MARYLAND

DEPARTMENT OF THE ENVIRONMENT

MARYLAND 5-YEAR NETWORK ASSESSMENT

Prepared for:
U.S. Environmental Protection Agency

Prepared by:
Ambient Air Monitoring Program
Air and Radiation Administration Management
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EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA) amended the ambient air monitoring regulations, 40 CFR 58.10(e), and finalized them on October 17, 2006. These amendments require state, or where applicable local, monitoring agencies to conduct a network assessment once every five years. The first network assessment is due to the Regional Administrator by July, 2010. The goals of this network assessment are as follows:

- Determine if the network meets the monitoring objectives of 40CFR58 Appendix D.
- Determine whether new sites are needed.
- Determine whether existing sites are no longer needed and can be terminated.
- Determine whether new technologies are appropriate for incorporation into the ambient air monitoring network.
- Consider the ability of existing and proposed sites to support air quality characterization for areas with relatively high populations of susceptible individuals (e.g., children with asthma).
- For any sites that are being proposed for discontinuance, determine the effect on data users other than the agency itself, such as nearby States and Tribes or health effects studies.
- Identify needed changes to $PM_{2.5}$ population-oriented sites.

After reviewing the network assessment that was completed to satisfy the requirements set forth by the EPA, the program came to several conclusions and recommendations which are the following:

- The minimum number of sites for all parameters is either met or exceeded.
- No ozone, SO_2, CO, PM_{10} or PAMS sites were found to be redundant.
- 2010 census results will be used to make decisions about moving $PM_{2.5}$ monitors from the urban areas to those counties with increasing population densities (Frederick, Queen Anne's and Southern Maryland).
- Three $PM_{2.5}$ sites were found to be redundant and one or more of the following sites should be considered as candidates for removal: NE Police, Fire Dept. 20 and Bladensburg VFD.
- New SO_2 and NO_2 sites will be required based on new regulations. The program is currently investigating locations for these new sites.
- Some monitor site objectives and representative scales may need to be changed.

- $PM_{2.5}$ FEM monitors, now designated as special purpose monitors, will be redeployed to satisfy the continuous monitoring requirements.

- Based on coarse resolution county level data it was determined that the $PM_{2.5}$ and ozone networks are adequately serving the sensitive populations of Maryland with the possible exception of Baltimore County.

- Discontinue NO_y monitoring at the Aldino Type 3 PAMS site since this measurement is no longer required.

- Re-evaluate Beltsville's designation as a Type 3 PAMS site for the Washington NAA using Radar Wind Profiler data of aloft winds over HU-Beltsville on high ozone days.

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ACRONYMS AND DEFINITIONS

AADT	Annual Average Daily Traffic
AQS	Air Quality System.
CAMD	Clean Air Market Divisions
CBSA	Core Based Statistical Area
CFR	Code of Federal Regulations
CMAQ	Community Multi scale Air Quality modeling system
CSA	Combined Statistical Area
CO	Carbon Monoxide
DCDOE	District of Columbia Department of the Environment
VADEQ	Virginia Department of Environmental Quality
EGU	Electrical Generating Unit
FEM	Federal Equivalent Method typically used by local and state agency to measure particulate matter and determine NAAQS attainment status.
FIPS	Federal Information Processing Standards
FRM	Federal Reference Method typically used by local and state agency to measure particulate matter and determine NAAQS attainment status.
HAPS	Hazardous Air Pollutants
IMPROVE	Interagency Monitoring of PROtected Visual Environments
MDE	Maryland Department of the Environment
MSA	Metropolitan Statistical Area typically used by the EPA to study air quality trends in major metropolitan areas across the U.S.
NAA	Non-attainment Area
NAAQS	National Ambient Air Quality Standards used for determining attainment status.
NAATS	National Air Toxics Trend Station
NCore	National Core multi-pollutant monitoring stations
NESCAUM	Northeast States for Coordinated Air Use Management
NO	Nitrogen Oxide
NO_2	Nitrogen Dioxide
NO_X	Oxides of Nitrogen (ozone precursor)
NO_Y	Total Reactive Nitrogen Species (ozone precursor)
O_3	Ozone
PAMS	Photochemical Assessment Monitoring Station
PWEI	Population Weighted Emissions Index
Pb	Lead
$PM_{2.5}$	Particulate matter with an equivalent diameter less then or equal to 2.5 μm.
PM_{10}	Particulate matter with an equivalent diameter less then or equal to 10 μm.
SIP	State Implementation Plan
SLAMS	State or Local Air Monitoring Stations
SO_2	Sulfur Dioxide
SPM	Special Purpose Monitor
tpy	tons per year
US EPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds

1. INTRODUCTION

The Maryland Department of the Environment (MDE) Air Monitoring Program (the Program) is required by the U.S. Environmental Protection Agency (EPA) to conduct and submit a 5-year network assessment to the Regional Administrator by July 1, 2010. This document fulfills this requirement as set forth by the ambient air monitoring regulations, 40 CFR 58.10(e) as amended by the U.S. Environmental Protection Agency (EPA) and finalized on October 17, 2006. These amendments require state, or where applicable local, monitoring agencies to conduct a network assessment once every five years the first of which is due to the Regional Administrator by July, 2010. The text of 40 CFR 58.10(d) requirements is as follows:

"(d) The State, or where applicable local, agency shall perform and submit to the EPA Regional Administrator an assessment of the air quality surveillance system every 5 years to determine, at a minimum, if the network meets the monitoring objectives defined in appendix D to this part, whether new sites are needed, whether existing sites are no longer needed and can be terminated, and whether new technologies are appropriate for incorporation into the ambient air monitoring network. The network assessment must consider the ability of existing and proposed sites to support air quality characterization for areas with relatively high populations of susceptible individuals (e.g., children with asthma), and, for any sites that are being proposed for discontinuance, the effect on data users other than the agency itself, such as nearby States and Tribes or health effects studies. For PM2.5, the assessment also must identify needed changes to population-oriented sites. The State, or where applicable local, agency must submit a copy of this 5-year assessment, along with a revised annual network plan, to the Regional Administrator."

EPA decided to require a periodic assessment because, '*ambient air monitoring objectives have shifted over time—a situation which has induced air quality agencies to re-evaluate and reconfigure monitoring networks. A variety of factors contribute to these shifting monitoring objectives:*

- *Air quality has changed—for the better in most geographic areas—since the adoption of the federal Clean Air Act and National Ambient Air Quality Standards (NAAQS). For example, the problems of high ambient concentrations of lead and carbon monoxide have largely been solved.*
- *Populations and behaviors have changed. For example, the U.S. population has (on average) grown, aged, and shifted toward urban and suburban areas over the past four decades. In addition, rates of vehicle ownership and annual miles driven have grown.*
- *New air quality objectives have been established, including rules to reduce air toxics, fine particulate matter ($PM_{2.5}$) and regional haze.*
- *The understanding of air quality issues and the capability to monitor air quality have both improved. Together, the enhanced understanding and capabilities can be used to design more effective air monitoring networks'* [EPA, 2008].

As a result of the previously mentioned factors, there is the potential that existing networks do not reflect current or new monitoring needs but rather the network may *have unnecessary or redundant monitors or ineffective and inefficient monitoring locations for some pollutants,* [EPA, 2008]. Doing a network assessment is an opportunity to discover how to refocus network resources to protect today's population and environment.

The State of Maryland, though the efforts of its various governmental agencies and programs has been measuring ambient air pollutant concentrations in the state for nearly 55 years. Currently it is the responsibility of the MDE Air Monitoring Program (the program) to measure ambient concentrations of air pollutants. A history of Maryland's monitoring sites is provided in Appendix A.1. Throughout the years, the ambient air monitoring networks have changed in response to the factors listed previously. It is anticipated that one of the results of this assessment will be to help the program determine if past changes to the networks have been sufficient to support current and or proposed future monitoring needs. Several of the more important features that have shaped the monitoring networks are the climate, extent, and topography of the state. These features have been known to contribute to the formation of some types of air pollutants and consequently have affected the design of historical and existing ambient air monitoring networks in the state. A climatology of the state is provided in Appendix A.2.

The program's approach to performing this 5-year assessment was to address every item required by 40 CFR 58.10(e) within the limitations of available data and analytical techniques. The analytical techniques used in this 5-year assessment required assembling and using a wide variety of data including but not limited to 2007 point source emissions estimates, air quality modeling results, meteorological data, population data, and ambient air pollutant monitoring data. The temporal scope was typically 2006-2008, and the spatial scope sometimes included data and information from the contiguous states around Maryland. When out-of-state information was used, its relevance to the 5-year assessment was explained. Some input data used by and the results generated by the analytical techniques are displayed on maps to help aid in visual analysis, interpretation, and presentation of the results. All results are reported based on the type of completed assessment and the confidence that can be attributed to the techniques and data used. A detailed explanation of all analytical techniques and data used is addressed in each section of this 5-year assessment.

The 5-year assessment was organized in such a way that Section 2 is comprised of separate subsections for each individual pollutant network (i.e., air toxics, carbon monoxide, lead, nitrogen dioxide, ozone, PAMS, particulate matter (PM_{10} and $PM_{2.5}$), sulfur dioxide), which make up Maryland's ambient air monitoring network. Section 3 addresses the requirement of determining if ozone and particulate monitors are appropriately located in areas with high populations of sensitive individuals. Section 4 examines new technologies that are available to measure ambient air pollutant concentrations. Section 5 summarizes the findings of the 5-year assessment and gives recommendations on how the networks might be modified in the next few years.

2. SPECIFIC POLLUTANT NETWORKS

Ambient air monitoring networks are typically classified by the pollutant that they measure and usually consist of more than one monitoring site location. The program operates several pollutant networks (e.g., an ozone network, a sulfur dioxide network, a $PM_{2.5}$ network, etc…). In addition, some of the networks measure groups of pollutants such as air toxics. A complete description of the Maryland air monitoring network(s) can be found in the Ambient Air Monitoring Network Plan for Calendar Year 2011[1]. In Section 2, the assessment of network monitoring objectives[2], the identification of redundant monitoring sites, and the identification of new sites are addressed.

EPA provided the states with software tools to identify redundant monitoring sites and to identify possible locations for new monitoring sites [Russo, 2010]. The tools were limited to only ozone (O_3), $PM_{2.5}$ and PM_{10} networks. Some of the tools could not be used for the Maryland $PM_{2.5}$ and PM_{10} networks, so the program devised equivalent tools for use with the PM networks and other networks that were not covered by the EPA tools. As an aid to making decisions about current, O_3, and $PM_{2.5}$ networks, a decision matrix approach for defining the relative value of each site in these networks was implemented following EPA's suggestions [Cavender, 2009].

To determine whether Maryland monitoring networks '*meet the monitoring objectives defined in appendix D*', the program searched for inconsistencies in the monitoring objective types and the related scale of representation (scale) assigned to each monitor in each network. Inconsistencies can arise from the changes delineated above which may have occurred since the original assignment of scales and objectives. Inconsistencies can also arise from errors made in the original assignments. Six basic monitoring objectives with their AQS objective types (in parentheses) have been defined in Appendix D to Part 58 1.1.1 as follows:

- Determine the highest concentration expected to occur in the area covered by the network (Highest Concentration)
- Measure typical concentrations in areas of high population density (Population Exposure)
- Determine the impact of significant sources or source categories on air quality (Source Oriented)
- Determine background concentration levels (General/Background)
- Determine the extent of regional pollutant transport among populated areas (Regional Transport)
- Measure air pollution impacts on visibility, vegetation damage, or welfare-based impact (Welfare Related Impacts)

'To clarify the nature of the link between general monitoring objectives, site types, and the physical location of a particular monitor, the concept of spatial scale of representativeness is defined. The goal in locating monitors is to correctly match the spatial scale represented by the sample of monitored air with the spatial scale most appropriate for the monitoring site type, air

[1] See http://www.mde.state.md.us/assets/document/MDNetworkPlanCY2011.pdf.
[2] The program assessed all monitoring requirements for each of the networks addressed in section 2, not just those related to monitoring objectives.

pollutant to be measured, and the monitoring objective. Thus, spatial scale of representativeness is described in terms of the physical dimensions of the air parcel nearest to a monitoring site throughout which actual pollutant concentrations are reasonably similar'[3] (more quantitative description of spatial uniformity can be found in Watson, 1997). The scales of representativeness, as defined in Appendix D to Part 58 1.2 (b) for the monitoring site types described previously are as follows:

- **Micro** Concentrations in air volumes associated with area dimensions ranging from several meters up to about 100 meters.
- **Middle** Concentrations typical of areas up to several city blocks in size with dimensions ranging from about 100 meters to 0.5 kilometer.
- **Neighborhood** Concentrations within some extended area of the city that has relatively uniform land use with dimensions in the 0.5 to 4.0 kilometers range.
- **Urban** Overall, citywide conditions with dimensions on the order of 4 to 50 kilometers. This scale would usually require more than one site for definition.
- **Regional** Usually a rural area of reasonably homogeneous geography and extends from tens to hundreds of kilometers.
- **National/Global** Concentrations characterizing the nation and the globe as a whole.

Each of the previously mentioned scales is not appropriate for use with each pollutant. For example, '*urban scale and regional scale are of little relevance to PM_{10}, because of the short transport distances for PM_{10}, especially when emitted near ground level. In contrast, because $PM_{2.5}$ is a secondary pollutant, larger spatial scales are relevant, because monitors in such locations will reflect regional emissions trends and transport patterns.*'[4] Appropriate scales for pollutants can be found in Table 6-2, [EPA, 2008]. Each of the previously mentioned scales is not appropriate for use with each objective type. For example, population exposure is not an appropriate objective for characterizing regional scale sites, because to have regional scale, a site must be located away from population centers. Appropriate scales for each objective can be found in Table D-1 of Appendix D to Part 58. Note that a site may have more than one objective, and different monitors located at the same site may have different scales depending on the pollutant that they measure.

Scale is also affected by the distance from roadways, traffic counts, probe heights, and probe distances to trees [40CFR58 Appendix E Table E-4]. Reviewing the networks against these siting criteria listed in 40CFR58 Appendix E was not part of this assessment. However, inconsistencies between assigned scales and any of these siting criteria are evaluated as a part of the program's periodic management system audits. Modifications to scales and objectives were made according to the findings of the audits. The last occurred in 2006, and a technical systems audit that reviewed some of these siting criteria was done in 2009 by EPA Region III. Traffic counts are a part of the siting criteria that change periodically and have the potential for changing a site's scales and the related monitoring objectives. To account for this potential, the program reevaluates the assigned scales whenever traffic counts are updated by the State Highway Administration.

Here are some examples of how discrepancies in monitoring objectives and their related representative scales were found:

[3] from Appendix D to Part 58 1.2 (a).
[4] See **Federal Register** / Vol. 71, No. 200 / Tuesday, October 17, 2006 / Rules and Regulations, p 61266.

- To determine if a site was correctly assigned the 'Highest Concentration' objective, the site's design values were compared with the other sites' in the network to determine if it did measure the highest concentration. Note that air quality modeling results were sometimes used to help locate new 'Highest Concentration' sites.
- To determine if a site was correctly assigned 'Population Exposure' as an objective, land use in the area defined by the site's scale was considered. Areas that have mixed land use may not serve as the best population exposure sites.
- To determine if a site was correctly assigned the 'General/Background' objective, the site's design values were compared with other sites in the network to determine if it had one of the lowest values. Wind roses and air quality model results were used to tell if it was on a transport path. 'Regional Transport' sites should be on a transport path; 'General/Background' sites should not.
- Sites assigned the 'Population Exposure' or the' General/Background' objective should not be significantly influenced by nearby emissions sources. Maps identifying the locations of major point sources relative to the location of monitoring sites were used to identify which monitors were close to sources. In some cases, air quality modeling was used to determine if sources had a significant impact on the measurements made at the site.
- Determining whether the scale was correctly assigned usually called for an appeal to the definition of scale: '… *throughout which actual pollutant concentrations are reasonably similar …'.* Inferences about the variation of pollutant concentrations were made by visual inspection of land use homogeneity, visual inspection of the location of major sources in relation to monitoring sites, and application of air quality modeling results.

2.1 Air Toxics Network

EPA Region III developed a regional air toxics network jointly with the state and local agencies in the late 1980's and early 1990's with the goal of characterizing ambient air toxics levels throughout Region III. There are four air toxics monitoring sites currently operating in Maryland. Three of these are urban sites (NE Police, Oldtown, and Essex) and for 15 years they have been monitoring for air toxics. The remaining site, HU-Beltsville, has operated for 4 years. None of the sites are designated as National Air Toxics Trends Stations (NATTS[5]) by EPA.

The assessment of the air toxics network was more difficult than the other networks due to the following:

- Thirty nine air toxic compounds needed to be assessed and not just one, as was the case with the other networks.
- Eighteen of 39 air toxic compounds measured during 2006-2008 had concentrations below 85% of their MDL.

- Most air toxics data follow highly skewed distributions making the use of statistical tests and statistical estimators, which assume a normal distribution of data, inappropriate for use with the air toxics data.

- Many median air toxic concentration differences for inter-site pairs were zero making calculation of the more appropriate relative concentration differences impossible; hence insufficient data was available to evaluate these compounds.

2.1.1 Compliance with Network Design Criteria

There are no federal or Maryland state regulations governing the design of air toxics networks. In addition, there are no NAAQS established for any of the measured air toxic compounds.

2.1.2 Assessment of Objective Types Assigned to Monitors

Although no design criteria exist for air toxics monitoring, the program assigned scales and objective types to the currently operating air toxics monitors. Population exposure was the objective assigned to all air toxics monitors, and all were assigned neighborhood scale except for Oldtown which was assigned middle scale because of its close proximity to a busy city intersection. All except HU-Beltsville are located near populated areas in or around Baltimore City. Land use in the vicinity of HU-Beltsville is not as homogenous as the other urban sites. a map representing the area surrounding the HU-Beltsville site is provided in Figure 2-1 which shows that the immediate surroundings at the HU-Beltsville site consist of primarily open space on the research campus of the Howard University Physics Department. There is a commercial – industrial strip to the west along nearby Route 1and low density residential neighborhoods to the

[5] A national network of 23 sites that samples air toxics every 6th day and whose objective is to determine trends in exposure related risks

north, east and south. A chart showing the median concentration profiles of several selected air toxic compounds from each of the air toxics sites is provided in Figure 2-2 and it indicates that relatively high concentrations of methyl-ethyl-ketone, a solvent, have been measured at HU-Beltsville suggesting the influence of a nearby source. Despite the location of nearby sources and the higher methyl-ethyl-ketone concentration, the concentrations of most other 'selected' (see Figure 2-2) air toxics were lower, as expected given the different land use and lower residential densities at HU-Beltsville than at the other urban sites. With the exception of the suspected nearby source influence, HU-Beltsville is probably more representative of general background levels of air toxics typically found in a suburban area located in a major inter-urban traffic corridor.

The Essex site is located on a small but very active parking lot in Baltimore County and the Oldtown site is near a busy Baltimore city intersection. Upon inspection of Figure 2-2 it can be seen that both sites have similar concentrations of air toxics from mobile source emissions. These air toxics[6] include the following: benzene, ethyl benzene, methyl tert-butyl ether, n-hexane, o-xylene, and toluene. This means that both the Essex and Oldtown sites are primarily influenced by fresh well mixed mobile source emissions. Figure 2-2 also indicates that the NE Police also has a similar mix of air toxics as those found at the Essex and Oldtown sites but at slightly lower concentrations.

[6] See SPECIATE 4.2 for profiles of gasoline related sources.

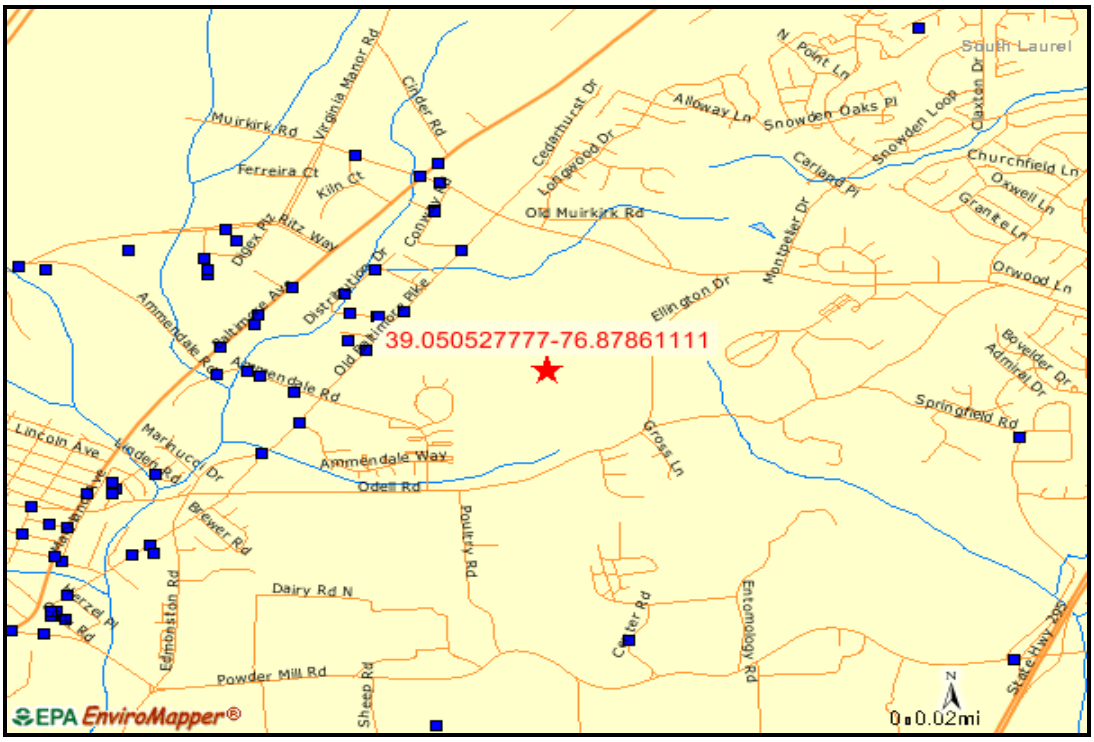

Figure 2-1. Map of the surrounding area near the HU – Beltsville site.

The red star marks the location of the site which is 0.3 miles east of a route 1 commercial-industrial area. Blue boxes mark the locations of permitted facilities.

All of the air toxics monitoring sites are useful for characterizing ambient levels of air toxics within their respective communities as well as for determining trends and the effectiveness of specific emission reduction activities. The Beltsville site will also prove useful in evaluating the air quality impacts of the Inter-county County Connector and associated development since it is located less than a mile from the eastern terminus.

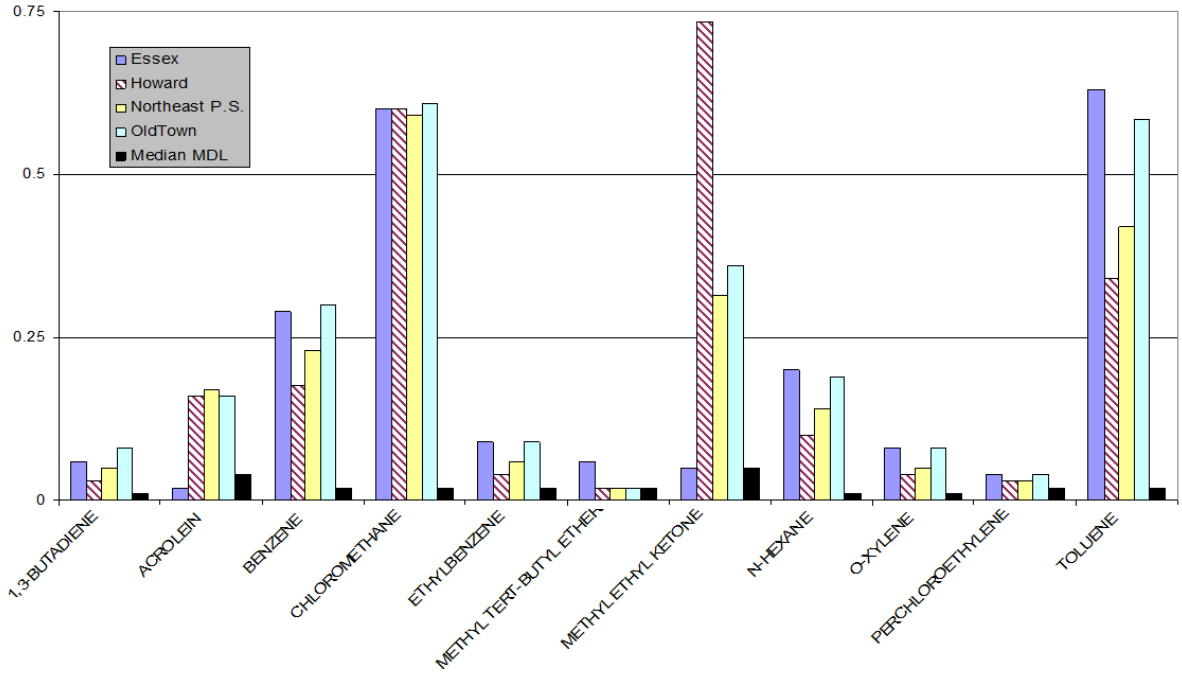

Figure 2-2. Median concentration profiles of selected air toxics parameters compared by site, 2006-2008.

Air toxic compounds selected for inclusion in Figure 2-2 had to have the following characteristics: at least one site pair that measured median concentrations that were significantly different[7]; the ratio of the air toxic compound's concentration to its MDL must have been greater then two for data measured for at least one of the sites. Note that all air toxic compounds that satisfy these characteristics also appear in Table 2-1 except for methyl-ethyl-ketone.

2.1.3 Identifying Redundant Sites

Following a similar evaluation method that was used to assess other pollutant networks, squared Spearman[8] correlation coefficients were calculated for inter-site pairs of each air toxic pollutant evaluated to determine if there was a relationship between air toxic measurements at different sites. Seventy – four percent of the squared Spearman correlations were less than 0.1. A small number of inter-site air toxic pairs had squared Spearman correlations between 0.7 and 0.8. Provided in Table 2-1 are the squared Spearman correlation coefficients for the most correlated site pairs. Not surprisingly, the HU-Beltsville air toxic pollutants did not correlate well with any of the urban sites. The HU-Beltsville site is both far from the other air toxics sites and samples in an area characterized by mixed land use while the other sites are in areas characterized by

[7] Significantly different means the Kruskal-Wallis hypothesis test found the medians to be statistically different at the .05 level of significance, and the data used in the test could be assumed to come from a random sample as required by Kruskal-Wallis.

[8] Spearman's was used instead of Pearson's method to better approximate the correlation given the highly skewed (non Gaussian distributions) toxic parameter data.

residential land-use. Relative concentration differences based on medians[9] are presented in Table 2-2. These were calculated for pairings of the urban sites for each air toxic pollutant using 2006-2008 data. Nothing in these site pairing results suggests that any of the site pairs have been measuring the same thing. However, general statistics of the relative concentration differences provided in Table 2-2, suggest that the Oldtown site measures higher air toxics concentrations than the NE Police does. This fact is consistent with Oldtown's proximity to a busy Baltimore City intersection. If the objective is to measure maximum air toxics concentrations, the program may prefer to keep the Oldtown as an air toxics site and terminate air toxics sampling at the NE Police However, if the purpose is to measure more typical urban air toxics concentrations, then the NE Ploice should be kept, and Oldtown air toxics sampling should be terminated. If intra-urban gradients of air toxics are of special interest, both sites should be retained.

Table 2-1. Squared Spearman correlation coefficients for the most correlated site pairs.

PARAMETER	ESSX-NEPS	NEPS-OLDT
BENZENE	0.77	0.80
CHLOROFORM	0.71	
ETHYLBENZENE		0.70
METHYL TERT-BUTYL ETHER		0.76
N-HEXANE	0.71	
O-XYLENE		0.70
TOLUENE		0.75

Table 2-2. Statistics of relative concentration differences of all air toxic parameters measured for the urban site pairs, 2006-2008.

SITE PAIR	NUM	MEAN	MEDIAN	LOWER 25%TILE	UPPER 75%TILE	NUM >0	NUM <0
NE Police-Essex	22	0.46	0.00	-0.25	0.00	2	9
Oldtown-Essex	22	0.73	0.00	0.00	0.45	10	4
NE Police.- Oldtown	24	-0.18	-0.22	-0.35	0.00	2	15

Note relative differences between 500 and 700 percent were calculated for ACROLEIN and METHYL ETHYL KETONE for the NE Police-Essex and Oldtown-Essex.

2.1.4 Identifying New Sites Needed

EPA did not supply or develop any tools for identifying new air toxics site locations, and without any objective network design criteria, there is no clear cut approach for doing so. In general, the existing sites could be moved or additional air toxics monitoring sites could be established in order to characterize ambient air toxics levels in other areas of the state, provided adequate funding is available, although it is unlikely that concentrations of most air toxics would be any greater than those measured in the highly urban environment of Baltimore City.

2.1.5 Effect of New or Proposed Network Design Regulations

None have been proposed for air toxics as of the time this report was written.

[9] The median is a more appropriate measure of central tendency when the data is skewed.

2.1.6 Recommended Network Changes

The recommended changes to the air toxics network are as follows:

- Consider discontinuing either Oldtown or NE Police depending on the monitoring objective for Baltimore City.

- Consider changing the monitoring objective for HU-Beltsville from population exposure to general/background.

EPA Region III and the states should jointly reassess the goals and objectives of the regional air toxics network. A part of this assessment should focus on what air toxic compounds should be reported and whether existing sites should be continued as trends sites or moved to characterize other areas of the individual states.

2.2 CO Network

2.2.1 Compliance with Network Design Criteria

The basic design criteria for CO are specified in 40CFR58 Appendix D. There are no minimum requirements for SLAMS monitors; however, each state must operate at least one NCore site with CO as one of the required monitoring parameters. Maryland has four CO monitoring sites and their type, objectives and representative scale are summarized in Table 2-3.

There are currently two primary NAAQS for CO, an 8-hr standard of 9 ppm and a 1-hr standard of 35 ppm. All CO monitoring sites meet the NAAQS, provided in Table 2-3 are details of the CO network.

Table 2-3. Monitoring details for the CO network.

SITE NAME	AQS ID	START DATE	REPRESENTATIVE SCALE	MONITORING OBJECTIVE	TYPE	2008 Design Value 8-hr (ppm)	2008 Design Value 1-hr (ppm)
Essex	240053001	4/1/1967	Middle	Highest concentration	SLAMS	2	3.0
HU-Beltsville	240033000	12/20/2006	Urban	General / Background	NCORE	0.9	1.1
Oldtown	245100040	1/1/1982	Middle	Highest concentration	SLAMS	2.3	3.3
Piney Run	240230002	6/1/2004	Regional	Regional transport	NCORE	0.3	0.4

2.2.2 Assessment of Objective Types Assigned to Monitors

The CO monitoring rule requires that where SLAMS CO monitoring is ongoing, at least one site must be a maximum concentration site for that area under investigation. This requirement is met by both the Essex and Oldtown sites, each of which has a monitoring objective of the highest concentration. The design values at these sites are the highest in the CO network.

The rule also states that micro scale and middle scale measurements are useful site classifications for SLAMS sites because most people have the potential for exposure at these scales. Both SLAMS stations in Maryland, Essex and Oldtown, have the representative scale of middle (0.1-0.5 km). This small scale is appropriate for these sites because they are located in urban environments where CO gradients are expected.

The Beltsville site is an NCore site and its representative scale is urban. HU-Beltsville is located in a suburban area that is not close to large CO sources and this justifies the urban representative scale as well as the population exposure monitoring objective. Piney Run is an NCore site located in a rural area at high elevation (781 m above sea level) in Western Maryland. The site location justifies the regional representative scale.

2.2.3 Identifying Redundant Sites

Statistical relationships between site pairs were examined to determine redundant sites. Daily maximum CO data from each site was examined for 2006-2008. Slopes, intercepts, squared Pearson's correlation coefficients and average percent differences among site pairs are provided in Table 2-4. All correlations (r^2) are smaller than 0.45 suggesting that the site pairs are not well correlated. The distance between Essex and Oldtown is only 11 km and this pair shows the largest correlation ($r^2 = 0.45$) and smallest difference (33%), however, the differences between the observations are large enough that the sites should not be considered redundant. Using these statistical relationships the program did not find any redundant sites.

Table 2-4. Statistical relationships between CO site pairs.

X	Y	SLOPE	INTERCEPT	R^2	AVERAGE PERCENT DIFFERENCE[A] (%)
HU-Beltsville	Essex	1.56	0.30	0.31	76.53
Piney Run	Essex	1.52	0.53	0.03	108.65
Oldtown	Essex	0.73	0.25	0.45	33.45
Piney Run	HU-Beltsville	0.57	0.27	0.04	57.16
Oldtown	HU-Beltsville	0.21	0.19	0.29	79.01
Oldtown	Piney Run	0.02	0.19	0.03	116.86

[A] Average percent difference was calculated with daily maximum CO values (Here X_i and Y_i): $100 * \sum_{i=1}^{n} \frac{|X_i - Y_i|}{(X_i + Y_i)/2}$

2.2.4 Identifying New Sites Needed

Given that CO concentrations at all sites are well below the NAAQS and the network requirements are being met, there is no pressing need to identify potential new sites.

2.2.5 Effect of New or Proposed Network Design Regulations

The CO NAAQS and monitoring rule are currently under review. EPA is expected to propose revisions to the CO NAAQS and monitoring rule January 2011. Changes required by any revisions will be addressed in future Annual Network Plans and/or Periodic Network Assessments dependent on the implementation schedule in the final rule.

2.2.6 Recommended Network Changes

No changes to the CO network are recommend because all monitors meet NAAQS requirements and no sites were found to be redundant.

2.3 Lead Network

The program does not currently operate any lead monitors in Maryland. The lead monitoring network was discontinued in 2003 with EPA approval because Maryland met all NAAQS requirements and the monitor values were consistently below the measurement detection limit.

On December 23, 2009 the EPA proposed to revise the ambient monitoring requirements for measuring airborne lead and these proposed regulations required that the program operate new lead monitors in Maryland. EPA is proposing to change the lead emissions monitoring threshold to 0.50 tons per year (tpy). Air quality monitoring agencies would use this threshold to determine if an air quality monitor is required to be placed near a facility emitting lead. States may request a waiver as allowed by 40 CFR Part 58, Appendix D, paragraph 4.5(a) (ii).

The Regional Administrator may waive the requirement in paragraph 4.5(a) for monitoring near lead sources if the State or, where appropriate, local agency can demonstrate the lead source will not contribute to a maximum lead concentration in ambient air in excess of 50% of the NAAQS (based on historical monitoring data, modeling, or other means). The waiver must be renewed once every 5 years as part of the network assessment required under 58.10(d).

There are no sources in Maryland that emit more than 1.0 typ of lead. However, there is one source in Maryland that emits between 0.5-1.0 tpy of lead, but preliminary modeling results (run by the program) indicate that the maximum lead concentration will be below 50% of the NAAQS. The program will wait until the rule is finalized to perform final model runs.

EPA is also proposing to require lead monitoring at sites comprising the "NCore Network" instead of the current requirement to place lead monitors in each Core Based Statistical Area (CBSA) with a population of 500,000 or more people. Under this proposal, lead monitoring at NCore sites would begin January 1, 2011.The program is currently investigating monitors to be placed at the HU-Beltsville and Piney Run NCore sites.

Fuel used for piston-engine aircraft still contains lead. As a result, EPA is proposing to treat airports identically to other sources of lead when determining if source-oriented lead monitoring is needed. There are two airports in Maryland that potentially emit more than 0.5 tpy of lead. The program will re-evaluate annual emissions and perform modeling for these two airport sources to determine if source-oriented lead monitors are required.

2.4 NO_2 Network

2.4.1 Compliance with Network Design Criteria

The basic design criteria for NO_2 are specified in 40CFR58 Appendix D. There are no minimum requirements for SLAMS monitors; however, each state must operate at least one NCore site with NO_2 as one of the required monitoring parameters. Maryland has five NO_2 monitoring sites in Maryland and their type, objectives and representative scale are summarized in Table 2-5. There are currently two primary standards for NO_2. The first primary standard is the annual average of 0.053 ppm. The second primary standard is an hourly standard where the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb. There is a secondary annual standard which is the same as the primary standard.

Table 2-5. Monitoring details for NO_2 network.

SITE NAME	AQS ID	START DATE	REPRESENTATIVE SCALE	MONITORING OBJECTIVE	TYPE
Essex	240053001	1/1/72	Neighborhood	Population Exposure	SLAMS
HU-Beltsville	240330030	9/29/06	Urban	General / Background	NCORE
Piney Run	240230002	1/1/07	Regional	Regional transport	NCORE
Oldtown	245100040	1/11/82	Middle	Highest Concentration	SLAMS
Aldino	240259001	6/1/97	Urban	Population Exposure	PAMS

2.4.2 Assessment of Objective Types Assigned to Monitors

The appropriate scales for NO_2 SLAMS monitoring sites are middle, neighborhood, urban and regional scale. The Essex site has a representative scale of neighborhood (0.5-4 km) and this designation is required due to its close proximity to large NO_2 sources. The monitoring objective for Essex is population exposure. The HU-Beltsville site is an NCore site and its representative scale is urban. HU-Beltsville is located in a suburban area that is not close to large NO_2 sources and this justifies the urban representative scale as well as the general/background monitoring objective. Piney Run is an NCore site located in Western Maryland and is directly in the path of transported aloft emissions of NO_2 which can be transported from neighboring states; its representative scale is regional. Piney Run is located in a rural area at high elevation (781 m

above sea level) not close to any large NO_2 sources which justifies the regional representative scale and the regional transport monitoring objective. The representative scale for Oldtown is middle (.01-0.5 km).The close proximity of Old Town to mobile source emissions of NO_2 justify the highest concentration objective. Aldino is located in a suburban area that is not close to large NO_2 sources and this justifies the urban representative scale as well as the population exposure monitoring objective.

2.4.3 Identifying Redundant Sites

Design values for 2008 could only be calculated for Essex. The required data capture of 75% for a two year period was not attained at any of the other sites. The statistical relationships between site pairs were examined to determine redundant sites. Daily maximum NO_2 data from each site was examined for 2006-2008. Slopes, intercepts, squared Pearson's correlation coefficients and average percent differences among site pairs were calculated and are provided in Table 2-6. All correlations (r^2) are smaller than 0.48 suggesting that the site pairs are not well correlated. The distance between Essex and Oldtown is only 11 km and this pair shows the greatest correlation ($r^2 = 0.53$) and smallest difference (25%), however, the differences between the observations are large enough that the sites should not be considered redundant. Using the previously mentioned statistical relationships the program did not find any redundant sites.

Table 2-6. Statistical relationships between NO_2 site pairs

X	Y	SLOPE	INTERCEPT	R^2	AVERAGE PERCENT DIFFERENCE[A]
HU-Beltsville	Essex	0.89	10.09	0.48	35.72
Piney Run	Essex	0.68	24.41	0.06	122.25
Oldtown	Essex	0.70	4.68	0.53	24.87
Aldino	Essex	0.50	22.07	0.12	78.46
Piney Run	HU-Beltsville	0.73	15.88	0.14	101.42
Oldtown	HU-Beltsville	0.49	4.76	0.37	48.98
Aldino	HU-Beltsville	0.60	12.67	0.26	54.75
Oldtown	Piney Run	0.10	3.82	0.05	129.99
Aldino	Piney Run	0.21	3.48	0.18	73.78
Aldino	Oldtown	0.75	24.49	0.26	93.81

[A] Average percent difference was calculated with daily maximum NO_2 values (Here X_i and Y_i): $100 * \sum_{i=1}^{n} \frac{|X_i - Y_i|}{(X_i + Y_i)/2}$

2.4.4 Identifying New Sites Needed

The program is considering new sites given the recent changes to the NO_2 NAAQS and monitoring rule. A more detailed discussion is provided in section 2.4.5.

2.4.5 Proposed Regulations

EPA has promulgated (2/9/2010) a new 1-hour NO_2 standard at the level of 100 parts per billion (ppb). This level defines the maximum allowable 1-hour NO_2 concentration anywhere in an area. In addition to establishing an averaging time and level, EPA also set a new "form" for the standard. The form is the air quality statistic used to determine if an area meets the standard. The form for the 1-hour NO_2 standard is the 3-year average of the 98th percentile of the annual distribution of daily maximum 1-hour average concentrations. In addition, EPA is also retaining, with no change, the current annual average NO_2 standard of 53 ppb (40 CFR Parts 50, 53 and 58). The EPA is considering the need for changes to the secondary standard under a separate review.

EPA has set new requirements for the placement of new NO_2 monitors in urban areas. These include:

- Near Road Monitoring

  • At least one monitor must be located near a major road in any urban area with a population greater than or equal to 500,000 people. A second monitor is required near another major road in areas with either:

  (1) population greater than or equal to 2.5 million people, or

  (2) one or more road segments with an annual average daily traffic (AADT) count greater than or equal to 250,000 vehicles.These NO_2 monitors must be placed near those road segments ranked with the highest traffic levels by AADT, with consideration given to fleet mix, congestion patterns, terrain, geographic location, and meteorology to identify locations where peak concentrations of NO_2 are expected to occur. Monitors must beplaced no more than 50 meters (about 164 feet) away from the edge of the nearest traffic lane.

- Community Wide Monitoring

  A minimum of one monitor must be placed in any urban area with a population greater than or equal to 1 million people to assess community-wide concentrations.

  An additional 53 monitoring sites will be required nation wide to assess community-wide levels in urban areas.

  Some NO_2 monitors already in operation may meet the community-wide monitor siting requirements.

- Monitoring to Protect Susceptible and Vulnerable Populations

  Working with the State, EPA Regional Administrators will site additional NO_2 monitors to help protect communities that are susceptible and vulnerable to NO_2 related health effects.

All new NO_2 monitors must begin operating no later than January 1, 2013.

2.4.6 Recommended Network Changes

It is recommended that the monitoring objective for Essex be changed from population exposure to highest concentration.

Maryland must site two near roadway NO_2 monitors within the Baltimore – Towson, MD CBSA. The program has received rankings of road segments by AADT (Annual Average daily Traffic) and is working with the Department of Transportation to evaluate potential sites. One near road NO_2 monitor must also be sited in the Montgomery County, Maryland portion of the Washington-Arlington-Alexandria, DC-MD-VA-WV, MSA, based on the combined rankings of road segments from the Virginia and Maryland counties and the District of Columbia that comprise the MSA. The program will work with the DOT to evaluate potential sites.

The Essex monitor is close to a number of NO_2 sources and has measured high NO_2 concentrations in the past and has been operating since 1972. This long history adds to the value of the site. The program recommends that the Essex site be considered as meeting the new monitoring regulations for a community wide monitoring site.

The Oldtown site is located in downtown Baltimore City. The sampling probe is located within 25 meters of a traffic intersection and is subjected to high levels of mobile emissions of NO_2. Baltimore City's estimated 2009 (US Census Bureau) population is 637,000. Using the new siting requirements the site does not meet any of the new criteria. The Piney Run and HU-Beltsville sites are part of the NCore program and therefore cannot be moved to address the new regulations. Both sites are not located near any large NO_2 emission sources nor are they located near large populations, so these sites may not be used to meet the new monitoring requirements.

2.5 Ozone Network

2.5.1 Compliance with Network Design Criteria

The basic design criteria for ozone (40CFR58 Appendix D, 4.1, hereafter referred to as the ozone monitoring rule or simply the rule) includes the following: minimum number of SLAMS/NCore sites/monitors to be operated; monitoring objectives; spatial scales, and the prescribed ozone monitoring season (defined as April through October for Maryland). The minimum number of SLAMS ozone monitors required in each of the inter-state MSA's located in Maryland is shown in Table 2-7 along with the number of ozone monitors deployed in each state comprising the individual MSA. The minimum number of sites is either met or exceeded in each MSA. In addition to the SLAMS ozone monitors, each state is required to operate at least one NCore site. The NCore sites are expected to compliment the SLAMS ozone data collection and both types of sites can be used to meet the minimum network requirements. Maryland currently operates two NCore sites, Piney Run and HU-Beltsville. The ozone network requirements are summarized in Table 2-8. The monitoring objectives and spatial scales are discussed in greater detail in section 2.5.2.

Table 2-7. Number of Ozone SLAMS Sites Required by Part 58 4.1 compared to number deployed (based on Table D–2 of Appendix D to Part 58- Ozone minimum monitoring requirements).

MSA Name	Monitors Deployed by State					Total Monitors	Population[A]	required ≥ 85% NAAQS[B]	Excess Monitors[C]
	DE	DC	MD	VA	WV				
Baltimore, MD	0	0	8	0	0	8	2552994	2	6
Hagerstown - Martinsburg, MD-WV	0	0	1	0	0	1	131923	1	0
Washington, DC-MD-VA-WV	0	3	5	7	0	15	4923153	3	12
Wilmington-Newark, DE-MD	1	0	1	0	0	2	586216	2	0

A – Population was obtained from AQS. MSA population is used together with the MSA's design value to determine the required number of monitors
B – based on tables available at http://www.epa.gov/airtrends/values.html. All areas had their maximum site >= 85% Ozone NAAQS.
C – excess monitors = total monitors deployed – number required

Table 2-8. Monitoring requirements for ozone networks.

REQUIREMENT	40CFR58 APPENDIX D REFERENCE	STATUS
Minimum number of SLAMS/NCORE monitors	4.1(a)/3(a), 3(b)	Met, Table 2-7
At least one population oriented site at location of max concentration	4.1(b)	Met at Aldino, Edgewood, Beltsville and South Carroll for the Baltimore MSA.
Ozone at SLAMS sites must be monitored during ozone season	4.1(i)	Met, April – October for Maryland

2.5.2 Assessment of Objective Types and Spatial Scales Assigned to Monitors

There are 17 ozone monitoring locations in Maryland and their objectives and representative scales are summarized in Table 2-9. It should be noted that the monitoring objectives and spatial scales were assigned to many of the ozone monitoring sites when the 1-hour ozone NAAQS was still in effect. Subsequent lowering of the NAAQS along with the longer averaging time and implementation of many stringent emission control programs may have significant impact on whether the original objectives and spatial scales are still appropriate.

Table 2-9. Monitoring details for ozone.

SITE NAME	MSA	PRIMARY OBJECTIVE	REPRESENTATIVE SCALE
Davidsonville	Baltimore, MD	Population Exposure	Urban
Aldino	Baltimore, MD	Highest concentration	Urban
Calvert	Washington, DC-MD-VA	Population Exposure	Urban
Edgewood	Baltimore, MD	Highest concentration	Urban
Essex	Baltimore, MD	Population Exposure	Neighborhood
Fairhill	Wilmington-Newark, DE-MD	Background	Regional
Frederick Airport	Washington, DC-MD-VA	Population Exposure	Urban
Furley	Baltimore, MD	Population Exposure	Neighborhood
Hagerstown	Hagerstown - Martinsburg, MD-WV	Population Exposure	Urban
HU-Beltsville	Baltimore, MD	Highest concentration	Urban
Millington	NA	Population Exposure	Urban
Padonia	Baltimore, MD	Population Exposure	Neighborhood
PG Equestrian Center	Washington, DC-MD-VA	Population Exposure	Urban
Piney Run	NA	Highest concentration	Regional
Rockville	Washington, DC-MD-VA	Population Exposure	Urban
South Carroll	Baltimore, MD	Highest concentration	Urban
Southern Maryland	Washington, DC-MD-VA	Background	Regional

Note, AQS Id's for the above sites may be found in Table B-1 in Appendix B.

The ozone monitoring rule requires at least one maximum concentration site in each MSA. The Maryland ozone network has four monitors assigned as maximum concentration sites,

and all in the Baltimore, MD MSA. Virginia and Washington DC maintain monitors assigned maximum concentration in the Washington, DC-MD-VA MSA. The Wilmington-Newark, DE-MD MSA contains monitors in Maryland and Delaware and this MSA is part of the larger Philadelphia-Camden-Vineland, PA, NJ, DE, MD Combined Statistical Area (CSA). This CSA contains two MSA's, the Wilmington-Newark, DE-MD MSA and the Philadelphia, PA—NJ MSA and the latter contains a maximum concentration site. The Hagerstown-Martinsburg, MD-WV MSA contains only one monitor in Maryland (the Hagerstown site) which is currently defined as an exposure site, not a maximum ozone concentration site. The Hagerstown-Martinsburg, MD-WV MSA is not downwind of any sources of ozone and ozone values within this MSA are expected to be consistent throughout. The program recommends adding the objective of highest concentration to the Hagerstown site.

The ozone monitoring rule requires that one of three scales be assigned to ozone monitor sites, including urban, neighborhood and regional. Sites associated with these scales are shown in Table 2-9 and Figure 2-3. Neighborhood scale sites should be located to measure typical city concentrations and should not be near the influence of major NO_x sources. The map in Figure 2-3 shows no major NO_x sources within the spatial scales of the three neighborhood sites (Essex, Furley and Padonia). The map does show that there is a large NO_x point source ~ 1 mile southeast of the Edgewood site. The Edgewood site is a maximum concentration site and NO_x emissions from the nearby source could have the impact of titrating ozone levels nearby. Based on preliminary modeling results it was determined that the maximum NO_x concentration from the nearby source does not impact the Edgewood ozone monitor. Thus the Edgewood monitor should retain its representative scale of urban.

The Fairhill site is assigned a regional scale which extends into the Philadelphia area. This site often observes ozone values similar to Philadelphia although at times Fairhill observations are very different. The regional scale ranges from 50-100 km whereas the urban scale ranges from 4-50 km. The ozone measured at Fairhill suggests that this site is more likely to exhibit the urban scale than the regional scale. The program recommends that the Fairhill scale be changed to urban.

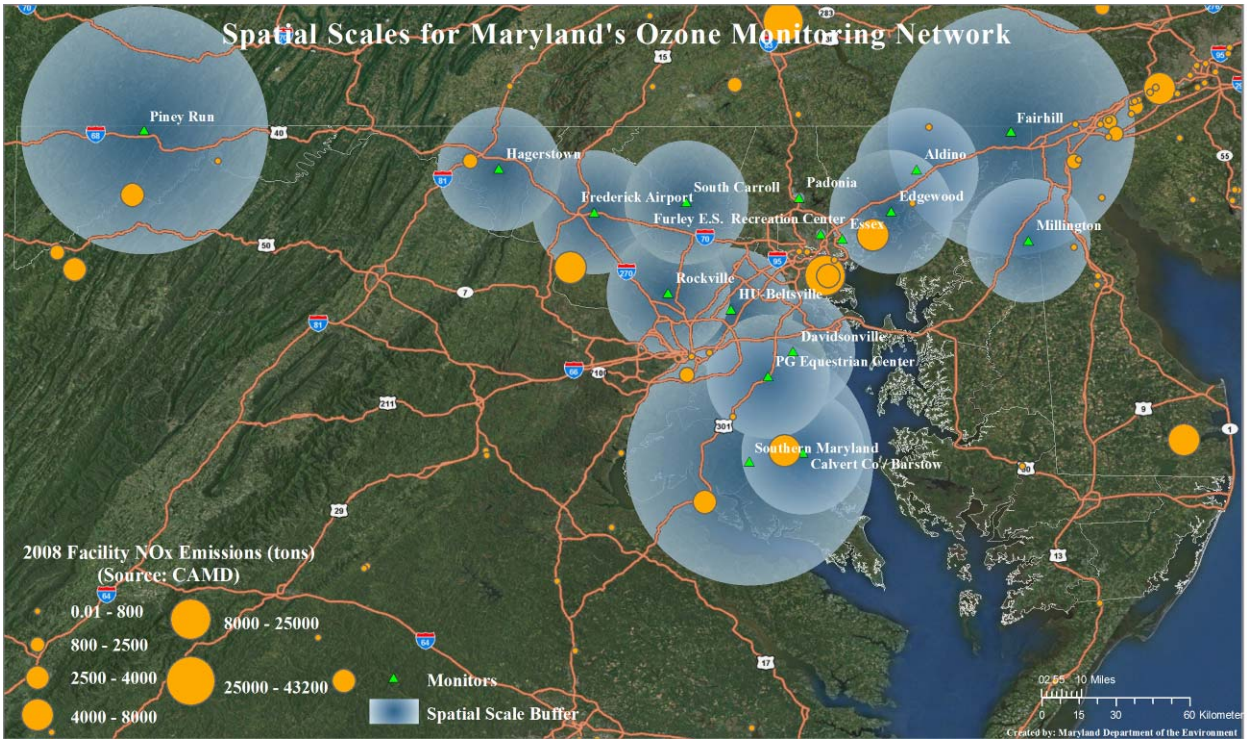

Figure 2-3. Locations of Maryland ozone monitors, large NO_x point sources and major highways. Also shown is the scale of the monitoring location.

The Maryland ozone monitoring network objectives include population exposure, highest concentration and background. The program examined population data using EPA tools to assess the population exposure objective. The program examined CMAQ model output and monitor design values to assess the background objective and the highest concentration objective. The results of these two assessments are described below.

Ten of the 17 sites have population exposure designations as a primary objective. To assist the states in preparing their network assessments, EPA developed area served tool [Rizzo, 2010]. In this tool, a spatial analysis technique known as Voronoi polygons is used to show the area represented by a monitoring site. The shape and size of each polygon is dependent on the proximity of the nearest neighboring sites to any particular site. Data from the 2000 Decennial Census and census county level estimates for 2008 were used to determine which census tract centroids were within each polygon. The area of the polygon with the census county level 2008 population estimates was used to calculate population density. Voronoi polygon population densities for the Maryland ozone monitoring network are shown in Figure 2-4. The population exposure sites are highlighted in blue. Some population exposure sites are associated with small population densities. The spatial scale assigned to the sites may be smaller than the Voronoi polygon area and thus the population density associated with sites may be larger than shown in Figure 2-4. The HU-Beltsville site is associated with a relatively large population density; therefore, the program recommends that the classification population exposure be added to the objectives of the HU-Beltsville monitoring site.

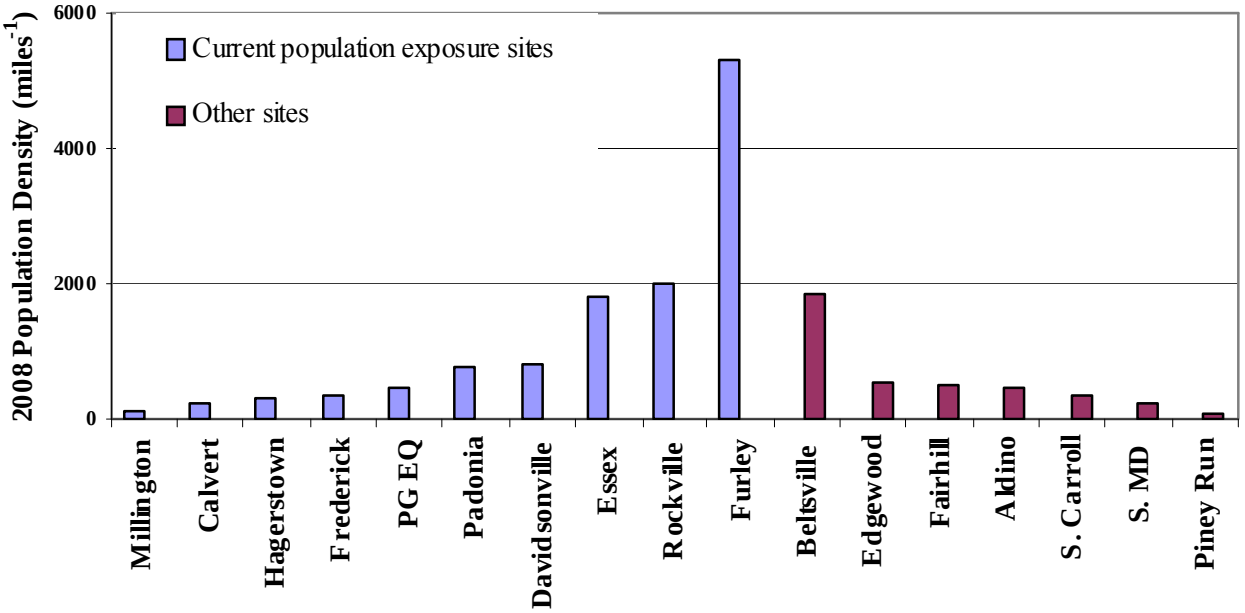

Figure 2-4. Population densities for Maryland ozone monitors.

The program examined CMAQ model output to assess the background monitoring objective for the ozone network. CMAQ modeled surface ozone concentrations are shown in Figure 2-5 for 16 high ozone days between 6/1/2002-7/4/2002 using 2009 emissions estimates (this modeling was performed in 2006). The average of the 8-hour maximum ozone concentration is shown. Details of the modeling are provided in Piety et al. [2006]. Fairhill and Southern Maryland are the only two background sites in the network and the modeling output shows these areas to have lower ozone concentrations. Fairhill is located to the northeast of Baltimore City along the I-95 corridor. Therefore it can be influenced by transport via the nocturnal low-level jet and typical westerly transport. Supporting documentation on transport at Fairhill is provided in Appendix A.2. CMAQ can underestimate transport at times [Gilliland et al. 2008] and this may explain why higher concentrations are not evident in Figure 2-5 at Fairhill. The program recommends changing the primary monitoring objective of the Fairhill site to regional transport.

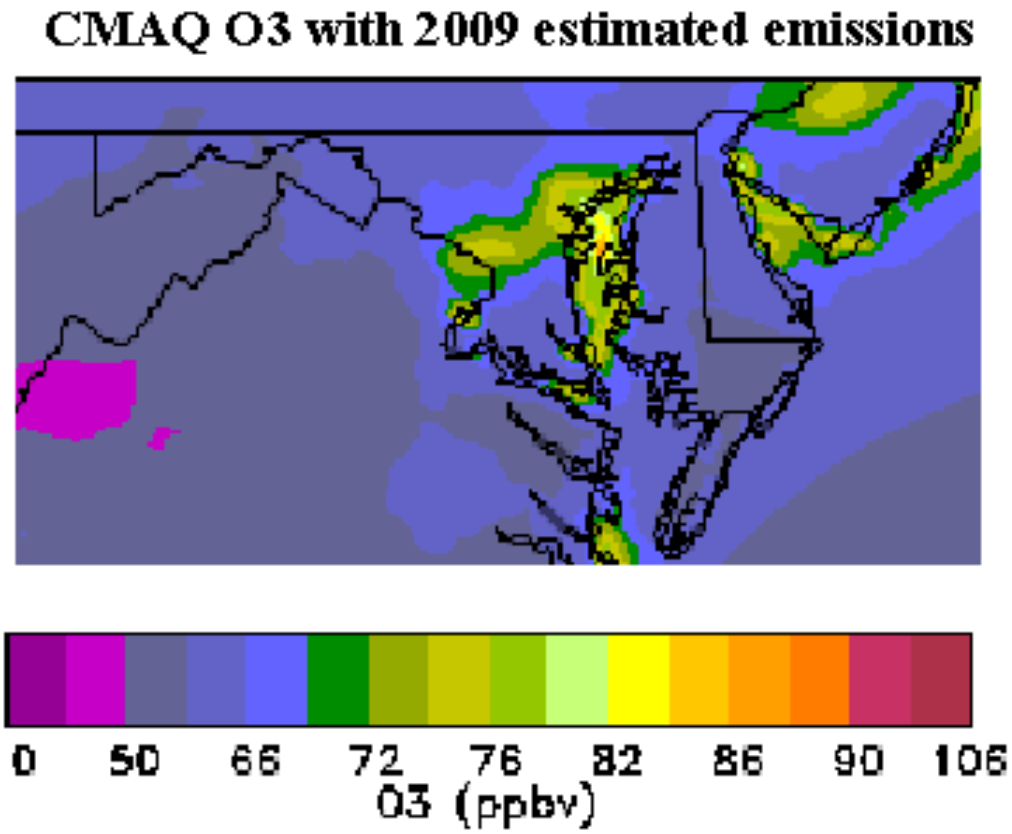

Figure 2-5. CMAQ modeled mean 8-hour maximum ozone during high ozone days (16 high ozone days between 6/1/2002-7/4/2002 using 2009 emissions estimates. Details of the modeling are in Piety et al. [2006]. See Figure 2-10 and Figure 2-3 for monitor locations.

The program also examined monitor design values from 2006-2008 in each MSA to assess the highest concentration monitoring objective. These monitor design values are provided in Figure 2-6. The Edgewood and Aldino sites have the highest ozone design values in the Baltimore, MD MSA and this confirms their highest ozone monitoring objectives. South Carroll and HU-Beltsville are currently designated as highest concentration sites but their design values are relatively smaller there than in other parts of the Baltimore, MD MSA. Since this MSA already has two other sites designated as highest concentration (Aldino and Edgewood), the program recommends changing the monitoring objective of the South Carroll site from highest concentration to population exposure. However, since the HU-Beltsville site is located in the Washington, D.C. Non-Attainment Area (NAA) and it has high ozone design values for the NAA, the program recommends keeping the highest concentration monitoring objective and adding population exposure objective.

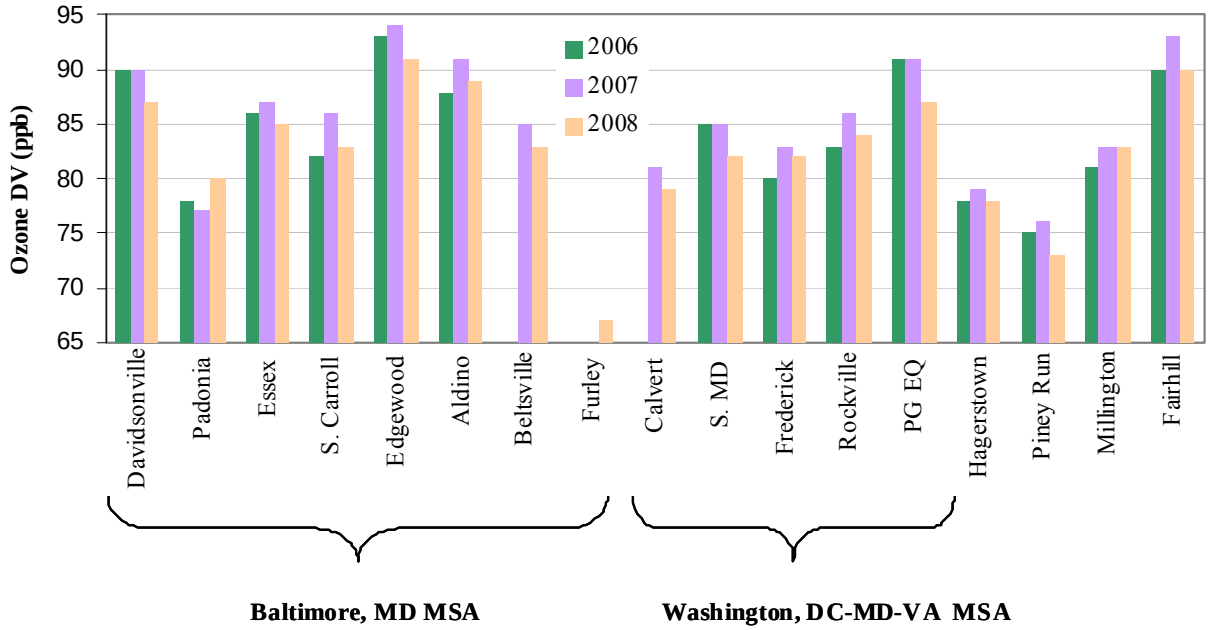

Figure 2-6. Ozone design values (DV) for Maryland ozone monitors for 2006-2008. The Hagerstown monitor is located within the Hagerstown-Martinsburg, MD-WV MSA and the Fairhill monitor is located within the Wilmington-Newark, DE-MD MSA.

2.5.3 Identifying Redundant Sites

EPA developed the cormat tool and the removal bias tool to enable states to test possible redundancies within the network [Rizzo, 2010]. The program used both tools to identify redundant sites and the tools as well as the results of the assessment are presented below.

The cormat tool calculates the correlation (r^2), relative difference and distance between pairs of sites. The tool examines sites in Maryland and out of state sites including Delaware, the District of Columbia, Virginia and West Virginia. All sites included in this analysis are shown in Figure 2-7. Correlations and average differences were calculated using data from the 2006-2008 ozone seasons. The Furley site began operating in August 2006, so correlations and differences relating to Furley were calculated using 2007-2008 ozone season data. The Rockville site did not operate in April, May and part of June 2007, so correlation and differences relating to Rockville were calculated using 2008 ozone season data. Detailed descriptions of calculation methods for correlation and relative differences are provided in Rizzo [2010]. It was necessary to supplement the correlation coefficients with the average relative percent concentration differences, because the squared correlation coefficients are only a measure of linearity - well correlated site pairs may nevertheless have significantly different values. Both calculations were aggregated to the site level and these were used for scoring the sites (Section 2.5.6).

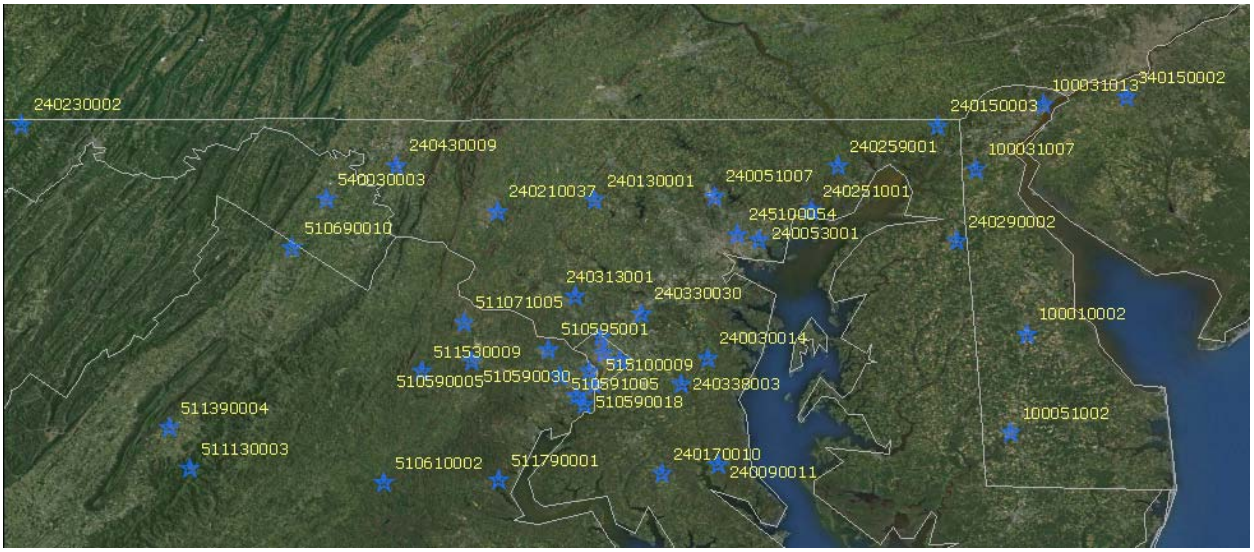

Figure 2-7. Ozone sites used in the redundant sites assessment.

Sites that measure nearly the same concentrations of ozone are those that are both highly correlated (large r^2) and have the smallest inter-site average relative percent concentration differences. The site-pairs having the 20 highest correlations are listed in Table 2-10 together with their distances and average relative percent concentration differences. All site pairs have correlations of at least 0.84 and their average differences are between 6-11%. Davidsonville and PG Equestrian Center have the largest correlation and they occur most frequently in Table 2-10. The high correlation among Davidsonville and PG Equestrian Center indicate that these sites may be redundant and candidates for removal.

Table 2-10. Top 20 correlated site pairs in the Maryland ozone network.

PLACE	SITE1	SITE2	DISTANCE (KM)	R^2	AVERAGE % DIFFERENCE
1	Davidsonville	PG Equestrian Center	13	0.924	6
2	Calvert	S. Maryland	17	0.902	6
3	Edgewood	Aldino	19	0.896	7
4	Frederick	Hagerstown	34	0.892	7
5	Hagerstown	VA, Rte. 669	44	0.883	9
6	DE, Lums	Millington	28	0.881	9
7	Fair Hill	Aldino	33	0.880	7
8	Calvert	PG Equestrian Center	32	0.876	8
9	Essex	Edgewood	19	0.875	8
10	PG Equestrian Center	VA, Mt. Vernon	30	0.874	8
11	Essex	Frederick	29	0.871	8
12	S. Maryland	PG Equestrian Center	34	0.858	8
13	Davidsonville	VA, Mt. Vernon	41	0.854	8
14	Davidsonville	S. Maryland	46	0.852	8
15	Frederick	VA, Ashburn	43	0.850	7
16	DC, River Terrace	PG Equestrian Center	20	0.845	9

PLACE	SITE1	SITE2	DISTANCE (KM)	R^2	AVERAGE % DIFFERENCE
17	Davidsonville	Calvert	41	0.845	8
18	DE, Bellevue	Millington	58	0.844	11
19	Davidsonville	VA, Lee Park	42	0.844	9
20	DC, River Terrace	HU-Beltsville	19	0.842	9

EPA developed the removal bias tool as another means to examine redundancies within the network [Rizzo, 2010]. In this tool, nearest neighbor ozone values weighted by distance from a site are used to calculate the ozone value for that site. The site may be considered redundant if the calculated ozone is not significantly different from the measured ozone at that site. Removal bias results from 2005-2008 are presented on EPA's Network Assessment website (http://www.epa.gov/ttn/amtic/netassess/ozone/).

The program used the removal bias results in combination with the correlation results provided in Table 2-10 to assess the redundancy of sites within the Maryland ozone network. There were a number of sites that may be considered redundant for two of the four years but only Aldino was considered redundant for three of the four years. Because Aldino was not well correlated with other sites, the program does not consider it redundant. PG Equestrian Center was considered redundant for two of the four years but Davidsonville was not considered redundant for any years. PG Equestrian Center was found to be redundant by both methods (correlation and removal bias tool) and this supports removing this site. Other factors must be considered when deciding to remove a site and they are further examined in Section 2.5.6 where the sites are scored.

2.5.4 Identifying New Sites Needed

The program has employed two methods to assess whether new sites are needed for the ozone monitoring network. The first method involves the EPA developed new sites tool [Rizzo, 2010]. The second method involves examining CMAQ modeled output of days exceeding the current ozone NAAQS. These two methods and the program's assessment are described below.

EPA developed the new sites tool to help states assess whether new sites were needed in the network [Rizzo, 2010]. In the new sites tool, the relationship between each pair of sites in the US monitoring ozone is examined to determine if there are enough differences between the sites to suggest a new site. The criteria used to determine the differences between a pair of sites are:

- maximum correlation (r^2 value)
- minimum distance between the sites
- minimum concentration difference between sites
- probability of exceeding 85% of the 8-hour ozone NAAQS for the pollutant

This tool was used to find site pairs that may be poorly correlated or show large differences in concentrations. In Maryland, all areas had over 90% probability for exceeding the 8-hour ozone NAAQS. Several potential new site locations for ozone monitors were identified using this tool.

Site pairs with weak correlations ($r^2 < 0.6$) were examined and the tool suggested a new site be added between Piney Run and the Martinsburg, West Virginia site. A map of Western Maryland showing the sites is provided in Figure 2-8. The elevation of the Piney Run site is 777 m while the elevation of the Martinsburg site is 141 m and this difference in elevation likely explains the weak correlation between sites. Seybold et al. [2005] show that the Piney Run site can sometimes be above the nocturnal boundary layer resulting in larger ozone concentrations (at night and during the following day) than those observed at Martinsburg.

The classification of $r^2 < 0.6$ as a weak correlation must be defined in a relative sense. For all comparisons among ozone monitors in and around Maryland, r^2 of 0.6 are the weakest. However, they still suggest good correlation and Rizzo [2010] states that correlations of 0.6 are high. The elevation differences and the relatively weak correlation suggest that it is not necessary to add another ozone site between Piney Run and Martinsburg.

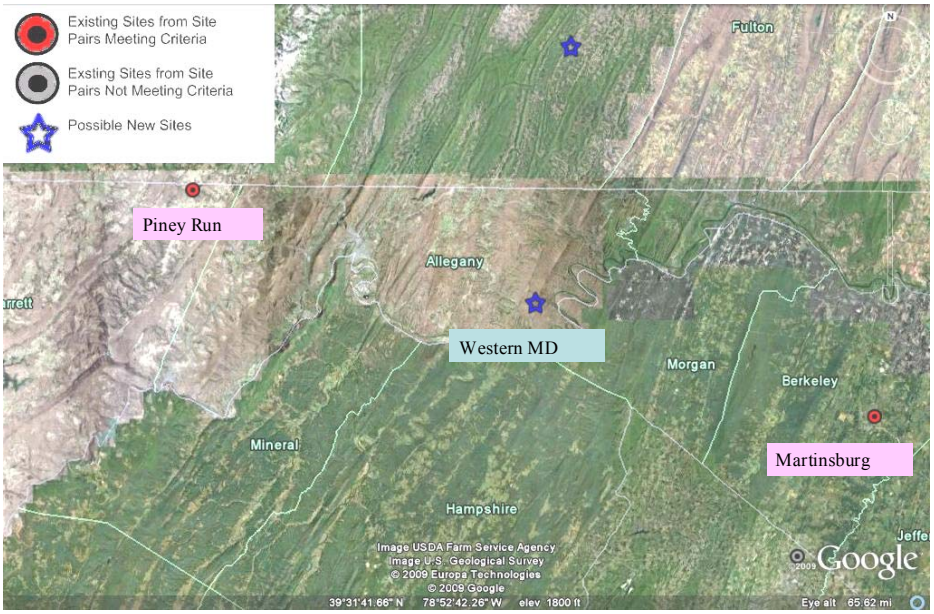

Figure 2-8. New site suggested in Western Maryland between Piney Run and Martinsburg. The correlation between the sites was weak ($r^2 < 0.6$)

A test examining sites with relatively good correlation ($r^2 < 0.75$) and large differences (differences < 10 ppb) were also performed. Large ozone differences were found between Furley and South Carroll, Furley and HU-Beltsville, and Furley and Davidsonville. This suggests that three new monitors may be needed to better characterize the concentration gradient in central Maryland. Shown in Figure 2-9 is a map of central Maryland showing the sites. The Furley monitor is located in Baltimore City, where fresh NO_x emissions from mobile source are prevalent. NO_x titration likely accounts for the lower concentrations typically measured at Furley. Therefore, these three new sites may not be necessary because the reason for the ozone gradient between Furley and the central MD sites is well understood.

Both of the previous examples illustrate inherent weaknesses of the new sites tool. Other information must be taken into consideration when evaluating recommendations based solely on the output of the new sites tool.

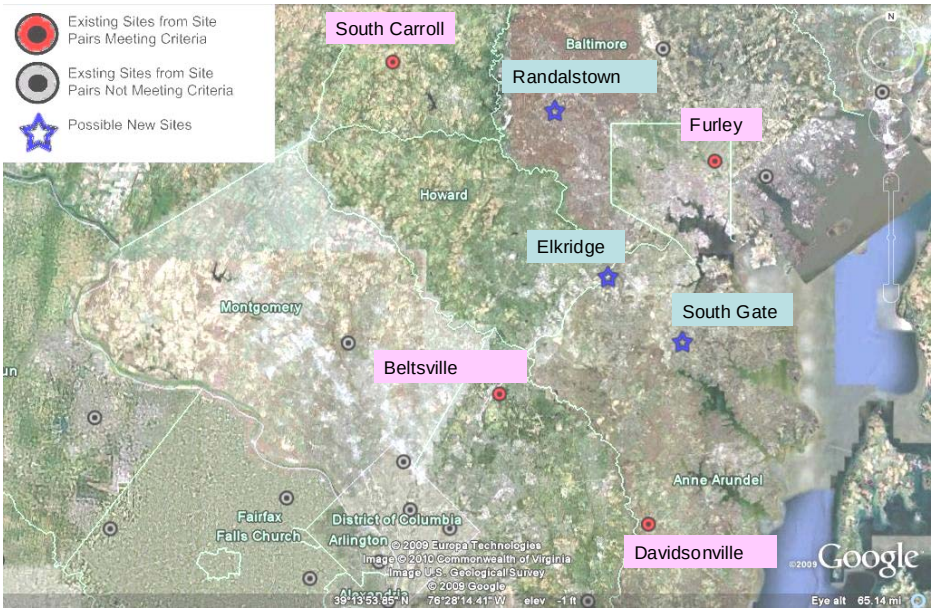

Figure 2-9. New sites suggested in central Maryland. The correlation among sites was strong ($r^2 < 0.75$) and the concentration difference between sites was 10 ppb.

The program also examined CMAQ modeled ozone output in order to identify locations that are likely to exceed ozone NAAQS and do not have nearby monitors. CMAQ model output of the number of days exceeding the ozone NAAQS daily standard of 75 ppb is shown in Figure 2-10. There are monitors near all locations in Maryland that exceed the NAAQS daily standard more than 20 days. There are areas over the Chesapeake Bay and on the border between Maryland and Virginia that show at least 50 days with ozone larger than 75 ppb. CMAQ may over-predict ozone over water and these days exceeding the NAAQS may result from the over-prediction. There are two Virginia monitors (Franconia and Mt.Vernon) near the Maryland-Virginia border measuring this CMAQ "hot spot" and thus the program does not recommend adding new monitors to the area.

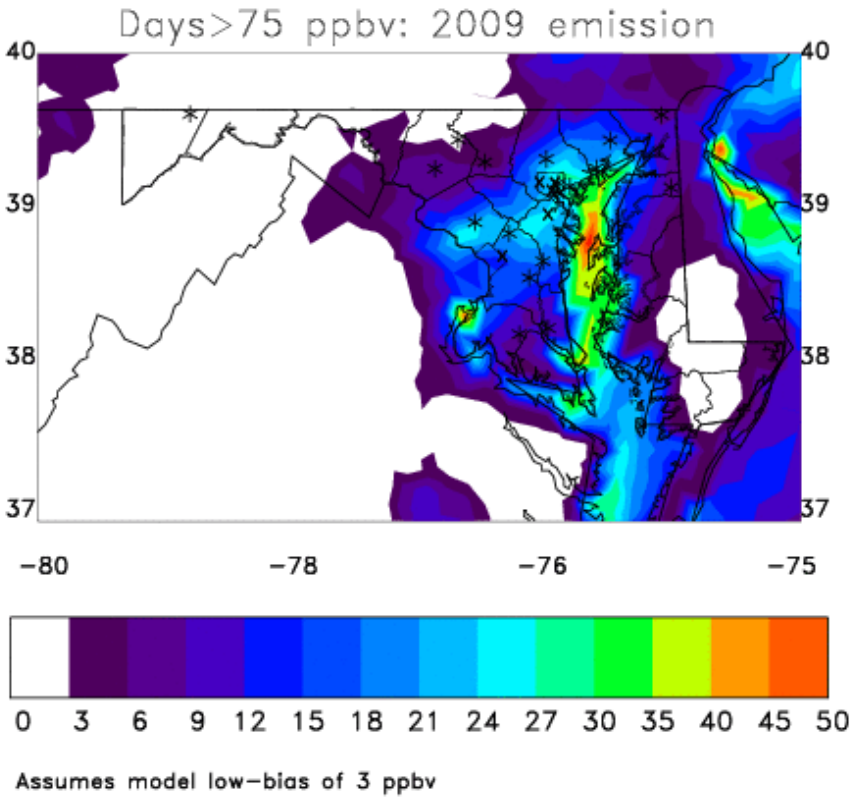

Figure 2-10. CMAQ model output of the number of days exceeding the ozone NAAQS current daily standard of 75 ppb. The current ozone monitor locations are shown with an asterisk.

2.5.5 Proposed Changes to the Ozone NAAQS and Monitoring Rule

On January 6, 2010, EPA proposed to strengthen the NAAQS for ground-level ozone. EPA proposed strengthening the 8-hour "primary" ozone standard, designed to protect public health, to a level within the range of 0.060-0.070 parts per million (ppm). EPA also proposed establishing a distinct cumulative, seasonal "secondary" standard, designed to protect sensitive vegetation and ecosystems, including forests, parks, wildlife refuges and wilderness areas. EPA proposed setting the level of the secondary standard within the range of 7-15 ppm-hours.

EPA had previously (July 8, 2009) proposed modifying the minimum ozone monitoring requirements to require one monitor to be placed in MSAs of populations ranging from 50,000 to less than 350,000 in situations where there is no current monitor and no history of ozone monitoring within the previous 5 years indicating a design value of less than 85 percent of the revised NAAQS. These urban areas would be required to operate at least one ozone monitor if monitoring is not already being conducted. EPA also proposed additional monitoring requirements in non-urban areas. States will be required to operate a minimum of three ozone monitors in non-urban areas which will be located in:

1. Areas such as some Federal, State or Tribal lands, including wilderness areas that have ozone-sensitive natural vegetation and /or ecosystems; lands with ownership may also be appropriate.
2. Micropolitan statistical area (10,000-50,000 people) expected to have ozone design value concentrations of at least 85 percent of the NAAQS.
3. The area of expected maximum ozone concentration outside of any MSA, potentially including the far-downwind transport zones of currently well-monitored urban areas.

In addition, EPA proposed lengthening the required ozone monitoring season to account for the tightened level of the revised NAAQS. The proposed ozone season for Maryland would start on March 1st and end on October 31st. It was also proposed that ozone monitors operated as part of NCORE be required to operate on a year-round schedule when the network is fully operational in 2011. EPA proposed that the revised ozone monitoring season for existing monitors be effective for the 2011 monitoring season. New ozone monitors are proposed to be operational no later than January 1, 2012.

Maryland currently has two MSA's with populations between 50,000 and 350,000 where there are no ozone monitors, Cumberland (population of 102,008) and Salisbury-Ocean Pines (population of 155,934). Under the proposed regulations one ozone monitor will be required in each of these MSA's. The program is currently exploring suitable ozone monitoring locations in these MSA's.

For the three non-urban monitors, the program will evaluate whether any of the existing sites (e.g. Calvert, Piney Run, Millington) will meet the requirements prior to seeking out new locations. Sites from other networks will also be taken into consideration (e.g. Blackwater NWR CASTNET site and Assateague Island NPS site). The program is also working with researchers at the University of Maryland to determine crop types and locations in Maryland that may be adversely affected by ozone. The results of this investigation will aid in decision making for new monitoring sites.

Any changes to the network necessary to meet these proposed new requirements will be addressed in MDE's Annual Network Plan due 7/1/2011, pending final approval of the proposed rule (expected in August 2010).

2.5.6 Recommended Network Changes

Any changes to the ozone network, particularly site removals, must be considered in relation to the site's overall value to the ozone network. A decision matrix was used to determine the relative value of each site in the ozone network. The decision matrix ranks the sites according to a weighted score which is the sum of normalized, individual criterion scores multiplied by a subjectively determined weighting factor:

The score for each criterion was calculated with the following equation [Cavender, 2009]:

$$\text{Score} = 100 * \text{weight} * (V_i - V_{min}) / (V_{max} - V_{min}) \qquad (1)$$

where V_i, V_{min} and V_{max} represent the value of the given criteria and the minimum and maximum values of criteria for all sites.

The criteria chosen for this network were:

- 2008 estimated population within Voronoi polygons associated with each site– important relative to the population oriented monitoring requirement but not highly weighted because of the reliability of the 2008 population estimates.
- 2008 population density within Voronoi polygons– sites in growth areas are more valuable than those whose population is flat or declining – not highly weighted as explained above.
- The number of parameters measured at the site.
- The site-average squared correlation coefficient (from section 2.5.3) – needed to quantify uniqueness of the concentrations measured relative to other sites/monitors.
- The site-average relative percent concentration difference (from section 2.5.3) – needed to quantify uniqueness of the concentrations measured relative to other sites/monitors.
- The site-specific 2008 design value (DV_{2008}) represented as a percentage of NAAQS.

The weight for the relative concentration difference was calculated as follows:

$$\text{Score} = 100^* \text{ weight } * (V_i - V_{max}) / (V_{max} - V_{min}) \qquad (2)$$

The weight for the relative concentration difference was calculated differently than the rest because the less correlated a site is with its neighbors the more unique and valuable it is. The ozone DV % NAAQS was calculated as follows:

$$\text{Ozone DV \% NAAQS} = DV_{2008} / 75 \text{ ppb} \qquad (3)$$

The results of the scoring are shown in Table 2-11. The Furley site has the lowest score and has the lowest ozone design values. This site would be a prime candidate for removal, however there are EPA mandates (40CFR Subpart B 58.10.11 d) requiring the site because it supports air quality characterization for areas with relatively high populations of susceptible individuals (e.g., children with asthma). In section 2.5.3 the PG Equestrian Center was identified as a redundant site because it was well correlated with other sites. The score for PG Equestrian Center was moderate, which means that given the other criteria this site is relatively important to the network. Given these considerations, the program does not recommend removing the PG Equestrian Center site.

Table 2-11. Decision matrix for the ozone network.

SITE	DESIGN VALUES [1] (PPM)	POPULATION 2008		POPULATION DENSITY 2008		NUMBER OF PARAMETERS		CORRELATION WITH OTHER SITES		RELATIVE CONCENTRATION DIFFERENCE		OZONE DV %NAAQS		SCORE
		WEIGHT:	0.33	WEIGHT:	0.50	WEIGHT:	0.50	WEIGHT:	1.00	WEIGHT:	1.00	WEIGHT:	1.00	
		RAW	POINTS	RAW	POINTS	RAW	POINTS	RAW	POINTS	RAW	POINTS	RAW	POINTS	
Davidsonville	0.087	322819	8	784	7	2	4	0.69	9	0.14	91	1.160	83	202
Padonia	0.08	358215	10	759	7	3	7	0.59	67	0.18	57	1.067	54	201
Essex	0.085	270208	7	1804	17	12	39	0.70	8	0.13	97	1.133	75	242
Calvert	0.079	166991	3	225	2	1	0	0.66	30	0.13	95	1.053	50	179
S. Carroll	0.083	205345	4	340	3	1	0	0.65	34	0.14	92	1.107	67	199
Fairhill	0.09	150178	2	488	4	4	11	0.62	51	0.15	79	1.200	96	243
S. MD	0.082	125376	1	212	1	1	0	0.67	22	0.14	92	1.093	63	179
Frederick	0.082	224018	5	337	3	1	0	0.68	19	0.13	96	1.093	63	185
Piney Run	0.073	192030	4	64	0	13	43	0.53	100	0.16	75	0.973	25	246
Edgewood	0.091	125822	1	535	4	3	7	0.67	21	0.15	82	1.213	100	216
Aldino	0.089	137441	2	469	4	5	14	0.67	21	0.14	89	1.187	92	222
Millington	0.083	92039	0	117	1	4	11	0.64	37	0.14	90	1.107	67	204
Rockville	0.084[2]	577350	18	2011	19	4	11	0.66	29	0.13	100	1.120	71	247
HU-Beltsville	0.083	541105	17	1847	17	15	50	0.70	6	0.13	95	1.107	67	251
PG Equestrian Center	0.087	108724	1	479	4	3	7	0.71	0	0.13	96	1.160	83	191
Hagerstown	0.078	178897	3	290	2	3	7	0.68	18	0.13	97	1.040	46	174
Furley	0.067[2]	988285	33	5305	50	1	0	0.66	26	0.24	0	0.893	0	109

[1] All design values are from http://www.epa.gov/airtrends/values.html and for 2008 unless otherwise noted.
[2] Furley and Rockville did not have complete data capture for 2006-2007 and these design values were calculated with available data.

The Program should consider making the following changes suggested in section 2.5.2:

- Add highest concentration to the Hagerstown site objectives.
- Change the scale of Fairhill to urban and change the objectives from background to regional transport.
- Add the population exposure objective to HU-Beltsville.
- Change the South Carroll primary monitoring objective from highest ozone concentration to population exposure.

2.6 PAMS Network

2.6.1 Compliance with Network Design Criteria

Design criteria for the PAMS network are based on locations relative to ozone precursor source areas and predominant wind directions associated with high ozone events (40CFR58Appendix D, 5.1). There are specific monitoring objectives associated with each location. The overall design should enable characterization of precursor emissions sources within the Non-Attainment Area (NAA), transport of ozone and its precursors, and the photochemical processes related to ozone nonattainment. Specific monitoring objectives associated with each of these sites may result in four distinct site types:

Type 1 sites are intended to characterize upwind background and transported ozone and its precursor concentrations entering the area and will identify those areas which are subjected to transport.

Type 2 sites are intended to monitor the magnitude and type of precursor emissions in the area where maximum precursor emissions are expected to impact and are suited for the monitoring of urban air toxic pollutants.

Type 3 sites are intended to monitor maximum ozone concentrations occurring downwind from the area of maximum precursor emissions.

Type 4 sites are intended to characterize the downwind transported ozone and its precursor concentrations exiting the area and will identify those areas which are potentially contributing to overwhelming transport in other areas.

A Type 2 site is required for each area. Only two sites are required for each area, providing all chemical measurements are made. The PAMS network for the Baltimore NAA is described in Table 2-12. There are three PAMS monitoring stations in the Baltimore, MD NAA: the HU-Beltsville Type 1 site, Essex Type 2 site and Aldino Type 3 site. Maryland contributes one station, the HU-Beltsville Type 3 station to the Washington, DC NAA PAMS network. Note that the HU-Beltsville PAMS station serves different objectives for the Baltimore and Washington NAA's. The required PAMS monitoring locations and frequencies from the PAMS monitoring rule are provided in Table 2-13. The requirements are all being met.

Table 2-12. Monitoring details for PAMS network

SITE NAME	PAMS TYPE	PARAMETERS OBSERVED	MONITORING OBJECTIVE
Essex	Type 2	O_3	Population exposure
		VOCs	Maximum precursor emissions impact
		NO_x	Maximum precursor emissions impact
		CO	Highest concentration

SITE NAME	PAMS TYPE	PARAMETERS OBSERVED	MONITORING OBJECTIVE
Aldino	Type 3	O_3	Highest concentration
		NO_y	Population exposure
HU-Beltsville	Type 1/3	O_3	Highest concentration
		VOCs	Upwind background
		NO_y, NO_x	General/Background
		CO	General/Background

Table 2-13. Summary of required PAMS monitoring locations and frequencies (CFR40 part 58 Appendix D 5.1).

MEASUREMENT	WHERE REQUIRED	SAMPLING FREQUENCY (ALL DAILY EXCEPT FOR UPPER AIR METEOROLOGY)	STATUS
Speciated VOC	Two sites per area, one of which must be a Type 2 site	During the PAMS monitoring period: (1) Hourly auto GC, or (2) Eight 3-hour canisters, or (3) 1 morning and 1 afternoon canister with a 3-hour or less averaging time plus Continuous Total Non-methane Hydrocarbon measurement.	Met at Essex (Type 2) and HU-Beltsville (Type 3)
Carbonyl sampling	Type 2 site in areas classified as serious or above for the 8-hour ozone standard	3-hour samples every day during the PAMS monitoring period.	Met at Essex (Type 2) and HU-Beltsville (Type 3)
NO_X	All Type 2 sites	Hourly during the ozone monitoring season.	Met at Essex (Type 2) and HU-Beltsville (Type 3)
NO_y	One site per area at the Type 3 or Type 1 site	Hourly during the ozone monitoring season.	Met at Aldino (Type 3) and HU-Beltsville (Type 3)
CO (ppb level)	One site per area at a Type 2 site	Hourly during the ozone monitoring season.	Met at Essex (Type 2) and HU-Beltsville (Type 3)
Ozone	All sites	Hourly during the ozone monitoring season.	Met at Essex, Aldino and HU-Beltsville
Surface met	All sites	Hourly during the ozone monitoring season.	Met at Essex, Aldino and HU-Beltsville
Upper air meteorology	One representative location within PAMS area	Sampling frequency must be approved as part of the annual monitoring network plan required in 40 CFR 58.10.	Met at HU-Beltsville.

2.6.2 Assessment of Objective Types Assigned to Monitors

The Essex Type 2 site monitoring objective is to measure maximum precursor emissions impact for all PAMS parameters with the exception of ozone (Section 2.5.2). This location is, at times, immediately downwind of Baltimore City and industrial areas with relatively high ozone precursor emissions. The site is situated in a parking lot near a roadway and this may influence measured values of VOCs, NO_x, and CO, although fresh, well-mixed mobile emissions are prevalent throughout the area, especially during the morning rush hour.

The Aldino Type 3 site monitoring objective is to measure maximum ozone concentrations downwind of the area of maximum precursor emissions for the Baltimore NAA. This site is well suited for this objective since it is not located near major roadways or large emission sources and is downwind of Baltimore City often during the ozone season. The site measures large ozone concentrations and from 2005-2009 ozone design values were 2nd and 3rd highest for the Baltimore, MD NAA. The Edgewood site had the highest ozone design values from 2005-2009 for the Baltimore, MD NAA. The influence of the bay breeze on the Edgewood site may be partially responsible for the high ozone values observed there [Landry et. al., 2010]. Therefore Edgewood may not be representative of true downwind ozone maxima for the Baltimore NAA.

The Aldino site also measures NO_y during the ozone season. On Oct. 17, 2006, EPA finalized revisions to the PAMS monitoring rule that reduced some of the minimum requirements including NO_y. NO_y monitoring is now only required at one site per PAMS area, either a Type 1 or Type 3. Historical data completeness for NO_y at Aldino during the ozone season has been poor due to a combination of instrument operational problems and resource limitations during the ozone season. Since this measurement is no longer required, the program recommends that NO_y be discontinued at Aldino.

HU-Beltsville is designated as a Type 1 site for the Baltimore NAA. The objective with respect to the Baltimore NAA is to measure background and transported ozone and precursor emissions. Originally, this Type 1 PAMS station was sited in Fort Meade, approximately 5km to the East-Northeast, but was moved in 2004 due to increased security measures implemented at the military base. Both locations have relatively similar land usage and emission characteristics, so significant differences in air quality are not likely. This location is ideally suited to measure transport between the Washington and Baltimore metropolitan area given the right conditions. Washington and Baltimore are close together (only 25 km apart) and there has been an increase in development within the corridor which may distribute pollution homogenously throughout the area. These urban growth characteristics make it difficult to assess how well the HU-Beltsville site meets the upwind PAMS site objectives. Currently the monitoring objective for VOC's at HU-Beltsville is population exposure. The population exposure objective is for SLAMS monitors and since VOC's are part of the PAMS network this objective should be changed to the Type 1 PAMS objective of upwind background.

HU-Beltsville is designated as a Type 3 PAMS site for the Washington NAA. The objective with respect to the Washington NAA is to measure maximum ozone concentrations downwind of the area of maximum precursor emissions. HU-Beltsville currently does not observe the highest ozone concentrations in the Washington NAA, although that does not

necessarily mean it is not located downwind of the area a maximum precursor emissions on high ozone days. This PAMS station was originally located at Fort Meade, as mentioned previously, which did experience large ozone values. It is unlikely that the move resulted in significant changes in ozone values. There have been significant local and regional NO_x reductions since 2003, possibly impacting the ozone values in the HU-Beltsville area. In addition, HU-Beltsville (and Fort Meade) is located in a major traffic corridor (MD Route 29, I-95, and the Baltimore-Washington Parkway) between the two metropolitan areas which could potentially suppress ozone levels. Virginia contributes a Type 1 site and DC contributes at Type 2 site to the Washington, DC NAA and these networks will be assessed in those states' 5-year Network Assessments.

The program examined wind roses from 2008-2009 summer months (Appendix A.2) at HU-Beltsville and these show winds originating from the west, southwest and northwest which does not place HU-Beltsville downwind of Washington, D.C., however, these years may not be representative of typical conditions and the wind roses actually should be examined for conditions on days when the ozone NAAQS was exceeded. McCarthy et al. [2008] recommended changing the location of HU-Beltsville in their Draft Network Assessment for the National PAMS program based upon observations that HU-Beltsville is not capturing the areas with the highest ozone concentration in recent years. As mentioned previously, this does not necessarily mean HU-Beltsville is not located downwind of the area of maximum precursor emissions. It is recommended that HU-Beltsville's designation as a Type 3 PAMS site for the Washington NAA is re-evaluated using Radar Wind Profiler data of aloft winds over HU-Beltsville on high ozone days.

2.6.3 Identifying Redundant Sites

The goals of the three PAMS sites are different and the distance between sites is far enough that these sites are not considered redundant.

2.6.4 Identifying New Sites Needed

The program currently meets the monitoring requirements for the minimum number of PAMS sites per PAMS area. No additional sites are under consideration.

2.6.5 Effect of New or Proposed Network Design Regulations

No revisions to the PAMS monitoring rule have been proposed or are scheduled to be proposed in the near future.

2.6.6 Recommended Network Changes

The Region III PAMS network was jointly developed by the states and the Region in the mid-nineties. Since that time, site characteristics may have changed dramatically for a wide variety of reasons. There may have been shifts in population and/or urban development. Implementation of strict emissions control programs may have changed emission patterns and the reactivity of hydrocarbon precursor mixtures. Additionally, Type 3 sites were originally intended to capture one-hour peak ozone concentrations. The regulatory emphasis is now on eight-hour exposures at a much lower threshold and further revision to the ozone NAAQS are

expected in August 2010. All of these issues raise questions as to the relevancy of the original PAMS goals and requirements. The answers to these questions are beyond the scope of this document.

The PAMS network in the northeast extends from Northern Virginia to Maine and cannot be realistically assessed on a piecemeal, state-by-state basis as is attempted here. This effort should be undertaken as a multi-regional or national level effort. EPA began such an effort in 2007 and a draft report was issued in September 2008 [McCarthy et al. 2008]. The review of this report was never completed due to resource limitations and a shift in priorities to NAAQS reviews. It is recommended that the national level assessment be revisited after the revised ozone NAAQS is promulgated and a new ozone implementation policy has been issued.

The program recommends changing the VOC monitoring objective at HU-Beltsville from population exposure to upwind background in order that the objectives are consistent with the PAMS Type 1 designation at HU-Beltsville.

2.7 $PM_{2.5}$ Network

2.7.1 Compliance with Network Design Criteria

Basic design criteria for $PM_{2.5}$ include: the minimum number of SLAMS/NCore sites/monitors to be operated, their monitoring objectives and spatial scales, and the minimum number of continuous and chemical speciation monitors that must be operated., see Appendix D to part 58, 4.7. The minimum number of SLAMS $PM_{2.5}$ monitors required in each of the inter-state MSA's (see Appendix, Figure B-1 for locations of MSA's) located in Maryland is shown in Table 2-14, along with the number deployed in each state comprising the individual MSA. The minimum number of sites is either met or exceeded in each MSA. In addition to the SLAMS ozone monitors, each state is required to operate at least one NCore site. The NCore sites are expected to compliment the SLAMS $PM_{2.5}$ data collection and both types of sites can be used to meet the minimum network requirements. Maryland currently operates two NCore sites, Piney Run and HU-Beltsville. The rest of the requirements are summarized in Table 2-15. A discussion of monitoring objectives and special scales can be found in Section 2.7.2.

The requirement for continuous monitors currently is not being met in the Baltimore MSA or in the Wilmington-Newark, DE-MD MSA, although this is due to a technicality. Four of the program's continuous monitors were designated as special purpose monitors (SPM) while being tested as FEM's. One of these monitors is in the Baltimore, MD MSA, one in the Wilmington-Newark, DE-MD MSA and two are in the Washington DC-MD-VA MSA. SPM's cannot be used to satisfy the requirement since they are temporary by definition. However, the continuous data is still being collected and is used to report the AQI and to support near real-time air quality mapping on AIRNow and other websites. Maryland currently contributes no continuous monitors to the Washington, DC-MD-VA for the same reason, although this MSA meets the requirements through other continuous monitors operated by DCDOE and VADEQ. After the expiration of the test period (anticipated by 8/22/10) the monitors will be redesignated and the requirements will again be formally met.

Table 2-14. Number of $PM_{2.5}$ SLAMS Sites Required by Part 58 4.7.1 (a), Compared to Number Deployed (based on TABLE D–5 OF APPENDIX D TO PART 58. PM2.5 Minimum Monitoring Requirements).

MSA Name	# FRM Monitors Deployed By State					Total Monitors	Population[A]	Required >= 85% NAAQS[B]	Excess FRM Monitors[C]	Required Continuous	Deployed Continuous
	DE	DC	MD	VA	WV						
Baltimore, MD	0	0	9	0	0	9	2552994	3	6	2	0
Hagerstown, MD-Martinsburg, WV	0	0	1	0	0	1	131923	1	0	1	1
Washington, DC-MD-VA	0	3	3	4	0	10	4923153	3	7	2	2
Wilmington-Newark, DE-MD	4	0	1	0	0	5	586216	2	3	1	0

A – Population was obtained from AQS. MSA population is used together with the MSA's max design value to determine the number of required monitors

B – Based on tables available at http://www.epa.gov/airtrends/values.html. All areas had their maximum site >= 85% of both $PM_{2.5}$ NAAQS.

C – Excess monitors = total monitors deployed – number required.

Table 2-15. Monitoring Requirements for $PM_{2.5}$ Networks

REQUIREMENT	APPENDIX D TO PART 58 REFERENCE	STATUS
Minimum number of SLAMS/NCore monitors	4.7.1(a), 3(a), 3(b)	Met, Table 1
At least one population oriented site at location of max concentration	4.7.1 (b) (1)	Met at Oldtown or Fire Dept. 20/Southeast P.S, but no site has been designated as "Highest Concentration" in the Baltimore MSA.
For areas required to have more than 1 SLAMS, a monitor in an area of poor air quality	4.7.1 (b) (2)	Met, list by area (see table 1)
Most monitoring in urban areas should be neighborhood scale	4.7.1 (c)	Met, all are neighborhood scale except for the Fairhill (regional) and HU-Beltsville (regional).
Continuous monitoring	4.7.2	Not met in the Baltimore MSA
Background and transport sites	4.7.3	Not met, a background monitor is sited in Fairhill. But no site has been designated as a transport site. Could use the IMPOVE monitor at Piney Run.
Chemical Speciation	4.7.4	Met, sited at Essex

2.7.2 Assessment of Objective Types Assigned to Monitors

These site objective types are required for $PM_{2.5}$ monitoring: highest/maximum concentration, population exposure, background, and transport. There are 14 $PM_{2.5}$ FRM

monitoring locations in Maryland and their objectives and scale of representativeness are summarized in Table 2-16.

The program does not have a formally designated transport site. However, an IMPROVE monitor and a continuous $PM_{2.5}$ monitor are both currently being operated at the Piney Run site and can be considered to technically fulfill this objective even though they are not FRM's or FEM's. The requirement for a transport site will be formally met by January 1, 2011, when the program deploys an FRM or FEM monitor at the Piney Run NCore site to meet the requirement for measuring PM_{course}.

Maximum concentration sites are located to determine the highest concentrations; their scale of representation is typically not background/transport. Population oriented sites have neighborhood or urban scales of representation, should not be influenced by single sources, and are located where large numbers of people live, work, or play [Watson,1997]. Background sites have urban or regional scales of representation, should measure the lower concentrations in the state/region, should not be along transport paths and should be located away from major sources, [Watson, 1997]. Objective types were evaluated according to those characteristics as follows.

Table 2-16. Monitor Objective Types and scales assigned to monitors in the Maryland $PM_{2.5}$

SITE NAME	MSA	PRIMARY OBJECTIVE	SCALE
Bladensburg	Washington, DC-MD-VA	Exposure	Neighborhood
Edgewood	Baltimore, MD	Exposure	Neighborhood
Essex	Baltimore, MD	Exposure	Neighborhood
Fairhill	NA	Background	Regional
Glen Burnie	Baltimore, MD	Exposure	Neighborhood
Hagerstown	Hagerstown, MD-Martinsburg, WV	Exposure	Urban
HU-Beltsville	Baltimore, MD	Exposure	Urban
NE Police	Baltimore, MD	Exposure	Neighborhood
NW Police.	Baltimore, MD	Exposure	Neighborhood
Oldtown	Baltimore, MD	Exposure	Middle
Padonia	Baltimore, MD	Exposure	Neighborhood
PG Equestrian Center	Washington, DC-MD-VA	Exposure	Neighborhood
Rockville	Washington, DC-MD-VA	Exposure	Neighborhood
Fire Dept. 20	Baltimore, MD	Exposure	Neighborhood

Note, AQS Id's for the above sites may be found in Appendix Table B-1.

No sites in the Maryland $PM_{2.5}$ network have been designated as maximum concentration sites for any of the MSA's contained within the state. Maximum design values for the Baltimore, MD MSA for both 24-hour and annual NAAQS have consistently been measured at both Oldtown and Fire Dept. 20, (see Table 2-19 for design values) indicating that one of these should be designated as the maximum concentration site. The other sites within Baltimore City measured concentrations nearly the same as Oldtown and Fire Dept. 20; and their concentrations are highly correlated with these sites as well, Table 2-19, suggesting that no other areas of the city might experience higher levels. Evaluation of CMAQ model results [Piety, 2006 shown in Figure 2-11], supports the designation of one of the Baltimore City sites as the maximum

concentration site for the Baltimore MSA. Further evaluation of the CMAQ model results with respect to the other MSA's in Maryland, suggest that: 1) Hagerstown should be designated as the maximum concentration site for the Hagerstown, MD-Martinsburg, WV, MSA; 2) one of the Washington, DC monitors should be designated as the maximum concentration site for the Washington, DC-MD-VA MSA, and 3) one of the Delaware sites should be designated as the maximum concentration site for the Wilmington-Newark, DE-MD MSA, see Appendix, Figure B-1 for map showing MSA's.

Many of the monitors are located within or near Baltimore City and, hence, are located 'where a substantial number of people … spend a significant fraction of their day', Part 58.1 To better determine the population around monitoring sites, the program used output from EPA's network assessment tool 'area served' (discussed in Section 2.4.6) that assigned population density to the area served, a quantity which it calculated for each $PM_{2.5}$ monitoring site, Table 2-19. Most sites associated with the highest population densities are assigned the population exposure objective type. Because the population densities associated with the Edgewood, Hagerstown, Padonia, and PG Equestrian Center sites fall in the lower third of the site list, they are less suitable for their assigned population exposure objective type than the other sites, a fact which is reflected in the scoring of their relative value, Table 2-19.

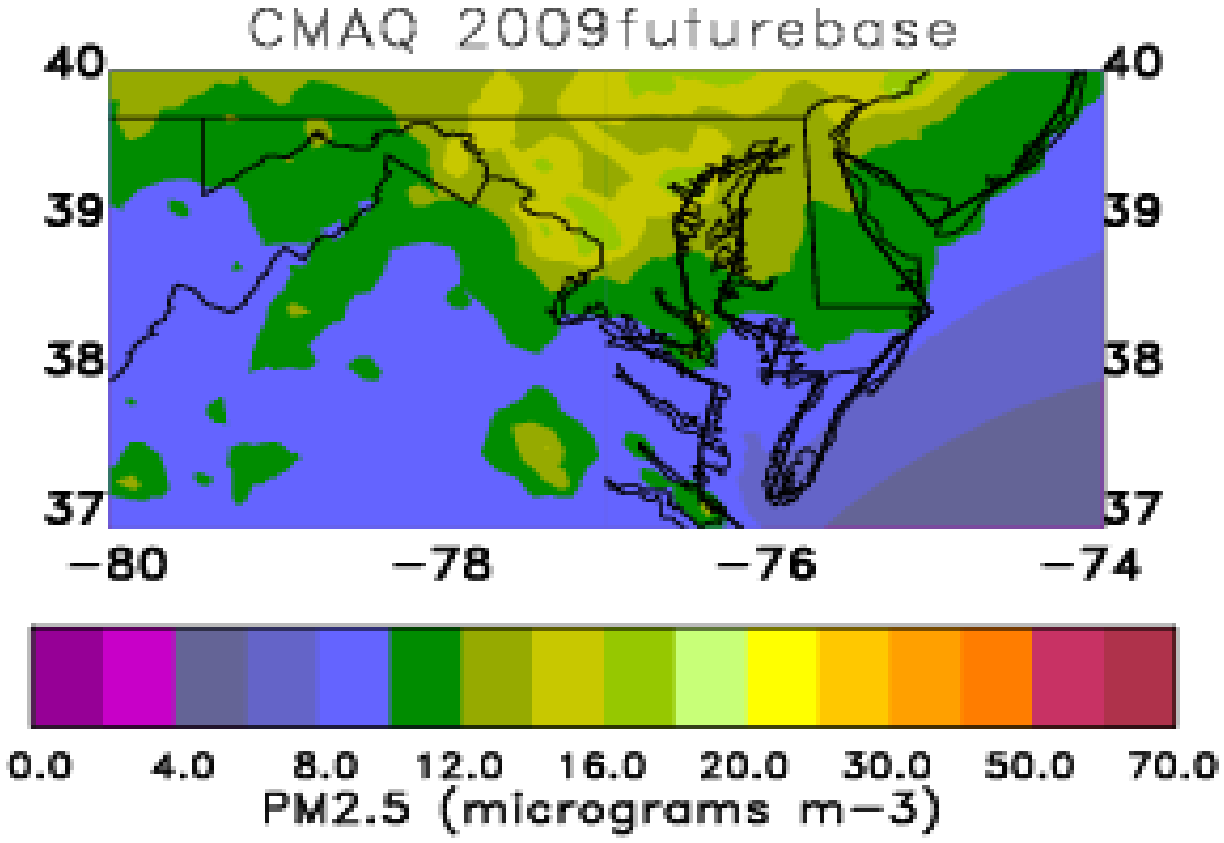

Figure 2-11. $PM_{2.5}$ Concentration predictions from the CMAQ, 2009 future base case run from [Piety, 2006].

All population oriented sites seem to have the proper spatial scales, either urban or neighborhood, with possible exception of the Fire Dept. 20 site. Several nearby major sources are located to its SSW, Figure 2-13. Those sources may have a disproportional influence on the amount of $PM_{2.5}$ measured at Fire Dept. 20 by virtue of their location and source strength; hence, the assignment of neighborhood scale to Fire Dept. 20 maybe questionable.

Provisions in CFR 58.10(e) specifically require the program to identify needed changes to population-oriented $PM_{2.5}$ sites. This requirement was intended to account for population that has grown and shifted from urban to suburban areas during the last few decades [EPA, 2006]. Changes in population occurring since monitoring of $PM_{2.5}$ began in 1999 are considered in this section. The program was limited to using population data available at the county level to make this part of the assessment. The program is also aware of the limitations (i.e. they are only estimates not actual population counts) of using the 2008 Maryland county-level population estimates obtained from the US Census Bureau (http://quickfacts.census.gov/qfd/states/24000.html), Figure 2-12. Census track or zip code level population would have been more appropriate for evaluating site locations by population[10], but the U.S. Census Bureau does not estimated population at that level of resolution. Nevertheless, seeming inadequacies do emerge. Modest growth or decreases in population density have taken place in the metropolitan areas where most of the $PM_{2.5}$ monitors are located, while the population density has increased most in Frederick, Queen Anne's, and the Southern Maryland counties. The 2010 census results will be used to make the final decisions about moving monitors from the urban areas to those counties.

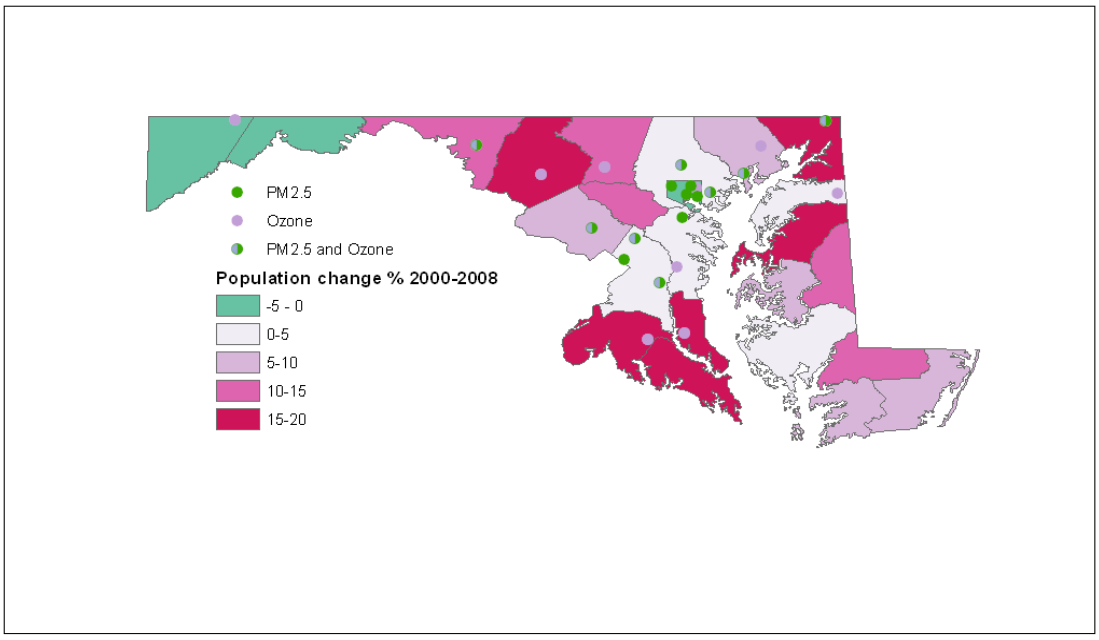

Figure 2-12. Percent change in Maryland population from 2000-2008, along with locations of monitoring sites. Note that percent change = (Pop2008 - Pop2000)/Pop2000

[10] Data at the sub-county level of resolution could better be used to locate a monitor nearest the area of highest population.

The network's only background site is Fair Hill in Northeastern Maryland. Its regional scale does not appear to be compromised by nearby major sources, Figure 2-13. Fair Hill measured the lowest or second lowest design values during 2004-2006, 2005-2007, and 2006-2008, consistent with what is expected of a background site. Wind patterns at Fairhill are also consistent with those of a background site, since the wind blows primarily from the northeast, with summer winds from the south through the west being somewhat frequent. Hence, the wind experienced there is usually not along the transport path (primarily downwind from Baltimore City) a fact which would make it a regional transport site [Watson, 1997].

With the exception of the designation of maximum concentration and transport site types and the operation of a continuous monitor in the Baltimore and Wilmington-Newark, DE-MD MSA's, the network meets the federal monitoring requirements for $PM_{2.5}$. However, the program should consider changing some objectives and scales relative to the comments in this section.

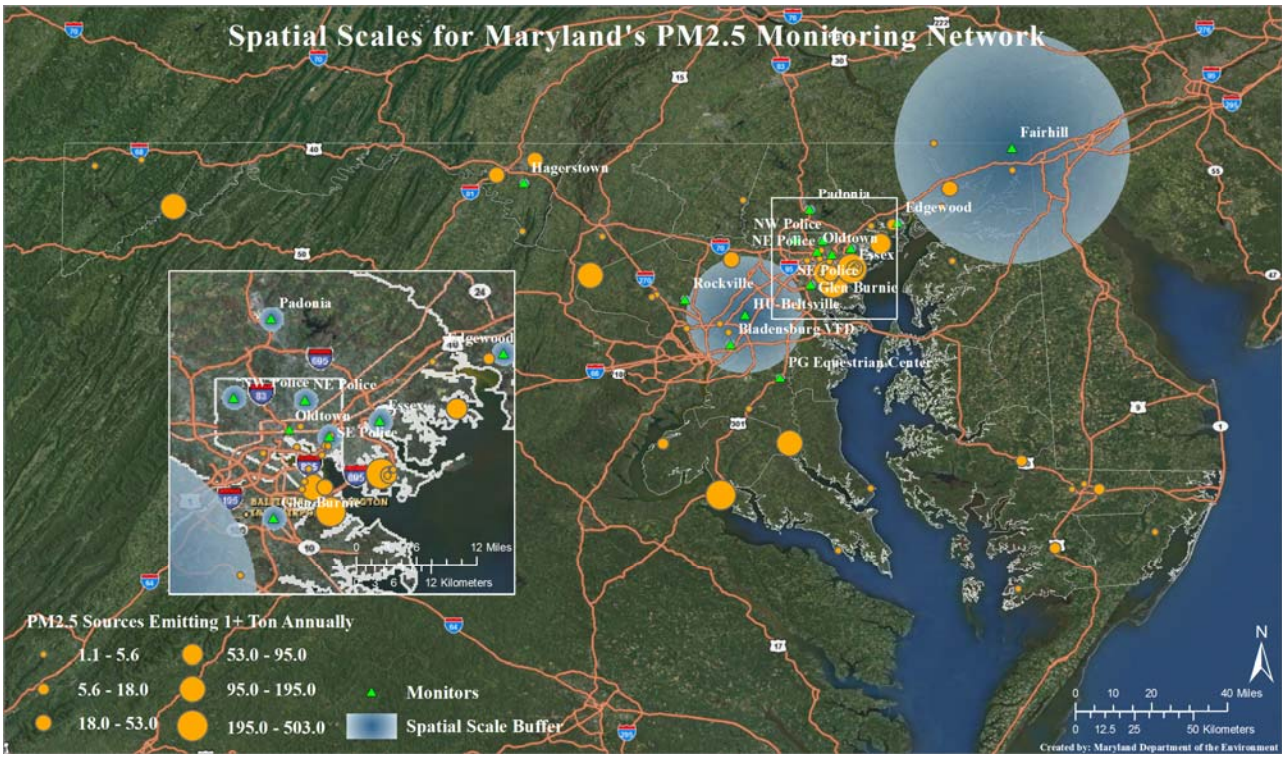

Figure 2-13. Locations of $PM_{2.5}$ SLAMS FRM monitors in Maryland with major point sources, major highways and scales.

2.7.3 Identifying Redundant Sites

The methodology used by the program to determine which existing $PM_{2.5}$ sites are candidates for relocation or removal is described in this section. Appropriate calculations were made to determine which sites are redundant (i.e. measuring nearly the same concentrations of $PM_{2.5}$). However, recommendations for moving or removal of sites were made only after the

candidate sites were ranked according to their value relative to all the other sites in the network, see Section 2.7.6. Three sites were identified as candidates for moving/removal as described below.

All Maryland FRM monitors collecting data every day or every 3rd day during the years 2006-2008 were used for this part of the assessment. Data collected at nearby out-of-state sites in Delaware, Washington, DC, and Virginia was also included[11], see Figure 2-14. Data capture was at least satisfactory (> 75%/quarter) for most sites with these exceptions: Bladensburg VFD insufficient 4th quarter, 2006; McMillan, DC insufficient 1st quarter 2008; and Columbia Pike, VA insufficient 2nd quarter, 2008; however, these deficiencies were judged as not large enough to prevent their use in this part of the assessment.

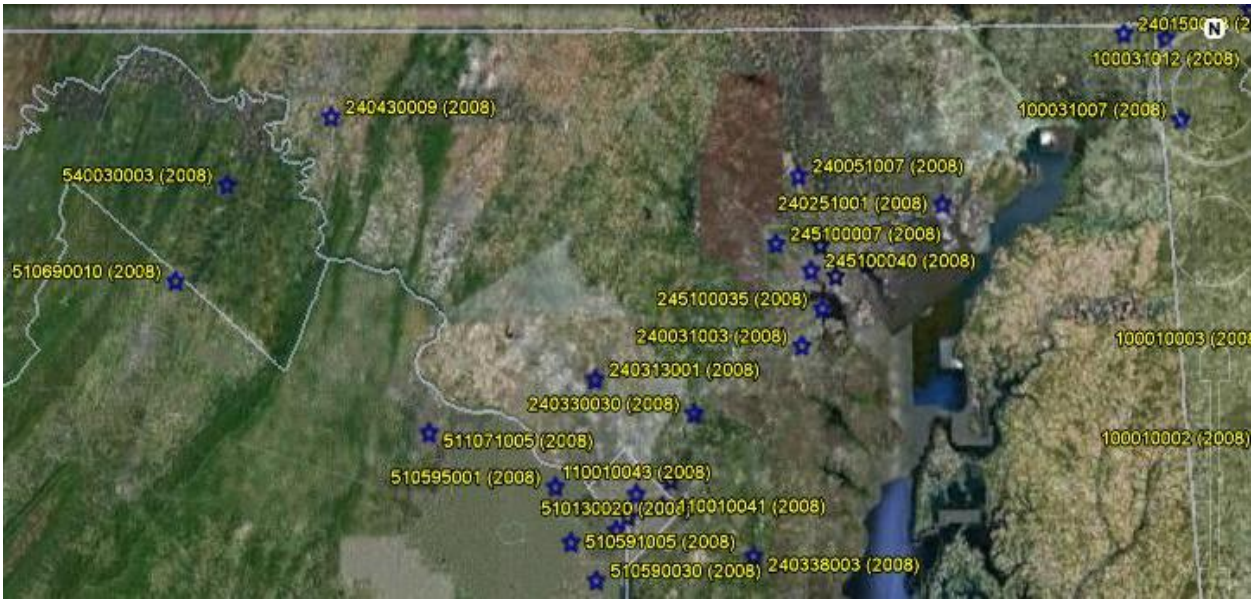

Figure 2-14. $PM_{2.5}$ sites used in the redundant sites assessment (see appendix Table B.1).

Calculations included the squared correlation[12] coefficient and the mean relative percent concentration difference[13] for all pairs of sites in the network as expanded to include nearby out-of-state sites. It was necessary to supplement the correlation coefficients with the average relative percent concentration differences, because the squared correlation coefficients are only a measurement of linearity; well correlated data site pairs may nevertheless have significantly different values. Both calculations were done at the site level, yielding the minimums, maximums, and averages, Table 2-17, needed for the purpose of the decision matrix in section

[11] Originally, 2 Southern Pennsylvania sites (420010001, 420450002) a Virginia site (510690010) and a West Virginia site (540030003) were included but were dropped, because correlations with the Maryland sites were so poor. The Virginia site had unacceptable data capture.

[12] All Pearson correlation coefficients were calculated by STATISTICA and were significantly different from zero at the .05 level.

[13] Relative difference for a single pair of measurements = $(conc_{site1} - conc_{site2})/.5*(conc_{site1} + conc_{site2})$.

2.7.6. To summarize the results, the maximum inter-site distance was 186 kilometers between the Hagerstown site and Delaware's Martin Luther King site. The minimum inter-site distance was 5 kilometers between Old Town and Fire Dept. 20. One third of the inter-site distance pairs were within 50 kilometers. The highest correlation was calculated for the Oldtown – Fire Dept. 20 site pair (.98) while the lowest was calculated for the Fairhill – McMillan, DC pair (.55). Forty-four percent of the squared correlation coefficients were greater than 0.8, and 8% were greater than 0.9. The lowest average relative percent concentration difference was calculated for the Oldtown – Fire Dept. 20 site pair (7%) while the highest was calculated for the Rockville – MLK Blvd, DE site pair (32%). Twenty percent of the average relative percent concentration differences were less than 15%. The squared correlation coefficients were found to be negatively correlated with both the inter-site distances and the average relative percent concentration differences, although there were some outliers.

Table 2-17. Summary Statistics for inter-site distance, r^2, and relative percent concentration difference

VAR	NUM	MEAN	MINIMUM	MAXIMUM
Dist (kilometers)	245	68.40	5.05	186.47
r^2	245	0.79	0.55	0.97
Avg. Rel. % difference	245	19	7	32

Sites that measure nearly the same concentrations of $PM_{2.5}$ are those that are both highly correlated (large r^2) and have the smallest inter-site average relative percent concentration differences. The site-pairs having the 20 highest correlations are listed in Table 2-18, together with their distances and average relative percent concentration differences. All site pairs have correlations of at least 0.9. Fire Dept. 20 appears as a member of the two most correlated pairs and appears as a member of six of the twenty inter-site pairs in. Additionally, it is highly correlated with all the sites in and near to Baltimore City. Bladensburg VFD is the third most correlated, and appears in five of the site pairs. NE Police is in the fourth and fifth most correlated pairs and appears in four pairs of the top 20. The rankings and frequency of appearance suggest that the Fire Dept. 20, NE Police and Bladensburg VFD sites are redundant and are good candidates for removal or relocation. When EPA's removal bias tool was applied, this result was not verified, as was the case with similar work completed for the ozone network, Section 2.5.3. This because the $PM_{2.5}$ data bundled with the removal bias tool was missing five $PM_{2.5}$ sites. Use of the removal bias tool without those sites would have distorted the results.

Table 2-18. Twenty most correlated site pairs in the Maryland $PM_{2.5}$ Network

PLACE	SITE1	SITE2	DISTANCE	R^2	AVGERAGE % RELATIVE DIFFERENCE
1	Oldtown	Fire Dept. 20	5.1	0.965	7
2	NE Police	Fire Dept. 20	6.6	0.964	10
3	34th. and Dix Streets, DC	Bladensburg, VFD	5.3	0.962	9
4	NE Police	NW Police	8.9	0.957	9
5	NE Police	Oldtown	5.1	0.956	10
6	NW Police	Padonia	13.8	0.947	10
7	NE Police	Padonia	14.0	0.946	10
8	Essex	Fire Dept. 20	6.8	0.946	10
9	Essex	NE Police	9.9	0.939	11
10	Park Services Office ,DC	Bladensburg, VFD	10.9	0.936	10
11	Bladensburg, VFD	S 18th and Hayes St, VA	14.4	0.934	11
12	NW Police	Oldtown	8.6	0.928	11
13	Glen Burnie	NE Police	19.4	0.923	11
14	NW Police	Fire Dept. 20	13.4	0.921	13
15	Essex	Oldtown	11.3	0.915	11
16	Glen Burnie	Fire Dept. 20	14.9	0.911	12
17	Bladensburg, VFD	Lee District Park, VA	24.0	0.906	16
18	HU-Beltsville	S 18th and Hayes St, VA	27.0	0.904	16
19	Bladensburg, VFD	Lewisville Pike, VA	23.0	0.902	14
20	Padonia	Fire Dept. 20	20.6	0.900	15

Note: out of state monitors are identified by DC or VA.

2.7.4 Identifying New Sites Needed

While the $PM_{2.5}$ network was found to comply with regulations governing the minimum number of SLAMS/NCore sites and the assessment demonstrated that redundant sites may exist, there may be locations where new sites are needed to better characterize $PM_{2.5}$ air quality throughout the state of Maryland. EPA developed a tool to help the states assess whether new sites were needed in a network. The 'new sites' tool examines the relationship between each pair of $PM_{2.5}$ monitoring sites in the USA and determines if there are enough differences between the sites to suggest a new site, see Section 2.5.4 for details about the 'new sites' tool. The criteria used to determine the differences between a pair of sites are:

- Maximum Pearson correlation coefficient (r^2),
- Minimum distance between the sites,
- Minimum concentration difference between sites,
- Probability of exceeding 85% of the 24-hour NAAQS for the pollutant.

The tool was used to find site pairs that are poorly correlated or show large differences in concentrations. In Maryland, all areas had more than a 50% probability of exceeding the 24-hour $PM_{2.5}$ NAAQS, with exception of the Frederick County area.

When the tool was parameterized to avoid the generation of redundant sites (i.e., those with r^2's < 0.9 and exceedance probabilities > 0%) no new $PM_{2.5}$ sites were suggested, even when the chosen concentration differences ranged from 2 – 5 $\mu g/m^3$ and the inter-site distance was set to be any distance greater than zero. Anywhere from fourteen to twenty-two new sites were suggested when the tool was parameterized by high correlations (r^2 < .95) and probabilities of exceedance > .20%. All of the suggested new sites were located near, and were highly correlated with existing sites. Therefore, they were considered as redundant and rejected from further consideration.

2.7.5 Effect of New or Proposed Network Design Regulations

None have been proposed for $PM_{2.5}$ as of this writing.

2.7.6 Recommended Network Changes

Modifications to the $PM_{2.5}$ network suggested up to this point in the network assessment, particularly the removal of sites, need to be considered in relation to the candidate site's overall value to the $PM_{2.5}$ network, as well as, EPA regulations governing network design (section 2.7.1) and System Modification, 40 CFR Part 58.14. In order to aid in the understanding of the overall effect of removing these candidate sites/monitors, a decision matrix was developed to determine the relative value of each site in the $PM_{2.5}$ network. The decision matrix ranks the sites according to a weighted score which is the sum of normalized, individual criterion scores multiplied by a subjectively determined weighting factor:

$$\text{Score} = 100 * \text{weight} * (V_i - V_{min}) / (V_{max} - V_{min})$$

Following Cavender, 2009. Here the weights were chosen subjectively, and V_i,V_{min}, and V_{max} represent the value given to the criteria with their minimum and maximum values, respectively. The criteria chosen for the network were:

- 2008 estimated population living within the area served by each site – important relative to the population oriented monitoring requirement but not highly weighted because of the reliability of the 2008 population estimates.

- Percent of 24-hour NAAQS – monitors that measure over or near the NAAQS are more important.

- Number of parameters measured at the site – relevant to decisions about site closure but not highly weighted, because the $PM_{2.5}$ monitor could be removed without closing the site.

- Site-average squared correlation coefficient and site-average relative percent concentration difference – needed to quantify uniqueness of the concentrations measured relative to other sites/monitors.

- Relative population density change from 2000 to 2008 – sites in growth areas are more valuable for keeping than those whose population is flat or declining – not highly weighted as explained above, Table 2-19.

- Number of years in operation was not used as a criterion, since the vast majority of the monitoring began in 1999.

Table 2-19. Decision Matrix for the $PM_{2.5}$ Network.

Site	2008 Design Values		Population 2008		Number of parameters		Correlation with Other Sites		Relative Conc. Difference		PM_{24}Hr DV %NAAQS		Population density 2000-2008		Score
			weight:	0.33	weight:	0.50	weight:	1.00	weight:	1.00	weight:	1.00	weight:	0.50	
	24-Hr	Annual	raw	points	raw	points	raw	points	raw	points	raw	points	raw	points	
Bladensburg, VFD	31	13.3	317660	12	1	0	0.904	12	0.18	26	89	50	3%	15	116
Edgewood	29	11.7	251938	9	2	3	0.884	36	0.20	63	83	25	9%	35	171
Essex	33	13.6	180367	5	12	34	0.896	21	0.18	34	94	75	4%	19	188
Fairhill	28	12.1	173563	5	3	6	0.851	75	0.22	95	80	13	14%	50	243
Glen Burnie	34	13.3	500831	21	2	3	0.912	2	0.16	1	97	88	6%	23	138
Hagerstown	30	12.2	348577	13	2	3	0.83	100	0.23	100	86	38	12%	44	299
HU-Beltsville	30	11.6	396161	16	17	50	0.901	15	0.18	31	86	38	7%	26	176
NE Police	33	12.8	282644	10	2	3	0.914	0	0.16	0	94	75	0%	6	94
NW Police	33	12.9	539562	23	1	0	0.903	13	0.17	9	94	75	4%	18	138
Oldtown	34	14	270406	9	9	25	0.884	36	0.19	39	97	88	-2%	0	197
Padonia	32	12.6	267195	9	2	3	0.909	6	0.17	10	91	63	7%	27	119
PG Equestrian Center	27	11.9	453629	19	2	3	0.877	44	0.19	44	77	0	10%	38	148
Rockville	28	11.3	731042	33	2	10	0.889	30	0.20	59	80	13	9%	35	179
Fire Dept. 20	35	14	84587	0	2	8	0.9	17	0.19	37	100	100	1%	9	171

Notes: 'Population 2008' consists of estimates made by EPA that were bundled into their 'area served' tool.

The 'correlation with other sites' was calculated for each $site_i$ by averaging each of the site-pair correlations in which $site_i$ appeared. The 'relative conc. difference' was calculated for each $site_i$ by averaging each of the site-pair relative concentration differences in which $site_i$ appeared.

Points/score = weight*100*(raw-min (raw))/ (max (raw)-min (raw)) except for 'correlation with other sites' whose points = weight*100*(raw-**max** (raw))/ (max (raw)-min (raw)), because the less correlated a site is with its neighbors the more unique and valuable it is.

Scores derived from the decision matrix, Table 2-19, range from a high of 299 at Hagerstown to a low of 94 at NE Police. The three lowest scoring sites, NE Police (94), Bladensburg VFD (116) and Padonia (119) should be considered as candidates for removal. Both the NE Police and Bladensburg VFD were also identified as redundant in the analysis presented in Section 2.7.3. Padonia was not previously identified as redundant and is more geographically isolated than the other sites, thereby enhancing its overall importance to the network (although this is not reflected in the decision matrix score). Fire Dept. 20 was also identified as redundant

in Section 2.1.3 although this is not consistent with its decision matrix score, primarily due to its high design value. However, Fire Dept. 20's location relative to major sources compromises its assigned neighborhood scale, making its scale either micro or middle scale. Therefore, its objective type could not be population exposure; making it less useful for determining compliance with the annual NAAQS. The higher scoring and nearby Oldtown site has nearly the same design values, so it could be used instead of Fire Dept. 20.

These proposed removals must leave the network in compliance with Part 58 4.7.1 (a) as discussed previously. Since the Baltimore MSA has six excess monitors, removal of two of them will leave the network in compliance. Removal of Bladensburg VFD from the Washington, DC-MD-VA MSA would also leave the area with six excess monitors. The monitor at River Terrace Elementary School in Washington, D.C. is only 5.3 kilometers away and is representative of PM-2.5 concentrations throughout the area.

Federal regulations specify several situations where the state or local agency can be fairly confident a request for monitor shutdown will be approved [40 CFR 58.14(c)], these situations are described in Table 2-20. Regardless of the outcome of the four tests listed below, the Regional Administrator may approve any monitor shutdown on a case-by-case basis. Although all Maryland $PM_{2.5}$ sites were attaining both NAAQS by the end of 2008, none meet all of the tests listed in Table 2-20.

Table 2-20. Status of tests for removal for candidate sites

TEST FOR REMOVAL	STATUS
The monitor showed attainment during the previous five years.	Not met, except at Padonia
The probability is less than 10% that the monitor will exceed 80% of the applicable NAAQS during the next three years based on the concentrations, trends, and variability observed in the past.	Not met, by any candidates
The monitor is not specifically required by an attainment plan or maintenance plan	Met
The monitor is not the last monitor in a nonattainment area or maintenance area that contains a contingency measure triggered by an air quality concentration in the latest attainment or maintenance plan adopted by the state and approved by EPA.	Met

In summary, recommendations for changes to the $PM_{2.5}$ network are as follows:

- Designate Oldtown a maximum concentration site for the Baltimore MD, MSA.
- Designated Hagerstown the maximum concentration site for the Hagerstown, MD-Martinsburg, WV, MSA.
- Designate one of the Washington, DC monitors as the maximum concentration site for the Washington, DC-MD-VA.

- Designate one of the Delaware sites as the maximum concentration site for the Wilmington-Newark, DE-MD.
- Officially designate Piney Run as a regional transport site once an FRM/FEM is deployed there.
- Deploy existing, continuous, special purpose monitors to satisfy the continuous, monitoring requirements in the Baltimore and Wilmington-Newark-DE-MD MSA's when the SPM status expires in August, 2010.
- Establish new sites in the counties where population has increased: Calvert, Frederick, Queen Anne's, and Saint Mary's.
- Decide which of these to shut down: NE Police, Fire Dept. 20 and Bladensburg VFD.
- Change the scale and objective of Fire Dept. 20 to 'middle' scale and 'source oriented' if the request to shut down the site is not approved.

2.8 PM_{10} Network

2.8.1 Compliance with Network Design Criteria

Basic design criteria for PM_{10} networks include the minimum number of SLAMS sites/monitors to be operated and their monitoring scales, see 40CFR58 Appendix D. Maryland's PM_{10} Network satisfies the requirement for the number of SLAMS monitors, as shown in Table 2-21, with two monitors in the Baltimore, MD MSA..

Table 2-21. Number of PM_{10} SLAMS Sites Required by Part 58 4.6 Compared to Number Deployed (Based on Table D–4 of appendix D to part 58. PM_{10} Minimum Monitoring Requirements).

MSA Name	Monitors Deployed By State						MSA Population[A]	required <= 80% NAAQS[B]
	DE	DC	MD	VA	WV	Total Monitors		
Baltimore, MD	0	0	2		0	2	2552994	2 - 4
Hagerstown, MD Martinsburg, WV	0	0	0	0	0	0	131923	0
Washington, DC-MD-VA	0	1	0	2	0	3	4923153	2 - 4
Wilmington-Newark, DE-MD	1	0	0	0	0	1	586216	1 - 2

A – Population was obtained from AQS. MSA population is used together with the MSA's max design value to determine the number of required monitors

B – Based on 2006 – 2008 design values in tables available at http://www.epa.gov/airtrends/values.html, all areas' maximum site concentration were <= 80% of the PM_{10} NAAQS, which qualified all of them for the 'low concentration category'. The greatest percent of the PM_{10} NAAQS was 35% at Fire Dept. 20 for 2007. Collocated monitors are not counted in the above.

Data capture for Maryland's FMC, Fairfield monitor was incomplete, because it was shutdown and moved to Glen Burnie.

2.8.2 Assessment of Objective Types Assigned to Monitors

In contrast with design requirements for other pollutant networks, there are no required objectives or objective types for PM_{10} monitoring. However, the monitoring scales are limited to micro, middle, and neighborhood. Both of the PM_{10} monitors in the Baltimore, MD MSA, Glen Burnie and Fire Dept. 20, are assigned to the neighborhood scale with population exposure as the monitoring objective. The monitors located at these sites are manual FEM's operated on a one-in-six day schedule.

In addition to the FEM PM_{10} monitors being operated in Maryland, a continuous monitor[14] is deployed at the Essex site in the Baltimore MSA. This monitor, as it is currently configured, has neither FRM nor FEM status. Therefore, it is of questionable usefulness and is recommended to be shut down.

2.8.3 Identifying Redundant Sites

Because the minimum number of PM_{10} sites is operating in the Baltimore MSA, no sites can be removed. However, to test whether one of the two sites should be moved, the inter-site squared Pearson correlation coefficient and the average difference between them were calculated. The Pearson correlation coefficient was 0.62 and the average difference was 13%[15]. The relatively low correlation and moderate concentration difference indicate that these two monitors are measuring something different and neither is a candidate for moving. These calculations are based on only 60 pairs of measurements collected from August, 2008 through 2009.

2.8.4 Identifying New Sites Needed

The EPA 'new sites' tool could not be used because the database did not contain Glen Burnie data and use of the tool with only one of the two Maryland PM_{10} sites may distort the results. The Glen Burnie site had not collected sufficient data during 2006 - 2008, because it was moved from its previous location, FMC, in August, 2008[16].

Given that PM_{10} concentrations at both sites are well below the NAAQS and the network requirements are being met, there is no pressing need to identify potential new sites. Additionally, with all the new requirements for more O_3, SO_2 and NO_2 monitoring sites in the near future, it is unlikely that funding new PM_{10} sites will be a priority for EPA. However, once enough data is available from the Glen Burnie site, the need for any new sites will be assessed.

2.8.5 Proposed Changes to the PM_{10} NAAQS and Monitoring Rule

No changes to either the NAAQS or the monitoring rule have been proposed at this time.

2.8.6 Recommended Network Changes

In summary, recommendations for changes to the PM_{10} network are as follows:

- Remove the continuous PM_{10} monitor located at the ESSEX site,
- Assess the network for new sites after enough data has been captured at Glen Burnie.

[14] The BAM instrument is not setup to measure at STP as required for FEM status.
[15] This average was calculated the same way as it was for other pollutants.
[16] See the Ambient Air Monitoring Network Plan For Calendar Year 2010

2.9 SO_2 Network

2.9.1 Compliance with Network Design Criteria

Basic SO_2 design criteria are specified in 40CFR58 Appendix D. There are no minimum requirements for SLAMS monitors; however, each state must operate at least one NCore site with SO_2 as one of the required monitoring parameters. Maryland has three SO_2 monitoring sites and their types, objectives and scale of representativeness are summarized in Table 2-22. There are currently two primary NAAQS for SO_2: (1) annual arithmetic mean concentration of 30 parts per billion (ppb), and (2) a 24-hour average concentration of 140 ppb (not to be exceeded more than once per year). Design values for the SO_2 NAAQS are shown in Table 2-22. Maryland has never violated the SO_2 NAAQS.

Table 2-22. Monitoring details for SO_2 network.

SITE NAME	AQS ID	START DATE	REPRESENTATIVE SCALE	MONITORING OBJECTIVE	TYPE	2008 ANNUAL DESIGN VALUE (PPB)	2008 24-HR DESIGN VALUE (PPB)
Essex	240053001	1/1/72	Neighborhood	Population Exposure	SLAMS	4.3	16.0
HU-Beltsville	240330030	9/29/06	Urban	General / Background	NCore	2.5	9.8
Piney Run	240230002	1/1/07	Regional	Regional transport	NCore	4.5	18.2

2.9.2 Assessment of Objective Types Assigned to Monitors

The appropriate scales for SO_2 SLAMS monitoring are the micro, middle and neighborhood scales. The Essex site has a representative scale of neighborhood (0.5-4 km) and this designation is required due to its close proximity to large SO_2 sources. The monitoring objective for Essex is population exposure. This objective should measure typical concentrations in areas of high population density. Given the close proximity of Essex to SO_2 sources and the relative high magnitude of the measurements, the program recommends changing the objective to highest concentration. 40CFR58 Appendix D 4.4(a) states that at least one of the SLAMS sites must be a maximum concentration site. Changing the monitoring objective for Essex would allow the program to meet this requirement.

The HU-Beltsville site is an NCore site and its representative scale is urban. Beltsville is located in a suburban area that is not close to large SO_2 sources and this justifies the urban representative scale as well as the population exposure monitoring objective. Piney Run is an elevated NCore site located in Western Maryland in the path of SO2 emissions which can be transported from neighboring states; its representative scale is regional. Piney Run is located in a

rural area at high elevation (781 m above sea level) not close to large SO_2 sources which justifies the regional representative scale and the regional transport monitoring objective.

2.9.3 Identifying Redundant Sites

Essex and Piney Run SO_2 design values are almost twice as large as the HU-Beltsville design values. The Essex site is suburban and within 25 km of large SO_2 sources. The Piney Run site is elevated and in a rural area. The distance between monitoring sites and emission sources and differences in land use at Essex and Piney Run are large enough that the monitors should not be classified as redundant.

2.9.4 Identifying New Sites Needed

The program is considering new sites given the proposed changes in regulations. A more detailed discussion is provided in section 2.9.5.

2.9.5 Proposed Regulations

On June 2. 2010, EPA revised the primary SO_2 NAAQS to establish a new 1-hour SO_2 standard at a level of 75 ppb, based on the 3-year average of the annual 99^{th} percentile (or 4^{th} highest) of 1-hour daily maximum concentrations (40 CFR Parts 50, 53 and 58). At the same time, EPA also revised the SO_2 monitoring rule. These revisions address specific minimum requirements to guide where SO_2 monitors should be placed. The revised monitoring rule requires monitors to be placed in Core Based Statistical Areas (CBSAs) based on a population weighted emissions index (PWEI) for the area. The rule specifies that CBSAs with index values greater than 1,000,000 will require 3 monitors, CBSAs with index values less than 1,000,000 but greater than 100,000 will require 2 monitors and CBSAs with index values less than 100,000 but greater than 5,000 will require one monitor.

The minimum number of monitors required for CBSAs wholly or partially located within Maryland is shown in Table 2-23. Based on EPA's proposed SO_2 monitoring regulation, two monitors are required for the Baltimore, MD MSA and a total of five monitors are required in the MSAs which Maryland shares with other states. The program will work with the other states and EPA Region III to determine where these monitors will be located.

Table 2-23. SO_2 NAAQS Revision Proposal - Prong 1 of the proposed network design - Population Weighted Emissions Index (PWEI) [Maryland CBSA's, only].

CBSA_ID	CBSA NAME	SO_2 PER CBSA IN TONS PER YEAR	CBSA POPULATION (2008 CENSUS EST.)	PWEI IN MILLION PERSONS-TPY	MONITORS REQUIRED
37980	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	109,961	5,838,471	642,003	2
47900	Washington-Arlington-Alexandria, DC-VA-MD-WV	225,485	5,358,130	1,208,179	3
25180	Hagerstown-Martinsburg, MD-WV	9,032	263,753	2,382	0
12580	Baltimore-Towson, MD	134,305	2,667,117	358,208	2

Maryland population estimates for 2008 are shown in Figure 2-14 [Rizzo, 2010]; with SO_2 emissions from EPA's Clean Air Markets Division (CAMD) and the Maryland SO_2 monitoring network. The Essex monitor appears to be appropriately located because it is near large SO_2 emission sources. Piney Run and HU-Beltsville are NCore monitoring sites. Populations were estimated for each Federal Information Processing Standards area (FIPS) by multiplying the county level population change (from 2000 to 2008) by the 2000 FIPS populations. FIPS codes are used by the US census bureau to identify county subdivisions. FIPS area populations within a county have not likely grown at the same rate and this presents a limitation of Figure 2-15.

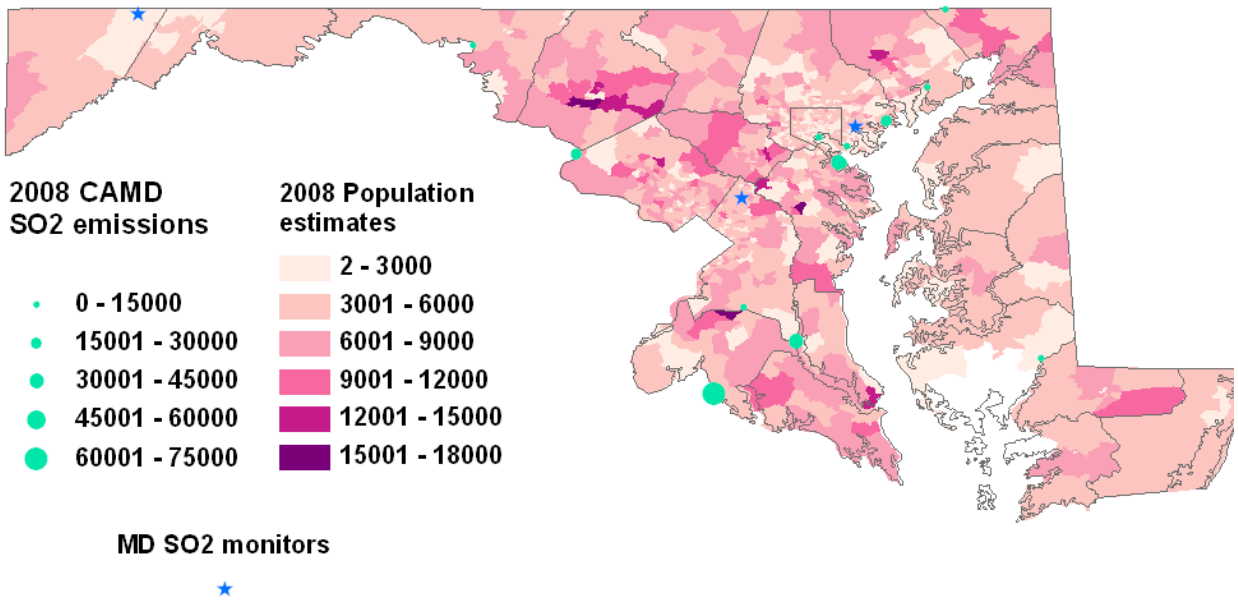

Figure 2-15. 2008 Population estimates, SO_2 emissions from CAMD and the current Maryland SO_2 monitoring network.

The Essex site is shown to be located in an area of likely maximum concentration in Figure 2-15. The HU-Beltsville and Piney Run sites are not close to large SO_2 sources; however, the Piney Run site has observed SO_2 peaks of up to 66 ppb (March 6, 2010), which may be the result of emissions of SO_2 being transported into Maryland from large pollutant sources located in neighboring states.

2.9.6 Recommended Network Changes

Maryland must site two SO_2 monitors near SO_2 emissions sources and large populations within the Baltimore, MD MSA as part of the first prong of the EPA proposed revisions to the SO_2 monitoring rule. Three additional monitors are also required as part of the second prong (this number may be larger if Maryland is required to contribute monitors to other MSA's). These changes are not required until January 1, 2013 if the EPA proposed regulations are finalized as written, and will be formally addressed in future Annual Network Plans.

The program is currently examining data like that presented in Figure 2-15 as well as air quality modeling output to choose appropriate locations for the potential new required SO_2 monitors. The Essex monitor is close to a number of SO_2 sources, measures large SO_2 concentrations and has been operating since 2003. This history adds to the value of the site. The program recommends that Essex be evaluated to see if it meets the new monitoring regulations. In the meantime, for the reasons cited above, the program recommends changing the objective of the Essex monitor to highest concentration.

The Piney Run and HU-Beltsville sites are part of the NCore program and therefore cannot be moved to address the new regulations. The Piney Run site does measure 1-hour SO_2 concentrations above 50 ppb at times and therefore should be evaluated as a candidate for meeting the new monitoring regulations. The HU-Beltsville site is not located near large SO_2 emission sources nor is it located near large populations, so this site may not be used to meet the new monitoring requirements.

3. SENSITIVE POPULATIONS

The Clean Air Act of 1990 established primary standards to set limits to protect public health, including the health of sensitive populations such as asthmatics, children and the elderly. The Air Quality Criteria document for Ozone and related photochemical oxidants [U.S. EPA, 2006] states that the elderly population (>65 years of age) appear to be at increased risk of ozone-related mortality and hospitalizations, and children (<18 years of age) experience other potentially adverse respiratory health outcomes with increased ozone exposure. The Integrated Science Assessment for Particulate Matter [U.S. EPA, 2009] states that older adults have heightened responses for cardiovascular morbidity with PM exposure and children are at an increased risk of PM-related respiratory effects. It should be noted that the health effects observed in children could be initiated by exposures to PM that occurred during key windows of development, such as in utero. The term sensitive populations may extend to other populations [U.S. EPA, 2006; U.S. EPA 2009] but discussion of these populations is beyond the scope of this assessment.

The program examined population demographics on a county level (and zip code level in Baltimore City) to assess whether Maryland's network of ozone and $PM_{2.5}$ monitors serves sensitive populations. For this analysis, those under 18 years of age and those older than 65 years of age are considered to be sensitive population groups (children and the elderly). Asthma hospitalization counts were also considered as a proxy for sensitive populations. Population counts were examined for each county (or Baltimore City zip code area) relative to the population counts within the state of Maryland; National demographic information was not considered for this assessment.

Figure 3-1, Figure 3-2 and Figure 3-3 contain maps with sensitive population distributions for the 24 counties in Maryland. The counties are ranked into four sensitive population categories shown with the color scales on the maps:

- Counties with the smallest (1-6) sensitive population counts (< 25th percentile).
- Counties with the smallest (7-12) sensitive population counts (< 50th percentile).
- Counties with the largest (13-18) sensitive population counts (< 75th percentile).
- Counties with the largest (19-24) sensitive population counts (<100th percentile).

The distribution of children and elderly populations in Maryland were also evaluated. County level sensitive population estimates for 2008 are shown in Figure 3-1. The population estimates are from the US census (http://quickfacts.census.gov). In Figure 3-1 sensitive populations are defined as children under 18 years of age and adults over 65 years of age. Counties with the largest sensitive populations (the six highest) are Prince George's County, Montgomery County, Anne Arundel County, Howard County, Baltimore City and Baltimore County. There are ozone and $PM_{2.5}$ monitors located in all of these counties except Howard County.

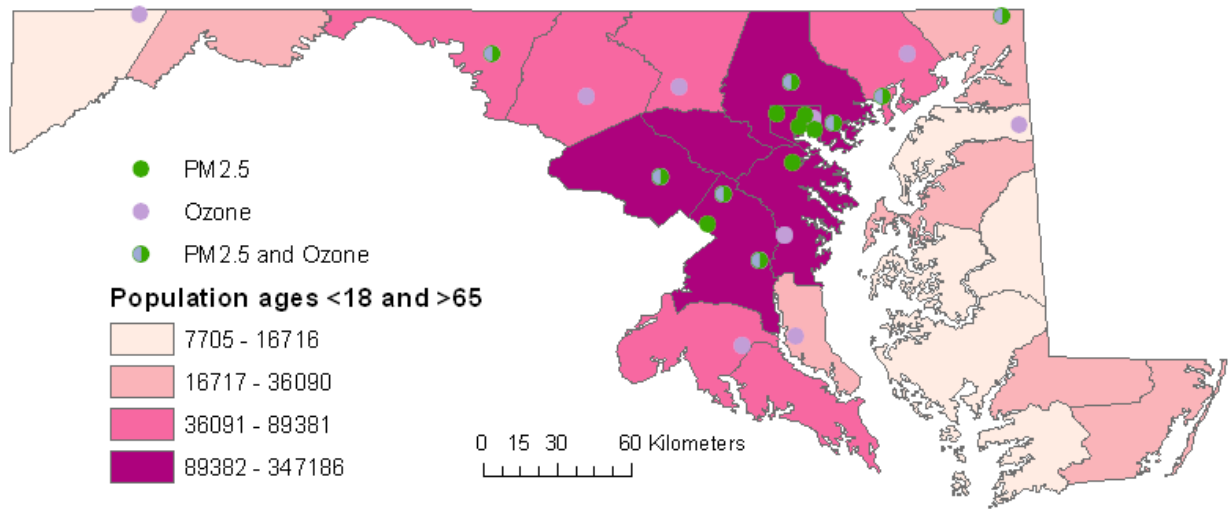

Figure 3-1. Maryland 2008 county level sensitive population estimates and ozone and $PM_{2.5}$ monitor locations.

In addition, annual asthma hospitalization discharges from the Department of Health and Mental Hygiene Family Health Administration Center for Maternal and Child Health were examined (http://fha.maryland.gov/pdf/mch/Asthma_Fact_Sheet2.pdf). The 2004-2006 annual asthma hospitalization discharges and Maryland's ozone and $PM_{2.5}$ monitor locations are shown in Figure 3-2. The counties with the largest asthma hospitalization discharges in Maryland are Montgomery County, Prince George's County, Anne Arundel County, Baltimore City, Baltimore County and Harford County. All of these counties contain both ozone and $PM_{2.5}$ monitors.

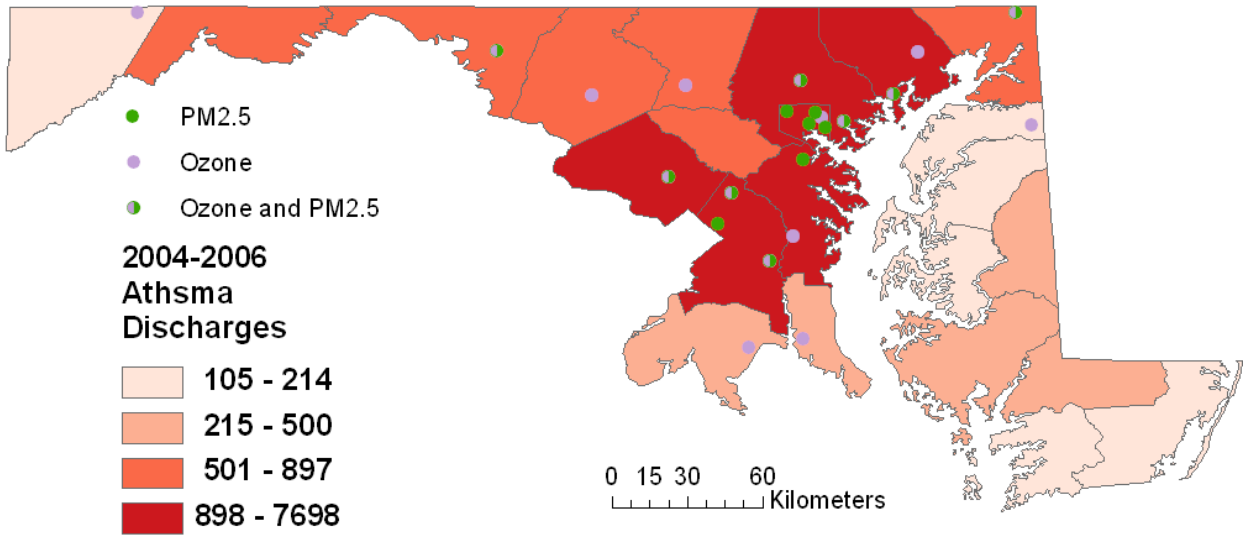

Figure 3-2. Maryland's 2004-2006 annual asthma hospitalization discharges and ozone and $PM_{2.5}$ monitoring locations.

The sensitive population data presented in Figure 3-1 and Figure 3-2 are limited by the coarse, county level scale. While the program does have monitors in counties with the largest sensitive populations (except Howard County), the question of whether those monitors serve sensitive populations still must be addressed. The program examined the representative scale of the monitors to address this question. Table 3-1 contains a list of Maryland counties with the largest sensitive populations showing their site scales by parameter. Monitors in Montgomery County, Prince George's County, Harford County and Anne Arundel County have neighborhood (0.5 – 4 km) and urban (4 – 50 km) site scales. The urban scale monitors cover most of the county level area and likely serve sensitive populations in those Maryland counties. While Howard County does not have any monitors, the site scales of the Beltsville and Rockville monitors extend into Howard County. Thus, sensitive populations in Howard County are likely served by monitors in the other adjacent counties. Baltimore City and Baltimore County monitors have middle (0.1 – 0.5 km) and neighborhood (0.5 – 4 km) site scales. These site scales are much smaller than the city and county size and it is possible that monitors in these areas are not serving all sensitive populations in Baltimore County or Baltimore City..

Table 3-1. Maryland counties with the largest sensitive populations and site scales by parameter.

COUNTY	SITE	PARAMETER	SCALE
Montgomery County	Rockville	Ozone	Urban
		PM2.5	Neighborhood
Prince George's County	HU-Beltsville	Ozone	Urban
		PM2.5	Urban
	PG Equestrian Center	Ozone	Urban
		PM2.5	Neighborhood
	Bladensburg	PM2.5	Neighborhood
Baltimore City	NE Police	PM2.5	Neighborhood
	NW Police	PM2.5	Neighborhood
	SE Police	PM2.5	Neighborhood
	Oldtown	PM2.5	Middle
	Furley	Ozone	Neighborhood
Baltimore County	Essex	Ozone	Neighborhood
		PM2.5	Neighborhood
	Padonia	Ozone	Neighborhood
		PM2.5	Neighborhood
Harford County	Aldino	Ozone	Urban
	Edgewood	Ozone	Urban
		PM2.5	Neighborhood
Anne Arundel	Glen Burnie	PM2.5	Neighborhood
	Davidsonville	Ozone	Urban

Note: Middle scale = 0.1-0.5 km Neighborhood scale = 0.5-4 km Urban scale = 4-50 km

There was more detailed and current information for Baltimore City's asthma hospitalization counts than for Maryland's counties. This data was examined for 2008 by zip codes in Baltimore City. The more detailed 2008 asthma hospitalization counts were only for children from age's birth -17 years with asthma obtained from the Baltimore Neighborhood Indicators Alliance (http://www.bniajfi.org/). Figure 3-3 contains a map of Baltimore City with 2008 asthma hospitalization counts by zip code for children ranging in age from birth – 17 years. Some $PM_{2.5}$ monitors in Baltimore City are located within zip codes that have large asthma hospitalization counts (Figure 3-3). There is good correlation among the Baltimore City $PM_{2.5}$ monitors (see Section 2.7.3) suggesting that $PM_{2.5}$ distributions are similar throughout the city. While not all zip code areas with large asthma hospitalization counts contain monitors, the spatial uniformity among $PM_{2.5}$ observations suggests that zip code areas without monitors are served by other monitors within the city. The program was unable to find a similar dataset for Baltimore County. Without higher resolution demographic data it is difficult to assess the sensitive populations served by monitors in Baltimore County. The program determined that for most of Maryland, with the possible exception of Baltimore County, the $PM_{2.5}$ and ozone network monitors serve areas with the largest sensitive populations.

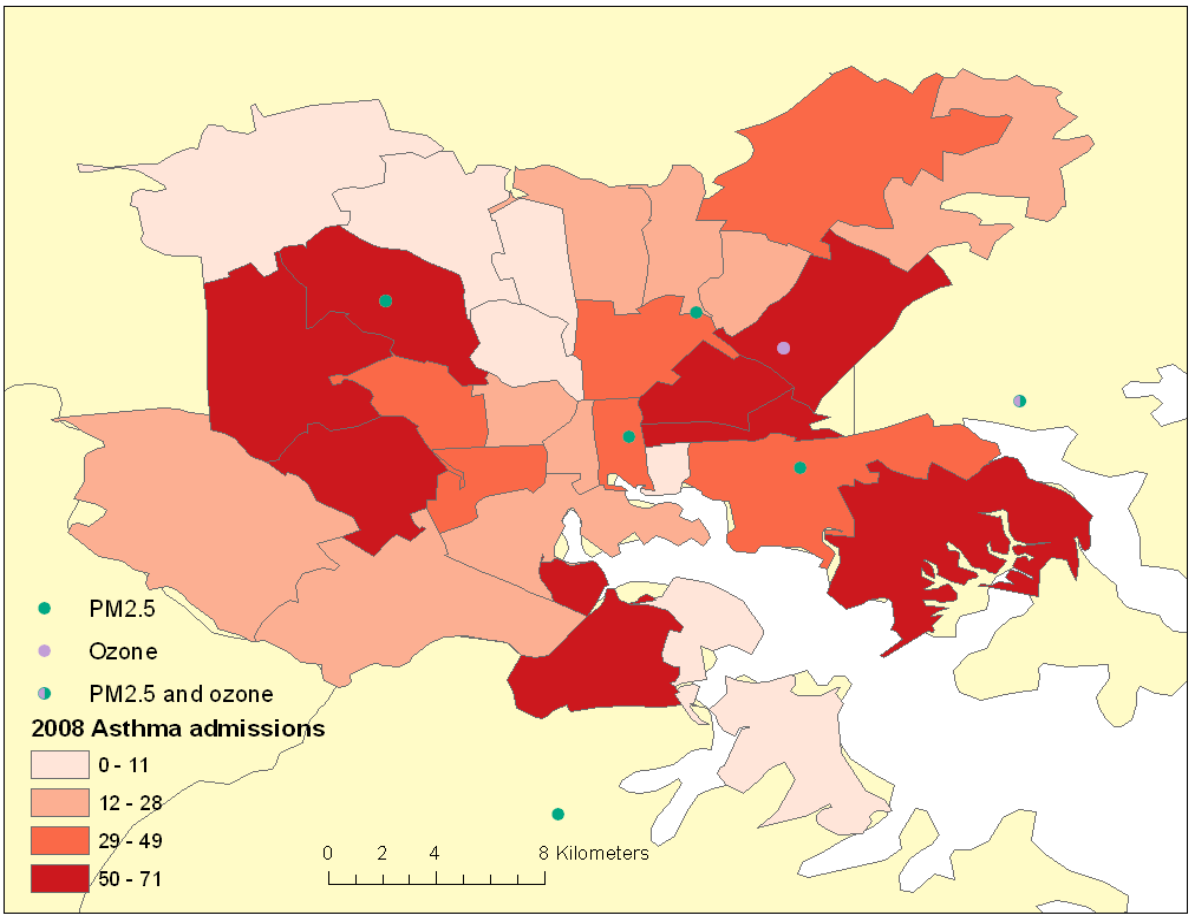

Figure 3-3. The number of children from birth -17 years of age with asthma that were hospitalized for asthma in 2008 and the ozone and $PM_{2.5}$ monitoring locations.

4. TECHNOLOGY

The program has been aggressively evaluating new monitoring technology for the last five years as it became apparent that new sophisticated monitoring techniques, hardware, software and gases would be required to meet new strict EPA requirements. The specific areas that the program addressed are the following:

- Monitors and samplers.
- Multi-gas calibrators and zero air sources.
- Gas cylinder standards.
- Data acquisition systems and high speed communications.
- Meteorological sensors and calibration devices.
- Portable monitors and samplers for surveys of areas not presently covered by routine monitoring.

4.1 Monitors and Samplers

EPA and individual states over the past several years have implemented various emissions control regulations in an effort to reduce ambient air concentrations of SO_2, NO_2 and CO. These emissions control regulations have been very successful and these three criteria pollutants ambient concentrations have been significantly reduced to the point that new monitors with much lower detection limits are now required to accurately measure these pollutant concentrations. These new monitors are known as "trace level" monitors and they use advanced detection methods such as very sensitive detectors, auto zero functions and digital communications to accurately measure the much lower ambient concentrations of SO_2, NO_2 and CO. "Trace level" monitors have already been installed at both NCore sites (HU-Beltsville and Piney Run) and is in the process of replacing older model monitors at other monitoring stations as resources allow.

The program is also planning on updating the current network of $PM_{2.5}$ samplers, which are filter based FRM's with new semi-continuous $PM_{2.5}$ samplers. These new semi-continuous $PM_{2.5}$ samplers use beta attenuation to measure ambient concentrations of $PM_{2.5}$ and recently have earned EPA approval as an equivalent FRM. Currently the program is identifying monitoring sites in the state that will begin using these new samplers to measure $PM_{2.5}$.

4.2 Multi-Gas Calibrators and Zero Air Sources

The trace level monitors will require new support instruments that will be able to accurately supply low concentrations of gas as to challenge the monitors during precision checks, calibrations, and audits. One such instrument is a trace level multi-gas calibrator which has the features of additional mass flow controllers and gas ports that are required to accurately blend gases to several parts per billion or even get as low as parts per trillion. The program has purchased five trace level multi-gas calibrators to replace the current support instruments in the network.

Another important support instrument used to help keep trace level monitors operating properly is a zero air source. A zero air source instrument is capable of scrubbing out pollutants from the air that could affect the target gas being monitored and is used in conjunction with the trace level multi-gas calibrator. The zero air source is used to supply contaminant free air to dilute the source gas to the concentration needed for precision checks, calibrations and audits. Due to the advancements made in zero air sources over the past couple of years the program has made it a priority to replace all zero air sources in the network with new state of the art sources capable of trace level results.

4.3 Gas Cylinder Standards

One of the most important steps in keeping the trace level monitors operating correctly is producing accurate and reliable gas concentrations that are used in the calibration process. The trace level monitors require lower concentrations of the target gas to make it easier to produce dilutions necessary for the desired gas concentrations. However achieving lower dilution level brings with it a number of issues related to lower concentrations in the gas cylinders. One issue is that of contamination, where even a 1 ppb of contamination can affect the resulting dilution. Another issue is at lower concentrations; the gas degrades faster and requires more frequent re-certifications of the cylinder. Typically re-certification of the cylinder is every 6 months versus 1-2 years for non-trace level gases. In addition, one of the challenges has been finding a vendor that is capable of generating accurate and reliable concentrations of the target gas. After using several vendors, the program found one vendor that meets our requirements.

4.4 Data Acquisition and Management System and High Speed Communications

The data acquisition and management system is at the heart of the air monitoring network. Data is collected from each monitoring instrument by a data logger and is stored until the central computer in the office polls the data logger and a transfer of data to the central computer is initiated. This transfer of data occurs approximately every hour. Within the past couple of years the program purchased a new data acquisition system capable of handling trace level pollutant measurements as well as remote diagnostics and remotely enabled checks on the instrument performance. The system is scalable, which means more instruments or stations can be added as the network expands or additional capability can be added for additional QA/QC procedures. The instruments communicate with the data logger via serial (digital) signals and the data logger communicates with the central computer using digital cellular technology. This communication setup allows for polling large amounts of data including instrument operating parameters, such as air flow, temperature, etc.

4.5 Meteorological Sensors and Calibration Devices

The program recently replaced all its existing meteorological instrumentation with an all-in-one weather transmitter. The all-in-one weather transmitter is made up of separate sensors that measure the following meteorological parameters: wind speed and direction, relative humidity, barometric pressure, temperature and precipitation. Currently, the program is in the process of evaluating instrumentation needed to conduct audits of the meteorological sensors. Twelve monitoring sites in the network currently have the all-in-one weather transmitter, but as new sites

are added to the network, the program plans to deploy additional all-in-one weather transmitters as resources allow.

4.6 Portable Monitors and Samplers

In the last few years, manufacturers have designed some analyzers and samplers that are much smaller in size and their power requirements are considerably less than the standard instrument models. The reduced power supply requirements mean the instruments can operate using solar panels and or batteries as their primary power source, and allows for deployment in remote areas that lack the standard power hookup. These new smaller self sufficient stand alone instruments can be quickly deployed and are ideal for special short term studies or for unusual events such as forest fires.

The program currently has a Met One E-BAMM that is capable of hourly measurements of $PM_{2.5}$ and PM_{10}. This instrument was deployed on top of a 100 meter tower at the HU-Beltsville NCore site to measure aloft $PM_{2.5}$ concentrations. In addition, the program also purchased a portable ozone monitoring system (POMS). Plans for the POMS include deploying it near the Edgewood monitoring station to collect ozone concentrations in the hopes of understanding how the development of the bay breeze affects ozone levels at the monitoring site. A second plan is to deploy the POMS unit to the eastern shore of Maryland to take measurements of ozone in areas not presently covered by routine ozone network operations.

5. SUMMARY AND CONCLUSIONS

The recommendations that resulted from work completed by the program to comply with EPA's network assessment requirements (40CFR58.10(d)) are summarized in this section. The assessment addressed every item in the regulation and covered all air monitoring networks operated by the program in Maryland. Recommendations coming from this assessment were necessarily limited by the techniques and data available at the time of assessment and, can be categorized by their certainty as follows:

- Implement now (pending approval of the EPA Regional Administrator),
- Decide after further analysis, better data or deliberation,
- Choose from a number of alternatives sometime involving more than one network.

It should be noted that all recommendations require approval of the EPA Regional Administrator and the availability of adequate resources (especially the establishment of new sites) prior to implementation. Site network specific recommendations related to the assessment of network monitoring objectives, the identification of redundant monitoring sites, and the identification of new sites are summarized in Table 5-1.

Table 5-1. Summary of site specific network assessment recommendations by monitoring site

SITE NAME	POLLUTANT	RECOMMENDED CHANGES	QUALIFIER
Aldino	NO_y	Discontinue measurement	Implement now
Bladensburg VFD	$PM_{2.5}$	Discontinue site	Await approval of EPA Regional Administrator
Calvert Co.	n/a	None	n/a
Davidsonville	n/a	None	n/a
Edgewood	n/a	None	n/a
Essex	PM_{10}	Discontinue continuous PM_{10} monitor	Implement now
	SO_2	Change objective type to 'highest concentration'	Implement now
Fairhill	Ozone	Change scale to urban and change objectives to regional transport	Implement now
Fire Dept. 20	$PM_{2.5}$	Change scale and monitoring objective (to 'middle scale' and 'source oriented') if request to shutdown is not approved	Deliberation needed
	$PM_{2.5}$	Discontinue this site or the NE Poilce. site	Choose from alternatives
Frederick Airport	n/a	None	n/a
Furley	n/a	None	n/a
Glen Burnie	n/a	None	n/a
Hagerstown	ozone	Designate as maximum concentration site for the Hagerstown-Martinsburg MSA	Implement now
	$PM_{2.5}$	Designate as a maximum concentration site for the Hagerstown MD-Martinsburg, WV, MSA	

SITE NAME	POLLUTANT	RECOMMENDED CHANGES	QUALIFIER
HU-Beltsville	PAMS	Consider changing the monitoring objective from population exposure to general/background	
	ozone	Add the population exposure objective to Beltsville	Implement now
Millington	n/a	None	n/a
NE Police	Air toxics	Consider discontinuing this site or Oldtown.	Choose from alternatives
	PM2.5	Discontinue this site or the Fire Dept. 20 site	
Oldtown	Air Toxics	Consider discontinuing this site or NE Police	Choose from alternatives
	$PM_{2.5}$	Designate as a maximum concentration site for the Baltimore MSA	Implement now
Padonia	n/a	None	n/a
PG Equestrian Center	n/a	None	n/a
Piney Run	$PM_{2.5}$	Officially designate as a regional transport site once the FEM/FRM is deployed there	Implement now
Rockville	n/a	None	n/a
South Carroll	ozone	Change the South Carroll primary monitoring objective from highest ozone concentration to population exposure	Implement now
Southern Maryland	n/a	None	n/a

Network-wide recommendations related to assessment of network monitoring objectives, the identification of redundant monitoring sites, the identification of new sites and other requirements are summarized in Table 5-2.

Table 5-2. Summary network-wide assessment recommendations.

POLLUTANT	RECOMMENDED CHANGES	QUALIFIER
PM_{10}	Determine whether new sites are needed	More data needed
$PM_{2.5}$	Opportunities for reconfiguration network in and near Baltimore city exist because of redundant measurements there	Choose from alternatives
	Existing continuous SPM monitors will be designated as FEM's and will be substituted for FRM's at all sites except for Oldtown where both the FRM and the continuous monitor will remain collocated. This deployment will satisfy the continuous monitoring requirements for the Baltimore and Wilmington-Newark, DE-MD MSA's	Implement now
	Establish new sites/monitors in the population growth counties like Frederick, and Queen Anne's and Southern Maryland counties	Choose from alternatives
	Designate one of the Delaware sites as the maximum concentration site for the Wilmington-Newark, DE-MD MSA	Deliberation needed
	Designate one of the Washington, DC monitors as a maximum concentration site for the Washington, DC-MD-VA MSA	Deliberation needed
Ozone and $PM_{2.5}$	Consider deploying additional $PM_{2.5}$ monitors to serve the sensitive populations in Baltimore County	Needs more recent data and deliberation

CFR40 58.10(d) requires the program to assess the effect on data users of proposed site removals. The program expects to be moving or removing air toxic sites/monitors, a PM_{10} monitor, and $PM_{2.5}$ sites/monitors sometime in the future. The annual ambient air monitoring network plan, which is posted on the web and made available for public comment, is used as a means disseminating information about network modifications to the general public and stakeholders. The program also works closely with local university contractors, and disseminates news of site changes to the surrounding state and local air monitoring agencies at, regional meetings and on regional conference calls (i.e. MARAMA Annual Air Monitoring Committee meeting). However, the program currently has no means of discovering and informing other data users such as health effects research community. The program looks forward to working with EPA and health organizations to explore options for tracking the status of key air quality sites[17].

In general, this network assessment found Maryland's air monitoring networks in compliance with most EPA regulations and fulfilling intended monitoring objectives. In some cases, the assigned monitoring scale and/or monitoring objective types were found to be in need of change. Some sites were identified as good candidates for removal. Besides the continuous PM_{10} monitor located at Essex, shutdowns of more than one $PM_{2.5}$ monitor and possibly an air toxics monitor will be pursued, but more deliberation needs to be done before decisions can be made about which existing sites should be shutdown and which new sites should be opened.

Using coarse resolution county level data, the program found that the $PM_{2.5}$ and ozone networks are serving sensitive populations in Maryland with the possible exception of Baltimore County. More recent data with more detailed spatial resolution is required to fully assess how well the network is serving sensitive populations. Using results from the 2010 census and EPA guidance the program plans to re-evaluate this objective.

For the air toxics and PAMS networks, it is recommended that regional and national scale assessment be performed, respectively, prior to implementing any recommendations from this assessment.

[17] See **61248 Federal Register** / Vol. 71, No. 200 / Tuesday, October 17, 2006 for the full text of EPA's promise to support the States and locals.

6. REFERENCES

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APPENDIX A – BACKGROUND

A.1 Maryland of Air Monitoring Network History

Ambient air quality monitoring began in Maryland in 1955 following the passage of the Air Pollution Control Act of 1955, the first federal legislation involving air pollution. Early sampling was conducted using manual methods (mostly high volume samplers). Parameters measured included total suspended particulates (TSP), soiling index, dustfall, and sulfation rate (an indicator of sulfur dioxide concentrations). TSP filters were analyzed for benzene soluables and the trace metals lead, chromium, iron, manganese and nickel.

From 1957 to 1966 Maryland's air monitoring network grew to 32 sites. In 1967, monitoring was expanded to include carbon monoxide, photochemical oxidants, total hydrocarbons and fluorides. By 1970, there were over 90 sites. In 1971, analysis of TSP filters for manganese and nickel was discontinued and continuous monitoring for carbon dioxide and total oxidants began. The following year, continuous monitoring was expanded to include photochemical oxidants, sulfur dioxide, nitrogen dioxide, nitric oxide and total hydrocarbons. By 1975 there were 160 sites in the network and non-methane hydrocarbons and benzo-a-pyrene were added to the list of monitored parameters. Nitrogen oxides and cadmium were added in 1977 and the total number of sites at that time was 135. A chronological listing of the number of monitoring sites in Maryland from 1957 through 2009 is shown in Figure 1.

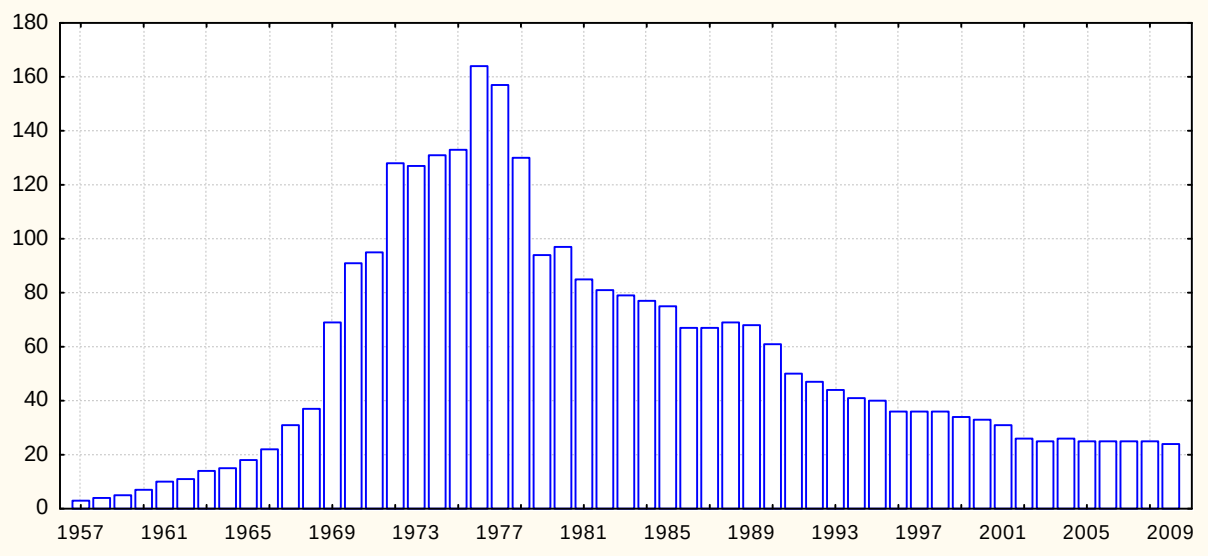

Figure A-1. Chronology of the number of air monitoring sites in Maryland.

In 1979, EPA promulgated uniform monitoring requirements establishing reference or equivalent monitoring methods, minimum numbers of required monitoring sites, public AQI reporting, annual monitoring network reviews, and quality assurance and quarterly and annual reporting of all data to EPA. With the establishment of these requirements and the discontinuation of

monitoring using non-standard methods, the number of monitoring sites dropped to just below 100.

Maryland began measuring inhalable particulates in 1984 using high volume samplers with a 0-10 micron size selective inlet. In July 1987, EPA replaced TSP as the indicator for particulate matter with PM-10 and by 1992 there were 26 PM-10 monitoring sites. Concurrently, TSP monitoring was drastically reduced to support the lead NAAQS only. Other trace metal analyses were also discontinued at this time.

By 1989, the total number of sites state-wide had declined to 60. Beginning in 1955, monitoring was accomplished through the cooperative efforts of local agencies and the State of Maryland. Carroll, Dorchester, Howard, Washington, and Wicomico County Health Departments supplied personnel for the operation of state-owned air sampling stations located within their jurisdictions. In addition, the following health departments operated their own air sampling stations and assisted in the operation of State-owned stations: Allegany, Anne Arundel, Baltimore, Frederick, Montgomery and Prince George's Counties. Baltimore City maintained its own sampling network and did not operate any state-owned stations. Over the intervening years, as the local jurisdictions gradually divested themselves of ambient air monitoring responsibilities for a variety of reasons, including budgetary limitations, many sites were discontinued. By the early 1990's all ambient air monitoring activities were centralized in the Maryland Department of the Environment (MDE). The overall number of monitoring stations continued to decline throughout the 1990's as many single pollutant sites were either discontinued or consolidated as multipollutant sites.

By the late 1980's, Maryland had begun measuring air toxics at a handful of sites state-wide. Subsequent to the passage of the Clean Air Act Amendments of 1990, three enhanced ozone monitoring sites, referred to as Photochemical Assessment Monitoring Stations or PAMS, were established during 1993 and 1994 to collect detailed information on volatile organic ozone precursors, nitrogen dioxide and meteorological parameters.

Following promulgation of the PM-2.5 NAAQS in 1997, MDE implemented a network of 18 FRM PM-2.5 samplers in 1999 and 2000. The PM-10 network was concurrently reduced. Two PM-2.5 chemical speciation sites were also established in 2000 to provide further information about the composition of PM-2.5 in Maryland. Semi-continuous monitoring for PM-2.5 with TEOM instruments began around the same time in order to provide near realtime data for AQI reporting and EPAs AirNow website. In recent years, MDE has discontinued the TEOMs and is now utilizing BAMM instruments for semi-continuous PM-2.5 monitoring.

In an effort to better understand the origin and nature of air pollution transported into Maryland from the Ohio River Valley and other areas to the west, MDE established a research monitoring station at Piney Run Reservoir in Garrett County in 2004. This site is outfitted with research grade instrumentation to monitor trace levels of SO2 and CO, semi-continuous organic and elemental carbon PM-2.5, semi-continuous sulfate PM-2.5 and NOy. Traditional semi-continuous BAMM PM-2.5, ozone and PM-2.5 chemical speciation are also measured.

MDE currently operates the following monitors: 17 Ozone, 1 SO2, 2 SO2 trace, 1 CO, 2 CO trace, 2 NOx, 3 NOy, 14 FRM PM2.5, 7 BAM PM2.5, 2 PM10, 1 BAM PM10, 2 PM2.5 Speciation, 4 Toxic, 1 Carbonyl, 3 PAMS, 11 Met, 2 Upper Air Profilers, 2 Nephelometers, 1 Athalometer, 2 SO4, 2 OCEC, 1 IMPROVE, 2 Haze Cams. The operational history of sites in the current network is shown in Figure 2..

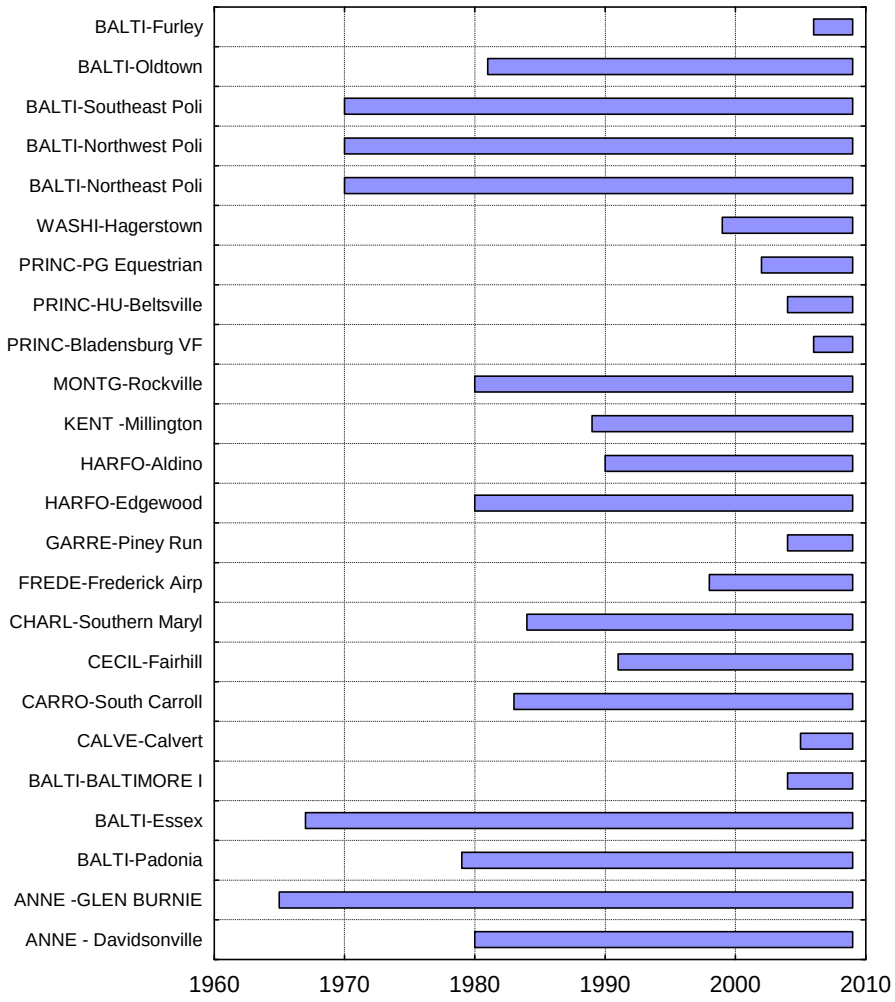

Figure A-2. Operational history of sites currently operating in the Maryland network.

Average site age is 21 years with a range of 3 to 44 years; most sites have operated 25 – 30 years

A.2 Maryland Climatology

A.2.1 General Meteorology

From: NOAA (2008), Local Climatological data annual summary with comparative data: Baltimore, Maryland (KBWI).

Baltimore-Washington International Airport lies in a region about midway between the rigorous climates of the North and the mild climates of the South, and adjacent to the modifying influences of the Chesapeake Bay and Atlantic Ocean to the east and the Appalachian Mountains to the west. Since this region is near the average path of the low pressure systems which move across the country, changes in wind direction are frequent and contribute to the changeable character of the weather. The net effect of the mountains to the west and the bay and ocean to the east is to produce a more equable climate compared with other continental locations farther inland at the same latitude.

Rainfall distribution throughout the year is rather uniform, however, the greatest intensities are confined to the summer and early fall months, the season for hurricanes and severe thunderstorms. Moisture deficiencies for crops occur occasionally during the growing season, but severe droughts are rare. Rainfall during the growing season occurs principally in the form of thunderstorms, and rainfall totals during these months vary appreciably.

In summer, the area is under the influence of the large semi-permanent high pressure system commonly known as the Bermuda High and centered over the Atlantic Ocean near 30 degrees N Latitude. This pressure system brings warm humid air to the area. The proximity of large water areas and the inflow of southerly winds contribute to high relative humidity during much of the year.

A.2.2 Data Mining for Climatology Associated with Ozone Events

From: Data mining, SAIC, (2006) Characterizing Maryland Ozone by Meteorological regime, prepared for Contract Number MDE-03-6.0-AMA, January 2006.

Areas of Maryland exceed the 8-hour ozone National Ambient Air Quality Standard on various days during a normal summer. These ozone episodes during the summer season are caused by local emissions and/or emissions transported into Maryland. Previous episodic studies suggest that high ozone concentrations in the Baltimore-Washington area can be attributed to significant transport of ozone and its precursors into the Baltimore-Washington area on hot, humid days.

SAIC [2006] performed a study to quantify the effect that the transported ozone and precursors had on the daily 8-hour ozone maxima for the months from May to September. Instead of a classical modeling approach, statistical techniques using data mining tools were employed. To employ these techniques, daily ozone measurements, surface and aloft

meteorology characteristics, indicators of persistent nocturnal low level jets, and back trajectories were collected from the Environmental Protection Agency, University of Maryland at College Park (UMD), and the National Oceanic and Atmospheric Administration. The data was quality controlled to produce the Maryland Meteorology and Ozone Dataset (MMOD). The MMOD contains 150 fields of information and 2448 records that cover the years from 1989 through 2004.

After the MMOD was created, the data mining tools established five meteorological regimes (clusters) for the **Baltimore** data that showed the following tendencies:

- Cluster 0 (544 records) - Sunny, variable winds, and a higher temperature difference between upper air and surface conditions
- Cluster 1 (464 records) - Cloudy, cool days with winds from east and northeast and the most precipitation
- Cluster 2 (178 records) - Hot and humid with upper air winds from west and moderate precipitation
- Cluster 3 (760 records) - Low wind speeds, limited clouds and little precipitation
- Cluster 4 (497 records) - High wind speeds with little precipitation [surface winds from west, upper winds from northwest]

Similarly the **Washington, DC** data was divided into five clusters with the following tendencies:

- Cluster 0 (606 records) – Sunny, hot days with higher-speed surface and aloft winds from west
- Cluster 1 (484 records) - Cloudy, cool days with winds from east and northeast, most precipitation, high morning wind speeds, and low wind variability
- Cluster 2 (447 records) – Sunny with limited precipitation and high temperature differences between surface and aloft; variable low surface wind speeds with upper winds from the north
- Cluster 3 (695 records) - Low wind speeds from the west with limited clouds and precipitation
- Cluster 4 (216 records) - High temperatures with moderate clouds, low-speed variable winds from the south, upper winds from the west, and moderate precipitation

Each cluster was then subdivided into those days with measured persistent nocturnal low level jets and those without. By comparison of the subclusters, it was determined that Baltimore and Washington 8-hour ozone concentrations increased by 7 and 5 ppb, respectively, on average days from May through September.

Association rule and classifier models were used to examine the fact that high ozone concentrations in Baltimore and Washington were often tied to high ozone concentrations during the previous night at high-elevation rural monitors. The regional nature of ozone concentrations was predicted by these data mining exercises by examining the nighttime ozone concentrations at Methodist Hill, Pennsylvania and Shenandoah National Park, Virginia. Based on these analyses, 23 to 36 ppb of regional ozone contributed to the Baltimore 8-hour ozone concentrations (which average 57 ppb). Similarly 21 to 32 ppb of regional ozone contributed to the Washington 8-hour ozone concentrations (average 53 ppb). These numbers are subject to uncertainty, and this was

expressed by the synoptic correlations between the urban and rural monitors (0.52 to 0.77 for the different clusters).

One-day back trajectories from NOAA's HYSPLIT model were also used to distinguish transported and local ozone concentrations within the clusters. However, the HYSPLIT output was tied too closely to the meteorological parameters used for clustering and did not offer significant insight into the contributions of transport.

A.2.3 Climatology Associated with $PM_{2.5}$ Events

From: Ryan, W.F. (2007), Conceptual Model of $PM_{2.5}$ Concentrations in Maryland.

Concentrations of $PM_{2.5}$ in the State of Maryland, while highest at urban monitors, are remarkably homogeneous across the state – particularly during the summer months. Maximum concentrations occur in the summer although urban monitors also observe a secondary, winter season peak. At all locations, annual mean concentrations are in excess of median concentrations due to a small number (~5-10%) of extremely polluted days. This subset of "dirty" days occurs primarily during the warm season (May-September) and is associated with light winds, strong low level inversions, regional scale transport of pollutants from west to east – similar to high O_3 episodes – and enhanced concentrations of sulfate particles. A similar transport pattern occurs in winter season cases also there is a higher frequency of stagnation in these cases as well as stronger near-surface inversions. Winter episodes thus feature a stronger influence of local emissions – especially carbon and nitrogen particles. Recently implemented regional control strategies, to the extent that they reduce sulfur and nitrogen emissions, may be effective at reducing $PM_{2.5}$ concentrations on the worst days although there remains significant local emission inputs to $PM_{2.5}$ in Maryland.

Ryan [2007] summarizes observations of fine particulate matter with an aerodynamic radius of ≤ 2.5 μm, also known as $PM_{2.5}$, in the State of Maryland during the period 2000-2005. Average $PM_{2.5}$ concentrations for this period at monitors across Maryland range from 12-17 μgm^{-3} with the highest concentrations observed at urban scale sites. Although urban monitors observe the highest concentrations, all Maryland $PM_{2.5}$ monitors are strongly correlated and the correlation between monitors is highest during the summer season.

Ryan [2007] shows that $PM_{2.5}$ is ubiquitous in Maryland, is not an overwhelmingly urban pollutant, and that all locations share in a common, regional scale "load" of $PM_{2.5}$. Although there is no fool-proof method to quantify the regional scale "load" of $PM_{2.5}$, comparisons of urban, suburban and remote rural monitors suggest that the regional component of $PM_{2.5}$ accounts for roughly 60-75% of the total observed $PM_{2.5}$. This fraction increases to 80-90% during the summer season.

$PM_{2.5}$ concentrations peak during the summer season (June-August) in Maryland although urban scale sites also have a secondary maximum during the winter (December-February) months. The summer maximum are driven primarily by increases in the amount of sulfate while winter season peaks are driven more by increases in nitrogen and carbon compounds. $PM_{2.5}$ concentrations also vary by the day of the week, on the order of 2-3 μgm^{-3}, with highest concentrations occurring near the end of the work week and lowest concentrations on Sunday. This reflects day of week differences in motor vehicle and industrial emissions. While average

concentrations do not vary significantly by the day of the week, the frequency of high $PM_{2.5}$ concentrations days (90^{th} percentile) is much greater during the work week.

$PM_{2.5}$ concentrations have a daily (diurnal) cycle with highest concentrations during the morning and afternoon rush hours, when emissions are highest and vertical mixing is weakest, and lowest concentrations during the well-mixed (diluted) afternoon hours.
The diurnal cycle is markedly different for the most severe (90^{th} percentile) cases. In those cases, the mid-day dilution effects are less evident so that concentrations remain nearly unchanged through the daylight hours. This effect is more pronounced in the summer months and suggests that the air aloft, which mixes downward in the afternoon, is heavily laden with transported $PM_{2.5}$. The highest $PM_{2.5}$ cases are characterized overwhelming by westerly transport of air parcels although, in winter, there is a secondary maximum of cases where re-circulation, or stagnation, occurs. Observations at rural monitors west of Maryland show that, on the worst $PM_{2.5}$ days, this air mass is primarily made up of sulfate particles.

A.2.4 Wind Roses

Wind roses for Edgewood, Fairhill, Piney Run and HU-Beltsville are presented below. Average 2008 and 2009 annual wind roses and average summertime (June-August) 2008 and 2009 wind roses are presented for each monitor.

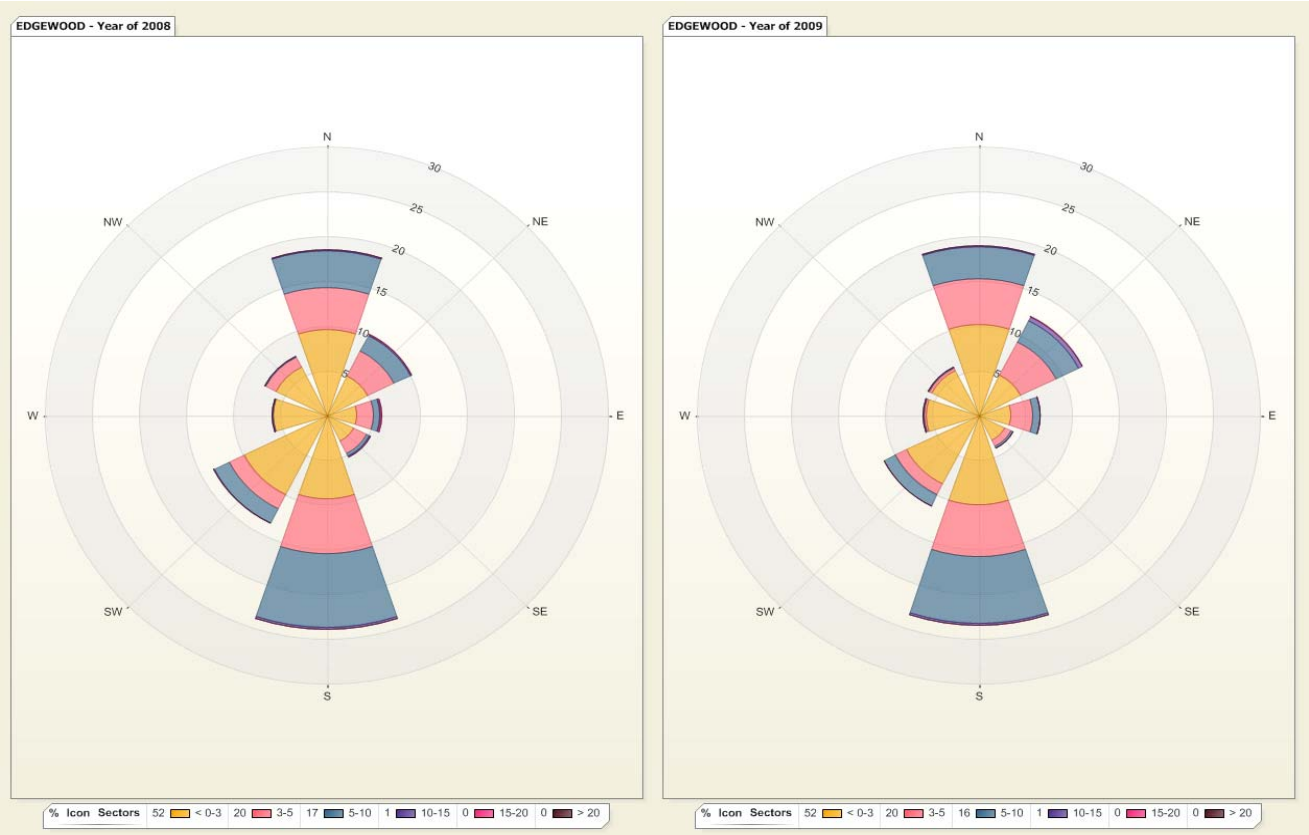

Figure A-3. Wind roses for Edgewood, annual average for 2008 and 2009.

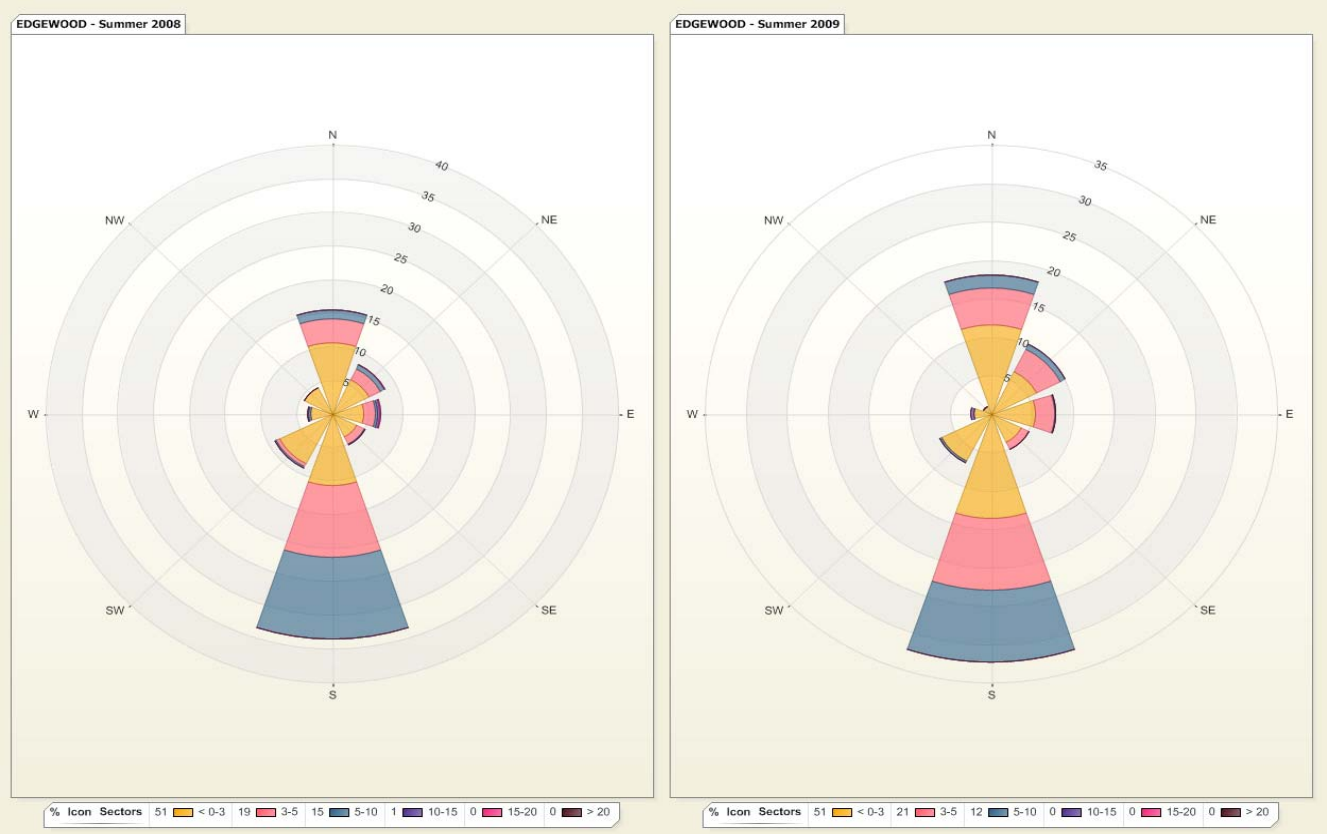

Figure A-4. Wind roses for Edgewood for June through August 2008 and 2009.

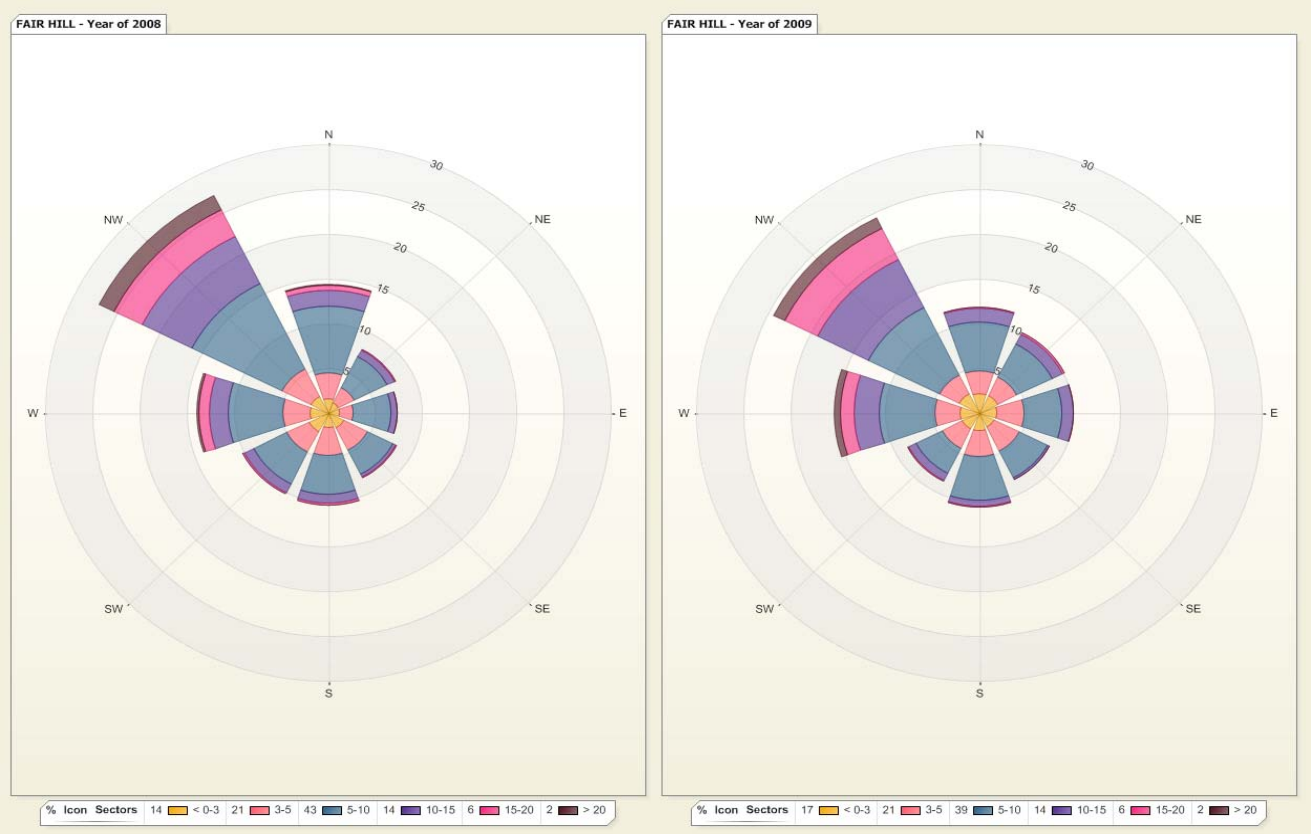

Figure A-5. Wind roses for Fairhill, annual average for 2008 and 2009.

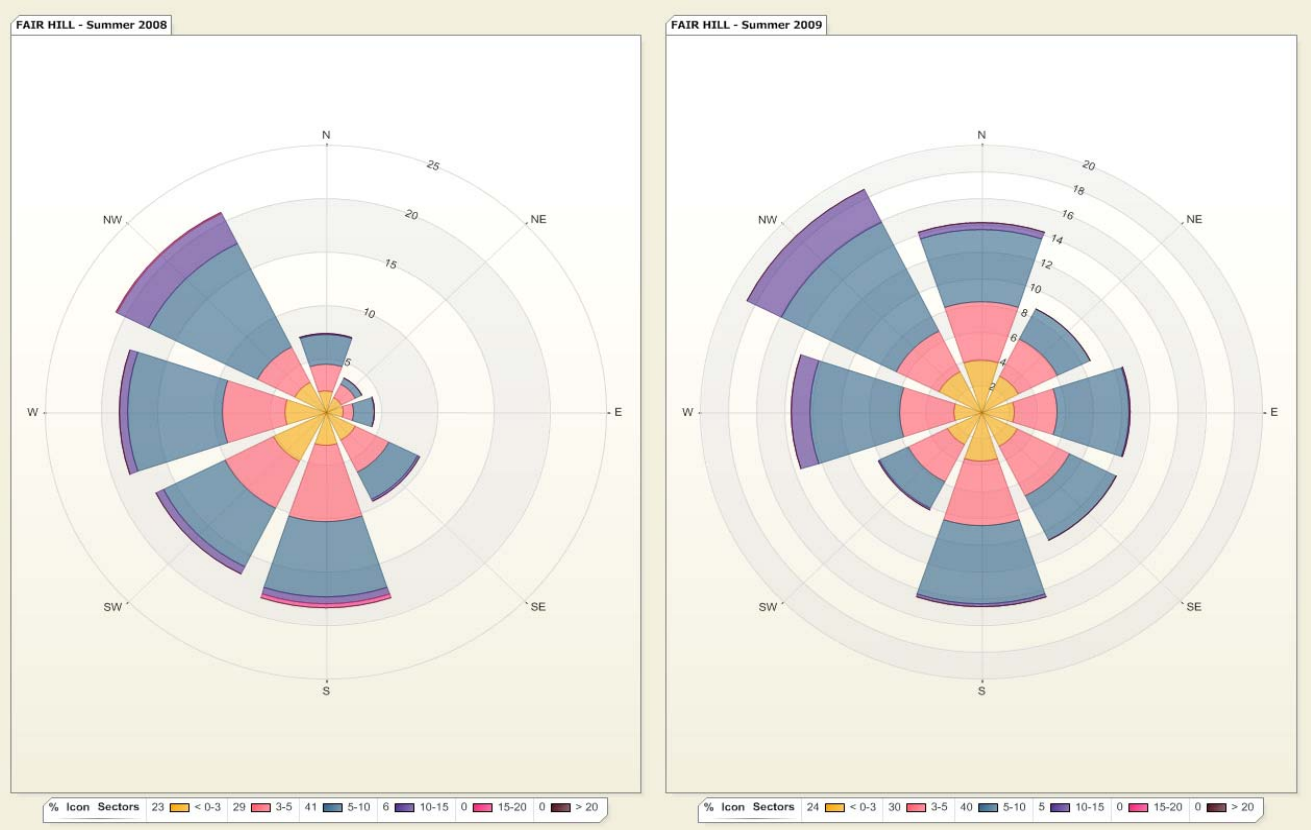

Figure A-6. Wind roses for Fairhill for June through August 2008 and 2009.

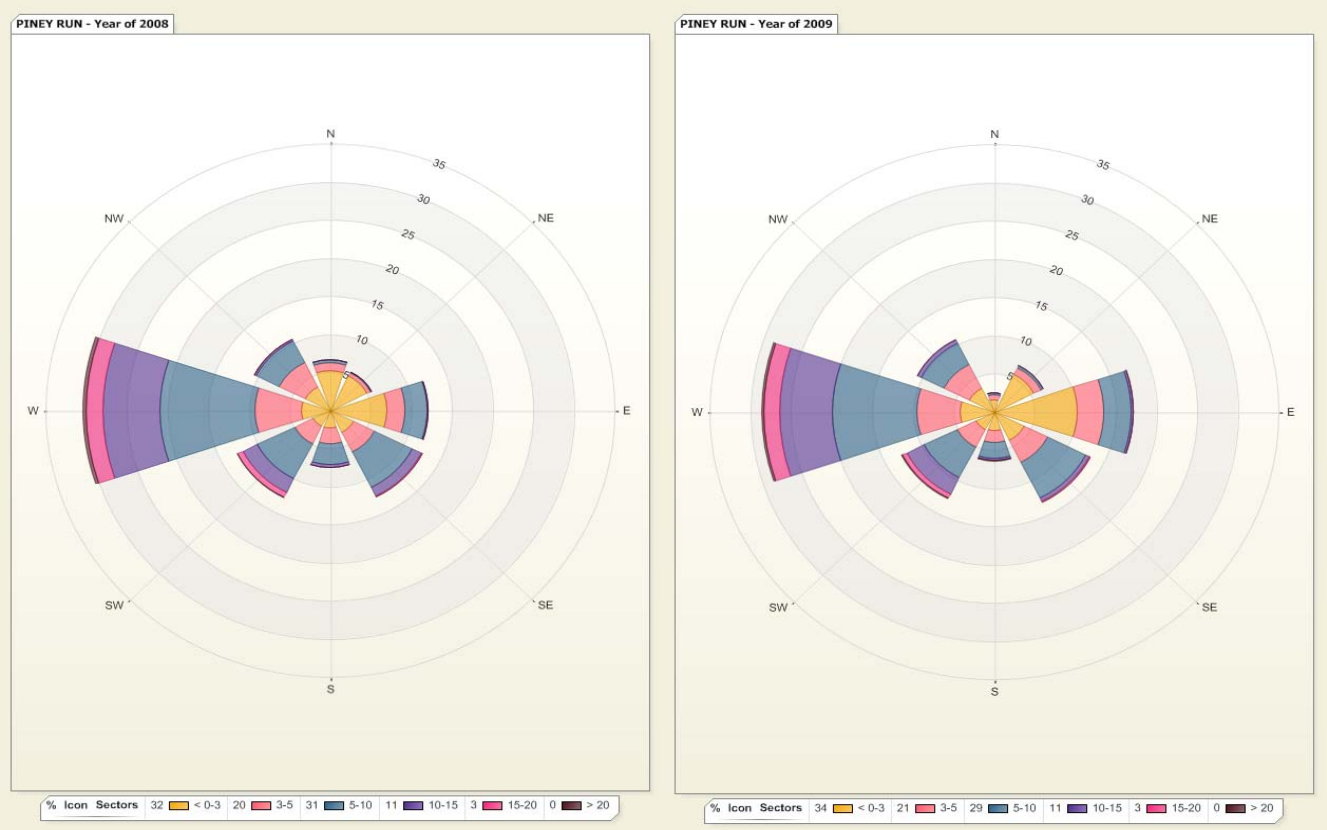

Figure A-7. Wind roses for Piney Run, annual average for 2008 and 2009.

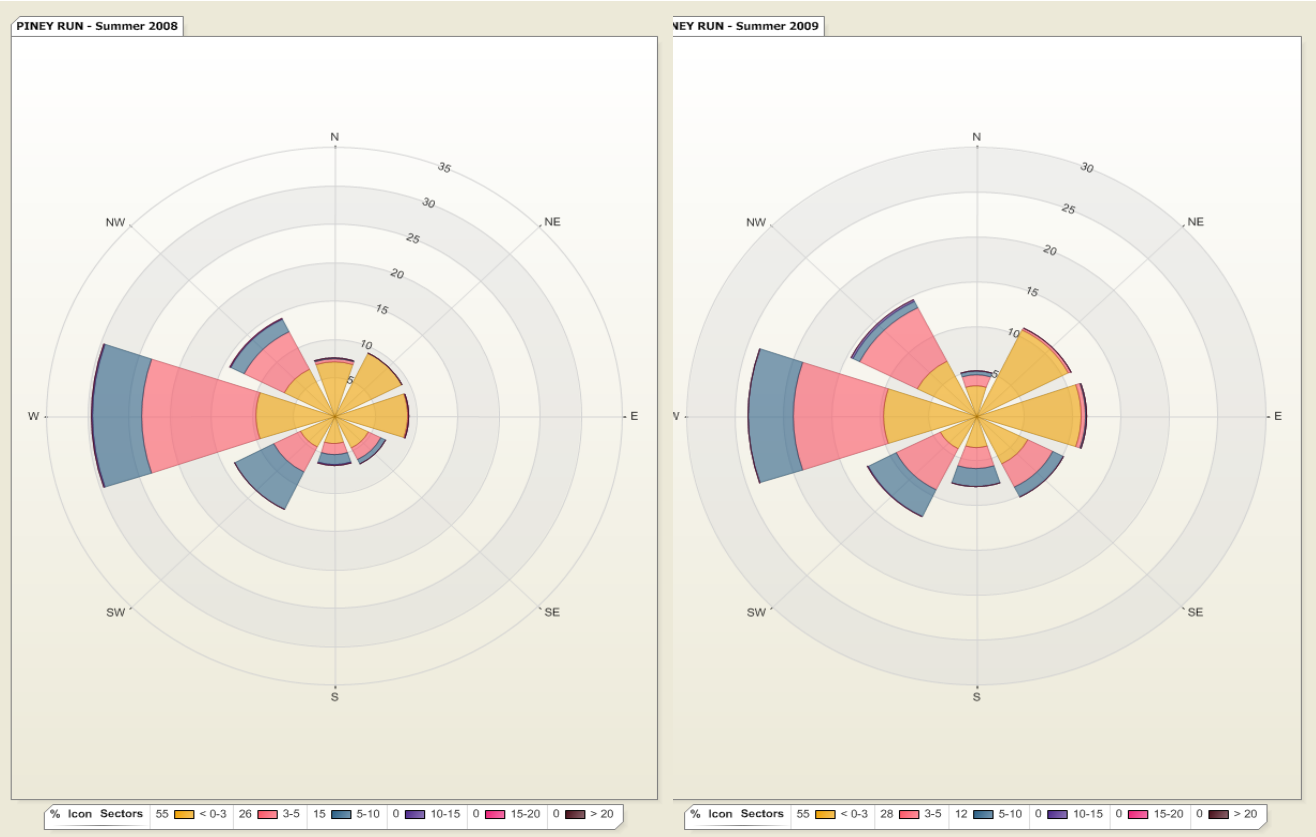

Figure A-8. Wind roses for Piney Run for June through August 2008 and 2009.

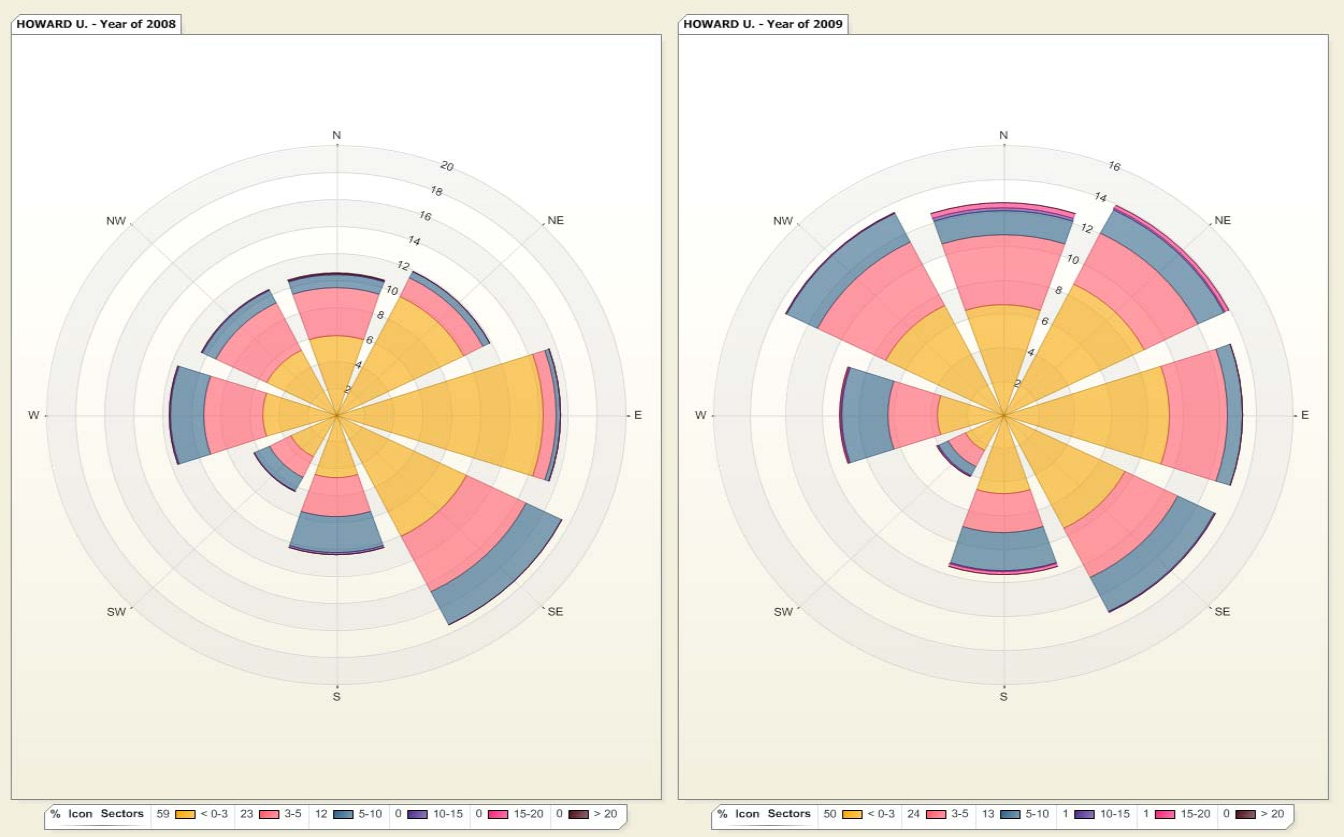

Figure A-9. Wind roses for HU-Beltsville, annual average for 2008 and 2009.

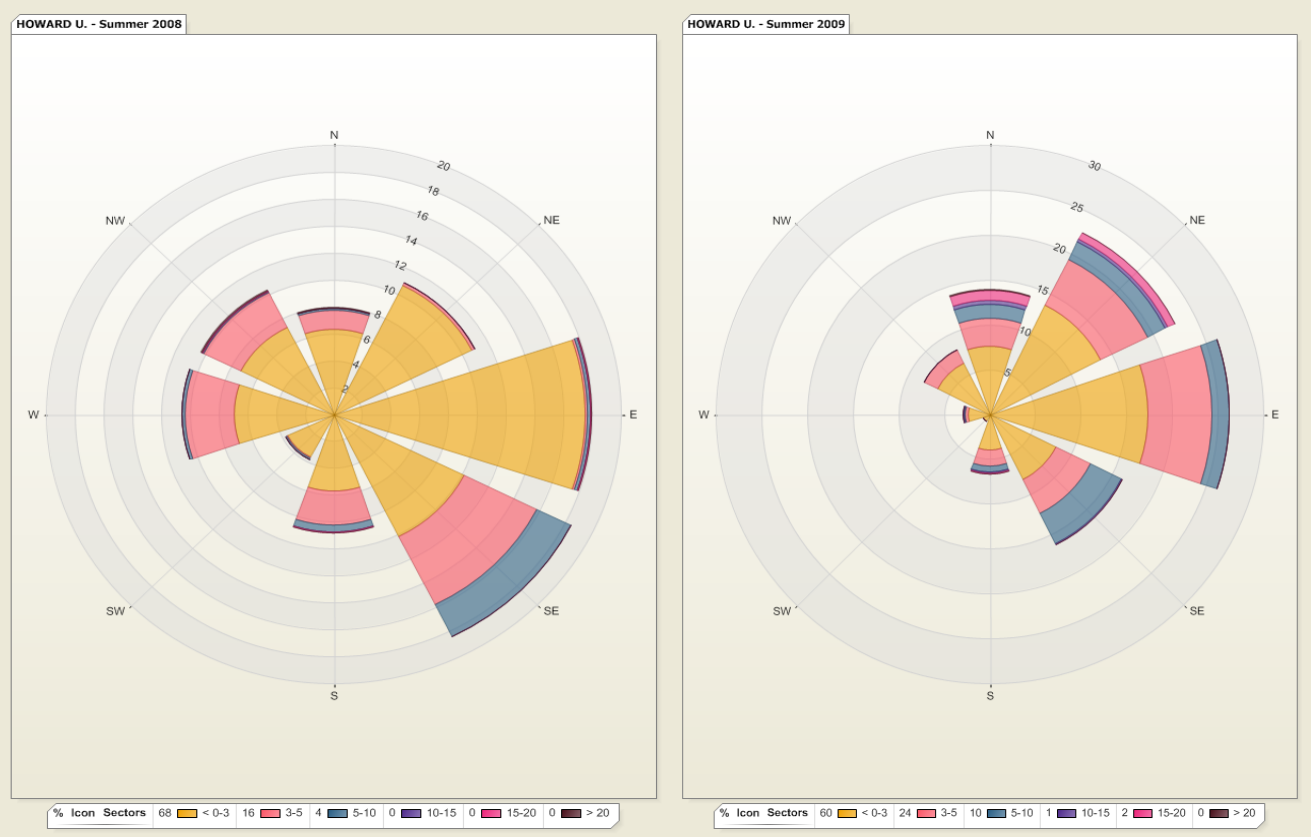

Figure A-10. Wind roses for HU-Beltsville for June through August 2008 and 2009.

APPENDIX B – GENERAL NETWORK INFORMATION

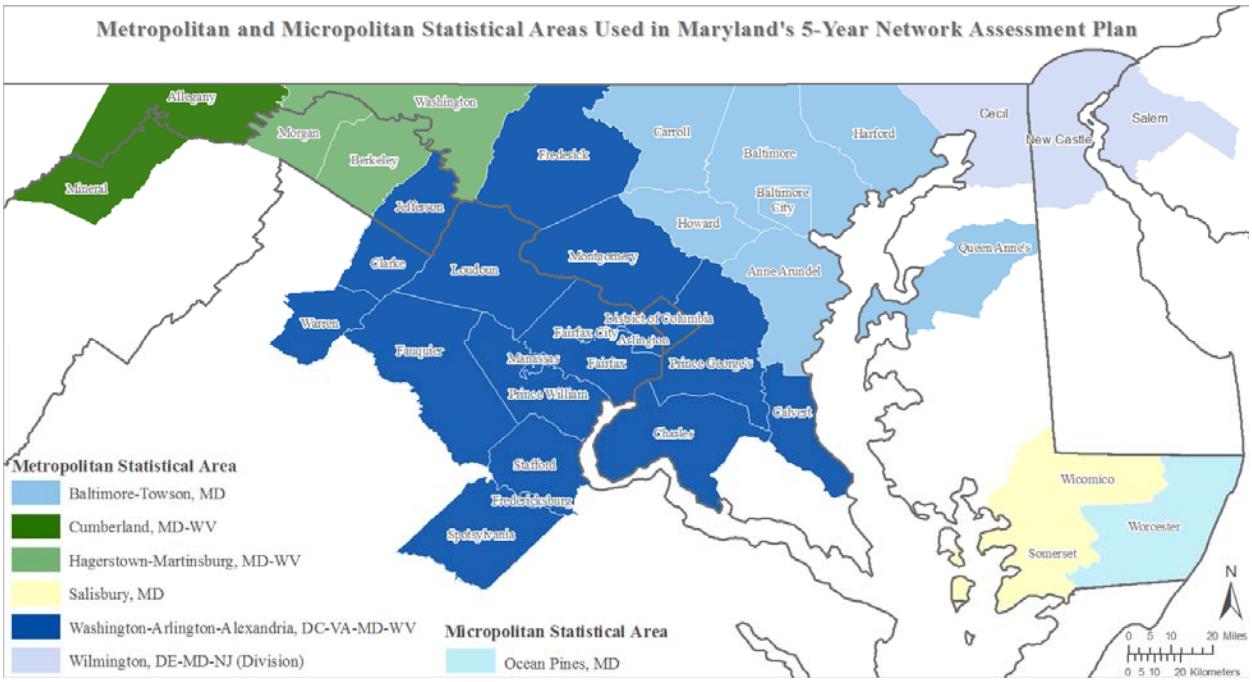

Figure B-1. Metropolitan and Micropolitan Statistical Areas Used in Maryland's 5-Year Network Assessment

Table B-1. Maryland's Air Monitoring Site Locations with AQS Id's

Site name, aqs id	Street address	City, county	Zip code	Latitude, longitude	Core based statistical area (cbsa)
Aldino, 240259001	3560 Aldino Road	Aldino, Harford	21028	39.563333, -76.203889	Baltimore-Towson
Fire Dept. 20 245100008	Balto. City Fire Dept. 20	Baltimore City	21224	39.287680, -76.547616	Baltimore-Towson
Bladensburg VFD, 240330025	Bladensburg Volunteer Fire Department, 4213 Edmonston Road	Bladensburg, Prince George's	20710	38.941697, -76.933698	DC-Arlington-Alexandria
Calvert Co, 240090011	350 Stafford Road	Barstow, Calvert	20678	38.536722, -76.617194	DC-Arlington-Alexandria
Davidsonville, 240030014	Davidsonville Recreation Center, 3801 Queen Anne Bridge Road	Davidsonville, Anne Arundel	21035	38.902500, -76.653056	Baltimore-Towson
Edgewood, 240251001	Edgewood Chemical Biological Center (APG), Waehli Road	Edgewood, Harford	21010	39.410000, -76.296667	Baltimore-Towson
Essex, 240053001	600 Dorsey Avenue	Essex, Baltimore	21221	39.310833, -76.474444	Baltimore-Towson

Site name, aqs id	Street address	City, county	Zip code	Latitude, longitude	Core based statistical area (cbsa)
Fairhill, 240150003	4600 Telegraph Road	Fairhill, Cecil	21921	39.701111, -75.860000	Wilmington, DE-MD-NJ
Frederick, 240210037	Frederick County Airport, 180 E Airport Drive	Frederick, Frederick	21701	39.408056, -77.375833	DC-Arlington-Alexandria
Frostburg Improve 240239000	Frostburg Reservoir	Finzel, Garrett	21532	39.705896, -79.012117	NA
Furley, 245100054	Furley E.S. Recreational Center, 4633 Furley Avenue	Baltimore City	21206	39.328890, -76.552500	Baltimore-Towson
Glen Burnie, 240031003	Anne Arundel Co Publick Works BLDG, 7409 Baltimore Annapolis Blvd	Glen Burnie, Anne Arundel	21061	39.169533, -76.627933	Baltimore-Towson
Hagerstown, 240430009	18530 Roxbury Road	Hagerstown, Washington	21740	39.565556, -77.721944	Hagerstown-Martinsburg
HU-Beltsville, 240330030	Howard University's Beltsville Laboratory, 12003 Old Baltimore Pike	Beltsville, Prince George's	20705	39.055277, -76.878333	Baltimore-Towson
Millington, 240290002	Millington Wildlife Management Area, Massey-Maryland Line Road (Route 330)	Massey, Kent	21650	39.305000, -75.797333	NA
NE Police, 245100006	Northeast Police Station, 1900 Argonne Drive	Baltimore City	21218	39.340556, -76.582222	Baltimore-Towson
NW Police, 245100007	Northwest Police Station, 5271 Reisterstown Road	Baltimore City	21215	39.344444, -76.685278	Baltimore-Towson
Oldtown, 245100040	Oldtown Fire Station, 1100 Hillen Street	Baltimore City	21202	39.298056, -76.604722	Baltimore-Towson
Padonia, 240051007	Padonia Elementary School, 9834 Greenside Drive	Cockeysville, Baltimore	21030	39.460833, -76.631111	Baltimore-Towson
PG Equestrian Center, 240338003	PG County Equestrian Center, 14900 Pennsylvania Ave.	Greater Upper Marlboro, Prince George's	20772	38.811940, -76.744170	D.C., Arlington, Alexandria
Piney Run, 240230002	Frostburg Reservoir, Finzel	Finzel, Garrett	21532	39.705916, -79.012028	NA
Rockville, 240313001	Lathrop E. Smith Environmental Education Center, 5110 Meadowside Lane	Rockville, Montgomery	20855	39.114444, -77.106944	DC-Arlington-Alexandria
South Carroll, 240130001	1300 W. Old Liberty Road	Winfield, Carroll	21784	39.444167, -77.041667	Baltimore-Towson
Southern Maryland, 240170010	Oaks Road	Hughesville, Charles	20622	38.504167, -76.811944	DC-Arlington-Alexandria

Table B-2. Air Toxic Parameters Measured in Maryland

AQS PARAMETER CODE	ABBRE.	PARAMETER DESCRIPTION	LIFETIME BY REACTION WITH OH
43218	13BUD*	1,3-BUTADIENE	2.8 hours
45807	14CBZ	1,4-DICHLOROBENZENE AKA-P-DICHLOROBENZENE	
43826	2CLET	1,1-DICHLOROETHYLENE AKA VINYLIDENE CHLORIDE	
43829	2CLPR*	1,2-DICHLOROPROPANE AKA PROPYLENE DICHLORIDE	weeks
43824	3CLET*	TRICHLOROETHYLENE	84 hours
43818	4CLET*	1,1,2,2-TETRACHLOROETHANE	
43844	6CLBD	HEXACHLOROBUTADIENE	
43503	ACETA*	ACETALDEHYDE AKA ACETIC ALDEHYDE	12 hours
43505	ACREN	ACROLEIN	17 hours
43704	ACRNT*	ACRYLONITRILE	2.4 days
43806	BRFM	BROMOFORM	
43819	BRMT	BROMOMETHANE AKA METHYL BROMIDE	
45201	BZ*	BENZENE	84 years
45809	BZCL	BENZYL CHLORIDE	
43831	C3H4Cl2	CIS-1,3-DICHLOROPROPYLENE	
45801	CLBZ	CHLOROBENZENE	
43812	CLEHN	CHLOROETHANE AKA ETHYL CHLORIDE	
43803	CLFM*	CHLOROFORM	months
43801	CLMT	CHLOROMETHANE AKA METHYL CHLORIDE	
42153	CS2	CARBON DISULFIDE	
43804	CTETL*	CARBON TETRACHLORIDE	decades
43843	DBRMT	1,2-DIBROMOETHANE AKA ETHYLENE DIBROMIDE	
43813	DCETH	1,1-DICHLOROETHANE AKA ELLRYLIDENE DICHLORIDE	
45203	EBENZ*	ETHYLBENZENE AKA-PHENYLETHANE	2 days
43815	ETHCL*	1,2-DICHLOROETHANE AKA ETHYLENE DICHLORIDE	
43502	FORM*	FORMALDEHYDE AKA-OXYMETHYLENE	26 hours
43802	MC	METHYLENE CHLORIDE AKA DICHLOROMETHANE	months
43372	MTBE	METHYL TERT-BUTYL ETHER	
43560	MTBTN	METHYL ISOBUTYL KETONE AKA HEXONE	
43552	MTETN	METHYL ETHYL KETONE	
43231	NHEXA*	N-HEXANE	
45204	OXYL*	O-XYLENE AKA-1,2-DIMETHYLBENZENE	
43817	PERC*	PERCHLOROETHYLENE AKA-TETRACHLOROETHYLENE	months
43504	PRPYD	PROPIONALDEHYDE	
45220	STYR*	STYRENE AKA ETHENYLBENZENE	
43830	tC3H4Cl2	TRANS-1,3-DICHLOROPROPYLENE	
43814	TCA	1,1,1-TRICHLOROETHANE AKA METHYL CHLOROFORM	
43820	TCA1	1,1,2-TRICHLOROETHANE	
45810	TCBZ	1,2,4-TRICHLOROBENZENE	
45202	TOLU*	TOLUENE AKA METHYLBENZENE	
43860	VC*	VINYL CHLORIDE	27 hours

* indicates HAPS that are volatile organic compounds (VOC's)