



# 2014 Sulfur Dioxide Summary

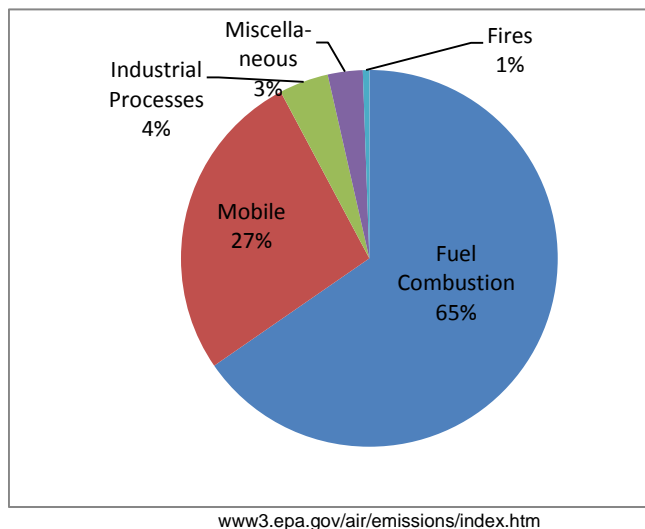
New Jersey Department of Environmental Protection

## SOURCES

Sulfur dioxide (SO<sub>2</sub>) is a heavy, colorless gas with a suffocating odor that easily dissolves in water to form sulfuric acid. SO<sub>2</sub> gases can be formed when fuels containing sulfur are burned, or when gasoline is extracted from oil. Most of the sulfur dioxide released into the air comes from combustion in electric utilities, especially those that burn coal with high sulfur content. Sulfur is found in raw materials such as crude oil, coal, and ores that contain metals, including aluminum, copper, zinc, lead and iron. Industrial facilities that derive their products from these materials may also release SO<sub>2</sub>. A pie chart summarizing the major sources of SO<sub>2</sub> in New Jersey is shown in Figure 1.

Figure 2 shows that SO<sub>2</sub> concentrations in New Jersey are generally higher in the winter than in the summer because of higher emissions from heating buildings and other sources, but peak SO<sub>2</sub> daily levels can occur anytime during the year. As shown in Figure 3. SO<sub>2</sub> levels tend to peak in mid- to late morning as emissions accumulate prior to being dispersed, when wind speeds and atmospheric mixing increase later in the day.

Figure 1  
2011 New Jersey SO<sub>2</sub> Emissions  
by Source Category



## HEALTH AND ENVIRONMENTAL EFFECTS

Sulfur dioxide causes irritation of the mucous membranes. This is probably the result of sulfurous acid forming when the highly soluble SO<sub>2</sub> dissolves at the surface of the membranes. Groups that are especially susceptible to the harmful health effects of SO<sub>2</sub> include children, the elderly, and people with heart or lung disorders such as asthma. When SO<sub>2</sub> concentrations in the air become elevated, people belonging to these sensitive groups and those who are active outdoors may have trouble breathing.

Sulfur dioxide reacts with other gases and particles in the air to form sulfates that can be harmful to people and the environment. Sulfate particles are the major cause of reduced visibility in the eastern United States. SO<sub>2</sub> can also react with other substances in the air to form acids that fall to the earth in rain and snow. Better known as acid rain, this acidic precipitation can damage forests and crops, can make lakes and streams too acidic for fish, and can speed up the decay of building materials and paints.

Figure 2  
Sulfur Dioxide Concentrations in New Jersey  
2014 Monthly Variation

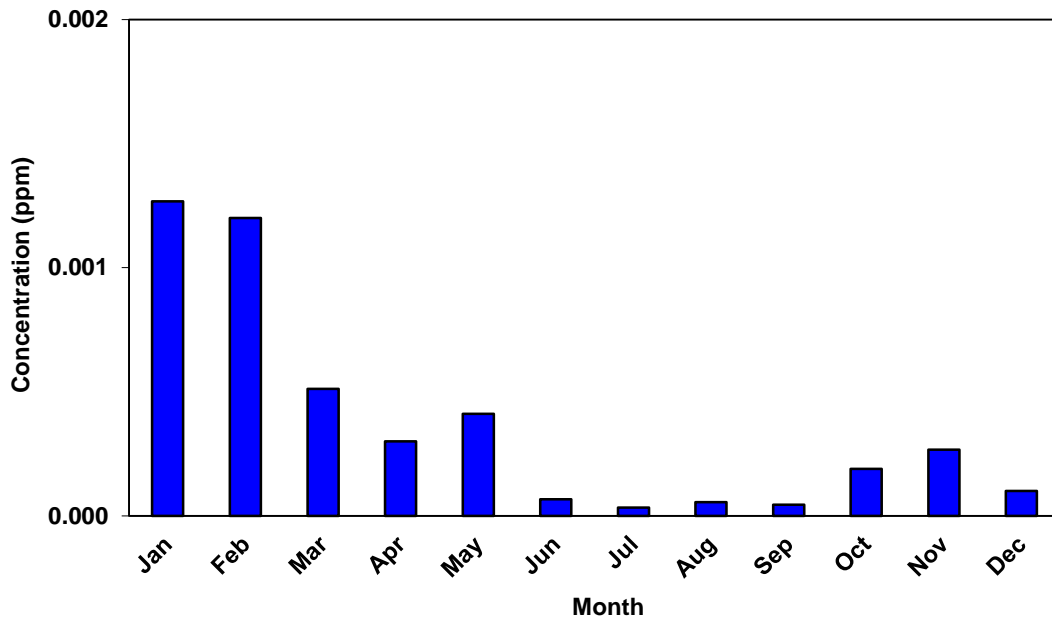
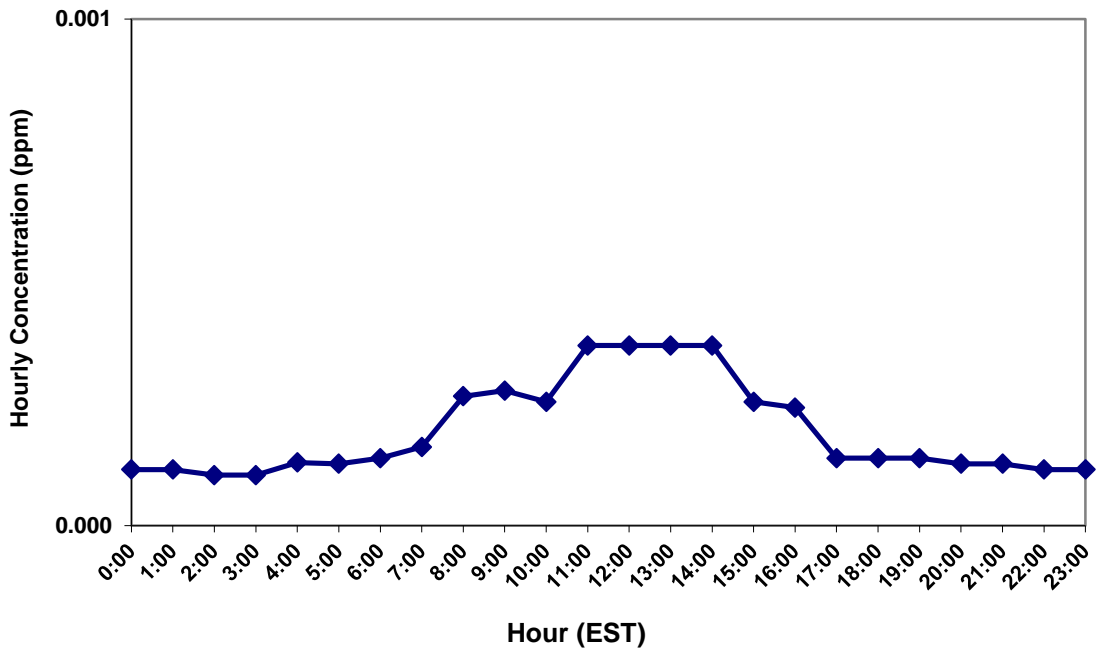


Figure 3  
Sulfur Dioxide Concentrations in New Jersey  
2014 Hourly Variation



## AMBIENT AIR QUALITY STANDARDS

From 1971 through June 2010, the National Ambient Air Quality Standards (NAAQS) for SO<sub>2</sub> were revised three times. In June 2010, based on its review of the air quality standard for oxides of sulfur (as measured by SO<sub>2</sub>), the United States Environmental Protection Agency (USEPA) established a new 1-hour NAAQS for SO<sub>2</sub> at a level of 75 parts per billion (ppb), and the old 24-hour and annual average NAAQS were revoked. USEPA did not revoke the existing 3-hour secondary NAAQS. The new 1-hour standard is based on the 3-year average of the 99th percentile of 1-hour daily maximum concentrations. However, the 1971 SO<sub>2</sub> standards remain in effect until one year after an area is designated as either in or out of attainment for the 2010 standard. In areas designated nonattainment for the 1971 standards, the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standards are approved. The 1971 NAAQS include an annual average health standard of 0.03 parts per million (ppm), based on a calendar year average of continuously monitored levels. There is also a 24-hour-average health-based standard of 0.14 ppm which is not to be exceeded more than once a year, and a secondary (welfare-based) 3-hour-average standard of 0.5 ppm that is also not to be exceeded more than once per year.

The New Jersey Ambient Air Quality Standards (NJAAQS) for SO<sub>2</sub> are similar to the federal standards, but are expressed in micrograms per cubic meter (µg/m<sup>3</sup>) instead of ppm, and are based on rolling averages rather than block averages. This means the state's primary 12-month standard is based on any twelve-month average recorded during two consecutive years, while the federal standard is based solely on the calendar year (block) average. New Jersey also has secondary 12-month, 24-hour, and 3-hour average standards. Table 1 summarizes the NAAQS and the NJAAQS for SO<sub>2</sub>.

Table 1  
National and New Jersey Ambient Air Quality Standards for Sulfur Dioxide  
Parts per Million (ppm), Parts per Billion (ppb)  
Micrograms per Cubic Meter (µg/m<sup>3</sup>)

Averaging Period	Type	New Jersey	National <sup>a</sup>
12-month average	Primary	80 µg/m <sup>3</sup> (0.03 ppm)	--
12-month average	Secondary	60 µg/m <sup>3</sup> (0.02 ppm)	---
24-hour average	Primary	365 µg/m <sup>3</sup> (0.14 ppm)	--
24-hour average	Secondary	260 µg/m <sup>3</sup> (0.10 ppm)	---
3-hour average	Secondary	1300 µg/m <sup>3</sup> (0.5 ppm)	0.5 ppm
1-hour average <sup>b</sup>	Primary	---	75 ppb

<sup>a</sup> National standards are block averages rather than moving averages.

<sup>b</sup> To attain this standard, the 3-year average of the 99<sup>th</sup> percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.

## MONITORING LOCATIONS

The state monitored SO<sub>2</sub> levels at nine locations in 2014. These sites are shown in Figure 4. The newest SO<sub>2</sub> monitoring site is at Camden Spruce Street, which became operational in April 2012. In September 2010, a monitoring station was established at the Columbia Wildlife Management Area (WMA) in Warren County. This was in support of a petition submitted to USEPA by the New Jersey Department of Environmental Protection (NJDEP) under Section 126 of the Clean Air Act that showed emissions from the Portland Generating Station, located in Pennsylvania, significantly contribute to nonattainment or interfere with maintenance of the 1-hour SO<sub>2</sub> NAAQS in New Jersey.

## SO<sub>2</sub> LEVELS IN 2014

In 2014, five exceedances of the 1-hour standard were recorded, all at the Columbia WMA site. The highest 99<sup>th</sup> percentile of the 1-hour daily maximum concentration for 2014 was 78 ppb. The highest 3-year average of the 99<sup>th</sup> percentile of the 1-hour daily maximum SO<sub>2</sub> concentrations was 75 ppb, also measured at the Columbia WMA station. The Camden Spruce Street and Bayonne sites did not have sufficient data from 2012-2014 to determine if these sites met the 1-hour SO<sub>2</sub> standard. (The Bayonne site did not operate between October 2012 and July 2013 because of damage from Superstorm Sandy. The Camden site started operating in April 2012.)

No other monitoring sites recorded exceedances of the primary or secondary SO<sub>2</sub> standards during 2014. The maximum 12-month average concentration recorded was 0.001 ppm, at Bayonne, Chester, Columbia, Elizabeth, Elizabeth Lab, and Jersey City sites. The maximum 24-hour average level recorded was 0.018 ppm at the Columbia WMA site. The highest 3-hour average recorded was 0.090 ppm at the Columbia WMA site. Summaries of the 2014 data are provided in Tables 2, 3, and 4, and Figures 5 and 6.

Figure 4  
2014 Sulfur Dioxide  
Monitoring Network

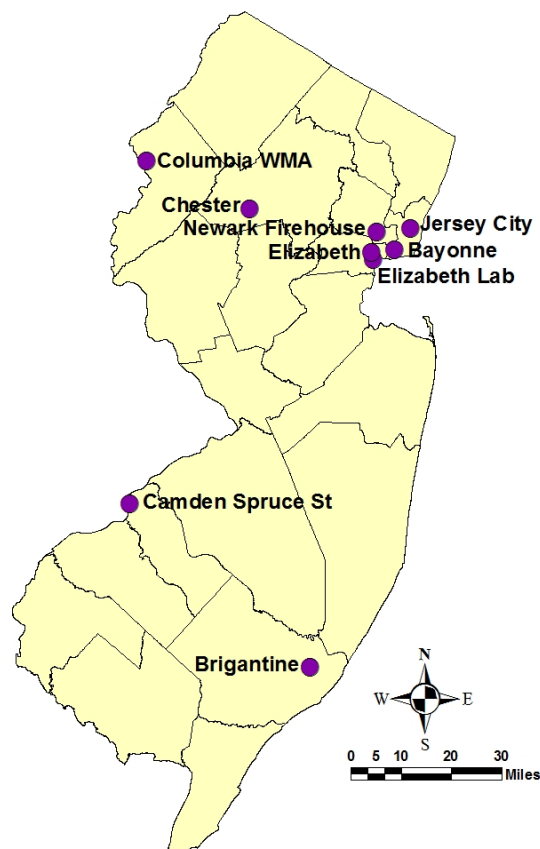


Table 2  
 2014 Sulfur Dioxide Concentrations in New Jersey  
 3-Year Average of the 99<sup>th</sup> Percentile  
 of Daily Maximum 1-Hour Averages  
 Parts per Billion (ppb)

Location	1-Hour Average (ppb)			3-Year Average 2012-2014
	Highest 1-Hr. Daily Maximum	2nd Highest 1-Hr. Daily Maximum	99th %-ile 1-Hr. Daily Maximum	99 <sup>th</sup> %-ile 1-Hr. Daily Maximum
Bayonne <sup>a</sup>	11	10	10	--
Brigantine	10.1	8.7	7.2	6.2
Camden Spruce St. <sup>b</sup>	10	10	10	--
Chester	20	17	12	10
Columbia WMA	124	104	78	75
Elizabeth	10	9	7	7
Elizabeth Lab	11	16	13	20
Jersey City	11	10	9	9
Newark Firehouse	13.0	10.5	8.9	9.9

a Bayonne site temporarily shut down October 2012 due to Superstorm Sandy, and restarted July 2013.

b Camden Spruce St. site started operating in April 2012.

Table 3  
 2014 Sulfur Dioxide Concentrations in New Jersey  
 3-Hour and Annual Averages  
 Parts per Million (ppm)

Monitoring Sites	3-Hour Maximum Average	3-Hour 2 <sup>nd</sup> Highest <sup>a</sup> Average	12-Month Maximum Average	Calendar Year Average
Bayonne	0.009	0.008	0.001	0.001
Brigantine	0.0096	0.0070	0.0005	0.0004
Camden Spruce St.	0.009	0.009	0.000	0.000
Chester	0.014	0.011	0.001	0.001
Columbia WMA	0.090	0.084	0.001	0.001
Elizabeth	0.008	0.007	0.001	0.001
Elizabeth Lab	0.037	0.011	0.001	0.001
Jersey City	0.010	0.009	0.001	0.001
Newark Firehouse	0.0094	0.0090	0.0010	0.0008

a Based on non-overlapping 3-hour moving averages.

Table 4  
 2014 Sulfur Dioxide Concentrations in New Jersey  
 24-Hour and Daily Averages  
 Parts per Million (ppm)

Monitoring Sites	24-Hour Maximum Average	24-Hour 2 <sup>nd</sup> Highest Average <sup>a</sup>	Daily Maximum Average	Daily 2 <sup>nd</sup> Highest Average
Bayonne	0.005	0.005	0.005	0.004
Brigantine	0.0044	0.0042	0.0035	0.0033
Camden Spruce St.	0.007	0.005	0.005	0.005
Chester	0.006	0.005	0.005	0.005
Columbia WMA	0.018	0.016	0.016	0.015
Elizabeth	0.005	0.004	0.004	0.004
Elizabeth Lab	0.007	0.005	0.006	0.005
Jersey City	0.007	0.006	0.006	0.005
Newark Firehouse	0.0062	0.0054	0.0060	0.0052

a Based on non-overlapping 24-hour moving averages.

Figure 5  
 2014 Sulfur Dioxide Concentrations in New Jersey  
 99<sup>th</sup> Percentile of the 1-Hour Daily Maximum Concentrations  
 3-Year Design Value (2012-2014)  
 Parts per Billion (ppb)

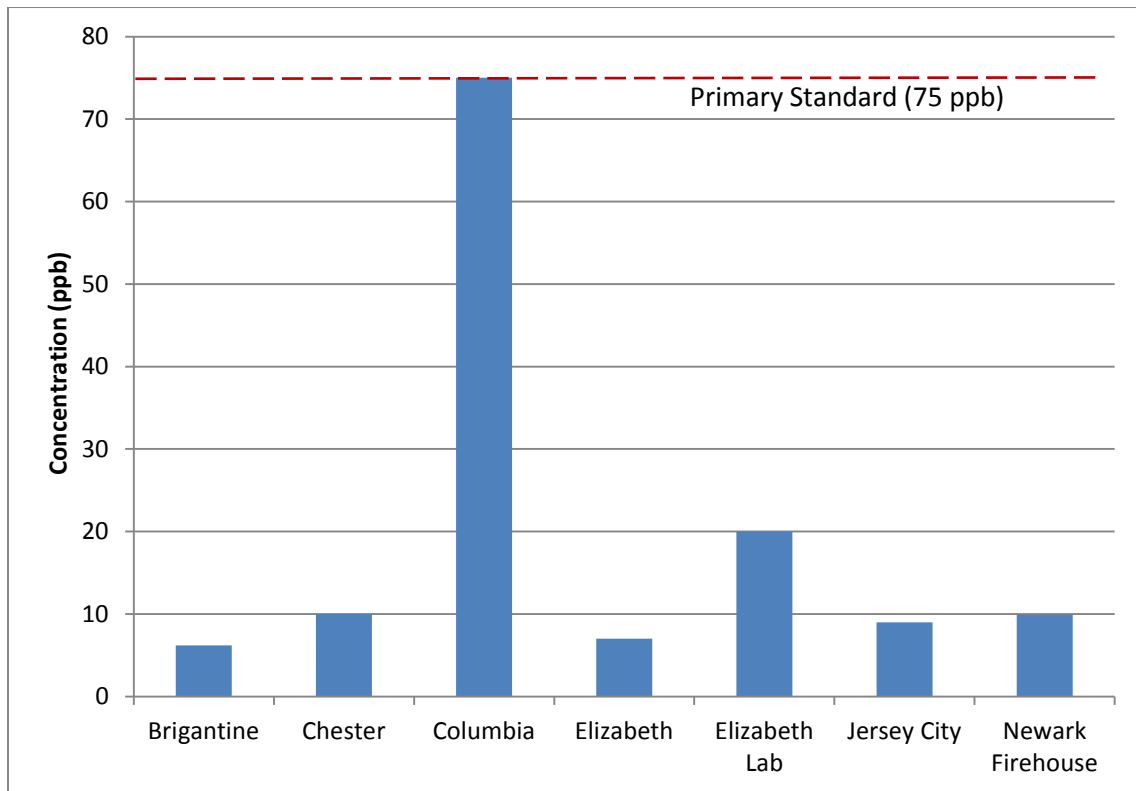
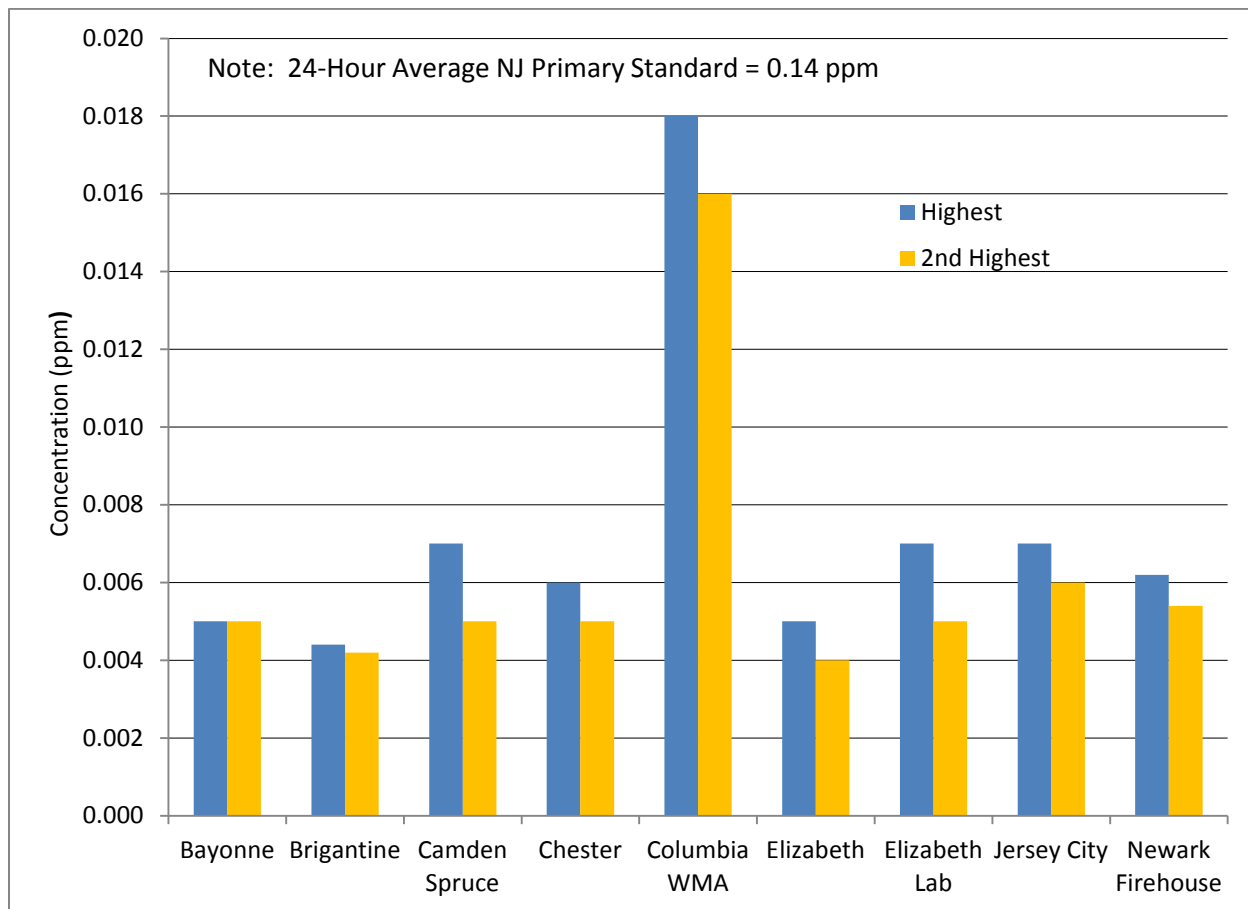


Figure 6  
 2014 Sulfur Dioxide Concentrations in New Jersey  
 Highest and 2<sup>nd</sup>-Highest 24-Hour Averages  
 Parts per Million (ppm)



## SO<sub>2</sub> TRENDS

Since the implementation of federal regulations requiring the nationwide use of lower sulfur fuels, SO<sub>2</sub> concentrations have improved significantly. The last time an exceedance of the 3-hour, 24-hour, or 12-month national and New Jersey AAQS for SO<sub>2</sub> was recorded was in 1980. A trend graph of SO<sub>2</sub> levels showing the daily average concentrations recorded in each year since 1975 for the highest site, average of all sites, and lowest site is provided in Figure 7. The graph uses the second-highest daily average.

Figure 8 shows the trend in one-hour concentrations of SO<sub>2</sub> since 2000. The graph uses the 99<sup>th</sup> percentile of the 1-hour daily maximum concentrations. The increase in maximum values that begins in 2010 is attributable to the start-up of the Columbia WMA site, which is impacted by the Portland Power Plant across the Delaware River in Pennsylvania.

Figure 7  
Sulfur Dioxide Concentrations in New Jersey, 1975-2014  
Second-Highest Daily Average  
Parts per Million (ppm)

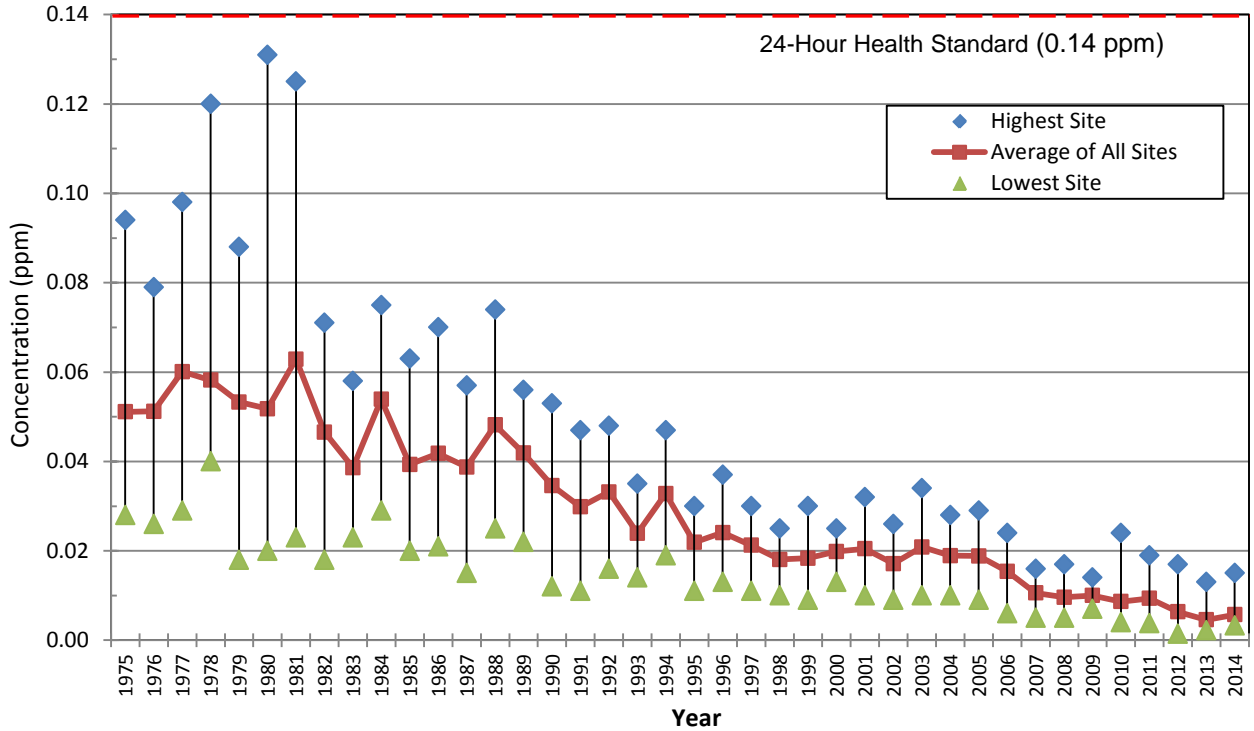
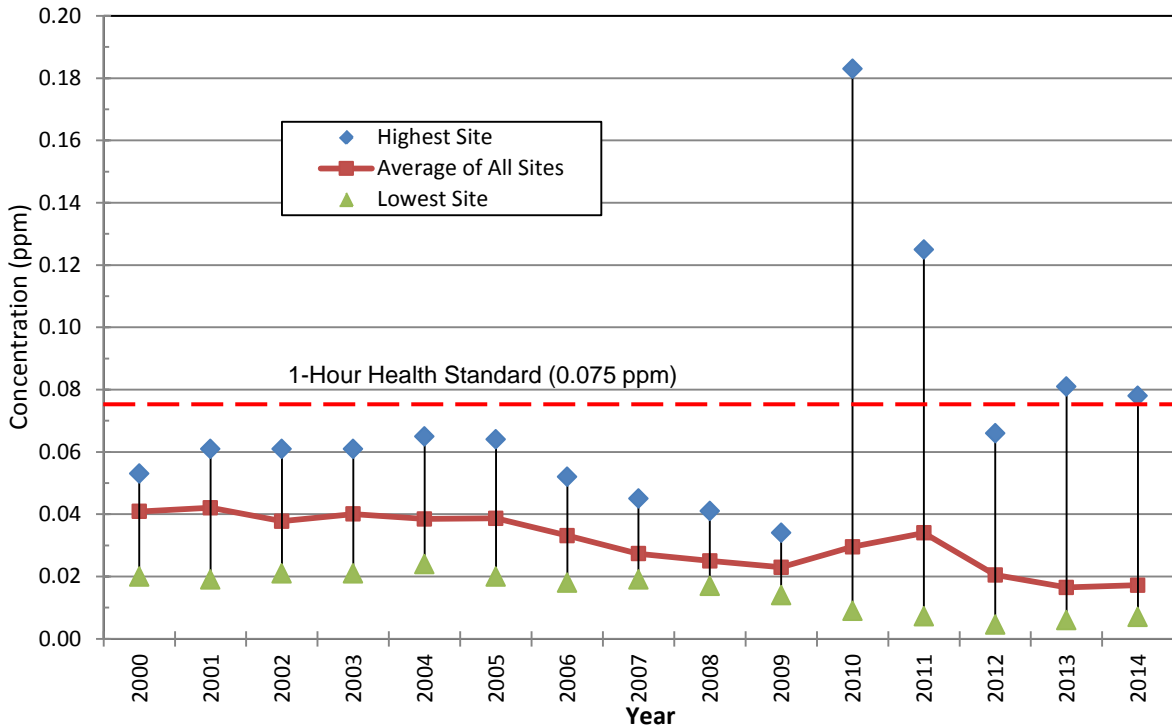


Figure 8  
Sulfur Dioxide Concentrations in New Jersey, 1975-2014  
99<sup>th</sup> Percentile of the 1-Hour Daily Maximum Concentration  
Parts per Million (ppm)



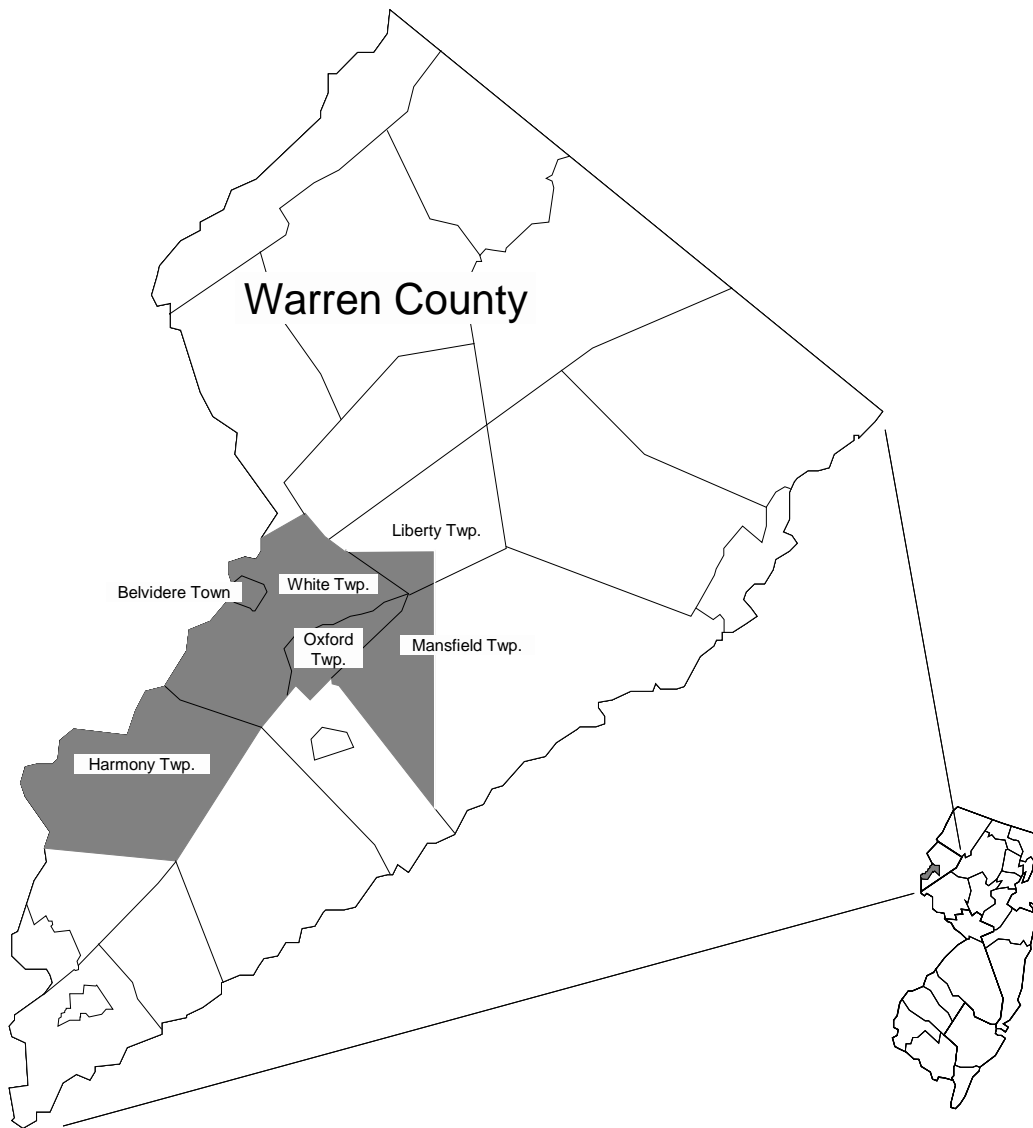


## COMPLIANCE WITH THE SO<sub>2</sub> STANDARDS IN NEW JERSEY

There is still a small portion of New Jersey that is classified as a non-attainment area for SO<sub>2</sub>, based on the 1971 12-month and 24-hour average primary NAAQS. This area is shown in Figure 8. The non-attainment designation is the result of air quality modeling studies done by NJDEP that predicted nonattainment of these standards within an area of Warren County, due to emissions of SO<sub>2</sub> from the Portland Power Plant across the Delaware River in Pennsylvania. In September 2010, New Jersey petitioned the USEPA under Section 126 of the Clean Air Act to take action against the Portland Power Plant. All of Warren County and portions of Sussex, Morris, and Hunterdon Counties were being impacted by SO<sub>2</sub> emissions from the plant, likely causing violations of the new (2010) 1-hour NAAQS. A detailed map of the affected area can be found at [www.state.nj.us/dep/baqp/docs/SO2%20package.pdf](http://www.state.nj.us/dep/baqp/docs/SO2%20package.pdf).

In support of the Section 126 petition, NJDEP established an SO<sub>2</sub> monitoring station in the Columbia Wildlife Management Area (WMA) in Knowlton Township, Warren County, in September 2010. In October 2011, the USEPA finalized a rule to grant New Jersey's petition. This final rule required the Portland Power Plant to reduce its SO<sub>2</sub> emissions such that the plant's contribution to predicted air quality standard violations would be lowered within one year, and completely eliminated within 3 years. The power plant has since been shut down. It is expected that Warren County and its vicinity will be able to attain the new SO<sub>2</sub> standard. The state is working with USEPA to have the area re-designated as being in attainment.

Figure 8  
Sulfur Dioxide Nonattainment Areas\* in New Jersey



**Legend**

■ Sulfur Dioxide Nonattainment Area  
(includes Belvidere Town; Harmony Township; Oxford Township;  
White Township; the portion of Liberty Township south of  
UTM northing 4,255,000 and west of UTM easting 505,000;  
and the portion of Mansfield Township west of UTM easting 505,000).

\*Nonattainment of the National Primary (Health) and Secondary (Welfare) Standards

## REFERENCES

Air Quality Criteria for Particulate Matter and Sulfur Oxides (1982): Assessment of New Findings on Sulfur Dioxide Acute Exposure Health Effects in Asthmatic Individuals, Supplement to the Second Addendum (1986), U.S. Environmental Protection Agency, Office of Health and Environmental Assessment, Research Triangle Park, NC, 1994.

Draft Guideline Document for Ambient Monitoring of 5-minute SO<sub>2</sub> Concentrations, USEPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 20, 2000.

Horstman, D., Roger, L. J., Kehrl, H. and Hazucha, M., Airway Sensitivity of Asthmatics to Sulfur Dioxide, EPA-600/J-86-282, Health Effects Research Lab, Research Triangle Park, NC, Clinical Research Branch, Environmental Monitoring and Services, Inc., Chapel Hill, NC, North Carolina University at Chapel Hill, NC, Prepared for USEPA, Research Triangle Park, NC, 1986.

How Sulfur Dioxide Affects the Way We Live, USEPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC, June 2009, [www.epa.gov/air/urbanair/SO2](http://www.epa.gov/air/urbanair/SO2)

International Agency for Research on Cancer (IARC). 1992, IARC Monographs; Vol 54.

Latest Findings on National Air Quality: 2000 Status and Trends, EPA-454/K-01-002, USEPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC, September 2001, [www.epa.gov/air/airtrends/aqtrnd00/brochure/00brochure.pdf](http://www.epa.gov/air/airtrends/aqtrnd00/brochure/00brochure.pdf)

National Air Quality and Emissions Trend Report, 1999, EPA-454/R-01-004, USEPA, Office of Air Quality Planning and Standards, Research Triangle Park, NC, March 2001, [www.epa.gov/air/airtrends/aqtrnd99/](http://www.epa.gov/air/airtrends/aqtrnd99/)

National Ambient Air Quality Standards, United States Environmental Protection Agency (USEPA), Air and Radiation, 2010. [www.epa.gov/air/criteria.html](http://www.epa.gov/air/criteria.html)

National Primary Ambient Air Quality Standards for Sulfur Dioxide, 40 CFR 50.4, US Government Printing Office, Washington DC, July 2001.

National Secondary Ambient Air Quality Standards for Sulfur Dioxide, 40 CFR 50.5, US Government Printing Office, Washington DC, July 2001.

Sittig, M., Handbook of Toxic and Hazardous Chemicals and Carcinogens Third Edition, Volume 2, Noyes Publications, Park Ridge, NJ, 1991.

"Revisions to Final Response to Petition From New Jersey Regarding SO<sub>2</sub> Emissions From the Portland Generating Station." Federal Register 76 (2011 December 22): 79574-79578.

ToxFAQs for Sulfur Dioxide, CAS# 7446-09-5, U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, June 1999, [www.atsdr.cdc.gov/tfacts116.pdf](http://www.atsdr.cdc.gov/tfacts116.pdf)