis, the tracer data showed that Page and Hopi Point were affected significantly by the NGS plume. During three episodes, average CD_4 tracer concentrations were generally much higher at Page and substantially higher at Hopi Point than at the other six sampling locations. The CD_4 tracer indicated that NGS contributions could account for total sulfur concentrations 2.5 times greater than those actually measured at Hopi Point. However, these tracer studies cannot account for losses in transit, nor can they reduce the large uncertainties regarding the conversion rates of SO_2 to SO_4^{2-} .

5. Cloudy conditions were observed during WHITEX haze episodes. These conditions favor the higher conversion rates required to generate significant SO_4^{2-} contributions from NGS at Hopi Point.

Quantitative Assessment

The committee concludes that a properly conceived and executed experiment, using a methodology and design similar to those used in WHITEX, might be useful to determine quantitatively the fraction of SO_4^{2-} aerosol and resultant haze in GCNP that is attributable to NGS emissions.

The committee concludes that an experiment based on the WHITEX methodology could provide a quantitative determination of the fractional contribution of NGS to haze in GCNP in simple—but highly improbable—cases, such as:

- If no CD_4 were measured in GCNP, then the unambiguous conclusion would be that NGS made no contribution to GCNP haze. The absence of measurable CD_4 would be evidence that no material of any kind was transported from NGS to GCNP.
- If CD_4 were measured in GCNP and background measurements showed that SO_4^{2-} from other sources were insignificant at that time, then all SO_4^{2-} detected could be attributed to NGS.

Beyond simple cases such as these, there is little consensus among those in the source apportionment field about which methods might be appropriate for apportioning haze due to secondary SO_4^{2-} . Labeling the sulfur or oxygen might provide a definitive test. However, because of the large background ^{34}S and the radioactivity of ^{35}S , use of these isotopes is impractical. Some believe that extensions of receptor-oriented techniques similar to those used in WHITEX, if applied with better tracers and better temporal and spatial resolution, might provide quantitative estimates.

Others believe that alternative analyses would provide more reliable quantitative estimates. For example, a mass balance might be developed to explain measured SO_2 and SO_4^{2-} concentrations across the sampling stations. The mass balance would incorporate emissions from all sources in the region, calculations of convective fluxes based on dynamic meteorological modeling, and wet and dry deposition (using measured values where possible). Others feel that source apportionment can best be achieved using deterministic models that couple transport, deposition, and known SO_2 -to- SO_4^{2-} conversion mechanisms. The validity of the models would be tested by comparing simulations with measurements from the sampling stations. This lack of consensus among experts is evidence of the need for further efforts to validate or otherwise evaluate methods used for source apportionment of secondary aerosols.

The committee concludes that WHITEX did not quantitatively determine the fraction of SO_4 aerosol and resultant haze in GCNP that is attributable to NGS emissions.

The committee found that the data analyses described in the NPS-WHITEX report contain weaknesses that preclude quantitative source apportionment. The report did not attempt to quantify the effects of departures from model assumptions on the analysis, nor did it establish an objective and quantitative rationale for selecting among various statistical models. In addition, the conceptual framework for DMB involves physically unrealistic simplifications, and their impact on quantitative assessments was not addressed. These points are elaborated in the following section.

Limitations of the WHITEX Study

Weaknesses in the Data Base

Uncertainties about Tracer Data. DMB and TMBR require that emissions from specific sources or source types be associated with unique tracers. In WHITEX, these tracers were CD_4 for NGS, As for copper smelters, and Se for coal-fired power plants (although the latter two sources each emit some Se and As, respectively). No tracer in WHITEX was used to evaluate urban emissions; therefore, the fraction of haze attributable to these sources is impossible to calculate. Furthermore, the source profile for power plants was based on limited aircraft measurements of NGS emissions downwind from the stacks. The copper-smelter profile was based on old and uncertain data from the literature. Variabilities and uncertainties in NGS CD_4 emission rates (which ranged from 2 to 5 mg CD_4 per MW during the study (Appendix 2, p. 75)) led to substantial uncertainties in the day-to-day relationship between CD_4 and NGS sulfur emissions. Moreover, at Hopi Point, CD_4 concentrations were determined for only 36 samples, an undesirably small data set for the types and large numbers of statistical analyses performed on the data.

Several questions have been raised about the accuracy of the data regarding CD_4 emissions from NGS and, specifically, the ratio of CD_4 : SO_2 . The rate of injection of CD_4 , normalized to power output, was known to vary during the experiment by a factor of 2.5, and these changes were factored into the WHITEX data analyses. However, the ratio of CD_4 : SO_2 was not measured in the stack (samples apparently were collected but not analyzed). The ratio was measured in the plume using samples collected from aircraft. In addition, a small leak was discovered in the CD_4 injection line after the experiment was completed.

The NPS-WHITEX report provides little documentation of procedures and quality assurance for the sampling and analysis of ambient CD_4 . Despite the known problems with emissions and the lack of documentation on ambient measurements, the committee concluded that the CD_4 data are among the most useful data obtained in WHITEX, because CD_4 is the most specific tracer available for NGS emissions. In addition, most of the difficulties with the CD_4 data pertain to daily variations in the concentrations, not the overall average concentrations. Nonetheless, deficiencies in the experimental design precluded quantitative results regardless of CD_4 data quality.

Absence of Measurements within the Grand Canyon. One of the greatest weaknesses of the study was that no measurements were made below the rim of the Grand Canyon, within the canyon itself. As suggested by meteorological considerations and supported by still photographs and a time-lapse video of the February 11-14 period, a strong shallow wind flowed over the Colorado plateau and cascaded into the eastern end of the canyon at Desert View. This suggests that sulfur concentrations in the canyon might have been considerably greater than was observed on the rim farther away at Hopi Point.

Inadequacy of Background Measurements. Because the WHITEX study originally focused on Canyonlands National Park, too few sampling stations were located in the area surrounding GCNP. Without data from additional stations, the effect of NGS emissions is difficult to differentiate from those of other sources in the region. These considerations are important for a thorough evaluation of the sources of SO_4^{2-} in GCNP. This issue is addressed in more detail below.

Departures from Statistical Assumptions

The statistical assumptions underlying TMBR are accurately identified in Appendix 6B of the NPS-WHITEX report. Analogous assumptions underlie DMB, because it too is based on regression analysis. The discussion of the TMBR assumptions concludes, "Ideally, if there was a constant background pollutant concentration . . . and if the tracer release was directly proportional to emissions, and emissions were conservative, the reported estimated average NGS contribution should be a reliable estimate of the actual value for the time period in question."

Each of the quoted conditions appears to have been violated by the WHITEX data. The nonproportionality of the CD_4 release rate and the nonconservation of SO_2 emissions are discussed at length in the NPS-

WHITEX report and this report. Less is known about the behavior of the background SO_4^{2-} , because insufficient attention was devoted to it in the placement of sampling sites and the selection of CD_4 samples for analysis. However, the concentration of non-NGS SO_4^{2-} in the region clearly varied significantly. For example, concentrations at Monticello increased from $0.27 \mu\text{g S/m}^3$ from late February 9 to $0.45 \mu\text{g S/m}^3$ early February 10 (Fig. 3); during this period, CD_4 was 9×10^{-5} ppt, corresponding to a maximum possible contribution from NGS of only about $0.05 \mu\text{g S/m}^3$ (Appendix 2, pp. 76, 77, 85 (eq. 6-10)). Samples collected at Green River, Canyonlands, and Bullfrog during this period were not analyzed for CD_4 .

The NPS-WHITEX report did not attempt to quantify the effects on its analyses of departures from the statistical assumptions that it identified. However, the potential magnitude of such effects is substantial. Unfortunately, the WHITEX design did not provide the data needed for a definitive resolution of this issue.

Formulation of Statistical Models

The SO_4^{2-} contribution attributed to NGS depends strongly on the model chosen, the tracers included in the model, and the criteria by which the model is fit to the data. The NPS-WHITEX report attached most significance to the TMBR and DMB models using the variables of CD_4 concentration $\times$ RH for NGS and As concentration $\times$ RH for copper smelters. Variable selection was critical to the interpretation of the results, because CD_4 is clearly not the only tracer correlating with GCNP SO_4^{2-} . Indeed, NPS noted in its reply to SRP's comments that two-thirds of the SO_4^{2-} variance can be accounted for by RH and As alone. To establish a more rational basis for quantitative attribution, more attention must be given to alternative formulations for TMBR and DMB and to criteria for selecting among them. However, even if these criteria were adequately considered, the statistical results would most likely remain non-robust in the sense that the source attributions generated by the various statistical models would probably still differ substantially from one another. One difficulty is that the number of plausible alternative models is substantial relative to the number of samples for which CD_4 data are available. As the number of models increases, so does the likelihood that one of them will test significant purely by chance.

The NPS-WHITEX report assumed SO_4^{2-} yields from NGS and smelter emissions to have been proportional to the ambient RH, as an index of their exposure to liquid water. This is a simple and indirect assumption, which scales intermittent processes along the entire trajectory at cloud level directly

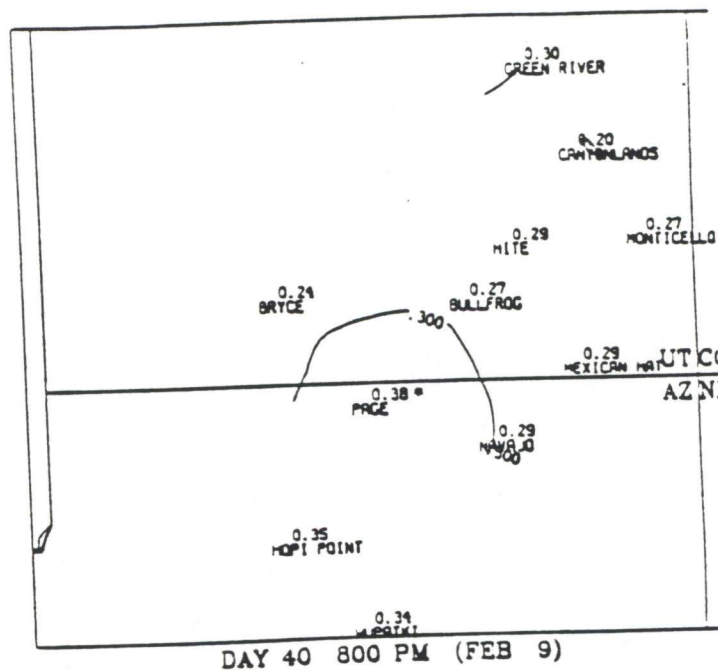
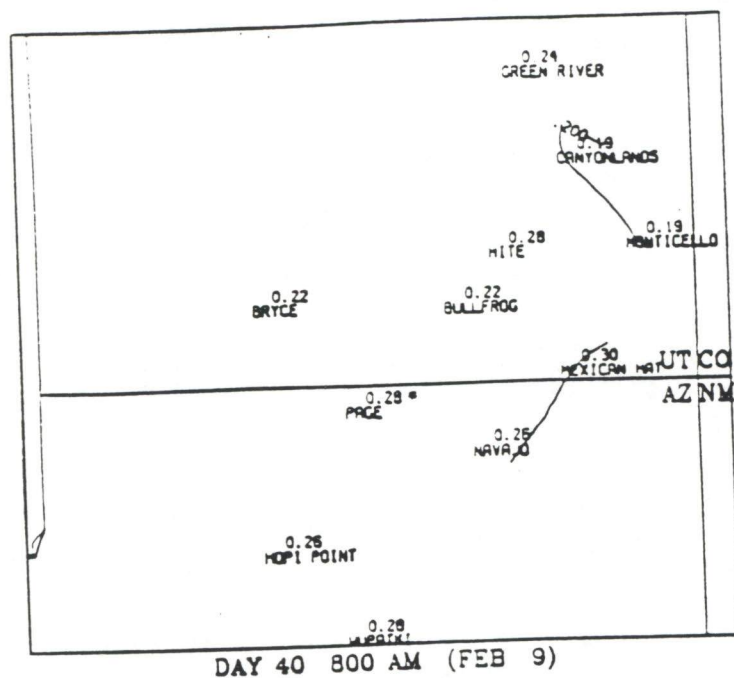


FIGURE 3 Fine particulate sulfur ($\mu\text{g}/\text{m}^3$) measured at WHITEX sampling sites, February 9-12, 1987. (Multiply by 3 to get sulfate.) Source: Malm, 1990.

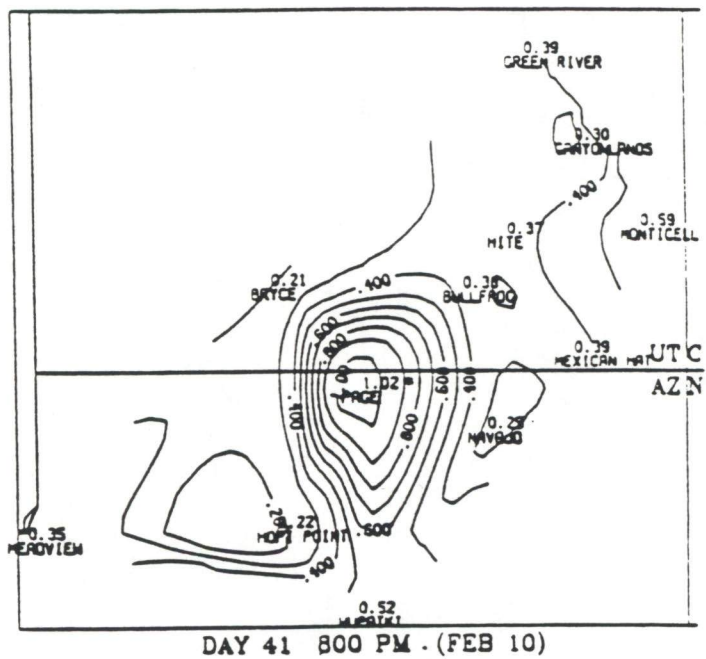
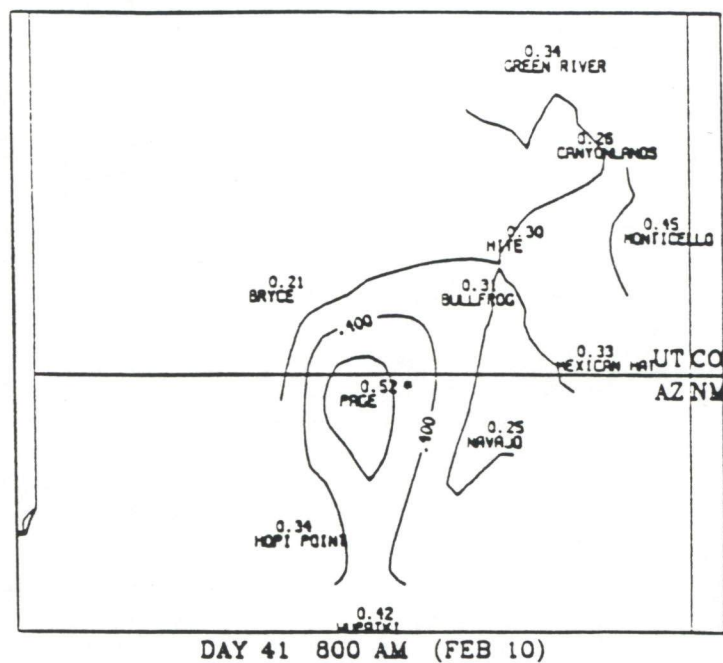


FIGURE 3 (continued).

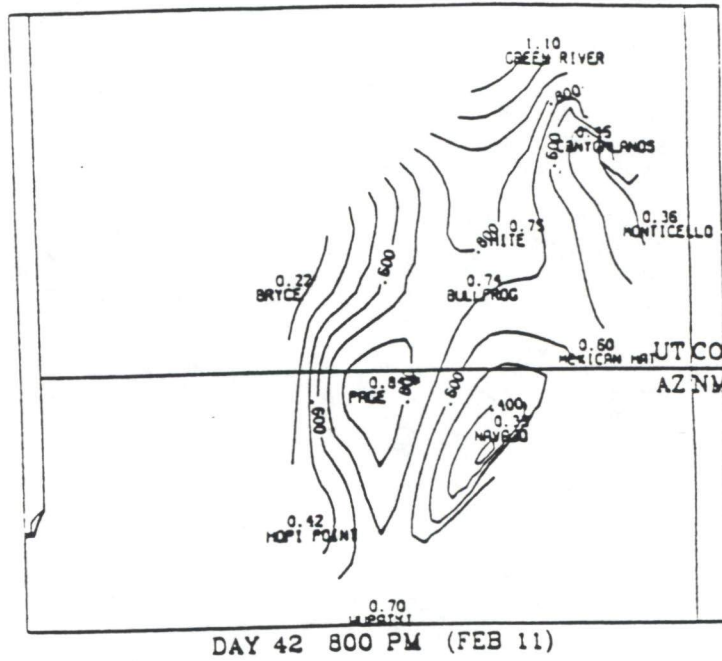
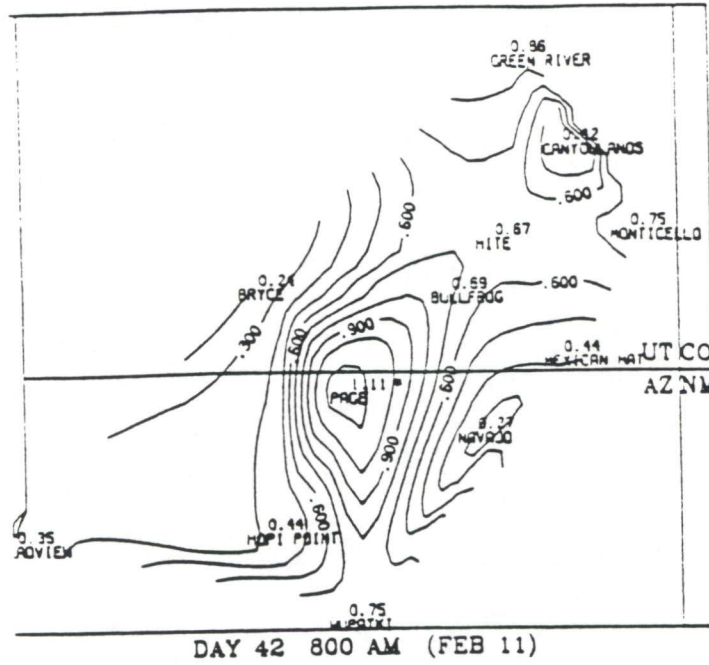


FIGURE 3 (continued).

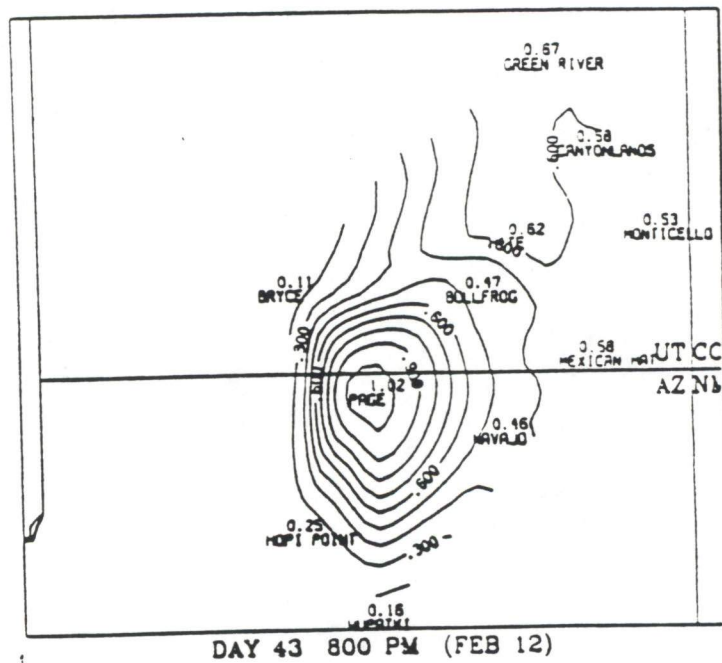
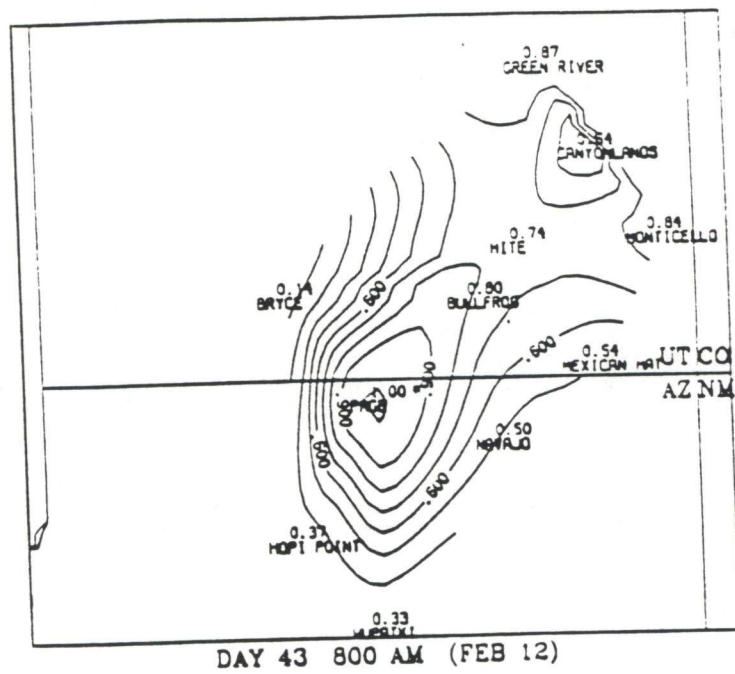


FIGURE 3 (continued).

to a continuous variable measured locally at ground level. The RH factor is critical to the explanatory power of the statistical models: without it, CD_4 alone can account for only 3% of the observed variance in SO_4^{2-} at Hopi Point and only 6% of the observed variance in total sulfur. Given the overriding importance of the RH scaling factor, the committee believes that the sensitivity of results to alternative assumptions should have been explored in formulating the models used for the TMBR and DMB analyses. The NPS-WHITEX report also assumes that the contributions of background sources, such as other power plants and urban areas, were unaffected by RH. No effort was made to justify this assumption. The committee believes the report should have considered the possibility that yields from other sources were also affected by RH.

Simplifications in the DMB Model

The DMB analyses are dependent on unique "plume ages." The validity of these ages is questionable, given that travel times from NGS to Hopi Point were estimated to be 12-48 h on February 11-12. Slow-moving air parcels typically contain a mixture of materials (possibly more than one plume) emitted from a variety of sources. Furthermore, plume ages were estimated only for NGS emissions and not for other contributing SO_4^{2-} sources. The effects of these simplifications on quantitative apportionment are unknown.

The DMB approach is based on linear models for the oxidation of SO_2 to SO_4^{2-} and for the deposition of SO_2 and SO_4^{2-} . In reality, both processes are likely to occur at rates that can vary greatly in time and space. The major transformation process for SO_2 during wintertime conditions is probably oxidation by hydrogen peroxide (H_2O_2)¹¹ in clouds. Oxidation rates by this process theoretically can exceed several percent per minute. Such high rates are maintained for only short periods due to rapid depletion of either H_2O_2 or SO_2 . In the absence of clouds, the photochemical conversion rate of SO_2 is very slow—close to 0%/min—under wintertime conditions at GCNP. The result is that under cloudy conditions, a significant portion of the SO_2 in an air parcel is rapidly transformed to SO_4^{2-} each time the parcel is entrained into a cloud; otherwise, the SO_2 remains essentially unconverted and, hence, cannot contribute significantly to haze conditions in GCNP.

Furthermore, deposition and oxidation are coupled processes. Because of

¹¹A more realistic model should include the heterogeneous oxidation of SO_2 in cloud water by ozone, oxygen (carbon or metal ion catalyzed), and other oxidants.

the nonuniform transformation rate of SO_2 to SO_4^{2-} , dry deposition rates also are nonuniform. Rainfall was measured between February 10-12 at the Grand Canyon Airport weather station; consequently, wet deposition occurred. Because rainfall in complex terrain is seldom spatially or temporally uniform, wet-deposition rates were probably not uniform. These nonuniformities in conversion and deposition rates lead to variabilities in the relationship between SO_4^{2-} concentrations measured at the receptor sites and tracer concentrations used in the regression analyses. Because these nonuniformities were not taken into account in the DMB formulation, the DMB results are of questionable applicability.

Potential Covariance of NGS and Other Source Contributions

Even if CD_4 , Se, and As were accepted as satisfactory tracers for all major sources that could potentially affect GCNP, a critical gap remains in the chain of evidence— CD_4 was not shown to add anything to the explanatory power of Se and As. In other words, the NGS tracer was not shown to correlate with any of the SO_4^{2-} variability that is not already accounted for by generic source tracers. One reason for this might be that CD_4 and Se are themselves correlated, with a correlation coefficient of 0.6. This suggests that the effects from NGS emissions and those from other Se sources affecting the Grand Canyon were correlated (and perhaps highly correlated considering imprecisions in the data set).

It is true, as stated by NPS, that a high degree of collinearity between CD_4 and Se is consistent with the conclusion that the emissions from other plants did not reach GCNP and that all Se came from NGS. However, the observed degree of collinearity is also consistent with the hypothesis that emissions from other plants did reach GCNP and that their SO_4^{2-} contributions were correlated with those of NGS. The latter hypothesis is not unreasonable, given that most other power-plant emissions occur also to the east and north in the Colorado River drainage basin, and that RH could have had a similar effect on those emissions. Under such conditions, it is difficult to distinguish statistically the relative effect of NGS from those of other coal-fired power plants in the region, given the limited number of data. The committee concludes that GCNP haze due to NGS emissions cannot be quantitatively estimated solely on the basis of TMBR and DMB analyses.

Estimates of the Range of Possible Impacts of NGS Emissions at Hopi Point

The WHITEX data can be used to estimate ranges of possible SO_4^{2-} effects from NGS. These estimates consist of a series of mass-balance calculations made on the basis of simplifying assumptions. These calculations are made for illustrative purposes and cannot, in themselves, prove or disprove that NGS emissions were responsible for GCNP haze, because measurements needed to confirm some of the assumptions were not made during WHITEX. The committee's estimates are summarized below. In discussing these estimates, the committee devised a set of three questions to address specific concerns.

Assuming that all NGS emissions are carried into GCNP under typical wind conditions, is the rate of NGS SO_2 emissions sufficiently large to produce total sulfur concentrations in GCNP that are comparable in magnitude to those measured during WHITEX at Hopi Point?

This is the simplest quantitative question that can be asked about the potential impact of NGS on haze in GCNP. This case ignores all complicating questions and focuses on the worst case—that all NGS sulfur emissions are carried into the Grand Canyon and distributed uniformly throughout it. Using the NGS emission rate during 1987 reported in the NPS-WHITEX report (163 tons SO_2 /day) (Appendix 2, p. 80), assuming the width and depth of the Grand Canyon range generally from 8 to 16 km and 0.9 to 1.2 km respectively, and assuming a mean wind speed of 2-4 m/sec (pers. comm., K. Gebhart, NPS, May 25, 1990), the total sulfur concentration within the canyon would be about 10-60 $\mu\text{g}/\text{m}^3$. This is much greater than the NPS-WHITEX-estimated upper limit of total sulfur attributed to NGS at Hopi Point over the period of the CD_4 analyses. This total sulfur concentration is also significantly greater than the total sulfur measured at this site during this period, when values were typically in the range of 0.2-1 $\mu\text{g}/\text{m}^3$ (absolute range, 0.07-1.50 $\mu\text{g}/\text{m}^3$, excluding the single value of 4.4 $\mu\text{g}/\text{m}^3$) (Appendix 2, pp. 84, 85).

Although crude, this estimate suggests that under appropriate conditions, the rate of SO_2 emissions from NGS is easily large enough to serve as the source of the sulfur measured in GCNP. The implicit assumptions in this upper-limit calculation are: 1) that the meteorological conditions enable the NGS plume to be transported into the Grand Canyon with little dispersion (i.e., that a substantial fraction of the NGS output actually enters the canyon), and 2) that there is relatively little loss of sulfur during transit. It is clear that

both assumptions often were not true to some degree during the experiment. Furthermore, this estimate does not address the question of the degree to which SO_2 is converted to SO_4^{2-} , a factor that is critically important to haze effects.

If the NPS-WHITEX estimates of sulfur transport from NGS to GCNP are correct, how much SO_2 might be expected to be converted to SO_4^{2-} aerosol during transit from NGS to GCNP under winter meteorological conditions such as those observed during WHITEX?

To address this question, the committee estimated upper and lower limits for the amount of conversion that could take place using data for the haze episode on February 11-12. Data were used from this episode because it is the focus of much of the WHITEX analysis. At Hopi Point on February 11-12, a maximum of about $2 \mu\text{g}/\text{m}^3$ $\text{S}(\text{CD}_4)$ could have come from NGS (Appendix 2, p. 85). This is based on the CD_4 concentrations at Hopi Point and the total sulfur : CD_4 ratio in the NGS plume. The total measured concentration of sulfur at Hopi Point was about $0.5 \mu\text{g}/\text{m}^3$ on February 11, and $0.25\text{--}0.4 \mu\text{g}/\text{m}^3$ on February 12 (Appendix 2, p. 84).

Minimum Conversion of SO_2 to SO_4^{2-} . In the absence of clouds, SO_2 conversion is controlled by homogeneous gas-phase photochemistry, and conversion rates are at a minimum. The NPS-WHITEX report provided estimates of the wintertime 12-h average daytime conversion rate (about 0.06%/h) and the 24-h average rate (about 0.03%/h) (SAI, 1985; Appendix 2, p. 81). The NPS-WHITEX-estimated transport times from NGS to Hopi Point during February 11-12 ranged from 12 h to 48 h (Appendix 2, p. 82).¹² The committee assumed that the maximum $2 \mu\text{g}/\text{m}^3$ $\text{S}(\text{CD}_4)$ at Hopi Point began its transit from NGS as SO_2 and that there was no loss from the plume due to wet or dry deposition. For a 12-h transit time and an oxidation rate of 0.06%/h, the maximum amount of secondary SO_4^{2-} aerosol generated during transit would be only $0.043 \mu\text{g}/\text{m}^3$ SO_4^{2-} . For a 48-h transit and a daily average homogeneous SO_2 oxidation rate of 0.03%/h, the concentration

¹²Figure 6.10 of the NPS-WHITEX report provides conversion rate estimates for December and March, two periods that bracket the February period of interest. Because the present objective is to estimate a lower limit on the SO_2 conversion, the conversion rate estimates for December are used. These conversion rates are consistent with experimental data on the SO_2 conversion rate that was observed to occur in the NGS plume during another visibility experiment (Richards et al., 1981).

would be only $0.086 \mu\text{g}/\text{m}^3 \text{SO}_4^{2-}$. Aerosol concentrations of this magnitude should have little effect on haze at Hopi Point. This conclusion is based on field measurements and on the relationship between SO_4^{2-} concentrations and haze (Trijonis et al., 1989).

From data in the NPS-WHITEX report on the primary-particle emission rate from NGS and the primary-particle concentration in the NGS plume, the committee also estimated an upper limit for the transport of primary-particle emissions from NGS to Hopi Point and concluded that NGS primary particles should not play an important role in GCNP haze.

The calculations above assume that the only effective processes are the generation of secondary aerosol through homogeneous gas-phase chemistry and the transport of primary aerosol. In reality, some depositional loss of SO_2 and aerosol during transport to Hopi Point is inevitable. Consequently, the actual contribution of NGS emissions would be lower than that calculated here.

Maximum Conversion of SO_2 to SO_4^{2-} . The maximum conversion rate would occur through heterogeneous oxidation of SO_2 by H_2O_2 (and O_3) to form SO_4^{2-} within cloud droplets. Video tapes show that clouds were present in the vicinity of the Grand Canyon during much of the study period. Measurements of H_2O_2 rarely are made in the atmosphere except in connection with a specific experimental program. None were made at or near the Grand Canyon during WHITEX. The nearest temporal and spatial measurements appear to be those of Van Valin et al. (1987). They found that for cloud-free conditions, H_2O_2 concentrations ranged between 0.1 and 0.5 ppb in February 1987 near Memphis, Tennessee, approximately the latitude of the Grand Canyon. Because H_2O_2 concentrations in the Grand Canyon were not measured, the committee assumed that, for the purpose of estimating the maximum oxidation rate, these data were representative of the NGS plume. If 0.1-0.5 ppb H_2O_2 reacts completely with SO_2 in an oxidant-limited system, about 0.4-2 $\mu\text{g}/\text{m}^3$ of SO_4^{2-} is formed. This concentration range includes the maximum 12-h average total SO_4^{2-} concentration measured at Hopi Point, 1.3 $\mu\text{g}/\text{m}^3$ (derived from Fig. 3) during February 11-12, and is below the limit of the maximum amount of NGS-sulfur that potentially could be present—6 $\mu\text{g}/\text{m}^3 \text{SO}_4^{2-}$ (2 $\mu\text{g}/\text{m}^3 \text{S}(\text{CD}_4)$).

This estimate suggests that the heterogeneous conversion of NGS-emitted SO_2 could account for virtually all of the SO_4^{2-} measured at Hopi Point on February 11-12. If all of the SO_4^{2-} measured at Hopi Point over February 11-12 were due to NGS emissions, then NGS definitely would have contributed to haze at Hopi Point. However, the validity of the assumptions regarding heterogeneous conversion are unknown.

Was there evidence that regional background $\text{SO}_4^{=}$ could have accounted for a significant fraction of the $1.3 \mu\text{g}/\text{m}^3$ $\text{SO}_4^{=}$ at Hopi Point on February 11?

This question can be addressed by examining the WHITEX data obtained at all sampling stations. Late on February 9, $\text{SO}_4^{=}$ levels were relatively uniform throughout the area northeast of NGS, in the range of $0.6\text{--}1 \mu\text{g}/\text{m}^3$ (Fig. 3). The same was true early on February 10, at all sites northeast of NGS except Monticello, where the concentration was about $1.4 \mu\text{g}/\text{m}^3$. (Data from Page were excluded from this background determination, because this site clearly was too close to NGS.) Thus, values in the range of $0.6\text{--}1 \mu\text{g} \text{SO}_4^{=}/\text{m}^3$ could be concluded to constitute the regional background for February 9, and early February 10.

Subsequent NGS emissions can be added to the background as the air mass passes over NGS and proceeds to GCNP. At Hopi Point on February 11, $\text{SO}_4^{=}$ concentrations were near $1.3 \mu\text{g}/\text{m}^3$. On February 12, the total $\text{SO}_4^{=}$ measured at Hopi Point was about the same as the initial regional $\text{SO}_4^{=}$ background estimate. If the committee's estimate of background $\text{SO}_4^{=}$ is correct, then the $\text{SO}_4^{=}$ increment above regional background that might be attributed to recent NGS emissions would be in the range of $0.3\text{--}0.7 \mu\text{g}/\text{m}^3$ out of the total $1.3 \mu\text{g}/\text{m}^3$ measured at Hopi Point on February 11.

The committee's assumption of the existence of background $\text{SO}_4^{=}$ concentrations says nothing about the possible sources of that background $\text{SO}_4^{=}$. It does not preclude the possibility that a significant portion of background $\text{SO}_4^{=}$ was derived from NGS emissions in the days preceding February 11. CD_4 concentrations at Mexican Hat and Monticello on February 9-10 were $8\text{--}9 \times 10^{-5}$ ppt (Appendix 2, p. 76-77). Samples collected at Green River, Canyonlands, and Bullfrog during this period were not analyzed for CD_4 . The measured concentrations imply an upper-bound NGS contribution of $0.15 \mu\text{g}/\text{m}^3$ $\text{SO}_4^{=}$ to the regional background, suggesting that on this occasion, most of the regional background $\text{SO}_4^{=}$ was actually not derived from NGS.

This illustration obviously is inexact; its primary purpose is to show the importance of accurate data on background concentrations for each air-parcel trajectory. Unfortunately, background $\text{SO}_4^{=}$ was not adequately addressed in the NPS-WHITEX report. A further analysis of the WHITEX data is warranted to assess the effect of regional background $\text{SO}_4^{=}$ on the amount of $\text{SO}_4^{=}$ measured at Hopi Point. Even if this analysis were pursued, background estimates at GCNP would remain uncertain, because the number of sampling stations was inadequate to evaluate this aspect. The existence of significant background $\text{SO}_4^{=}$ concentrations implies that, if NGS emissions were controlled, wintertime haze at GCNP likely would be reduced but not eliminated.

THE COMMITTEE'S CONCLUSIONS IN PERSPECTIVE

The committee cautions that its conclusions do not resolve whether EPA should require NGS to install the best available retrofit technology. First, the committee's conclusions are not binding on EPA or any other government agency. Second, even if accepted by EPA, the committee's conclusions would not dictate a particular result to EPA's rule making. Section 169A of the Clean Air Act generally requires the installation of BART on any "major stationary source" built after 1962 if that source "emits any air pollutant which may reasonably be anticipated to cause or contribute to any impairment of visibility" in a listed Class I area, such as GCNP. The phrase "may reasonably be anticipated" suggests that Congress did not intend to require EPA to show a precise relationship between a source's emissions and all or a specific fraction of the visibility impairment within a Class I area. Rather, EPA is to assess the risk in light of policy considerations regarding the respective risks of overprotection and underprotection (U.S. Congress, 1977). These considerations transcend scientific issues and are, therefore, outside this committee's purview.

CONCLUSIONS

The committee concludes that an experiment such as the WHITEX study provides a valuable data base that sheds light on the nature and magnitude of the haze problems at GCNP. The use of CD_4 as a tracer was innovative and added considerable power to the program. NPS and the members of the WHITEX team are to be commended for including the use of this unique and powerful tracer in WHITEX and for attempting to use CD_4 in qualitative and quantitative assessments of the impact of NGS emissions on haze at GCNP. The NPS mounted a very complex atmospheric measurement and analysis program at many field sites in a region that is logistically difficult to service, and NPS went well beyond the original planned feasibility study. On the basis of the data presented in the NPS-WHITEX report, the committee concludes that, at some times during the study period, NGS contributed significantly to haze at Hopi Point in GCNP. The committee bases this qualitative assessment on evaluations of meteorological, photographic, chemical, and other physical evidence.

The committee also concludes that aspects of the WHITEX data analysis preclude a quantitative determination of the exact fraction of the Grand Canyon haze problem that is attributable to NGS. These aspects are primarily related to problems with implementation and interpretation of multiple linear regression models. The NPS-WHITEX report makes few attempts to quantify

the sensitivity of the analyses to departures from model assumptions or to establish an objective and quantitative rationale for selecting among various statistical models. In addition, there were weaknesses in the data base. Especially damaging were the absence of measurements within the Grand Canyon itself and the inadequate consideration of background SO_4^{2-} concentrations in the vicinity of the GCNP.

The committee does not believe that its report resolves the regulatory issues before EPA regarding NGS. These issues involve policy considerations outside the committee's purview.

In closing, the committee stresses that the deficiencies of the NPS-WHITEX report appear largely due to unexpected problems that often accompany the use of new scientific approaches. WHITEX may, therefore, be valuable to other researchers in designing and carrying out source-attribution studies.