MARYLAND
Department of the Environment

Seasonal Report

2017 Fine Particles ($PM_{2.5}$)

OVERVIEW

Fine particle pollution (also called $PM_{2.5}$) continues to decrease across the state of Maryland and remains in attainment of the $PM_{2.5}$ standard. Over the past decade or so, the number of days with high $PM_{2.5}$ concentrations has significantly decreased (*Figure 1).* This is in large part thanks to the adoption of regulations to reduce emissions of $PM_{2.5}$ precursors such as sulfur dioxide (*SO_2*) and nitrogen oxides (*NO_x*). Despite improvements, $PM_{2.5}$ is still present throughout the year with occasionally isolated spikes particularly during the winter months. Due to its small size (*<2.5μm in diameter*), $PM_{2.5}$ can penetrate deep into the lungs resulting in adverse breathing and heart health effects if concentrations become too high. When $PM_{2.5}$ concentrations are high enough to cause potential health concerns in sensitive population groups (USG), the Air Quality Index (AQI) exceeds 100. The best way to determine how bad $PM_{2.5}$ is in a given year is by tracking the number of days the daily 24-hour average concentration of $PM_{2.5}$ (midnight to midnight) exceeds the AQI value of 100, otherwise known as an “exceedance day”. In 2017, there was just one day which exceeded the Environmental Protection Agency’s (EPA) health based threshold.

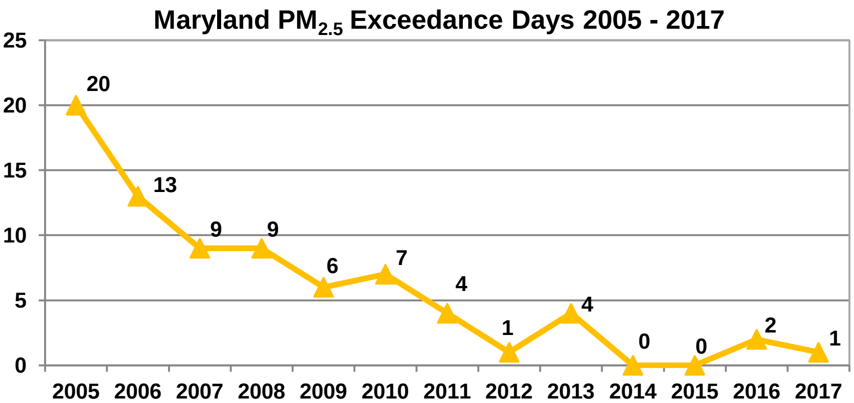

Figure 1: Number of days where the AQI surpassed 100 at any $PM_{2.5}$ monitor in Maryland annually, 2005-2017.

Summer vs. Winter $PM_{2.5}$

Unlike surface ozone, $PM_{2.5}$ is not dependent on abundant sunshine and warm temperatures. This means that $PM_{2.5}$ has the potential to be an issue year round. When $PM_{2.5}$ monitoring began in 1999, fine particle pollution was most significant during the summer months when higher dew points and generally weaker surface winds aided in its production. Between the timeframe of 1999 and 2005, nearly half (45.5%) of the total number of $PM_{2.5}$ exceedance days occurred during the summer months of June-August. However, as regional emissions have continued to decline in recent years, not only has there been a drop off in the total number of exceedance days, but there has also been a shift in the seasonality of $PM_{2.5}$ exceedance days. Summertime exceedance days of $PM_{2.5}$ are essentially a thing of the past for the state of Maryland (*Figure 2).* The last $PM_{2.5}$ exceedance day that occurred in June, July or August was all the way back in 2011!

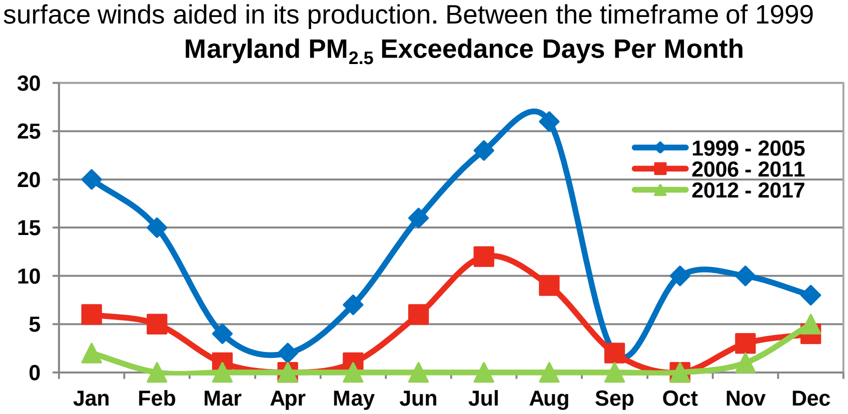

Figure 2: Monthly breakdown of the total number of $PM_{2.5}$ exceedance days for the timeframes of 1999-2005, 2006-2011 and 2012-2017 in Maryland.

During the summer, a stagnant weather pattern with high dew points can cause high fine particulate concentrations to accumulate. However, intense sunlight can also lead to increased surface mixing, resulting in higher daytime mixing heights. What this pattern typically results in is high $PM_{2.5}$ concentrations during the overnight and early morning hours. However, the air begins to clean out as daytime mixing increases leading to a 24-hour $PM_{2.5}$ concentration typically under the standard. In the early to mid-2000’s when the regional air mass was much “dirtier”, despite this daytime mixing, exceedances were still common. With a much cleaner regional air mass, given the continued NO_x and SO_2 reductions, daytime “cleaning out” is enough to bring fine particle concentrations below the 24-hour standard.

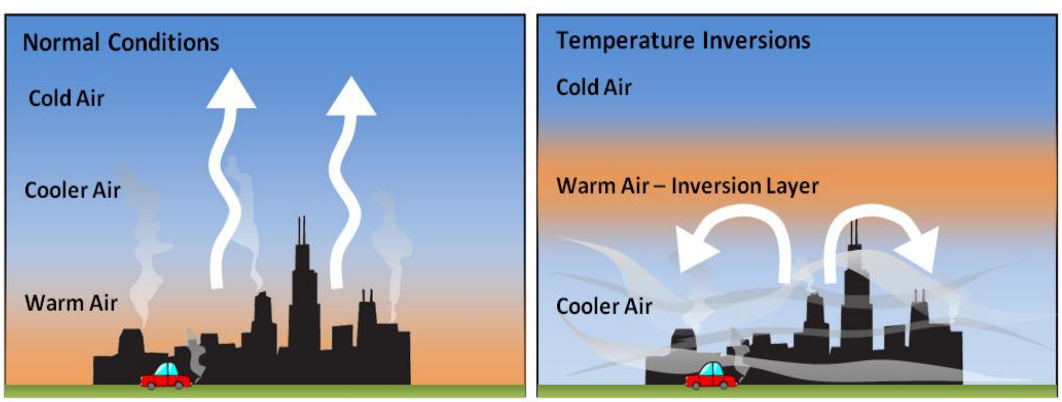

Figure 3: Conceptual comparison showing pollutant impacts under “normal conditions” (decrease in temperature with height) and temperature inversions (increase in temperature with height).

So why are wintertime $PM_{2.5}$ exceedances still an isolated problem? In the last 6 years, all 8 exceedance days occurred during the cold months of November – February. As mentioned, summertime sunshine leads to better daytime mixing and an overall cleaner air mass. With colder winter temperatures, a lower mixing depth can be a significant problem. There can also be instances where

AQI 0-50 Good	51-100 Moderate	101-150 USG*	151-200 Unhealthy	201-300 Very Unhealthy	301-500 Hazardous

*Unhealthy for Sensitive Groups

MARYLAND DEPARTMENT OF THE ENVIRONMENT
1800 Washington Boulevard | Baltimore, MD 21230
410-537-3000 | 1-800-633-6101
Larry Hogan, *Governor* | Boyd Rutherford, *Lt. Governor* | Ben Grumbles, *Secretary*

Seasonal Report

2017 Fine Particles ($PM_{2.5}$)

MARYLAND Department of the Environment

Summer vs. Winter $PM_{2.5}$ (*cont.*)

temperatures aloft are slightly warmer than at the surface. This vertical temperature profile is known meteorologically as an inversion *(See figure 3).* In rare instances, these inversions can last throughout the day and in some cases, multiple days. When this occurs, all pollutants either emitted or created become trapped and concentrated near the immediate surface. Despite lower emissions regionally in recent years, it is this steady increase of $PM_{2.5}$ and $PM_{2.5}$ precursors focused right at the immediate surface which can lead to these isolated wintertime $PM_{2.5}$ exceedance days.

FEATURED EPISODE: December 4th 2017

$PM_{2.5}$ concentrations began to gradually rise beginning Friday, December 1st as a large high pressure system took control of the region. Weak, stagnant flow along with general subsidence (*sinking air*); both of which are synonymous with large wintertime high pressure systems allowed for conditions to gradually deteriorate. In addition, relatively low daytime mixing heights along with overnight and early morning surface inversions aided in the gradual increase in $PM_{2.5}$ concentrations between December 1st and 3rd (*Figure 4).*

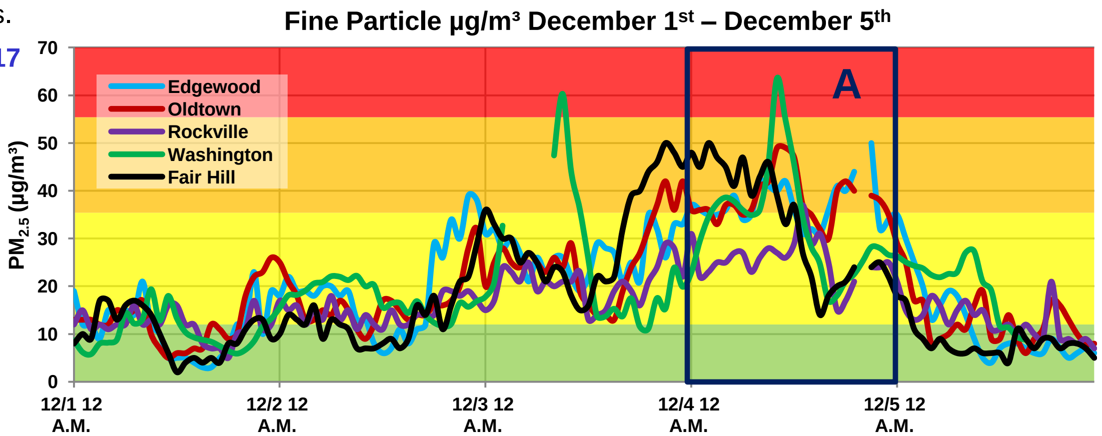

Figure 4: $PM_{2.5}$ concentrations (µg/m³) for several monitors between the timeframe of December 1st – December 5th 2017. Horizontal coloring matches with appropriate AQI ranges. December 1st – 3rd shows the gradual increase in $PM_{2.5}$ concentrations leading up to the exceedance event on the 4th marked by the blue box labeled "A".

Temperatures during the weekend overnight hours were also quite cold, with overnight lows at BWI airport dipping down into the upper 20's and low 30's. Localized wood burning as a source of heat was prominent across the entire area throughout the weekend, further supporting the deterioration of the air mass. Dew points across the region were also on the rise through the weekend, aided by light precipitation early Saturday morning. High water vapor levels in the lower atmosphere is important as it can aid in the creation of fine particulate matter. With a fairly saturated environment, low mixing heights and a deteriorating air mass, conditions were ripe for high $PM_{2.5}$ concentrations leading up to the December 4th event.

By December 4th, the large high pressure system which dominated the region over the last several days was slowly starting to push east and out of the region. At the surface, the stagnant dirty air mass remained in place. Aloft however, winds began to turn more southwesterly out ahead of an approaching cold front. This allowed warming in the mid-levels of the atmosphere. With cool temperatures already in place at the surface and an inflow of warmer air aloft, an inversion was able to strengthen and persist throughout the entire day. During the morning of the 4th, temperatures at ground level in nearby Sterling, VA were 28.2°F (-2.1°C). When compared to just 700 feet above the surface, the temperature shot up to 46°F (7.8°C). This is an impressive 17.8°F (9.9°C) increase in temperature in a very shallow layer above the surface. With an inversion that strong, any pollutants present or being emitted were trapped and focused right at the immediate surface. $PM_{2.5}$ concentrations during this time frame were well above the USG threshold for many locations across the region (*Figure 4*). All of these ingredients came together to create a "perfect storm" of conditions, leading to a classic winter season $PM_{2.5}$ exceedance day. Figure 5 shows the visibility on the exceedance day versus just two days later after the cold front passed through. Although some of the reduced visibility on the 4th is tied to the elevated dew points, there is a clear and very drastic difference.

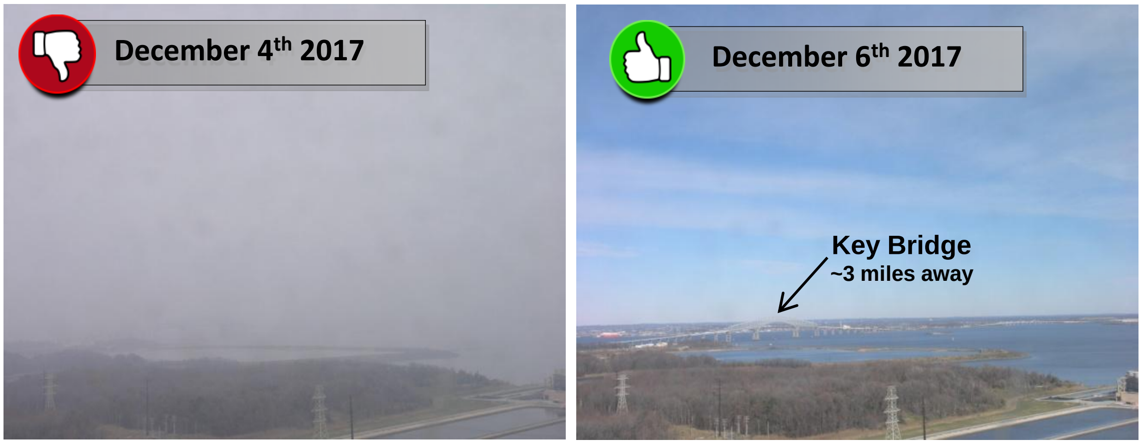

Figure 5: Visual comparison of the featured event date, December 4th (Left) and a Good Air Quality day just two days later on December 6th 2017 (Right). Key Bridge location and approximate distance is noted on the right.

In total two Maryland monitors (Edgewood and Oldtown) recorded 24-hour $PM_{2.5}$ concentrations above the USG threshold at 37.35 and 38.35 µg/m³, respectively. Despite the Washington, D.C. monitor recording the highest 1-hour $PM_{2.5}$ concentration in the region at 63.5 µg/m³, it was just under the 24-hour standard at 32.96 µg/m³. This was the first $PM_{2.5}$ exceedance day in the state of Maryland since November 25, 2016.

AQI 0-50 Good	51-100 Moderate	101-150 USG*	151-200 Unhealthy	201-300 Very Unhealthy	301-500 Hazardous

MARYLAND DEPARTMENT OF THE ENVIRONMENT
1800 Washington Boulevard | Baltimore, MD 21230
410-537-3000 | 1-800-633-6101
Larry Hogan, *Governor* | Boyd Rutherford, *Lt. Governor* | Ben Grumbles, *Secretary*