Pre-Public Notice Draft
1-17-2013

Ozone Advance Action Plan
Richmond-Petersburg Area:

Charles City County
Chesterfield County
Hanover County
Henrico County
Prince George County
City of Colonial Heights
City of Hopewell
City of Petersburg
City of Richmond

DRAFT 01-17-2013

Summary

This Ozone Advance Action Plan covers the Richmond-Petersburg 1997 ozone National Ambient Air Quality Standards (NAAQS) Maintenance Area, consisting of the counties of Charles City, Chesterfield, Hanover, Henrico, and Prince George as well as the cities of Colonial Heights, Hopewell, Petersburg, and Richmond. On May 21, 2012, the United States Environmental Protection Agency designated this area as attaining the 2008 ozone NAAQS. To help ensure clean, healthy air into the future, the leaders from these jurisdictions have worked cooperatively with the Virginia Department of Environmental Quality and a number of stakeholders to create this Action Plan, which details the numerous clean air programs that are in place and will be implemented to reduce ozone precursors. Many of these programs have the co-benefit of also reducing fine particulate matter ($PM_{2.5}$) precursors. Air quality in the Richmond-Petersburg area will continue to improve through the implementation of these programs. Major stakeholders in this process include the Richmond Area Metropolitan Planning Organization; the Crater Metropolitan Planning Organization; Virginia Department of Mines, Minerals, and Energy; the Virginia Department of Transportation; the Virginia Port Authority; United States Army Military Base – Fort Lee; Dominion Virginia Power; Virginia Clean Cities Coalition; Richmond RideFinders; and Virginia Commonwealth University. Additionally, participation in the Ozone Advance program and this Action Plan were the subject of numerous area informational sessions, and the Action Plan was provided to the public for comment and review. Air quality in the Richmond-Petersburg area has improved significantly in the last 15 years. Actions taken as part of this Action Plan, and various upwind reductions of ozone and $PM_{2.5}$ precursors, will continue to improve air quality well into the future.

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Commonly Used Abbreviations

APMT	APM Terminal	kW	kilowatts
AQS	Air Quality System	kWh	kilowatt-hours
ASIP	Association for Southeastern Integrated Planning	lb	pound
BRAC	Base Realignment and Closure Act	lb/MWh	Pound/megawatt - hour
CAA	Clean Air Act	LEAP	Local Energy Alliance Program
CAIR	Clean Air Interstate Rule	LEED	Leadership in Energy and Environmental Design
CAMD	Clean Air Markets Division	MACT	Maximum achievable control technology
CASTNET	Clean Air Status and Trends Network	MAR	Marine, Air, and Rail
CEDS	Comprehensive Environmental Data System	mmbtu	million British thermal units
CFR	Code of Federal Register	$\mu g/m^3$	micrograms per cubic meter
CMAQ	Community Multiscale Air Quality model	MI/EMS	Mission Integrated Environmental Management System
CMAQ	Congestion, Mitigation, and Air Quality	MOVES2010b	Motor Vehicle Emission Simulator version 2010b
CMPO	Crater Area Metropolitan Planning Organization	MRAQC	Metropolitan Richmond Air Quality Committee
CO	Carbon monoxide	MW	Megawatts
DC	Direct Current	MWh	Megawatt-hours
DMME	Virginia Department of Mines, Minerals, and Energy	NAAQS	National Ambient Air Quality Standard
EGU	Electrical generating unit	NBTP	NO_X Budget Trading Program
EPA	United States Environmental Protection Agency	NEV	Neighborhood electric vehicles
EV	Electric vehicles	NIT	Norfolk International Terminals
FAMPO	Fredericksburg Area Metropolitan Planning Organization	NMHC	Nonmethane hydrocarbons
FGD	Flue gas desulfurization unit	NMIM	National Mobile Inventory Model
g/bhp-hr	grams/brake horsepower - hour	NMOC	Nonmethane organic carbons
g/kWh	grams/kilowatt - hour	NNMT	Newport News Marine Terminal
g/MWh	grams/megawatt - hour	NO_X	Nitrogen oxides
GSHP	Ground source heat pump	OTC	Ozone Transport Commission
GWAQC	George Washington Air Quality Committee	OTR	Ozone Transport Region
HAP	Hazardous air pollutants	PHEV	Plug-in electric hybrid
HRAQC	Hampton Roads Air Quality Committee	PJM	PJM Interconnection LLC
HRTPO	Hampton Roads Transportation Planning Organization	PM	Particulate matter
IRP	Integrated Resource Planning	$PM_{2.5}$	Fine particulate matter less than 2.5 angstroms in diameters
ITS	Intelligent Transport System	PM_{10}	Fine particulate matter less than 10 angstroms in diameter
kg/day	kilograms/day	PMT	Portsmouth Marine Terminal
km	kilometers	ppb	parts per billion

Commonly Used Abbreviations

ppm	parts per million
PTE	Potential to emit
PV	Photovoltaic
REVi	Richmond Electric Vehicle Initiative
RMG	Rail mounted gantry cranes
RREA	Richmond Regional Energy Alliance
SCC	State Corporation Commission
SCR	Selective Catalytic Reduction
SF	Square foot
SO_2	Sulfur dioxide
SPADP	Southeast Propane Autogas Development Program
TEU	twenty foot equivalent container units
TMP	Transportation Management Plan
tpy	tons per year
ULSD	Ultra low sulfur diesel
VCC	Virginia Clean Cities, Inc.
VCU	Virginia Commonwealth University
VDEQ	Virginia Department of Environmental Quality
VDOT	Virginia Department of Transportation
VEMP	Virginia Energy Management Program
VIP	Virginia Inland Port
VOC	Volatile organic compounds
VPA	Virginia Port Authority

1. Introduction

The Richmond-Petersburg area has been designated attainment for the 2008 ozone National Ambient Air Quality Standard (NAAQS), based on 2009-2011 air quality monitoring data. To preserve and further improve air quality, the regional leaders have decided to explore ways to facilitate additional reductions of nitrogen oxides (NO_X) and volatile organic compounds (VOC), the precursor emissions for ozone formation, through the development of an Ozone Advance Action Plan. This Ozone Advance Action Plan provides background data, including emission inventories and modeling analyses, demonstrating that (1) emissions in the Richmond-Petersburg area will significantly decrease between now and 2020 and (2) ozone air quality in this area will also improve significantly between now and 2020. This Plan provides information on a number of new or on-going programs that will provide additional emission reductions to help further improve both ozone and fine particulate ($PM_{2.5}$) air quality. This document will serve as a framework for the area to comply with any future NAAQS that may be promulgated, such as the next ozone NAAQS that is due to be promulgated in 2014, and it will help address any future violations of the 2008 ozone NAAQS quickly.

The air quality in the Richmond-Petersburg area is expected to benefit from significant reductions in emissions of NO_X and VOC in coming years. Section 2.3, Emission Inventories, provides information on these emissions estimates and their basis. Air quality modeling demonstrates that air quality will be well beneath the 2008 ozone NAAQS by 2020, as noted in Section 2.4, Ozone Air Quality Modeling. The programs included in this Action Plan are generally not included in the area's overall emissions estimates and will provide further air quality benefit beyond that predicted by the air quality modeling. Also, these programs often will provide co-benefits in that they will reduce emissions of sulfur dioxide (SO_2), which is a significant precursor to fine particulate matter ($PM_{2.5}$). The Richmond-Petersburg area has always been in compliance with federal $PM_{2.5}$ NAAQS; however, additional reductions of precursors can only improve air quality further.

The programs in this Action Plan include regulatory programs that are federally enforceable, voluntary programs that are undertaken both for air quality purposes as well as for other purposes such as energy savings or fuel savings, and public outreach programs that will help the citizens of the Richmond-Petersburg area understand how their behavior affects air quality so that they can adjust their actions accordingly. The stakeholders involved in this plan include the Virginia Department of Mines, Minerals, and Energy (DMME), the Virginia Department of Transportation (VDOT), the Virginia Port Authority (VPA), the Richmond Area Metropolitan Planning Organization, the Crater Metropolitan Planning Organization, Virginia Commonwealth University (VCU), US Army Garrison - Fort Lee, Virginia Clean Cities (VCC), and Dominion Virginia Power. These stakeholders have worked together with the Virginia Department of

Environmental Quality (VDEQ) to ensure that the Richmond-Petersburg Ozone Advance Action Plan will help protect healthy air quality and continue to improve air quality into the future.

2. Background and Data

The Richmond-Petersburg 1997 ozone NAAQS maintenance area consists of the counties of Charles City, Chesterfield, Hanover, Henrico, and Prince George, and the cities of Colonial Heights, Hopewell, Petersburg, and Richmond. Figure 1 shows the area in yellow and beige, with the locations of the ozone monitoring sites denoted by red triangles. Richmond-Petersburg is a vibrant, diverse area that is experiencing rapid growth, and this growth is expected to continue into the foreseeable future. In 2008, the region was home to approximately 1,030,000 people, a number that is expected to increase to over 1,440,000 people by 2035. Employment in the region is also expected to rise in a similar fashion as population, with the 2008 total of approximately 537,000 jobs increasing to around 713,000 jobs by 2035. Table 1 provides a summary of the socioeconomic data for this area, broken down by individual jurisdiction.

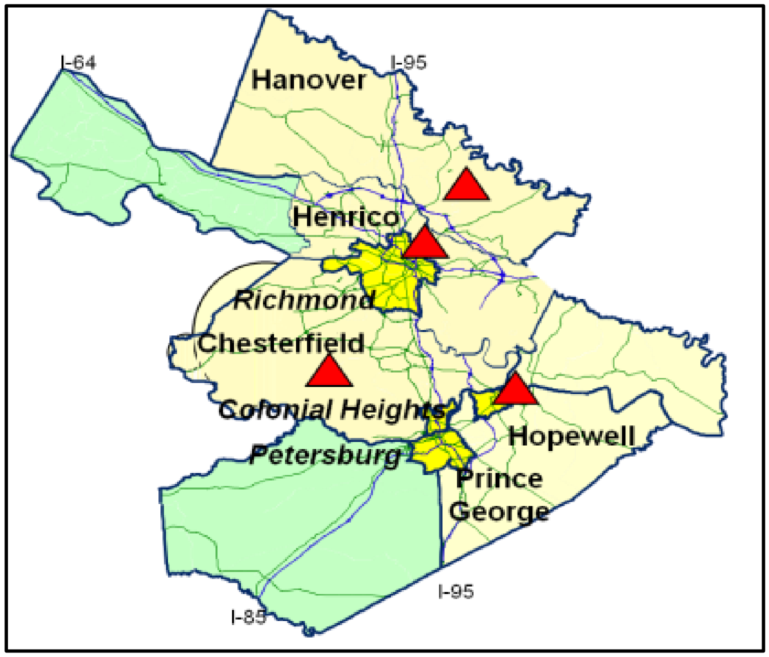

Figure 1: Richmond-Petersburg Geographical Boundaries

Table 1: Richmond-Petersburg Socioeconomic Data, 2008 and 2035

Jurisdiction	Population		Auto		Household		Employment	
Year	**2008**	**2035**	**2008**	**2035**	**2008**	**2035**	**2008**	**2035**
Charles City	7,212	9,938	8,507	11,921	2,897	4,351	1,550	2,136
Chesterfield	313,888	462,138	266,980	396,432	115,632	172,711	113,428	166,144
Colonial Heights	17,414	18,948	11,880	13,415	7,034	8,393	11,004	11,003
Hanover	94,415	161,375	92,282	149,719	33,652	57,186	42,380	71,696
Henrico	305,577	438,324	244,808	350,456	122,990	191,850	181,906	260,926
Hopewell	22,497	24,902	14,787	15,753	9,042	10,968	8,473	8,473
Petersburg	32,379	32,484	20,117	19,750	12,871	15,338	14,104	14,103
Prince George	35,611	66,851	22,232	33,903	10,159	20,012	15,900	15,839
Richmond	206,430	226,487	118,671	181,376	86,977	103,716	148,380	162,783
Richmond-Petersburg Totals	**1,035,423**	**1,441,447**	**800,264**	**1,172,726**	**401,254**	**584,524**	**537,125**	**713,110**

Data Source: VDOT

2.1. Ozone Air Quality

The Richmond-Petersburg area has had a long history of planning requirements for various ozone NAAQS. Under the 1991 1-hour ozone NAAQS of 0.012 parts per million (ppm) or 124 parts per billion (ppb), the Richmond-Petersburg area was originally designated a moderate nonattainment area on November 6, 1991 (56 FR 56694). The area's air quality improved, and the Metropolitan Richmond Air Quality Committee (MRAQC), the local planning organization certified under § 174 of the federal Clean Air Act (CAA), created a redesignation request and maintenance plan for submittal to the United States Environmental Protection Agency (EPA). These documents were subsequently approved by EPA on November 17, 1997 (62 FR 61237). The 1991 ozone NAAQS maintenance plan contained area-wide emission caps, mobile source budgets, and contingency measures.

On April 30, 2004 (69 FR 23941), the Richmond-Petersburg area was designated as a moderate nonattainment for the 1997 ozone NAAQS, which was set at a level of 0.08 ppm or 84 ppb. Again, the area implemented a number of control measures that resulted in significant reductions in ozone, and the area qualified for attainment status. A redesignation request and a maintenance plan were developed by MRAQC and sent to EPA. Final approvals of the redesignation request and maintenance plan were published on June 1, 2007 (72 FR 30485), and the area was designated attainment/maintenance for the 1997 ozone NAAQS.

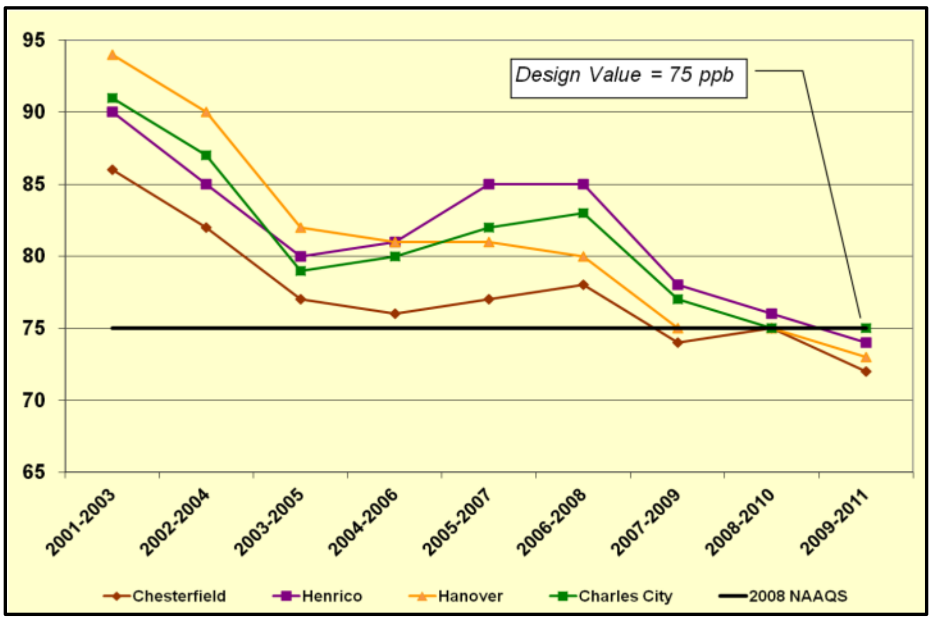

Figure 2: Richmond-Petersburg Ozone Air Quality

On May 21, 2012 (77 FR 30160), the Richmond-Petersburg area was designated as attainment for the 2008 ozone NAAQS. This standard was set at .075 ppm or 75 ppb. The attainment determination was made in large part on air quality monitoring data from 2009-2011. As shown in Figure 2, air quality in the Richmond-Petersburg area has significantly improved in the last 10 years. The data in Figure 2 is provided in Table 2. These data have been quality assured, certified, and provided to EPA's Air Quality System (AQS) database.

Table 2: Richmond-Petersburg 3-Year Monitoring Site Average, 4th Highest Values

3 Year Period	Chesterfield 51-041-0004	Henrico 51-087-0014	Hanover 51-085-0003	Charles City 51-036-0002
2001-2003	86 ppb	90 ppb	94 ppb	91 ppb
2002-2004	82 ppb	85 ppb	90 ppb	87 ppb
2003-2005	77 ppb	80 ppb	82 ppb	79 ppb
2004-2006	76 ppb	81 ppb	81 ppb	80 ppb
2005-2007	77 ppb	85 ppb	81 ppb	82 ppb
2006-2008	78 ppb	85 ppb	80 ppb	83 ppb
2007-2009	74 ppb	78 ppb	75 ppb	77 ppb
2008-2010	75 ppb	76 ppb	75 ppb	85 ppb
2009-2011	72 ppb	74 ppb	73 ppb	75 ppb

Data Source: VDEQ-Air Quality Monitoring Division

2.2. $PM_{2.5}$ Air Quality

The Richmond-Petersburg area has historically been in compliance with all $PM_{2.5}$ NAAQS. Figure 3, Figure 4, and Table 3 provide the $PM_{2.5}$ design value data for the area. The strong trend toward improving $PM_{2.5}$ air quality is expected to continue.

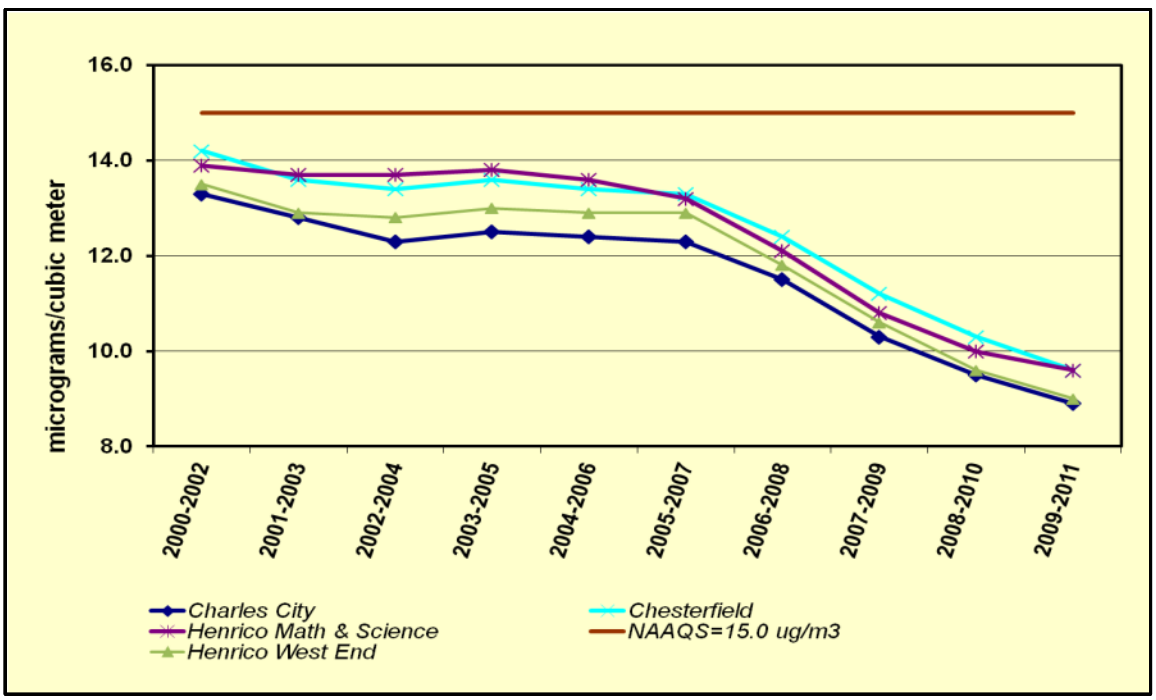

Figure 3: Annual $PM_{2.5}$ 3-Year Averages

Table 3: Annual and Daily $PM_{2.5}$ 3-Year Averages

3 Year Period	Chesterfield 51-041-0003		Henrico Math & Science 51-087-0014		Henrico West End 51-087-0015		Charles City 51-036-0002	
	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily
2001-2003	13.6 µg/m^3	34 µg/m^3	13.7 µg/m^3	33 µg/m^3	12.9 µg/m^3	31 µg/m^3	12.8 µg/m^3	34 µg/m^3
2002-2004	13.4 µg/m^3	33 µg/m^3	13.7 µg/m^3	32 µg/m^3	12.8 µg/m^3	30 µg/m^3	12.3 µg/m^3	33 µg/m^3
2003-2005	13.6 µg/m^3	32 µg/m^3	13.8 µg/m^3	32 µg/m^3	13.0 µg/m^3	29 µg/m^3	12.5 µg/m^3	32 µg/m^3
2004-2006	13.4 µg/m^3	30 µg/m^3	13.6 µg/m^3	31 µg/m^3	12.9 µg/m^3	28 µg/m^3	12.4 µg/m^3	30 µg/m^3
2005-2007	13.3 µg/m^3	30 µg/m^3	13.2 µg/m^3	31 µg/m^3	12.9 µg/m^3	29 µg/m^3	12.3 µg/m^3	30 µg/m^3
2006-2008	12.4 µg/m^3	28 µg/m^3	12.1 µg/m^3	29 µg/m^3	11.8 µg/m^3	27 µg/m^3	11.5 µg/m^3	28 µg/m^3
2007-2009	11.2 µg/m^3	24 µg/m^3	10.8 µg/m^3	26 µg/m^3	10.6 µg/m^3	24 µg/m^3	10.3 µg/m^3	24 µg/m^3
2008-2010	10.3 µg/m^3	21 µg/m^3	10.0 µg/m^3	23 µg/m^3	9.6 µg/m^3	21 µg/m^3	9.5 µg/m^3	21 µg/m^3
2009-2011	9.6 µg/m^3	21 µg/m^3	9.6 µg/m^3	22 µg/m^3	9.0 µg/m^3	20 µg/m^3	8.9 µg/m^3	21 µg/m^3

Data Source: VDEQ-Air Quality Monitoring Division

Figure 4: Daily $PM_{2.5}$ 3-Year Average

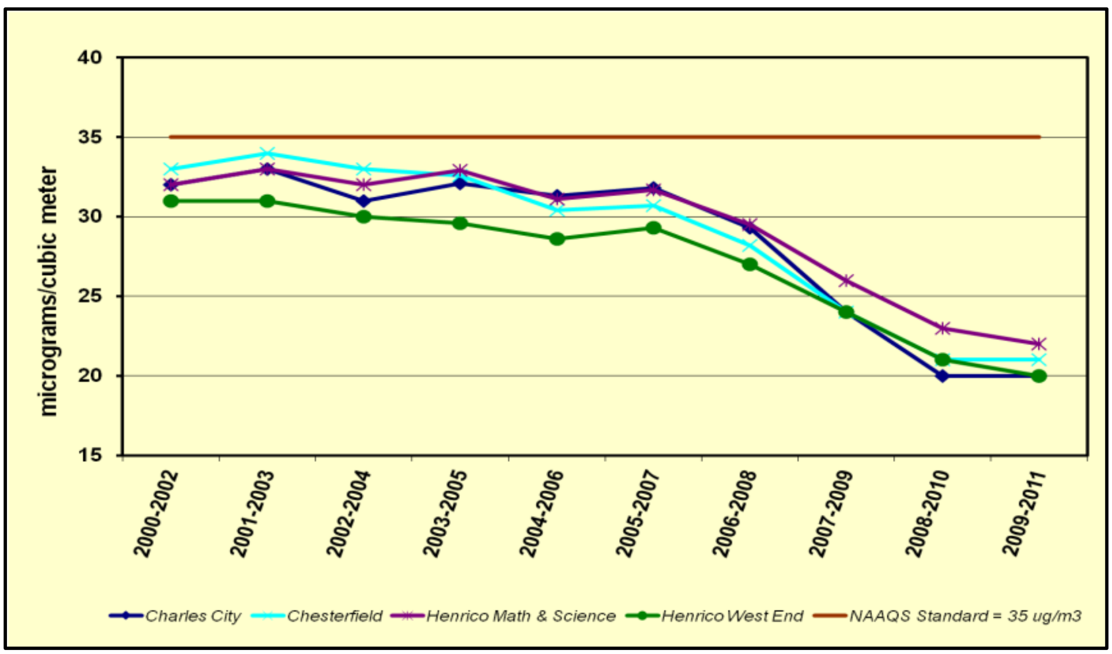

Figure 5 provides the speciation data from the Henrico County Math and Science Center $PM_{2.5}$ speciation monitor. Sulfates are a significant contributor to $PM_{2.5}$ throughout the Commonwealth. Richmond-Petersburg has recently experienced significant SO_2 reductions, and these reductions are expected to continue into the future, as discussed in the following section. The sulfate portion of the $PM_{2.5}$ concentration in the Richmond-Petersburg area should therefore continue to decrease, further improving air quality.

All data provided in this section have been certified, quality-assured, and submitted to EPA via AQS.

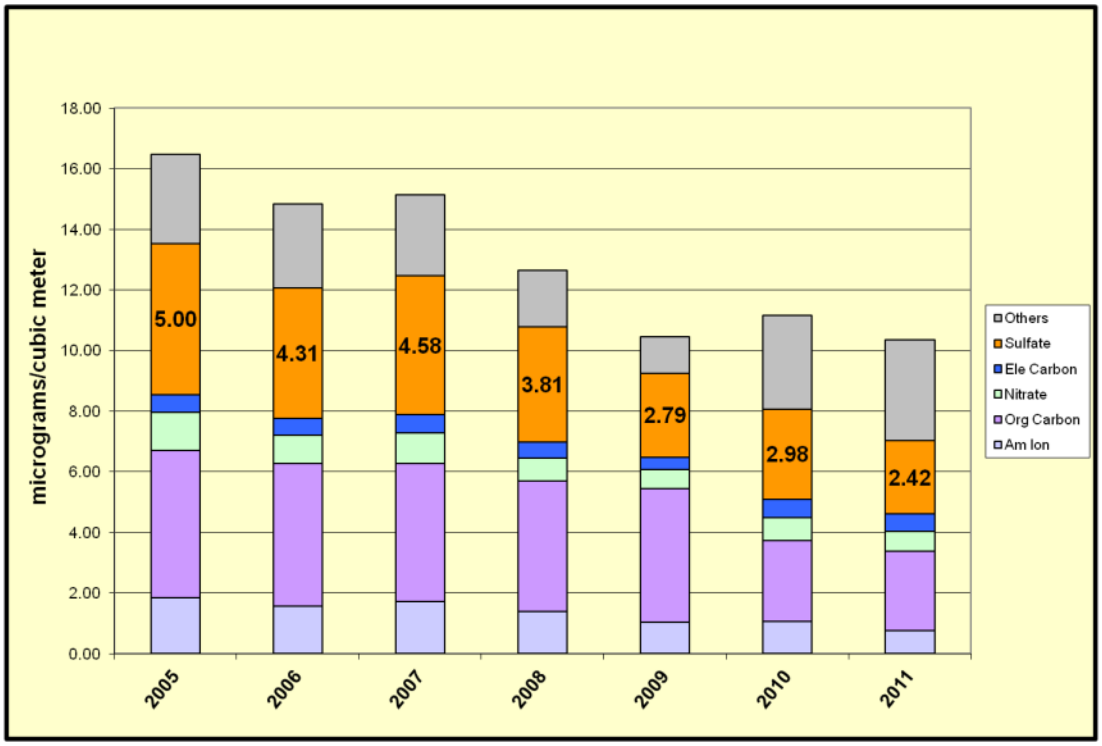

Figure 5: Henrico Speciation Data - VDEQ Air Quality Monitoring Division

2.3. Emission Inventories

This section presents the 2007, 2017, and 2020 emission estimates for the Commonwealth of Virginia and for the Richmond-Petersburg area. These estimates were developed using a variety of methods and data. Emissions of NO_X, VOC, and carbon monoxide (CO), the precursors to ozone, are expected to decrease greatly between 2007 and 2017 and through 2020. Figure 6 and Figure 7 show the estimated emissions in tons/year (tpy) for the Commonwealth of Virginia, and Figure 8 and Figure 9 show the estimated emissions in tpy for the Richmond-Petersburg area. Emissions of SO_2 are also expected to be significantly reduced. While SO_2 is not a factor in the formation of ozone, it is a precursor to $PM_{2.5}$.

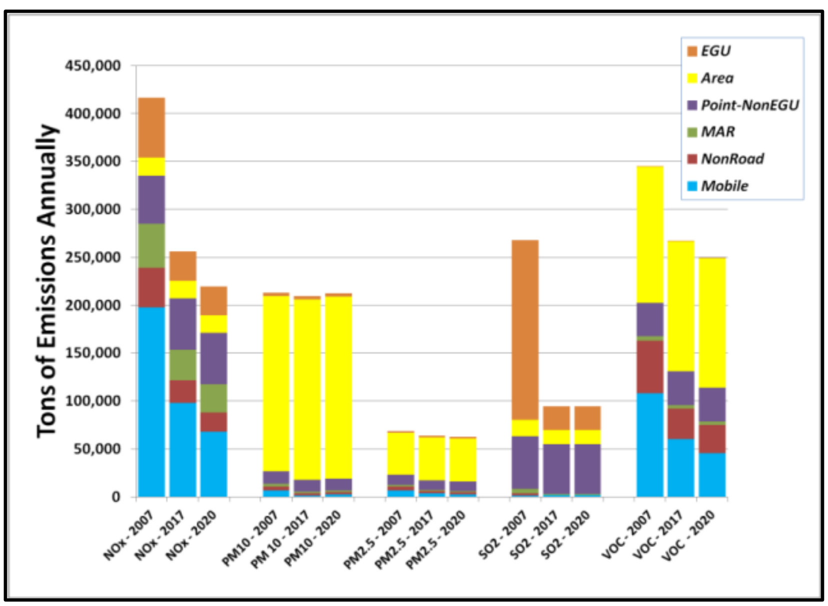

Figure 6: Virginia Emissions Estimates

The reductions in the mobile and non-road sectors are generally attributable to several important federal measures that control total hydrocarbons, $PM_{2.5}$, CO, and NO_X. These measures are discussed in more detail in Section 2.3.2 and Section 2.3.3. These already-implemented federal control programs for vehicles, heavy duty diesel on-road engines, and non-road engines continue to provide air quality benefit due to turnover of older equipment for new equipment. The phase-in of reduced sulfur content requirements for many types of fuels between 2007 and 2012 has also been instrumental for reductions of SO_2 as well as NO_X, CO, and $PM_{2.5}$ since reduced sulfur content in fuels allows control devices to function better. The reduced sulfur content of fuels facilitates the use of state-of-the-art controls on new equipment.

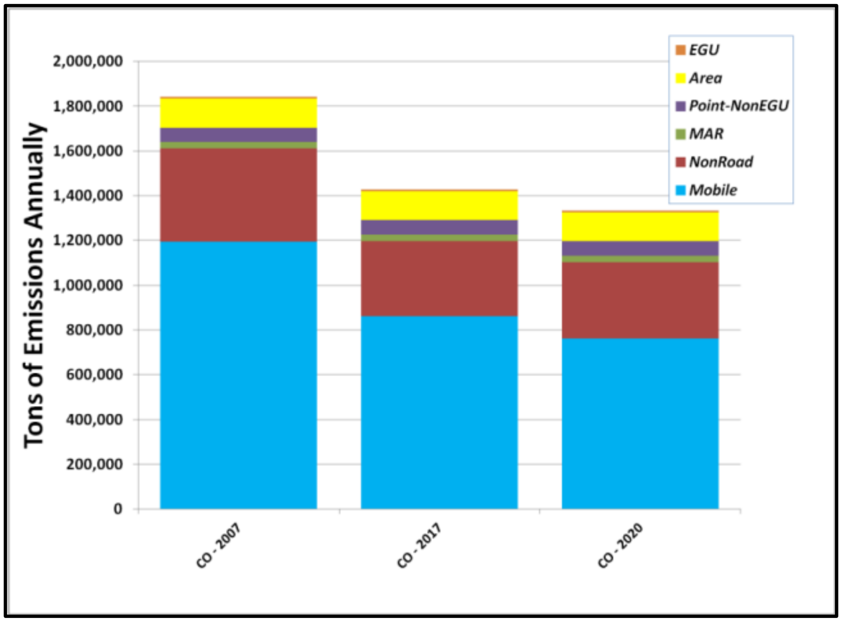

Figure 7: Virginia Emission Estimates, CO

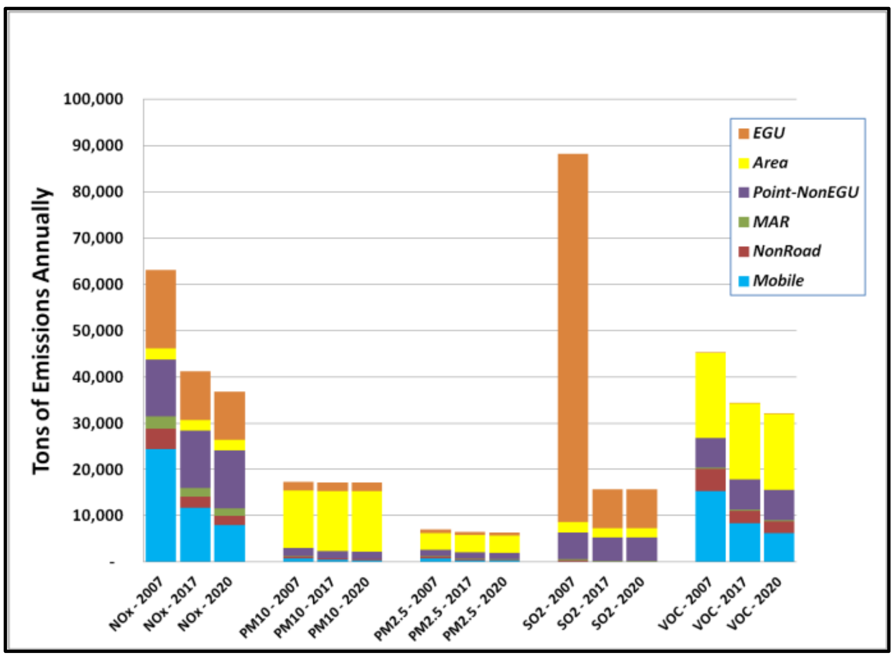

Figure 8: Richmond-Petersburg Emission Estimates

Another factor that must be considered in long range emission estimates is the reduced price of natural gas. Older, inefficient coal-fired power plants that are not economically viable for retrofit with control equipment are being switched to natural gas, which burns much more cleanly than coal. New, state-of-the-art combined cycle operations have been constructed in the Commonwealth to supplant the power from retired coal-fired units. These combined cycle operations have very low emission rates and produce electricity in a much more efficient manner than the older, coal-fired units. Industrial

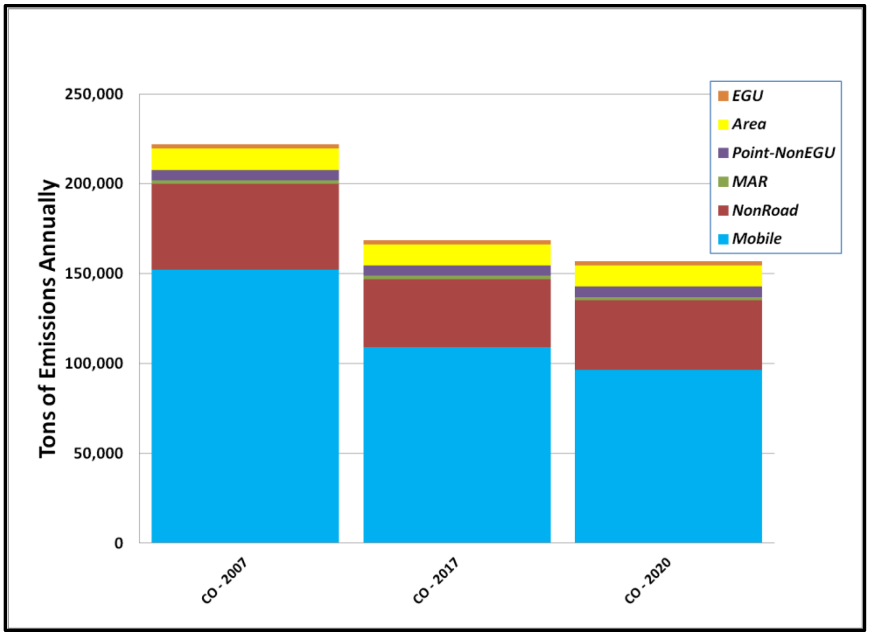

Figure 9: Richmond-Petersburg Emission Estimates, CO

facilities that need steam for manufacturing purposes are retiring coal-fired units and replacing them with new, low-emitting, natural gas units. Additionally, more residences are converting to natural gas, where available, using high efficiency furnaces and water heaters. These devices not only have lower emission factors per unit of fuel, they also are more efficient and consume less fuel in their operations.

2.3.1. Point Source Emissions

Point source emissions are generally larger emitting facilities such as industrial manufacturing facilities. The 2007 emissions data from this emissions source sector was gathered through Virginia's Comprehensive Environmental Data System (CEDS). Facilities reporting to VDEQ use a variety of methodologies to estimate emissions. These methodologies may include federal emission factor estimation techniques, models, throughput records, source-specific emissions testing, and continuous emissions monitors. Facility owners are required to certify their emissions data, and the data is quality-assured by VDEQ staff. For electrical generating units (EGUs), hourly emissions of NO_X and SO_2, as well as heat input and gross load, are reported to EPA's Clean Air Markets Division (CAMD) on a quarterly basis.

The 2007 data have been extrapolated to 2017 and 2020 using different estimation techniques, depending on the type of industry or sector. Non-EGU point sources are generally developed using factors that are specific to the type of industry represented. Factors that show a decline in emissions or decline in productivity have been updated to unity, so that 2017 and 2020 data are equivalent to 2007 data for those facilities. EGU point sources are established in this inventory using Energy Information Administration data from AEO2011. Since each EGU may have significant emissions, the EGU inventory has also been supplemented with changes based on known permit actions, enforcement orders, and information gleaned from planning documents submitted to the PJM Interconnection LLC (PJM) systems operator and the State Corporation Commission (SCC). For newly permitted facilities that have not yet been constructed, the inventory values included here represent maximum permitted limits. More information on EGU estimates may be found in Appendix A.

As Figure 8 shows, the point source sector combining the EGU and point-nonEGU categories is a large portion of the NO_X emissions inventory, and the point sector dominates the SO_2 inventory for the area. Many federal and state programs have resulted in significant emissions decreases from the point source sector. In the Richmond-Petersburg area, SO_2 emission reductions are expected to be especially pronounced. Examples of various point source emission reduction programs that affect these inventory estimates include the NOx Budget Trading Program and the Clean Air Interstate Rule (CAIR), which greatly reduced the emissions of NO_X and SO_2 from power plants; various maximum achievable control technology (MACT) standards, which reduced emissions of VOC and SO_2 as a co-benefit of the reductions required for various hazardous air pollutants (HAPs); and federal and state consent agreements, which reduced SO_2 emissions at local manufacturing facilities. More emission reductions are expected by 2017 and 2020. These trends hold true for both the Richmond-Petersburg area and the Commonwealth of Virginia.

2.3.2. Mobile Source Emissions

Mobile emissions are generated by vehicles and trucks that use the transportation system. The 2007 and 2020 mobile source sector emissions inventories were developed using EPA's most recent model for estimating on-road emissions, MOVES2010b. Mobile source sector emissions estimates for 2017 were developed using linear interpolation.

NO_X emissions from the mobile sector constitute a significant portion of the overall NO_X emissions inventory for both the Richmond-Petersburg area and the Commonwealth as a whole. Between 2007 and 2020, these emissions are expected to decrease significantly, mainly due to the effect of two federal rules, the 2007 Heavy-Duty Highway Rule and the Tier 2 Vehicle and Gasoline Sulfur Program.

The 2007 Heavy-Duty Highway Rule (40 CFR Part 86, Subpart P) set a particulate matter (PM) emissions standard for new heavy-duty engines of 0.01 grams per brake-horsepower hour (g/bhp-hr), which took full effect for diesel engines in the 2007 model year. This rule also included standards for NO_X and nonmethane hydrocarbons (NMHC) of 0.20 g/bhp-hr and 0.14 g/bhp-hr, respectively. These diesel engine NO_X and NMHC standards were successfully implemented between 2007 and 2010. The rule also required that sulfur in diesel fuel be reduced to facilitate the use of modern pollution-control technology on these trucks and buses. EPA required a 97% reduction in the sulfur content of highway diesel fuel -- from levels of 500 ppm to 15 ppm.

The Tier 2 Vehicle and Gasoline Sulfur Program (40 CFR Part 80, Subpart H; 40 CFR Part 85; 40 CFR Part 86) is a fleet averaging program for on-road vehicles, modeled after the California LEV II standards. This program became effective in the 2005 model year. The Tier 2 program allows manufacturers to produce vehicles with emissions ranging from relatively dirty to very clean, but the mix of vehicles a manufacturer sells each year must have average NO_X emissions below a specified value. Mobile emissions continue to benefit from this program as motorists replace older, more polluting vehicles with cleaner vehicles.

2.3.3. Non-Road Emissions Sector

The non-road emissions sector includes estimates of emissions from equipment that contain various types of combustion engines, but these engines are not used to propel equipment on the roads and highways. Examples include pumps, generators, and turbines, as well as engines used for forklifts, earth moving equipment, lawnmowers, marine transport, rail transport, and air transport. Marine, rail, and air transport emissions are often referred to as “MAR”.

The majority of the emissions from this source sector are estimated using EPA’s National Mobile Inventory Model (NMIM). NMIM was used to estimate 2007, 2017, and 2020 emissions from this source category. While the population estimates for these equipment types increase over time, emissions decrease, due mainly to the Nonroad Diesel Emissions Program (40 CFR Part 89). EPA adopted these NO_X, hydrocarbons, and CO emission standards for several groups of nonroad engines. The nonroad diesel rule set standards that reduced emissions by more than 90% from nonroad diesel equipment and, beginning in 2007, the rule reduced fuel sulfur levels by 99% from previous levels. The reduction in fuel sulfur levels applied to most nonroad diesel fuel in 2010 and applied to fuel used in locomotives and marine vessels in 2012.

Emissions from MAR are estimated using category-specific emission estimation tools and emission factors. As shown in Table 5, MAR is not a significant emissions sector in the Richmond-Petersburg area.

2.3.4. Area Emissions Sector

The area sector of the emissions inventory consists of categories where large populations of emitters exist, but each emitter has small emissions. This sector is heavily dependent on population and employment sectors. In general, the reductions achieved by the control programs associated with the area emissions inventory sector are offset by growth in population and employment sectors.

2.3.5. Emissions Estimates

Table 4 presents the Virginia-wide emissions estimates. Table 5 presents the emission estimates for the Richmond-Petersburg area. The estimates in these tables include the effects of the federal control programs described above as well as many other federally and state enforceable efforts.

They do not include most of the additional reductions that are the results of the control programs described in this Action Plan. Where control programs listed in the Action Plan are included within these inventories, the description of that control program notes this information.

Table 4: Virginia Emission Estimates, 2007-2017-2020

Year	Mobile	NonRoad	MAR	Point-nonEGU	Area	EGU	Total:
CO, tpy							
2007	1,195,237	415,093	28,444	63,079	132,098	7,255	1,841,208
2017	861,200	335,531	28,605	65,740	129,479	7,255	1,427,809
2020	760,988	341,458	29,183	66,212	128,937	7,255	1,334,034
NO_X, tpy							
2007	197,822	41,325	45,600	50,265	19,056	62,309	416,376
2017	97,694	23,658	32,268	53,236	18,411	30,650	255,917
2020	67,656	20,189	29,495	53,591	18,520	30,271	219,721
PM_{10}, tpy							
2007	6,798	4,132	2,402	13,028	183,341	3,375	213,076
2017	954	2,693	1,603	12,517	188,211	3,375	209,353
2020	2,553	2,317	1,498	12,602	190,097	3,375	212,443
$PM_{2.5}$, tpy							
2007	6,499	3,937	2,074	10,296	44,102	1,812	68,719
2017	3,365	2,548	1,321	9,885	44,851	1,812	63,781
2020	2,424	2,184	1,222	9,947	45,216	1,812	62,804
SO_2, tpy							
2007	1,434	2,329	4,674	54,486	17,098	187,671	267,692
2017	1,533	61	1,395	52,044	14,880	24,546	94,459
2020	1,562	63	1,214	52,338	14,616	24,600	94,394
VOC, tpy							
2007	108,001	55,135	4,312	35,018	142,218	689	345,373
2017	59,957	32,141	3,710	35,461	135,379	689	267,338
2020	45,543	29,303	3,622	35,593	135,002	689	249,753

Table 5: Richmond-Petersburg Emission Estimates, 2007-2017-2020

Year	Mobile	NonRoad	MAR	Point-NonEGU	Area	EGU	Total:
CO, tpy							
2007	152,324	47,651	1,842	5,745	12,016	2,314	221,892
2017	109,271	37,702	1,780	5,882	11,698	2,314	168,646
2020	96,355	38,669	1,842	5,940	11,637	2,314	156,757
NO_X. tpy							
2007	24,401	4,467	2,564	12,261	2,419	17,043	63,156
2017	11,747	2,398	1,792	12,433	2,334	10,546	41,252
2020	7,951	2,031	1,641	12,453	2,351	10,402	36,828
PM_{10}, tpy							
2007	805	414	106	1,646	12,484	1,811	17,267
2017	438	279	65	1,543	12,998	1,811	17,134
2020	328	242	60	1,549	13,192	1,811	17,182
$PM_{2.5}$, tpy							
2007	770	396	94	1,407	3,631	761	7,058
2017	417	264	56	1,321	3,714	761	6,533
2020	312	229	52	1,326	3,754	761	6,432
SO_2, tpy							
2007	135	248	275	5,679	2,298	79,532	88,167
2017	144	7	56	5,130	2,003	8,427	15,767
2020	147	7	41	5,147	1,968	8,439	15,750
VOC, tpy							
2007	15,381	4,717	227	6,484	18,392	172	45,373
2017	8,349	2,728	184	6,576	16,437	172	34,447
2020	6,240	2,588	179	6,610	16,362	172	32,150

These tables demonstrate that Virginia and the Richmond-Petersburg area are expected to experience significant drops in emissions of NO_X, the most important ozone precursor in the this area. These reductions should facilitate ozone air quality that not only complies with the 2008 ozone NAAQS, but makes strong progress toward meeting any future NAAQS.

2.4. Ozone Air Quality Modeling

Air quality modeling for the Richmond-Petersburg area was performed by the Ozone Transport Commission (OTC) and was conducted for a 2007 base year in addition to a 2020 future year. For 2020 this modeling study predicts air quality concentrations that are well beneath the 2008 ozone NAAQS for all monitoring locations within the Commonwealth. The future year modeling accounts for federal, state, and local control measures that are expected to occur prior to 2020 and are federally enforceable. However, most of the programs listed in this Action Plan are not included in the modeling. These emissions reductions will provide further air quality benefit beyond that predicted by this air quality modeling study.

2.4.1. Air Quality Model Configuration

This analysis used EPA's Models-3/ Community Multiscale Air Quality (CMAQ) modeling system. The configuration of the CMAQ modeling system was chosen based on the results of the model sensitivity testing performed during previous OTC ozone modeling efforts. Details on the emissions inventories used in the modeling are provided in Appendix B. The 36/12

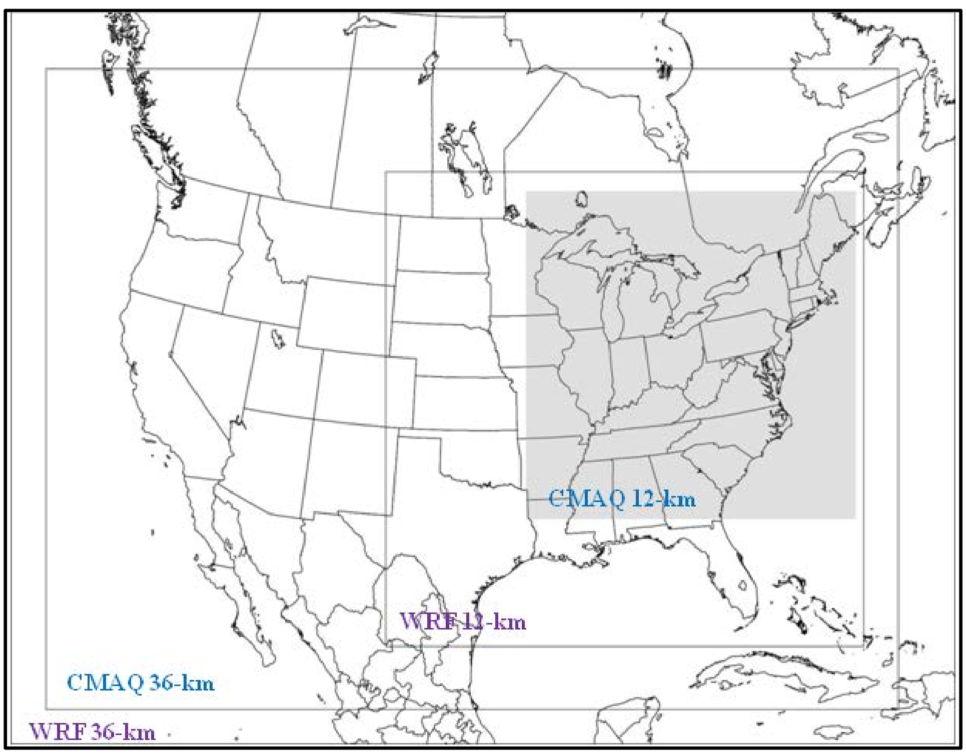

Figure 10: Modeling Grid

kilometer (km) horizontal grid system used in modeling is displayed in Figure 10. The CMAQ configuration is presented in Table 6.

Table 6: OTC Modeling CMAQ Configuration

Model Option	OTC Level 3 CMAQ Configuration
Model Version	CMAQ 4.71
Horizontal Resolution	36/12 km
Vertical Spacing	34 layers
Emissions Inventories	MARAMA/OTC Level 3
Meteorology	WRF v3.1 OTC Modeling
Gas Phase Chemistry	CB05
Gas Phase Chemistry Solver	EBI
Aerosol Chemistry	AERO5
Aqueous Phase Chemistry	ACM
Horizontal Advection	Yamartino
Vertical Advection	Yamartino
Horizontal Diffusion	Eddy diffusivity dependent on grid
Vertical Diffusion	ACM2 (inline)
Boundary Conditions	36 km derived from 2007 GEOS-CHEM -- 12 km derived from 36 km
Initial Conditions	Default with 15 day spin-up

2.4.2. Model Performance Evaluation

To quantify model performance, several statistical measures were calculated and evaluated. The statistical measures selected were based on the recommendations outlined in "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze," (see http://www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf).

Model performance statistics were calculated for the Ozone Transport Region (OTR) and Virginia. The evaluation included 210 AQS monitoring sites and 20 Clean Air Status and Trends Network (CASTNET) monitoring sites. Figure 11 shows the locations of these AQS and CASTNET sites across the OTR and Virginia.

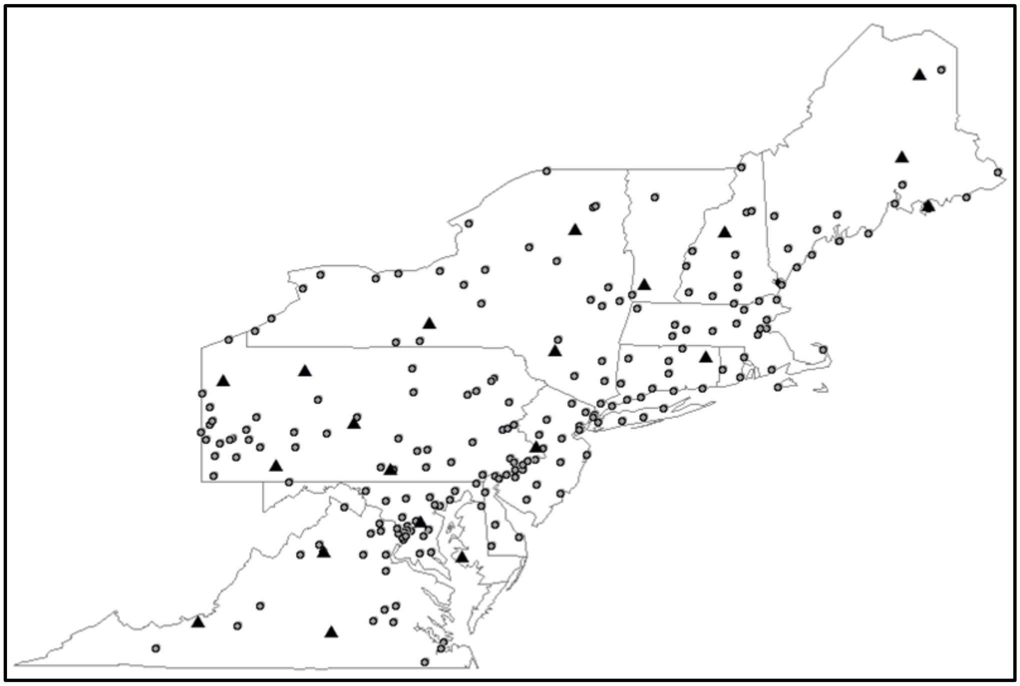

Figure 11: Locations of AQS (circles) and CASTNET (triangles) Monitoring Sites

The OTC CMAQ modeling platform performs well and within recommended modeling guidelines. Figure 12 compares predicted to observed average daily maximum 8-hour ozone concentrations for the OTR and Virginia. The model slightly over-predicts ozone, but it captures day-night and seasonal patterns very well. Figure 13 illustrates the average diurnal variation of ozone aggregated across the AQS (top panel) and CASTNET (bottom panel) sites within the OTR and Virginia.

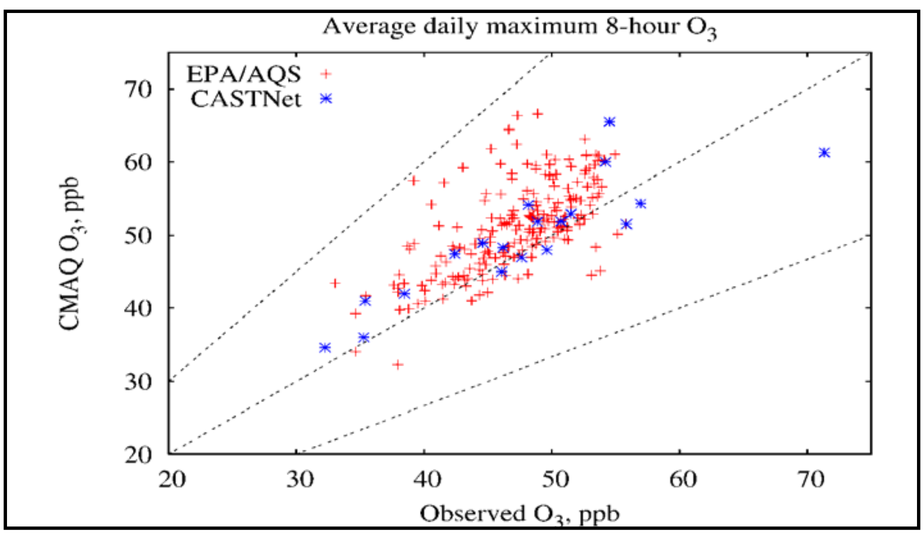

Figure 12: Predicted Versus Observed Average Daily Maximum 8-Hour Ozone

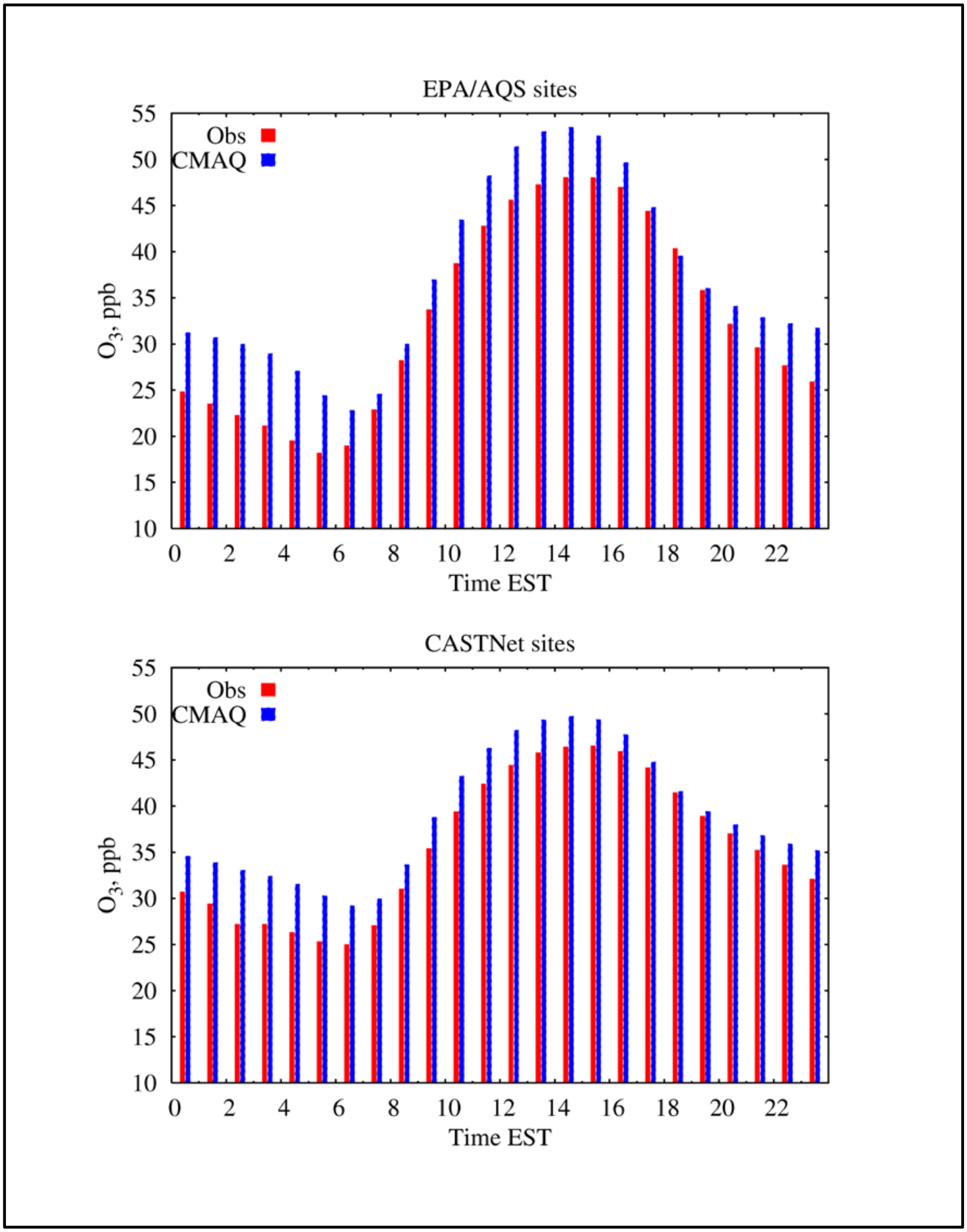

Figure 13: Average Diurnal Variation in Ozone

Additional statistical information on CMAQ ozone model performance for the 2007 base case is provided in Appendix B.

2.4.3. Ozone Modeling Results for 2020

The air quality modeling results based on the 12-km grid modeling domain are presented in Figure 14. These modeling results clearly demonstrate that the entire Commonwealth of Virginia, and the majority of the modeling domain, are projected to be in compliance with the 2008 ozone NAAQS of 75 ppb by 2020. In addition, there is a significant margin of safety in the Richmond-Petersburg area should the standard be lowered in the future.

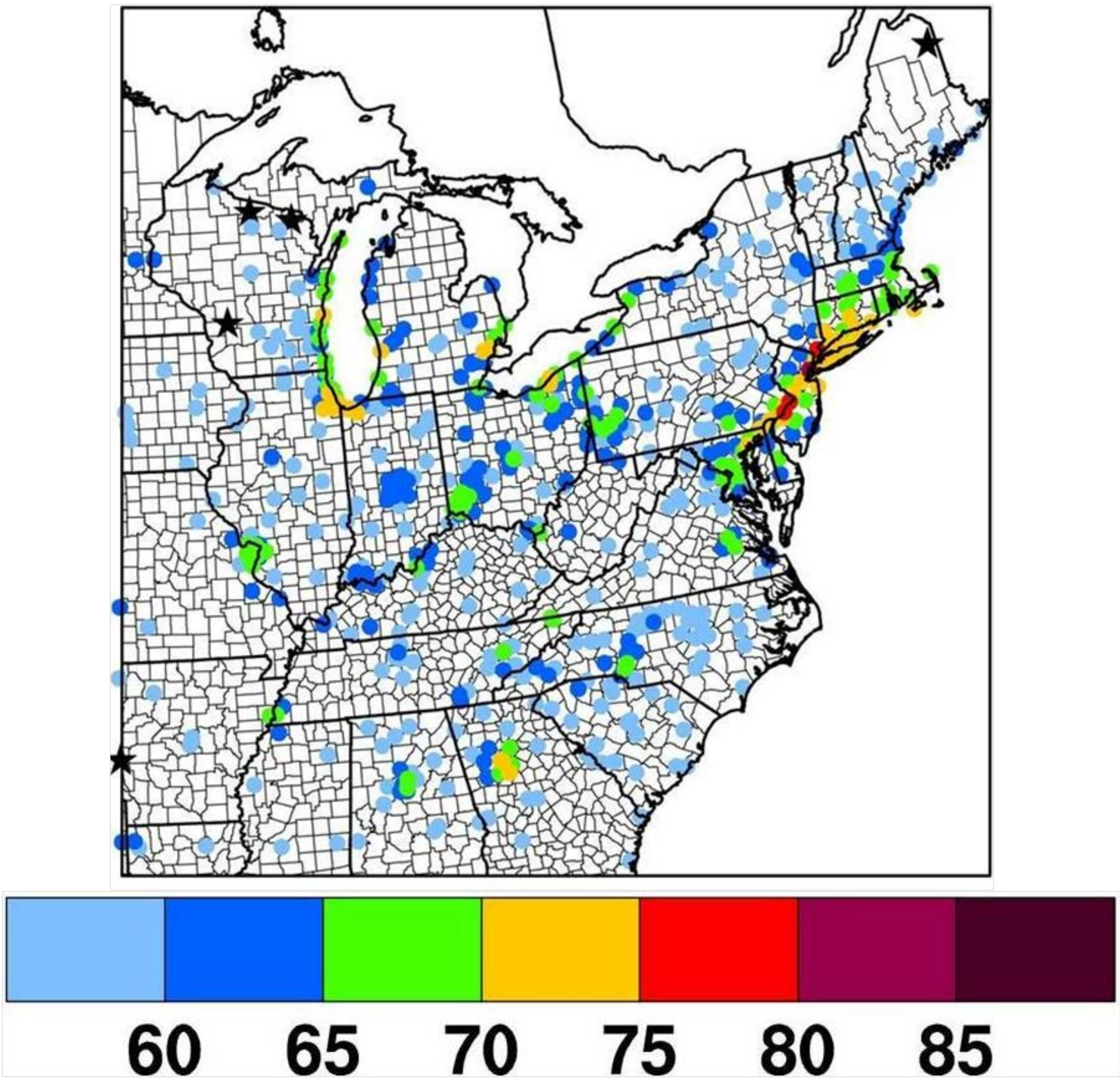

Figure 14: 2020 Ozone Modeling Results

Table 7 provides a summary of the 2007 base year and 2020 future year modeling results for the Richmond-Petersburg area.

Table 7: Richmond-Petersburg Ozone Modeling Predictions

AIRS I.D.	Site Name	Latitude	Longitude	2007 Base Design Value	2020 Future Design Value
51-085-0003	Hanover	37.6061	-77.2188	78.7 ppb	63 ppb
51-087-0014	Henrico	37.5565	-77.4003	82.7 ppb	67 ppb
51-041-0004	Chesterfield	37.3575	-77.5936	76.3 ppb	64 ppb
51-036-0002	Charles City	37.3444	-77.2593	80.7 ppb	67 ppb

Many of the programs included in this Action Plan are not included in the area's overall emissions estimates and will provide further air quality benefit beyond that predicted by the air quality modeling.

The modeling included in this Action Plan may be updated in the future or as part of the annual Action Plan report to reflect updated SIP quality modeling platforms

2.5. Assessment of Relative Air Quality Impacts

Ozone formation is driven by two major classes of directly emitted precursors: NO_X and VOC. The relationship of peak ozone concentrations can be plotted as a function of VOC and NO_X emission rates as illustrated in Figure 15. This figure is a simplified illustration but shows that two distinct regimes exist with different ozone-NO_X-VOC sensitivity. In the NO_X-limited regime (with relatively low NO_X and high VOC), ozone increases with increasing NO_X and changes little in response to increasing VOC. The NO_X saturated or VOC-limited regime has ozone decreases with increasing NO_X and ozone increases with increasing VOC. The dotted line represents a local maximum for ozone versus NO_X and VOC, separating the NO_X-limited and VOC-limited regimes. The relationship between ozone, NO_X, and VOC is driven by complex nonlinear photochemistry and there is no simple rule of thumb for distinguishing NO_X-limited from VOC-limited conditions. Ozone-precursor sensitivity predictions are usually derived from 3-dimensional Eulerian chemistry/transport models such as CMAQ.

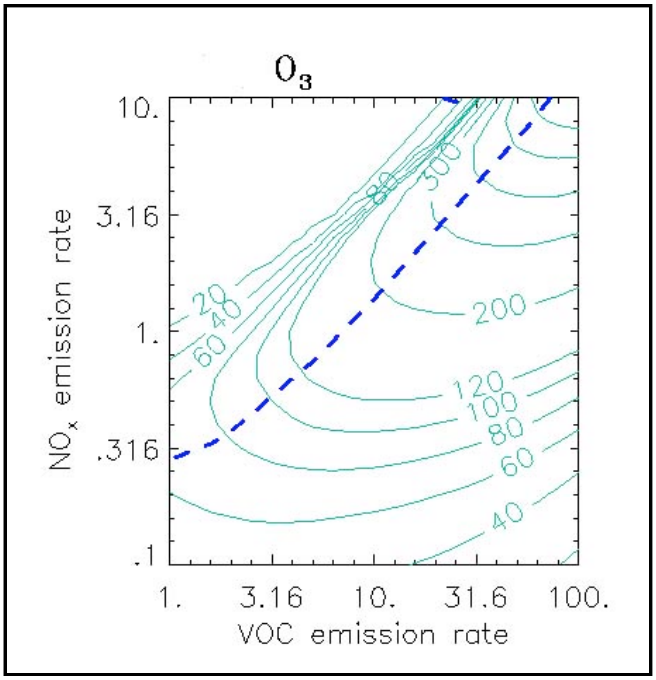

Figure 15: Peak Ozone Concentrations as a Function of VOC and NO_X Emission Rates

CMAQ includes state-of-the-science capabilities for modeling multiple air quality issues, including tropospheric ozone formation, and accounts for the reactivity of the various VOC species.

Studies in recent years have examined the sensitivity of surface ozone formation to precursor species concentrations of VOC and NO_X. These studies have invariably concluded that peak ozone concentrations are more sensitive to NO_X emissions over most of the United States. This conclusion is due in part to substantial decreases in NO_X emissions, primarily from stationary sources and particularly over the last two decades, which have lead to an additional reduction in the NO_X-VOC emissions ratio. Another factor is that peak summertime ozone formation is more sensitive to changes in NO_X with increasing temperature because emissions of highly reactive, biogenic isoprene increase with temperature and thus increase the total VOC emissions available for reaction. Very few exceptions exist to this rule; only a few urban core areas such as Chicago and New York City have historically shown reductions in ozone due to the implementation of VOC emissions control measures.

Georgia Institute of Technology (Georgia Tech) conducted a series of emissions sensitivities in 2009 as part of the Association for Southeastern Integrated Planning (ASIP) project. The study examined the impact of NO_X and VOC emission reductions on 8-hour ozone concentrations. CMAQ model simulations for a summer ozone episode (June 1 – July 10, 2002) were conducted. One of the sensitivity runs examined the effects of a 30% reduction in domain-wide anthropogenic VOCs on ozone formation. The impacts were then normalized by emissions. A summary of the results for Virginia are provided in Figure 16.

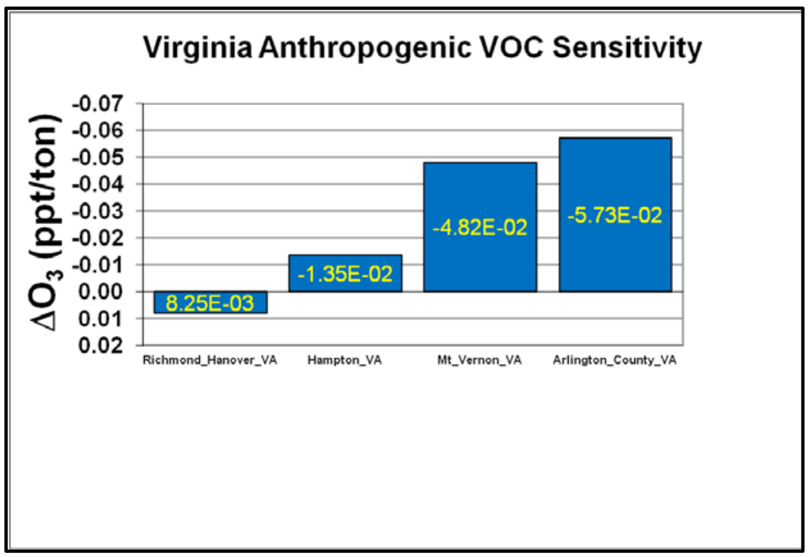

Figure 16: Ozone Response to Reductions in Anthropogenic VOC (Boylan, 2009)

A second sensitivity run examined the effects of a 30% reduction in ground level NO_X for jurisdictions within Virginia on ozone formation. The impacts were then normalized by emissions. A summary of the results of the receptor locations in Virginia is provided in Figure 17. The model response to ground level NO_X reductions was two orders of magnitude (i.e., more than 100 times) greater than the response from anthropogenic VOC reductions.

Similarly, a third sensitivity run examined the effects of a 30% reduction in Virginia point source NO_X on ozone formation. The impacts were again normalized by emissions. A summary of the results is provided in Figure 18. The model response to point source NO_X reductions was two to three orders of magnitude (i.e., more than 100-1,000 times) greater than the response from anthropogenic VOC reductions. The model response for this sensitivity was more variable and dependent on the location of the point source relative to the receptor locations as compared to the sensitivity run for ground level NO_X.

These sensitivities demonstrate that NO_X reductions are more efficacious than VOC reductions for improvement in ozone air quality in the Commonwealth.

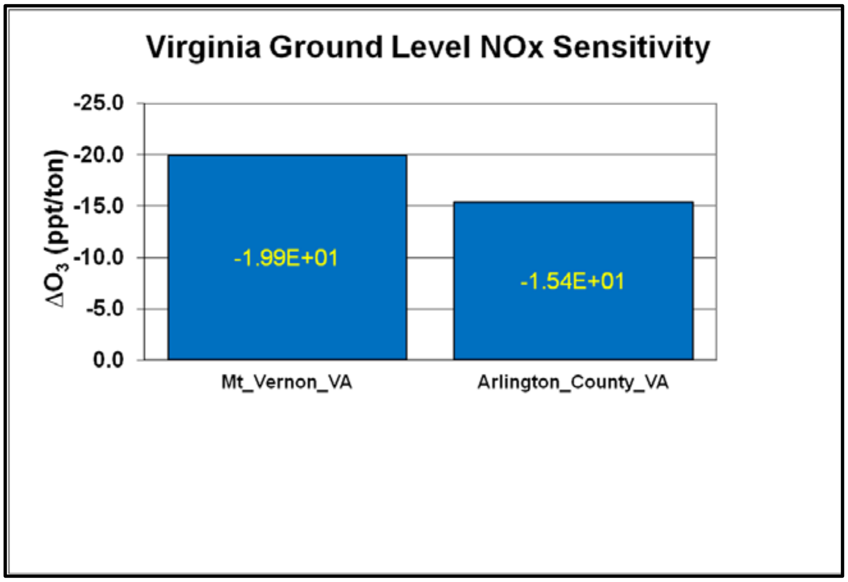

Figure 17: Ozone Response to Reductions in Ground Level NO_X (Boylan, 2009)

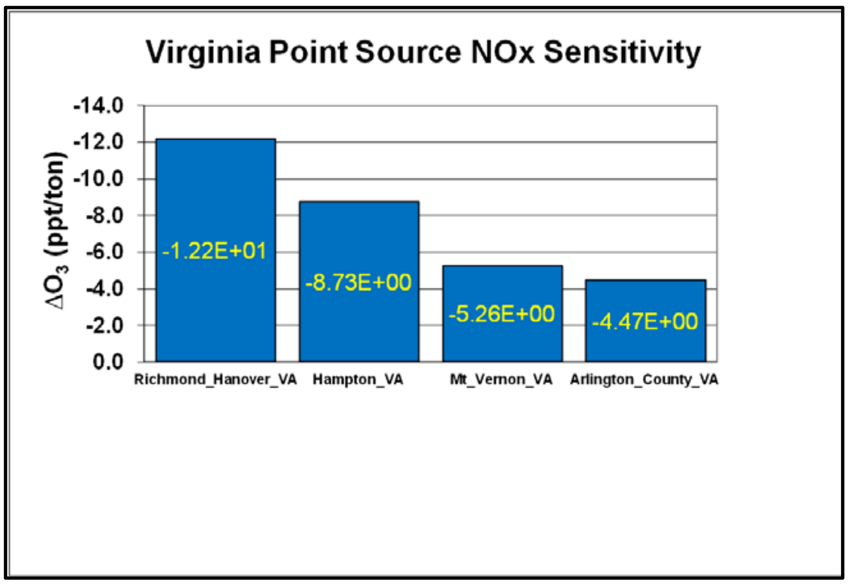

Figure 18: Ozone Response to Reductions in Point Source NO_X (Boylan, 2009)

More information on the Georgia Tech/ASIP sensitivity modeling may be found in Appendix B.

3. Action Plan Control Programs

The following sections give detailed information on a number of new and ongoing programs that will provide additional emission reduction benefits to Virginia and the Richmond-Petersburg area. These programs are directionally correct, and not only will reduce ozone precursors, but many of these programs will also reduce $PM_{2.5}$ precursors. Where possible, the reductions from the programs are quantified, and the organizations responsible for the implementation of each program are provided. To the extent possible, timelines for implementation of each program are also provided. Each program description specifically states if the reductions associated with the program or action have been included in the emissions inventories listed in Table 4 and Table 5.

3.1. Metropolitan Planning Efforts

The Richmond-Petersburg area has been proactive in establishing a strong planning effort aimed at reducing emissions from vehicle miles traveled. The area has access to Congestion Mitigation and Air Quality (CMAQ) funding, which has been used by the Tri-Cities Area Metropolitan Planning Organization and the Richmond Area Metropolitan Planning Organization for a wide variety of efforts designed to improve air quality between 2012 and 2017. These efforts will include improvements and construction of new bicycle paths, improvements to the Main Street Station, implementation of Intelligent Transport System (ITS) signal systems, port of zone improvements, and transit system improvements, as well as those described in greater detail below. The total estimated reductions of NO_X and VOC from these programs are significant, and estimated emission reductions may be found in Appendix C. More data on these programs may be found at www.richmondregional.com and www.craterpdc.org. These emission reductions are not included in the estimates provided in Table 4 and Table 5.

3.1.1. 64 Express

Beginning in late 2008, a container-on-barge service began operating between the Port of Richmond and the VPA terminals in Hampton Roads. This service, called the 64 Express, started as a partnership between the VPA, the Richmond Area Metropolitan Planning Organization, and the Hampton Roads Transportation Planning Organization. Initially, the program was funded via a grant from the U.S. Maritime Administration's America's Marine Highway Program, funds from the CMAQ program, and other state and local funding sources. This service provides an alternative to trucking imports bound for regional distribution or exports from the region to international markets. The service mitigates highway system impacts associated with goods movement by shifting individual containers from truck to barge. Each barge transit reduces congestion, reduces maintenance and operations-related highway system costs, and on a per-ton-mile basis produces fewer VOC or NO_X emissions than either rail or truck alternatives. A fully loaded barge has the capacity to carry up to 100 containers (see Figure 19).

Figure 19: 64 Express

During the first year of operation, the barge transported approximately 6,000 containers, removing 12,000 truck trips from the I-64 corridor. Since then, additional barges and weekly trips have been added to the route as demand has increased. According to the VPA, in 2011 4% of the port's cargo was moved by barges, which is equivalent to 28,800 trucks per year or 79 trucks per day on regional roadways. A VPA study estimates that the 64 Express will remove about 285 trucks per day from this corridor in 2040.

This program received a national award from the Association of Metropolitan Planning Organizations in October of 2009 for Innovative Practices in Metropolitan Transportation Planning. Additionally, several areas of the country are now looking at the 64 Express as a model for implementation in their regions.

This program is highly beneficial to air quality. Estimates indicate that the program is responsible for 11,200 kilograms/day (kg/day) of VOC reductions and 3,563 kg/day of NO_X reductions, roughly 4,400 tpy of VOC and 1,400 tpy of NO_X. As the program expands, these benefits will continue to increase. This program will also improve the quality of life for all citizens using the I-64 corridor by reducing truck traffic congestion. Emission reduction estimates from this program were not included in the emissions estimations provided in Table 4 and Table 5. More information may be found at http://www.64express.com/. Emissions estimates may be found at https://fhwaapps.fhwa.dot.gov/cmaq_pub/HomePage/ using case number VA20090013.

3.1.2. RideFinders

RideFinders is a travel demand management service funded through CMAQ. This service provides residents and employers in the Richmond region with commuter services that support and advance the use of carpooling, vanpooling, public transit, biking, walking, and telework alternatives to driving alone. RideFinders helps commuters eliminate more than 30 million annual vehicle miles traveled, which removes 5,000 vehicle trips per day from the roadways in the Richmond-Petersburg region. The RideFinders' *FY 2012 TDM Program Impact Report* (see http://www.ridefinders.com/FrontEnd/HTML/images/rf_impact-report-final-11-5-12.pdf) conservatively estimated the air quality benefit from this program in fiscal year 2012 to be 23,900 pounds per year (lb/year) NO_X (12.0 tpy NO_X) and 12,500 lb/year VOC (6.3 tpy VOC). These reductions are not part of the emissions estimates included in Table 4 and Table 5. This program is expected to continue to grow into the future, providing additional air quality benefit in coming years. More information on RideFinders may be found at www.ridefinders.com.

3.2. VCU Sustainability Efforts

VCU is a public research university located in Richmond, Virginia. VCU is one of the largest universities in Virginia and has more than 32,000 students, including approximately 24,000 undergraduates, 8,000 graduate students, and a network of more than 160,000 alumni. With over 19,000 employees, VCU and VCU Health Systems are also the largest single employer in Richmond. The university consists of the 90.6 acre Monroe Park Campus, 52.4 acre Medical College of Virginia Campus, 34 acre Virginia BioTechnology Research Park, 494 acre Inger and Walter Rice Center for Environmental Life Sciences, and an 88 acre farm in Ashland for a total of 725 acres. Many campus facilities are housed in historic buildings, and the oldest dates back to 1816. Of VCU's 208 buildings, 54 are considered historic, and 40 were built prior to 1900. VCU also owns Virginia's first LEED platinum building, the Walter L. Rice Education Building.

As part of its commitment to campus sustainability, VCU has initiated a number of energy efficiency/renewable energy programs that have reduced air emissions and that will minimize VCU's impact on the environment and air quality into the future. More information can be found on VCU's wide ranging efforts at www.vcugoesgreen.vcu.edu. The air quality benefits from the many programs underway at VCU have not been included in estimates of emissions found in Table 4 and Table 5.

3.2.1. Solar Energy

VCU Facilities Management has installed a 710 photovoltaic (PV) panel array with an output of 163.3 kilowatts (kW) direct current (DC) on the N-Deck parking garage on the MCV Campus. This array provides annual energy savings of 184,000 kilowatt-hours (kWh). Another 780 PV panel array has been installed on the Monroe Park Campus West Broad Street Deck parking garage (see Figure 20). This array is one of the largest university arrays in Virginia, with an output of 179.4 kW DC and an annual energy savings of 200,000 kWh. VCU Facilities Management has also installed three pole-mounted, dual-axis, solar PV trackers. The annual output of 3.6 kW DC from each contributes to an annual energy savings of 24,000 kWh.

Figure 20: West Broad Street Deck 780 PV

A conservative estimate of the air quality benefit from the use of the solar arrays is 408 lb/year of NO_X and 652.8 lb/year of SO_2. These reductions are based on the 2011 annual overall emission estimates from Dominion Virginia Power (Dominion) of 0.0005 tons NOx/MWh and 0.0008 tons SO_2 /MWh (www.dom.com/about/environment/report/). The equations below demonstrate how these emissions reductions were derived, using the annual estimated energy savings in conjunction with the Dominion emission estimates.

3.2.2. VCU Dashboard

VCU's Energy Dashboard gives students, faculty, and employees a way to better understand the impact of ongoing efforts toward reducing utility usage and air emissions. This dashboard combines measurement and verification data to help educate users on the success of various projects to reduce energy and water usage. The website shows graphics of each building or campus structure and the utility utilization rate for that structure. The rate can be depicted in a number of different units, such as kWh, cost, or gasoline. Different time scales may be chosen, and various structures may be compared. Figure 21 provides an example of the output of the Dashboard, showing savings in terms of pounds of coal not burned. The VCU Energy Dashboard may be found at www.buildingdashboard.com/clients/vcu/ .

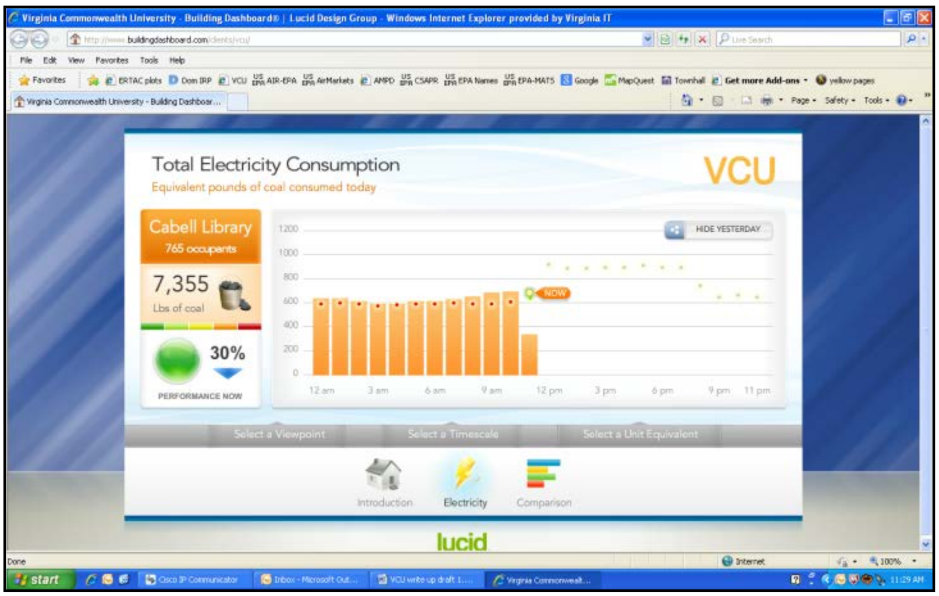

Figure 21: VCU Dashboard Example

3.2.3. VCU Sustainable Building Program

Leadership in Energy and Environmental Design (LEED) is a suite of rating systems for the design, construction, and operation of green buildings, homes, and neighborhoods. Developed by the U.S. Green Building Council, LEED is intended to provide building owners and operators a framework for identifying and implementing practical and measurable green building solutions. With 607,714 square feet (SF) of LEED-certified building space, VCU has a large portfolio of LEED-certified buildings. Over a three-year period, VCU has invested over $192 million and received LEED certification for nine buildings that have been constructed or renovated. Over the next three years, an additional six buildings (816,000 SF) that have been designed to a minimum of LEED Silver standards will be constructed or renovated for over $339 million. These 15 buildings represent an investment by VCU of over half-billion dollars and total just under 1,500,000 SF. Currently, one-eighth of the total campus gross square feet are comprised of LEED designed buildings. By 2015, one-sixth of the total campus gross square feet will be comprised of LEED designed buildings.

3.2.3.1. Certified LEED Buildings

In addition to the buildings listed in Table 8, VCU has two certified ENERGY STAR buildings, the VCU Physical Plant Administration Building, which was certified in 2011, and the VCU President's House, which was certified in 2012.

Table 8: VCU Certified LEED Buildings

Building	Certification
Walter L. Rice Education Building	Certified LEED Platinum (New Construction) – March 27, 2009
W. J. Baxter Perkinson, Jr. School of Dentistry Building	Certified LEED Silver (New Construction) –April 16, 2010
R. Blackwell Smith Jr. Building Renovation	Certified LEED Silver (Commercial Interiors) – June 30, 2011
Jonah L. Larrick Student Center	Certified LEED Silver (New Construction) – October 1, 2010
Cary Street Gym	Certified LEED Gold (New Construction) – January 2011
Molecular Medicine Research Building	Certified LEED Silver (New Construction) – December 15, 2010
Health and Life Sciences Laboratory	Certified LEED Bronze (New Construction) – February 15, 2011
Grace and Henry Street Parking Deck - East	Certified LEED Silver (New Construction) – 2012
Laurel Street Parking Deck	Certified LEED Silver (New Construction) – October 2012

3.2.3.2. New Construction, Buildings Under Construction, or in Design Phase

The buildings listed in Table 9 are under construction or in the design phase.

Table 9: VCU Planned LEED Certifications

Building	Certification
West Grace South Residence Hall	Opened in August of 2012, this hall has been constructed to meet the standards for LEED Silver certification.
VCU School of Medicine Building	Construction began in September 2010 and is scheduled to be completed in the spring of 2013. This building is being constructed to meet the standards for LEED Silver.
West Grace North Residence Hall	Construction began in January of 2012 and is slated for completion in July of 2014. This hall is being constructed to meet the standards for LEED Silver certification.
University Learning Center	Scheduled for completion in the fall of 2013, this $44 million, this building will be seeking LEED Silver certification.
James Branch Cabell Library Addition and Renovations	This project is being designed to meet the standards for LEED Silver certification
VCU Institute for Contemporary Art	Scheduled to open in 2015, this building will be seeking LEED Platinum certification

3.2.4. VCU Wind Turbine Study

In spring of 2012, VCU installed a wind turbine on the top of the southeast stair tower of the Pollak Building. Figure 22 shows the view of the wind turbine from the building's vegetated roof. The Eddy GT, 1kW vertical axis wind turbine is designed to produce energy at lower wind speeds. This turbine will help determine the average wind speed for the area and will supply data to evaluate the feasibility of additional wind turbine capacity on the VCU campus. If feasible, the installation of additional wind turbine capacity could also reduce air emissions and therefore benefit air quality.

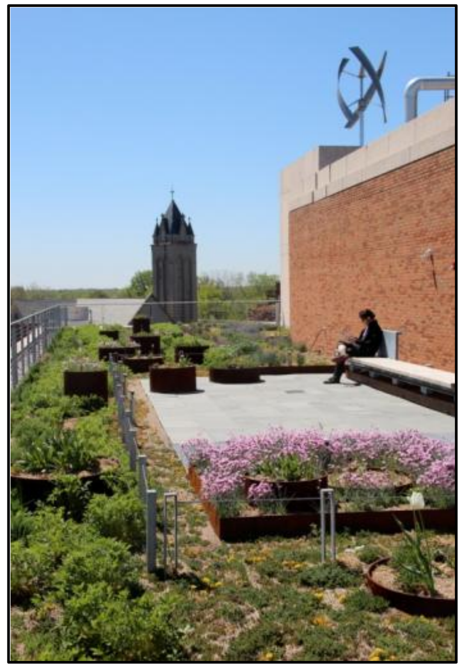

Figure 22: Pollak Building Wind Turbine

3.2.5. VCU Micro-Grid

VCU has partnered with Dominion to create an on-campus micro-grid, a smaller, defined portion of the electrical grid. This micro-grid will be located in the VCU School of Engineering's West Hall and will allow VCU and Dominion to test energy-efficient technology, share power consumption data, predict future maintenance costs based on equipment energy analyses, and maximize energy conservation. The project will make continuous, real-time energy adjustments to the building, lights, and equipment to save energy and costs, up to 4% annually.

The monitoring devices installed in the micro-grid will allow VCU to identify signatures of electrical equipment, such as refrigerators or window air conditioning units. These devices will cycle compressors on and off to reduce peak load. The 230 portable voltage meters will help Dominion fine-tune delivery of electricity when and where it is needed, to reduce waste as well as to reduce peak power consumption. This will enable VCU and Dominion to gather voltage data and analyze energy volume, timing, noise, and cleanliness; estimate energy usage trends; and review equipment performance.

3.3. Division of Energy - Energy Efficiency Programs

DMME's Division of Energy serves as the state energy office and oversees a variety of programs that aim to reduce the consumption of energy throughout the Commonwealth of Virginia. These energy savings, which are facilitated in part by the programs described below, will have a beneficial effect on all facets of the Commonwealth's environment. The generation of electricity is a significant contributor to the ozone precursor NO_X. As these energy efficiency programs are developed and take full effect, the reduction in NO_X emissions should help to improve ozone air quality in all parts of the Commonwealth. The emission reductions associated with the programs listed below have not been included in the inventory estimates listed in Table 4 and Table 5.

More detail on the following programs, as well as other programs offered by DMME, may be found at www.dmme.virginia.gov/divisionenergy.shtml.

3.3.1. Virginia Energy Management Program

The Virginia Energy Management Program (VEMP) was established within DMME in response to Governor McDonnell's Executive Order 19 "Conservation and Efficiency in the Operation of State Government" (see http://www.governor.virginia.gov/PolicyOffice/Executive Orders/). VEMP provides direction for Virginia's energy management program. VEMP's mission is to create a self-sustaining, fee-based, privately-capitalized enterprise that will deliver energy and water savings, emission reductions, and new jobs through comprehensive retrofits of public facilities. The current staff of six employees has developed a roadmap to meet the Governor's order, which establishes a public facilities retrofit program. The objectives of this program that relate directly to improving air quality are:

- Retrofitting 27 million square feet of public buildings by 2020,
- Reducing energy expenses by 20% at executive branch agencies and colleges by 2020,
- Deploying $177 million of private capital between 2011 and 2020 in energy-efficiency improvements to Virginia's public buildings,
- Reducing peak demand by 88 MW no later than 2020.

Quantification of air quality benefits from the reduction of 88 MW of peak electrical demand can be estimated in a number of ways. One approach is to assume that avoided peak demand would have been supplied by demand response programs and therefore would have been generated primarily by diesel engines burning ultra low sulfur diesel (ULSD). Emissions from these types of engines can be approximated very conservatively through the manufacturer's engine certification for Tier 4 regulatory requirements, which mandate an emission rate of no more than 0.67 grams/kilowatt-hour (g/kWh) of NO_X. The equation below demonstrates this methodology. This approach results in estimated emission reductions of 130 lb/hour of NO_X.

Another way to quantify the potential air quality benefit from the reduction of 88 MW at peak demand is to assume that the electrical generating units with the highest operating expenses will be backed down. In Virginia, these units are generally the older, less efficient residual oil-fired boilers. CAMD data for 2011 show that these units in Virginia operated with emission rates of about 2.293 pounds/megawatt-hour (lb/MWh) of NO_X and 7.408 lb/MWh of SO_2. As demonstrated by the equation below, this approach results in estimated emission reductions of approximately 200 lb/hr of NO_X and 651.9 lb/hr of SO_2.

These reductions are especially important since peak electrical demand hours often correspond with high ozone readings and poor air quality.

3.3.2. Energize Virginia

Energize Virginia is a revolving loan fund administered by the federal Department of Energy that supports qualifying energy efficiency and renewable energy projects and programs. The first request for proposals for this fund was issued December 5, 2011, and awards from this fund are expected to be approximately $6,000,000. Loans from Energize Virginia may be used to finance renewable energy generation systems and energy conservation equipment, technology, controls, measures, and programs, including those that advance the goals of Governor McDonnell's Executive Order 19. Also eligible are differential costs for alternative fuel and advanced technology vehicles, alternative fuel refueling equipment, and vehicle energy conservation programs, including those that advance the goals of Executive Order 36, "Moving Toward Alternative Fuel Solutions for State-Owned Vehicles" (see http://www.governor.virginia.gov/PolicyOffice/Executive Orders/). This program is directionally correct and will help improve air quality through the use of cleaner alternative fuels and the reduction in use of various fossil fuels.

3.3.3. Residential Retrofit Pilot Program

DMME, in conjunction with several local non-profit organizations, is running programs that seek to reduce energy use in residential dwellings. Organizations such as the Richmond Regional Energy Alliance (RREA) and the Charlottesville-based Local Energy Alliance Program (LEAP) have retrofit targets of 1,350 homes by the end of calendar year 2013. These pilot programs are designed to create long-term, sustainable, energy efficiency programs in various areas of the Commonwealth. A goal of the pilot programs is to reduce energy consumption by at least 20% in each of the retrofitted homes. Another goal of the pilot programs is to become self-sustaining over the long term so that eventually all Virginians will have access to the retrofits that will save energy, reduce home energy costs, and improve the environment.

A rough estimate of the air quality benefit from the full implementation of these pilot programs solely from the reduction of electricity consumed in these households is 1,712 lb/year of NO_X and 2,789 lb/year of SO_2, as demonstrated in the following equations. These estimates are based on the following data and sources:

- Annual household electrical usage in Virginia 6,341 kWh (www.greenandsave.com)
- Dominion's annual estimation of overall emissions from electrical generation in 2011 are 0.0005 tons/MWh of NOx/MWh and 0.0008 tons/MWh of SO_2 (www.dom.com/about/environment/report/)

3.4. Fort Lee Sustainability Programs

United State Army Garrison – Fort Lee (Fort Lee), located in Prince George County, Virginia, is one of the largest and most diverse military posts worldwide and is the home of the Combined Arms Support Command. The daily population of Fort Lee averages approximately 34,000 people and includes members from all branches of the military service, their families, government civilians, and contractors. The "Army Strategy for the Environment: Sustain the Mission-Secure the Future" has sustainability as its foundation (see http://www.asaie.army.mil/Public/ESOH/doc/ArmyEnvStrategy.pdf). Many of the strategies being employed by Fort Lee will also benefit ozone and $PM_{2.5}$ air quality. These directionally correct programs are not included in the emissions estimates listed in Table 4 and Table 5 and will assist the Richmond-Petersburg area in maintaining and further improving air quality. More information on the Army's programs may be found at www.sustainability.army.mil and www.lee.army.mil.

3.4.1. Low NO_X Burner Requirements

The major source of pollutant emissions on Fort Lee is from external combustion units such as boilers and water heaters. Fort Lee has instituted a low NO_X performance standard requiring all new and replaced fuel-burning equipment to meet a 30 ppm threshold, and contractors must submit certified documentation to the Environmental Management Office prior to equipment procurement. Any installed equipment that does not meet or exceed this standard is replaced or retrofitted in order to comply with the performance standard.

During the extensive growth from Base Realignment and Closure (BRAC) operations, every piece of fuel burning equipment installed was certified to 30 ppm NO_X or lower. Compared to the amount of NO_X emitted from uncontrolled equipment, the use of certified low NO_X equipment has annually reduced NO_X emissions by an estimated 18,884 pounds.

3.4.2. Sustainable Building Practices

All new construction and major renovations that take place on Fort Lee must meet at a minimum the LEED Silver standard. Since 2005, the LEED Silver standard has been applied to all new construction and major renovation on Fort Lee, saving thousands of dollars from reduced energy and water consumption. Construction during the last five years includes over 60 buildings and numerous renovations. Four projects have been certified Gold with two pending, while three have been certified Silver with seven pending.

3.4.3. Renewable Energy

Fort Lee currently has two large barracks, totaling 217,000 SF, equipped with ground source heat pumps (GSHP). By harnessing geothermal energy through GSHPs, the installation reduces demand for natural gas, which is the largest single source of emissions on post. The current GSHPs provide 3,342 million British thermal units (mmbtu) of thermal energy each year (0.7% of demand) with an annual energy cost savings of $21,000. Two other major barracks projects are in the final design stage and will reap much of the same energy savings and air pollution reductions from harnessing geothermal energy and reducing reliance on natural gas.

3.4.4. Transportation and Mobile Sources at Fort Lee

Fort Lee's Master Planning Division is in the process of drafting a Transportation Management Plan (TMP), assessing travel needs that extend beyond Fort Lee's boundaries to alleviate traffic and parking issues resulting from Fort Lee's mission activities. The TMP is aimed at incorporating incentives to reduce air pollution in the region by decreasing the number of single occupancy vehicle trips, conserving fuel, and alleviating traffic congestion. This plan involves the collaboration of many stakeholders across the Fort Lee community. Aligning the TMP with broader state-wide transportation plans will ensure positive collaboration of Fort Lee's shared objectives in regard to mitigating congestion and enhancing the efficiency of the roadway networks.

Through the Mission Integrated Environmental Management System (MI/EMS), Fort Lee has established goals and initiatives to meet Executive Order 13423, "Mobile Source Emission Reductions" (see http://www.gsa.gov/portal/content/102452). This Order requires agencies to improve energy efficiency and reduce transportation emissions by reducing energy intensity 3% annually, reducing fleet petroleum use 2% annually, and increasing reliance on renewable energy by 10% annually.

To meet mandated decreases in petroleum usage for federal agencies, Fort Lee has acquired 19 Neighborhood Electric Vehicles (NEVs) since 2010. With a maximum speed of about 25 mph, these vehicles are ideal for short trips around Fort Lee. While a gas-fueled car costs approximately $3 to travel 35 miles, a NEV costs $1 to charge in a standard 110-volt outlet for the same distance. As NEVs are zero-emission, total-electric vehicles, Fort Lee is helping to improve air quality while saving money in fuel costs. Between calendar year 2010 and calendar year 2011, Fort Lee decreased its vehicle fuel consumption by 37%. In 2011, to further reduce reliance on non-renewable petroleum resources, Fort Lee added 14 hybrid gasoline vehicles to its fleet. The 2012 replacement schedule included seven additional hybrids and one 100% electric van.

3.5. Dominion Virginia Power Programs

Dominion is one of the nation's largest producers and transporters of energy, with a portfolio of approximately 27,400 megawatts of generation; 11,000 miles of natural gas transmission, gathering and storage pipeline; and 6,300 miles of electric transmission lines. Dominion is focused on meeting energy needs in an environmentally responsible manner and has a large number of programs designed to promote the use of alternative fuels and alternative fuel vehicles as well as energy conservation.

3.5.1. Energy Conservation Program

Dominion is working toward helping the Commonwealth of Virginia meet its energy goal of 10% voluntary energy conservation enacted by the Virginia General Assembly in 2007 (Chapter 933 of the 2007 Acts of Assembly). To help meet this goal, Dominion has implemented a number of programs designed to help residential and commercial customers reduce energy usage. Each of these programs will provide environmental benefits and translate into financial savings for customers. Information is not available to quantify the expected impact on air emissions from this program; however, the programs are directionally correct and will improve air quality through avoiding emissions.

Residential Programs:

- Smart Cooling Rewards
- Income-Qualifying Home Improvement
- Home Energy Check-Up
- Heat Pump Tune-Up
- Duct Testing and Sealing

Business Programs:

- Energy Audit
- Duct Testing & Sealing

More information on each of these programs may be found at www.dom.com/dominion-virginia-power/customer-service/energy-conservation/ec-programs.jsp.

3.5.2. Generating Unit Retrofits and Fuel-Switches

As part of a federally-enforceable April 2003 Consent Decree between Dominion Virginia Power and EPA (United States v. Virginia Electric and Power Co., Civil Action No. 03-CV-517A, entered 10/10/2003), Dominion has installed SO_2 and/or NO_X control devices for on a number of coal-fired units in the Commonwealth of Virginia. The Chesterfield Power Station, located in the Richmond-Petersburg area, has had three of the four coal fired units retrofitted with selective catalytic reduction (SCR) for NO_X control since 2002. These units have also been retrofitted for SO_2 control, with the fourth unit being tied into the SO_2 flue gas desulfurization (FGD) equipment in 2012. The FGD equipment at Chesterfield Power Station achieves approximately 95% reduction of SO_2 emissions, as well as significant emission reductions in other acid gases, mercury emissions, and direct particulate matter. The emissions benefits from these control devices have been included in the emissions estimated listed in Table 4 and Table 5. More detail on these assumptions and estimates may be found in Appendix A.

Dominion has also converted three formerly coal-fired power plants to biomass, a renewable energy source, and will be completing these projects some time in 2013. The capacity of each of these facilities is 63 MW, and one of these power plants is located in Hopewell, Virginia. The switch to biomass as the primary fuel should reduce emissions of NO_X, SO_2, and mercury from these facilities. The benefits of these fuel switches have been included in Table 4 and Table 5, and more information on these estimates may be found in Appendix A.

3.6. Virginia Clean Cities Programs

The mission of the Virginia Clean Cities, Inc. (VCC) is to increase national energy security; improve air quality and public health in the Commonwealth of Virginia; and develop economic, academic, and resource opportunities in the Commonwealth through petroleum reduction. VCC draws stakeholders from all levels of government, the commercial sector, and the manufacturing sector in its quest to cultivate an advanced transportation community in which citizens may learn about a wide range of options and technologies for on road and off road engines. The "2011 Annual Report for Virginia Clean Cities" (see http://www.vacleancities.org/tools-resources/reports/) estimates that in 2011, this program helped to reduce Virginia's reliance on petroleum products by the equivalent of over 8,700,000 gallons of gasoline. This directionally correct program is expanding every year to take on more challenges and will continue to provide air quality benefit for the Richmond-Petersburg area as well as throughout the Commonwealth by promoting clean, alternative fuels as well as energy efficiency improvements. The sections below provide information on a few of the notable projects facilitated by VCC. The emission benefits from these projects are not included in the emissions inventories presented in Table 4 and Table 5. More information on this organization may be found at www.vacleancities.org.

3.6.1. Luck Stone Partnership

Funding provided by EPA to VCC and James Madison University helped launch the first construction repowering project in Virginia to reduce harmful diesel pollution at four Luck Stone plants operating in Richmond, Charlottesville, Leesburg, and Burkeville. EPA's $710,000 Diesel Emissions Reduction Act grant, combined with over $2,000,000 from Luck Stone, enabled the company to repower or replace eleven off-road construction vehicles with new, more efficient diesel engines and generators. This project was completed in 2012. The new engines resulted in a 50% reduction in NO_X and 65% reduction in $PM_{2.5}$ for each piece of equipment. Annually, the project will result in reductions of 31 tons of NO_X, 2 tons of $PM_{2.5}$, and 3 tons of VOC from the four plants. In addition, the project created about 20 jobs.

3.6.2. Virginia Get Ready Project

VCC created and manages the Virginia Get Ready effort, which recently produced the Virginia Get Ready: Electric Vehicle Plan. The goal is to establish Virginia as a leader in the adoption of electric vehicles in order to reduce vehicle emissions, increase energy independence, and generate economic development for the Commonwealth. The city of Richmond has been an important partner in this Electric Vehicle (EV) Initiative. VCC and DMME were awarded a major planning grant for electric vehicles through the Clean Cities Community Readiness and Planning for Plug-In Electric Vehicles and Charging Infrastructure grant program. The primary objective of the Richmond Electric Vehicle Initiative (REVi) is to advance the Richmond region as an attractive and sustainable market for electric vehicle technology (see Figure 23). The activities of this planning project will lay an educational and policy groundwork for electric vehicle adoption and charging infrastructure installation in the Richmond area and the Commonwealth at large. A Richmond Regional Strategic Plan will be developed and will identify and foster policies to expedite infrastructure implementation specific to the Richmond Region and prepare the Commonwealth for successful deployment of plug-in electric drive vehicles. Program modeling and planning activities will reflect local needs and barriers, and the activities will include a comprehensive team of over 50 local and national experts to facilitate success. The project has been successful at public outreach events including an Electric Vehicle Rally and Business Case for Electric Vehicle Charging Stations Forum and press conference. These events have resulted in extensive statewide media coverage for electric vehicles and infrastructure. Ford Motor Company has chosen Richmond as one of the first 25 “EV Ready” cities in the country and as a launch market for its all-electric vehicle line. While emission reductions associated with this program are at this time difficult to quantify, this is an important, directionally correct program that will benefit air quality well into the future. Table 10 provides data on the growth rates associated with EV transportation in the Commonwealth.

Figure 23: The Omni-Richmond Hotel's Charging Station

Table 10: EV Six Month Growth Rates (February to September 2012)

Milestone	Richmond Region	Statewide
Hybrid Vehicles	129%	142%
PHEV* and EV	400%	334%
EV only:	160%	228%
Charging Locations:	200%	145%

Data Source: Virginia Clean Cities, Inc *PHEV: Plug-in Hybrid Electric Vehicle

3.6.3. Southeast Propane Autogas Development Program

Virginia Clean Cities manages the Southeast Propane Autogas Development Program (SPADP). SPADP is a large-scale Recovery Act alternative fuel project aimed at building propane autogas infrastructure in the southeast United States and encouraging public and private fleets in the region to adopt propane autogas. Propane fuel savings in the program exceed $1.50 per gallon and the fuel represents reductions of 20% in CO and of 40% in NO_X. The program is converting over 1,200 vehicles from gasoline to propane autogas including 125 in Virginia, implementing propane autogas fueling stations along high-traffic routes with partner Alliance AutoGas, and deploying a wide-reaching communications campaign to increase awareness and usage of propane autogas. SPADP provides Virginia with a platform for the state fleet alternative fuel transition effort, which was initiated in October 2012. Although this program is not specific to the Richmond-Petersburg area, the environmental benefits from this program should help to improve local area quality as well as air quality across the Commonwealth.

3.7. Local Industry Reductions-Honeywell Hopewell SCR Installation

Honeywell International Inc.-Hopewell Plant is a caprolactam manufacturing facility in Hopewell, Virginia. As a result of negotiations to resolve federal compliance issues, VDEQ issued a federally enforceable permit to this facility dated June 28, 2011, that requires the installation and operation of eight SCR systems on eight of the ten largest-emitting units on site. These units currently have a NO_X potential to emit (PTE) of over 10,000 tpy, and their actual emissions of NO_X are generally in the 7,400-8,100 tpy range. The permit requires that an SCR be installed on eight of these ten units, and each SCR is expected to achieve NO_X reductions of at least 95%. Once the eight SCRs are installed and operating, the collective NO_X PTE of the ten units will be reduced to 1,850 tpy. The permit requires installation of the SCR in a phased manner, where two SCR were required to begin operating on December 31, 2012. Others are required on a timeline such that all eight SCR are installed and operating by June 30, 2019. Construction of the first two SCR is shown in Figure 24.

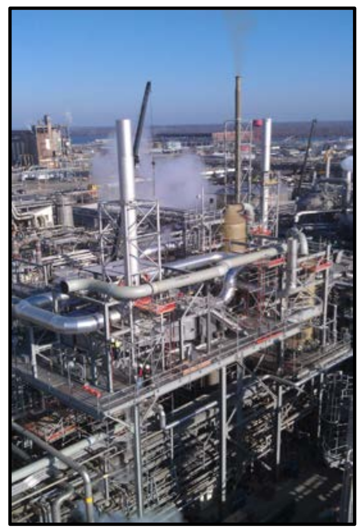

Figure 24: Honeywell SCR Project

Table 11 provides data on the actual emissions of these units from 2007 through 2011, and the expected emission rates after control, as listed in the June 28, 2011 permit. As the table demonstrates, the emissions from this equipment are historically between 7,400 tpy and 8,100 tpy NO_X. After installation of controls, this equipment will be allowed to emit no more than 1,850 tpy of NO_X. This control program represents the reduction of at least 5,791.6 tpy of NO_X by June 30, 2019, as compared to actual 2011 annual emissions. The benefits from this program are not included in the overall NO_X emission estimates listed in Table 4and Table 5 and should help improve ozone air quality in the region and throughout the Commonwealth.

Table 11: Honeywell Hopewell NO_X Reductions

	Actual Emissions of NOx, tpy					Permitted Limits of NOx, tpy			
	2007	2008	2009	2010	2011	6/30/13	6/30/15	6/30/2017	6/30/2019
Nitrite Towers									
A	969.4	1,151.6	1,305.3	1,228.7	1,152.3	1,673.0	1,673.0	117.0	117.0
B	863.6	881.4	855.1	971.7	938.4	1,844.0	123.0	123.0	123.0
C	949.2	1,129.9	1,090.1	1,055.5	1,001.4	102.0	102.0	102.0	102.0
D	366.3	435.5	451.8	420.8	332.2	600.0	600.0	600.0	33.0
E	426.6	495.0	541.0	454.4	422	600.0	600.0	600.0	600.0
Disulfonate Towers									
A	1,129.1	1,029.4	1,085.3	1,004.2	1,124.8	1,244.0	1,244.0	87.0	87.0
B	898.8	891.6	954.4	879.4	895.7	1,092	84.0	84.0	84.0
C	882.3	899.4	812.5	878.1	843.7	72.0	72.0	72.0	72.0
D	518.7	534.7	493.9	577.1	399.7	600.0	600.0	600.0	32.0
E	471.6	552.8	518.6	538.5	531.4	600.0	600.0	600.0	600.0
Totals:	**7,475.6**	**8,001.3**	**8,108.0**	**8,008.4**	**7,641.6**	**8,427.0**	**5,698.0**	**2,985.0**	**1,850.0**

Data Source: VDEQ-CEDS.

3.8. Regional Reductions

Since air quality is not solely dictated by emissions within any particular area, but is heavily influenced in the case of the Commonwealth by transported emissions, this section describes other emission reduction efforts that are occurring outside of the Richmond-Petersburg area. Depending on meteorological conditions on any summer day, the reductions described in this section could improve the air quality in the Richmond-Petersburg area and may lessen the transported ozone and precursor load. These reductions are commercial or industrial boilers that are switching from burning coal to burning natural gas, and each of these facilities have received federally enforceable permits to make this conversion. The emission reductions associated with each fuel switch are considerable. These reductions have not been included in the summary of emissions for Virginia found in Table 4.

3.8.1. Invista

Invista owns and operates a synthetic fiber production facility located in Waynesboro, Virginia. The facility has a powerhouse consisting of three boilers that predominantly use coal, with a total heat input of approximately 600 million British thermal units/hour (mmbtu/hr). Table 12 provides emissions information on the existing powerhouse for the facility.

Table 12: Invista Powerhouse Emissions 2007-2011, SO_2 and NO_X

Year	Tons NO_X/Year	Tons SO_2/Year
2011	184.0	567.8
2010	198.5	629.1
2009	237.7	768.1
2008	275.7	843.2
2007	353.2	924.2

Data Source: VDEQ-CEDS

The facility received a federally enforceable permit from VDEQ to retire the existing boilers and in their place install two new, natural-gas fired boilers that use distillate oil and liquefied petroleum gas as back-up fuels. These new units are permitted 33.8 tpy NO_X and 2.3 tpy SO_2. This change would reduce the NO_X emissions by more than 100 tpy and the SO_2 emissions by more than 500 tpy, as compared to 2011 values. These reductions have not been included in the Virginia-wide emissions estimates listed in Table 4. The facility commenced construction on these boilers in December of 2012.

3.8.2. Celco

Celanese Acetate, LLC (Celco) is a large manufacturing facility located in Giles County, Virginia. The facility primarily manufactures cellulose acetate flake and fiber using wood pulp and acetic acid as raw materials. To facilitate operations, the plant has a steam plant consisting of seven coal fired boilers and two natural gas boilers. The seven coal fired boilers have a capacity of approximately 1,400 mmbtu/hr heat input. The facility received a federally enforceable permit on December 6, 2012, allowing the construction of six natural gas boilers that will be used in place of the seven coal fired boilers. The retirement of the seven coal fired boilers, which operate with minimal pollution control, and their subsequent replacement by natural gas boilers with low NO_X burners, will reduce emissions of SO_2 and NO_X significantly from this facility. Table 13 provides the power house emissions since 2007 from this facility.

The total emissions from the new natural gas boilers are limited to no more than 333 tpy of NO_X and 6 tpy of SO_2. Therefore, the steam plant will emit 3,000 tons of NO_X and 6,000 tons of SO_2 less than previous years, once these changes are made. The estimated time frame for these changes to take effect is 2015. These reductions were not included in the overall emissions estimates provided in Table 4.

Table 13: Celco Powerhouse Emissions 2007-2011, SO_2 and NO_X

Year	Tons NO_X/Year	Tons SO_2/Year
2011	3,539.9	6,540.2
2010	3,438.8	6,325.1
2009	3,775.9	6,551.1
2008	3,907.1	6,631.5
2007	3,609.2	6,499.9

Data Source: VDEQ-CEDS

4. Ozone Advance Reporting Requirements and Checklist

As part of the Action Plan process, VDEQ intends to report annually to EPA on the programs contained in this document. To facilitate the reporting process, VDEQ will coordinate with stakeholders and report to EPA using the checklist in Appendix D. This checklist is not intended to be prescriptive or a mandate. Rather, it provides a structure to the reporting process and potential milestones for each control program listed within this action plan. The checklist in Appendix D may also be used to report on other initiatives not included in this plan or future initiatives that are still being formulated.