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DENVER • PORTLAND

# UPDATED AIR QUALITY TRENDS FOR THE COLUMBIA RIVER GORGE

**PREPARED FOR:** Klickitat County

**PREPARED BY:** Kent Norville, Ph.D.

**PROJECT NO.:** 174-5

**COPIES:** File

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In 2003, Air Sciences Inc. reviewed air quality data from 1989 to 2002 from various monitors located in and around the Columbia River Gorge (CRG) in order to examine trends in air quality. The results of that summary concluded that, in general, air quality is improving in the urban areas and that visibility in the region is not getting worse, but is maintaining a constant level.

This memorandum summarizes an update to the air quality trends report with the addition of data from 2003 to 2005. In addition, this report addresses the ammonium nitrate data issue identified in the 2003 trends report and includes a discussion on a visibility trends figure produced in 2004 by the USFS.

## Data Sets

Data sources for this summary include: the Oregon DEQ 2004 and 2005 Annual Reports, Interagency Monitoring of Protected Visual Environments (IMPROVE) database, the Visibility Information Exchange Web System (VIEWS), and EPA's Aerometric Information Retrieval System (AIRS) database. The AIRS database was used to retrieve monitoring data from Washington.

Monitoring by Oregon and Washington generally focuses on the urban area and the criteria pollutants (nitrogen dioxide [$NO_2$], particulate matter with diameter less than 10 microns [$PM_{10}$], particulate matter with diameter less than 2.5 microns [$PM_{2.5}$], ozone [$O_3$], and carbon monoxide [CO]) and some air toxics. Table 1 shows a list of the urban monitoring stations and pollutants.

The IMPROVE monitoring program was established in 1985 to aid the creation of Federal and State implementation plans for the protection of visibility in Class I areas (156 national parks and wilderness areas) as stipulated in the 1977 amendments to the Clean Air Act. The objectives of IMPROVE are: (1) to establish current visibility and aerosol conditions in mandatory Class I areas; (2) to identify chemical species and emission sources responsible for existing man-made visibility impairment; (3) to document long-term trends for assessing progress towards the national visibility goal; and (4) with the enactment of the Regional Haze Rule, to provide regional haze monitoring representing all visibility-protected federal Class I areas where practical. A few of the IMPROVE monitors are located outside of the Class I areas. These include Puget Sound, CRG, and the Spokane Indian Reservation. The IMPROVE network looks at the long-term trends of reconstructed fine mass (RCFM), measured particulate species (e.g., nitrates, sulfates, carbon compounds, and speciated elements), and light extinction around the region. Table 2 shows the considered IMPROVE stations.

**Table 1: Urban Monitoring Stations**

| Station | Pollutants |
|---|---|
| Portland (OR) Milwaukee HS | $O_3$ |
| Portland (OR) SE Lafayette | CO, $NO_2$, $PM_{10}$, $PM_{2.5}$, light scattering |
| Portland (OR) Roselawn | $O_3$ |
| Vancouver (WA) 4th Plain | $PM_{2.5}$ |
| The Dalles (OR) | $PM_{2.5}$ |
| Pendleton (OR) McKay Creek | $PM_{10}$, $PM_{2.5}$ |
| Kennewick (WA) | $PM_{2.5}$ |

**Table 2: IMPROVE Monitoring Stations**

| Station | Data Period |
|---|---|
| Wishram (WA) east side of CRG | 1993 to present |
| Mt. Zion (WA) west side of CRG | 1996-1998, 2001 to present |
| Hells Canyon (OR) | 2000 to present |
| Mt. Hood (OR) | 2000 to present |
| Mt. Rainier (WA) | 1988 to present |
| Puget Sound (WA, urban site) | 1996 to present |
| Spokane Indian Reservation (WA) | 2001 to present |
| Starsky (OR, Eagle Cap) | 2000 to present |
| Three Sisters (OR) | 1993 to present |
| White Pass (WA, Mt. Adams, Goat Rocks) | 1993 to present |

## Urban Area Trends

Figures 1 to 11 show the long-term trends in the criteria pollutants ($NO_2$, $O_3$, $PM_{10}$, and $PM_{2.5}$) and light scattering as measured in and around the CRG. Most of these stations are located in urban areas. For the criteria pollutants, the averaging time used is based on requirements for determining compliance with state and federal standards. Generally, more than five years of data are needed to suggest a trend. In fact, these data indicate that trends over the span of a few years are not always representative of long-term decade trends, suggesting about ten years of data are needed to resolve the long-term trends of some of the pollutants.

Figure 1 and 2 show the maximum 1-hour and annual $NO_2$ concentrations measured at Portland. There is a downward trend of approximately 0.002 ppm per year in the maximum hourly averages and about 0.0004 ppm per year in the annual averages. In 2005, the annual $NO_2$ concentration is about 20% of the standard.

Figure 3, 4, and 5 show the maximum, highest 2$^{nd}$ highest, and annual $PM_{10}$ concentrations measured in Portland and Pendleton, with trend lines. In Figure 3, the Pendleton trend line excludes the 1993 data point due to its extreme value with respect to the other values so that a more representative trend can be shown. For the 24-hour concentrations, there is a clear downward trend of about 5 $\mu g/m^3$ per year in both cities. For the annual average, the trend is about 1 $\mu g/m^3$ per year. In 2005, the maximum 24-hour $PM_{10}$ was about 30 percent of the standard and the annual average was about 40 percent of the annual standard.

**Figure 1: Maximum 1-Hour $NO_2$ Concentrations in Portland**

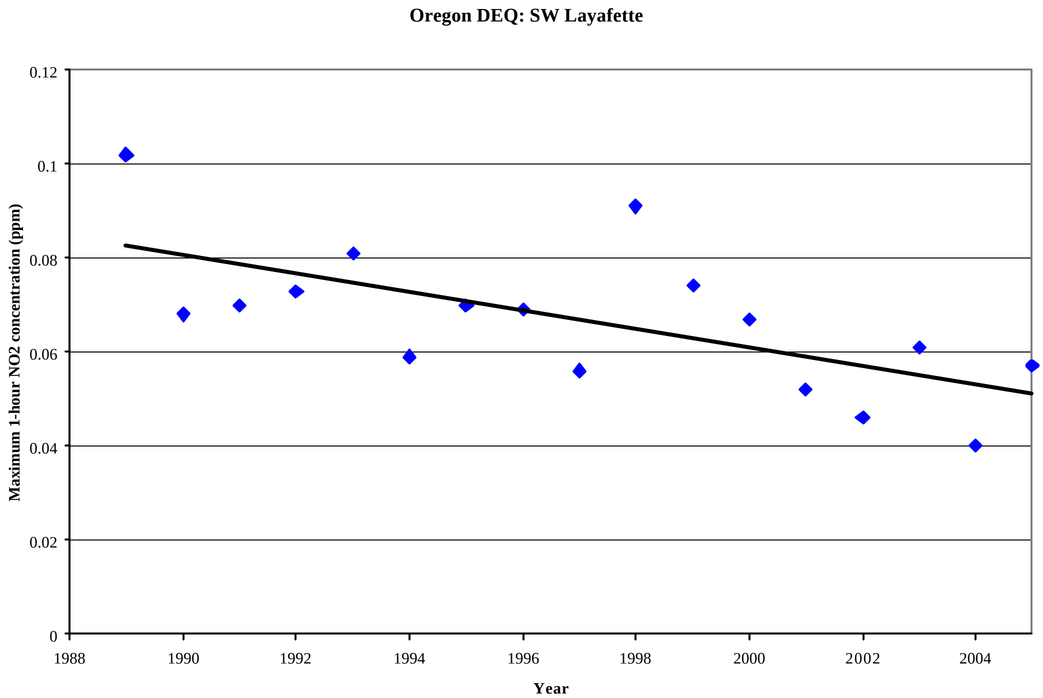



**Figure 2: Annual $NO_2$ Concentrations in Portland**

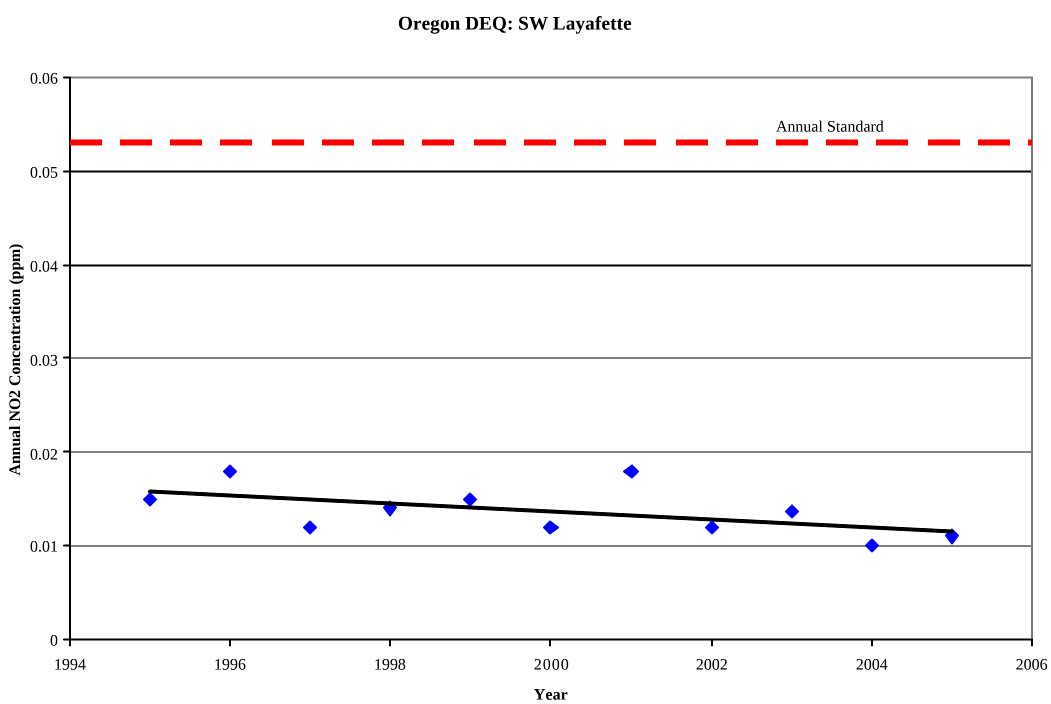


**Figure 3: Maximum 24-hour $PM_{10}$ Trend from Pendleton and Portland with Trend Lines**

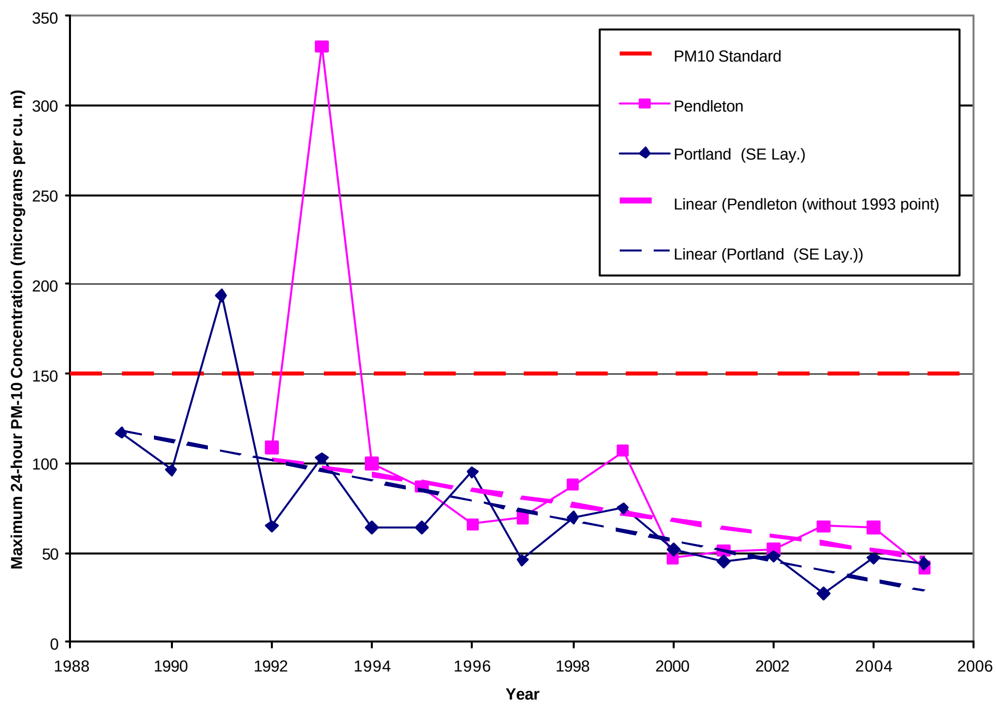



**Figure 4: High 2nd High 24-hour $PM_{10}$ Trend from Pendleton and Portland**

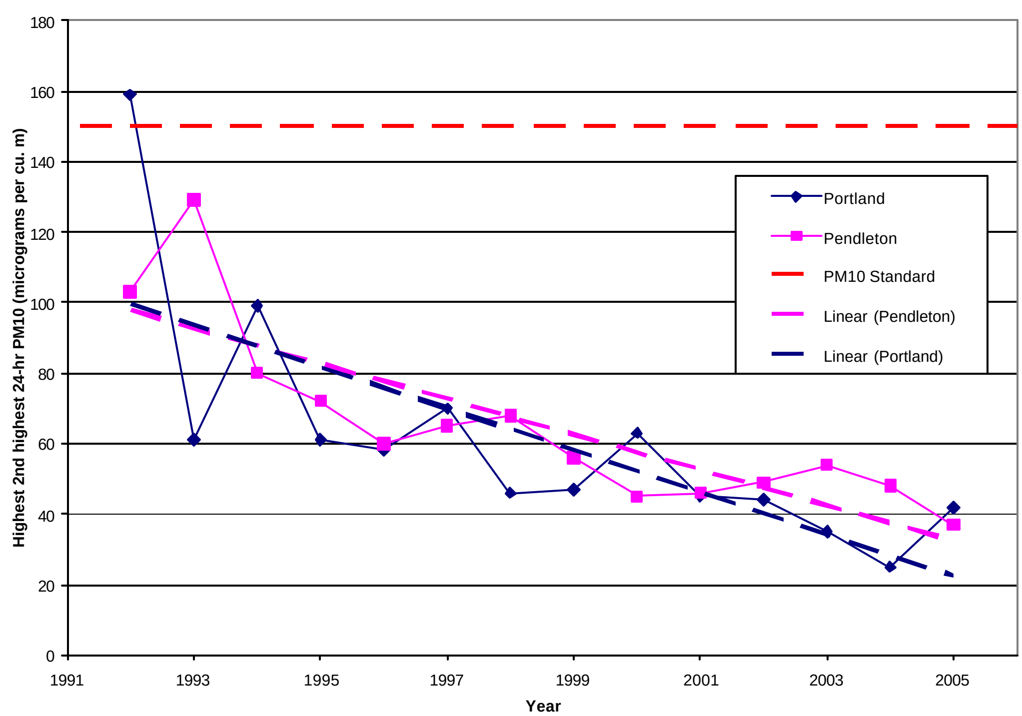
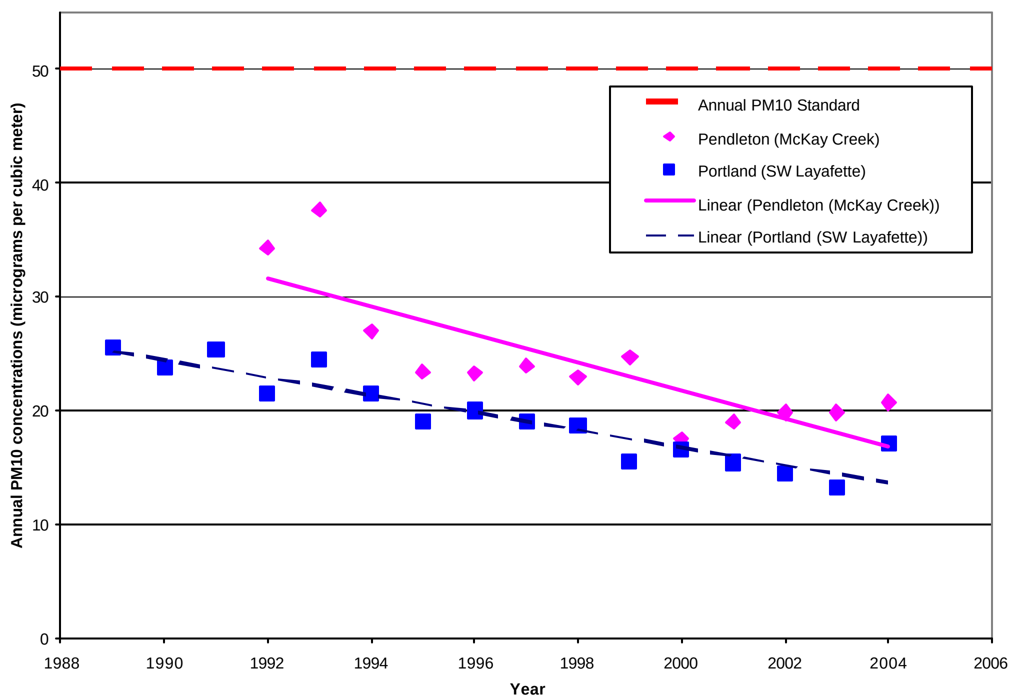


**Figure 5: Annual $PM_{10}$ Trend from Pendleton and Portland**



For the pollutants associated with secondary particle formation (e.g., $PM_{2.5}$, ozone, sulfates and nitrates), the trends are less dramatic but indicate a constant or slight improvement. In the case of ozone (Figure 6), the long-term trend is downward but the trend on the last decade is generally flat, with values across the region being comparable, despite approximately a 40-percent increase in population and vehicle mile traveled (Figure 7) over the same time period.

In early 2006, EPA proposed to lower the 24-hour $PM_{2.5}$ standard from 65 $\mu g/m^3$ to 35 $\mu g/m^3$. If EPA decides to promulgate the new standard in late September, the new standard could take effect in December 2006. Then, based on three years of monitoring, the states would make their initial attainment designations by December 2007 and their final designations in December 2009. For all areas designated non-attainment, the States would have until December 2013 to develop State Implementation Plans (SIP) outlining how states will reduce pollution to meet the standards.

For $PM_{2.5}$, monitoring began in 1999 and 2000. Figure 8 shows the three-year average 98th percentile $PM_{2.5}$ concentrations for sites across Oregon, as reported by Oregon DEQ. The Dalles site (on the left) in the CRG has low values compared with the rest of the state and is less than the proposed $PM_{2.5}$ standard of 35 $\mu g/m^3$. Figure 9 shows the $98^{th}$ percentile 24-hour $PM_{2.5}$ concentrations from various monitors across the CRG region. These data show a considerable year-to-year variability with an overall flat trend. $PM_{2.5}$ from the IMPROVE Mt. Zion and Wishram sites are included for reference. The urban values are higher than the rural CRG values; however, the instrumentation between the DEQ and IMPROVE sites is different.

The annual $PM_{2.5}$ concentrations (Figure 10) are less variable and generally indicate a flat trend. The annual $PM_{2.5}$ standard is 15 $\mu g/m^3$. The Pendleton monitor shows a slight upward trend for four years but was discontinued in 2003. The Dalles site shows a downward trend. However, several more years of monitoring will be needed to verify the actual trends.

Figure 11 shows the maximum 24-hour light scatter measured in Portland and Pendleton. The long-term trend at all stations is downward. The Pendleton station shows an upward pattern in the last few years consistent with the $PM_{10}$ concentrations (Figures 3 through 5). This station seems to exhibit a stair step type pattern (a dramatic decrease then small increase). We suspect this stair step pattern is due to a local influence because it is not seen in any of the other sites.

**Figure 6: Fourth Highest 8-Hour Ozone**

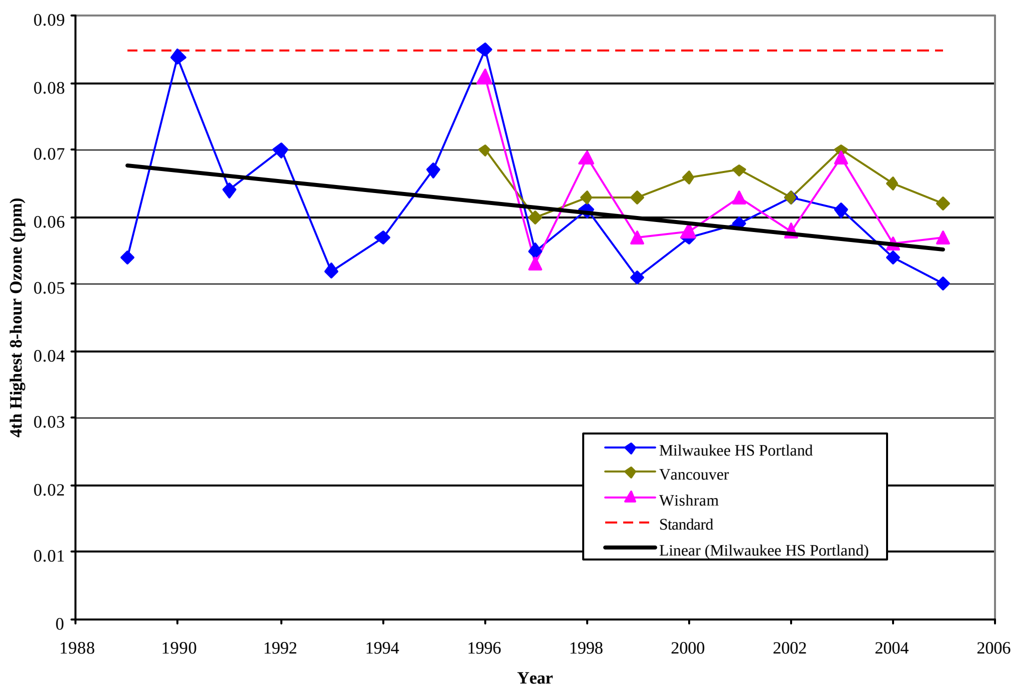
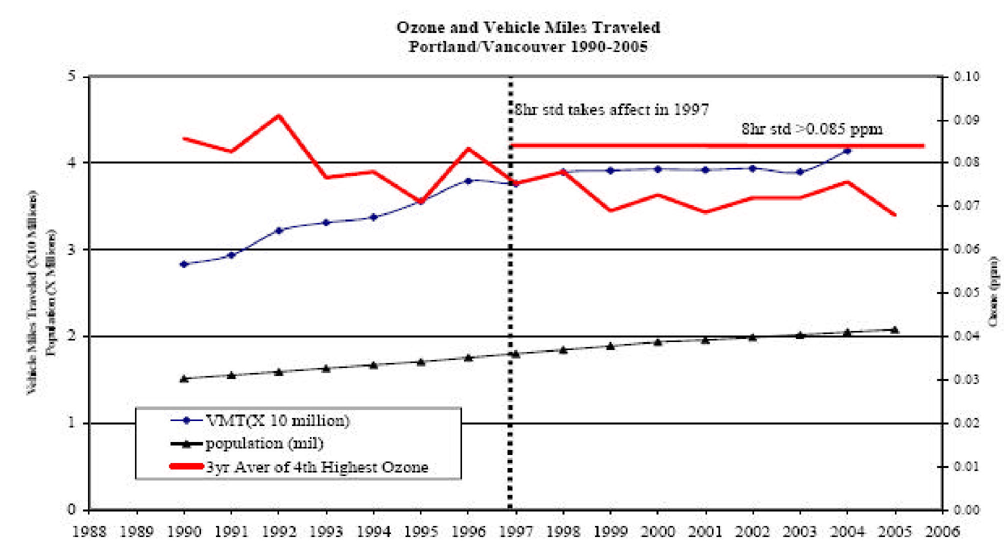


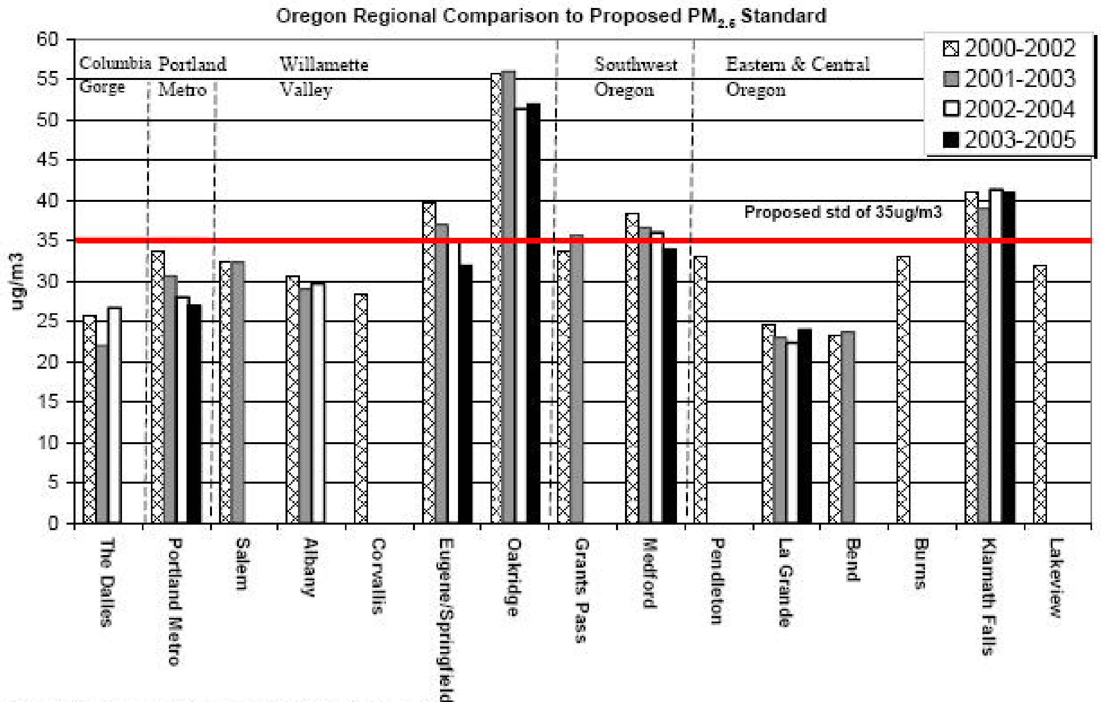

**Figure 7: Portland/Vancouver Ozone Trend with Vehicle Miles Traveled (VMT) and Population Growth (from DEQ 2005 Annual Report)**




Ozone is the 3yr average of the fourth highest 8hr average at the maximum site in Portland

Figure 30b. Portland/Vancouver ozone trend using the three year average of fourth highest eight hour ozone value with Vehicle Miles Traveled and Population trends.

**Figure 8: Oregon $PM_{2.5}$ Three-Year Average 98th Percentile (from Oregon DEQ 2005 Annual Report)**




1. Based on maximum 3 yr aver. of 98th Percentile using filter data
2. Many cities do not have 3yr averages after 2002 because of resource reallocation and funding cuts

**Figure 9: 98th Percentile $PM_{2.5}$ Concentrations**

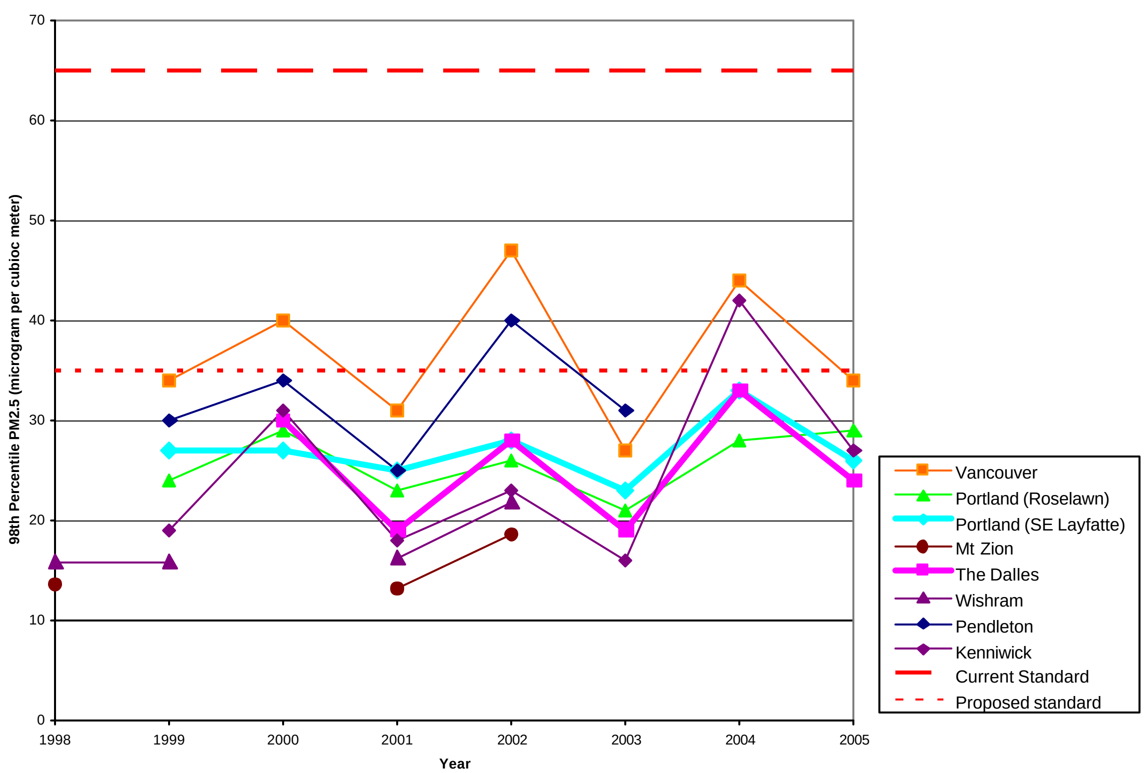


**Figure 10: Annual $PM_{2.5}$ Concentrations**

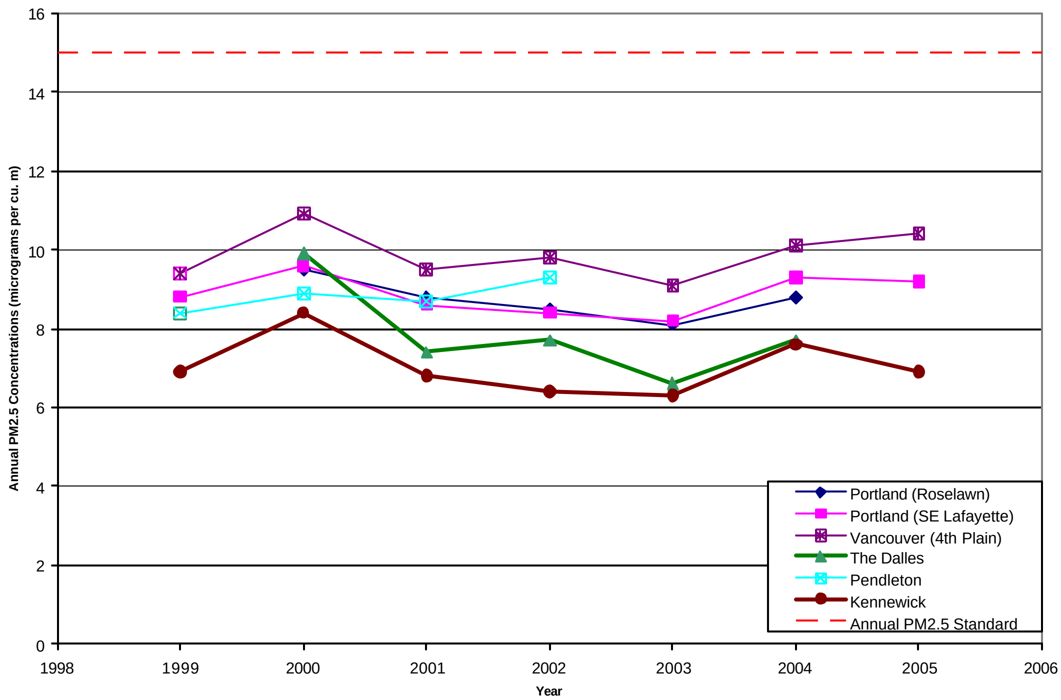
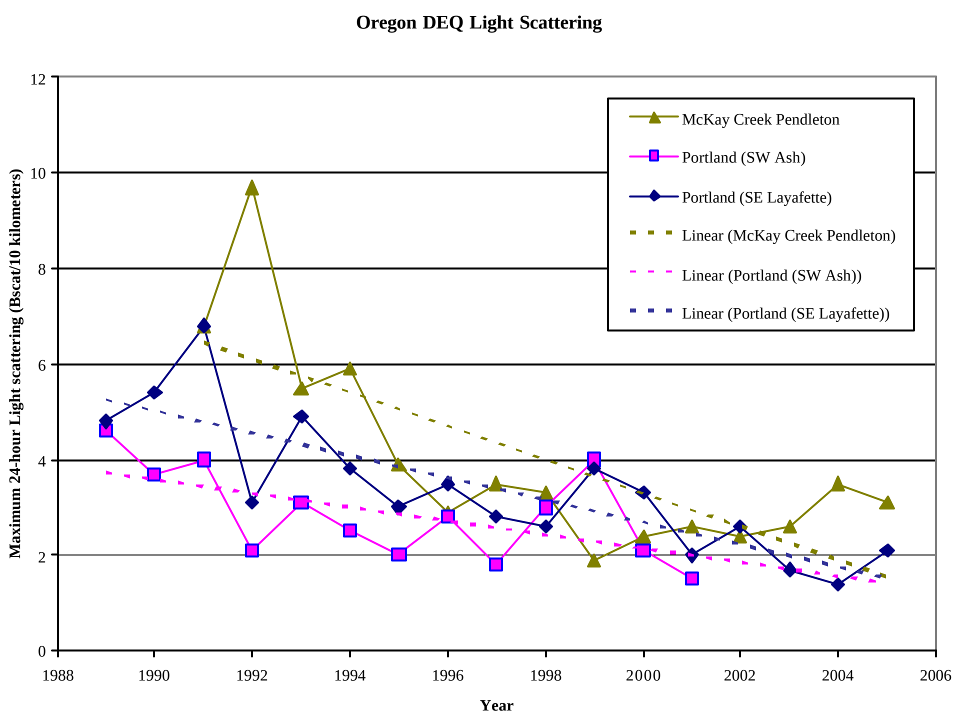



**Figure 11: Maximum 24-Hour Light Scattering from Portland and Pendleton**



## IMPROVE Stations

Best 20%, middle 20% and worst 20% day light extinction data from the IMPROVE stations are shown in Figures 12a through c for the IMPROVE stations around the CRG. These data were obtained from the Visibility Information Exchange Web System (VIEWS) trends graphic viewer (http://vista.cira.colostate.edu/dev/web/AnnualSummaryDev/Trends.aspx). The stations include Mt. Zion, Wishram, Mt. Hood, Mt. Rainier, Three Sisters, Spokane Indian Reservation, Starsky (in Eagle Cap), Hells Canyon, White Pass, and Puget Sound. The Puget Sound station is an urban station. In calculating summary values, VIEWS only reports data for years that pass the Regional Haze Rule (RHR) completeness requirements.

In all cases, the highest extinction is found at the urban station in Puget Sound. The next highest extinction values occur at the lower elevation stations (e.g., Mt Zion, Wishram, and Spokane Indian Reservation) in the CRG and Columbia Basin, which are heavily influenced by the population centers. The higher mountain sites (e.g., Mt Hood, Three Sisters, and White Pass) have the lowest extinction values. For the stations with a long-term continuous record that is more than five years (Wishram, Mt Rainier, and Three Sisters), a trend line is included. For best 20% and middle 20% extinction days, all three sites show a downward trend. For the worst 20% case, the high elevation sites (Mt. Rainier and Three Sisters) also show a downward trend. However, the Wishram trend line was removed from Figure 12c because of data problems associated with this site, which are discussed below.

Figure 13a shows the 2004 daily aerosol extinction values for the Wishram site, with the worst 20% days highlighted in red. The year 2004 was selected because it was the most recent year of data available. Most of the worst 20% days occur in the late fall and winter months. This is a typical pattern for the lower elevation stations and is also seen at Mt. Zion, Hells Canyon, Puget Sound, and Spokane Indian Reservation monitors. Figure 13b shows the daily extinction pattern at Mt. Hood which is a high elevation station. For the high elevation stations, the highest extinctions typically occur during the spring and summer months. Note that the Y-axis scale of the Wishram panel is approximately five times the Y-axis scale of the Mt. Hood panel. The low elevation stations are within the wintertime stagnate layer, which traps pollutants under low wind speed and high relative humidity conditions, resulting in the highest extinction values. The high elevation stations are above the wintertime inversion layers and therefore have much lower wintertime extinction values.

Figure 14a and b shows the spatial distribution of 2004 best 20% and worst 20% day extinction across the entire continental U.S. IMPROVE network. Again, 2004 was selected because it was the most recent year of data available. Most of the Northwest IMPROVE sites are located in remote mountainous areas, away from the urban centers, so that the effect of the urban centers and valley locations are greatly under-represented in these figures. The highest extinctions are seen in the eastern Mississippi Valley states (Ohio, Kentucky, Tennessee) and some eastern states (Pennsylvania, West Virginia). The lowest extinction values are found along the Rocky Mountain Corridor (i.e., Utah, western Colorado and Wyoming). The Pacific Northwest generally has low to moderate extinction values, with hot spots around the lower elevation stations (Puget Sound, Wishram, Mt Zion, and Spokane Reservation). Note that the hot spot around Puget Sound is not well resolved because of averaging effect in the numerical contouring.

**Figure 12: Best 20% Days Extinction ($Mm^{-1}$) for IMPROVE Sites Around the CRG with Trend Lines on Long-Term Stations (Wishram, Mt. Rainier, and Three Sisters)**

Only data from years meeting the RHR completeness requirements are reported.

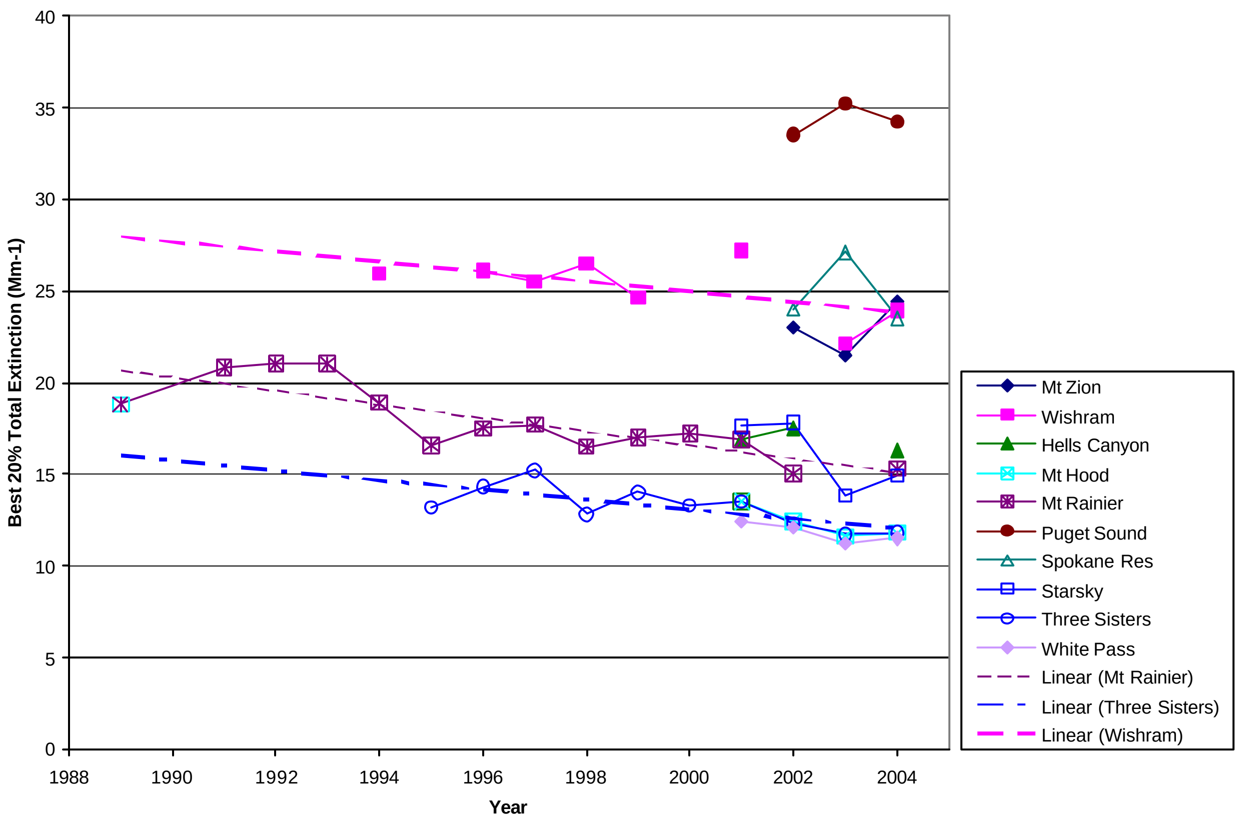


**Figure 12b: Mid 20% Days Extinction ($Mm^{-1}$) for IMPROVE Sites Around the CRG with Trend Lines on Long-Term Stations (Wishram, Mt. Rainier, and Three Sisters)**

Only data from years meeting the RHR completeness requirements are reported.

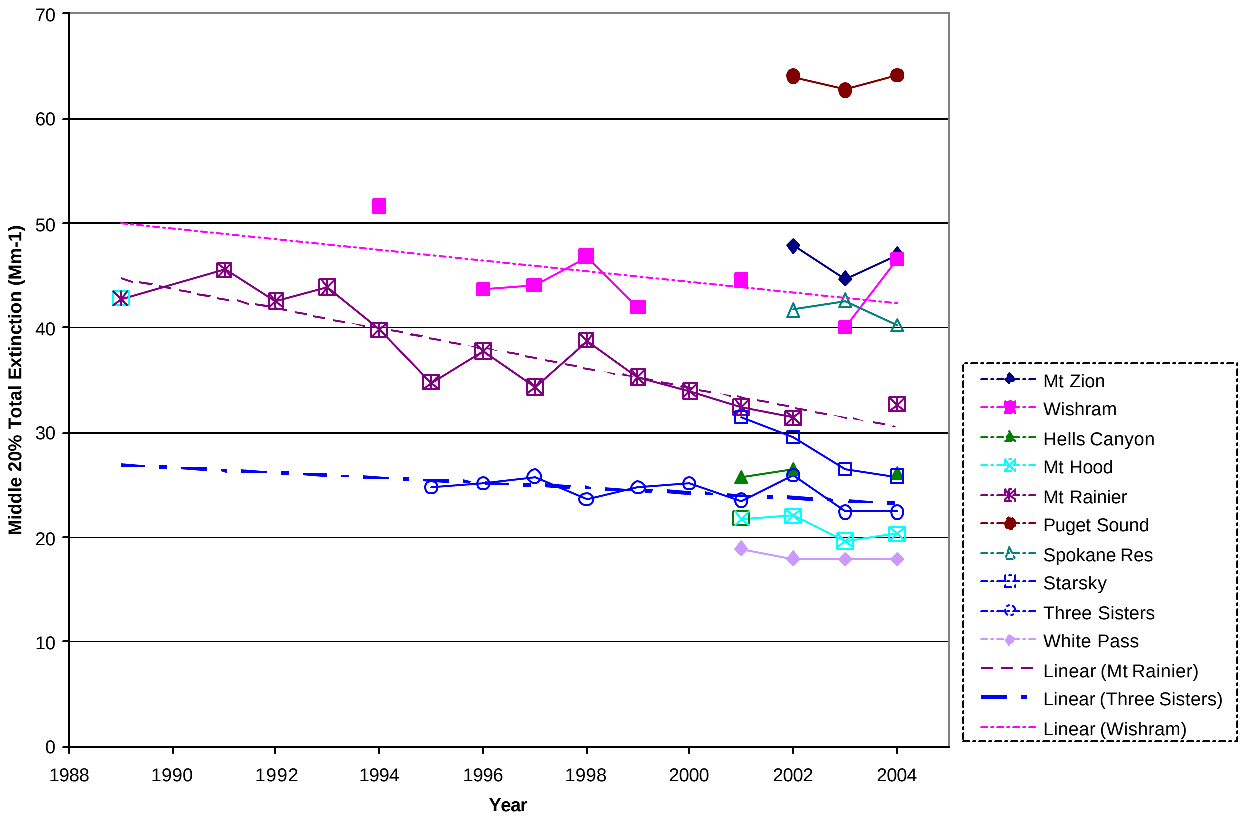


**Figure 12c: Worst 20% Days Total Extinction ($Mm^{-1}$) for IMPROVE Sites Around the CRG with Trend Lines on Long-Term Stations (Mt. Rainier, and Three Sisters)**

The trend line for Wishram was not included because of data anomalies impacting the site (discussed in text). Only data from years meeting the RHR completeness requirements are reported.

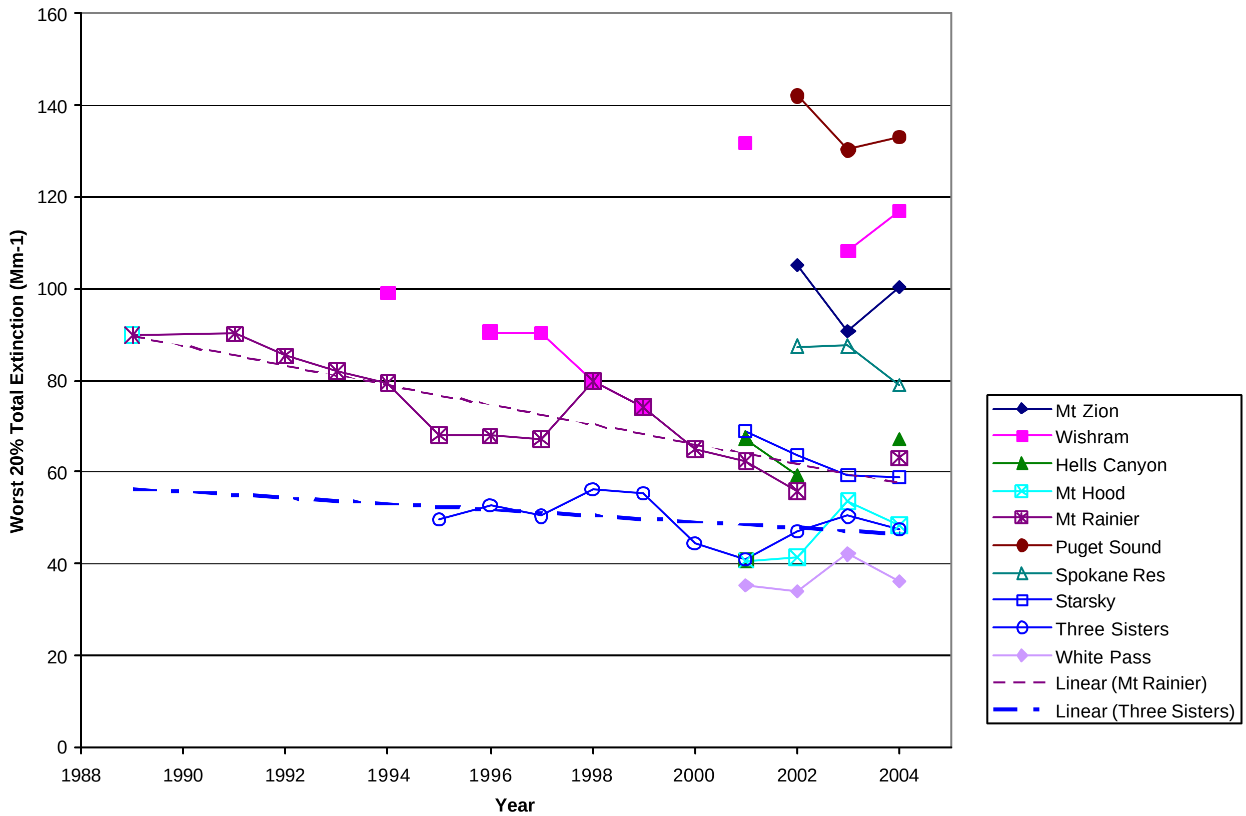


**Figure 13a: 2004 Daily Aerosol Extinction at Wishram**

Wishram is a low elevation site. The worst 20% days are highlighted in red. (From the VIEWS)

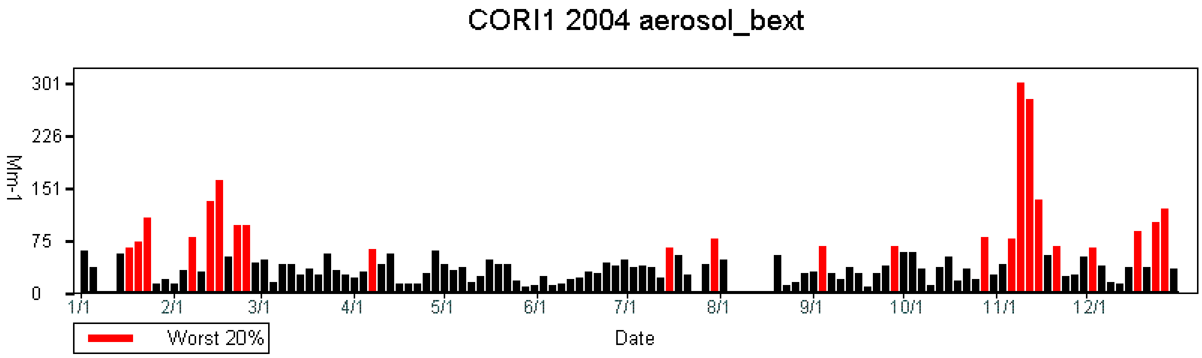



**Figure 13b: The 2004 daily aerosol extinction at Mt. Hood**

Mt. Hood is a high elevation site. The worst 20% days are highlighted in red (From the VIEWS). Note that the Y-axis scale is different than in Figure 13a.

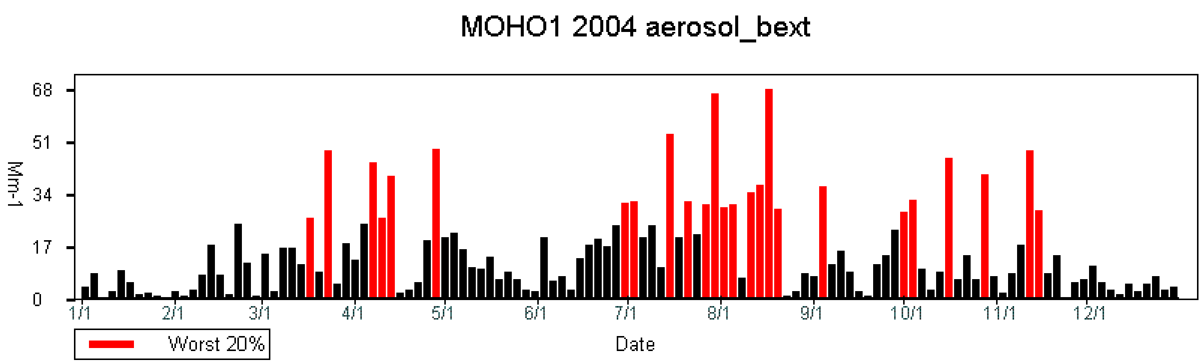


**Figure 14a: Spatial Distribution of the 2004 Best 20% Aerosol Extinction**

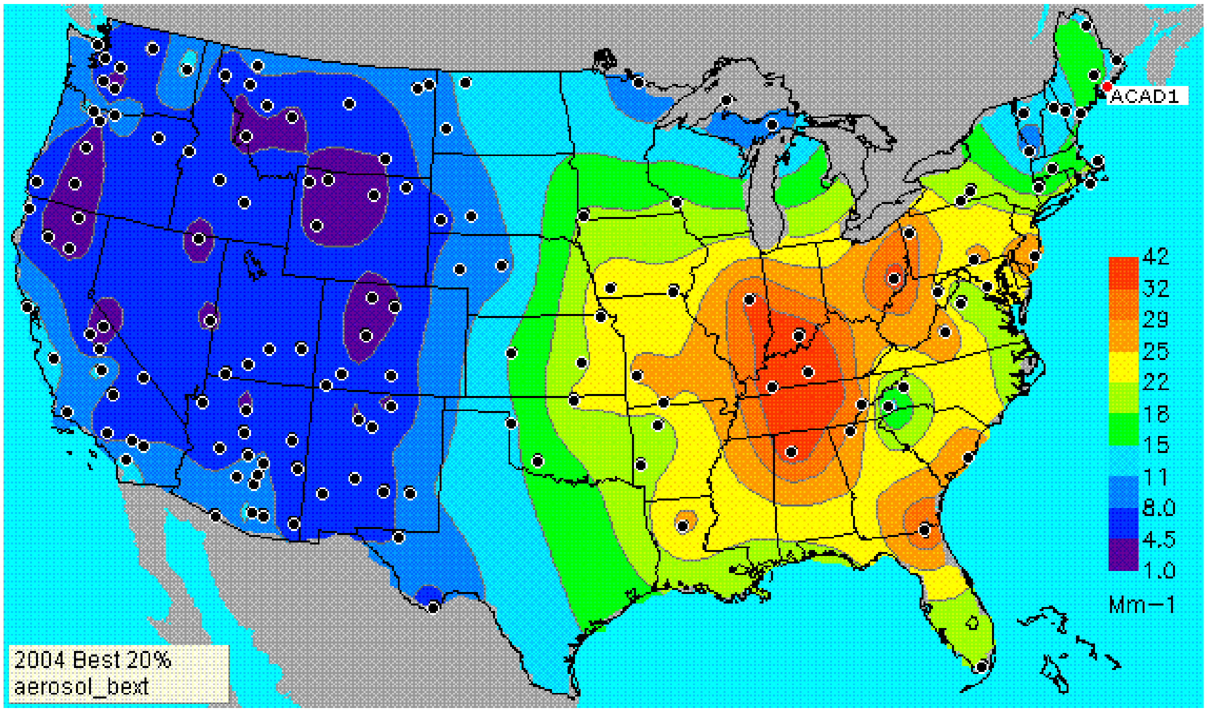
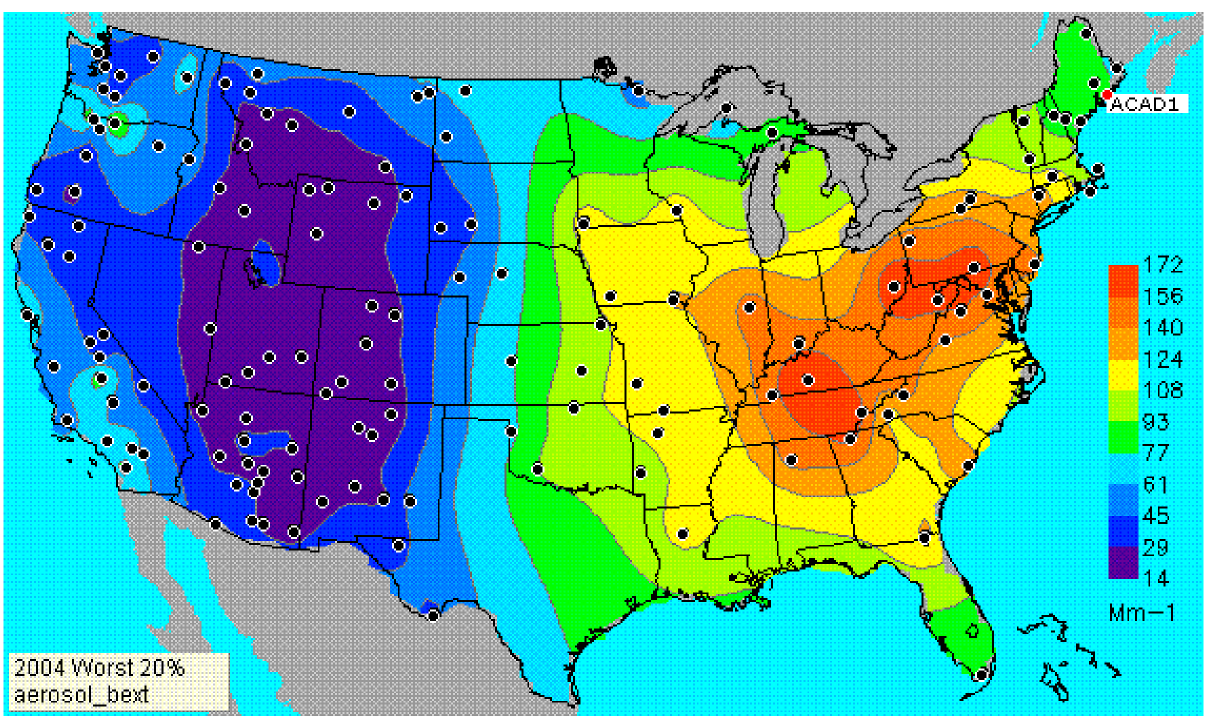



**Figure 14b: Spatial Distribution of the 2004 Worst 20% Aerosol Extinction**



## IMPROVE Ammonium Nitrate Issues.

The 2003 AQ trends outlined issues associated with the IMPROVE nitrate concentrations. In the fall of 2000, the Wishram and Mt. Zion IMPROVE sites (as well as all other IMPROVE sites across the country) were re-fitted with the Version 2 IMPROVE configuration. In the following winter (and subsequent winters), there is a dramatic increase in the wintertime nitrate concentrations as compared with the previous historical record (as shown in Figure 15). The dramatic change in the nitrate behavior has also been observed in other sites across the country. These nitrate spikes are seen in other sites (Mt. Zion to a lesser extent, Spokane Reservation, Starkey site in the Blue Mountains), but are not obvious in the high elevation stations (e.g., Mt. Hood, Mt. Rainier, Three Sisters).

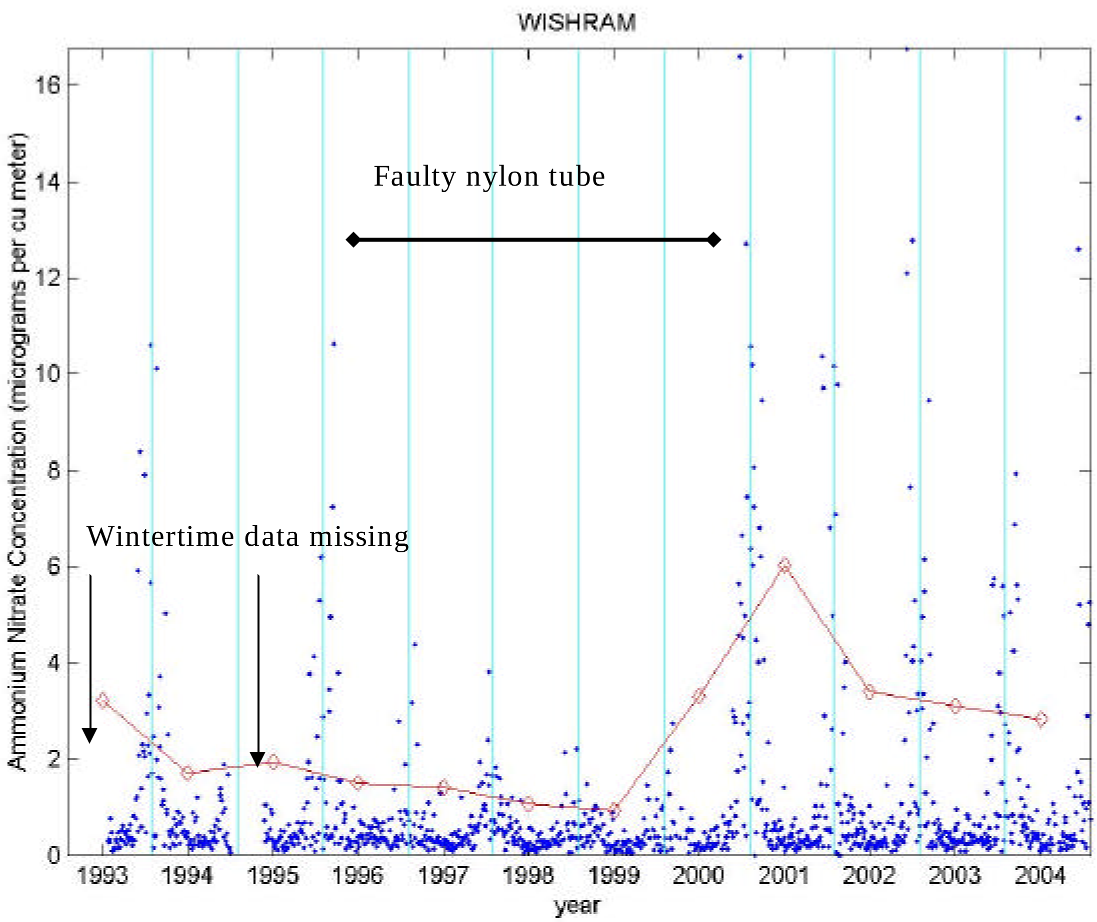
This behavior was identified by the IMPROVE steering committee.

> "UCD (U.C. Davis) is conducting assessments of the possible affects of historic sampling / analysis protocol changes on trends analysis of the data. Nitrate changes at Mammoth Cave show a marked increase during Winter 2000 from previous years. Several sites show similar behavior. Sulfur was also high at all sites during the season; four collocated CASTNet sites concur. Several possible causes for these changes were suggested: 1) the high nitrates during 2000 may be due to the first cold winter after several mild ones; 2) something may be occurring in the measurements we don't understand; 3) an extraneous source of nitrate and sulfate may exist, maybe from across the Pacific Ocean, and 4) different factors may be responsible for the nitrate and sulfate spikes in the east and west." (IMPROVE steering committee meeting summary, June 2003, page 3)
>
> "Abrupt changes occurred in nitrate data at many IMPROVE sites, which affected both magnitude and variability." … "The second change occurred in 2000 data, but no known change in the denuder protocol occurred at that time. The amount of change varies by site." (IMPROVE steering committee meeting summary, June 2003, page 4)

Since this report, U.C. Davis determined that there was a manufacturing problem with the nylon tubes used during the 1996-2000 period which caused nitrate to be under-reported (Chuck McDade, personal communication with Kent Norville, January 6, 2006). Thus, staff at U.C. Davis state that the 1996-2000 nitrate data should be discounted and that the post-2000 data are reasonable. This issue would have the biggest impact on the high extinction days when nitrate is dominant (like during winter stagnation events), and less impact on the best days when the nitrate contribution is smaller. Thus, the worst-case Wishram 1996-2000 extinction data should be discounted. Since the mid and best 20% cases are typically not nitrite dominated, the downward trend in the best 20% and mid 20% extinction days at Wishram (Figure 12a and b) is probably reasonable. Even though there are nitrate data before 1996, there are wintertime data gaps in the 1993 to 1996 period, so that there is a likely under-prediction of the worst-case nitrate during those years. Note that the peaks in the 1993-1994 and 1995-1996 are consistent with the observed peaks in post 2000. The bottom line is that the pre-2001 nitrite data are suspect or biased to the low side and should be viewed with considerable caution.

**Figure 15: Wishram Ammonium Nitrate Extinction Values With Yearly 90th Percentile Values (diamonds)**

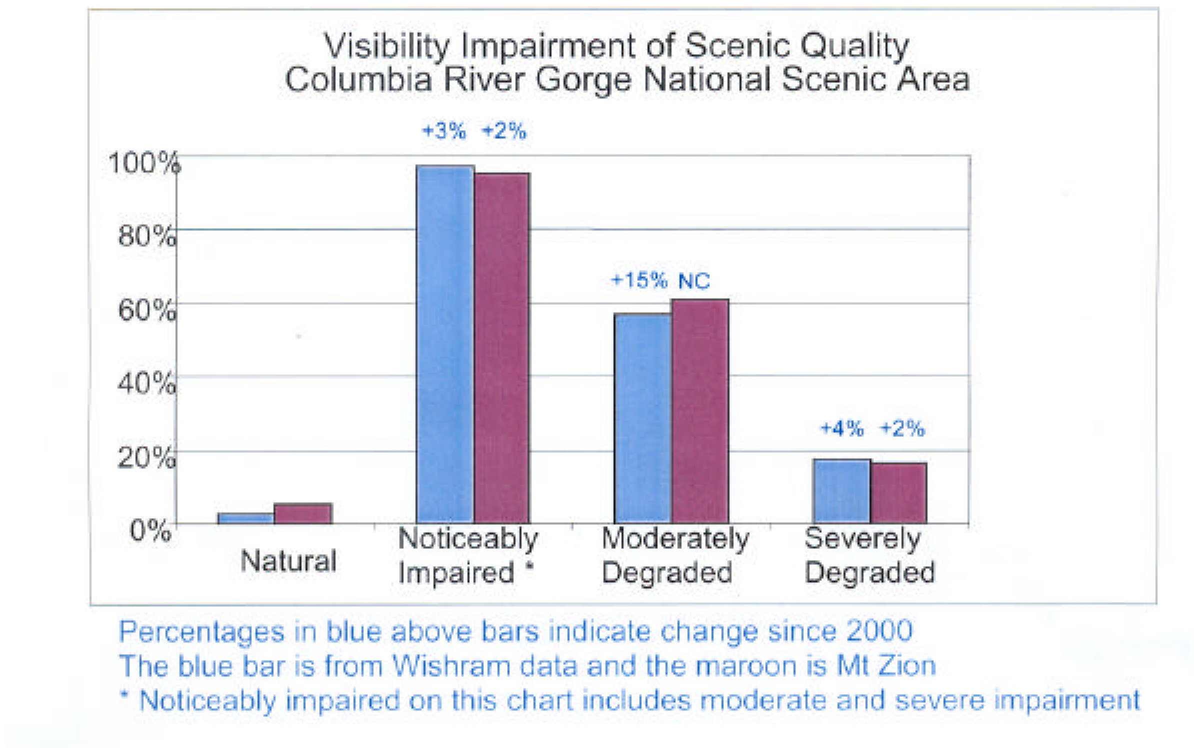
The 1996-2000 period when the faulty nylon tubes use used is identified. The two arrows indicate wintertime gaps period before 1996.



## Discussion of the USFS 2004 Visibility Trends Figure

In 2004, the USFS released several documents that contained a figure (shown below in Figure 16) showing the change in visibility impairment from 2000.

**Figure 16: USFS Figure Indicating an Increase in Impairment in the CRG**
Note that "NC" means "No change."




The accompanying text states:

> "The blue percentages above each bar indicate change from 2000 to 2003. The most notable and surprising is the increase in moderate impairment at Wishram – up 15%. The increases are primarily due to ammonium nitrate. It is also notable and significant that relatively small or no change occurred at Mt. Zion on the West end of the Gorge. Note that, as is true with any short term air quality monitoring information, year to year meteorological variability will affect the results."

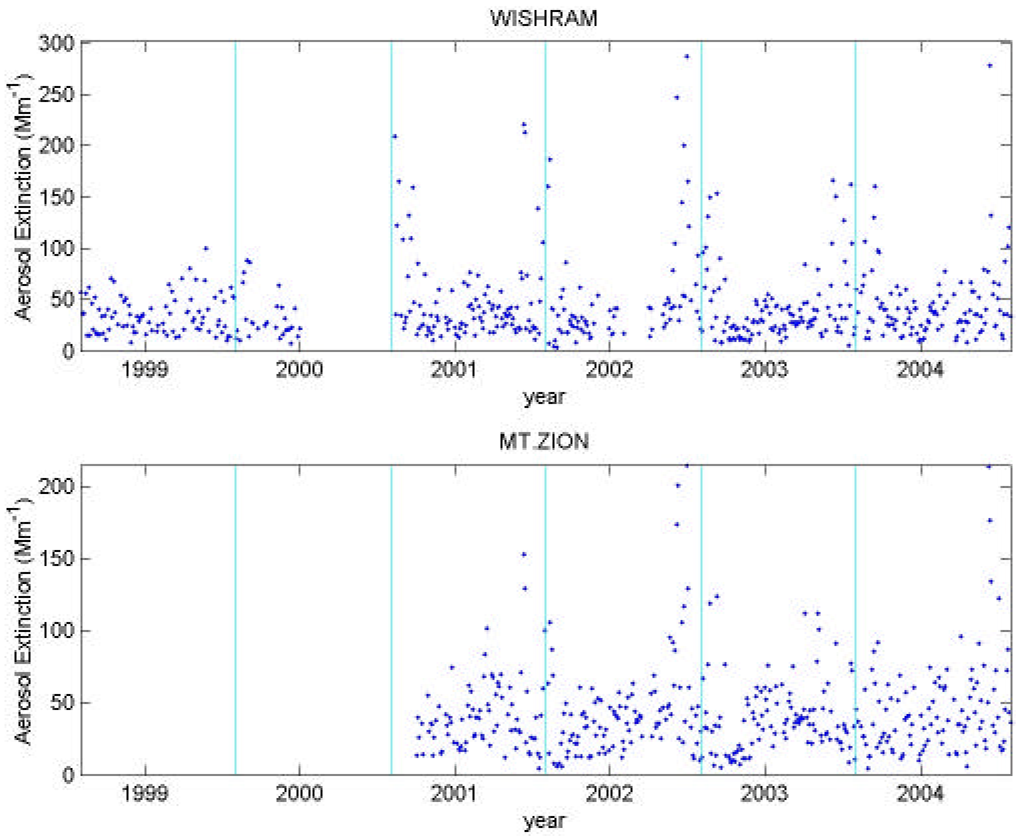
Based on the Figures 12a through c, the Wishram and Mt. Zion bars shown in the figure are reasonable and consistent with low elevation site. However, it is not clear how the percentages (numbers above the bars) were calculated. Figure 17 shows the 1999 to 2004 Wishram and Mt. Zion daily extinction values. The Mt. Zion site was not operational during 1999 and 2000 so that a 2000 baseline could not be established. Although the Wishram site was operational in 2000, the extinction could not be calculated for the last half of 2000 due instrument problems (no soil contribution). As a result, the 2000 Wishram data set failed to meet the RHR completeness requirements and, as a result, does not appear in the VIEWS summaries (e.g., Figures 12a through c). Furthermore, the faulty nitrate tubes were used in the first half of 2000, which would result in an under-estimate of the nitrate extinction. Therefore, because of the data issues and incomplete data record, any 2000 baseline for the Wishram site is highly questionable. Finally, because year-to-year variability is significant (as noted by the USFS and shown in the figures), the use of less than five-year time period to indicate a meaningful trend is also questionable. If, for example, the 2001 to 2004 period were used, there would be both upward and downward trends in the data (as indicated by Figures 12a through c).

The text also states:

> "In the Severe category (>70mm-1) virtually all features of the scene are lost – for example in the camera view from Wishram (at the URL above) you would not be able to see Mt. Hood at all and most features in the view are gone except those within a few miles of the camera or viewer."

Many of these high extinctions are associated with high relative humidity linked with wintertime stagnant fog or rain events. Under these conditions, it is unlikely that an observer would not be able to see Mt. Hood because of fog, clouds, or rain, all of which are natural.

**Figure 17: 1999-2003 Daily Extinction Value from Wishram and Mt. Zion**



## Summary

Table 3 summarizes the pollutants considered and indicates the trend of the data, along with the relevant figure number and the source of the data. These data indicate that air quality has generally been improving, even with a significant steady increase in the state population. For pollutants associated with secondary particle formation (e.g., sulfates, nitrates) the long-term trend lines have been decreasing and there is no evidence of significant increases. Short-term trends are difficult to determine due to the natural variability.

**Table 3: Summary of Air Quality Trends Around the Columbia River Gorge**

| Figure # | Pollutant | Trend | Data source |
|---|---|---|---|
| 1 | Maximum hourly nitrogen dioxide ($NO_2$) | Downward (improving) over 15 years | Oregon DEQ |
| 2 | Annual $NO_2$ | Downward (improving) over 15 years | AIRS |
| 3 and 4 | Maximum and highest 2nd highest daily particulate matter with diameter less than 10 microns ($PM_{10}$) | Downward (improving) since 1989 | Oregon DEQ |
| 5 | Annual $PM_{10}$ | Downward (improving) since 1990 | Oregon DEQ |
| 6 and 7 | 4th highest 8-hour and 3-year average of 4th highest 8-hour ozone | Modest downward trend from 1988, flat since 1998 | Oregon DEQ, AIRS |
| 8,9 | 98th percentile particulate matter with diameter less than 2.5 microns ($PM_{2.5}$) | Flat (constant), limited data since 1999 | Oregon DEQ, AIRS |
| 10 | Annual $PM_{2.5}$ | Flat (constant) or slight downward, limited data since 1999 | Oregon DEQ, AIRS |
| 11 | Light Scattering | Downward (improving) since 1990 | Oregon DEQ |
| 12 | IMPROVE extinction | Long-term downward in long term stations since 1989 | IMPROVE |
| 15 and 17 | Wishram and Mt. Zion nitrate and extinction | Inconclusive due to record gaps and instrument issues | IMPROVE |