1. Introduction

Reason for the Study

In 1977, in Section 169A of the Clean Air Act, Congress set 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 results from manmade air pollution." Section 169A also required EPA to promulgate regulations to assure reasonable progress toward meeting the national goal for mandatory Class I areas where visibility is an important air quality related value. On November 30, 1979, EPA identified 156 areas, including Grand Canyon National Park (GCNP), where visibility is an important air quality related value. On December 2, 1980, EPA promulgated the required visibility regulations. In broad outline, the visibility regulations require the States to coordinate their air pollution control planning activities with the appropriate Federal Land Managers to develop a program to assess and remedy visibility impairment from new and existing sources.

More recently, Congress reaffirmed its desires to address visibility issues by adding section 169B to the Clean Air Act amendments of 1990. Section 169B calls for a substantial research program to study regional haze, and requires the Administrator of EPA to establish a visibility transport commission for the region affecting the visibility of GCNP.

In January and February, 1977, the National Park Service (NPS), acting in its capacity as the Federal Land Manager for GCNP, conducted a study known as the Winter Haze Intensive Tracer Experiment (WHITEX). WHITEX involved a six-week long intensive monitoring period during which an artificial tracer was released from the Navajo Generating Station (NGS) northeast of GCNP. National Park Service analysis of optical, air quality and meteorological data indicated a significant fraction of the haze in GCNP during this time period was due to sulfates resulting from NGS emissions (Malm *et al.*, 1989).

Salt River Project (SRP), the operators of Navajo Generating Station, conducted a study during early 1990. The SRP study also indicated a contribution of NGS emissions to haze in GCNP, but at a lower frequency of occurrence. A difference in prevailing meteorological conditions during the years of the NPS and SRP studies would at least partially account for the differences in magnitude and frequency of impacts identified by the two studies. The results and limitations of the NPS and SRP studies are described briefly in section 2.

Based on these studies and additional evidence presented, EPA has proposed regulations that would require substantial reduction of sulfur dioxide emissions from NGS. While NGS has been linked to a portion of the haze at GCNP, it is generally recognized that a number of other area and point sources also contribute to haze at GCNP. One potential source is the Mohave Power

Project (MPP), a 1580 Megawatt, coal-fired steam electric power plant located in Laughlin, Nevada, southwest of GCNP and operated by the Southern California Edison Company (SCE). Like NGS, MPP has no pollution control equipment for sulfur dioxide. Congress, desirous of additional information concerning the sources of visibility impairment in GCNP, added $2.5 million to the fiscal 1991 appropriation for EPA to conduct "a pollution tracer study at the Mohave Powerplant". Project MOHAVE (Measurement Of Haze And Visual Effects) is EPA's response to this congressional mandate.

Goals of the Study

The primary goal of Project MOHAVE is to determine the contribution of the MPP to haze at GCNP and other mandatory Class I areas where visibility is an important air quality related value. This implies a quantitative evaluation of the intensity, spatial extent, frequency, duration and perceptibility of the MPP contribution. The improvement in visibility that would result from control of MPP emissions is included in the primary goal. Secondary goals include an increased knowledge of the role of other sources on haze in GCNP and the southwestern United States in general. Because knowledge of regional transport and air quality levels is necessary to separate the effect of MPP from other sources, meeting the primary goal will result in increased knowledge about the impacts from other sources.

It is hypothesized that the maximum impacts of MPP on visibility at GCNP occur during periods with clouds present (to facilitate transformation of SO_2 to sulfate) and wind directions that transport the MPP plume toward GCNP. The study is designed to test this hypothesis.

Project MOHAVE Organization

The EPA Office of Air Quality Planning and Standards (OAQPS) in Durham, North Carolina has overall management responsibility for Project MOHAVE. Robert Bauman is the manager of Project MOHAVE and has selected staff from the Environmental Monitoring Systems Laboratory (EMSL) in Las Vegas as the technical advisors. Staff includes Marc Pitchford, a National Oceanic and Atmospheric Administration (NOAA) employee assigned to EPA and Dr. Mark Green, a Desert Research Institute (DRI) employee working under a cooperative agreement with EPA. To be advised in the overall direction of the study, Mr. Bauman has formed a steering committee composed of government and industry scientists. The steering committee includes:

Dr. Carol Ellis	Southern California Edison Company
Dr. William Malm	National Park Service
Dr. Peter Mueller	Electric Power Research Institute
Marc Pitchford	EPA (EMSL-LV)

Dr. William Wilson EPA (AREAL)

Temporary technical advisory panels provided recommendations during a planning workshop, as discussed later in this section. Coordination committees, composed of Project MOHAVE participants and their contractors responsible for various components of the study, will meet on an ad hoc basis to refine and coordinate in the following areas:

(1) Monitoring
(2) Modeling
(3) Data Management
(4) Data Analysis

These committees will facilitate joint analyses with SCE and other contributing participants. The participants in Project MOHAVE include Federal agencies, universities and private companies. A list of the main participants and their areas of responsibility is given in the summary table presented in Appendix 1.

Study Planning and Review to Date

The first significant planning effort was the formulation of a conceptual study plan. The conceptual plan outlined the main components of the study and gave generalized approaches for each aspect of the study. Preliminary monitoring locations and schedules were also identified. The purpose of the conceptual plan was to serve as a preliminary planning document to provide a common starting point for outside review. The conceptual plan was reviewed by (1) the Project MOHAVE steering committee, (2) members of the Haze in National Parks and Wilderness Areas Committee of the National Research Council, National Academy of Sciences (3) participants in a Project MOHAVE planning workshop (a group of about 40 experts), and (4) various other individuals. The conceptual plan underwent several revisions; the most recent version, which led to the current plan, is presented in Appendix 2.

The Haze in National Parks and Wilderness Areas Committee was briefed on the conceptual plan on March 14, 1991 at the University of California-Irvine. Individual members of the Committee asked clarifying questions and made some suggestions on the conceptual plan. Several of the members made additional comments at later dates. The Committee as a whole did not comment on the plan.

During the week of April 23, discussions were held between SCE, DRI, and EPA in Las Vegas to formulate conceptual models of conditions during which MPP emissions may be transported to GCNP. This included a review of the dynamic processes affecting MPP plume transport and dispersion, and the diurnal and seasonal variation of these processes. Also considered were issues concerning chemical transformation and deposition, in particular gas-phase and aqueous phase oxidation and the roles of clouds and H_2O_2. These discussions and

a summary of the meeting provided by SCE and DRI helped in selecting the intensive study periods as well as providing insight about the important physical mechanisms.

A planning workshop was held April 30-May 2 in Denver. Thirty-nine individuals with expertise in one or more study components attended. A plenary session was held first during which the conceptual plan was presented. Following the plenary session, subgroups met to make recommendations on the study components. The subgroup topic areas were: 1) tracer, 2) air quality measurements, 3) emissions, 4) deterministic modeling and upper air measurements, and 5) quality assurance. Another plenary session followed, during which clarifying questions were asked and different subgroups coordinated their plans. The subgroups again met to compile recommended study components; these were presented in a final plenary session. After the workshop, a small group met to evaluate the recommendations and plan the implementation of the study. A list of the participants attending the workshop appears in Appendix 3.

In July 1991, a table summarizing the main components of the study and the responsible persons for each component, and a map showing expected monitoring locations were prepared. These were sent out to study participants. The purposes of the summary table and map were to provide an update on the plan and to ensure that the Project MOHAVE staff and other study participants had a mutual understanding of the responsibilities and plans for each study component. The summary table was updated after review by participants. It is presented in Appendix 1. More detailed descriptions of the information in the summary table appear in subsequent sections of this plan.

Study Schedule

The field measurement portion of the study will last for one year, from September 1991 through August 1992. Intensive monitoring and tracer release periods are scheduled for January 4-31, 1992 and July 15-August 25, 1992. A list of milestones of and anticipated dates of completion major operational phase is given below. Coordination, data review, and planning meetings will be scheduled as appropriate.

MILESTONE	DATE
Deploy year-round monitoring equipment	9/91
Deploy winter intensive equipment	11/91-12/91
Winter intensive study	1/92
Begin data processing	3/92

Preliminary analysis of winter intensive	5/92
Deploy summer intensive equipment	6/92
Summer intensive study	7/92-8/92
End monitoring	9/92
Preliminary analysis of summer intensive	12/92
Receive final monitoring and modeling data	3/93
Draft report	7/93
Final report	12/93

Plan Organization

This plan is composed of 12 sections and 8 appendices. Section 2 discusses current knowledge, including recent tracer studies and data available for further study. Section 3 provides an overview of the field study design in terms of monitoring locations and schedules. Section 4 describes the tracer aspects of the study. Sections 5-7 discuss the air quality, meteorological, and optical monitoring plans. Emission inventory and source characterization are outlined in Section 8. In Section 9, data management and validation are discussed. Section 10 details the descriptive data analysis and interpretation study components. The methods of attribution to be used appear in Section 11. Section 12 describes the overall quality assurance plan.