Ozone

Background

Ozone found in the lower atmosphere, or ground-level ozone (often called smog) is created by chemical reactions involving nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight and warm temperatures.

High ground-level ozone is harmful to human health and the environment. The impacts on human health range from eye irritation to severe respiratory distress that can lead to chronic illness and premature death. Ground-level ozone lowers resistance to diseases such as colds and pneumonia. It also damages lung tissue, intensifies heart and lung diseases such as asthma, and causes coughing and throat irritation. Children and people with asthma are most at risk[1] although even healthy adults doing heavy exercise or manual labor outdoors may experience the unhealthy effects of ozone.

High ozone has a deleterious effect on the environment, particularly plant life, resulting in crop and forestry losses. In addition, ozone has the ability to break down the basic components of everyday products that we rely on for shelter, mobility and aesthetics. High ozone produces cracks in rubber and damages exterior paint on buildings, motor vehicles and boats. The effects of ozone result from it being a strong oxidant. Ozone is especially reactive with certain molecules, including those found in rubber, the photosynthetic apparatus of green plants, and the membranes lining the lung's air passages.[2]

New Jersey ground-level ozone formation is mainly a daytime problem during the summer months because it is greatly enhanced by warm temperatures and abundant sunlight. The ozone season currently runs from April 1 to October 31 with the highest or "peak" ozone concentrations usually occurring between 2 p.m. and 8 p.m. from June 1st through August 31st. Effective January 1, 2017, The U.S. Environmental Protection Agency (USEPA) is extending the ozone monitoring season by one month to include March in New Jersey. Weather patterns have a significant effect on ozone formation, and hot, dry summers will result in higher ozone concentrations than cool, wet ones.

Annual emissions data do not provide the information needed to analyze the impacts of peak emissions, especially those from power plants operating during high electric demand days, which generally coincide with high temperature and high ozone levels. Therefore, maximum daily emission values are more valuable to assess the occurrences of elevated ozone concentrations.

The primary pollutants that contribute to ozone formation are NO_x and VOCs. "Nitrogen oxides" is a generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Some nitrogen oxides form naturally. The primary sources of human-made NO_x emissions in New Jersey are motor vehicles, construction equipment, power plants and industrial, commercial, and residential fuel combustion.

Volatile organic compounds are substances which contain carbon that evaporate easily. Primary sources of human-made VOC emissions are consumer products, such as household cleaners, paints and solvents, motor vehicles, lawn and garden equipment and gasoline stations. VOCs emitted from trees and other plant life also contribute to the creation of ozone in some regions.

Air quality is affected by both local emissions of ozone precursors and by pollution transported into the area by the wind. Transported pollution has a serious impact on New Jersey's air quality just as pollution from New Jersey affects areas downwind of it. As a result, controlling ozone pollution requires a broad range of measures to reduce sources of precursors both in New Jersey and in upwind regions. New Jersey's ozone control efforts have involved discussions with many states covering most of the eastern half of the country.

Goals

National Ambient Air Quality Standards (NAAQS) for ground-level ozone were first established in 1979 (a standard for total photochemical oxidants was previously established in 1971). These national health standards were revised in 1997 from a maximum 1-hour concentration of 0.12 parts per million (ppm) to a maximum 8-hour concentration of 0.08 ppm. The standard was changed, effective May 27, 2008, to a maximum 8-hour average concentration of 0.075 ppm (75 parts per billion (ppb)). On Oct. 1, 2015, the USEPA strengthened the NAAQS for ground-level ozone to 70 ppb.

To show compliance with the standard, the three-year average of the annual fourth-highest daily maximum 8-hour average concentration measured at any site within an area (multi-state for New Jersey) must not exceed the standard.[3] This is known as the "design value". New Jersey is part of two multi-state areas which are in nonattainment of the standard (nonattainment areas).

Status and Trends

The New Jersey Department of Environmental Protection (Department or NJDEP) currently measures ozone concentrations at 16 sites in New Jersey. One way to measure improvement in ozone air quality is by looking at the number of days ozone is above the health standard across the State. Every site that exceeds the standard on a given day is counted as one ozone exceedance site day. Thus, if all 16 sites exceed the standard on one day, it counts as 16 site days. The trend in ozone levels as measured by site days above the 8-hour standard shows a substantial decrease during the last decade, although there is much year-to-year variation due primarily to variations in the weather. Eleven of the sixteen sites have been collecting data for at least fifteen years. The trend in total site days found above the 75 ppb standard from 2000 through 2014 for these eleven sites is shown in Figure 1. Analysis of these data shows a statistically significant declining trend (p-value < 0.05).

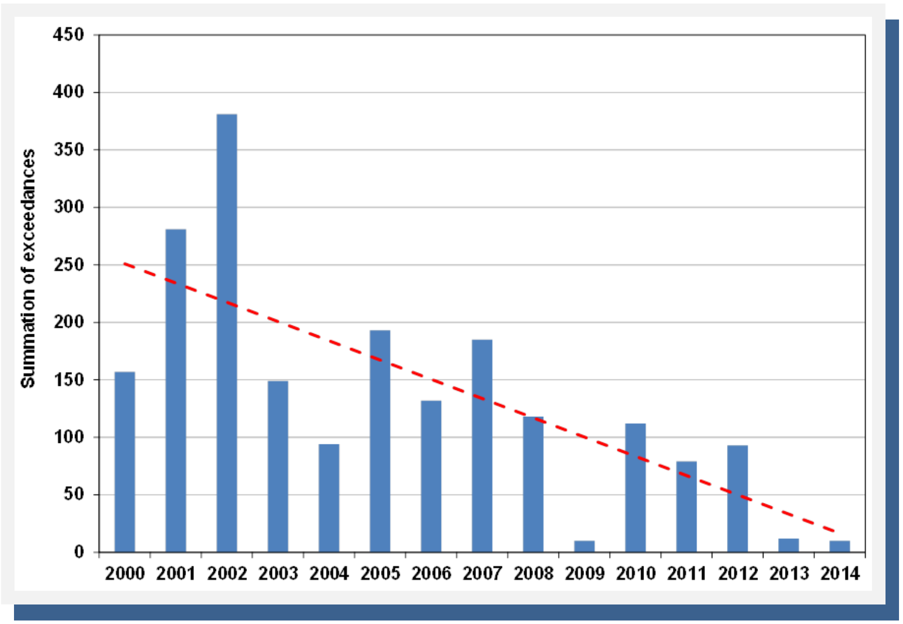

Figure 1: The number of site days above the 8-hour 0.075 ppm ozone standard at 11 sites in New Jersey. The red line shows the statistically significant linear trend with time.

The annual maximum ozone concentrations occurring at any monitoring site in New Jersey for a given year are shown in Figure 2. The maximum value does not necessarily occur at the same site from year to year. Not all New Jersey monitoring sites ran continuously from 1985 to present day. A decrease in the annual maximum ozone concentrations, as measured both over 1-hour and 8-hour periods, is also evident over time. Trend analyses of these data indicate that both the 1-hour average and 8-hour average maximum ozone concentration show a significant decline (p-values < 0.05). The 1-hour average shows a decline of approximately 49% from 1985 to 2014 and the 8-hour average declined approximately 31% from 1998 to 2014.

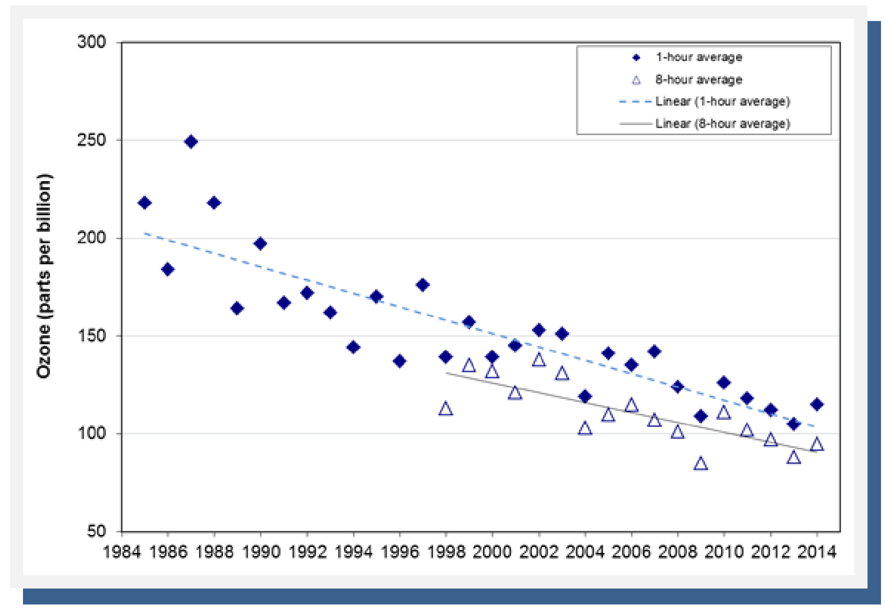

Figure 2: Maximum Ozone Concentrations occurring at any monitoring site in New Jersey. Notes: The solid and dashed lines represent statistically significant linear trends with time.

Design values or 3-year averages are the metrics that are compared to the NAAQS levels to determine compliance. Figure 3 shows a historical trend of the 8-hour ozone design values for New Jersey monitors. Similar to the maximum value data, the maximum design values are not necessarily measured at the same site from year to year and not all New Jersey monitoring sites ran continuously from 1985 to

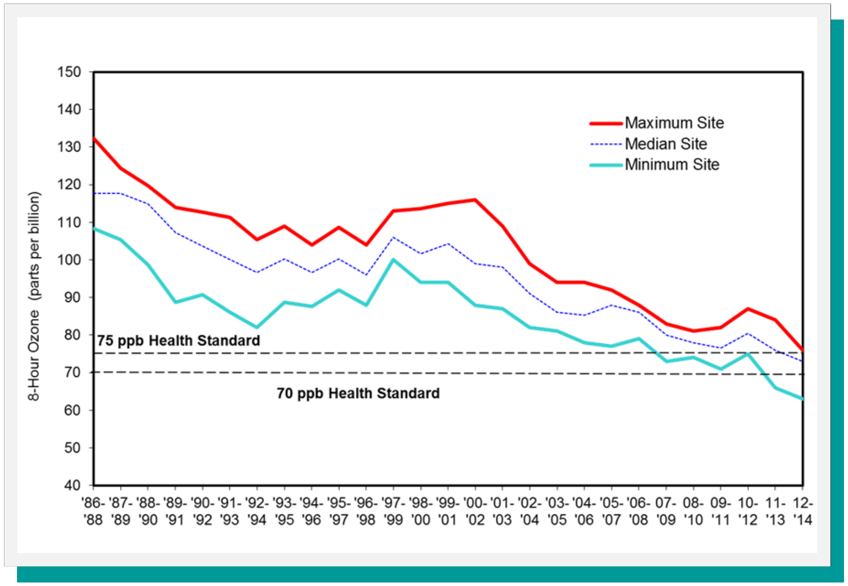

Figure 3: Design Values - 3 Year Average of 4th Highest Daily 8-Hour Maximum (occurring at any site in New Jersey).

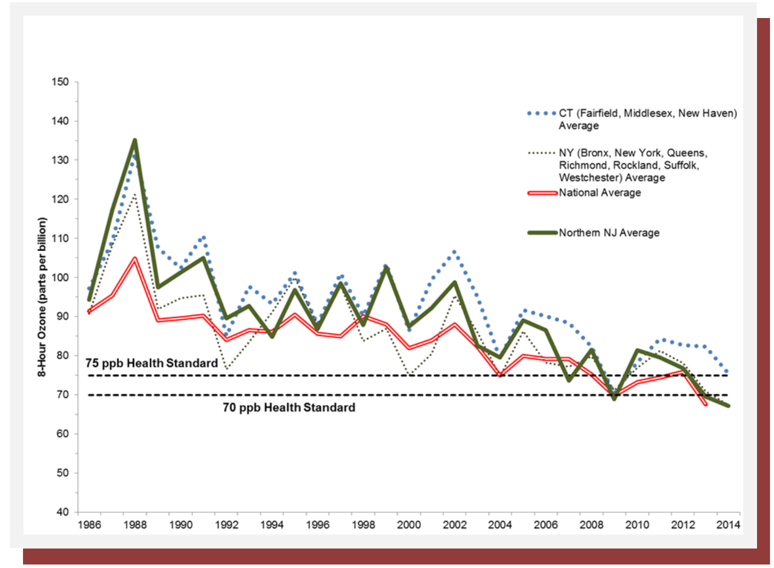

Figure 4: New Jersey 8-Hour Ozone Air Quality, 1986-2014, 4th Highest 8-Hour Daily Maximum Ozone Concentration, Northern New Jersey Ozone Nonattainment Area

Figures 4 and 5 show a historical trend of the annual 8-hour ozone 4th highest daily maximum concentration in New Jersey's northern and southern nonattainment areas and the national average. The figures show New Jersey data and the portion of the five states in our multistate nonattainment areas. As shown in the figures, the highest concentrations are in Connecticut in New Jersey's northern nonattainment area and in Maryland in New Jersey's southern nonattainment area.

Trends in ground level ozone are influenced by many factors including emissions of NO_x and VOCs (ozone precursors), weather conditions and emission reductions brought about by control measures. Short term fluctuations are most likely due to weather conditions. The long term trend shows ozone concentrations decreasing significantly due to State and federal requirements to reduce emissions of NO_x and VOCs.

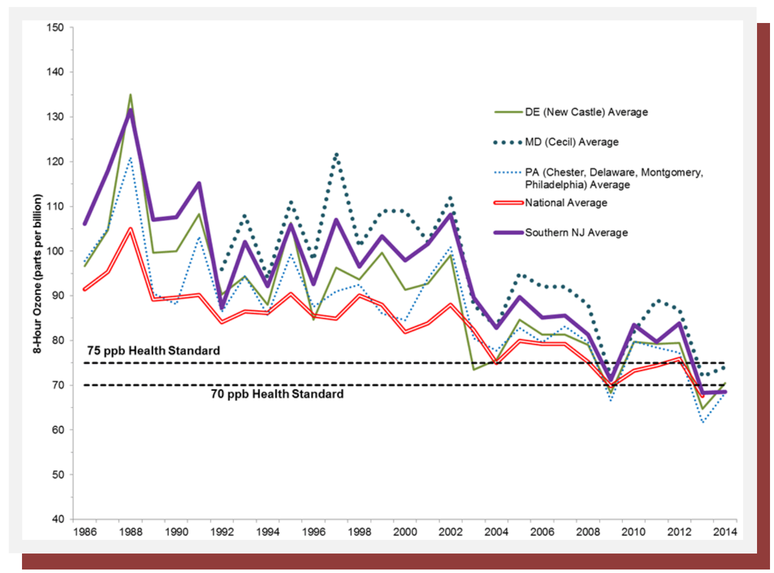

Figure 5: New Jersey 8-Hour Ozone Air Quality, 1986-2014, 4th Highest 8-Hour Daily Maximum Ozone Concentration, Southern New Jersey Ozone Nonattainment Area

Initially in the 1980's and 1990's, reducing emissions of VOCs was the primary means of lowering concentrations of ground-level ozone in New Jersey. Several important VOC control measures were implemented in 1988 and 1989, including reductions in the volatility of gasoline, the installation of gasoline vapor recovery systems at gasoline stations (Stage I and II), and regulations to reduce the volatility of paints. Several other VOC regulations were implemented in the 1990's and 2000's such as new engine standards for motor vehicles and off-road equipment, consumer products, additional paint controls, autobody refinishing, solvent degreasing, gasoline cans, asphalt paving, storage tanks, fuel loading and unloading at marine terminals, and refinery controls.

NO_x was recognized as an important precursor to ozone in the Clean Air Act of 1990. State and federal NO_x controls which contribute to the decreasing ozone trend include regulations for new engine standards for motor vehicles and off-road equipment, National and State low-emission vehicle (LEV) programs, the NO_x Budget Trading Program (NBP) for power plants (1999 and 2003), New Jersey power plant and refinery controls (post 2002), New Jersey's high electric demand day and multi-pollutant power plant rules (post 2009).

Outlook & Implications

The State expects additional emission reductions of ozone precursors in the future due to existing State and federal controls that have been adopted and will be implemented in the future. These controls include new engine standards for motor vehicle and off-road equipment, New Jersey's high electric demand day and power plant controls and the federal Tier 3 motor vehicle standards. The federal Mercury and Air Toxics Standards (MATS) rule aimed at reducing toxic pollutants from power plants and anticipated voluntary modifications in the electric power industry due to conversions to natural gas will also have the benefit of reducing emissions of NOx.

Transported pollution has a serious impact on New Jersey's air quality just as pollution from New Jersey affects areas downwind of it. As a result, reductions in ozone in the future will require emission reductions in both NO_x and VOCs achieved over a large multi-state region, with a focus on high electric demand days and ozone episodes.

More Information

See the NJDEP Bureau of Air Monitoring Web site, http://www.njaqinow.net/Default.aspx, and the site developed by USEPA, NOAA, and other entities at http://airnow.gov.

References

[1]New Jersey Department of Environmental Protection. Bureau of Air Quality Planning. Ozone. Accessed Nov. 2014 at http://www.nj.gov/dep/baqp/ozone.html.

[2]Spiro, Thomas, and William Stigliani, 2003, *Chemistry of the Environment, 2nd Edition*, Prentice Hall, Upper Saddle River, NJ 07458, page 226.

[3]New Jersey Department of Environmental Protection. 2012 Air Quality Report: Ozone Summary. Accessed Nov. 2014 at http://www.njaqinow.net/App_Files/2012/Ozone2012.pdf

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