Richmond, VA NATTS Network Assessment Review

- Established 2008: Carbonyls, Chromium VI, PAHs, PM_{10} Metals, and VOCs
    - Chromium VI ended in in 2016
- For the NATTS Network Assessment (2008-2018):
    - 18 of 18 Method Quality Objective (MQO) Core HAPs were included in the national trends
    - 176 of 177 pollutant datasets were suitable for trends analysis
    - Annual Average and 3-Year Rolling Average Concentrations were generally flat over time, with the exception of a few pollutants (benzene, cadmium (PM_{10}), naphthalene, and nickel (PM_{10})).
    - 100% Reporting of Datasets
- Method Quality Objectives (MQO): 2008-2018
    - Completeness: Met 85% completeness in 177 of 177 pollutant datasets
    - Method Detection Limits: Met MDL Target Ratio of 1.00 in 165 of 196 pollutant datasets
    - Bias: Met ±25% for 153 of 161 pollutant datasets
    - Overall Method Precision: Met ≤15% CV for 48 of 56 pollutant datasets
    - Analytical Method Precision: Met ≤15% CV for 79 of 108 pollutant datasets
- Analytical Laboratories for 2018

VOC	Carbonyl	PM_{10} Metals	Chromium VI	PAHs
VADCLS	VADCLS	VADCLS	NA	ERG

- Equipment Year Deployed

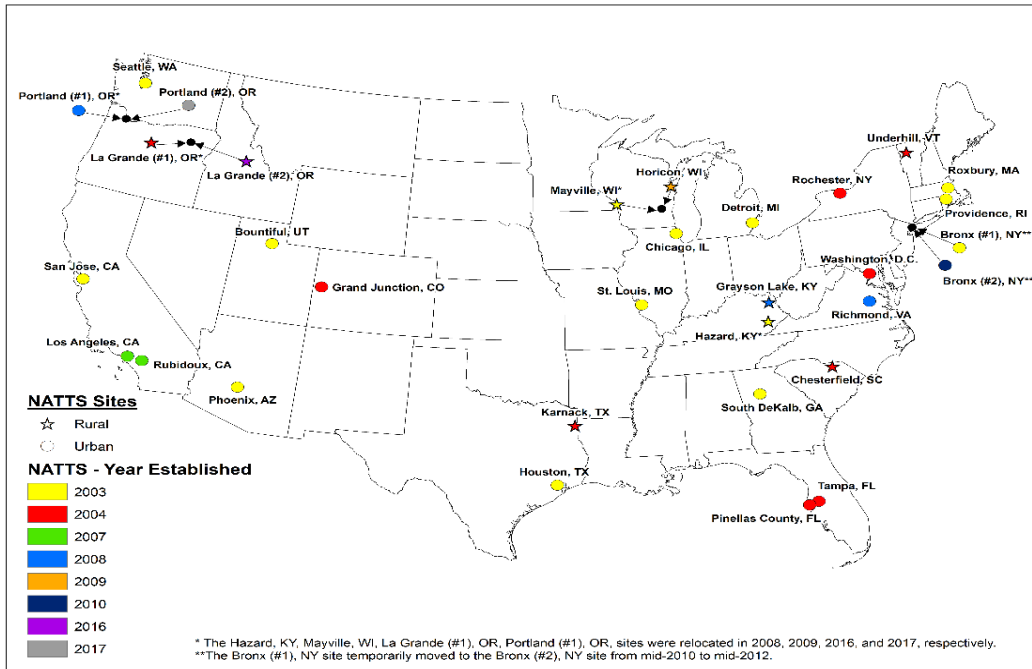| Equipment Type	VOC	Carbonyl	PM_{10} Metals	Chromium VI	PAHs
Sampler	2018	2014	2009	2008	2008
Analytical	2004	2012	2006	2001	2014
Preconcentrator	2012	NA	NA	NA	NA
Standards Preparation	2004	NA	NA	NA	NA
Canister Cleaning	2018	NA	NA	NA	NA
Extraction	NA	NA	2010	2011	2004

National Summary: NATTS data were collected at 27 locations across the United States, with sites beginning in 2003 or later (Figure 1) for 19 core HAPs. Over 528,000 concentrations (primary, secondary, and replicate) were generated and analyzed for this assessment. Pollutant datasets were scored to assess whether they were suitable for trends analysis. Each pollutant dataset was evaluated against four MQOs: Completeness; Sensitivity; Bias; and Precision. Datasets that were suitable (A- or B-rated) for six consecutive years were used for national trends analysis (Table 1).

National trends were determined by comparing the most recent 3-year blocked averages (e.g., 2013-2015 vs. 2016-2018) to determine if the NATTS Trends DQO was being met:

To be able to detect a a15 percent difference (trend) between the annual mean concentrations of successive 3-year periods within acceptable levels of decision error.

Of the 19 core HAPs. 18 were assessed for the NATTS Trends DQO. Due to sampling and analytical issues, acrolein was not considered for trends analysis (Table 2). This assessment showed that across the network, 15 of those 18 pollutants were decreasing between the 3-year blocks, while two of those pollutants were increasing between the 3-year blocks. One pollutant did not exhibit a trend.

Table 1. NATTS Network Assessment: Count and Percentage of Suitable Datasets by Pollutant Group

Pollutant Group	A-rated		B-rated		Does Not Meet	
	#	%	#	%	#	%
VOCs	1,452	53%	737	27%	555	20%
Carbonyls	523	67%	193	25%	66	8%
PM$_{10}$ Metals	1,418	61%	685	30%	213	9%
Chromium VI	159	74%	29	13%	27	13%
PAHs	410	74%	124	22%	18	3%
Total = 6,609	3,962	60%	1,768	27%	879	13%

Table 2. Three-Year Block Averages for National Trends

Pollutant	Units	# Sites	Block 1	Block 2	% Difference
Acetaldehyde	µg/m^3	19	1.51	1.39	-7.7%
Arsenic (PM$_{10}$)	ng/m^3	21	0.71	0.68	-3.2%
Benzene	µg/m^3	19	0.65	0.59	-10.2%
Benzo(a)pyrene	ng/m^3	21	0.113	0.087	-23.2%
Beryllium (PM$_{10}$)	ng/m^3	20	0.012	0.009	-26.4%
Butadiene, 1,3-	µg/m^3	19	0.071	0.063	-10.9%
Cadmium (PM$_{10}$)	ng/m^3	21	0.170	0.097	-43.0%
Carbon Tetrachloride	µg/m^3	15	0.59	0.56	-4.7%
Chloroform	µg/m^3	20	0.256	0.255	-0.4%
Chromium VI	ng/m^3	18	0.029	0.026	-7.7%
Formaldehyde	µg/m^3	19	2.77	2.68	-3.3%
Lead (PM$_{10}$)	ng/m^3	21	3.08	2.81	-8.9%
Manganese (PM$_{10}$)	ng/m^3	20	8.06	7.93	-1.6%
Naphthalene	ng/m^3	20	66.70	51.08	-23.4%
Nickel (PM$_{10}$)	ng/m^3	19	1.28	1.05	-18.0%
Tetrachloroethylene	µg/m^3	19	0.149	0.174	17.2%
Trichloroethylene	µg/m^3	19	0.020	0.022	10.7%
Vinyl Chloride	µg/m^3	17	0.0051	0.0048	-5.5%

Figure 1. NATTS Site and Year Established

* The Hazard, KY, Mayville, WI, La Grande (#1), OR, Portland (#1), OR, sites were relocated in 2008, 2009, 2016, and 2017, respectively.
**The Bronx (#1), NY site temporarily moved to the Bronx (#2), NY site from mid-2010 to mid-2012.

NATTS Monitoring Site Report: Richmond, VA

Site Information

Region	3
NATTS Site Type	Urban
County	Henrico
AQS Site Code	51-087-0014
NATTS Operating Agency	VA Dept. Environmental Quality
Latitude	37.55655
Longitude	-77.400411
AQS Land Use	Residential
AQS Location Setting	Suburban
10-Mile Population	318,611

Figure 2. NATTS Site Location

Pollutant Datasets Evaluation: Suitable for Trends (Y=yes; Y(T)=yes, and used for DQO Trends; N=No; "--"=not rated

Final Pollutant Name	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Acetaldehyde	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Arsenic (PM_{10})	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Benzene	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Benzo(a)pyrene	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Beryllium (PM_{10})	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Butadiene, 1,3-	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Cadmium (PM_{10})	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Carbon tetrachloride	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Chloroform	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Chromium VI	--	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	--	--	--
Formaldehyde	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Lead (PM_{10})	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Manganese (PM_{10})	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Naphthalene	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Nickel (PM_{10})	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Tetrachloroethylene	--	Y	Y	Y	N[a]	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Trichloroethylene	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)
Vinyl chloride	--	Y	Y	Y	Y	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)	Y(T)

[a]: Reported MDL to NATTS Target Ratio greater than 2.0

Analyte	Units	Site Type	# Data Records	% Detections	Arithmetic Mean[b]	Percentile Value[c]						
						5th	10th	25th	50th	75th	90th	95th
Acetaldehyde	µg/m³	Urban	15,704	100%	1.77 ± 0.02	0.50	0.66	0.97	1.45	2.19	3.24	4.04
	µg/m³	Rural	4,930	100%	1.20 ± 0.04	0.36	0.46	0.65	0.93	1.38	2.02	2.76
	µg/m³	All Sites	20,634	100%	1.63 ± 0.02	0.44	0.58	0.86	1.31	2.00	3.02	3.86
Arsenic (PM$_{10}$)	ng/m³	Urban	14,968	97%	0.89 ± 0.04	0.10	0.19	0.34	0.58	0.99	1.70	2.41
	ng/m³	Rural	4,622	96%	0.49 ± 0.02	0.04	0.08	0.17	0.35	0.59	0.94	1.28
	ng/m³	All Sites	19,590	97%	0.79 ± 0.03	0.06	0.14	0.29	0.52	0.89	1.54	2.19
Benzene	µg/m³	Urban	15,984	99%	0.86 ± 0.01	0.25	0.30	0.43	0.66	1.05	1.64	2.21
	µg/m³	Rural	2,494	95%	0.43 ± 0.02	0.04	0.13	0.21	0.33	0.52	0.78	1.01
	µg/m³	All Sites	18,478	99%	0.81 ± 0.01	0.19	0.26	0.39	0.61	0.98	1.55	2.09
Benzo(a)pyrene	ng/m³	Urban	12,336	70%	0.096 ± 0.004	ND	ND	ND	0.04	0.11	0.24	0.37
	ng/m³	Rural	3,179	36%	0.067 ± 0.009	ND	ND	ND	ND	0.02	0.13	0.37
	ng/m³	All Sites	15,515	63%	0.090 ± 0.004	ND	ND	ND	0.03	0.10	0.23	0.37
Beryllium (PM$_{10}$)	ng/m³	Urban	15,783	75%	0.051 ± 0.006	ND	ND	0.00003	0.005	0.018	0.050	0.101
	ng/m³	Rural	4,687	49%	0.023 ± 0.003	ND	ND	ND	ND	0.005	0.017	0.072
	ng/m³	All Sites	20,470	69%	0.045 ± 0.005	ND	ND	ND	0.003	0.012	0.049	0.100
Butadiene, 1,3-	µg/m³	Urban	15,388	81%	0.092 ± 0.002	ND	ND	0.025	0.058	0.114	0.215	0.302
	µg/m³	Rural	2,185	29%	0.012 ± 0.001	ND	ND	ND	ND	0.017	0.046	0.059
	µg/m³	All Sites	17,573	75%	0.082 ± 0.002	ND	ND	ND	0.049	0.104	0.199	0.287
Cadmium (PM$_{10}$)	ng/m³	Urban	16,360	92%	0.21 ± 0.02	ND	0.01	0.05	0.09	0.17	0.42	0.63
	ng/m³	Rural	4,684	87%	0.10 ± 0.01	ND	ND	0.03	0.06	0.11	0.20	0.29
	ng/m³	All Sites	21,044	91%	0.18 ± 0.01	ND	0.01	0.04	0.08	0.16	0.35	0.56
Carbon Tetrachloride	µg/m³	Urban	14,713	99%	0.569 ± 0.003	0.361	0.433	0.496	0.562	0.651	0.737	0.798
	µg/m³	Rural	2,189	92%	0.534 ± 0.016	ND	0.180	0.402	0.537	0.633	0.727	0.798
	µg/m³	All Sites	16,902	98%	0.565 ± 0.003	0.304	0.408	0.490	0.559	0.649	0.736	0.798
Chloroform	µg/m³	Urban	16,068	87%	0.265 ± 0.022	ND	ND	0.093	0.132	0.217	0.420	0.668
	µg/m³	Rural	3,802	43%	0.052 ± 0.003	ND	ND	ND	ND	0.095	0.144	0.230
	µg/m³	All Sites	19,870	79%	0.224 ± 0.018	ND	ND	0.064	0.113	0.196	0.364	0.586
Chromium VI	ng/m³	Urban	8,414	74%	0.036 ± 0.002	ND	ND	ND	0.020	0.042	0.081	0.120
	ng/m³	Rural	2,586	41%	0.018 ± 0.004	ND	ND	ND	ND	0.017	0.031	0.051
	ng/m³	All Sites	11,000	66%	0.032 ± 0.001	ND	ND	ND	0.016	0.036	0.073	0.114

Table 3. NATTS Network Assessment Data (2003-2018) - National Distribution Statistics By Type[a]

Analyte	Units	Site Type	# Data Records	% Detections	Arithmetic Mean[b]	Percentile Value[c]						
						5th	10th	25th	50th	75th	90th	95th
Formaldehyde	$\mu g/m^3$	Urban	16,118	100%	3.11 ± 0.04	0.66	0.99	1.60	2.47	3.84	5.63	7.25
	$\mu g/m^3$	Rural	5,002	100%	2.22 ± 0.05	0.53	0.68	1.06	1.69	2.74	4.19	5.45
	$\mu g/m^3$	All Sites	21,120	100%	2.90 ± 0.04	0.61	0.86	1.43	2.29	3.59	5.38	6.96
Lead (PM_{10})	ng/m^3	Urban	16,366	100%	4.21 ± 0.13	0.72	0.98	1.55	2.64	4.56	8.35	11.90
	ng/m^3	Rural	4,680	99%	2.10 ± 0.16	0.37	0.50	0.84	1.41	2.37	3.91	5.36
	ng/m^3	All Sites	21,046	99%	3.74 ± 0.11	0.55	0.80	1.31	2.31	4.04	7.41	10.56
Manganese (PM_{10})	ng/m^3	Urban	16,141	100%	9.80 ± 0.32	1.09	1.51	2.52	4.92	10.21	20.10	30.08
	ng/m^3	Rural	4,627	99%	3.96 ± 0.14	0.46	0.73	1.36	2.57	4.75	8.54	12.13
	ng/m^3	All Sites	20,768	100%	8.50 ± 0.25	0.85	1.23	2.15	4.18	8.89	17.98	26.70
Naphthalene	ng/m^3	Urban	12,332	100%	74.63 ± 1.14	15.62	21.27	33.55	55.89	94.64	150.05	196.16
	ng/m^3	Rural	3,301	100%	24.47 ± 1.38	3.74	4.73	7.74	13.86	26.25	50.88	79.17
	ng/m^3	All Sites	15,633	100%	64.04 ± 1.00	6.58	10.92	23.37	45.59	83.31	137.54	181.75
Nickel (PM_{10})	ng/m^3	Urban	16,125	97%	1.85 ± 0.05	0.25	0.41	0.67	1.11	2.00	3.52	5.27
	ng/m^3	Rural	4,623	85%	0.65 ± 0.08	ND	ND	0.10	0.28	0.64	1.15	1.89
	ng/m^3	All Sites	20,748	94%	1.58 ± 0.04	ND	0.15	0.47	0.92	1.73	3.14	4.74
Tetrachloroethylene	$\mu g/m^3$	Urban	15,612	86%	0.25 ± 0.01	ND	ND	0.06	0.13	0.25	0.48	0.74
	$\mu g/m^3$	Rural	2,272	36%	0.09 ± 0.04	ND	ND	ND	ND	0.04	0.08	0.16
	$\mu g/m^3$	All Sites	17,884	79%	0.23 ± 0.01	ND	ND	0.04	0.11	0.22	0.44	0.70
Trichloroethylene	$\mu g/m^3$	Urban	15,843	41%	0.040 ± 0.002	ND	ND	ND	ND	0.051	0.107	0.164
	$\mu g/m^3$	Rural	3,388	13%	0.021 ± 0.003	ND	ND	ND	ND	ND	0.017	0.250
	$\mu g/m^3$	All Sites	19,231	36%	0.037 ± 0.002	ND	ND	ND	ND	0.041	0.105	0.167
Vinyl Chloride	$\mu g/m^3$	Urban	14,778	19%	0.0044 ± 0.0003	ND	ND	ND	ND	ND	0.0137	0.0257
	$\mu g/m^3$	Rural	2,444	8%	0.0040 ± 0.0009	ND	ND	ND	ND	ND	ND	0.0156
	$\mu g/m^3$	All Sites	17,222	17%	0.0043 ± 0.0003	ND	ND	ND	ND	ND	0.0126	0.0254

[a] Statistics presented are from pollutant datasets which were suitable for trends.

[b] The arithmetic mean is the average of all samples results which include actual measured values. If no chemical was registered, then a value of zero is used when calculating the mean.

[c] ND: No results of this chemical were registered by the laboratory analytical equipment.

Table 4. Summary Statistics for Richmond, VA

Analyte	Units	# Data Records	% Detection	Arithmetic Mean[a]	Percentile Value[b]						
					5th	10th	25th	50th	75th	90th	95th
Acetaldehyde	$\mu g/m^3$	633	100%	1.48 ± 0.04	0.79	0.91	1.11	1.38	1.72	2.17	2.51
Arsenic (PM_{10})	ng/m^3	623	100%	0.76 ± 0.04	0.24	0.30	0.44	0.64	0.96	1.35	1.71
Benzene	$\mu g/m^3$	619	97%	0.56 ± 0.03	0.16	0.23	0.32	0.47	0.71	0.97	1.27
Benzo(a)pyrene	ng/m^3	600	66%	0.07 ± 0.01	ND	ND	ND	0.03	0.09	0.18	0.24
Beryllium (PM_{10})	ng/m^3	620	20%	0.0016 ± 0.0004	ND	ND	ND	ND	ND	0.003	0.010
Butadiene, 1,3-	$\mu g/m^3$	619	1%	0.003 ± 0.002	ND	ND	ND	ND	ND	ND	ND
Cadmium (PM_{10})	ng/m^3	623	99%	0.124 ± 0.011	0.020	0.032	0.051	0.090	0.155	0.240	0.320
Carbon Tetrachloride	$\mu g/m^3$	619	96%	0.535 ± 0.015	0.322	0.435	0.476	0.525	0.599	0.672	0.733
Chloroform	$\mu g/m^3$	619	47%	0.064 ± 0.007	ND	ND	ND	ND	0.104	0.151	0.159
Chromium VI	ng/m^3	464	48%	0.008 ± 0.001	ND	ND	ND	ND	0.014	0.020	0.025
Formaldehyde	$\mu g/m^3$	633	100%	3.01 ± 0.14	1.19	1.42	1.84	2.45	3.77	5.32	6.51
Lead (PM_{10})	ng/m^3	623	100%	2.35 ± 0.25	0.77	0.93	1.40	1.93	2.62	3.65	4.39
Manganese (PM_{10})	ng/m^3	623	100%	2.65 ± 0.13	0.78	1.04	1.55	2.39	3.26	4.43	5.49
Naphthalene	ng/m^3	600	100%	82.73 ± 4.82	25.36	31.34	45.73	67.69	102.09	148.83	180.10
Nickel (PM_{10})	ng/m^3	623	100%	0.72 ± 0.03	0.36	0.40	0.50	0.62	0.84	1.14	1.34
Tetrachloroethylene	$\mu g/m^3$	619	41%	0.089 ± 0.013	ND	ND	ND	ND	0.140	0.218	0.351
Trichloroethylene	$\mu g/m^3$	619	3%	0.015 ± 0.017	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	$\mu g/m^3$	619	0%	0.0011 ± 0.0016	ND	ND	ND	ND	ND	ND	ND

[a] :The arithmetic mean is the average of all samples results which included actual measured values. If no chemical was registered, then a value of zero is used.

[b] ND: No results of this chemical were registered by the laboratory analytical equipment.

Table 5. Analytical Labs Supporting this Site

Pollutant Group	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
VOCs	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS
Carbonyls	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS
PM_{10} Metals	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS	VADCLS
Chromium VI	ERG	ERG	ERG	ERG	ERG	ERG	ERG	ERG	ERG	--	--
PAHs	ERG	ERG	ERG	ERG	ERG	ERG	ERG	ERG	ERG	ERG	ERG

--: Not Applicable

VADCLS: Virginia Division of Consolidated Laboratory Services
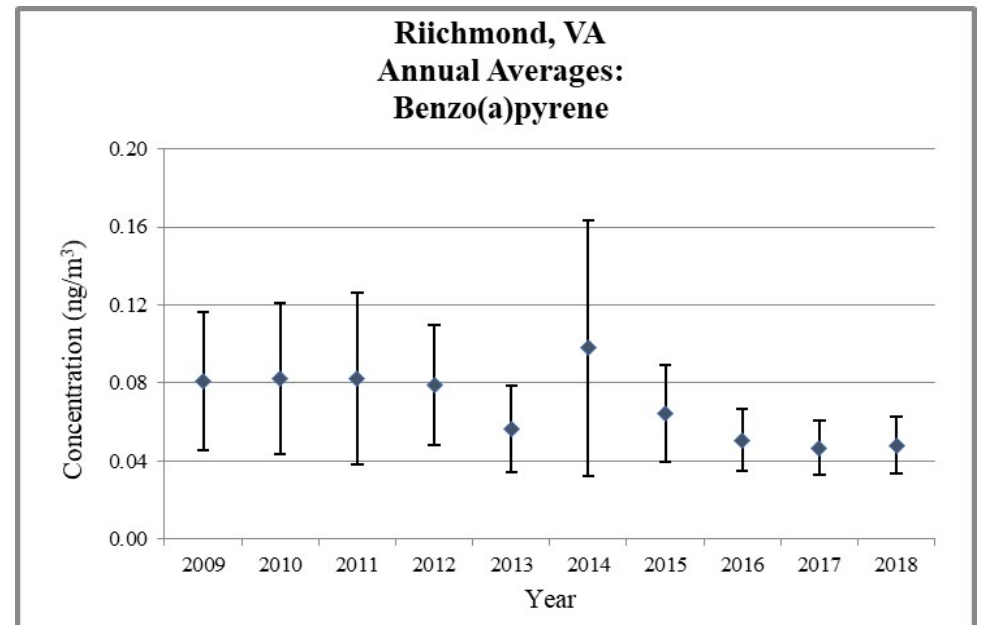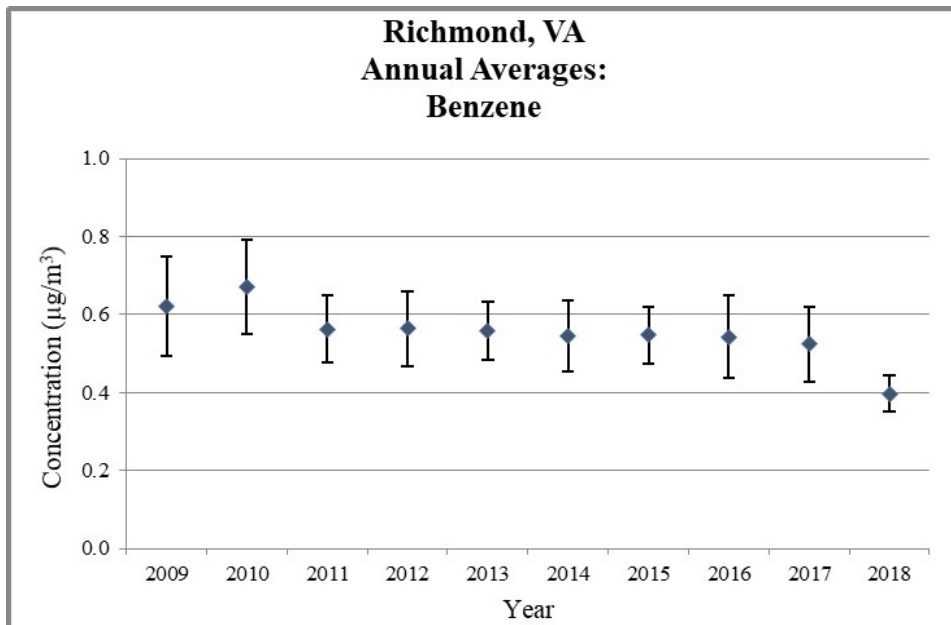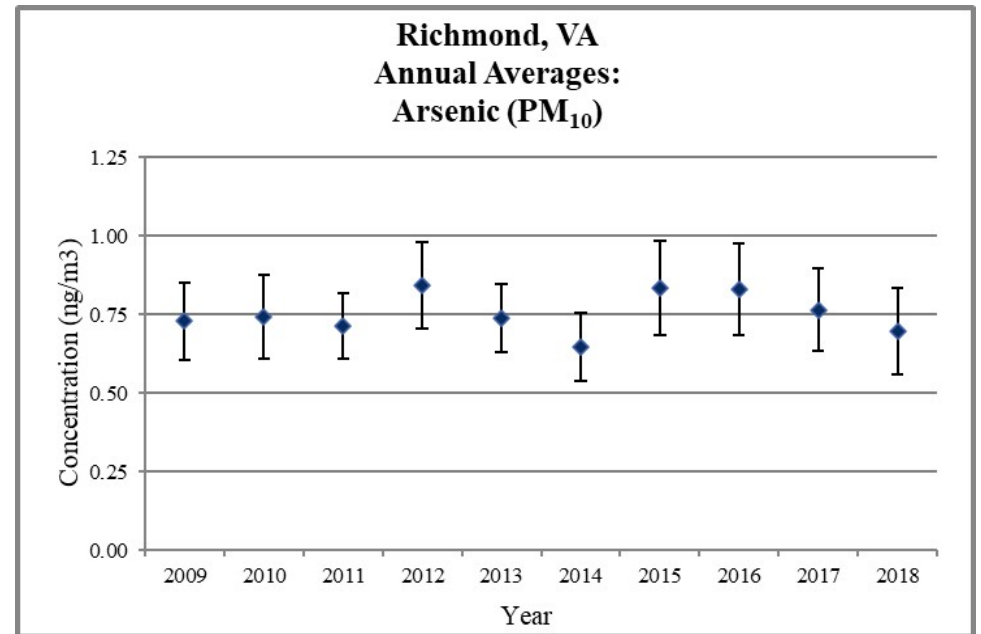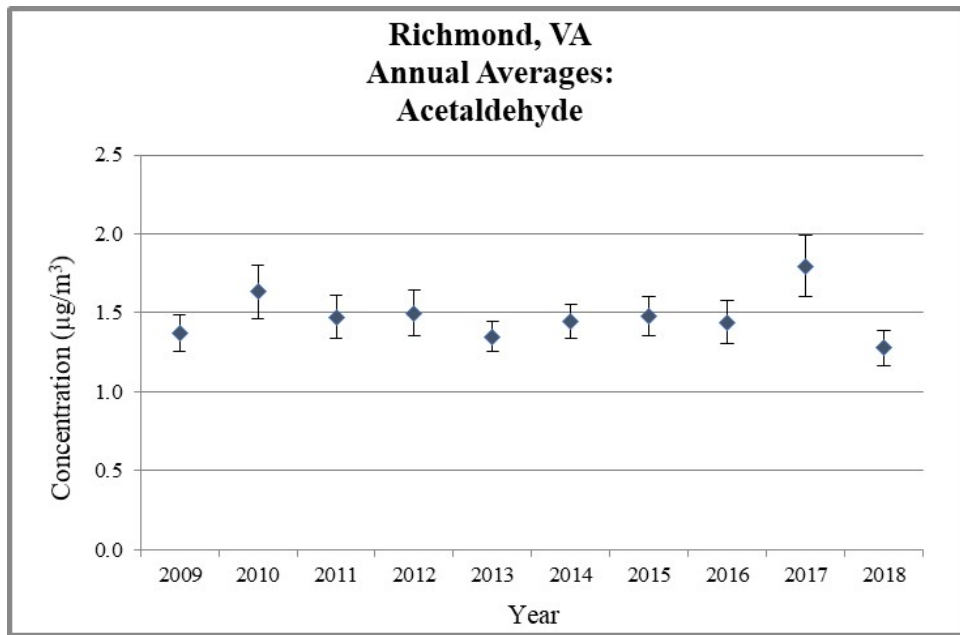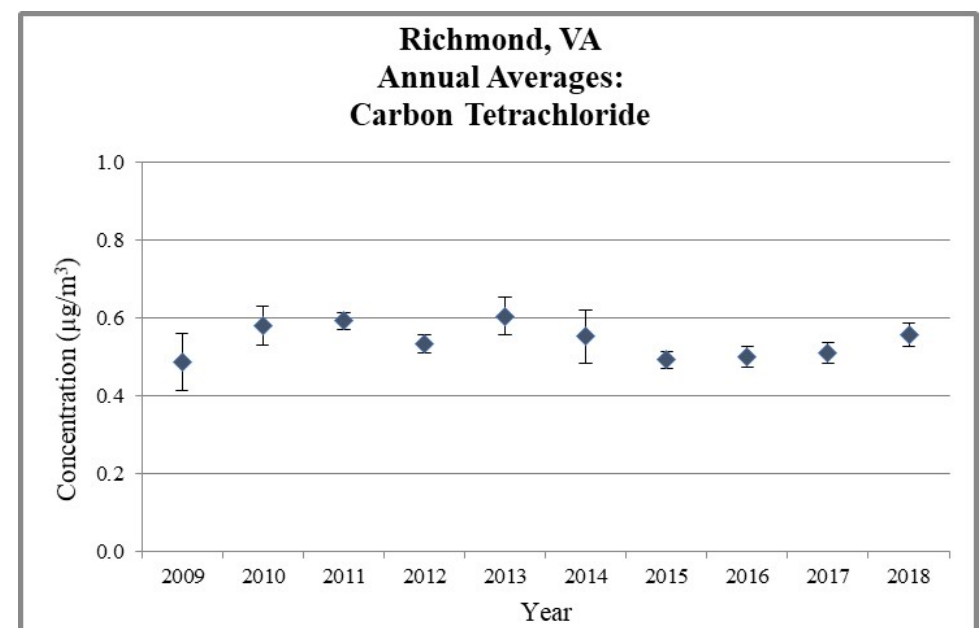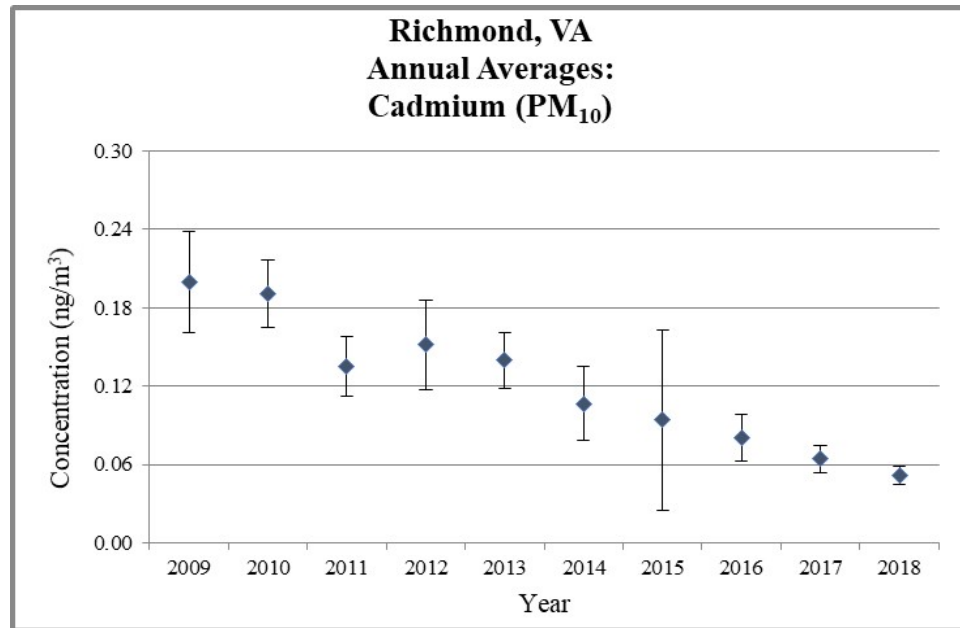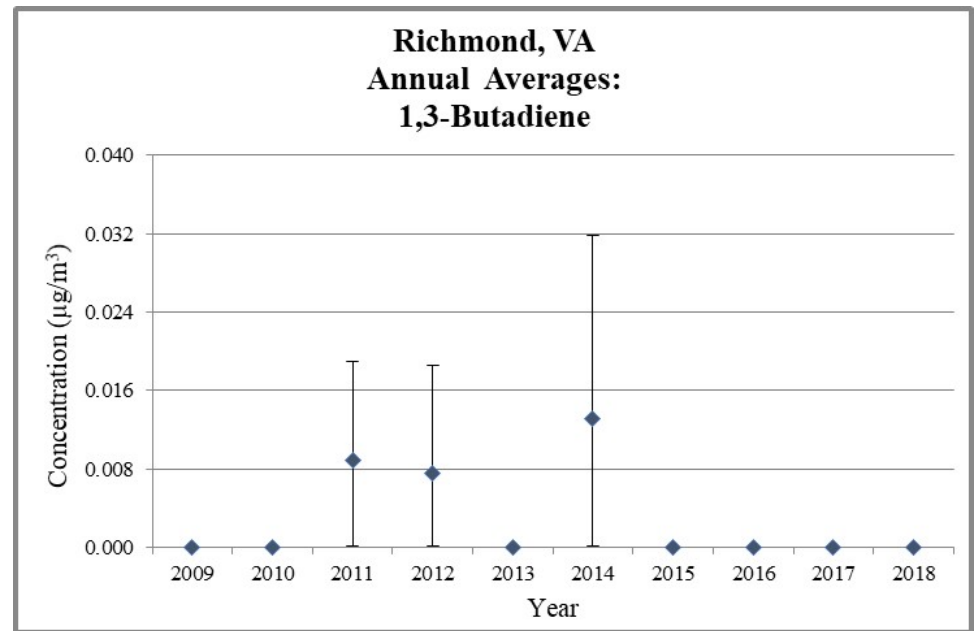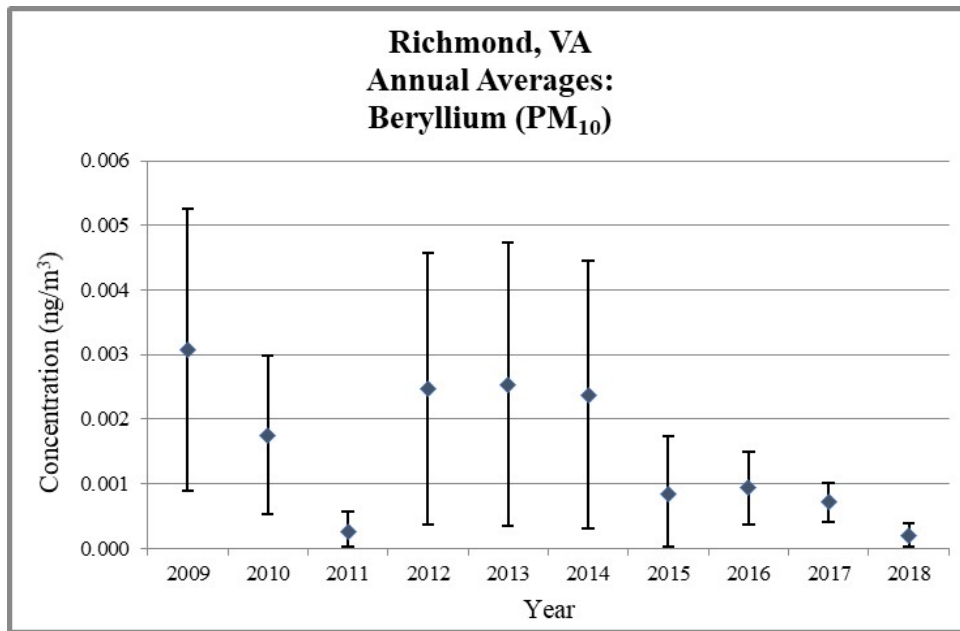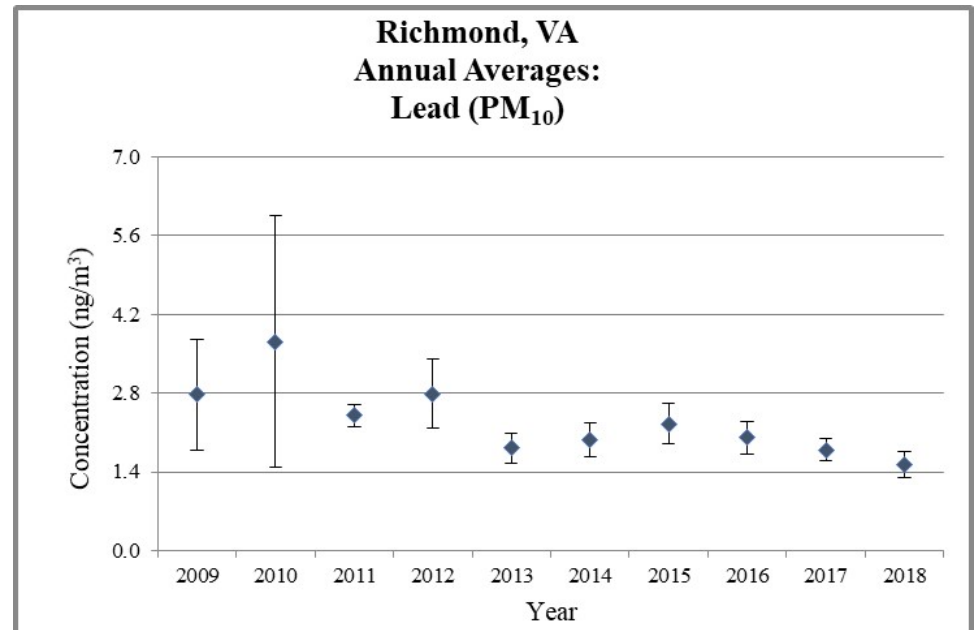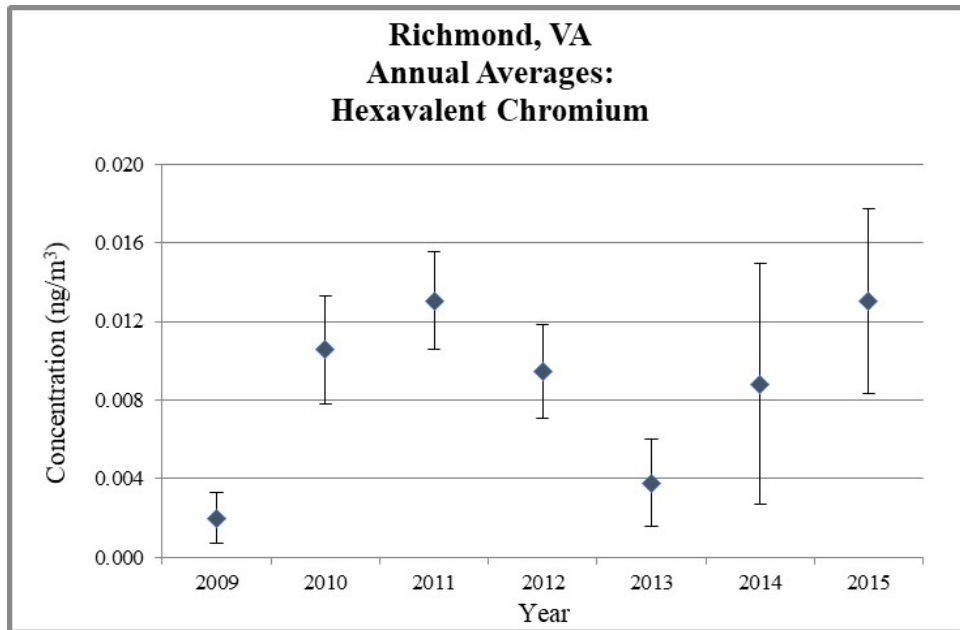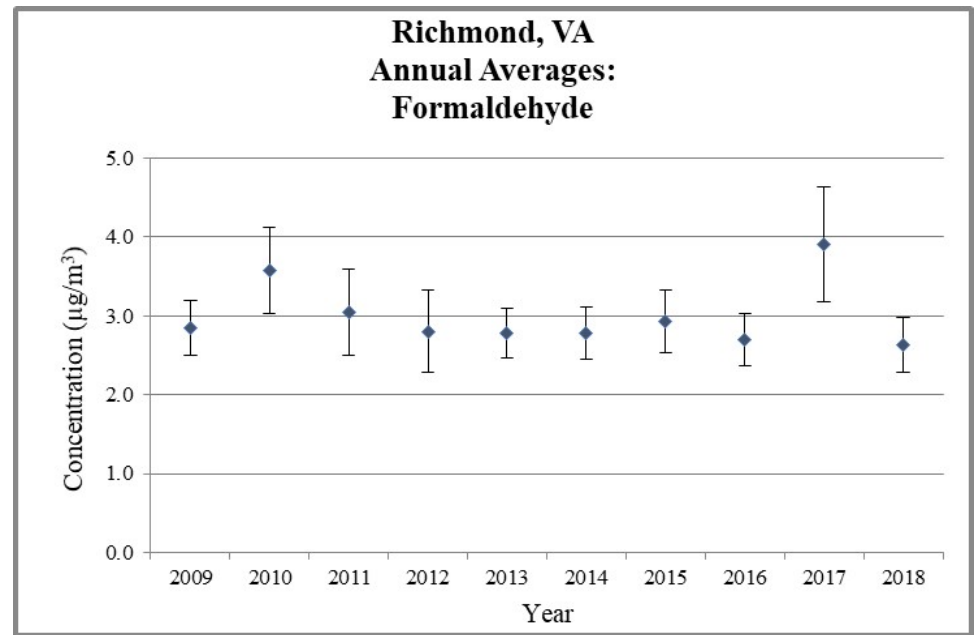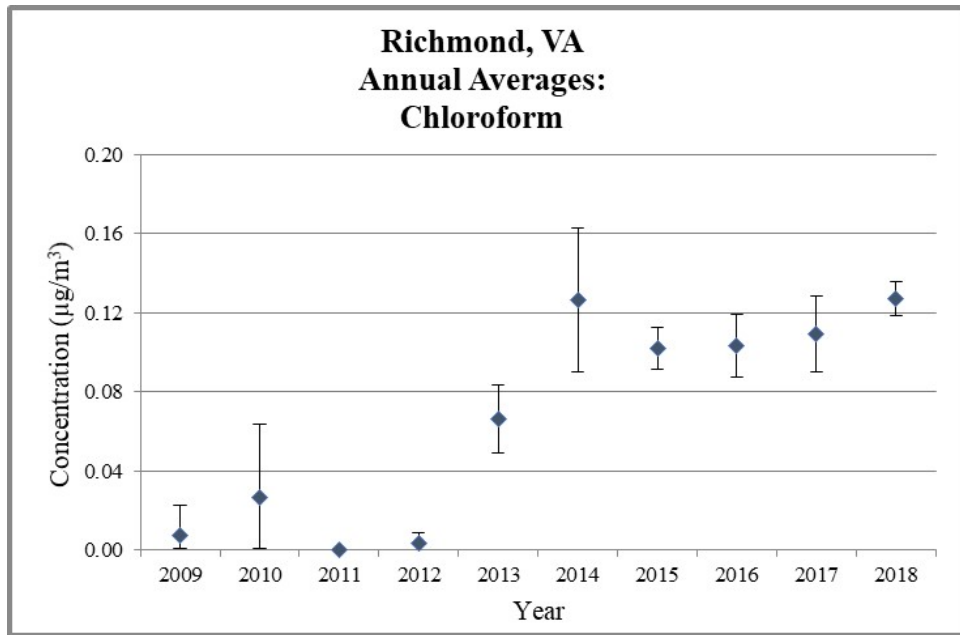
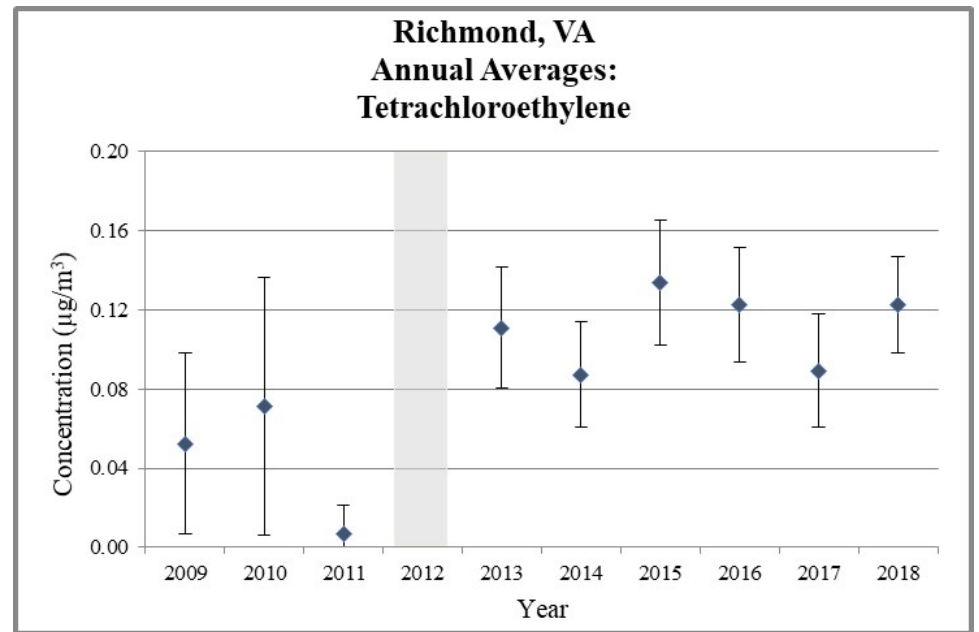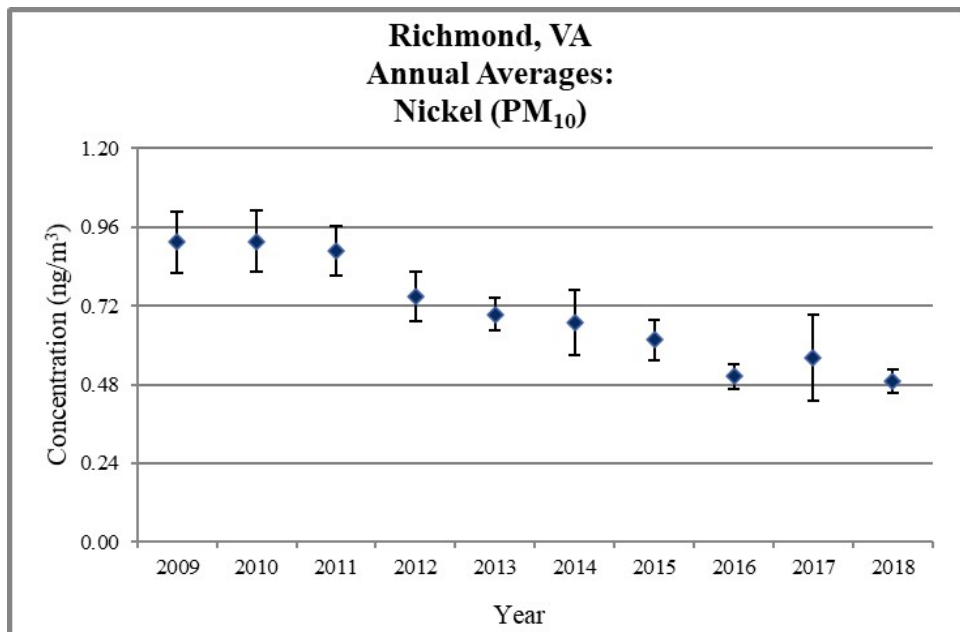ERG: Eastern Research Group, Inc.

Figure 3. Richmond, VA Annual Average Concentrations

Richmond, VA Annual Averages: Acetaldehyde

Richmond, VA Annual Averages: Arsenic (PM₁₀)

Richmond, VA Annual Averages: Benzene
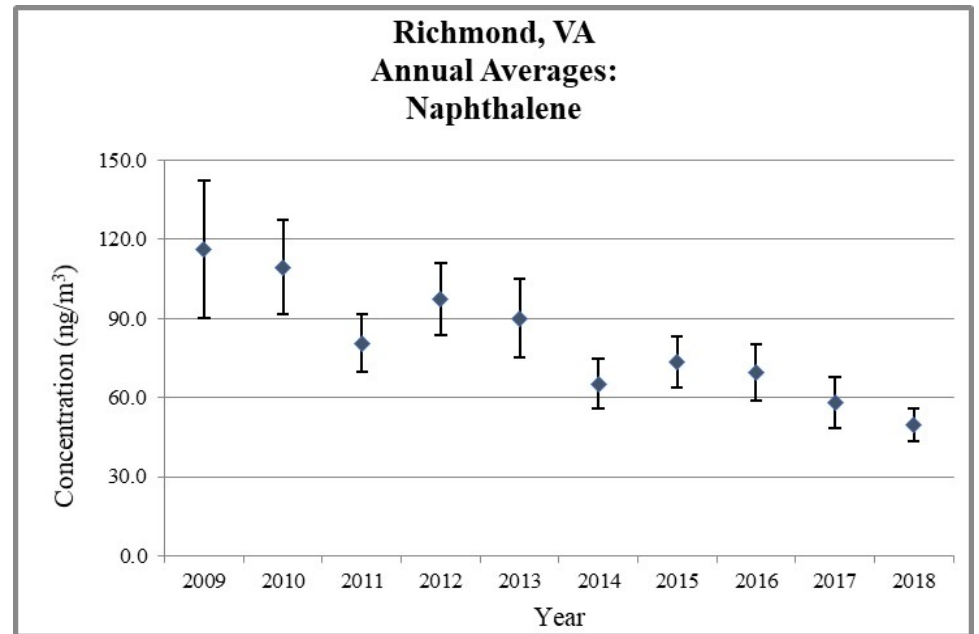
Riichmond, VA Annual Averages: Benzo(a)pyrene

Figure 3. Richmond, VA Annual Average Concentrations

Figure 3. Richmond, VA Annual Average Concentrations

Richmond, VA Annual Averages: Chloroform

Richmond, VA Annual Averages: Formaldehyde

Richmond, VA Annual Averages: Hexavalent Chromium

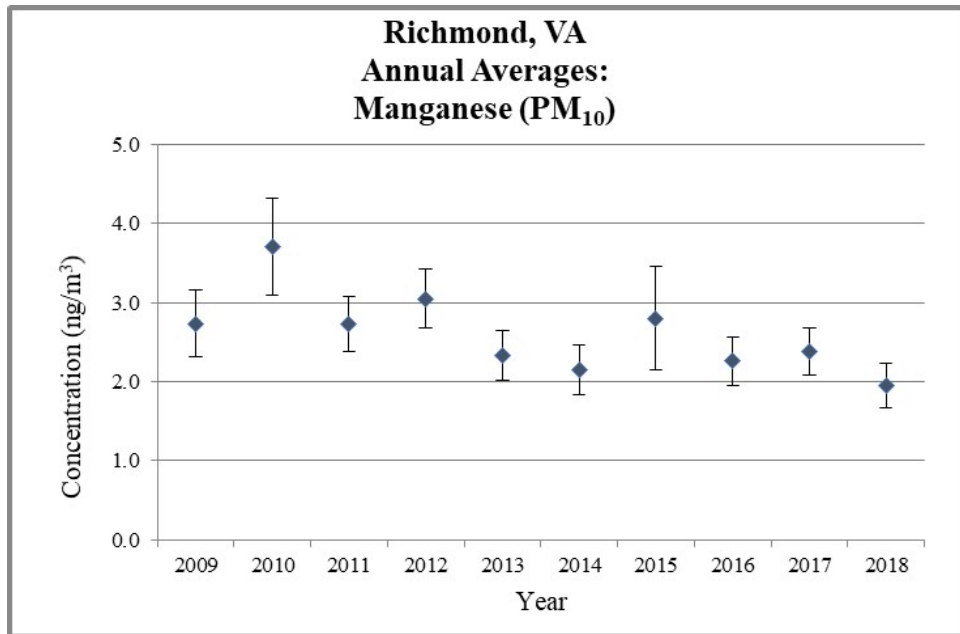Richmond, VA Annual Averages: Lead (PM$_{10}$)

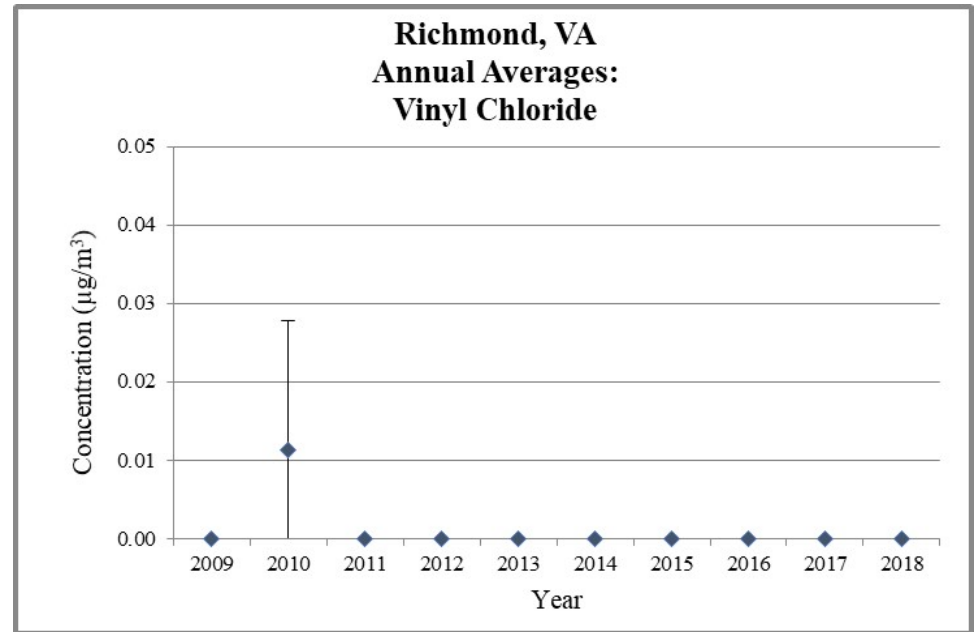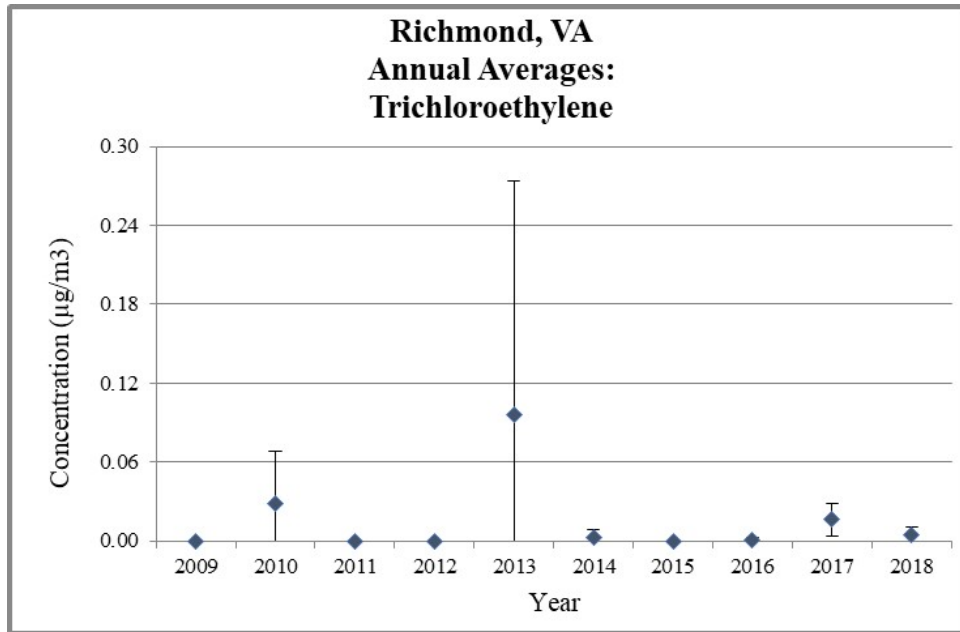**Figure 3. Richmond, VA Annual Average Concentrations**

Figure 3. Richmond, VA Annual Average Concentrations

Does not meet MQO

Figure 4. Richmond, VA - 3-Year Rolling Average Concentrations

Richmond, VA
3-Year Rolling Averages:
Acetaldehyde

Richmond, VA
3-Year Rolling Averages:
Arsenic (PM$_{10}$)

Figure 4. Richmond, VA - 3-Year Rolling Average Concentrations

Richmond, VA
3-Year Rolling Averages:
Benzene

Richmond, VA
3-Year Rolling Averages:
Benzo(a)pyrene

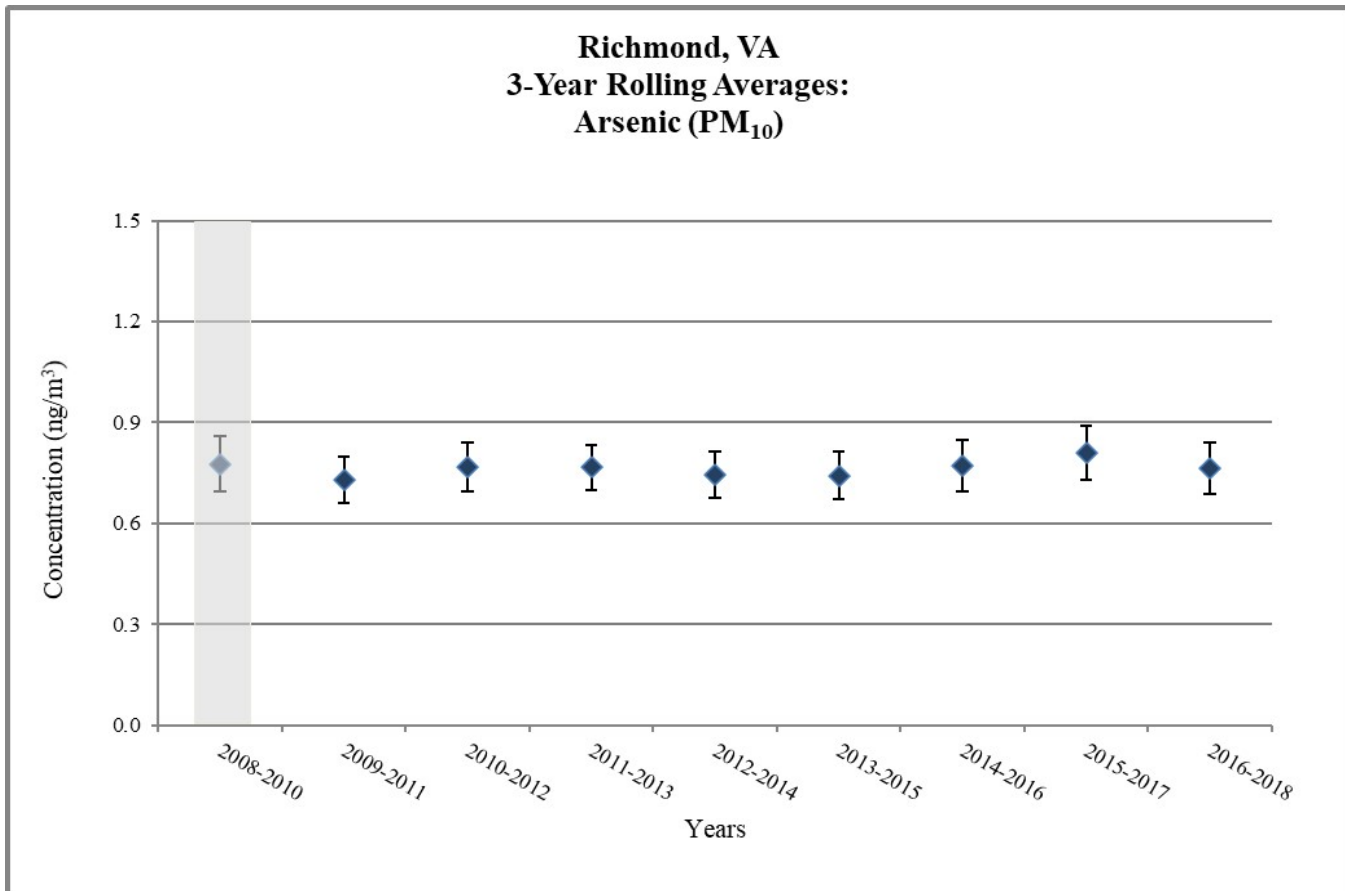**Figure 4. Richmond, VA - 3-Year Rolling Average Concentrations**

Richmond, VA
3-Year Rolling Averages:
Beryllium (PM$_{10}$)

Richmond, VA
3-Year Rolling Averages:
1,3-Butadiene

Figure 4. Richmond, VA - 3-Year Rolling Average Concentrations

Richmond, VA
3-Year Rolling Averages:
Cadmium (PM$_{10}$)

Richmond, VA
3-Year Rolling Averages:
Carbon Tetrachloride

Figure 4. Richmond, VA - 3-Year Rolling Average Concentrations

Richmond, VA
3-Year Rolling Averages:
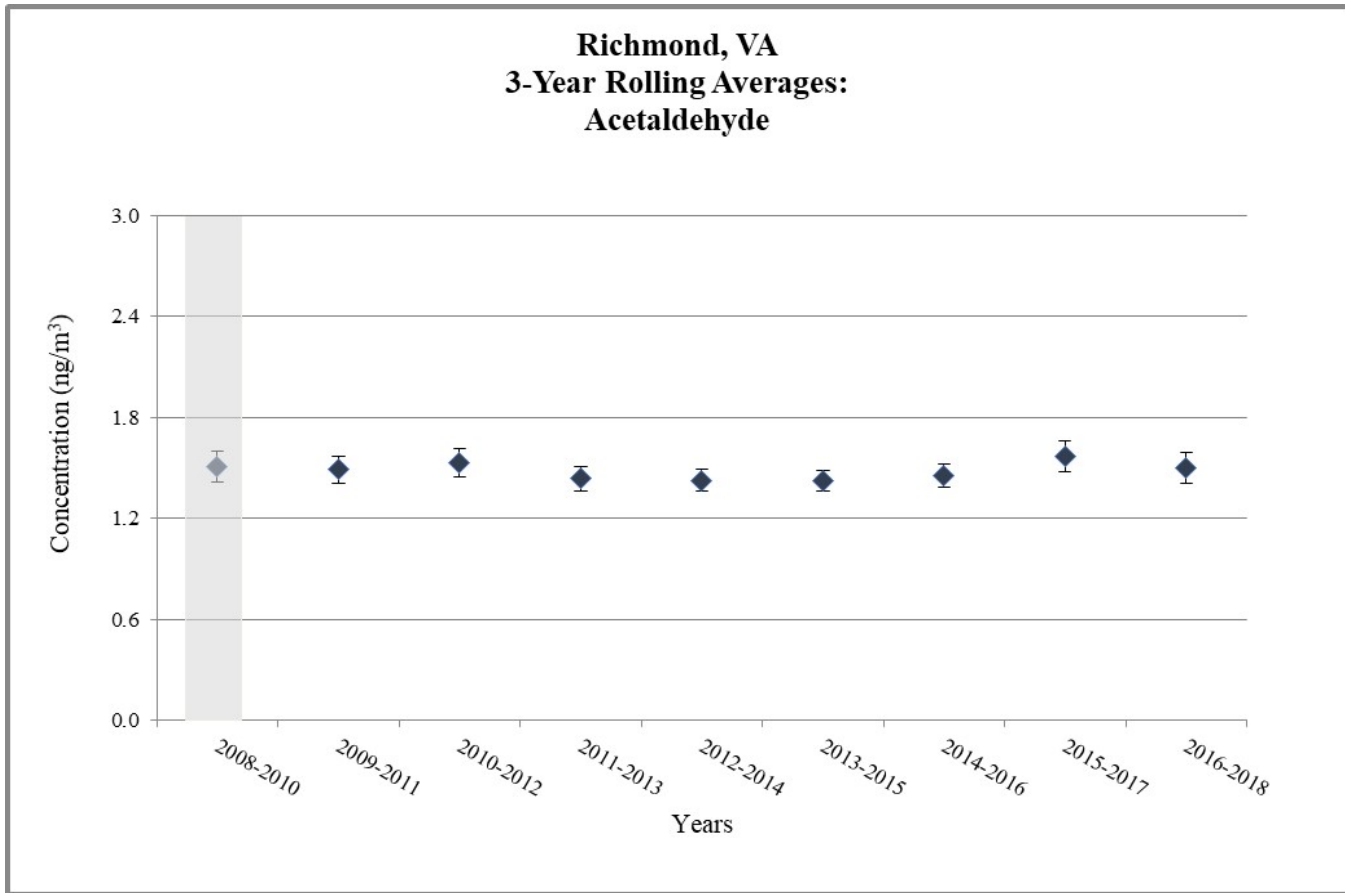Chloroform

Richmond, VA
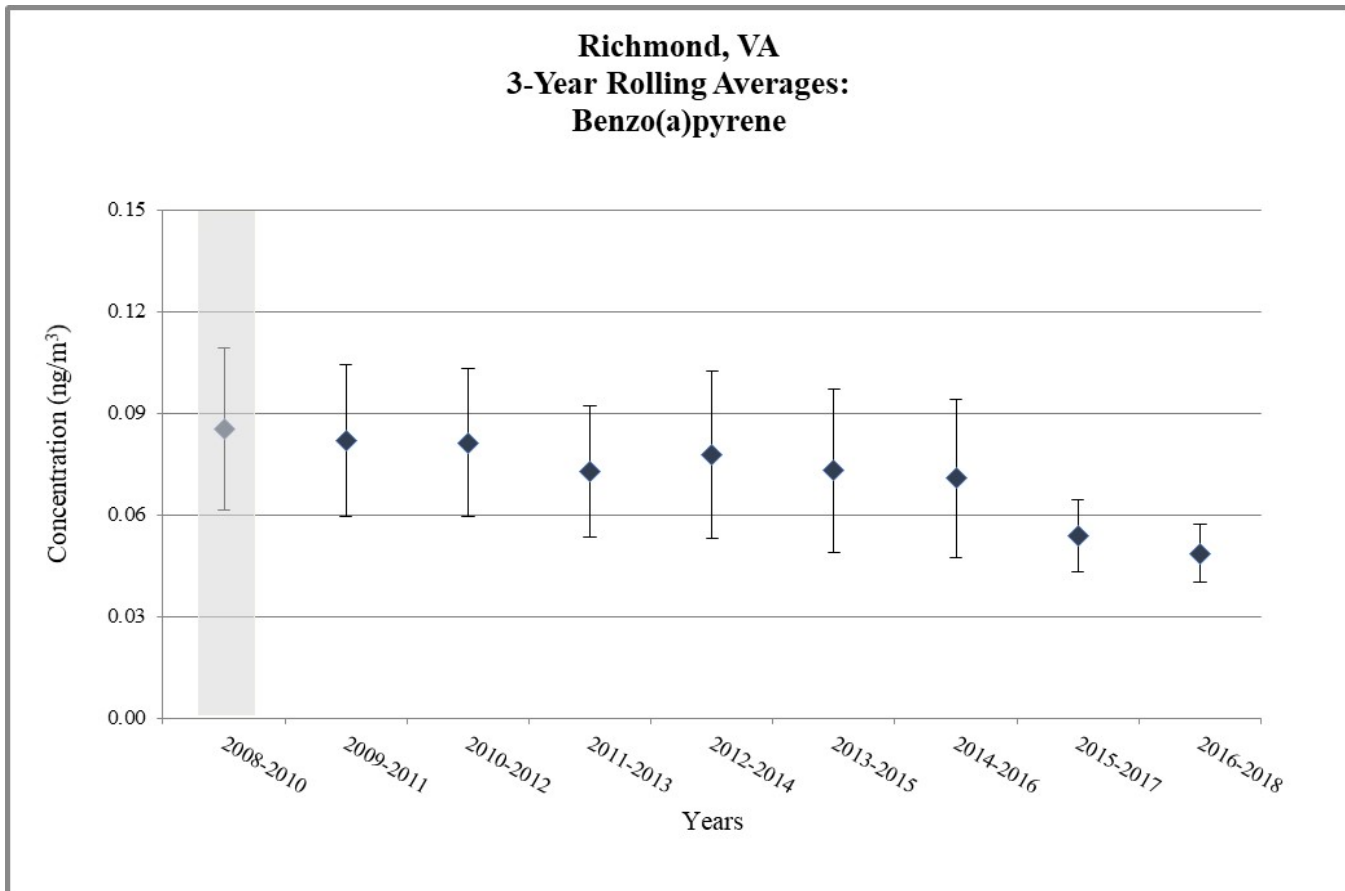3-Year Rolling Averages:
Formaldehyde

Figure 4. Richmond, VA - 3-Year Rolling Average Concentrations

Richmond, VA
3-Year Rolling Averages:
Hexavalent Chromium

Richmond, VA
3-Year Rolling Averages:
Lead (PM₁₀)

Figure 4. Richmond, VA - 3-Year Rolling Average Concentrations

Richmond, VA
3-Year Rolling Averages:
Manganese (PM_{10})

Richmond, VA
3-Year Rolling Averages:
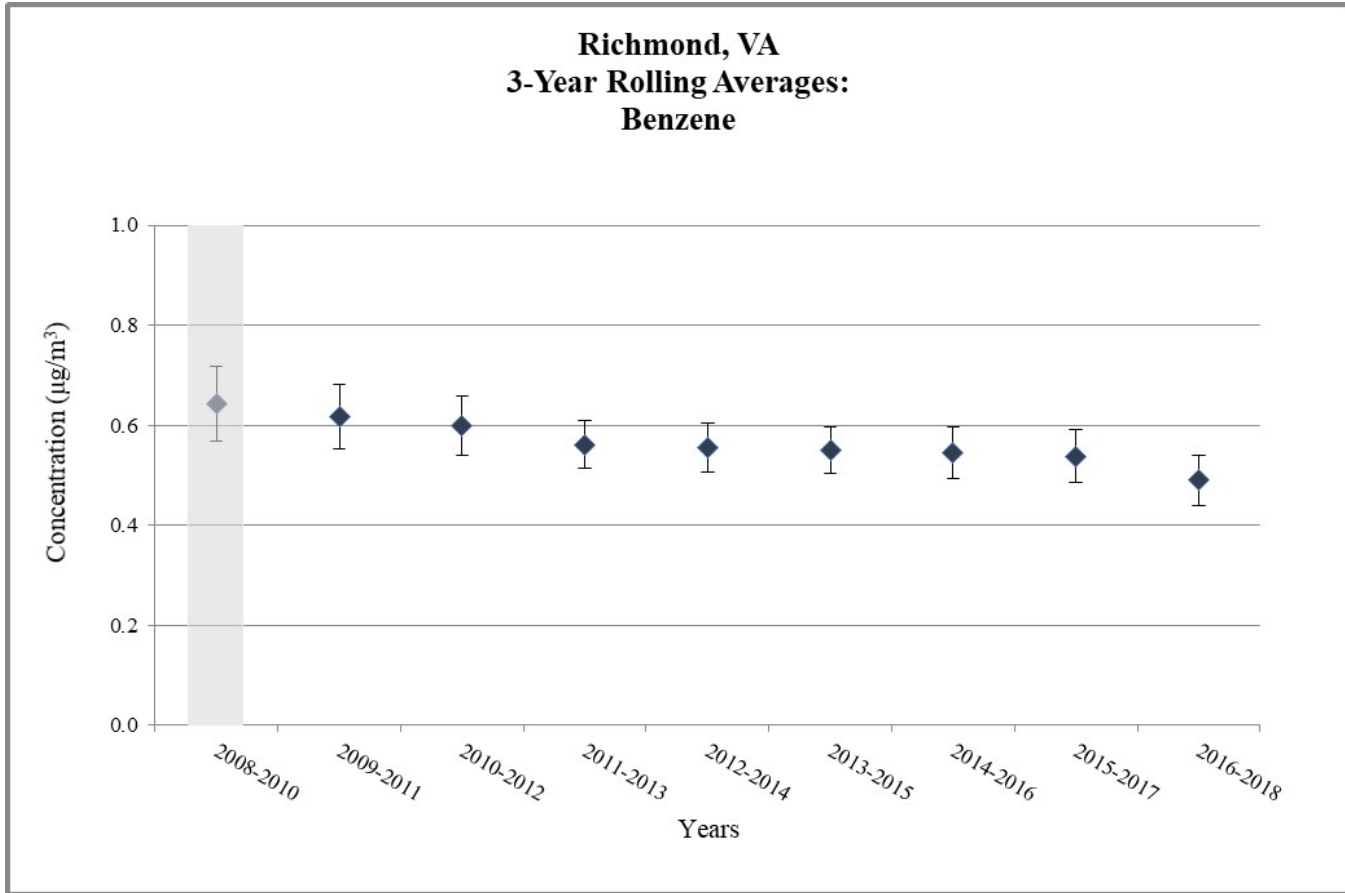Naphthalene

Figure 4. Richmond, VA - 3-Year Rolling Average Concentrations

Richmond, VA
3-Year Rolling Averages:
Nickel (PM₁₀)

Richmond, VA
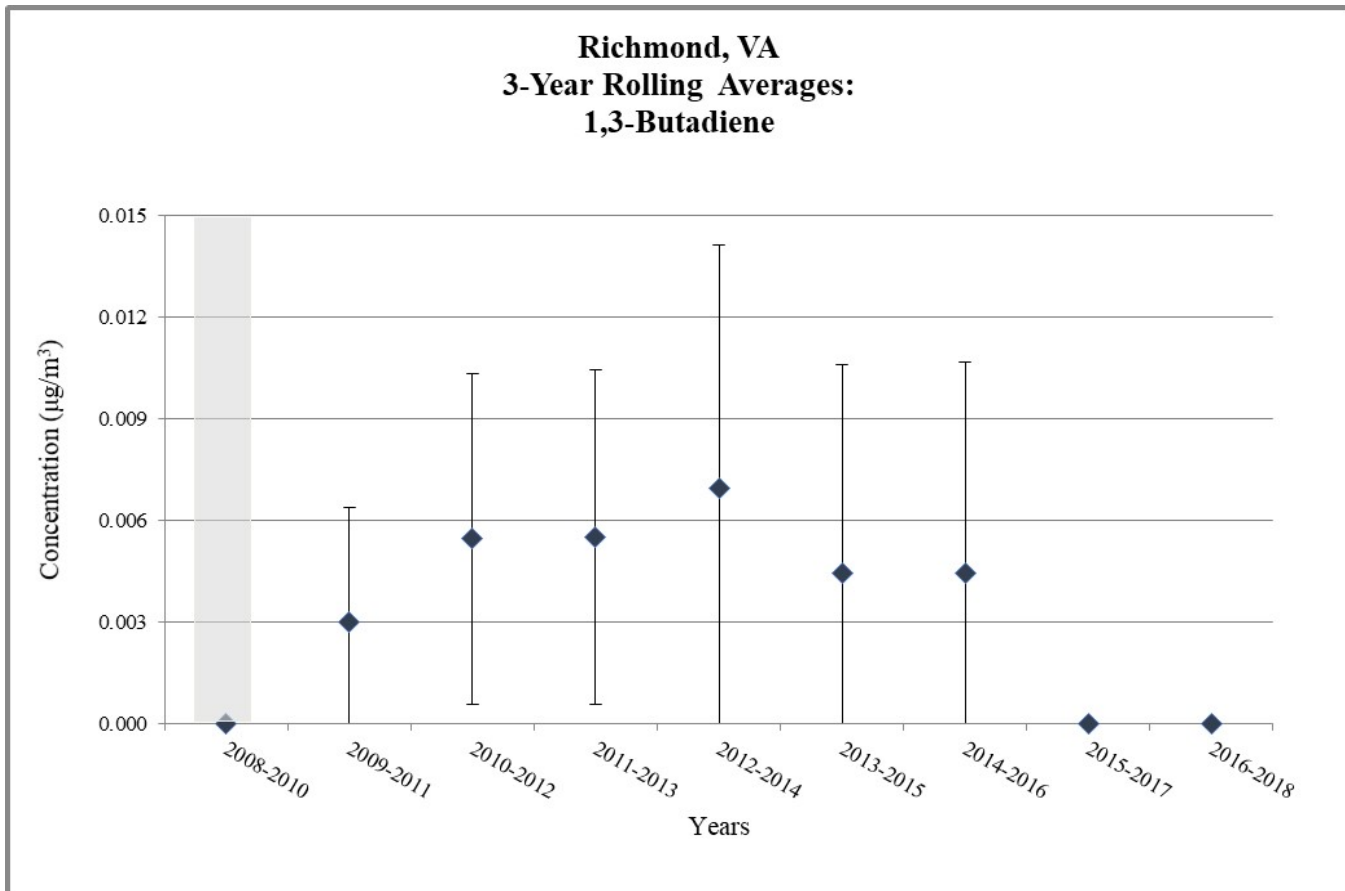3-Year Rolling Averages:
Tetrachloroethylene

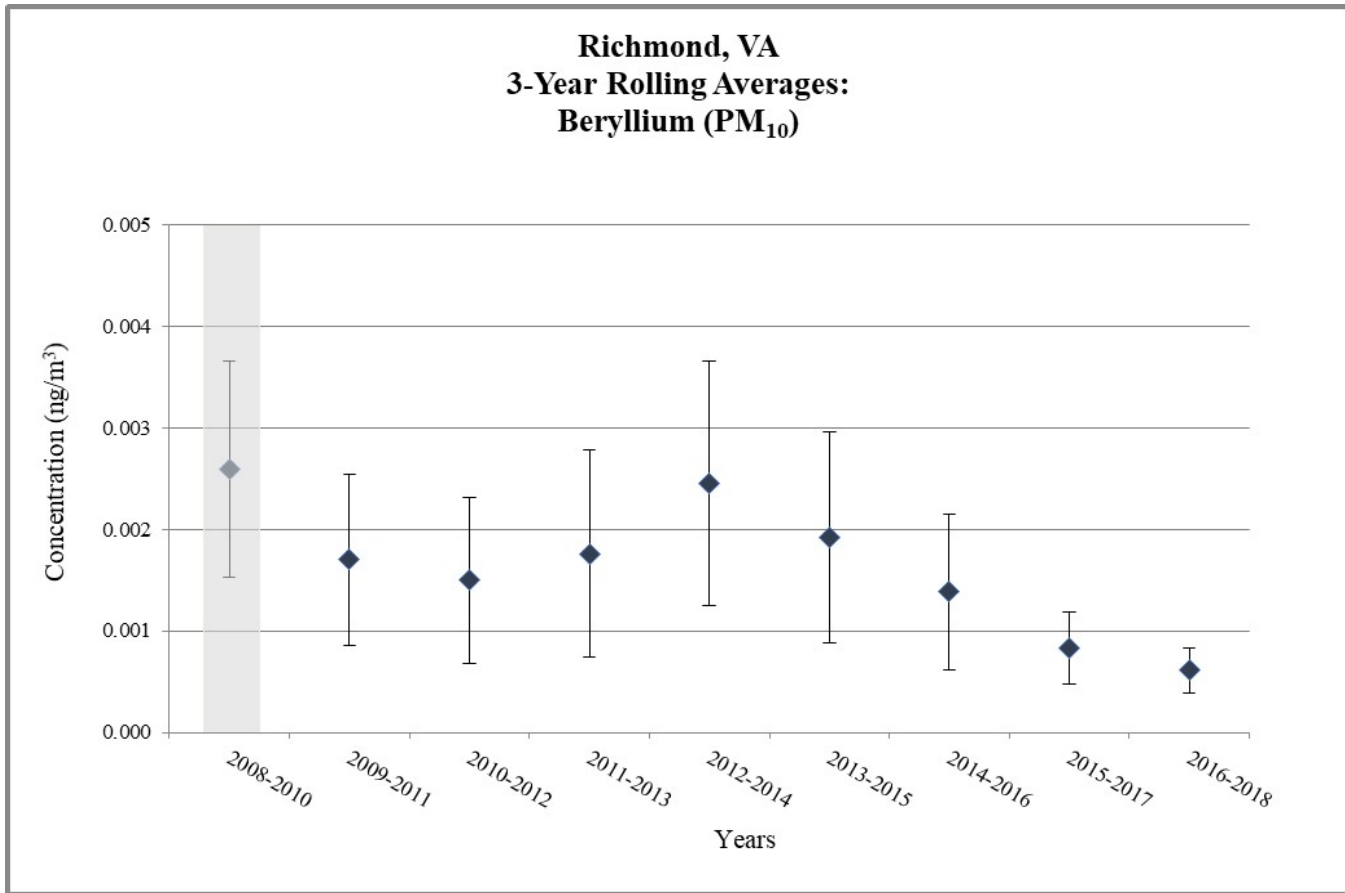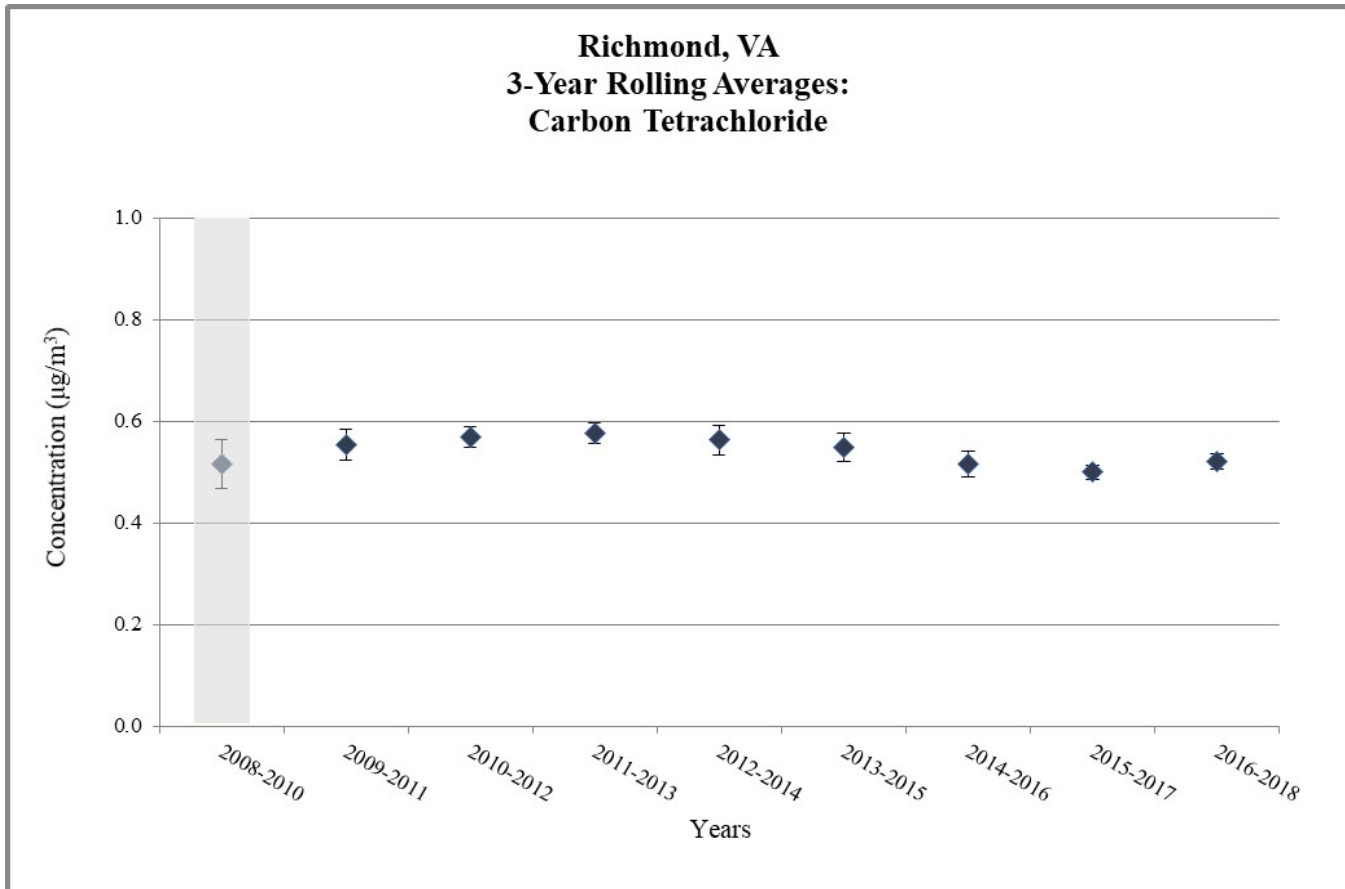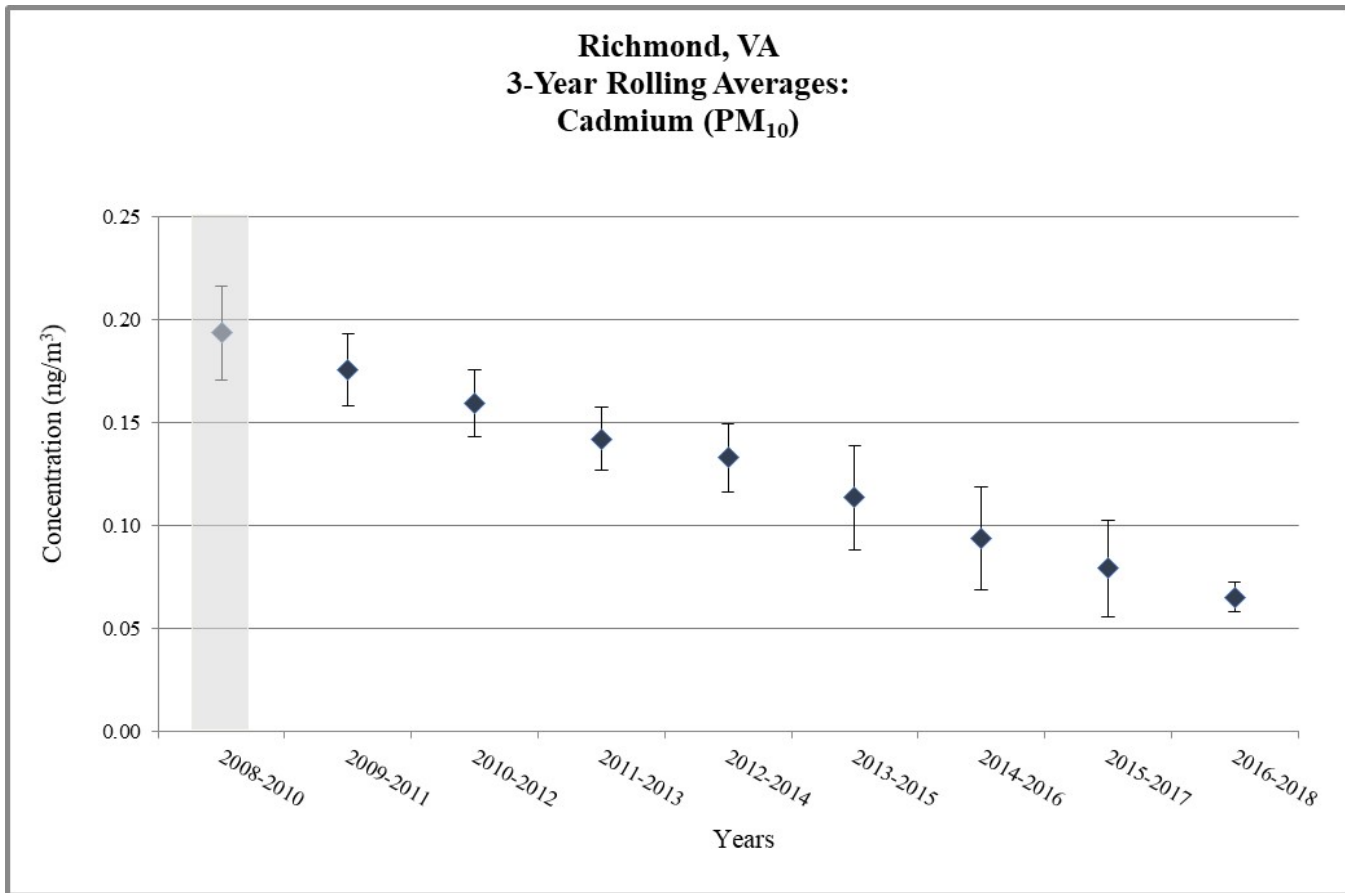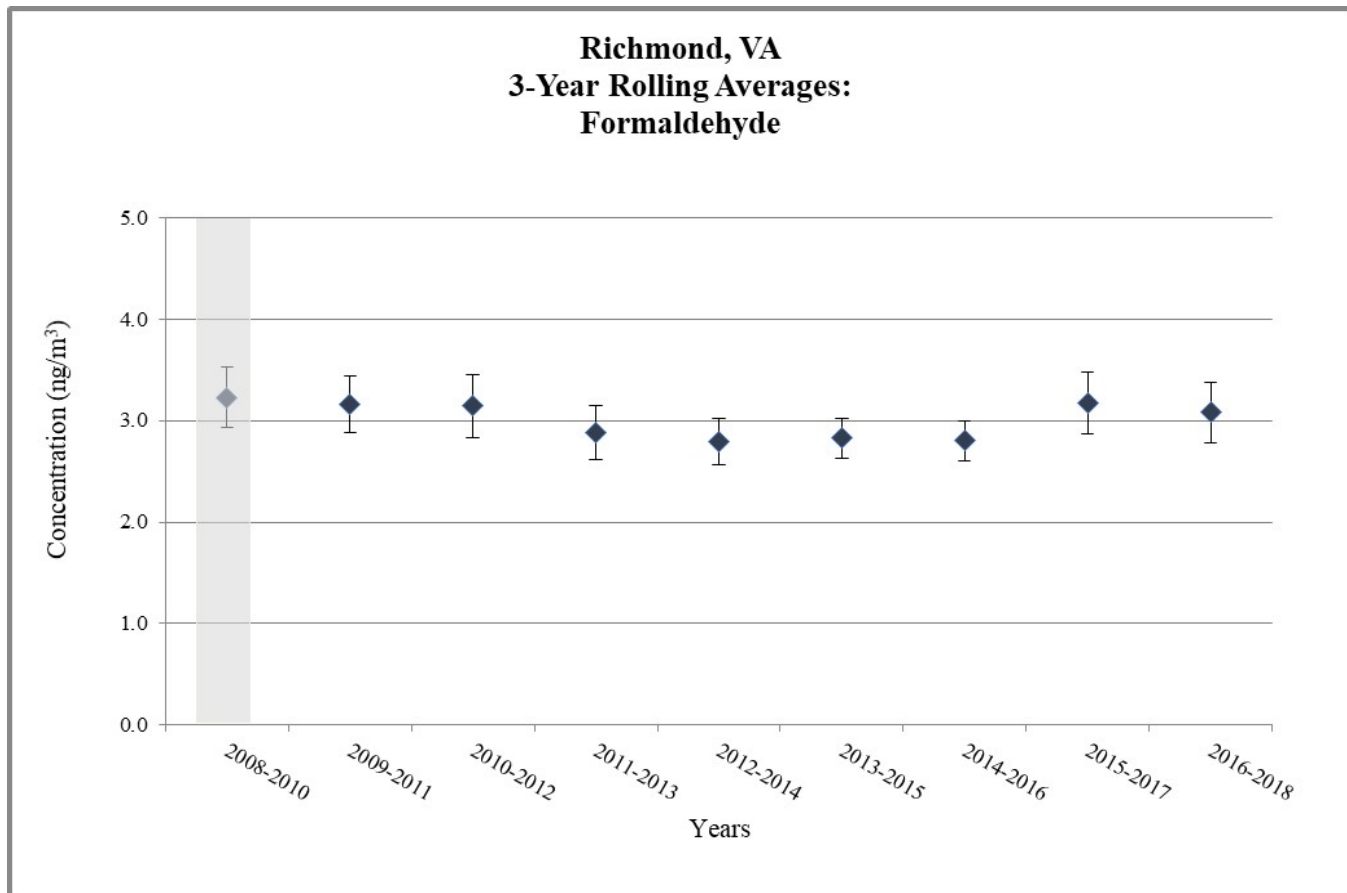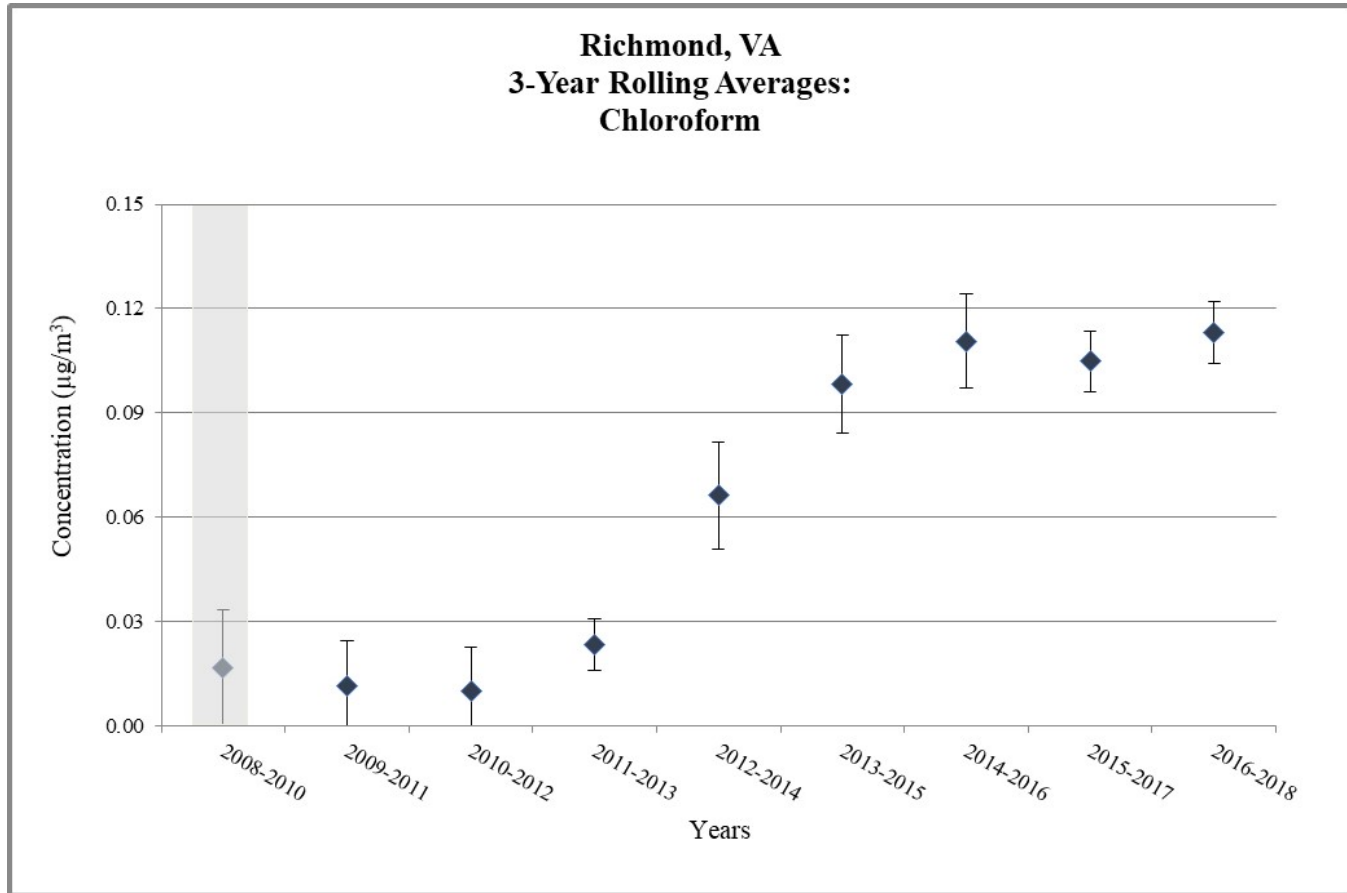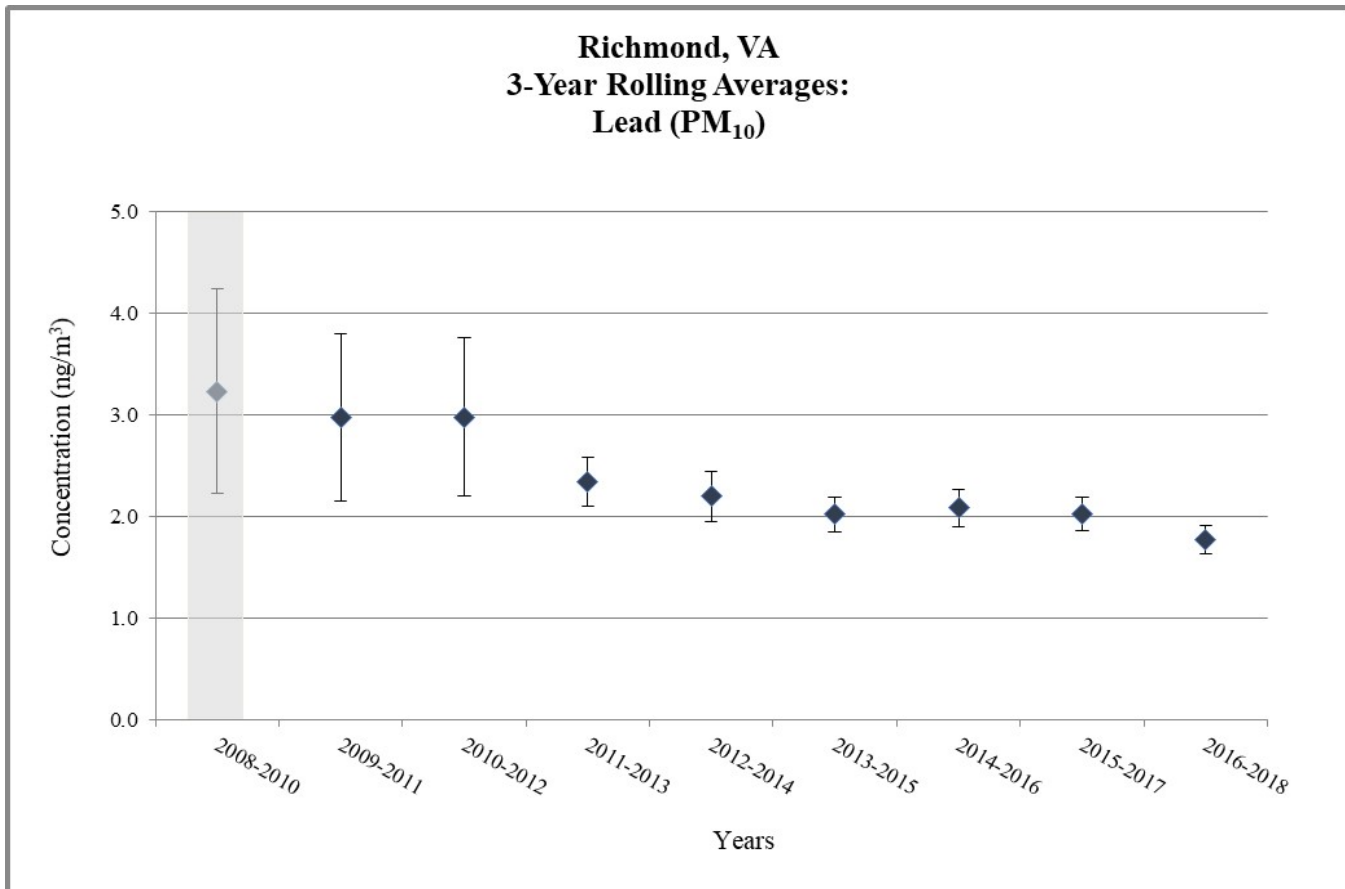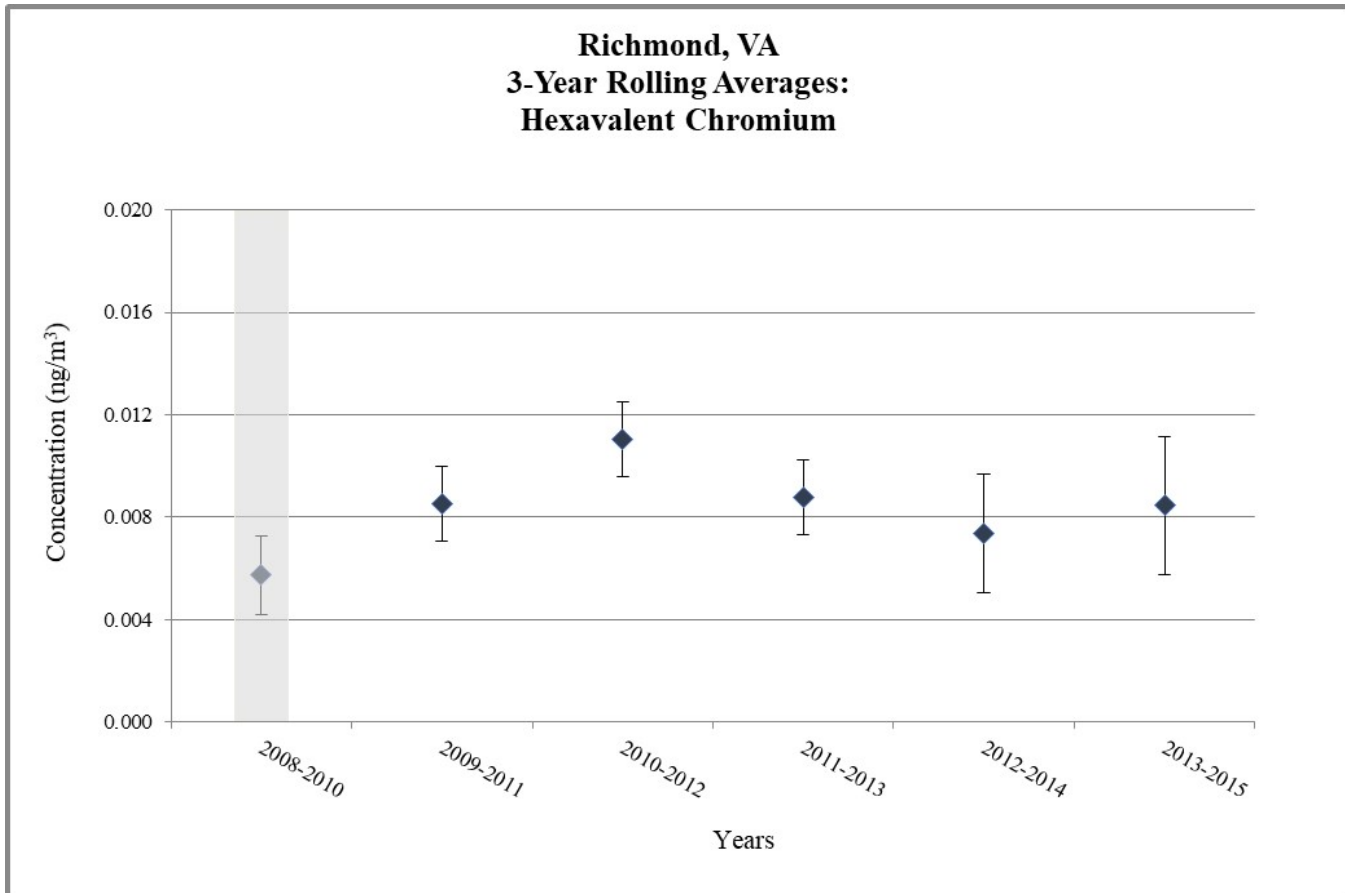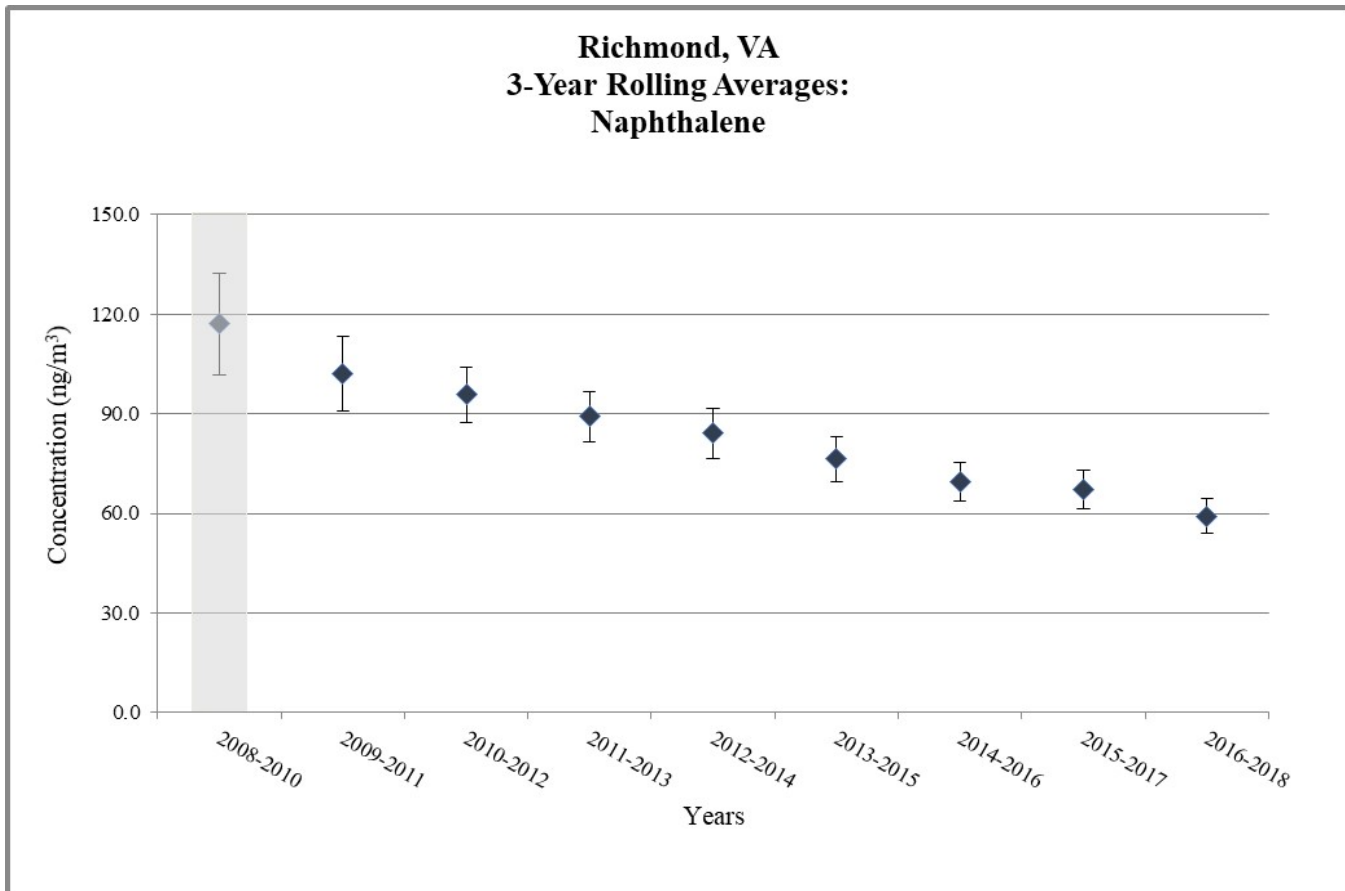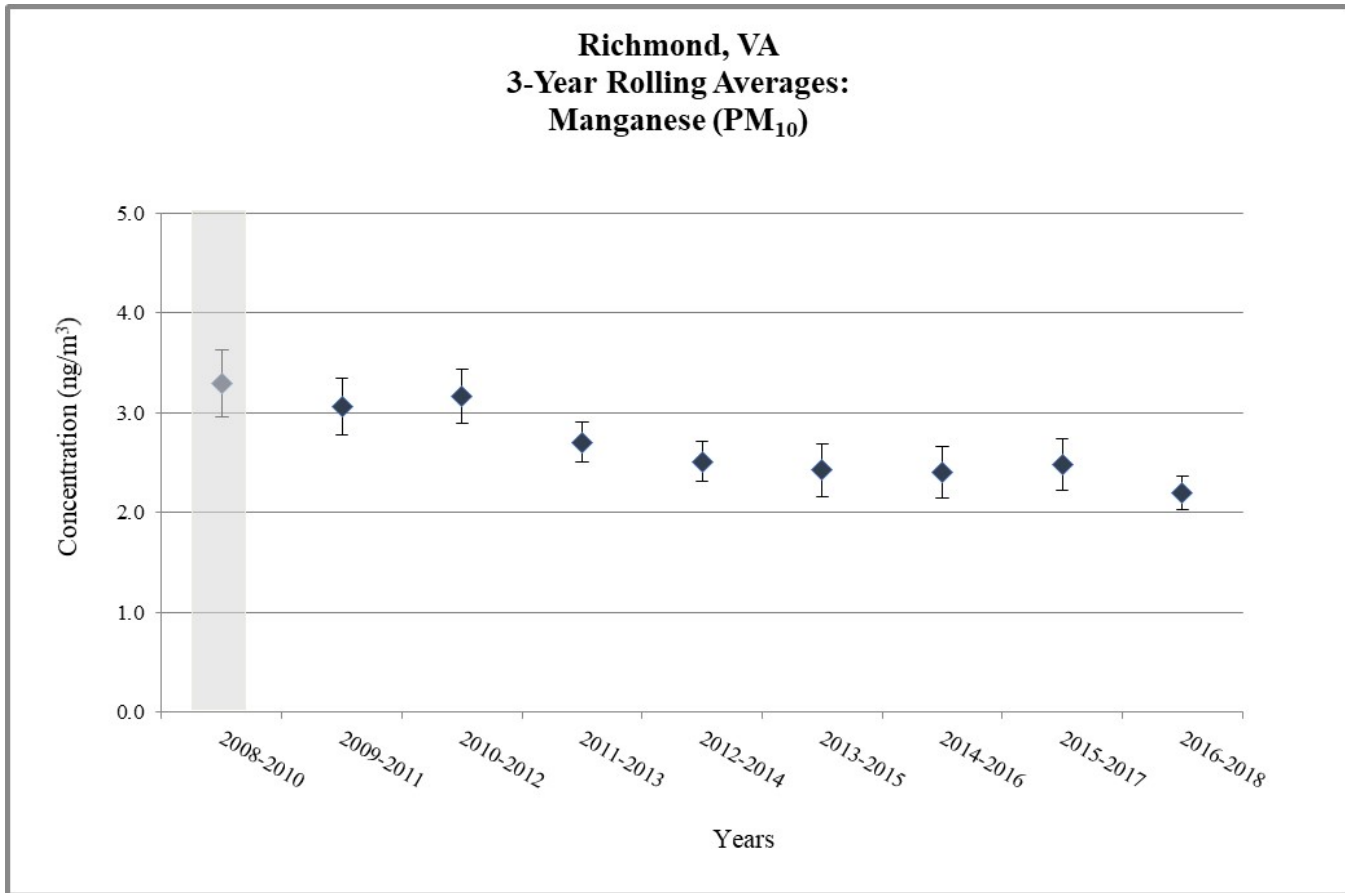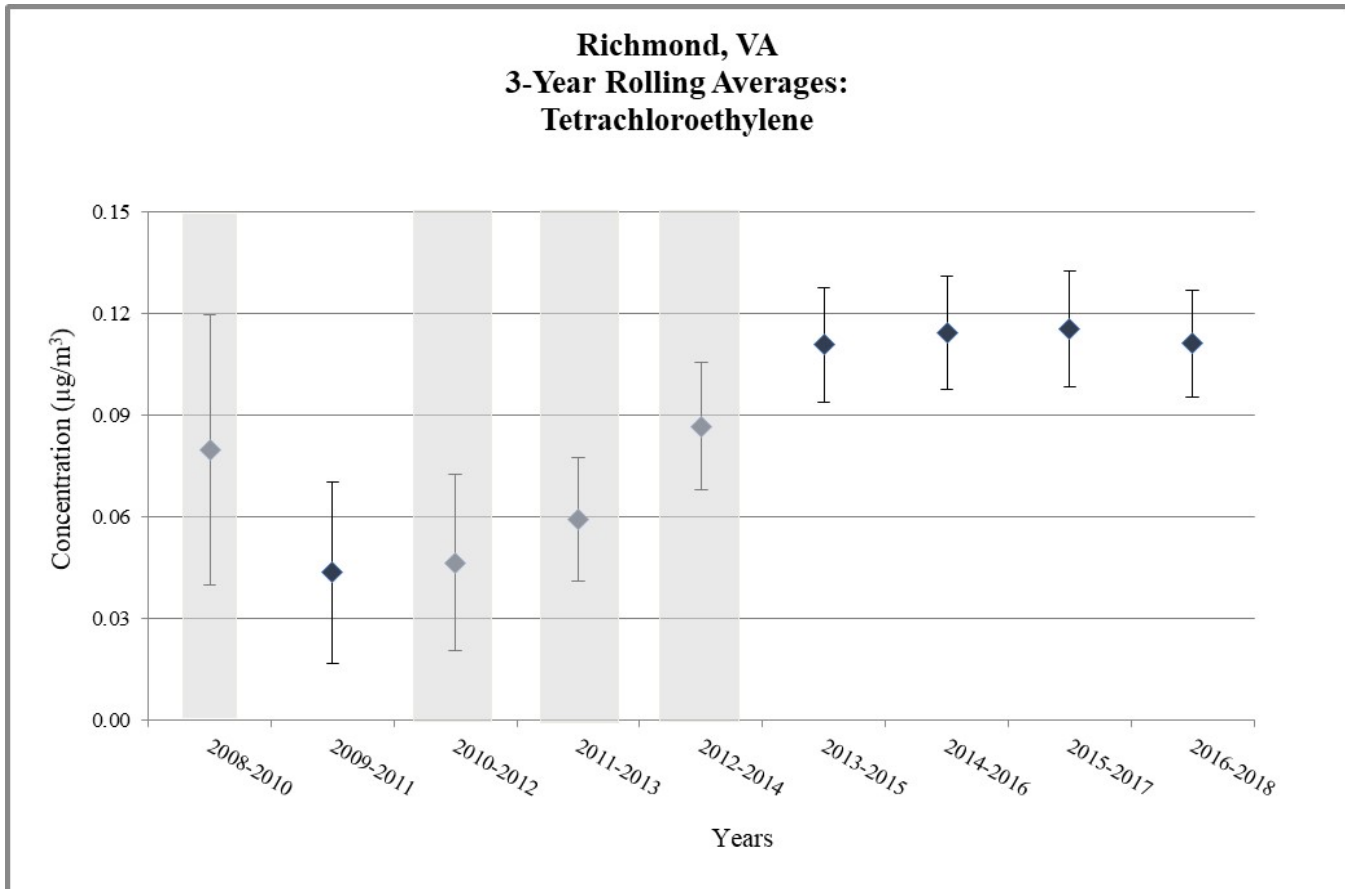**Figure 4. Richmond, VA - 3-Year Rolling Average Concentrations**

Richmond, VA
3-Year Rolling Averages:
Trichloroethylene

Richmond, VA
3-Year Rolling Averages:
Vinyl Chloride

Does not meet MQO or wasn't able to collect enough samples

Table 6. NATTS Network Assessment: MQO#1 - Completeness Percentage at Richmond, VA

Pollutant Group	Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Carbonyl	Acetaldehyde	--	100	100	98	100	100	98	100	98	98	98
Carbonyl	Formaldehyde	--	100	100	98	100	100	98	100	98	98	98
Chromium VI	Chromium VI	--	100	100	100	100	98	100	95	--	--	--
PAH	Benzo(a)pyrene	--	100	98	100	92	95	93	93	98	95	98
PAH	Naphthalene	--	100	98	100	92	95	93	93	98	95	98
PM$_{10}$ Metals	Arsenic (PM$_{10}$)	--	98	100	97	98	98	97	98	97	98	98
PM$_{10}$ Metals	Beryllium (PM$_{10}$)	--	98	100	97	98	98	97	98	97	93	98
PM$_{10}$ Metals	Cadmium (PM$_{10}$)	--	98	100	97	98	98	97	98	97	98	98
PM$_{10}$ Metals	Lead (PM$_{10}$)	--	98	100	97	98	98	97	98	97	98	98
PM$_{10}$ Metals	Manganese (PM$_{10}$)	--	98	100	97	98	98	97	98	97	98	98
PM$_{10}$ Metals	Nickel (PM$_{10}$)	--	98	100	97	98	98	97	98	97	98	98
VOC	Benzene	--	98	100	100	95	97	98	100	95	95	89
VOC	Butadiene, 1,3-	--	98	100	100	95	97	98	100	95	95	89
VOC	Carbon tetrachloride	--	98	100	100	95	97	98	100	95	95	89
VOC	Chloroform	--	98	100	100	95	97	98	100	95	95	89
VOC	Tetrachloroethylene	--	98	100	100	95	97	98	100	95	95	89
VOC	Trichloroethylene	--	98	100	100	95	97	98	100	95	95	89
VOC	Vinyl chloride	--	98	100	100	95	97	98	100	95	95	89

	A-rated: ≥85%
	B-rated: Between 75% to 85%
	Does not meet: ≤75%
--	No data available

Table 7. NATTS Network Assessment: MQO#2 - Reported Method Detection Limits (MDLs) at Richmond, VA

Pollutant Group	Pollutant Name	Target MDL	Units	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Carbonyl	Acetaldehyde	0.45	$\mu g/m^3$	0.23	0.08	0.14	0.14	0.17	0.080	0.04	0.04	0.06	0.06	0.19
Carbonyl	Formaldehyde	0.98/0.08[a]	$\mu g/m^3$	0.064	0.055	0.079	0.079	0.041	0.28	0.28	0.60	0.28	0.28	0.70
Chromium VI	Chromium VI	0.08	ng/m^3	0.08	0.05	0.01	0.05	0.04	0.05	0.05	0.05	0.05	--	--
PAH	Benzo(a)pyrene	0.91	ng/m^3	0.11	0.08	0.06	0.06	0.08	0.08	0.05	0.22	0.10	0.04	0.02
PAH	Naphthalene	29.00	ng/m^3	0.022	0.010	0.01	0.01	0.01	0.01	0.02	0.01	0.04	0.11	0.09
PM$_{10}$ Metals	Arsenic (PM$_{10}$)	0.23	ng/m^3	0.40	0.10	0.12	0.08	0.08	0.08	0.08	0.08	0.08	0.31	0.19
PM$_{10}$ Metals	Beryllium (PM$_{10}$)	0.42	ng/m^3	0.02	0.01	0.02	0.02	0.02	0.02	0.04	0.02	0.021	0.021	0.021
PM$_{10}$ Metals	Cadmium (PM$_{10}$)	0.56	ng/m^3	0.16	0.01	0.02	0.02	0.03	0.03	0.03	0.03	0.02	0.02	0.05
PM$_{10}$ Metals	Lead (PM$_{10}$)	15.0	ng/m^3	0.006	0.001	0.001	0.003	0.002	0.002	0.002	0.001	0.001	0.003	0.005
PM$_{10}$ Metals	Manganese (PM$_{10}$)	5.0	ng/m^3	0.018	0.006	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.018	0.035
PM$_{10}$ Metals	Nickel (PM$_{10}$)	2.1	ng/m^3	0.09	0.09	0.10	0.04	0.04	0.04	0.10	0.04	0.04	0.13	0.17
VOC	Benzene	0.13	$\mu g/m^3$	0.76	1.33	0.69	0.61	1.03	0.39	0.39	0.76	0.61	0.61	0.42
VOC	Butadiene, 1,3-	0.10	$\mu g/m^3$	1.06	0.69	1.95	1.08	1.48	1.13	0.77	0.77	0.40	0.40	0.40
VOC	Carbon tetrachloride	0.17	$\mu g/m^3$	0.81	1.15	1.63	1.11	1.11	1.15	1.15	1.59	1.04	1.04	1.04
VOC	Chloroform	0.50	$\mu g/m^3$	0.23	0.35	0.49	0.37	0.29	0.36	0.34	0.34	0.21	0.21	0.21
VOC	Tetrachloroethylene	0.17	$\mu g/m^3$	1.92	1.36	1.24	1.12	2.51	1.20	1.60	1.60	0.88	0.88	0.88
VOC	Trichloroethylene	0.5/0.2[a]	$\mu g/m^3$	0.41	0.28	0.66	0.18	0.72	1.42	0.94	0.94	0.94	1.02	0.97
VOC	Vinyl chloride	0.11	$\mu g/m^3$	0.95	0.79	1.25	1.23	1.56	1.09	0.81	0.81	0.28	0.28	0.28

(green)	A-rated: MDL to Target MDL ratio ≤ 1
(yellow)	B-rated" MDL to Target MDL ratio between 1 and 2
(red)	Does Not Meet MDL to Target MDL ratio>2
--	No data available

[a]: For the 2012 sampling year, the Target MDL for this pollutant was reduced.

Table 8. NATTS Network Assessment: MQO#3 - Bias Percent Difference at Richmond, VA

Pollutant Group	Pollutant Name	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Carbonyls	Acetaldehyde	a	-11.0	1.6	-3.7	a	-5.5	-3.9	a	-4.3	2.7	-10.6
Carbonyls	Formaldehyde	a	-6.5	2.4	-0.8	a	3.2	0.1	a	-17.5	1.8	-9.3
Chromium VI	Chromium VI	a	5.6[b]	10.5[b]	a	19.5	-6.5	6.1	--	--	--	--
PAH	Benzo(a)pyrene	a	-1.7	-2.3	-2.1	25.2	-5.7	-16.3	-14.2	-10.5	-22.4	-14.8
PAH	Naphthalene	a	-7.7	-17.1	-13.9	21.4	25.5	0.7	-11.4	-9.5	-11.6	-20.7
PM$_{10}$ Metals	Arsenic (PM$_{10}$)	15.6	22.3	-8.0	-6.8	12.9	-3.1	0	a	-1.2	-2.0	-5.3
PM$_{10}$ Metals	Beryllium (PM$_{10}$)	-1.7	29.1	-9.4	-8.2	14.3	2.1	c	a	-3.0	-3.7	-3.5
PM$_{10}$ Metals	Cadmium (PM$_{10}$)	6.7	17.1	-15.1	-11.5	8.3	-4.8	c	a	-0.4	-4.7	-1.3
PM$_{10}$ Metals	Lead (PM$_{10}$)	5.1	77.5	-21.6	-7.5	10.2	-3.4	11.9	a	-1.5	-5.8	-0.7
PM$_{10}$ Metals	Manganese (PM$_{10}$)	-20.1	-7.8	-17.8	-6.5	8.9	-9.5	7.4	a	-0.3	-3.1	0.6
PM$_{10}$ Metals	Nickel (PM$_{10}$)	5.0	11.1	-6.1	-8.9	-0.3	4.7	d	a	29.4	15.8	12.6
VOC	Benzene	a	-21.2	-13.2	23.8	a	-3.4	11.1	-3.5	-11.6	0.9	-4.3
VOC	Butadiene, 1,3-	a	-16.6	6.1	17.9	a	18.9	3.8	-8.5	4.4	1.1	11.5
VOC	Carbon tetrachloride	a	-17.6	9.2	3.1	a	4.5	4.4	8.8	16.3	11.2	-7.6
VOC	Chloroform	a	-29.0	-9.3	-5.5	a	-0.6	-2.2	-0.7	-7.0	3.6	3.6
VOC	Tetrachloroethylene	a	-6.5	-6.5	14.7	a	30.1	15.7	-10.7	1.4	-5.7	-0.7
VOC	Trichloroethylene	a	-9.4	-1.8	6.7	a	26.1	13.4	-9.2	6.3	-7.6	-1.5
VOC	Vinyl chloride	a	-20.6	-5.9	18.0	a	8.8	18.0	-16.4	-1.4	3.6	4.0

(green)	A-rated:±25%
(yellow)	B-rated: Between 25% to 35% or between -25% to -35%
(red)	Does not meet:>35% or <35%
--	No data available

[a]: No Proficiency Test samples were sent for this pollutant and year.

[b]: Proficiency Test results are from the National Contract Lab for EPA's School Air Toxics Monitoring Program. The %Difference was -5.55% in 2009 and 10.53% in 2010.

[c]: The Proficiency Test sample for this pollutant was 0; the site reported a concentration as "< MDL", rather than 0. EPA accepted this result.

[d]: Although a Proficiency Test sample was sent to the lab supporting this site and year, the results were nullified by EPA due to QA issues.

Table 9. NATTS Network Assessment: MQO#4 - Overall Method Precision %CV at Richmond, VA

Pollutant Group	Pollutant Name	Overall Method precision % CV										
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Carbonyls	Acetaldehyde	32.8	2.9	--	2.6	2.4	3.0	1.9	6.7	2.4	1.7	2.2
Carbonyls	Formaldehyde	56.5	1.9	--	2.5	3.9	2.9	2.4	7.9	3.4	2.7	2.8
Chromium VI	Chromium VI	a	6.7	7.8	11.5	13.9	35.5	6.1	6.5	19.7	--	--
PAH	Benzo(a)pyrene	--	--	--	--	--	--	--	--	--	--	--
PAH	Naphthalene	--	--	--	--	--	--	--	--	--	--	--
PM$_{10}$ Metals	Arsenic (PM$_{10}$)	--	--	--	--	--	--	--	--	--	--	--
PM$_{10}$ Metals	Beryllium (PM$_{10}$)	--	--	--	--	--	--	--	--	--	--	--
PM$_{10}$ Metals	Cadmium (PM$_{10}$)	--	--	--	--	--	--	--	--	--	--	--
PM$_{10}$ Metals	Lead (PM$_{10}$)	--	--	--	--	--	--	--	--	--	--	--
PM$_{10}$ Metals	Manganese (PM$_{10}$)	--	--	--	--	--	--	--	--	--	--	--
PM$_{10}$ Metals	Nickel (PM$_{10}$)	--	--	--	--	--	--	--	--	--	--	--
VOC	Benzene	7.2	9.3	17.4	8.1	7.1	13.6	7.0	5.1	32.8	--	--
VOC	Butadiene, 1,3-	a	a	a	a	10.9	a	12.9	a	a	--	--
VOC	Carbon tetrachloride	9.2	10.1	15.8	5.8	5.6	6.5	15.0	6.5	6.6	--	--
VOC	Chloroform	a	a	a	a	a	a	a	a	11.7	--	--
VOC	Tetrachloroethylene	9.9	9.4	a	10.9	0.0	a	0	37.2	8.7	--	--
VOC	Trichloroethylene	a	a	a	a	a	a	a	a	a	--	--
VOC	Vinyl chloride	a	a	a	a	a	a	a	a	a	--	--

(green)	A-rated:≤ 15% CV
(yellow)	B-rated: Between 15%CV to25% CV
(red)	Does Not Meet: >25% CV or did not report Precision (required in the NATTS Workplan Template since 2012)
--	No data available

[a]: Although both primary and secondary data were reported, both sets of values were less than the MDL. Thus no %CV was calculated.

Table 10. NATTS Network Assessment: MQO#4 - Analytical Precision %CV at Richmond, VA

Pollutant Group	Pollutant Name	Analytical Method precision % CV										
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Carbonyls	Acetaldehyde	--	--	--	2.1	2.4	1.3	0.6	0.6	0.6	0.7	1.0
Carbonyls	Formaldehyde	--	--	--	2.1	0.8	1.3	0.4	0.4	0.4	0.8	0.5
Chromium VI	Chromium VI	--	2.9	5.1	7.2	7.8	9.3	18.2	4.6	13.3	--	--
PAH	Benzo(a)pyrene	--	--	--	--	10.1	a	2.4	a	a	0.5	1.2
PAH	Naphthalene	--	--	--	--	0.5	1.3	14.7	0.7	3.3	3.2	1.1
PM$_{10}$ Metals	Arsenic (PM$_{10}$)	--	--	--	--	b	2.6	7.0	3.0	5.8	4.9	2.4
PM$_{10}$ Metals	Beryllium (PM$_{10}$)	--	--	--	--	b	a	a	a	a	a	a
PM$_{10}$ Metals	Cadmium (PM$_{10}$)	--	--	--	--	b	36.9	40.9	10.3	38.0	17.3	22.3
PM$_{10}$ Metals	Lead (PM$_{10}$)	--	--	--	--	b	9.0	10.9	7.7	10.7	3.3	5.5
PM$_{10}$ Metals	Manganese (PM$_{10}$)	--	--	--	--	b	3.3	3.0	2.8	2.4	2.1	1.9
PM$_{10}$ Metals	Nickel (PM$_{10}$)	--	--	--	--	b	12.6	18.0	3.4	9.8	12.1	6.7
VOC	Benzene	--	--	--	--	b	7.6	4.6	3.7	4.7	8.0	3.0
VOC	Butadiene, 1,3-	--	--	--	--	b	b	a	a	a	b	b
VOC	Carbon tetrachloride	--	--	--	--	b	6.7	31.4	7.1	7.6	4.2	6.4
VOC	Chloroform	--	--	--	--	b	a	a	0	10.1	0	0
VOC	Tetrachloroethylene	--	--	--	--	b	a	a	1.2	0	a	0
VOC	Trichloroethylene	--	--	--	--	b	b	0	6.4	0	b	a
VOC	Vinyl chloride	--	--	--	--	b	b	a	a	a	b	b

	A-rated:≤ 15% CV
	B-rated: Between 15%CV to25% CV
	Does Not Meet: >25% CV or did not report Precision (required in the NATTS Workplan Template since 2012)
--	No data available

[a]: The primary and/or replicate value were less than the MDL, so no calculation could be made.

[b]: Per the NATTS Workplan template, analytical replicates were required to be reported to AQS for this sampling year

Appendix A. Equipment Inventory

Pollutant Type	Year(s)	Manufacturer/Model, Extraction Type, and Year
		Sampling Equipment
Carbonyls	2008-2014	ATEC 8000 Cartridge Sampler (Year Deployed: 1999)
	2015-2018	ATEC 8000 Cartridge Sampler (Year Deployed: 2014
Chormium VI	2008-2008	PM10 Sequential Air Sampler (Year Deployed: 2008)
	2009-2016	ERG Chromium VI sampler (Year Deployed: 2008)
PAHs	2008-2018	Tisch Environmental PUF+ Sampler (Year Deployed: 2008)
PM_{10} Metals	2008	Wedding RFPS-1087-066 Hi-Vol Sampler (Year Deployed: <1988)
	2009-2018	Wedding RFPS-1087-066 Hi-Vol Sampler (Year Deployed: 2009)
VOCs	2008-2014	Xontech 910PC Canister Sampler (Year Deployed: <1988)
	2015-2017	Xontech 910PC Canister Sampler (Year Deployed: 2015)
	2018	Xontech 901 (Year Deployed: 2018)
		Analytical Equipment
Carbonyls	2008-2011	Dionex ASI-100 HPLC, UVD-170U multiple wavelength detector (Year Deployed: <2000)
	2012-2014	Agilent 1260 Infinity HPLC with DAD (Year Deployed: 2012)
	2015-2018	Agilent 1260 Infinity/variable wavelength absorbance detector (Year Deployed: 2012)
Chormium VI	2008-2016	Dionex 300 ion chromatography system (Year Deployed: 2001)
PAHs	2008-2013	HP/Agilent 5890/5971 GC/MS (Year Deployed: 2008)
	2014-2018	HP/Agilent 7890B/5975C GC/MS (Year Deployed: 2014)
PM_{10} Metals	2008-2018	HP/Agilent 7500ce ICP-MS (Year Deployed: 2006)
VOCs	2008-2014	HP/Agilent 6890N/5973 GC/MS (Year Deployed: <2002)
	2015-2018	HP/Agilent 6890N/5973 GC/MS (Year Deployed: 2004)
		Preconcentrator Equipment
VOCs	2008-2011	Entech 7100A (Year Deployed: <2002)
	2012-2018	Entech 7200 (Year Deployed: 2012)
		Standards Preparation Equipment
VOCs	2008-2018	Entech 4600A (dynamic dilution) (Year Deployed: 2004)
		Canister Cleaning Equipment
VOCs	2008-2011	Entech 3100A (Hot) (Year Deployed: 2006)
	2012-2017	Entech 3100 (Hot) (Year Deployed: 2012)
	2018	Entech 3100-D (Hot) (Year Deployed: 2018)
		PM_{10} Extraction Equipment
PM_{10} Metals	2008	Thermolyne 2200 (hotblock) (Year Deployed: unknown)
	2009-2009	Environmental Express SC182 (Hotblock) (Year Deployed: 2009)
	2010-2018	Environmental Express SC182 (Hotblock) (Year Deployed: 2010)
		Chromium VI Extraction Equipment
Chormium VI	2008-2010	Branson 8510 (Sonicator) (Year Deployed: 2001)
	2011-2016	Branson Shaker (Year Deployed: 2011)
		PAHs Extraction Equipment
PAHs	2008-2018	Dionex -300 (ASE) (Year Deployed: 2004)