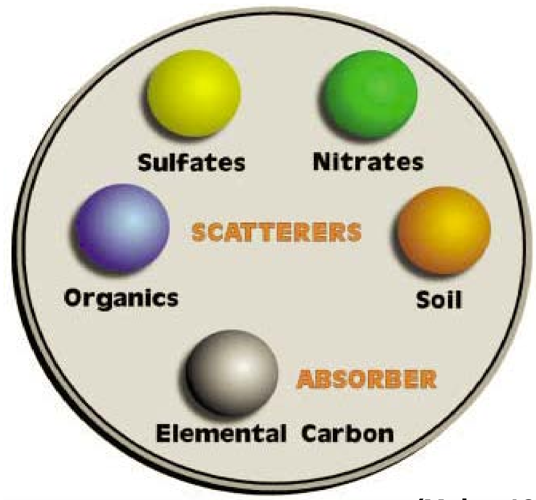
2011 Regional Haze & Visibility

New Jersey Department of Environmental Protection

THE BASICS OF HAZE

Haze is a type of visibility impairment usually associated with air pollution, and to a lesser extent, moisture in the atmosphere. Small particles and certain gaseous molecules can cause poor visibility by scattering or absorbing light before it reaches an observer (Figure 1). When high concentrations of such pollutants are well mixed in the atmosphere they form a uniform haze that can obscure distant objects.

Figure 1
Contributors to Visibility Impairment



(Malm, 1999)

Air pollutants come from a variety of natural and man-made sources and can occur at any time of year. Natural sources include small particles at the ocean surface and windblown dust and soot from wildfires and volcanoes. Man-made sources, which are the primary cause of visibility impairment includes motor vehicle emissions, electric utility and industrial fuel burning emissions, and manufacturing operations.

Pollution from both natural and man-made sources can be transported over long distances and across state boarders on prevailing winds causing the problem of regional haze.

ANATOMY OF REGIONAL HAZE

Data collected over the last decade shows that fine particle concentrations are highest in the industrialized and densely populated areas of the Northeast and Mid-Atlantic. These particles are a major contributor to visibility impairment at all times of the year. The following categories of air pollutants are the major contributors to haze. (Source - www.hazecam.net)

Sulfate particles form in the air from sulfur dioxide gas. Most of this gas is released from coal-burning power plants and other industrial sources, such as smelters, industrial boilers, and oil refineries. Sulfates are the largest contributor to haze in the eastern U.S., due to the large number of coal-fired power plants that affect the region. In humid environments, sulfate particles grow rapidly to a size that is very efficient at scattering light, thereby exacerbating the problem in the East.

Organic carbon particles are emitted directly into the air and are also formed by the reaction of various gaseous hydrocarbons. Sources of direct and indirect organic carbon particles include vehicle exhaust, vehicle refueling, solvent evaporation (e.g., paints), food cooking, and various commercial and industrial sources. Gaseous hydrocarbons are also emitted naturally from trees and from fires, but these sources usually have only a small or short-term effect on overall visibility.

Nitrate particles form in the air from nitrogen oxide gas. This gas is released from virtually all combustion activities, especially those involving cars, trucks, off-road engines (e.g., construction equipment, lawn mowers, and boats), power plants, and other industrial sources. Like sulfates, nitrates scatter more light in humid environments.

Elemental carbon particles are very similar to soot. They are smaller than most other particles and tend to absorb rather than scatter light. The "brown clouds" often seen in winter over urban areas and in mountain valleys can be largely attributed to elemental carbon. These particles are emitted directly into the air from virtually all combustion activities, but are especially prevalent in diesel exhaust and smoke from the burning of wood and wastes.

Soils are very similar to dust. It enters the air from dirt roads, fields, and other open spaces as a result of wind, traffic, and other surface activities. Whereas other types of particles form from the condensation and growth of microscopic particles and gasses, crustal material results from the crushing and grinding of larger, earth-born material. Because it is difficult to reduce this material to microscopic sizes, crustal material tends to be larger than other particles and tends to fall from the air sooner, contributing less to the overall effect of haze.

Particles and Visibility

Figure 2 (below) shows the makeup of fine particles collected at the Interagency Monitoring of Protected Visual Environments (IMPROVE) site located north of Atlantic City in the Edwin B. Forsythe National Wildlife Refuge (Brigantine).

Figure 2
Composition of Fine Particles on Days with Good Visibility Compared to Days with Poor Visibility
Brigantine, NJ
July 2010 – June 2011**

Average Fine Mass Composition on Days with Good Visibility

Ammonium Nitrate	0.20 µg/m³	10.7%
Ammonium Sulfate	0.98 µg/m³	53.2%
Elemental Carbon	0.10 µg/m³	5.4%
Organic Carbon	0.46 µg/m³	24.9%
Soils	0.11 µg/m³	5.9%
Total 1.85 µg/m³		

Average Fine Mass Composition on Days with Poor Visibility

Ammonium Nitrate	2.79 µg/m³	20.0%
Ammonium Sulfate	6.70 µg/m³	48.1%
Elemental Carbon	0.60 µg/m³	4.3%
Organic Carbon	2.92 µg/m³	21.0%
Soils	0.92 µg/m³	6.6%
Total 13.94 µg/m³		

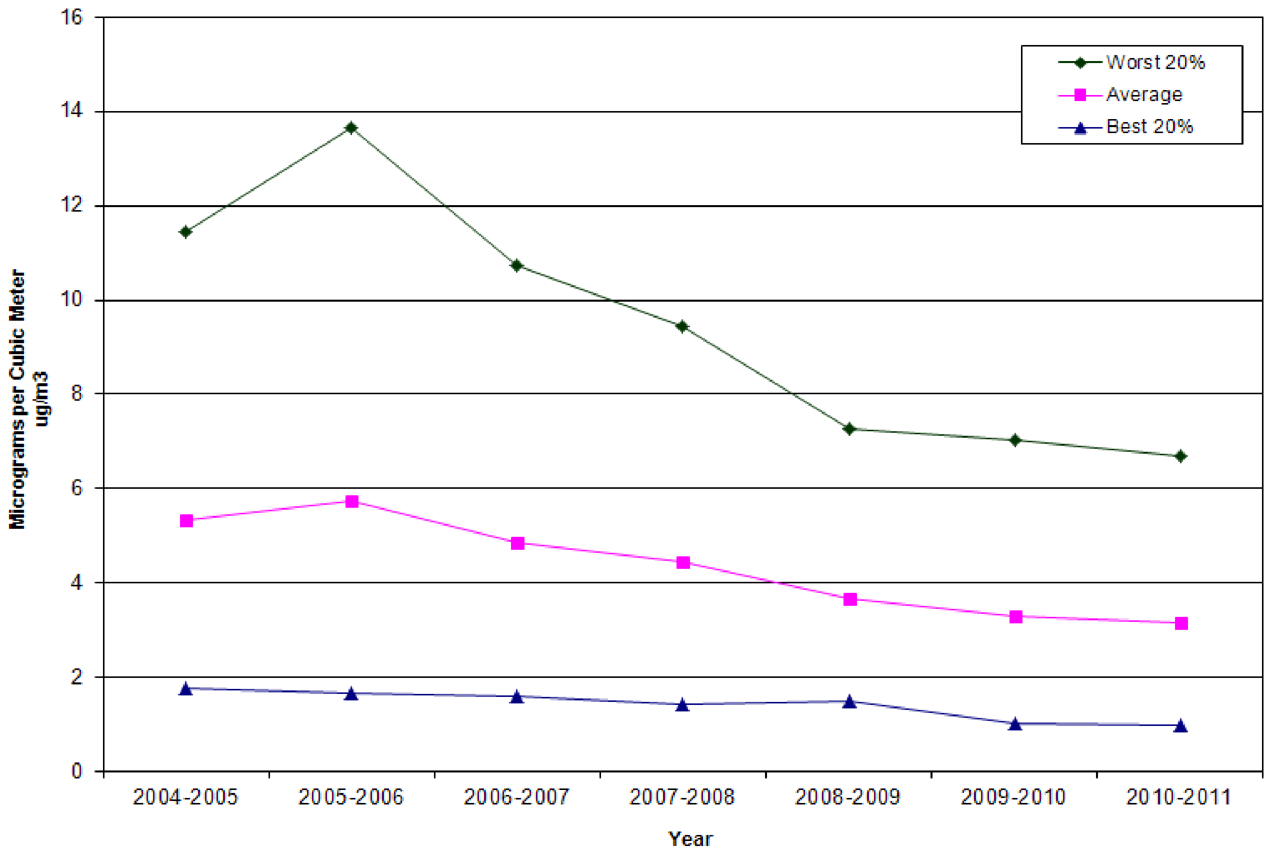
** For this report annual data for a given year is defined as data from July 1st – June 30th of the following year

Most visibility impairment is due to sulfate, which can have a greater effect on light extinction (a measure of visibility impairment), due to its ability to accumulate water and grow in size during humid conditions. Evaluations of the data for 2010-2011 indicate that sulfates accounted for approximately half of the total fine particle mass on both days with good and bad visibility. Higher sulfate values in the summer can be attributed to the greater photochemical conversion of sulfur dioxide (SO2) to sulfate that result from the increased sunlight during the summertime. (Malm, 1999)

The graph below (Figure 3) represents the annual trend of sulfates expressed in micrograms per cubic meter measured at the Brigantine National Wildlife Refuge.

The graph shows the annual average for each year as well as the average concentration on the days with the best visibility, and the average on the days with the worst visibility, using the upper and lower 20% of the data as a cut off. Sulfate trends have improved over the last few years as a result of more stringent guidelines from both the United States Environmental Protection Agency (USEPA) and statewide planning to improve overall air quality and visibility issues.

Figure 3
Sulfate Trend Summary**
Brigantine, NJ
2004-2011



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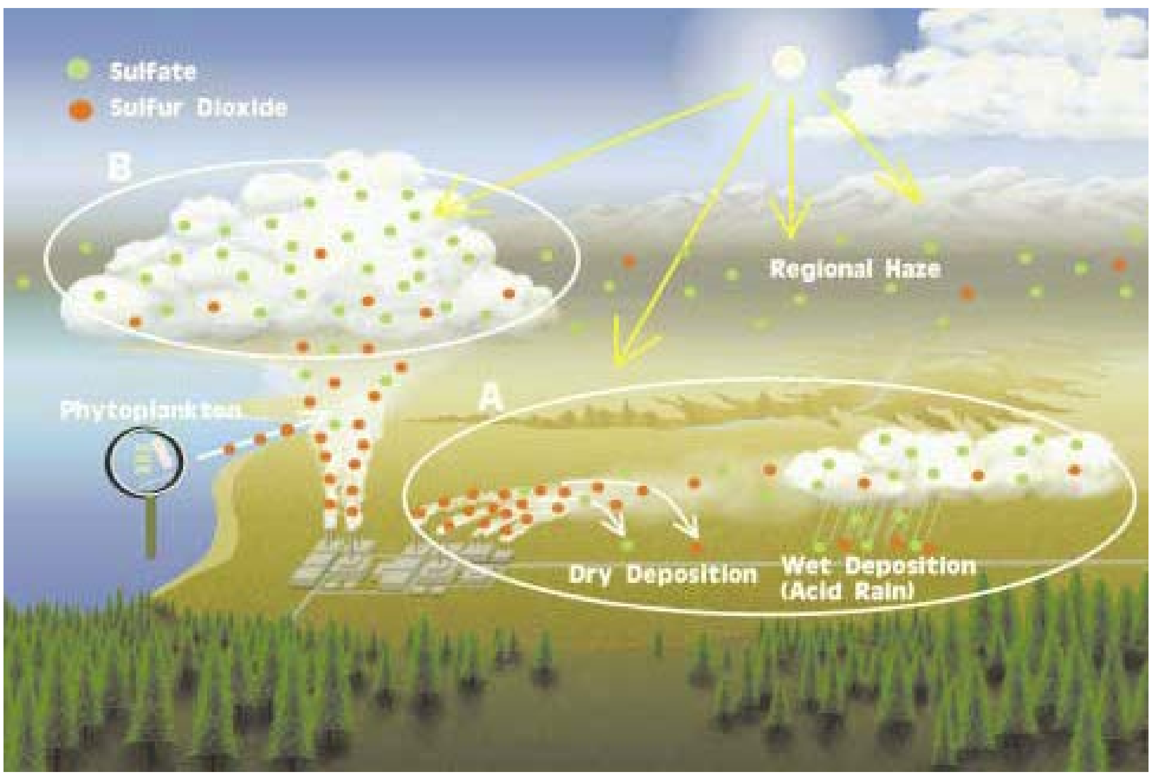
How is Haze Regulated?

In 1999, the U.S. Environmental Protection Agency announced a major effort to improve air quality in national parks and wilderness areas aimed at achieving national visibility goals by 2064. The Regional Haze Rule calls for state and federal agencies to work together to improve visibility in 156 National Parks and wilderness areas such as the Grand Canyon, Yosemite, the Great Smokies and Shenandoah. This "regional haze rule" addresses the combined visibility effects of numerous pollution sources over a wide geographic region and how they impact Class I areas. Class I areas, as defined by the Clean Air Act, include national parks greater than 6,000 acres, wilderness areas and national memorial parks greater than 5,000 acres, and international parks that existed as of August 1977. This definition includes the Edwin B. Forsythe National Wildlife Refuge in Brigantine, New Jersey. The rule requires the states, in coordination with the Environmental Protection Agency, the National Park Service, U.S. Fish and Wildlife Service, the U.S. Forest Service, and other interested parties, develop and implement air quality protection plans to reduce the pollution that causes visibility impairment. The first State plans for regional haze were due in the 2003-2008 timeframe. New Jersey proposed its first plan in September 2008 and was finalized in July 2009 for its Class I Area in Brigantine.

ENVIRONMENTAL EFFECTS

Regional haze is most closely associated with its effects on prized vistas such as the Grand Canyon, Acadia National Park, or Class I Areas, such as Brigantine. Its impacts may be difficult to quantify but it certainly has a negative overall effect on aesthetics and the outdoors, and how natural areas throughout the nation are enjoyed. Haze also affects urban areas and scenes, and can obscure or eclipse the view of an urban skyline or other important urban landmarks such as the Washington Monument. The pollution that causes regional haze has additional effects on the environment through the acidic makeup of fine particles, such as sulfates. Sulfates eventually make their way into the ecosystem through atmospheric deposition - that is, they are transferred from the air into the water and soils (Figure 4). Too much atmospheric deposition can have adverse environmental effects by upsetting the delicate balance of the ecosystem; thus, causing damage to waterways, plants, soils, and wildlife (see section on Atmospheric Deposition).

Figure 4
Illustration of How Sulfates Enter the
Ecosystem by way of Deposition



Monitoring of Haze in New Jersey

Typical visual range in the eastern U.S. is 15 to 30 miles, or about one-third of what it would be without man-made air pollution. In the West, the typical visual range is 60 to 90 miles, or about one-half of the visual range under natural conditions. Haze diminishes this natural visual range. (www.hazecam.net).

Visibility and haze are monitored in two locations in New Jersey, Newark and Brigantine. The monitor in Newark measures the impact of haze on visibility by using a digital camera. The camera is located inside the New Jersey Transit building and is pointed at the New York City skyline. On clear days the entire skyline, as well as each individual building, is easily distinguishable (Figure 5). The Manhattan skyline appears non-existent when conditions conducive to haze formation are in place (Figure 6).

Visibility Camera – New Jersey Transit Building

Figure 5

Figure 6

The IMPROVE site located within the Edwin B. Forsythe National Wildlife Refuge in Brigantine monitors haze and visibility using a digital camera. Figure 7 below is an example of a clear day in Brigantine as the Atlantic City skyline is easily distinguishable along the horizon. The example of a hazy day in Brigantine is illustrated below in Figure 8 and the skyline is barely visible.

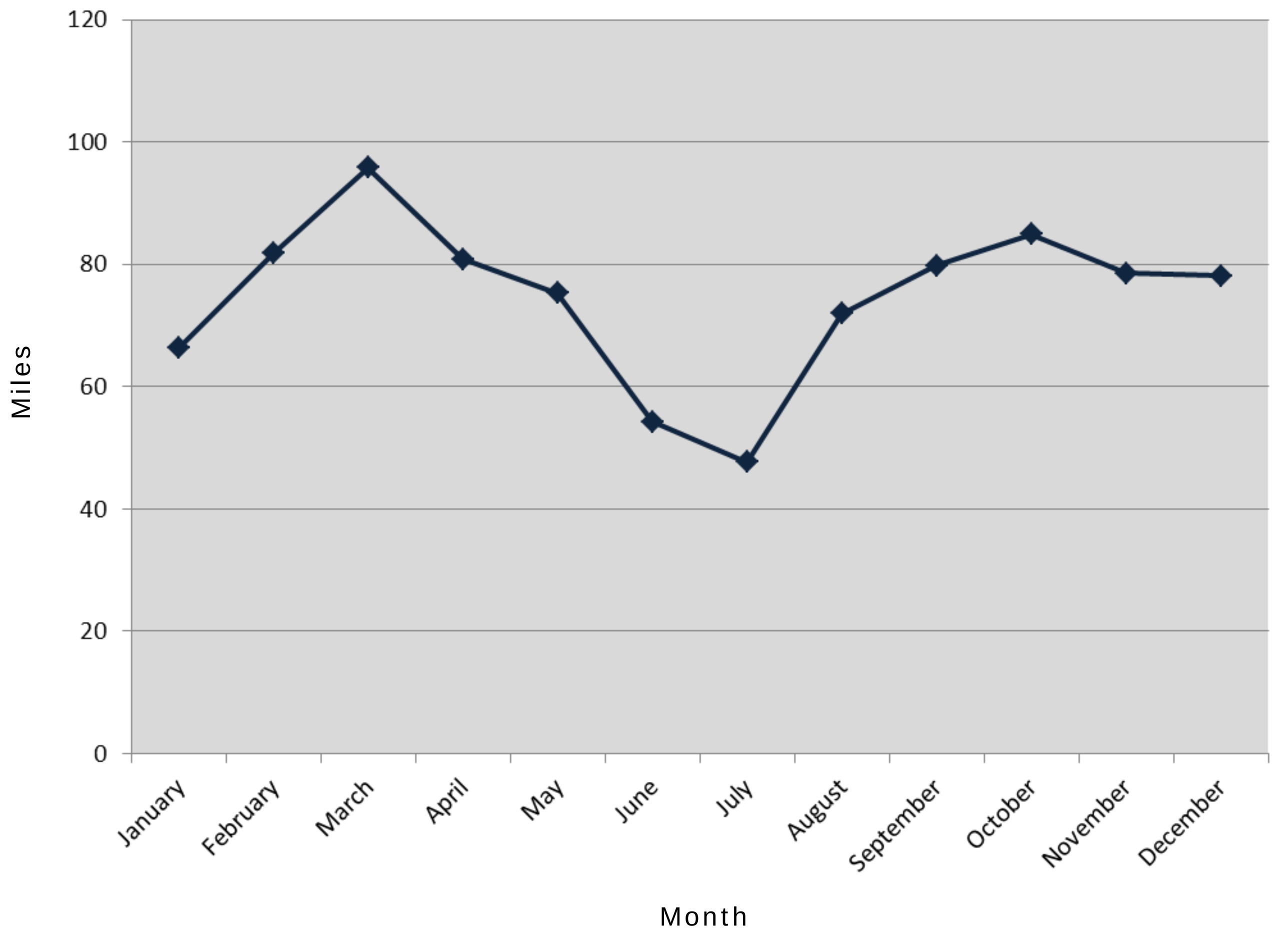
Visibility Camera – Brigantine National Wildlife Refuge

Figure 7

Figure 8

Brigantine also provides a real-time direct measurement of the light scattered by particles in the air that can interfere with visibility using a nephelometer. The data below (Figure 9) helps distinguish visual range in miles using a monthly average. This graph shows that monthly visual range is most impaired during the summertime months when hazy and humid conditions are most apparent.

Figure 9
Monthly Average Visual Range
Brigantine, NJ



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