VISIBILITY INDEX
BASELINE PROJECT

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FOREWORD

In order to attempt to develop a visibility index for Bernalillo County, NM, the City of Albuquerque, Environmental Health Department, Air Quality Division conducted a visibility index baseline project. Air Quality Index values for particulates were compared with measured visibility data and correlated to digital images.

This document will detail the components of the project and provide guidance for the continuation of this important work. This document serves as a final report to the City Council as required by FY2004 Priority Objective #8 under Environmental Protection and Enhancement Goal (R-03-210) and continued in FY2005 Priority Objective #5 under the Environmental Protection and Enhancement Goal (R-04-65).

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1.0 Purpose

The purpose of the Visibility Index Baseline Project is to attempt to correlate measured health based Air Quality Index values for particulate matter with measured visibility data. It is anticipated that this process can be used to correlate visual air quality with an acceptable visual range structured on health-based data.

2.0 Funding

The project was funded by the US EPA Fine Particulate Matter (PM) Grant. The analytical infrastructure included a visibility monitor (nephelometer), two digital cameras, two computers, and supplies. It should be noted that the operations of the systems have continued to be funded through this grant program and the Air Quality Division anticipates that EPA will continue the funding through the next federal funding cycle, beginning in October 2005 and ending in September 2006.

3.0 Scope

The conceptual model used for establishing a visibility baseline is one that correlates the City of Albuquerque (COA), Environmental Health Department (EHD), Air Quality Division's (AQD)Ambient Air Monitoring Network measured particulate matter data in the categories of coarse and fine particulate matter, (coarse particulate matter is smaller than 10 microns in aerodynamic diameter, fine particulate matter is 2.5 microns and smaller in aerodynamic diameter) and measured visibility data, so that a visibility index for the Middle Rio Grande Airshed can be attempted. Particulate matter data interpolation and correlation to a library of digital photos will be evaluated so that a, or some, model may be explored for attempting to establish the visibility baseline. It should be noted that this preliminary work is limited to federal funding. In order to pursue and implement a long-term study, a funding source must be identified.

4.0 Causes of Visibility Impairment

Visibility impairment is caused by the scattering and absorption of light by particles and gases emitted by, or formed as a result of, natural and human-caused activities. Air pollution limits the distance one can see as well as degrades the color, clarity and texture of a scene.

The concentration and size of the particles in the air play an important role in reducing visibility, as does the humidity of the air. Small particles are inefficient *scatterers* of light however, as particles gets larger to about 0.1 micron in size, they scatter light more efficiently causing a greater reduction in visibility. Larger particles (greater than 2.5 microns) are much less efficient in scattering light and contribute less towards visibility reduction.

Fine particles, particles less than about 2.5 microns, tend to be man-made, while coarse particles (larger than 2.5 microns), tend to have a natural origin. Fine particles cause most of the visibility impairment and have the greatest adverse health effects.

"Meteorological factors, such as wind, cloud-cover, rain and temperature are affected by pollution, and they in turn affect pollution. Pollutants emitted that are well mixed will appear as a uniform haze. When pollutants are emitted into a stable atmosphere, usually one of two things will happen, depending on whether there is surface wind or not. If a wind is present, the emitted pollutants usually form a plume. If there are no surface winds or if pollutants are emitted into a stagnant air mass over periods of days, a layer of haze forms near the ground and continues to build as long as the stagnation condition persists. Layered hazes are usually associated with emissions that are local in nature as opposed to pollutants that are transported over hundreds of kilometers." (National Park Service, 1999, Introduction to Visibility, p. 19)

5.0 Overview

Figure 1 on page three shows the placement of the visibility monitor at the Del Norte High School Ambient Air Monitoring station. The location was selected because of the analytical infrastructure of the station and its solar angle perspective for year-round digital photo acquisition. In order to understand visibility impairments it is important to note that when measuring particulate matter visibility impairments the observer, in this case the digital cameras, the sun must be behind the observer. This technique is based on the US EPA Method 9 for Visual Determination of the Opacity of Emissions from Stationary Sources.

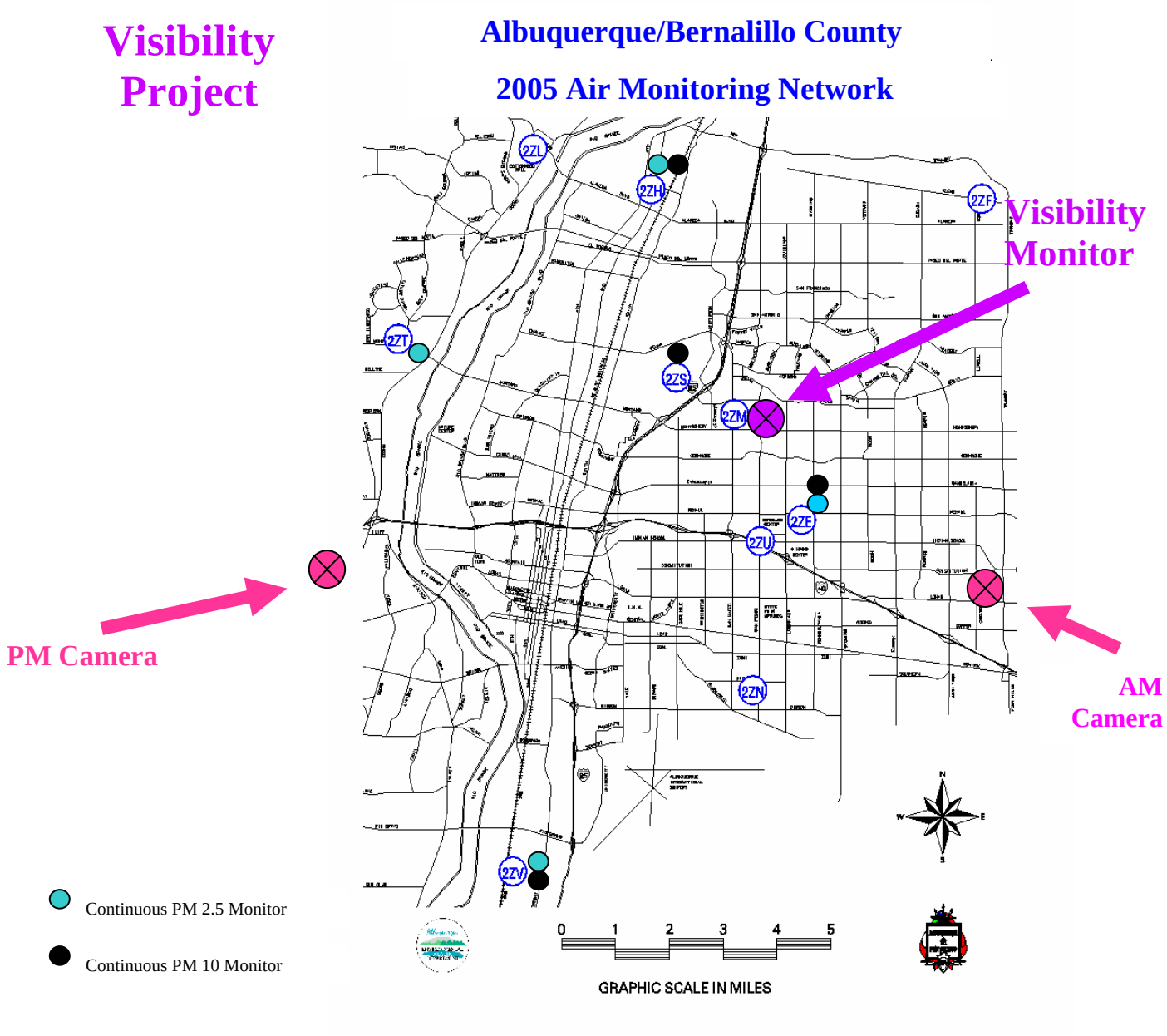

Figure 1 – Map of Continuous PM 10, PM 2.5 Ambient Air Monitors and Visibility Monitor & Digital Camera Placement

Two digital cameras were installed at strategic vantage points that maintained the integrity of the Method 9 technique. The east side camera that is installed on the APD Foothills substation, located at Chelwood and Lomas takes hourly photographs in the morning to early afternoon. The APD Foothills camera captures photos viewing west of the Uptown area with the Jemez volcanoes in the background (Photo 1). The west side camera that is installed on the 911 COMM Center, at 114th Street and Sunset Gardens takes hourly photographs in the afternoon to evening. The 911 COMM Center camera captures photos eastern views of the Downtown area with the Sandia/Manzano range in the background (Photo 2). Both cameras capture photographs with the visibility monitor within their view.

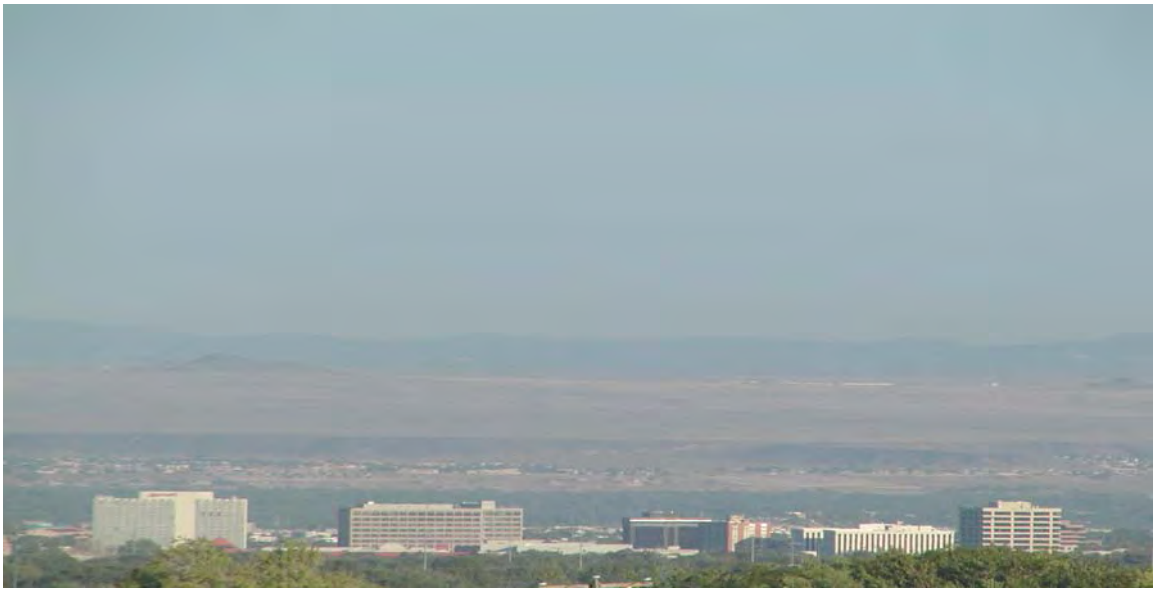

Photo 1 –Western View of Uptown area with the Jemez Volcanoes in Background

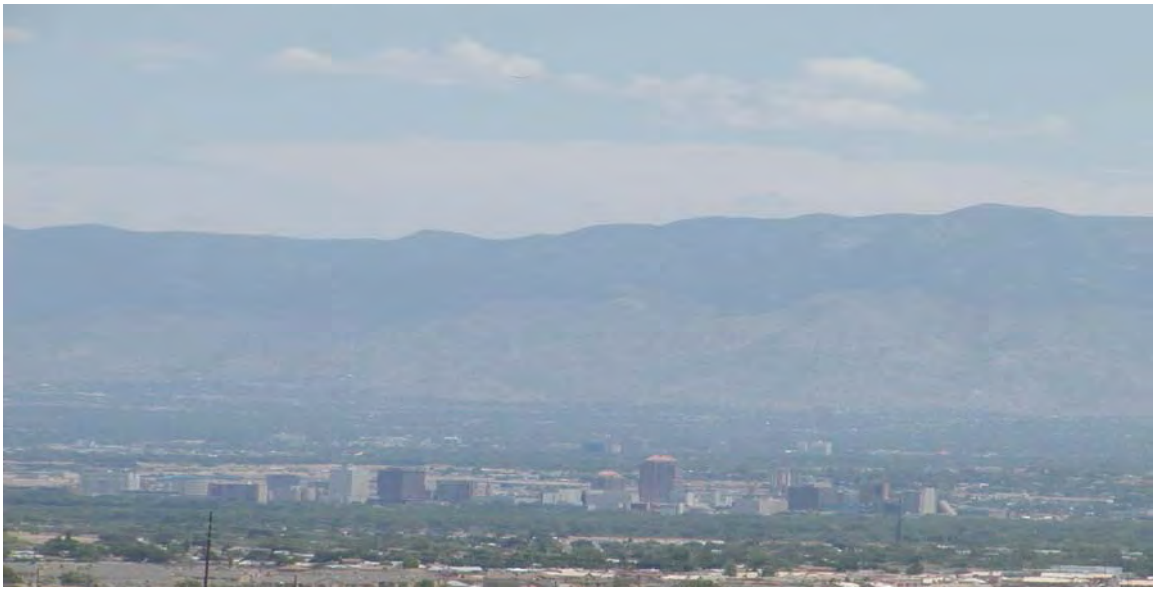

Photo 2 – Eastern View of Downtown area with Sandia/Manzano Range in Background

6.0 Instrumentation

The following is a description of the equipment used for this project:

6.1 Nephelometer:

The Optec NGN-2 integrating nephelometer (Photo 3) is used to assess visibility impairment by estimating the particle scattering coefficient of ambient air. The nephelometer provides a direct measurement of the light scattered by aerosols and gases in a sampled air volume.

Photo 3 – NGN-2 Nephelometer at Del Norte Ambient Air Monitoring Station

6.2 Digital Cameras:

The digital cameras (Olympus model C2100) used in this project are capable of capturing, storing, and transmitting high-resolution digital images. Each system consists of a high-resolution digital camera and a supporting computer with image capturing software.

Digital images are captured every hour, stored on the system's internal hard drive, and uploaded by telephone to AQD's server. Photo 4 is a picture of the COMM Center camera site and Photo 5 depicts the Foothills camera site.

Photo 4 – COMM Center camera site

Photo 5 – Foothills camera site

7.0 Method

The conceptual method for development of a visibility baseline is based upon the health based US EPA's Air Quality Index (AQI). The purpose of the AQI is to help you understand what local air quality means to your health. To make it easier to understand, the AQI is divided into six categories:

Each color-coded category corresponds to a different level of health concern. The six levels of health concern and what they mean are:

- **"Good"** The AQI value for your community is between 0 and 50. Air quality is considered satisfactory, and air pollution poses little or no risk.
- **"Moderate"** The AQI for your community is between 51 and 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms.
- **"Unhealthy for Sensitive Groups"** When AQI values are between 101 and 150, members of sensitive groups may experience health effects. This means they are likely to be affected at lower levels than the general public. For example, people with lung disease are at greater risk from exposure to ozone, while people with either lung disease or heart disease are at greater risk from exposure to particle pollution. The general public is not likely to be affected when the AQI is in this range.
- **"Unhealthy"** Everyone may begin to experience health effects when AQI values are between 151 and 200. Members of sensitive groups may experience more serious health effects.
- **"Very Unhealthy"** AQI values between 201 and 300 trigger a health alert, meaning everyone may experience more serious health effects.
- **"Hazardous"** AQI values over 300 trigger health warnings of emergency conditions. The entire population is more likely to be affected.

It is anticipated that building off the AQI will give the visibility baseline approach a credible health-based foundation.

In this attempt to correlate the AQI, visibility data, and digital cameras photos, it will be necessary to evaluate very clear low-particulate matter data (usually after heavy rains) to very high-particulate matter data (usually during fire episodes). It should be noted that the Central Rio Grande Airshed is typically in *GOOD* to *Mid-MODERATE* AQI ranges. A cleaner environment will definitely have an impact to the statistical feasibility of data interpretation.

7.1 Data Interpolation Method

The hourly PM 10 AQI values for the Singer Chappell Monitoring Station (2ZS) were evaluated on 5/20/04, and compared to the visibility measured at the Del Norte Monitoring Station. As expected, Figure 2 shows that as the AQI value increases, visibility decreases.

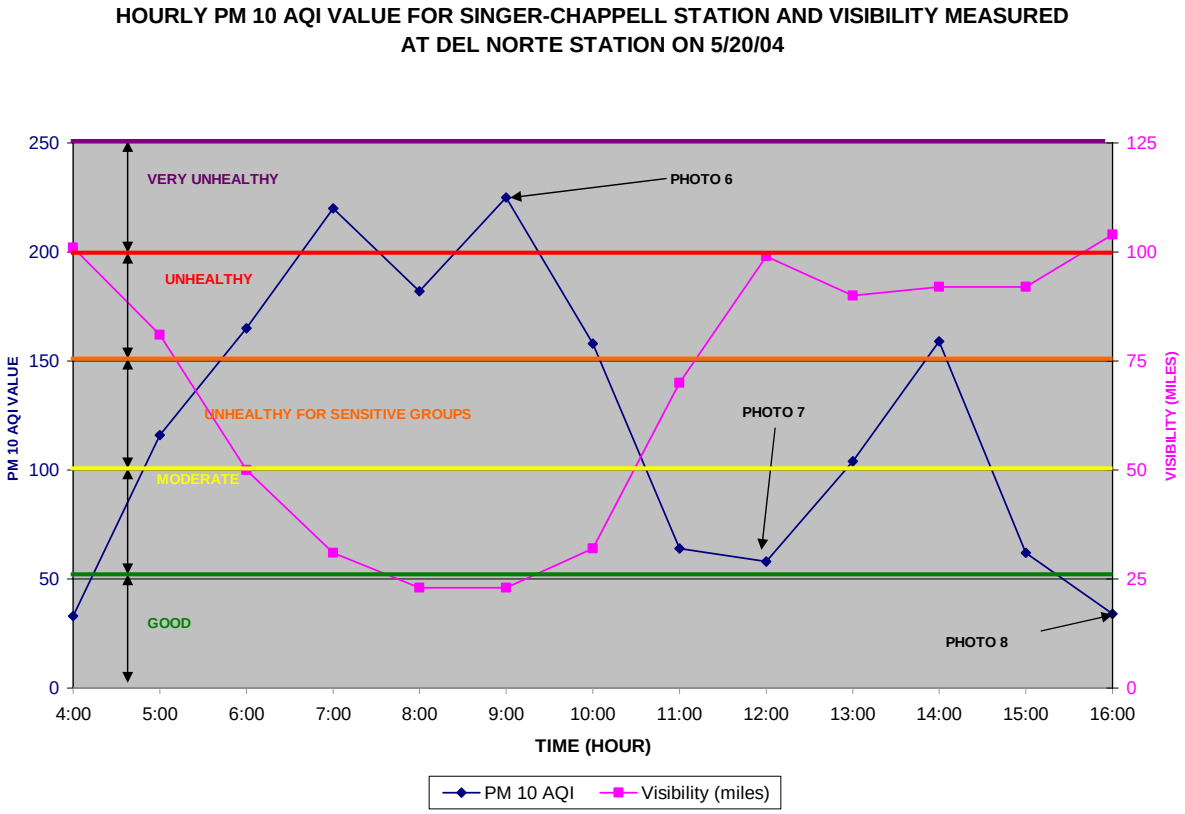

Figure 2 Graph of PM 10 AQI Values versus PM 10 Concentration

Photos 6, 7 and 8 are pictures taken on 5/20/04 when the hourly PM 10 AQI values varied from 33 up to 225. The pictures clearly show a gradual improvement in visibility as the AQI decreases.

Photo 6 - FOOTHILLS AT 09:00 ON 5/20/04 – AQI VALUE OF 225, VISIBILITY AT 23 MILES

Photo 7 – FOOTHILLS AT 12:00 ON 5/20/04 – AQI VALUE OF 58, VISIBILITY AT 99 MILES

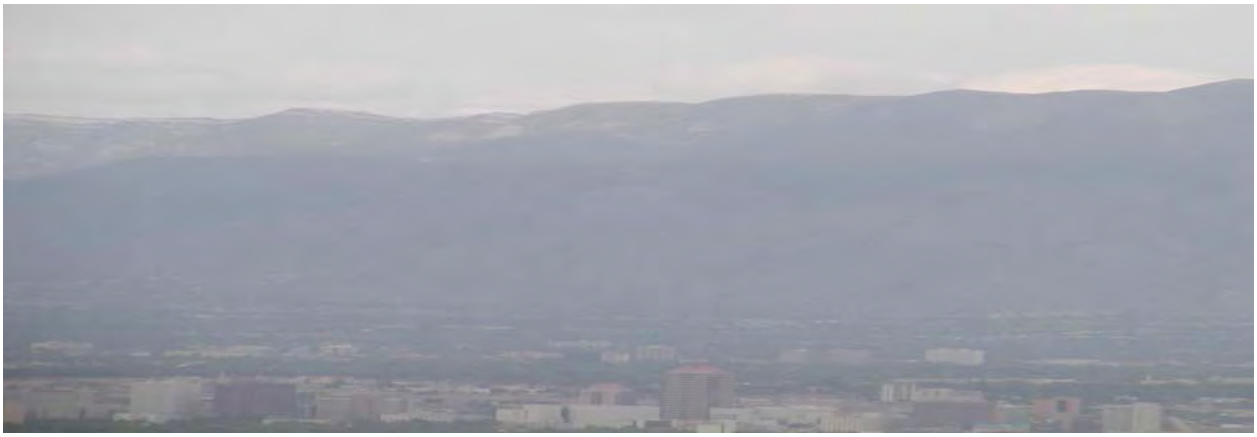

Photo 8 – COMM CENTER AT 16:00 ON 5/20/04 – AQI VALUE OF 34, VISIBILITY AT 104 MILES

The PM 2.5 AQI value for the South Valley Monitoring Station for 10/24/03 was compared to the visibility measured at the Del Norte Monitoring Station. Figure 3 below also shows that as the AQI increases, visibility decreases.

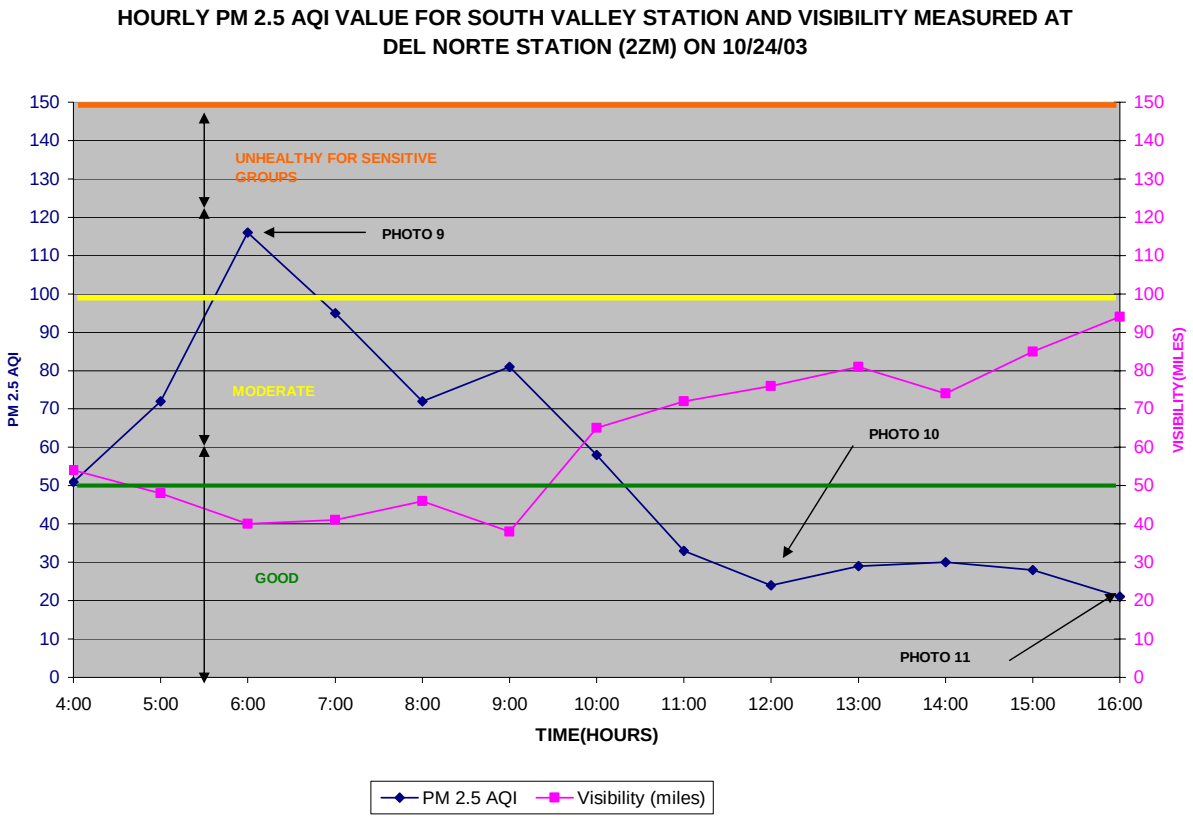

Figure 3 Graph of PM 2.5 AQI Values versus PM 2.5 Concentration

Photos 9, 10, and 11 were pictures taken on 10/23/04 when the hourly PM 2.5 AQI values varied from 21 up to 116. The pictures clearly demonstrate that the clarity of images improves as the AQI decreases.

Photo 9 – FOOTHILLS AT 06:00 ON 10/24/03 – AQI VALUE OF 115, VISIBILITY AT 40 MILES

Photo 10 – COMM CENTER AT 12:00 ON 10/24/03 – AQI VALUE OF 24, VISIBILITY AT 77 MILES

Photo 11 – COMM CENTER AT 16:00 ON 10/24/03 - AQI VALUE OF 21, VISIBILITY AT 95 MILES

8.0 Future Work

In order to establish a better correlation between particulate matter and visibility, it is necessary to increase the number of real time nephelometers to all sites operating continuous PM fine monitors. In addition, the number of camera sites should also be increased to capture more digital images for baseline data.

It is anticipated that with an expanded network of visibility monitors and digital cameras, an interactive visibility web application can be developed. It is envisioned that this application will provide the public with access to daily digital images and associated visibility index.

The funding utilized for this project will expire on 9/30/06. Long-term funding must be obtained to continue this project.

9.0 References:

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