

Emission and Air Quality Trends Review 1999-2011

Virginia

July 2013

Project Objective

- ❑ To develop and present publicly available information on trends in emissions and ambient air quality in the U.S. since 1999 in easy to understand visual and tabular formats

Emission Trends

- ❑ Study Team collected and processed U.S. EPA emission inventories for years within the study period of interest (1999-2011)

- ❑ By pollutant and source category
 - electric utility coal fuel combustion
 - mobile sources
 - industrial fuel combustion & industrial processes
 - all other

Emissions Data Summary

- Data Obtained from EPA National Emission Inventory (NEI) and Trends Websites
 - EPA's Trends reports and emission comparisons include interpolations of all categories between key years (1999, 2002, 2005, 2008, 2011) at county-pollutant level
 - Represented Pollutants: VOC, NO_x, SO₂, and PM_{2.5}
- Project Improvement
 - The Study Team augmented above data with year specific CEM emissions (2002 through 2011)

Emission Changes

- ❑ The following slides also include the tonnage-based emissions change from 1999 to 2011 for each pollutant
- ❑ Negative values indicate decrease in emissions, positive values indicate an increase

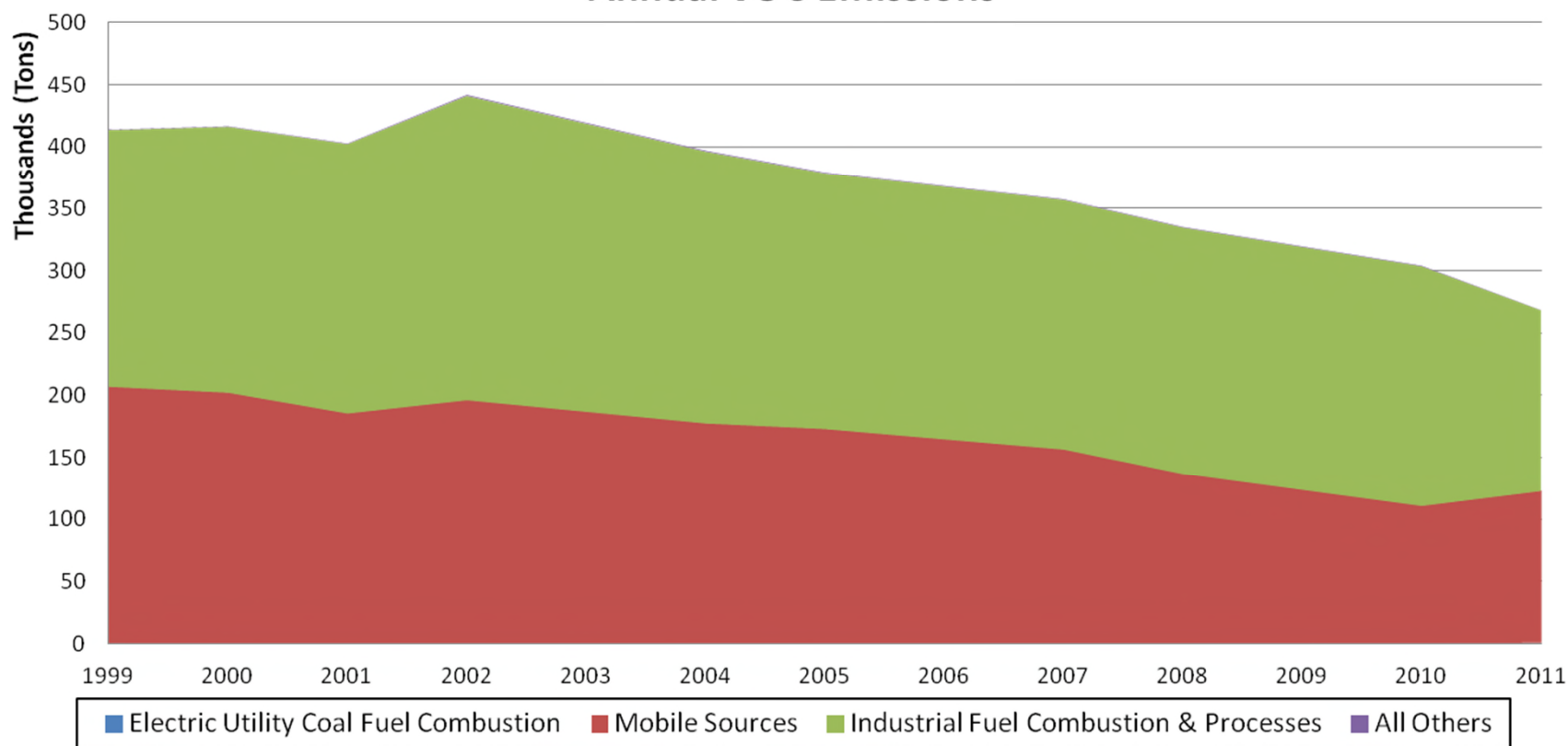
Virginia Emission Trends (VOC)

Source Category	Annual Emissions (Tons)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	458	447	423	290	267	285	277	219	205	529
Mobile Sources	206,798	185,336	186,732	173,008	164,785	156,561	136,782	123,807	110,832	122,499
Industrial Fuel Combustion & Processes	206,441	216,672	231,628	205,386	202,851	200,318	197,783	195,248	192,714	145,460
All Others	280	422	687	592	506	513	475	449	472	212
Total	413,978	402,877	419,470	379,276	368,409	357,678	335,317	319,723	304,224	268,701

Source Category	Annual Emissions Change (Percent since 1999)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	0%	-2%	-8%	-37%	-42%	-38%	-39%	-52%	-55%	16%
Mobile Sources	0%	-10%	-10%	-16%	-20%	-24%	-34%	-40%	-46%	-41%
Industrial Fuel Combustion & Processes	0%	5%	12%	-1%	-2%	-3%	-4%	-5%	-7%	-30%
All Others	0%	51%	145%	112%	81%	83%	70%	60%	68%	-24%
Total	0%	-3%	1%	-8%	-11%	-14%	-19%	-23%	-27%	-35%

Virginia Emission Trends (VOC)

**Major Source Category Summary
Annual VOC Emissions**



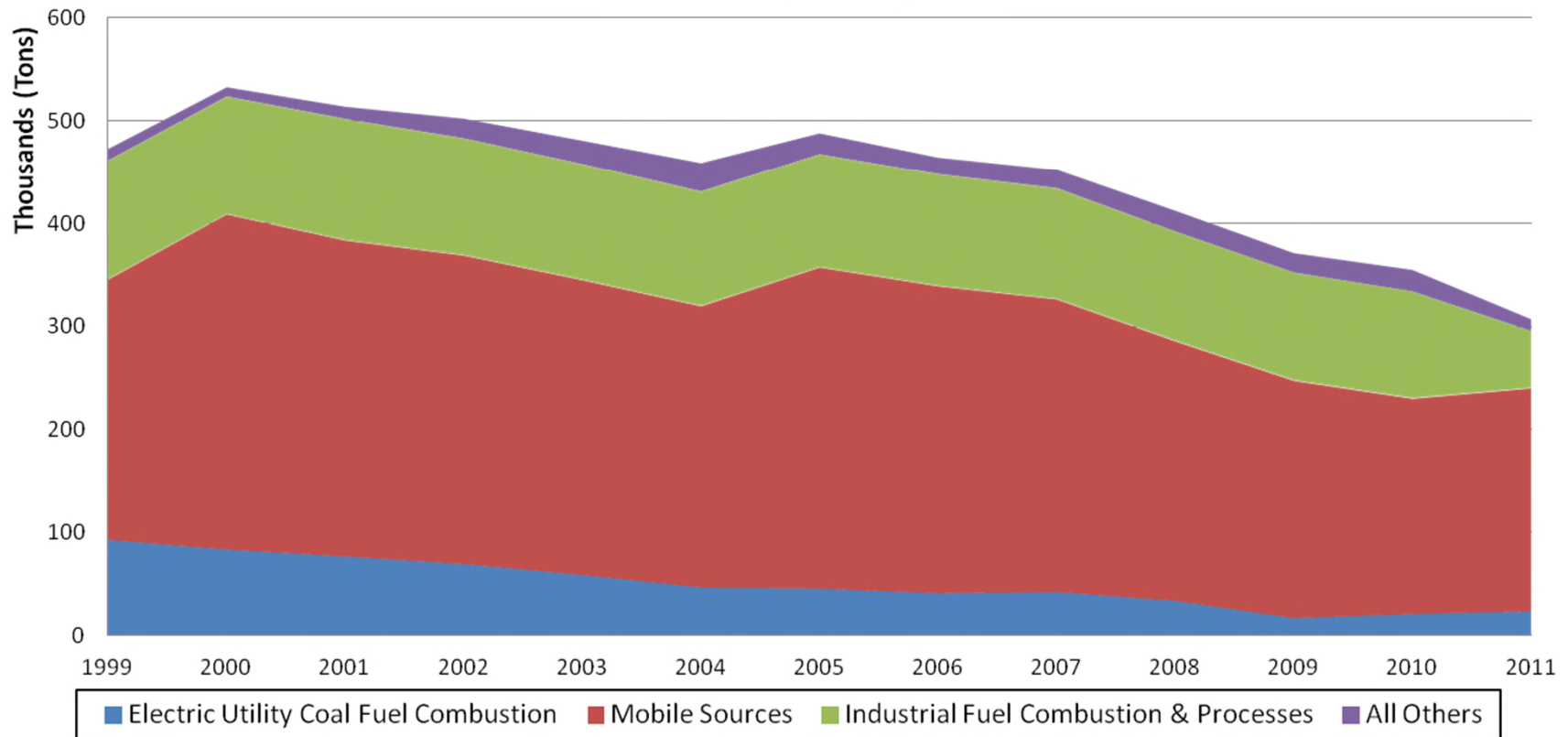
Virginia Emission Trends (NO_x)

Source Category	Annual Emissions (Tons)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	92,533	76,448	58,429	45,211	40,745	41,834	33,364	16,510	20,613	23,106
Mobile Sources	253,149	307,201	286,698	312,258	298,458	284,657	252,550	231,063	209,576	217,213
Industrial Fuel Combustion & Processes	115,567	118,199	112,500	109,837	108,488	107,431	105,830	104,364	103,402	54,832
All Others	11,251	11,799	22,871	20,385	16,215	17,908	20,090	18,664	20,761	11,350
Total	472,500	513,646	480,498	487,692	463,906	451,831	411,834	370,601	354,352	306,502

Source Category	Annual Emissions Change (Percent since 1999)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	0%	-17%	-37%	-51%	-56%	-55%	-64%	-82%	-78%	-75%
Mobile Sources	0%	21%	13%	23%	18%	12%	0%	-9%	-17%	-14%
Industrial Fuel Combustion & Processes	0%	2%	-3%	-5%	-6%	-7%	-8%	-10%	-11%	-53%
All Others	0%	5%	103%	81%	44%	59%	79%	66%	85%	1%
Total	0%	9%	2%	3%	-2%	-4%	-13%	-22%	-25%	-35%

Virginia Emission Trends (NO_x)

Major Source Category Summary
Annual NO_x Emissions



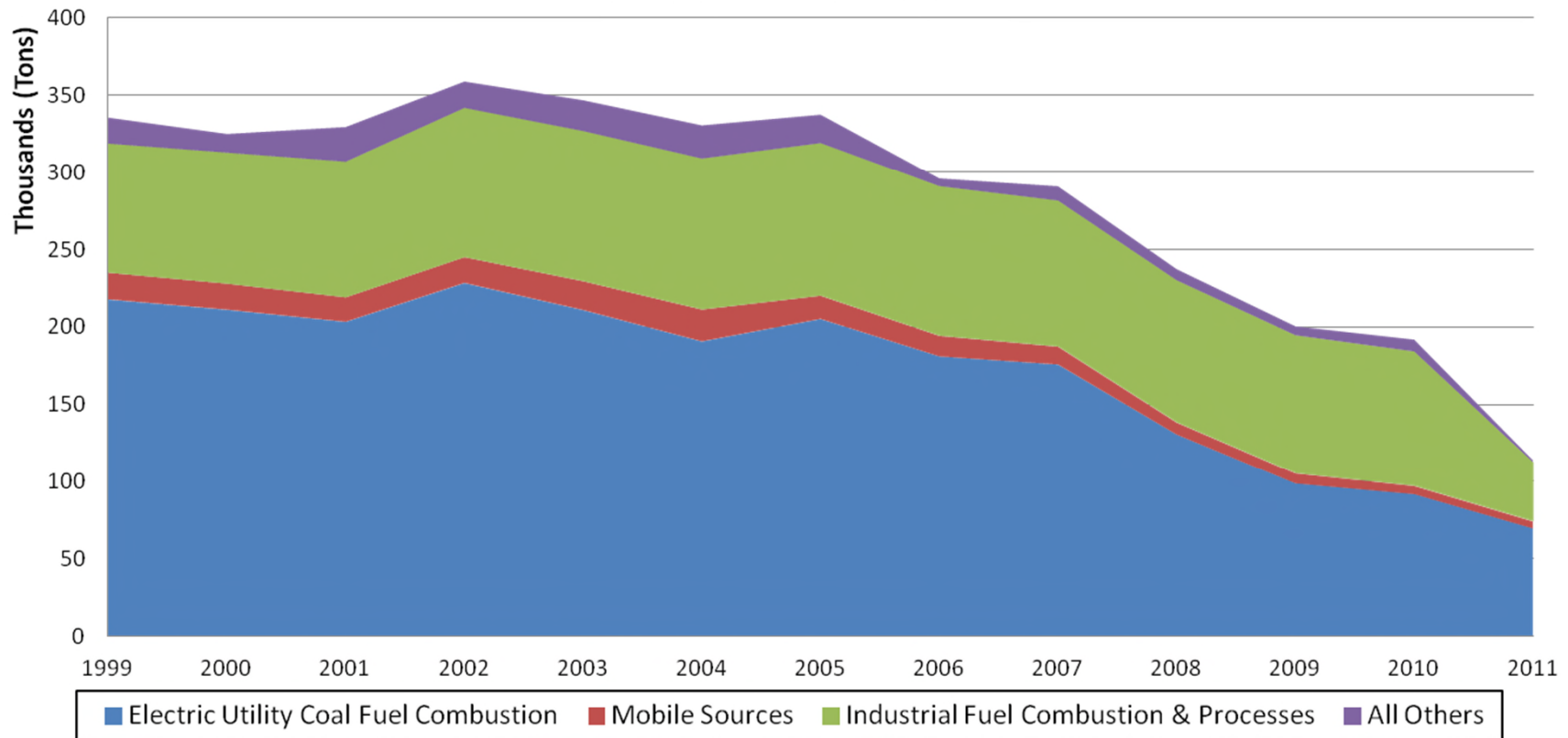
Virginia Emission Trends (SO₂)

Source Category	Annual Emissions (Tons)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	217,746	203,299	210,895	205,157	181,021	175,764	130,556	98,703	91,730	69,535
Mobile Sources	17,150	15,689	18,502	14,907	13,183	11,460	7,708	6,479	5,251	4,544
Industrial Fuel Combustion & Processes	84,065	88,219	97,681	99,206	96,760	94,366	91,814	89,410	87,158	38,480
All Others	16,822	22,492	19,969	18,426	5,019	9,230	7,152	5,708	7,598	1,143
Total	335,783	329,699	347,047	337,695	295,984	290,820	237,230	200,300	191,737	113,702

Source Category	Annual Emissions Change (Percent since 1999)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	0%	-7%	-3%	-6%	-17%	-19%	-40%	-55%	-58%	-68%
Mobile Sources	0%	-9%	8%	-13%	-23%	-33%	-55%	-62%	-69%	-74%
Industrial Fuel Combustion & Processes	0%	5%	16%	18%	15%	12%	9%	6%	4%	-54%
All Others	0%	34%	19%	10%	-70%	-45%	-57%	-66%	-55%	-93%
Total	0%	-2%	3%	1%	-12%	-13%	-29%	-40%	-43%	-66%

Virginia Emission Trends (SO₂)

**Major Source Category Summary
Annual SO₂ Emissions**



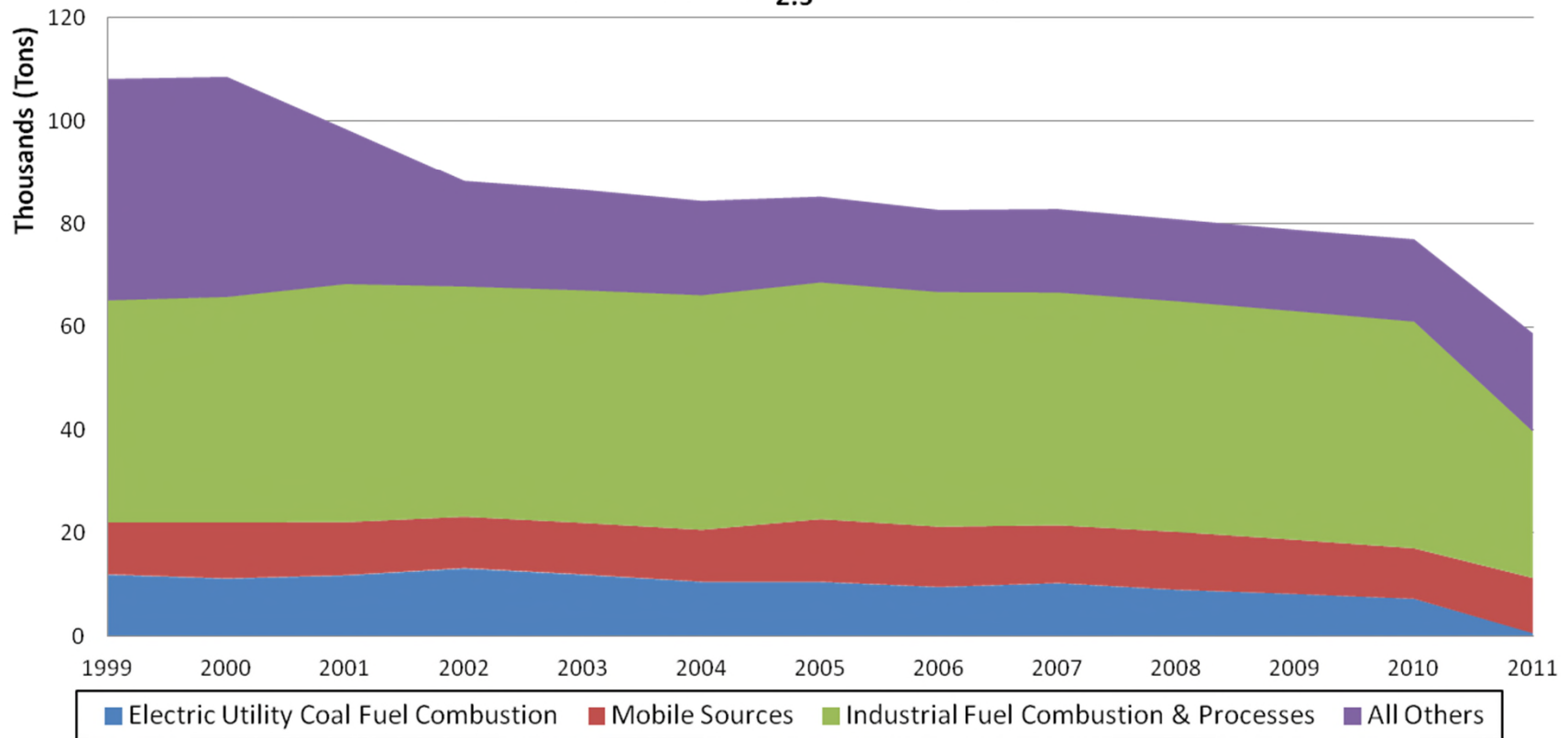
Virginia Emission Trends (PM_{2.5})

Source Category	Annual Emissions (Tons)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	11,992	11,837	11,978	10,560	9,567	10,326	9,022	8,207	7,283	625
Mobile Sources	10,013	10,246	9,965	12,103	11,632	11,160	11,180	10,465	9,750	10,678
Industrial Fuel Combustion & Processes	43,201	46,278	45,196	45,998	45,606	45,235	44,837	44,439	44,068	28,554
All Others	43,017	30,154	19,478	16,597	15,879	16,133	15,858	15,736	15,918	18,997
Total	108,223	98,515	86,617	85,258	82,684	82,854	80,898	78,846	77,019	58,854

Source Category	Annual Emissions Change (Percent since 1999)									
	1999	2001	2003	2005	2006	2007	2008	2009	2010	2011
Electric Utility Coal Fuel Combustion	0%	-1%	0%	-12%	-20%	-14%	-25%	-32%	-39%	-95%
Mobile Sources	0%	2%	0%	21%	16%	11%	12%	5%	-3%	7%
Industrial Fuel Combustion & Processes	0%	7%	5%	6%	6%	5%	4%	3%	2%	-34%
All Others	0%	-30%	-55%	-61%	-63%	-62%	-63%	-63%	-63%	-56%
Total	0%	-9%	-20%	-21%	-24%	-23%	-25%	-27%	-29%	-46%

Virginia Emission Trends (PM_{2.5})

Major Source Category Summary
Annual PM_{2.5} Emissions



Emission Trends Summary

- All pollutants have decreased since 1999 in aggregate across Virginia
- NOx and SO2 from Electric Utility Fuel Combustion sources show significant decrease over time as a result of Acid Rain Program, NOx Budget Trading Program and CAIR control implementation
- Onroad emission step increase seen between 2004 and 2005 is the result of EPA's method change and MOVES model integration for estimating onroad mobile source emissions

Air Quality Design Values

□ Ozone

- Annual 4th highest daily maximum 8-hour average averaged over three consecutive years
- Current standard = 0.075 ppm

□ PM_{2.5} Annual

- Annual arithmetic mean of quarterly means averaged over three consecutive years
- Current standard = 12 ug/m³

□ PM_{2.5} 24-Hour

- Annual 98th percentile of daily averages averaged over three consecutive years
- Current standard = 35 ug/m³

State-Wide Design Value (DV) Trends

- ❑ Trends in state-wide maximum DV and average DV
 - Max DV: Maximum DVs over all valid trend monitoring sites in the state in each overlapping three year period
 - Average DV: Average of DVs over all valid trend monitoring sites in the state in each overlapping three year period
- ❑ Compute linear trend via least-squares regression

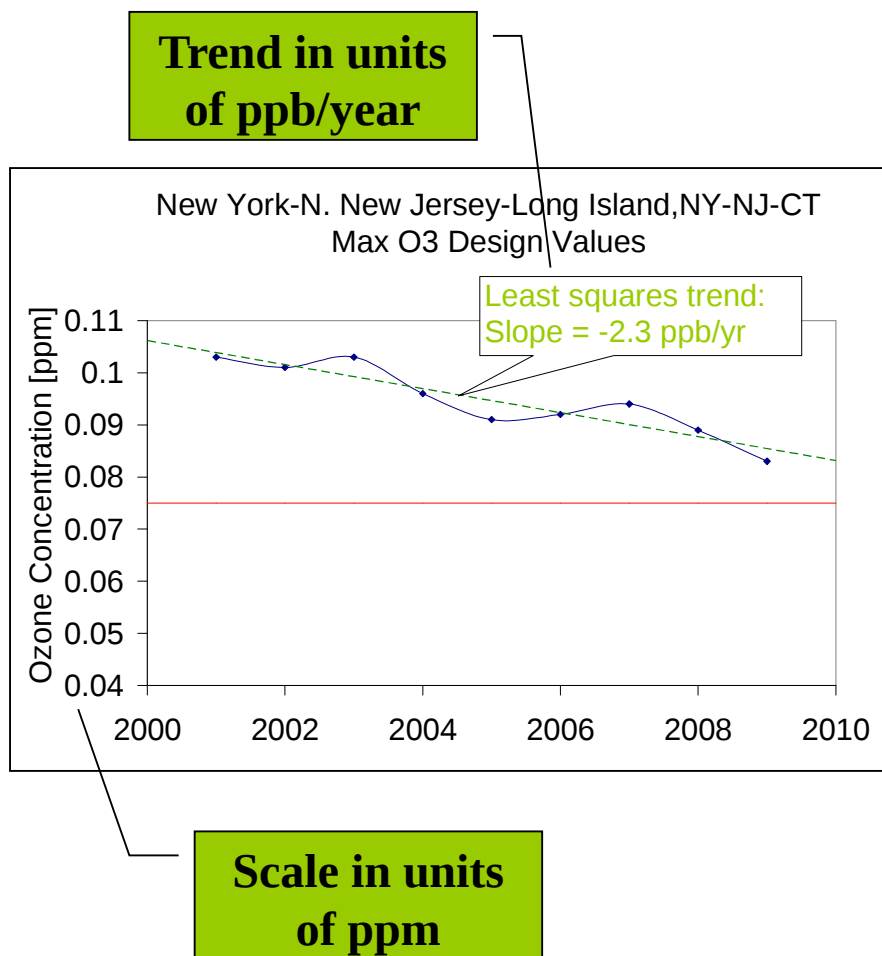
Data Handling Procedures

- O₃ design value (DV) for each overlapping three-year period starting with 1999-2001 and ending with 2009-2011
 - DV calculated using annual 4th highest daily max 8-hr averages and percent of valid observations, based on EPA data handling conventions
 - Data associated with exceptional events that have received EPA concurrence are omitted
 - Selection of trend sites require valid DV in 9 out of 11 three-year periods between 1999 and 2011
 - Identification of nonattainment areas is with respect to the 2008 8-hour standard only

Data Handling Procedures

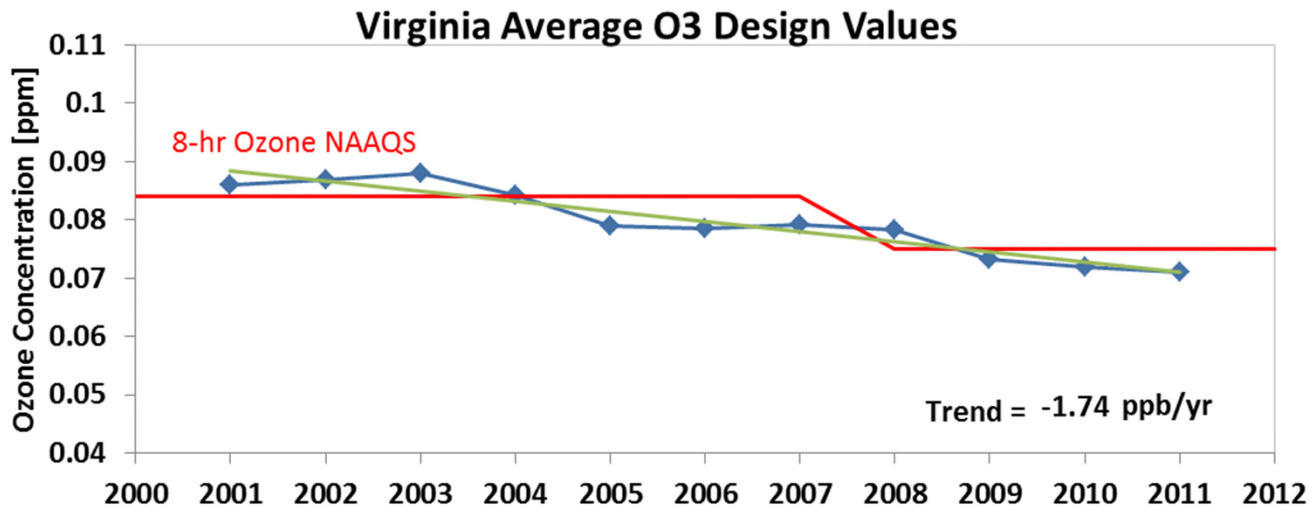
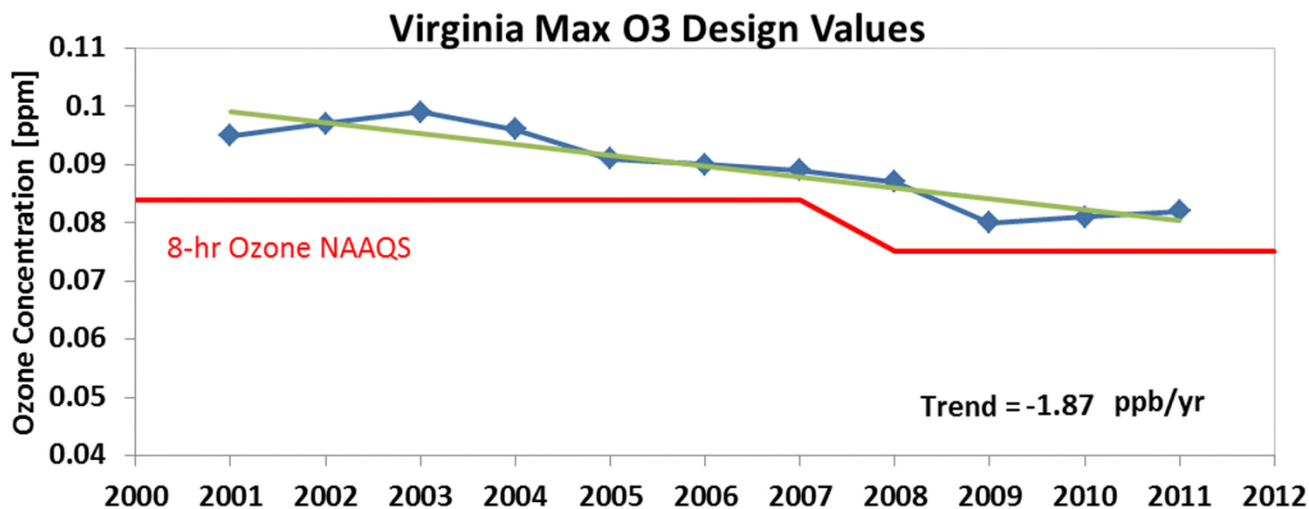
- Annual PM_{2.5} DV and 24-hr PM_{2.5} DV for each overlapping three-year period starting with 1999-2001 and ending with 2009-2011
 - DV calculations based on EPA data handling conventions
 - Data extracted from monitors that have a non-regulatory monitoring type are omitted
 - Selection of trend sites require valid DV in 9 out of 11 three-year periods between 1999 and 2011

Trend Calculation



- Trends based on linear least squares fit to rolling three year design values (DVs)
- Negative trend indicates improving air quality
- DVs based on each 3-year period: 1999-2001, 2000-2002, ... 2009-2011
- Notes
 - On plots, DVs are for three year period ending in year shown (i.e., 2009-2011 DV plotted as 2011 value)
 - Ozone trend values expressed as ppb/year (1,000 ppb = 1 ppm); DVs are plotted as ppm

Max/Ave O₃ DVs and Trend



Ozone Trends by Site in Virginia

Monitoring Sites	County	2009-2011 DV [ppm]	Trend [ppm/yr]
5101300204420101	Arlington, VA	0.08	-1.89
5103300014420101	Caroline, VA	0.07	-1.28
5103600024420101	Charles City, VA	0.075	-1.52
5104100044420101	Chesterfield, VA	0.072	-1.44
5105900054420101	Fairfax, VA	N/A	-1.92
5105900184420101	Fairfax, VA	N/A	-1.87
5105900304420101	Fairfax, VA	0.082	-1.41
5105950014420101	Fairfax, VA	N/A	-1.15
5106100024420101	Fauquier, VA	0.064	-1.90
5106900104420101	Frederick, VA	0.066	-1.92
5108500034420101	Hanover, VA	0.073	-2.40
5108700144420101	Henrico, VA	0.074	-1.52

Note: Only monitoring sites meeting data completeness criteria listed

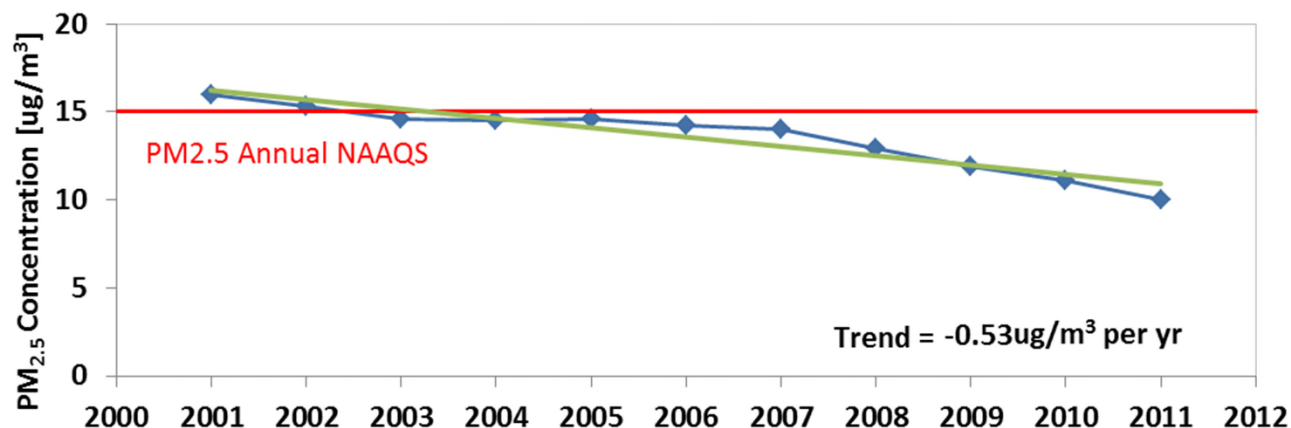
Ozone Trends by Site in Virginia

Monitoring Sites	County	2009-2011 DV [ppm]	Trend [ppm/yr]
5110710054420101	Loudoun, VA	0.073	-1.62
5111300034420101	Madison, VA	0.071	-1.71
5113900044420101	Page, VA	0.066	-1.83
5115300094420101	Prince William, VA	0.069	-1.81
5116110044420101	Roanoke, VA	0.068	-1.95
5116300034420101	Rockbridge, VA	0.063	-1.81
5117900014420101	Stafford, VA	0.072	-1.61
5119700024420101	Wythe, VA	0.064	-1.85
5151000094420101	Alexandria, VA	0.077	-1.65
5180000044420101	Suffolk, VA	0.071	-1.92
5180000054420101	Suffolk, VA	0.07	-1.38

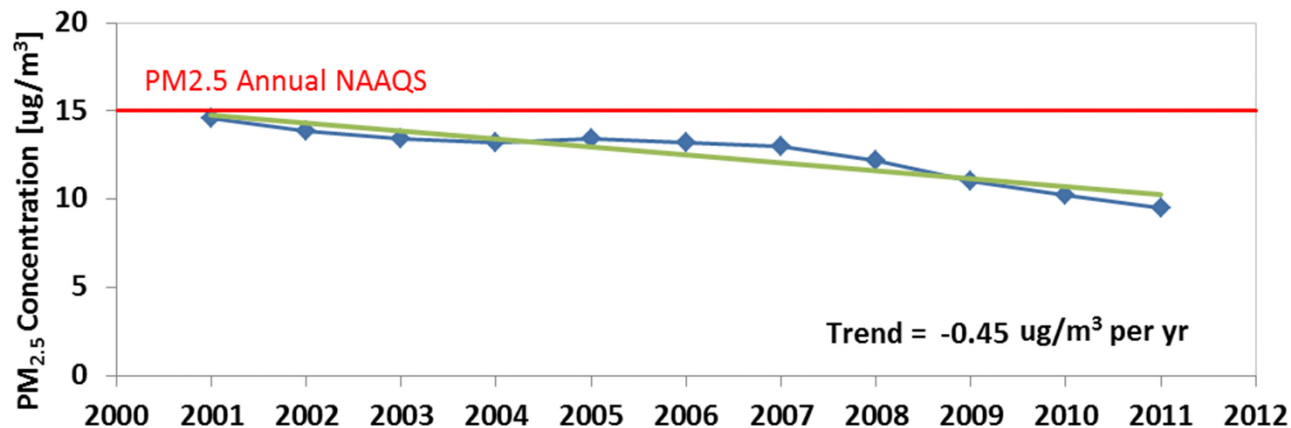
Note: Only monitoring sites meeting data completeness criteria listed

Max/Ave PM_{2.5} Annual DVs and Trend

Virginia Max PM_{2.5} Annual Design Values

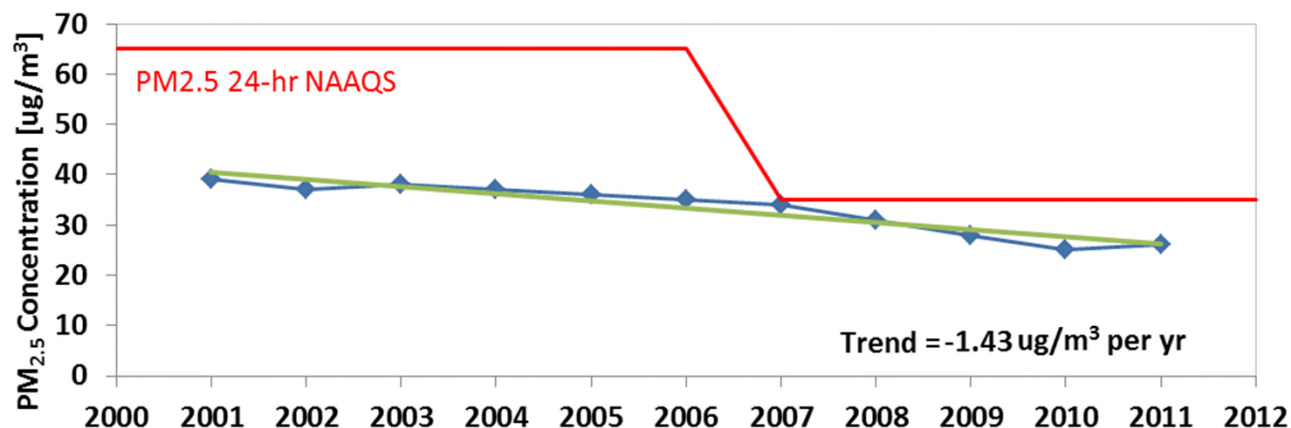


Virginia Average PM_{2.5} Annual Design Values

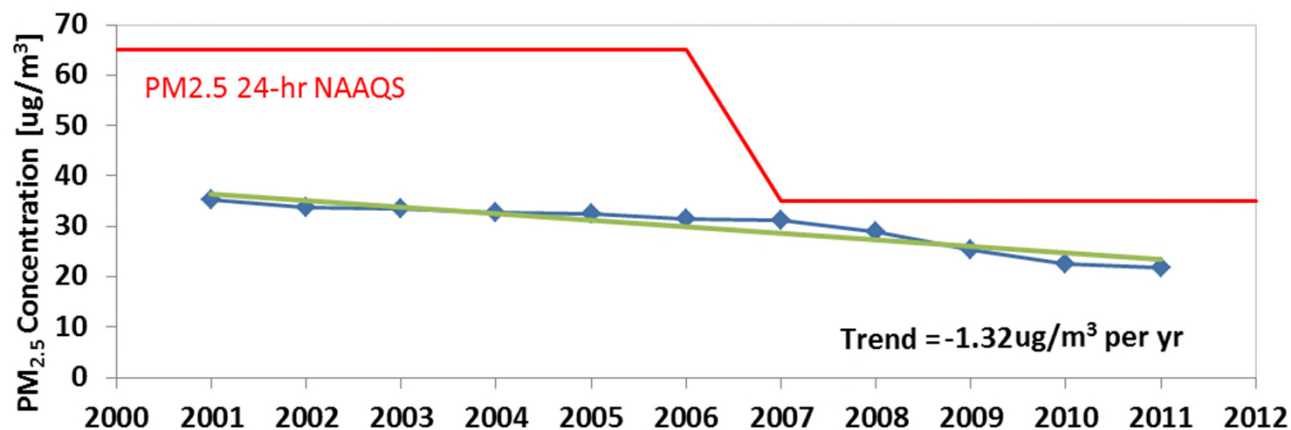


Max/Ave PM_{2.5} 24-Hour DVs and Trend

Virginia Max PM_{2.5} 24-Hour Design Values



Virginia Average PM_{2.5} 24-Hour Design Values



PM_{2.5} Trends by Site in Virginia

Monitoring Site	County	2009-2011 DV [ug/m ³]		Trend [ug/m ³ per year]	
		Annual	24-Hr	Annual DV	24-Hr DV
510130020	Arlington	N/A	N/A	-0.47	-1.42
510360002	Charles City	8.9	20	-0.46	-1.35
510410003	Chesterfield	9.6	21	-0.48	-1.56
510590030	Fairfax	9.6	24	-0.47	-1.46
510595001	Fairfax	N/A	0	N/A	-1.22
510870014	Henrico	9.6	22	-0.51	-1.22
510870015	Henrico	9.0	20	-0.47	-1.26
511071005	Loudoun	9.5	20	-0.48	-1.65
511390004	Page	9.3	22	-0.43	-1.23
515200006	Bristol city	9.9	21	-0.57	-1.60
517100024	Norfolk city	10.0	26	-0.31	-0.82
518100008	Virginia Beach city	9.6	23	-0.32	-0.93

Note: Only monitoring sites meeting data completeness criteria listed

Air Quality Trends Summary

- Average O_3 and $PM_{2.5}$ design values have decreased since 1999 in Virginia
- O_3 and annual $PM_{2.5}$ design values have decreased since 1999 in Washington, DC-MD-VA, the only currently designated O_3 and $PM_{2.5}$ non-attainment area in Virginia