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THE DEVELOPMENT OF AN AIR TOXICS MONITORING STRATEGY FOR MICHIGAN

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EXECUTIVE SUMMARY

The Air Quality Division (AQD) began its program to monitor air toxics in January 1990. Over time, there has been a recognition that this program needs to be improved to meet current needs. This need for an improved air toxics monitoring program in Michigan has been underscored by several recently released reports and recommendations. The February 1999 report, Michigan's Relative Risk Task Force Report on Air Quality Issues recommended the Michigan Department of Environmental Quality (MDEQ) make collection of high quality ambient air data on hazardous air pollutants a high priority. With regards to persistent bioaccumulative air toxics, this Task Force recommended the implementation of improved monitoring which incorporates selected watershed ecosystem evaluation to characterize "hot spot" and understand the air contribution to the overall risk of these pollutants.

The Task Force findings regarding the need for additional monitoring data as a high priority was also supported by the Michigan Environmental Science Board (MESB), established by Governor John Engler, in their February 2000 report, Analysis of the Michigan Department of Environmental Quality's Administered Standards to Protect Children's Health. Further recommendations for additional air toxics monitoring were provided by the MESB in their July 2001 report, Recommended Environmental Indicators Program for the State of Michigan. The Southeast Michigan Council of Governments (SEMCOG) also found in their November 1999 report, A Profile of Southeast Michigan's Environment: Identification of Environmental Indicators and Initial Data Collection, that the collection of more monitoring data for air toxics in southeast Michigan is needed to adequately evaluate control strategies for emissions to the air.

On a federal level, formal recognition of the need for increased measurements of air toxics in ambient air has also occurred. Various projects and initiatives supporting this goal are underway nationwide.

Given the recommendations of the Michigan Relative Task Force, MESB, and SEMCOG, and considering national efforts, the AQD has pursued development of a comprehensive air toxics monitoring strategy for Michigan to meet the needs of its programs, stakeholders and the public.

The strategy has been developed as two separate parts, including an ambient monitoring network and a separate atmospheric deposition network. The atmospheric deposition network addresses persistent bioaccumulative toxics, whereas the ambient monitoring network covers all other air toxics.

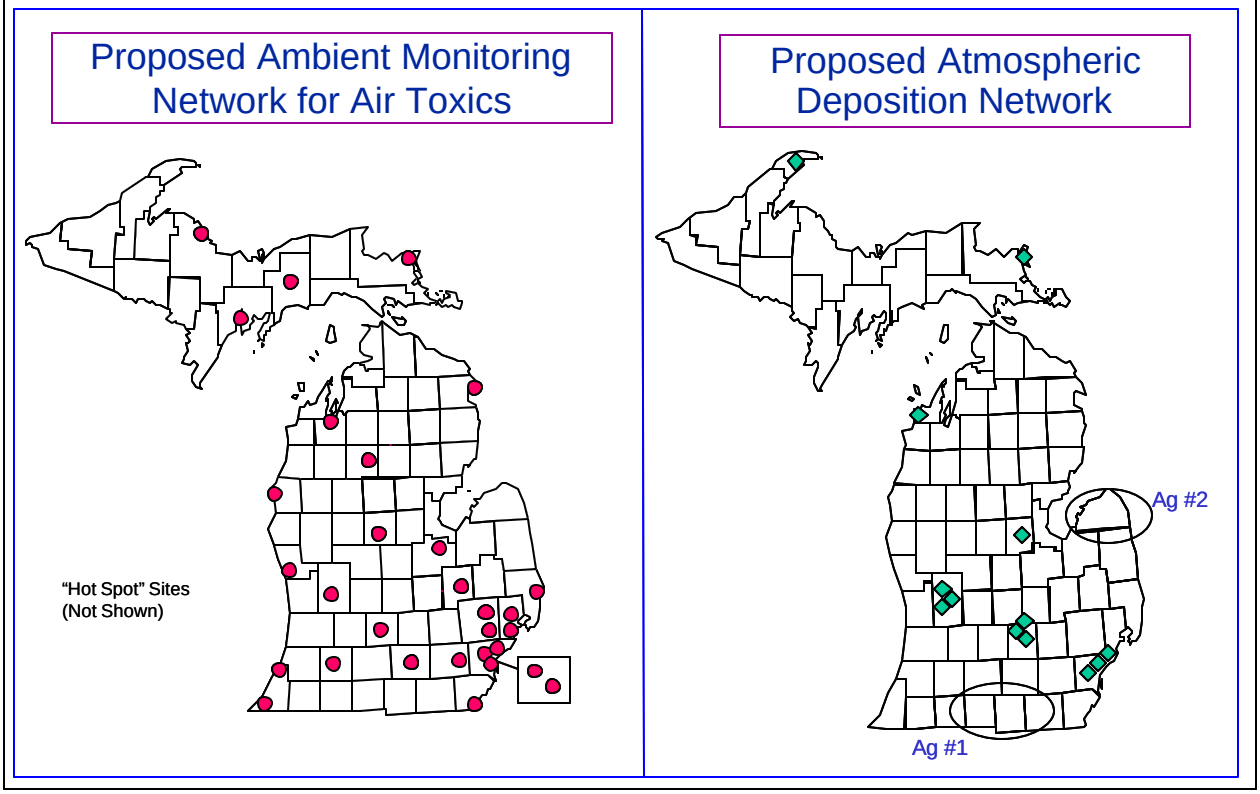
The strategy was developed to address several objectives, and include the following:

- Assess Temporal Trends.
- Assess Spatial Variability.
- Determine Population Exposure.
- Perform Special Purpose Monitoring In Microscale Environments.
- Support And Evaluate Dispersion And Receptor Models.
- Environmental Indicators.

The proposed ambient network will consist of 35 sites and take five years to become fully deployed. Levels of 59 volatile organic compounds (VOCs), 13 carbonyl compounds, and 14 trace metals, including hexavalent chromium, will be determined using a once every six day sampling schedule at these sites. Polynuclear aromatic hydrocarbons (PAHs) will also be measured initially at six sites to provide further information on the need to include this class of compounds in the monitoring network.

The portion of the network that addresses atmospheric deposition will range from four to twelve sites, and take three years to reach complete deployment. Pollutants to be monitored include mercury, polychlorinated biphenyls (PCBs), and dioxins and furans. Mercury analysis will include continuous measurements of elemental mercury (vapor phase) and reactive gaseous mercury, as well as particulate mercury levels sampled every six days. PCBs samples will be collected by sampling particulate and vapor phases for 24-hours, once every 12 days. Dioxins and furans will be determined using monthly composite samples. Precipitation samples to address wet deposition will either be collected as monthly composites for PCBs or as single events for mercury. Figure 1 summarizes the proposed networks.

Figure 1: Summary of Ambient Toxics and Atmospheric Deposition Monitoring Networks



Once deployed, the annual budget for both the ambient and atmospheric portions of the strategy is estimated to be about $3.4 to $4.8 million. Depending on the year and purpose of the monitoring project, the annual budgets for the individual networks range from about $950,000 to $2.9 million. Currently funding is not available to implement this strategy. It is anticipated that as

funding becomes available, the strategy will be used as a guide to help implement an expanded air toxics monitoring program.

This strategy will be reassessed periodically considering changing resources, monitoring results, departmental priorities, and emerging issues. Therefore, this strategy is to be considered a living document.

PURPOSE AND STRATEGY FORMAT

There are two purposes behind the creation of this document. The first purpose is to describe the process, estimate the costs, delineate future plans that relate to monitoring toxic compounds in the air in Michigan, as well as to propose an optimal (yet somewhat practical and achievable) design for an air toxics monitoring network for the state. The second purpose of this document deals with funding the monitoring network proposed in this strategy. Currently resources are not available to implement the proposed monitoring network. This document will provide the background information that can be used for pursuing funding sources and demonstrate that Michigan has an air toxics monitoring strategy in place that can be used as a guide to implement such a program. Monitoring for air toxics in Michigan is important and funding is needed for this effort. Many reports generated on both state and federal levels, as discussed in **Part 1, Section 1A**, have highlighted the necessity for more data on air toxics. Air toxic data will also be useful for air quality planning in the State as well as policy decision-making.

This strategy has been developed as two separate parts, including one that addresses the development of the ambient monitoring network, and the other that addresses the atmospheric deposition network. Due to the differences in network design principles, the types of pollutants measured, costs, and potential funding sources, each part has been written to be a stand alone document. This approach may have resulted in some redundancy when each portion is combined into the complete document.

The strategy will be reassessed periodically, considering changing resources, monitoring results, departmental priorities, and emerging issues. Therefore, this strategy is to be considered a living document.

This document is intended to serve as only a preliminary step toward the further development and expansion of a comprehensive air toxics program for the State of Michigan. Comprehensive site selection criteria, detailed risk assessment techniques, and specialized modeling applications are beyond the scope of this strategy.

PART 1: Ambient Monitoring Network

1. INTRODUCTION

In the late sixties and early seventies, air quality programs at both the state and federal level were initiated to address the often-visible air pollution problems existing at the time. These early programs focused on the criteria pollutants (particulate matter [$PM_{2.5}$ and PM_{10}], sulfur dioxide [SO_2], nitrogen dioxide [NO_2], carbon monoxide [CO], ozone [O_3], and lead [Pb]). The ambient air monitoring programs during this time also addressed only criteria pollutants (**35**).

As the air pollution problems from criteria pollutants began to be addressed, and the air became visibly cleaner, there became a growing awareness of the potential health and environmental threats from toxic air pollutants. The AQD began addressing air toxics in the permitting process in the late seventies; however, no ambient air monitoring program for these pollutants was in existence at that time. Throughout the seventies and most of the eighties, the emphasis in monitoring continued to be with the criteria pollutants.

Finally, in January 1990, the AQD began a program to monitor for toxic air pollutants that pose a risk through inhalation. The goal of this initial program was to begin to characterize the ambient levels of toxic air pollutants in the major urban areas in Michigan. Since this program began, there has only been adequate funding to run approximately three sites per year. For the first five years, approximately 40 toxic organic compounds and 13 trace metals were analyzed at these sites.

In June 1995, the AQD also began monitoring for an additional group of toxic organic compounds called carbonyl compounds (aldehydes and ketones). Other ambient air toxics monitoring that has supplemented this program over the past ten years includes monitoring around hazardous waste facilities, participation in the United States Environmental Protection Agency's (USEPA's) urban air toxics monitoring program (October 1988-October 1989), projects funded from enforcement cases, and a couple of projects funded through grants (**36**-**41**). Except for the monitoring around hazardous waste facilities, which is required under rules promulgated under Part 111 of the Natural Resources and Environmental Protection Act (Act 451), all of this supplemental monitoring has been of limited term. **Appendices A** in both parts summarize past and current monitoring efforts that pertain to toxic air contaminants.

While the above programs have provided some limited data regarding ambient levels of air toxics, the inadequate nature of the database has been criticized in reports associated with various projects and initiatives, which are discussed in more detail below, further highlighting the need for a comprehensive strategy to fully address the needs of the AQD's air programs. Additionally, analysis of the limited data set indicates some toxic air contaminants are at levels of concern and warrant further investigation and characterization. This need for a strategy has also been identified in the AQD's Targets and Means for FY 2000 and 2001 (**42**). Specifically, the AQD committed to developing this strategy by September 30, 2001.

A. Initiatives Supporting the Development of the Strategy

In recent years, there have been several reports and recommendations urging the expansion of Michigan's Air Toxic Monitoring Program. The February 1999 report, Michigan's Relative Risk Task Force Report on Air Quality Issues (**43**) recommended the MDEQ make collection of high quality ambient air data on hazardous air pollutants a high priority. With regards to persistent bioaccumulative air toxics, the Task Force recommended the implementation of improved monitoring which incorporates selected watershed ecosystem evaluation to characterize "hot spots" and understand the air contribution to the overall risk of these pollutants. The MESB, established by Governor John Engler, also supported the Task Force findings regarding the need for additional monitoring data as a high priority in their February 2000 report, Analysis of the Michigan Department of Environmental Quality's Administered Environmental Standards to Protect Children's Health (**44**). As part of the MDEQ budget bill for the 2001 fiscal year, the MDEQ will be required to report by September 30, 2001, the progress made in implementing the recommendations of the above MESB report.

The MESB continued their recommendation for additional air toxics monitoring in their July 2001 report, Recommended Environmental Indicators Program for the State of Michigan (**45**). Also, environmental indicators in southeast Michigan were reviewed in the November 1999 report, A Profile of Southeast Michigan's Environment: Identification of Environmental Indicators and Initial Data Collection (**46**), published by SEMCOG. The authors conclude that the collection of more monitoring data for air toxics in southeast Michigan is needed to adequately evaluate control strategies for emissions to the air.

On a federal level, formal recognition of the need for increased measurements of air toxics in ambient air also has occurred. Various projects and initiatives supporting these goals are underway nationwide. In September 1999, the USEPA, along with representatives from the State and Territorial Air Pollution Program Administrators/Association of Local Air Pollution Control Officials (STAPPA/ALAPCO) began work to develop an air toxics monitoring strategy concept paper describing the creation of a nationwide toxics network (**1,2,18,19**). Their primary goal is to validate the results obtained from modeling air toxics levels nationwide and the secondary goal is to set up a trends network. As an outcome from this process, analyses are planned nationwide that will assess the quality of and determine comparability of air toxics measurements collected by states having air toxic databases (**47**). Also, pilot-monitoring projects will be conducted during 2000 and 2001 at a few selected urban, rural, and small cities nationwide to investigate concentration gradients of toxic air contaminants in various environments (**17**). Efforts are also underway on both regional and national fronts to evaluate monitoring priorities and budgetary commitments, which will impact funding of future networks measuring ambient levels of toxics. Michigan will be coordinating the state strategy with these regional and national efforts.

The recommendations of the Michigan Relative Risk Task Force, MESB, and SEMCOG, along with national efforts, support the AQD's efforts to develop a comprehensive air toxics monitoring strategy to meet the needs of its programs, stakeholders, and citizens.

B. Approach

In September 1999, a small AQD workgroup was created to guide the progress and direction of the project, form the initial monitoring objectives, design the network, create the budgets, and act as liaison to the Division Chiefs and management. Ms. Cathy Simon, Chief of the Toxics Unit, and Ms. Mary Ann Heindorf, Environmental Quality Specialist in the Air Monitoring Unit, acted as lead staff for the overall project. Ms. Joy Taylor Morgan, Environmental Quality Specialist in the Toxics Unit, provided the lead for developing the atmospheric deposition monitoring network. Mr. Robert Sills, Toxicologist Specialist in the Toxics Unit and the late Mr. Paul Shutt, Chief of the Air Quality Evaluation Section were also members of the workgroup. Several other AQD staff also provided assistance on an as needed basis. During each major stage of the project, feedback was solicited from AQD staff and members of the Air Advisory Group, consisting of representatives from industry, environmental groups, small businesses, local groups, and state representatives. The strategy was also submitted to a panel for scientific peer review.

2. MONITORING GOALS AND OBJECTIVES

A. Goal Statement

The goal of the Michigan air toxics monitoring strategy is twofold. The first goal is to develop an approach for the determination of concentrations of toxic compounds in the ambient air. The second goal is to obtain data in order to meet the monitoring objectives below.

These goals will aid in the statewide characterization of toxic compounds in the ambient air. This information will be used to support human exposure and health risk assessments, to determine temporal trends, to evaluate changes in the environmental quality, and to assess impacts on the environment. This will be accomplished by measuring the levels of critical compounds at selected key locations across the state, by characterizing conditions at representative areas which would infer the likely conditions at other areas and time periods, and by supporting the development and evaluation of potential modeling techniques. The strategy, when implemented, will be a valuable resource in support of Michigan's environmental programs for protecting and improving air quality and Michigan's environment.

B. Objectives

Several objectives have been identified for the two components of this strategy. These objectives include the following:

1. Assess Temporal Trends
2. Assess Spatial Variability
3. Determine Population Exposure
4. Perform Special Purpose Monitoring in Microscale Environments
5. Support and Evaluate Dispersion and Receptor Models
6. Environmental Indicators

Each objective is discussed in more detail below and rational for its inclusion as part of the ambient network is provided. **Section 4, Ambient Network Budget**, also provides the rationale for prioritization of deployment of sites to meet these objectives.

1) Assess Temporal Trends

Long-term monitoring occurring for at least ten years at fixed sites allows the determination of changes in ambient concentrations of toxic air pollutants over time. The determination of temporal trends in the concentrations of air toxics can be used to verify actual improvements in environmental quality. Reductions in emissions and improvements in control technologies must not be limited to what is calculated and reported in emission inventories, but must be linked to actual environmental measurements.

Long-term monitoring must be performed at selected sites to provide a clear indication of environmental conditions over time.

Added benefits arising from improved temporal coverage include the availability of more information to evaluate the efficacy of air toxics programs and facilitate better decisions about the future direction of these programs. Additionally, this information will be useful for prioritizing future work, which may include sampling in a more in-depth or source specific basis.

2) Assess Spatial Variability

Concentrations of toxic air pollutants can vary spatially across different areas of the state. These concentrations may be influenced by several factors including the type of sources located in an area, the number of sources, local meteorological conditions, varying terrain, etc. To adequately characterize the spatial variations in ambient levels of toxic air pollutants, it is necessary to locate monitors in areas representative of these different environments. These monitors will be in operation for three or more years.

Improved spatial coverage will allow the determination of homogeneity or variability across distances that may be as small as an urban area, or as large as the state. It is also important to assess differences between background concentrations that are measured in urban, suburban, and rural locations. Variations may also exist between sites with similar land use characteristics that are removed from each other such as rural locations in the Lower Peninsula and its counterpart in the Upper Peninsula.

Urban scale saturation monitoring will allow the identification of gradients across metropolitan areas and detailed investigation of the impacts of various sources on the surrounding community. Greater spatial coverage across the state will allow the determination of the extent of transport into the state. Both will aid the identification of maximum impact sites and the analysis of patterns and trends in ambient air toxics measurements. Improved spatial coverage will also provide valuable information regarding existing levels of air toxics to help address the public concern regarding incremental impacts of new sources, and be applied as an aid in new source review permitting decisions.

3) Determine Population Exposure

It is important that monitors are located in areas representative of where most people live, work, and play at population-oriented sites. Data from these monitors would be used to assess population exposure rather than detect the maximum possible concentrations of air toxics dominated by single source(s). This data will help determine exposure levels of toxic air pollutants for the majority of the population and facilitate assessment of risk from such exposure.

4) Perform Special Purpose Monitoring in Microscale Environments

Some of Michigan's population may be exposed to significantly higher concentrations of air toxics than the general population due to proximity to large emitters of toxic air pollutants, or in areas where many sources are located. It is important to identify and characterize these microscale environments since people living in these areas will be

exposed to the greatest risks from air toxics. **Section 3.A.4**, describes the process that will be used to identify these locations. It is envisioned that short-term monitoring will be conducted at these locations, rotating many monitors from site to site, improving geographical coverage. Contingent upon the results obtained in subsequent data analyses, it is anticipated that these monitoring sites would operate a minimum of one year to supply data that will be used to estimate annual exposure. Seasonal variations, fluctuations in meteorology, and site specific conditions will all serve to influence the concentrations of air toxics. Monitoring for a minimum of a year will insure that measured concentrations reflect the variability of these conditions.

5) Support and Evaluate Dispersion and Receptor Models

One of the major goals of the national air toxics network currently being planned by the USEPA, is to provide data to support and evaluate dispersion and exposure models (**1,2**). Due to the high costs associated with monitoring, reliable modeling systems, and emission inventories are the best approach for assessing population exposure and ambient concentrations across the nation, according to the USEPA. Before widespread application of these tools, it is important to validate their results under a wide range of conditions. Ambient concentrations of air toxics will be made available to the USEPA to support national efforts.

Another tool, receptor modeling, can be performed to isolate the relative contributions of various source categories to the overall pollutant load. The identification of these sources and the relative magnitude of their contributions allow the development and application of appropriate control strategies in order of importance of control and to verify emission inventories. Receptor modeling is one of the goals of a Photochemical Assessment Monitoring Station (PAMS) and $PM_{2.5}$ speciation data analysis activities. Future needs for receptor modeling could also drive the location of new sites, dependent upon future priorities within the AQD. Data collected by the toxics network could be used in these analyses and provide a “reality check” to be performed on the model outputs.

6) Environmental Indicators

The air toxics monitoring network should be designed so that the data collected may be used as an indicator of environmental quality (**3,4,45**). This objective is specifically mentioned in the AQD’s Targets and Means for FY 2000. While other measures such as emissions inventory data may provide some information about the quality of the air, ambient monitoring data provides the most direct measure. It is anticipated that the monitoring locations that will be selected to address spatial and temporal trends objectives will also supply data to be used as an indicator of environmental quality. Likewise, expansion of the monitoring network to address the objective of atmospheric deposition will also provide data to be used as an environmental indicator (**45**).

3. AMBIENT NETWORK DESIGN PRINCIPLES

A. Summary of Ambient Network

Section 3.B. provides the rationale for the design of the proposed ambient network. This network contains 30 fixed longer term sites that will address ambient levels of air toxics for time periods exceeding one year as well as five (5) short-term special purpose sites.

Data collected from these 30 fixed sites will be used to address all objectives one through six, as discussed in the previous section except for objective 4 – special purpose monitoring. **Figure 2** summarizes the design of the ambient monitoring network for the 30 fixed sites. These 30 fixed sites include:

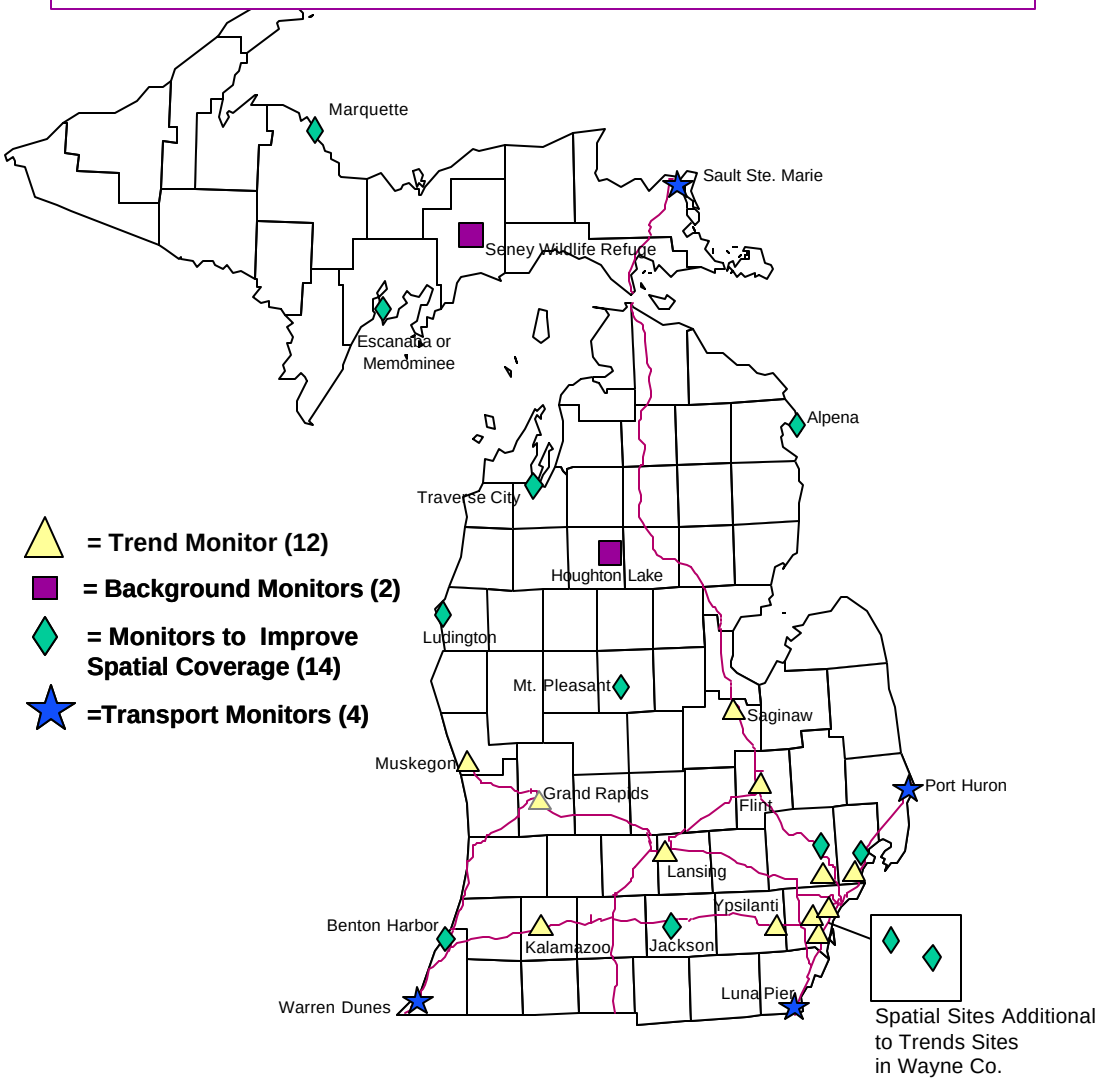
- trend sites to measure long-term changes in air quality.
- background monitors to provide measurements of toxic air contaminants in locations away from the influence of metropolitan areas.
- transport sites to provide an indication of levels of toxic compounds emitted from upwind or area sources moving into a metropolitan area.
- additional sites to provide information about how levels of air toxic compounds vary spatially throughout the state.

The sites that are coded with a triangle in **Figure 2** represent the current and proposed long-term trend sites. Background sites are represented by a square and also may operate long-term. Sites coded with a diamond are located to improve the spatial coverage of the network. The planned duration of operation of these sites is dependent upon evaluation of preliminary results obtained at each location, but generally spatial sites are expected to operate for three or more years.

In addition to the above 30 sites, five special purpose monitors will operate each year, rotating to a different location. The specific sites selected for a given year will reflect the highest priority locations at that time. The rationale for special purpose monitoring site selection is discussed further in **Section 3.B.4**.

The pollutants to be monitored in the ambient network include the following: 59 VOCs, 13 carbonyl compounds, and 14 trace metals that include hexavalent chromium. A complete listing of the specific compounds to be monitored is provided in **Appendix C** of the ambient section. PAHs will also be measured at six sites, initially, to assess ambient levels.

Figure 2: Proposed Ambient Monitoring Network for Air Toxics



B. Ambient Network Design Considerations Tailored to Each Objective

The following section provides an iterative approach to the development of an air monitoring network for air toxics and is intended to be transparent. Each monitoring objective will drive the selection of monitoring locations designed to collect information to address that particular objective. At this point, exact sites have not been identified, but locations are limited to a generalized area only. This is intended to create a crude picture of the overall network, incorporating various monitoring objectives into the entire design. Once the network begins to be deployed, various area-specific metrics such as population density, traffic patterns, meteorological patterns, land-use characteristics, and emission sources will be considered to identify candidate sites. Placement of the monitors, such as distance from trees and buildings, conform to established siting criteria.

The criteria pollutant (O_3, SO_2, NO_2, Pb, PM_{10}, $PM_{2.5}$ and CO) monitoring program has been on-going for many years. As a result, federal guidance on network design is well established. The criteria network guidance provides some basic principles and concepts that may be useful in the design of an air toxics monitoring network.

Under the criteria monitoring program, there are three categories of monitoring sites. The National Air Monitoring Stations (NAMS) are designated as trend sites having a long-term commitment to continued operation. This is a subset of and follows the same siting requirements as the State and Local Air Monitoring Stations (SLAMS), which still conduct rigorous monitoring and conform to many federal regulations, but may be closed by the state or local government after their purpose has been exhausted. See **Appendix B** for the locations of monitoring stations for the criteria pollutants. These generally provide better spatial coverage to the network and allow the state to "fill-in" any missing areas that may need monitoring. The Special Purpose Monitoring Stations (SPMs) may use a greater array of monitoring techniques and operate over a shorter period of time. Data generated by the SPMs may or may not be comparable to the National Ambient Air Quality Standards (**5,6**).

Contingent upon adequate funding, it is envisioned that a series of air toxics monitoring sites will be established, with a subset committed to a long-term monitoring similar to the NAMS sites for priority pollutants. The SLAMS type toxics monitors will provide supplementary information so that better spatial coverage may be obtained. Monitoring to determine maximum concentrations would be conducted by the SPM type toxics monitors over a limited time frame. The NAMS/SLAMS equivalent monitoring sites will meet the criteria set forth by the national air toxics network (**6,7**).

The data from all sites will be reviewed periodically to determine if the site is continuing to provide data to meet the objectives of the strategy. If measurements from a site are no longer needed, the site will be eliminated or moved to a new location. For example, if measurements from a specific location are redundant with those from a nearby monitor, or if construction around the site changes air flow patterns, the site may be closed. Additional information describing the criteria that will be used to close a site is discussed in the Network Review Section. The air toxics monitoring network will be a dynamic entity subject to annual review and evaluation continuously evolving to meet the changing needs of the State of Michigan.

The development and implementation of the ambient monitoring network will also be coordinated with any efforts by the State of Michigan to establish Master Stations. The establishment of a system of Master Stations where environmental indicator data would be consistently and uniformly collected was recommended by the MESB in their report, Recommended Environmental Indicators Program for the State of Michigan (**45**). The MESB recommended establishing between 10-25 Master Stations in order to reasonably represent the major landscape/waterbody type and geographic regions across Michigan. A wide range of biological, physical, and chemical parameters would be monitored at the Master Stations to provide long term trend data.

1) Temporal Trends

In designing a monitoring network to meet the objective of measuring temporal trends, two different criteria were considered. These included population levels within metropolitan statistical areas (MSAs) and modeled concentrations of air toxics from USEPA's Cumulative Exposure Project (CEP) (**8-11)**.

Population distributions and MSAs have been used previously to design the trend network for the criteria pollutants. For example, the NAMS are long-term monitors that collect data on criteria pollutants which are used to assess trends as well as support national assessments and decisions. Because the NAMS networks focus on community exposure, the network is designed using population distributions. The specific population level and associated geographical entity (urban area, MSA, city, etc.) that triggers a federal monitoring requirement vary by pollutant.

In designing the temporal trends network for this strategy, a similar approach to that used in the design of the NAMS network was taken. To allow the application of design principles similar to those used nationally, definitions of census terms are presented in **Table 1** as background information. The first criterion considered for this network was population distributions within each consolidated MSA (CMSA) or MSA in the state. An initial decision was made to locate the trend monitors in the major MSAs within the state. There are seven MSAs in Michigan, which are listed in **Table 1** (**10**), and shown by the map in **Figure 3**.

As discussed above, the decision to locate trend monitors in the major MSAs based on population distribution is consistent with the design of national trend networks for the criteria pollutants (**6,12**). A further consideration, which supports this approach, is the Urban Air Toxics Strategy (UATS) being developed under the provisions of Section 112(k) of the federal Clean Air Act (**13**). Goals of the UATS include a 75 percent reduction in the incidence of cancer and a substantial reduction in non-cancer risks from air toxics in urban areas. Location of long-term trend monitoring sites in the major urban areas will provide valuable information in helping to measure progress towards these goals.

As shown by the population levels of each MSA found in **Table 1**, there appears to be a natural break in the database between the Bay City-Midland-Saginaw MSA, with a population of 403,000, and the Benton Harbor MSA, with a population of 162,000. Considering this break in the data, it was decided to locate the trends monitors in those MSAs with a population greater than 400,000. A further decision was then made to use a ratio of one trend monitor for approximately every 400,000 people.

Use of the above ratio for siting monitors would result in ten trend sites for the Detroit MSA, two trend sites for Grand Rapids-Muskegon-Holland MSA, and one trend site in each of Ann Arbor, Lansing-East Lansing, Kalamazoo-Battle Creek, Flint, and Saginaw-Bay City-Midland MSAs. Considering the costs of operation of such a large trend network in the Detroit MSA, it was decided that five sites would be more reasonable, and could still meet the objective of providing adequate trend data for this area.

Figure 3: MSAs in Michigan and Trend Sites

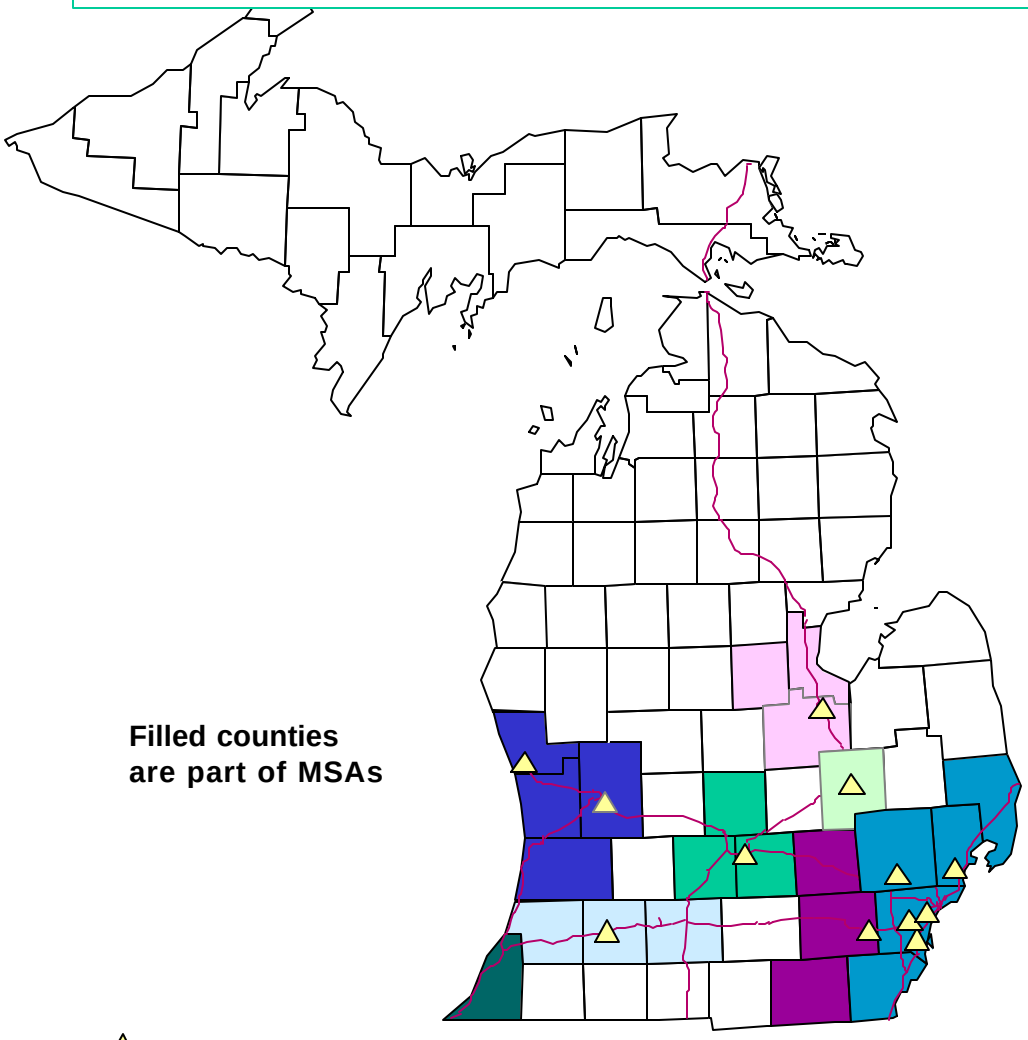


TABLE 1: Population Distribution and Trend Site Locations

Metropolitan Statistical Area[1]	County	2000 Population, in 1,000's	Number of Trend Toxics Monitors by MSA	Tentative Trend Locations by County	County Rank CEP Index$_{(ITSL)}$	County Rank CEP Index$_{(IRSL)}$
Detroit-Ann Arbor-Flint CMSA		**5,456**				
Detroit PMSA		**4,442**	**5**			
	Lapeer	88			16	43
	Macomb	788		1	48	4
	Monroe	146			38	20
	Oakland	1,194		1	43	5
	St. Clair	164			58	22
	Wayne	2,061		3	30	3
Ann Arbor PMSA		**579**	**1**			
	Lenawee	99			65	41
	Livingston	157			14	38
	Washtenaw	323		1	61	14
Flint PMSA		**436**	**1**			
	Genesee	436		1	55	6
Grand Rapids-Muskegon-Holland MSA		**1,089**	**2**			
	Allegan	106			82	48
	Kent	574		1	31	16
	Muskegon	170		1	63	17
	Ottawa	238			70	18
Kalamazoo-Battle Creek MSA		**453**	**1**			
	Calhoun	138			28	23
	Kalamazoo	239		1	6	9
	Van Buren	76			67	80
Lansing-East Lansing MSA		**448**	**1**			
	Clinton	65			76	49
	Eaton	104			60	24
	Ingham	279		1	45	8
Saginaw-Bay City-Midland MSA		**403**	**1**			
	Bay	110			49	10
	Midland	83			81	2
	Saginaw	210		1	21	13
Benton Harbor MSA		**162**				
	Berrien	162			54	19
Jackson MSA		**158**				
	Jackson	158			20	11

Definitions of MSA, CMSA & PMSA are on the next page.

DEFINITIONS TO TABLE 1	
MSA	Metropolitan Statistical Area is defined as "a core area containing a large population nucleus, together with adjacent communities having a high degree of economic and social integration with that core." Areas that meet these definitions of a metropolitan area are based on the 1990 census. The "current standards provide that each MSA must include at least: (a) One city with 50,000 or more inhabitants or (b) A census bureau-defined urbanized area (of at least 50,000 inhabitants) and a total population of at least 100,000 (75,000 in New England)." "Under the standards the county (or counties) that contain the largest city becomes the central county (counties), along with any adjacent counties that have at least 50 percent of their population in the urbanized area surrounding the largest city. Additional 'outlying counties' are included in the MSA if they meet specific requirements of commuting to the central counties or other selected requirements of metropolitan character (such as population density and percent urban)."
CMSA	Consolidated Metropolitan Statistical Area is a MSA with a population of one million or more if: (1) Separate component areas can be identified within the entire area by meeting statistical criteria specified in the standards; (2) Local opinion indicates there is support for the component areas. The component areas are PMSAs.
PMSA	Primary Metropolitan Statistical Area is a component area of the CMSA.
County Rank CEP Index	County Rank Cumulative Exposure Project Index. There are 83 counties in Michigan. The county with the highest relative risk is ranked 1, the lowest is 83 (see **Appendix D**).
ITSL	Initial Threshold Screening Level (see **Appendix D**).
IRSL	Initial Risk Screening Level (see **Appendix D**)

To refine the choice of a monitoring site from the MSA level to the county level, the results of USEPA's CEP were analyzed to determine a CEP Index value and County Rank for each county in Michigan. The CEP Index and County Rank were utilized to provide a relative ranking of modeled concentrations of air toxics compared to a health benchmark value. Using this approach, the larger the CEP Index, the greater the relative risk when comparing results from each county. The county with the largest CEP Index was ranked number one, the second largest number two, and so on. The methodology for this approach is described further in **Appendix D.** The results are provided in **Table 1.**

For the Detroit, Ann Arbor, Flint, Kalamazoo-Battle Creek, and Lansing MSAs, those counties with the highest population also had the highest CEP-derived ranks. Based on this information, trend monitors were sited in the following counties: Wayne (three monitors), Macomb, Oakland, Washtenaw, Genesee, Kalamazoo, and Ingham.

In the Saginaw-Bay City-Midland MSA, Midland County has a significantly higher index value than Bay and Saginaw Counties, but the lowest population. Midland County was not selected for a trend site because of ongoing air monitoring studies in the county. Dow Chemical Company has been conducting an ambient air-monitoring program for air toxics in the Midland area since 1991. This program has been required under the hazardous waste permitting program, and is expected to continue for some time. Between the remaining two counties, Saginaw County has almost twice the population as Bay County, and the $CEP_{(IRSL)}$ ranks are only slightly different between these counties. Considering this, Saginaw County was selected as the trend site for this MSA.

In the Grand Rapids-Muskegon-Holland MSA, Allegan County was eliminated from consideration as a trend site because it had the lowest population and a significantly lower CEP-derived rank value than the counties of Kent, Muskegon, and Ottawa. The index values for these three remaining counties were very similar. Since Kent County has significantly higher population than either Muskegon or Ottawa, it was selected as the first trend site for this MSA. Although Muskegon County has a slightly lower population than Ottawa County, it was selected as the second trend site for this MSA, to provide more spatial representation of trend sites within the MSA. Since the greater metropolitan Grand Rapids area spans both Ottawa and Kent County, the trend site in Kent County could be an indicator for Ottawa County. Furthermore, locating the second site in Muskegon would provide better characterization of potential differences in the trends of air toxics within the MSA.

The map in **Figure 3** shows the initial trend network design sites selected at the countywide level. It is anticipated that these sites would be located in the following cities:

County	City
Macomb	Warren
Oakland	Southfield
Wayne	Detroit (2 sites), Dearborn (1 site)
Kent	Grand Rapids
Muskegon	Muskegon
Kalamazoo	Kalamazoo
Ingham	Lansing
Saginaw	Saginaw
Washtenaw	Ypsilanti
Genesee	Flint

Specific selection of monitoring sites will include a more detailed analysis considering additional factors such as the influence of topography, natural air basins, and dominant wind patterns. Detailed site selection information is discussed in **Section 3.C.1**.

2) Spatial Variability

The spatial component of the toxics network is envisioned to use design principles similar to those used by the SLAMS Criteria Network. SLAMS monitors supply data for a variety of purposes and are generally located to determine[1]:

- the highest concentrations in each MSA
- concentrations in densely populated areas
- impact from significant sources/source categories
- general background levels
- extent of regional transport in populated areas
- welfare-related (i.e.: visibility impairment and effects on vegetation) impacts in rural and remote areas.

[1] Guidance for Network Design and Optimum Site Exposure for PM2.5 and PM10. OAQPS December 15, 1997.

These monitors allow flexibility into the design of the network incorporating the need for sites to assess the impacts of transport, background levels, population exposure, and to improve spatial coverage to assess concentration gradients and maximum impact sites. SLAMS sites generally operate for three or more years and are not influenced by a predominant point source. (Monitors to assess the influence from point sources will be discussed in the special purpose monitoring section of the network design.)

In designing the spatial network, background monitors and transport (advection) sites were identified first. Once these sites were selected, the remaining network was created by adding sites to improve spatial coverage by dividing the state into four regions. Sites within these regions were selected by examining existing trend site locations, population distribution, and emission inventory information. Meteorological data will also be considered when exact locations are selected for the monitors. The basis for selection of the spatial trends sites is discussed below.

Background monitors are intended to provide measurements of toxic air contaminants in locations away from the influence of metropolitan areas, population centers, and emission sources. Longer-term operation of background monitors will provide valuable information about changes in the baseline air quality. Also, to characterize geographically diverse areas with terrain and land use differences, several background sites may be necessary. Currently, the Houghton Lake monitor is measuring background concentrations of toxic compounds and reflects rural levels that result from mixing, reaction, decomposition, and dispersion of emissions from cities further upwind. This data is probably indicative of background levels in relatively unpopulated areas of the state. It was decided this site should continue to provide data representative of such areas. To collect measurements of concentrations in truly pristine areas, minimizing the impacts of any emission sources, it was decided to add an additional monitoring site in the Upper Peninsula. A pristine area, designated as a Class 1 area by the federal government, is located at Seney Wildlife refuge in Schoolcraft County. As part of the Interagency Monitoring for Protection of Visual Environments (IMPROVE) and fine particulate ($PM_{2.5}$) networks, a monitoring site has been established at the National Park's Office at the Refuge. This site was selected to represent more pristine areas.

Transport sites are intended to provide an indication of levels of toxic compounds emitted from upwind sources or from mixtures of area sources moving into a metropolitan area. Analysis of ambient levels of ozone has indicated that proximity to Lake Michigan and Chicago plays a very important role in transport of elevated ozone levels from the southwestern most site in Coloma, northeastward along the shoreline toward Holland, onward to Muskegon, Ludington, and Frankfort. The impact of the land-lake breezes and emissions from Chicago and Gary should also influence levels of air toxics in the region. Transport of air toxics along a similar pattern has not been investigated. It was decided to locate a site at Warren Dunes State Park to provide an assessment of levels being transported into the southwest portion of the state. Meteorological equipment at this location will aid in data analysis.

In addition to the west shore of Michigan, air toxics may be transported from Toledo into the Detroit area. The MDEQ is operating a site upwind from Detroit at Luna Pier as part

of the $PM_{2.5}$ network. Co-location of air toxics sampling equipment may be possible at this site. This information would evaluate the air quality entering the Detroit metropolitan area and allow assessments of degree of impact of local sources on the overall burden. Therefore, Luna Pier was also selected as a transport site.

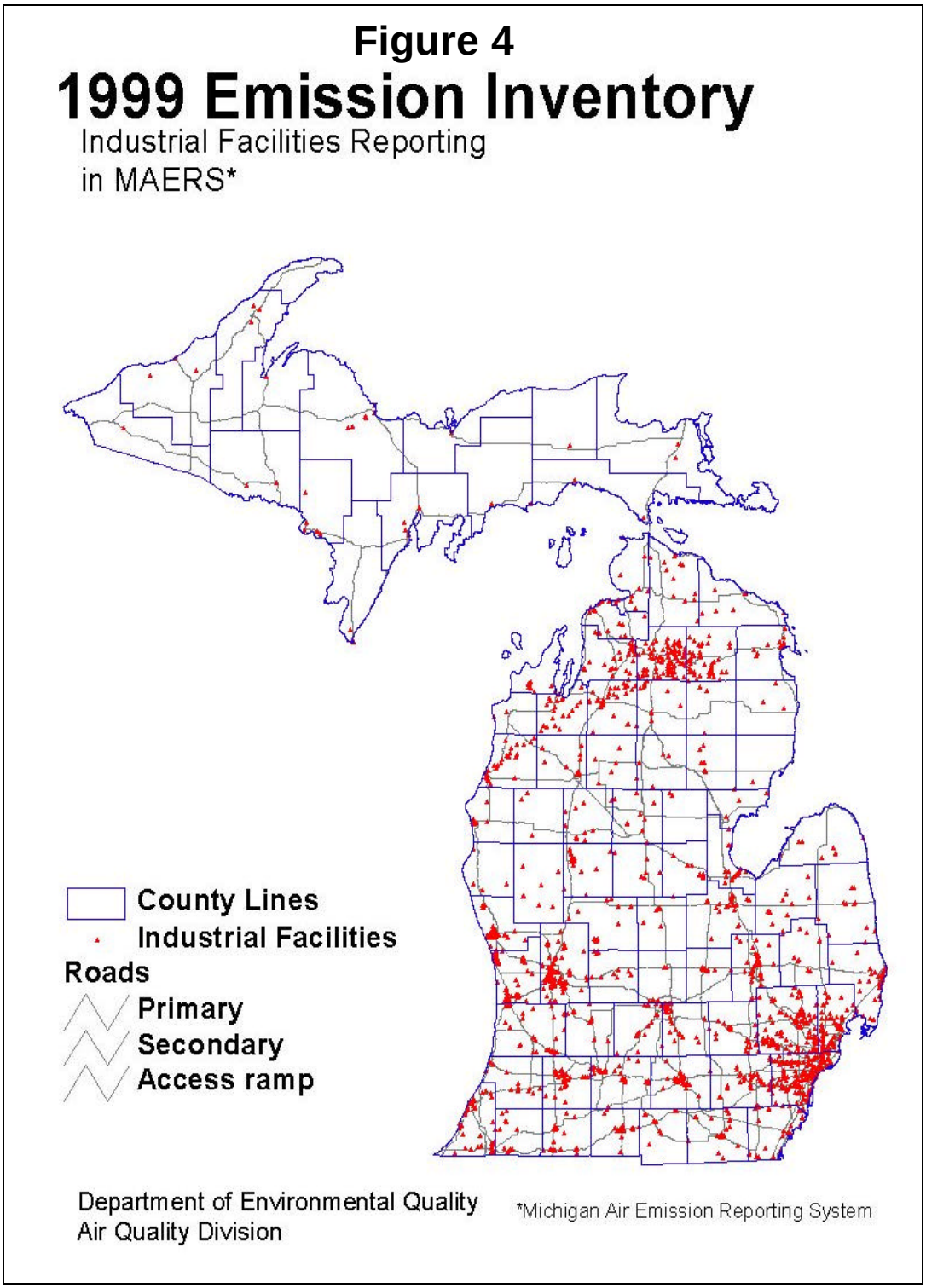
Michigan residents have logged odor complaints in both Sault Ste. Marie and in along the Michigan coast, south of Port Huron. These sites may be considered as either transnational transport sites or as special purpose sites, depending on the number of industries impacting on the local air quality levels. If a single source dominates, they will be part of the special purpose monitoring network design. The sites will be considered transnational transport sites if many sources are contributing to reduced air quality. For the purpose of this strategy, Sault Ste. Marie and Port Huron have been selected as transport sites.

After the selection of the background and transport sites, additional monitoring sites were then identified to improve spatial coverage. Different approaches were used to improve distribution of monitors across the state. In general, the results of these approaches suggested deploying additional monitors in only the lower portion of the southern peninsula. Most of these approaches were weighted by population, emission, and risk estimates, all of which are higher in the lower portion of the state, hence supporting monitor deployment in this area. **Figure 4** shows the location of major roadways and stationary sources throughout Michigan. To allow better coverage across the upper portion of the state, another approach was taken that divided the state into four regions and then considered similar information, as well as source types, on a regional basis instead of statewide. Such an approach ensured spatial coverage in all four regions. These four regions included: the Upper Peninsula, the upper portion of the Lower Peninsula, the lower portion of the Lower Peninsula, and southeast Michigan.

Examination of population levels shows that the most populated areas in the Upper Peninsula are Marquette (21,977) and Sault Ste. Marie (14,689) with Escanaba (13,659) and Menominee (9,398) placing third and forth (**10**). Sault Ste. Marie has already been selected as a transnational transport site. A spatial monitor in Marquette is supported, as is a second in Escanaba. The relatively close geographical proximity of Escanaba and Menominee suggests the selection of one or the other as a spatial site. Escanaba has the greater population, hence it was selected for the spatial monitoring site.

The largest population centers in the upper portion of the Lower Peninsula include:

- Mount Pleasant in Isabella County 23,285 people
- Traverse City in Grand Traverse County 15,116 people
- Big Rapids in Mecosta County 12,603 people
- Alpena in Alpena County 11,354 people
- Ludington and Pere Marquette Township 10,572 people
- Cadillac in Wexford County 10,104 people



Based on these population levels, spatial monitors were selected for Mount Pleasant and Traverse City. Big Rapids is relatively close to Mount Pleasant, so Mount Pleasant is preferred due to its size. Many oil and gas wells are near Mount Pleasant and a monitor here may reflect additional variability due to these sources. Alpena and Ludington were selected as additional locations to improve spatial coverage. The total population of the City of Ludington and the adjacent Pere Marquette Township totals 10,572, making the

population similar to other small cities in the area. Estimated emissions and relative risk based on CEP data support the selection of Ludington as another spatial site. Cadillac was not selected as a spatial site because it has been suggested as a potential special purpose site and will be addressed in the next section.

Examination of population distributions across the lower portion of the Lower Peninsula of Michigan indicates that there are a few very populous centers that have been omitted from the trend subset of sites. These include Ann Arbor, Battle Creek, Bay City, Midland, and Adrian. For Washtenaw County, Ann Arbor is larger than Ypsilanti and is a potential alternative choice to the trend site in Ypsilanti. Kalamazoo has been selected as a trend site, but Battle Creek is also within that MSA suggesting an additional monitoring location to improve spatial coverage. However, such a site in Battle Creek would be redundant with a site in Jackson, the next county to the east. Jackson is suggested as a spatial site.

There are currently four industrial monitoring sites in Midland, so extra monitoring is not suggested unless the industrial sites close. Monitoring in Bay City would be redundant with Saginaw and Midland. Therefore, no supplemental sites are suggested in either Midland or Bay City.

The population in Benton Charter Township is not an adequate reflection of the population in the area as it is spread between both St. Joseph and Benton Harbor. A better population estimate is 35,990 (**10**). Therefore, a monitor is included in Benton Harbor to reflect this revised population estimate.

TABLE 2: Major Population Centers In The Lower Portion Of The Lower Peninsula

	City	Population 1990	Comments
1.	Grand Rapids City	189,126	Trend Site
2.	Flint City	140,761	Trend Site
3.	Lansing City	122,700	Trend Site
4.	Ann Arbor City	109,592	
5.	Kalamazoo City	80,277	Trend Site
6.	Saginaw City	69,512	Trend Site
7.	Battle Creek City	53,540	
8.	Muskegon City	40,283	Trend Site
9.	Bay City	38,936	
10.	Midland City	37,819	
11.	Jackson City	37,446	Spatial Site
12.	Benton Harbor/St. Joseph	35,990	Spatial Site
13.	Holland City	25,086	
14.	Adrian City	22,097	
15.	Owosso City	16,322	

In addition to providing improved spatial coverage across the state, these monitors can also be located to improve resolution within a major metropolitan area. Given the plethora of sources within the Detroit metropolitan area, characterization of air toxics and

assessment of spatial gradients would be enhanced by deploying a few additional monitoring sites. For southeast Michigan, the populations of all cities within the Detroit MSA were compared, because the population density may warrant the addition of more than one monitoring site per county. The 1990 population levels for various cities and townships are shown in **Table 3** (**10**).

Three trend sites have been selected proposed for Wayne County (two in Detroit City and one in Dearborn) and one trend site each for Macomb and Oakland Counties that are based on the total countywide population totals. Because of the large population and diversity of sources in Wayne County, it was decided that two spatial sites in addition to the three trends sites were needed to provide adequate spatial characterization. Livonia was selected as one of these spatial sites to improve spatial coverage. Westland, which is just south of Livonia, would be a redundant site. A last spatial site in Taylor or Allen Park, which covers a very small landmass just east of Taylor, was also selected. This brings the total trend and spatial monitors in Wayne County to five.

TABLE 3: Major Cities in Southeast Michigan

	City	Population 1990	County	Comments
1.	Detroit City	1,027,974	Wayne	2 trend sites
2.	Warren City	144,864	Macomb	1 trend site
3.	Sterling Heights City	117,810	Macomb	
4.	Livonia City	100,850	Wayne	1 spatial site
5.	Dearborn City	89,286	Wayne	1 trend site
6.	Clinton Township	85,866	Macomb	1 spatial site
7.	Westland City	84,724	Wayne	
8.	Southfield City	75,728	Oakland	1 trend site
9.	Farmington Hills City	74,652	Oakland	
10.	Troy City	72,884	Oakland	
11.	Pontiac City	71,166	Oakland	1 spatial site
12.	Taylor City	70,811	Wayne	1 spatial site
13.	St. Clair Shores City	68,107	Macomb	

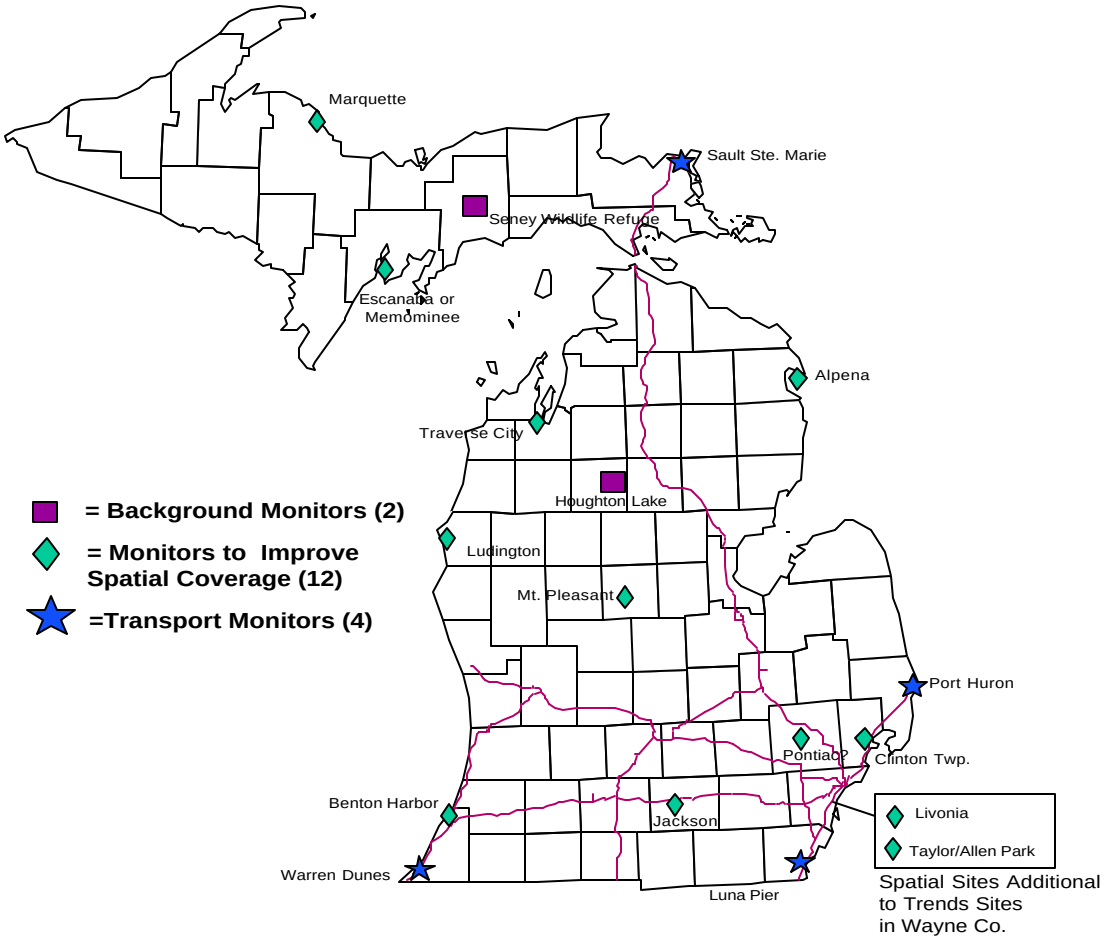
For Macomb County, Warren has been identified as a potential trend site. Sterling Heights is adjacent to the north of Warren, so it was considered redundant with the trend site. Clinton Township is downwind of Warren and Detroit City, and was selected as the spatial site, resulting in a total of two monitors to be placed in Macomb County.

For Oakland County, Southfield is a possible location for the trend site. The population in Farmington Hills, Troy, and Pontiac are all similar so the choice should be based on emissions density or CEP estimates as a supplementary spatial site. The total number of monitors in Oakland County would be two, including one trend site and one spatial site.

By placing monitors in distinctly different sub-regions within the urban area, the spatial variability of annual average concentrations may be determined within in the MSA. The City of Detroit contains the majority of the population and covers approximately 25 percent of the landmass. Although it takes up the majority of space and population,

spatial distribution of monitors across different cities and counties will allow the determination of gradients across the MSA. The exact locations and distribution of the monitoring sites will be determined upon the completion of the pilot study assessing gradients of concentrations of air toxics in the Detroit urban area. Existing monitoring data will also be reviewed with CEP and National Air Toxics Assessment (NATA) estimates. After preliminary data are collected, the composition of the sites will be reviewed and possibly altered. **Figure 5** summarizes the generalized locations of transport, background, and spatial sites[2].

Figure 5: Proposed Spatial, Background, and Transport Sites



[2] In an attempt to address the equity of the proposed deployment, the data below compares population distributions and monitor assignment. The Upper Peninsula is skewed with a high number of monitoring sites, but spatial coverage will suffer by modifications.

Upper Peninsula	78,479 people/monitor	Upper Lower Peninsula	172,782 people/monitor
Lower Lower Peninsula	455,373 people/monitor	Southeast Michigan	381,081 people/monitor

3) Population Exposure

No additional monitoring sites beyond those selected to meet the temporal trends and spatial characterization objectives are envisioned at this time to address the population exposure objective. The trend and spatial sites will be located in areas where people live, work and play. By careful selection of proposed locations, the data generated by these monitors should reflect average concentrations of toxics in ambient air, not maximum levels, which are assessed by the special purpose monitoring component of the program. The trend and spatial site monitors are not meant to identify populations at greater risk due to the higher exposure levels of air toxics. Emissions inventory data, dispersion modeling, and the special purpose monitoring network are all tools that will be used for this program. The data from the trends and spatial site monitors will be useful in characterizing concentrations typical in various urban areas. The spatial monitors will operate for at least a year and up to three years while the trend monitors will operate longer. The relatively long commitment to air monitoring at these sites will allow estimation of annual average concentrations.

4) Special Purpose Monitoring

A multifaceted approach was used to identify potential short-term monitoring locations used to identify and characterize maximum levels of air toxics. The AQD district offices were solicited for recommendations of sites in their districts based on citizen complaint logs, compliance and enforcement issues, and staff's expertise and knowledge regarding the sources in their district. Additionally, data from the USEPA's CEP and NATA study, which provides modeled estimates of air toxics, were evaluated to help identify potential monitoring locations (**8**). This information resulted in an initial list of approximately 40 sites to consider for special purpose monitoring.

Special purpose monitoring sites represent a short-term monitoring commitment. Monitors at these sites will be operated for a minimum of one year. A minimum of one year of data is needed to characterize the range of concentrations of air toxics that may occur due to changes in the magnitude and nature of emissions in the area, as well as potential influences due to seasonal variations in the weather. Collection of data for the duration of at least one year will also provide an estimate of the annual average concentration of each air toxic compound, which is needed for evaluating the potential health risks due to exposure from these compounds. The monitoring commitment at each site will be evaluated after a complete year of data is collected. In general it is expected that monitoring at a given location will terminate after one year. However, there may be instances where the data indicates continued monitoring at the site would be appropriate. For example, a trend of increasing concentrations of one or more compounds over the year may provide support for continued characterization of the air shed.

If insufficient funds are available to allow simultaneous monitoring at all potential special purpose locations, the sites will be prioritized so that investigation of the concentrations of toxic air compounds can occur sequentially, from highest to lowest priority. Given that this is a long term strategy, and priorities are expected to change over time, the process for prioritizing the list of potential sites needs to accommodate shifting priorities. The initial

list of potential sites will be prioritized by staff. Division management will review and approve the list. Monitoring will then begin at the top priority sites for which there is available funding. The priority list will be reviewed on an annual basis by a similar process as described above, considering data already collected, new information, and changing priorities.

5) Support and Evaluate Dispersion and Receptor Modeling

No additional monitoring sites are envisioned for this objective beyond those selected to meet the temporal trends, spatial characterization, and special purpose monitoring objectives. The data collected by the trends, spatial, and special purpose monitors will be compared to the modeled results to assess comparability between the actual measured values and those derived by various estimation techniques. The above databases often reflect annual averages, and hence will be more comparable to ambient data that is collected for an entire year. Data to support evaluation of and use of various models will be made available to interested parties. Data will also be available for use in receptor models.

6) Environmental Indicators

Data from the trend and spatial sites will provide a useful indication of the state of the environment in populated areas (**3,4**). The transport and background sites will provide supplementary information. Additional monitoring sites are not envisioned at this time to address this monitoring objective.

C. Additional Monitoring Considerations for the Ambient Air Toxics Network

1) Physical Criteria for Ambient Site Selection

The first consideration in the selection of a potential location is to examine the size of the air mass that will be sampled and the determination of compatibility with the desired monitoring objective. The spatial scale of representativeness refers to the size of an air parcel that has relatively homogeneous concentrations of the analyte of interest. **Microscale** defines volumes of air that have dimensions from several meters up to 100 meters. **Middle scale** covers several city blocks, ranging from 100 meters to 0.5 kilometer (km). **Neighborhood scale** covers an extended area of the city with relatively uniform land use and covers 0.5 to 4 km. Sampling from an **urban scale** air mass will reflect the city-wide conditions from 4 to 50 km in size. **Regional scale** air masses cover a rural homogeneous area ranging from 10's to 100's of kilometers. Thus, sizes of air masses that are reflective of ambient concentrations may vary from 100's of kilometers down to a few meters (**5,6**).

Most of the sites proposed in this monitoring plan will be selected to address the neighborhood scale of representation so that average concentrations within 0.5 to 4 km air masses may be measured. These measurements are more reflective of typical population exposure and may be used to estimate long-term population risk. Also,

according to USEPA[3], data collected from neighborhood scale sites will be most useful in assessing the accuracy of the results of the ASPEN dispersion model. The transport and background monitors will be located to measure regional scale air masses. The special purpose monitors will be located to assess levels along smaller scales such as urban or microscale air masses.

Once the appropriate scale of representation is selected, a general monitoring area is selected that is consistent with the monitoring objectives and the spatial scale. Background information that includes land use patterns, emission inventories, population densities, traffic distributions, climatological and meteorological data, and any monitoring data will be considered. Candidate monitoring sites are selected from within the general area by eliminating from consideration all locations that may be unduly influenced by non-representative emission sources or unusual topography. As an example of sites excluded from monitoring would be locations impacted by emissions from a single source or sites where the wind patterns may be unique such as those occurring within a small valley.

Monitoring locations will be selected to comply with established siting guidelines which provide specifications about the set back requirements for distances from major roads, stationary sources, inlet heights, etc. The probe siting criteria below have been compiled using the requirements for PAMS, NAMS and SLAMS monitors (**7**). The physical criteria for site selection will meet the standards set forth by the Federal Register. The sampling inlets for the various types of monitors will be within the breathing zone which corresponds to 3 to 15 meters above ground level. The probe should be more than 1 meter vertically or horizontally away from any supporting structure. All inlets should be 20 meters or more from the drip lines of trees. The distance between any obstacle and the probe is at least twice the height that the obstacle protrudes above the sampler. There should be at least 270 degrees of unrestricted air flow that includes the predominant and second most frequent dominant wind direction. Co-located monitors need to be separated 1 to 4 meters apart. If any of the monitors are located on a roof top, they should be 2 or more meters away from walls, parapets, penthouses, etc. It is recommended by USEPA that there are no furnaces or incinerator flues in the vicinity.

Co-located meteorological equipment should be away from the influence of trees, buildings, steep ridges, slopes cliffs, and hollows. The tower should extend 10 meters above the ground.

2) Target Compounds

For the ambient portion of this strategy, levels of VOCs, carbonyls, trace metals, PAHs, and hexavalent chromium will be assessed. As shown in **Table 4** and the following discussion, many of the compounds of concern can be measured by using four different laboratory methods, each geared to quantitate groups of substances, based upon their chemical and physical properties. Hence, four different laboratory protocols (TO-15, TO-

[3] Air Toxics Monitoring *Concept* Paper, Office of Air Quality Planning and Standards, Revised Draft February 29, 2000. From page 22 part 3.2.3

11A, IO-3.4, 8270) allow the determination of most of the compounds identified (25-27, 27A). The discussion below outlines the rationale behind inclusion of various substances as compounds targeted by the strategy. To provide an estimate upon which to base budget projections and the anticipated costs associated with implementation of this strategy, all four categories of compounds as well as hexavalent chromium were used to develop the budget shown in **Section 4**. This approach maximizes the amount of information collected to address the majority of the monitoring objectives.

Diesel emissions are believed to be an important contributor to risk, however, an analytical method to measure it is lacking. Instead, as a surrogate coupled with receptor modeling, particulate material as well as elemental and organic carbon are used instead. Currently, these forms of carbon are assessed as $PM_{2.5}$ at three sites in the Detroit Pilot Project (Allen Park, East 7 Mile and Lodge/696). These measurements are being conducted to supplement the pilot project, but are routinely measured through the fine particulate and regional haze monitoring programs. Upon completion of the Detroit Pilot Project, the data will be reviewed and this strategy will be reassessed for determining the contribution and importance of diesel emissions. Furthermore, speciated $PM_{2.5}$ including elemental carbon will continue at Michigan's trend site located at Allen Park in Detroit. Other speciation sites that will become operational within the next two years include: Houghton Lake, Grand Rapids, Kalamazoo, Dearborn, Flint, Holland, and Ypsilanti. Additional elemental carbon measurements will be made at the Seney Wildlife Refuge in Schoolcraft County and at Eagle Harbor, both in the Upper Peninsula as part of the IMPROVE monitoring program. Also, levels of elemental carbon will be measured in Sault Ste. Marie by a tribal monitoring program.

PAHs were not included at every site proposed in this strategy as a cost containment measure. Instead, six sites will be established as part of a preliminary assessment. Initially, samples will be collected on a once every six day sampling frequency. Once data from the Detroit Pilot Project is evaluated, this number of sites and sampling frequency will be revisited.

Conceptually, the air toxics compounds targeted for monitoring should be those which are most relevant for public health protection, and which enable the achievement of the goals and the six objectives discussed earlier. Also, accurate and reliable analytical methods should be available for the target compounds. The air toxics monitoring strategy is intended to be broadly inclusive, particularly for the initial listing of the substances which may warrant consideration for monitoring, as shown in **Table 4.** Not all parameters will necessarily be measured at every site; monitoring will be tailored to address the particular objective(s) applicable to each site. Also, there are practical considerations pertaining to the cost or feasibility of monitoring for certain substances. Monitoring is method driven and groups of compounds with similar chemical and physical properties are often determined by a particular analytical method. Thus, ambient levels of some compounds with low priority may be available as a result of the selected methodology.

Table 4: List of Substances Considered for the Monitoring Network

	Criteria for Inclusion (1)											
Substance	**112 (b) HAPs**	**Urban HAPs**	**SLs**	**TRI 1998 (4)**	**CEP tracts**	**NATA tracts**	**NATA counties**	**CORE cpds.**	**PBT**	**Currently Monitored by MDEQ?**	**Compound Class**	**Method**
acetaldehyde	x	x	x	x	x	x	x	x		yes	Carbonyl	TO-11A
acrolein	x	x	x		x	x	x					
acrylonitrile	x	x			x	x	x		x	yes	VOC	TO-15
arsenic	x	x			x	x	x	x	x	yes	T. Metal	6010
benzene	x	x	x	x	x	x	x	x		yes	VOC	TO-15
beryllium	x	x			x	x	x	x	x	yes	T. Metal	6010
1,3-butadiene	x	x	x		x	x	x	x			VOC	TO-15
cadmium	x	x	x		x	x	x	x	x	yes	T. Metal	6010
carbon tetrachloride	x	x	x		x	x	x	x		yes	VOC	TO-15
chloroform	x	x	x		x	x		x		yes	VOC	TO-15
chromium (total)	x	x			x			x	x	yes	T. Metal	6010
hexavalent chromium (Cr+6) (footnote 2)											T. Metal	CA method 39
coke oven emissions	x	x										
diesel emissions (footnote 3)												
dioxins (2,3,7,8-TCDD TEQ)	x	x			x	**5**	**5**		x		dioxin	TO-9A
ethylene dibromide (1,2-dibromoethane)	x	x	x		x	x	x			yes	VOC	TO-15
propylene dichloride (1,2-dichloropropane)	x	x	x					x		yes	VOC	TO-15
1,3-dichloropropene	x	x	x		x	x	x			yes, cis & tran	VOC	TO-15
ethylene dichloride (1,2-dichloroethane)	x	x	x		x					yes	VOC	TO-15
ethylene oxide	x	x			x							
formaldehyde	x	x	x	x	x	x	x	x		yes	Carbonyl	TO-11A
hexachlorobenzene	x	x							x		Semi-Vol	8270
hydrazine	x	x										
lead	x	x						x	x	yes	T. Metal	6010
manganese	x	x	x		x	x		x	x	yes	T. Metal	6010
mercury	x	x							x			
methylene chloride (dichloromethane)	x	x	x	x	x	x		x		yes	VOC	TO-15
nickel	x	x	x		x	x	x	x	x	yes	T. Metal	6010
PCBs	x	x							x		PCB	TO-9A
polycyclic organic matter (POM)	x	x				x			x			
quinoline	x	x			x	x						
1,1,2,2-tetrachloroethane	x	x	x			x					VOC	TO-15
perchloroethylene (tetrachloroethylene)	x	x			x			x		yes	VOC	TO-15
trichloroethylene	x	x	x	x	x	x		x		yes	VOC	TO-15
vinyl chloride (chloroethane)	x	x	x		x			x		yes	VOC	TO-15
1,1,2-trichloroethane	x		x							yes	VOC	TO-15
1,1-dichloroethene (vinylidene chloride)	x		x		x					yes	VOC	TO-15
1,4-dichlorobenzene	x		x		x					yes	VOC	TO-15
chloromethane (methyl chloride)	x		x		x					yes	VOC	TO-15
ethylbenzene	x			x						yes	VOC	TO-15
hexachloro-1,3-butadiene	x		x							yes	VOC	TO-15
xylene (o,m,p) (dimethyl benzenes)	x			x						yes	VOC	TO-15
styrene	x		x	x	x	x				yes	VOC	TO-15
toluene	x			x						yes	VOC	TO-15
acrylamide	x				x							
alpha-hexachlorocyclo-hexane	x								x			
lindane (gamma-hexachlorocyclohexane)	x								x			

Table 4: List of Substances Considered for the Monitoring Network, continued

	Criteria for Inclusion (1)											
Substance	**112 (b) HAPs**	**Urban HAPs**	**SLs**	**TRI 1998 (4)**	**CEP tracts**	**NATA tracts**	**NATA counties**	**CORE cpds.**	**PBT**	**Currently Monitored by MDEQ?**	**Compound Class**	**Method**
methoxychlor	x											
bis (2-ethylhexyl) phthalate	x				x				x		Semi-Vol	8270
chlordane	x								x			
chloroprene	x				x							
DDT/DDE	x								x			
dieldrin									x			
ethyl acrylate	x				x							
glycol ethers	x			x								
hexane	x			x							VOC	TO-15
propylene oxide	x				x							
toxaphene	x								x			
hydrogen chloride (hydrochloric acid)	x			x								
methanol	x			x								
ammonia				x								
methyl ethyl ketone	x			x							VOC	TO-15
ethylene				x								
methyl isobutyl ketone	x			x							VOC	TO-15
n-butyl alcohol				x								
1,2,4-trimethylbenzene				x							VOC	TO-15
N-methyl-2-pyrrolidone				x								
zinc				x						yes	T. Metal	6010
sulfuric acid				x								
chloroethane				x							VOC	TO-15
phenol	x			x							Semi-Vol	8270
propylene				x								
naphthalene	x			x							Semi-Vol	8270
1,1-dichloro-1-fluoroethane				x								
carbonyl sulfide	x			x								
triethylamine	x			x								
methyl tert-butyl ether	x			x							VOC	TO-15
hydrogen fluoride	x			x								
copper				x								
diisocyanates				x								
barium				x					x			
acetamide	x											
acetonitrile	x										VOC	TO-15
acetophenone	x										semi-vol	8270
2-acetylaminofluorene	x											
acrylic acid	x											
allyl chloride	x											
4-aminobiphenyl	x										semi-vol	8270
aniline	x										semi-vol	8270
o-anisidine	x											
asbestos	x											
benzidine	x										semi-vol	8270
benzotrichloride	x											
benzyl chloride	x									yes	VOC	TO-15
biphenyl	x											
bis (chloromethyl) ether	x											
bromoform	x									yes	VOC	TO-15

Table 4: List of Substances Considered for the Monitoring Network, continued												
	Criteria for Inclusion (1)											
Substance	112 (b) HAPs	Urban HAPs	SLs	TRI 1998 (4)	CEP tracts	NATA tracts	NATA counties	CORE cpds.	PBT	Currently Monitored by MDEQ?	Compound Class	Method
calcium cyanamide	x											
captam	x											
carbaryl	x											
carbon disulfide	x											
catechol	x											
chloramben	x											
chlorine	x											
chloroacetic acid	x											
2-chloroacetophenone	x											
chlorobenzene	x									yes	VOC	TO-15
chorobenzilate	x											
chloromethyl methyl ether	x											
cresols/ cresylic acid (isomers, mixtures)	x											
o-cresol	x											
m-cresol	x											
p-cresol	x											
cumene	x											
2,4D, salts & esters	x											
diazomethane	x											
dibenzofurans	x										semi-vol	8270
1,2-dibromo-3-chloropropane	x											
dibutylphthalate	x										semi-vol	8270
3,3-dichlorobenzidine	x										semi-vol	8270
dichloroethyl ether (bis(2-chloroethyl)ether)	x										semi-vol	8270
dichlorvos	x											
diethanolamine	x											
N,N-dimethyl aniline	x											
diethyl sulfate	x											
3,3-dimethoxy benzidine	x											
dimethyl carbamoyl chloride	x											
dimethyl formamide	x											
1,1-dimethyl hydrazine	x											
dimethyl phthalate	x										semi-vol	8270
dimethyl sulfate	x											
4,6-dinitro-o-cresol, and salts	x											
2,4-dinitrophenol	x										semi-vol	8270
2,4-dinitrotoluene	x								x		semi-vol	8270
1,4-dioxane	x											
1,2-diphenylhydrazine	x										semi-vol	8270
epichlorohydrin	x											
1,2-epoxybutane	x											
ethyl carbamate (urethane)	x											
ethyl chloride (chloroethane)	x											
ethylene glycol	x											
ethylene imine (aziridine)	x											
ethylene thiourea	x											
ethylene dichloride (1,1-dichloroethane)	x											
heptachlor	x											
hexachlorocyclopentadiene	x										semi-vol	8270

Table 4: List of Substances Considered for the Monitoring Network, continued

	Criteria for Inclusion (1)											
Substance	**112 (b) HAPs**	**Urban HAPs**	**SLs**	**TRI 1998 (4)**	**CEP tracts**	**NATA tracts**	**NATA counties**	**CORE cpds.**	**PBT**	**Currently Monitored by MDEQ?**	**Compound Class**	**Method**
hexachloroethane	x										semi-vol	8270
hexamethylene-1,6-diisocyanate	x											
hexamethylphosphoramide	x											
hydroquinone	x											
isophorone	x											
maleic anhydride	x											
methyl bromide (bromomethane)	x											
methyl chloroform (1,1,1-trichloroethane)	x									yes	VOC	TO-15
methyl hydrazine	x											
methyl iodide (iodomethane)	x											
methyl isocyanate	x											
methyl methacrylate	x											
4,4-methylene bis(2-chloroaniline)	x											
methylene diphenyl isocyanate (MDI)	x											
4,4-methylenedianiline	x											
nitrobenzene	x								x		semi-vol	8270
4-nitrophenyl	x											
4-nitrophenol	x										semi-vol	8270
2-nitropropane	x											
N-nitroso-N-methyl urea	x											
N-nitrosodimethylamine	x											
N-nitrosomorpholine	x											
parathion	x											
pentachloronitrobenzene	x										semi-vol	8270
pentachlorophenol	x								x		semi-vol	8270
p-phenylenediamine	x								x			
phosgene	x											
phosphene	x											
phosphorus	x											
phthalic anhydride	x											
1,3-propane sulfone	x											
beta-propiolactone	x											
propionaldehyde	x									yes	carbonyls	TO-11A
propoxur (Baygon)	x											
1,2-propylenimine (2-methyl aziridine)	x											
quinone	x											
styrene oxide	x											
titanium tetrachloride	x											
2,4-toluene diamine	x											
2,4-toluene diisocyanate	x											
o-toluidine	x											
1,2,4-trichlorobenzene	x										semi-vol	8270
2,4,5-trichlorophenol	x										semi-vol	8270
2,4,6-trichlorophenol	x										semi-vol	8270
trifluralin	x											
2,2,4-trimethyl pentane	x											
vinyl acetate	x											
vinyl bromide	x											
antimony	x								x			

Table 4: List of Substances Considered for the Monitoring Network, continued

	Criteria for Inclusion (1)											
Substance	**112 (b) HAPs**	**Urban HAPs**	**SLs**	**TRI 1998 (4)**	**CEP tracts**	**NATA tracts**	**NATA counties**	**CORE cpds.**	**PBT**	**Currently Monitored by MDEQ?**	**Compound Class**	**Method**
cobalt	x											
cyanide compounds	x											
fine mineral fibers	x											
radionuclides (including radon)	x											
selenium	x								x			
silver									x			
thallium									x			
di(n)octyl phthalale									x			
1,3-dinitrobenzene									x			
2,6-dinitrotoluene									x		semi-vol	8270

Footnotes:
1. The criteria for inclusion are described in the accompanying text.
2. Pilot Core: hexavalent chromium to be analyzed only at ceratin sites, based on infrastructure availability.
3. UATS noted that deisel emissions contain many HAPS, and thus are collectively considered under the overall program and UAT strategy, although it is not a specifically listed HAP. Elemental carbon may be measured as a surrogate.
4. The top 36 substances in the 1998 TRI are included. These are > 100,000 lbs/year.
5. Dioxin inventory and modeling are under development.

The prioritization and selection of substances from the list for monitoring is shown in **Table 4** and described further below. The criteria have not been weighted with different degrees of importance, but rather are used to provide an overall indication of which compounds should be included in the monitoring strategy. The criteria utilized, and the rationale for inclusion, are as follows:

Clean Air Act Amendments Section 112(b) Hazardous Air Pollutants (HAPs)

The Clean Air Act Amendments (CAAA) of 1990 included the Section 112(b) list of 188 (originally 189) hazardous air pollutants (HAPs) (**14**). The specific criteria utilized by the Congress and USEPA in establishing this list are not available in detail. However, Section 112(b)(2) describes this list of substances as those which present (or may present) through inhalation or other routes of exposure, a threat of adverse human health effects or adverse environmental effects, via ambient concentrations, bioaccumulation, deposition, or otherwise. Additionally, Section 112 (b)(3) describes the information which is needed in order to modify the list through additions or deletions. That evidence must demonstrate whether (or not) the emissions, ambient concentrations, bioaccumulation, or deposition of the substance can cause adverse effects to human health or adverse environmental effects. Therefore, this list represents (on a national scale) the non-criteria pollutants which are of concern under the CAAA, and provides one criterion to consider in the selection of compounds to be included in the Michigan Air Toxics Monitoring Strategy.

Urban Hazardous Air Pollutants (Urban HAPs)

On July 19, 1999, the USEPA finalized the "National Air Toxics Program: The Integrated Urban Strategy." This is commonly referred to as the urban air toxics strategy (UATS) (**13**). This program includes the urban HAPs list of 33 substances which USEPA

considers to pose the greatest potential public health concern in the largest number of urban areas nationwide, considering emissions from major, area, and mobile sources.

Screening Levels

The Michigan and the federal air pollution control programs do not provide ambient air toxics standards for public health protection. However, the MDEQ, AQD, does have risk-based screening levels which are health protective ambient air impacts under the new source review program. The screening levels include annually averaged concentrations associated with 1-in-1 million incremental cancer risk, and concentrations protective of noncancer effects with annual or short-term averaging times. Although these are not ambient air quality standards, they do provide relevant health protective benchmarks for the general population via the inhalation route of exposure. Ambient air monitoring data for air toxics from 1988-1997 for all Michigan sites (excluding industrial sites) were compared to the screening level health benchmarks. **Table 4** includes an "X" for those substances which were measured (annually averaged or 24-hour, as appropriate) above a chemical-specific screening level.

Toxics Release Inventory (TRI) for 1998

Annually, certain categories of stationary source facilities are required under the USEPA's Toxics Release Inventory (TRI) to estimate pollutant emissions, if their quantities of use or manufacture exceed threshold quantities (**15**). Such emissions data are not a surrogate for exposure or risk estimates, because they do not account for atmospheric dispersion, transformation, exposure, or toxicity. They are also of limited use because they do not include other sources of emissions, or sources which do not exceed the reporting thresholds. However, statewide quantities of air emissions of specific substances can serve as a crude indicator of potential inhalation exposure attributable to the reporting facility types. Therefore, these data may serve as a criterion for consideration in the air toxics monitoring strategy. The highest air-emitted 36 substances reported for 1998 are flagged in **Table 4**. Statewide total air emissions of these substances equal or exceed 100,000 pounds per year.

CEP Census Tract Concentrations

In 1998, the USEPA released the results of a landmark assessment of the 1990 emissions and ambient air concentration modeled estimates of the HAPs, known as the CEP (**8**, **9**, **11**). Their emissions inventory accounted for point, area, and mobile emission sources, "background" levels for 28 substances, atmospheric reactions contributing to the formation of seven substances, and atmospheric dispersion. The cumulative estimated ambient air levels (annually averaged) were then compared to health-protective benchmark concentrations. The resulting concentrations were estimated at the census-tract level, although the spatial accuracy of the estimates were considered to be reliable only at the scale of county-wide or larger. The study was restricted to only 148 of the 188 HAPs, due to the unavailability of adequate emissions or toxicity data for 40 of the HAPs. For the present initiative, substances were flagged in **Table 4** if the CEP estimated annually-averaged levels exceeded a health benchmark (DEQ-AQD screening level) in at least one Michigan census tract. Although census tract predictions may have much poorer accuracy than larger scale estimates, they were deemed appropriate for the present initiative because the intent is not to determine the

correct placement of the impacts but to account for the highest predicted impacts relative to health benchmarks.

NATA Census Tract Concentrations

In 2000, the USEPA began a staged-release of the 1996 emissions inventory and modeled impact estimates of the urban HAPs list (33 substances) plus diesel emissions (**16**). (It should be noted that diesel emissions are included, although not a specifically listed HAP, because these emissions contain many HAPs and were thus collectively considered under the USEPA's overall program and the urban air toxics strategy.) This initiative, called NATA, was patterned after the CEP project, with updated emissions inventories and other improvements. As with the CEP, the estimated cumulative ambient air concentrations were derived for each census tract, with reliability recommended at the county-scale or larger. As discussed above for the CEP, the present initiative utilized the NATA estimated impacts at the census tract level, with comparison to health benchmark levels. **Table 4** includes a flag for NATA if the modeled impacts in at least one census tract exceeded the health benchmark concentration. It should be noted that the NATA assessment addressed only 34 substances, which is a subset of the 148 HAPs evaluated for the CEP, and the flags (and absence of flags) in **Table 4** should be interpreted accordingly. Also, at the time of this report development, the USEPA had not yet released a draft of their estimated concentrations for dioxins.

National Scale Air Toxics Assessment (NATA) County Average Concentrations

This column of **Table 4** indicates those substances (13 carcinogens and one noncarcinogen, acrolein) which had at least one county average concentration estimate which exceeded the health benchmark.

Air Toxics Pilot Projects – Core Compounds (Core cpds)

The USEPA final report of the "USEPA FY 2000 State and Local Agency Grant Guidance and Allocation; National Air Toxics Monitoring Pilot Program" was released on July 2000 (**17**). That report includes in the "Options for Monitoring" a list of 18 "core compounds" which should be measured at all of the pilot study urban areas (including Detroit). These compounds were selected by a steering committee composed of USEPA scientists as well as representatives from State and Local Air Agencies and reviewed by USEPA's Science Advisory Board. Detailed information about the process that was used to select Core compounds is not available at this time. Core compounds are flagged with "X" in **Table 4**.

Several other compounds were designated by USEPA as "Maximum" indicating that they should be measured at one sampling site in each pilot study urban area if feasible (arsenic, ethylene dibromide, 1,3-dichloropropene, ethylene dichloride, hexavalent chromium, mercury, and 1,1,2,2-tetrachloroethane). Some compounds were not listed in the "core" or "Max" groups due to the need for further method development (acrylonitrile, ethylene oxide, and acrolein) or resource concerns (2,3,7,8-TCDD TEQ). General information about the Pilot City Program (**1,2,17-19**) and detailed information about the Detroit Pilot Project (**20**) is provided **Section 9**.

Other Information Included in Table 4

In addition to the various classifications of toxic air contaminants discussed in the previous sections, **Table 4** also includes a column for the "compound class" designation, which pertains to the sampling and analytical methods. This is useful information because it infers the availability and type(s) of sampling and analytical methods employed for each substance, and it also indicates why data for some "low priority" substances are being collected (at negligible additional cost) as part of the analysis for a family of substances (e.g., VOC). **Table 4** also has a column indicating which compounds are currently being routinely measured in the Michigan air toxics monitoring network. Other substances are not presently being routinely monitored for various reasons, although they may have some contemporary monitoring information as a result of special monitoring projects (e.g., mercury).

The **Table 4** substances can, in the near future, be flagged with designations indicating priority for monitoring. This has not yet been done because **Table 4** (and this report overall) was developed as an account of the air toxics monitoring which *could* be conducted for fulfillment of the goals and objectives. The actual selection of substances to be monitored in the future implementation of the strategy will need to take into account the parallel efforts of other studies and research initiatives, the cost, the availability of analytical methods, and other feasibility issues. Also, the implementation of the strategy may result in flexibility and variability in the substances monitored at different locations in order to best utilize the available funding to address the highest priority concerns and monitoring objectives.

In conclusion, most of the high priority compounds listed in **Table 4** may be determined using methods to assess VOCs, carbonyls, and trace metals. A discussion of the criteria for classification as a persistent, bioaccumulative toxic (PBT) pollutant is included in the design of the atmospheric deposition network in **Part 2 Section 4.**

3) Methods

The air sampling instrumentation, sample handling protocols, analytical methods, laboratory techniques, and quality assurance protocols will all follow conventional procedures. For some compounds, or substances, there are no satisfactory analytical methods. It is beyond the scope of this project to develop methods, and as a result, only compounds with established analytical methods will be addressed in this strategy, at this time. Once methods are developed, new compounds will be considered. Some of the compounds and substances not addressed by this strategy due to lack of methodology include: acrolein, coke oven emissions, diesel emissions, ethylene oxide, and quinoline.

Air sampling instrumentation will be commonly available equipment that ranges from Anderson Canister samplers, carbonyl sorbent cartridge samplers, high volume filter samplers, and Anderson Polyurethane foam samplers.

Sampling handling will follow the MDEQ, AQD, Standard Operating Procedures specific to each method (**21-24**). Chain of custody will be followed during all phases of sample collection and data generation.

The analytical methods and laboratory techniques used by the laboratory to analyze samples generated by toxics network will adhere to standard methods set forth by the USEPA. The methods are driven by the chemical and physical properties of the compounds and can be broken down into various groups including VOCs, carbonyls (aldehydes and ketones), PAHs and trace metals. The VOCs will be collected using canister samplers and the contents will be analyzed using gas chromatography/Mass spectrometry (method TO-15) (**25**). Carbonyl samples will be collected on cartridges and analyzed by HPLC coupled with 2,4-dinitrophenylhydrazine derivatization (method TO-11A) (**26**). PAHs will be collected using Anderson PS-1 PUF samplers by passing air samples through XAD-2 resin. The sorbent will be extracted and analyzed by gas chromatography coupled with mass spectrometry (method 8270) (**27A**). Trace metals will be collected by high volume samplers on glass fiber filters and analyzed by inductively coupled plasma spectrophotometry ICP (IO-3.4) (**27**). Hexavalent chromium is collected by passing air through specially treated filters which are extracted and analyzed by ion chromatography coupled with post column derivatization using a method from California (**27B**). A list of analytes by each method, as well as method detection limits for the MDEQ laboratory is included **Appendix C**.

Depending on the sample capacity and ability to handle the number of samples involved, the analysis may be subcontracted to the national contract laboratory (Eastern Research Group, ERG) and/or sent to the MDEQ Laboratory. A list of analytes for ERG is also included in **Appendix C.** In either case, good laboratory practices or good automated laboratory practices will be used to insure the generation of high quality data (**29**).

4) Sampling Frequency, Duration, and Collection Efficiency

Tentatively, the ambient air toxics network will collect 24-hour samples for air toxics on a once every six day schedule. However, the sampling frequency may be adjusted, pending the outcome of the Detroit Pilot Study and other pilot projects nationwide. The Detroit Pilot Project is discussed in detail in **Section 9.B.** The study began April 2001 and is scheduled to end in April 2002 (**20,30**). In addition to providing data upon which to base the design of a national monitoring network, one objective of the Pilot is to determine the optimal sampling frequency to assess ambient levels of air toxics. Sampling dates will coincide with the $PM_{2.5}$ and PM_{10} sampling schedules for various non-daily criteria pollutants published by the USEPA[4]. The USEPA is in the process of supporting an air toxics data analysis study through a contract with Battelle. Battelle's recommendations will also be considered before the sampling frequency is solidified **(30A**).

[4] Schedules governing the collection of particulate samples are published by the USEPA on an annual basis. The sampling frequency contained within these schedules varies from once every 3 days to once every 6 days. To increase comparability of the air toxics data with measurements of speciated particulate material, overlap with scheduled sampling days will be maximized.

The trend sites will operate for at least ten years. The spatial sites will operate for at least three years. Transport and background sites will operate for at least seven years with a longer term commitment. Special purpose sites will operate for a minimum of one year.

A target of 75 percent data capture per quarter and overall 75 percent data capture per year reflected the sample collection efficiency for the network.

4. AMBIENT NETWORK BUDGET

For the ambient budget summarized in **Table 5**, it is anticipated that seven sites could be established per year, taking five years to deploy the complete ambient network. The deployment schedule will depend upon various factors that include: stipulations from funding sources, priorities of the AQD, and emerging scientific data, but, in general, trend sites will be given the highest priority. To optimize the selection of monitoring sites, this strategy does not rely on the existing infrastructure, rather assumes all new locations are created. From an operations standpoint, establishing more than seven sites per year is not realistic as evidenced by lessons learned through recent efforts establishing the fine particulate network. The time frames associated with identifying and securing access to new sites can exceed one year. Coupled with staffing and instrumentation costs, a phased-in approach is more realistic. After complete deployment is achieved, the special purpose monitors will rotate to survey as many of the suggested locations as possible.

Table 5: Ambient Network Budget Summary

3% inflation rate assumed.

Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
New Sites Established	7	7	7	7	7	5
Total Sites Operational	7	14	21	28	35	35
Total Instrumentation/year	$417,300	$363,118	$471,787	$602,308	$781,999	$141,980
Total Operational & Laboratory Analysis	$736,653	$1,273,305	$1,793,696	$2,314,262	$2,835,007	$2,913,520
Total Personnel	$355,000	$402,215	$564,929	$659,461	$679,245	$699,622
Annual Total	**$1,508,953**	**$2,038,638**	**$2,830,412**	**$3,576,031**	**$4,296,251**	**$3,755,122**

Description	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
New Sites Established	5	5	5	5	5	5
Total Sites Operational	35	35	35	35	35	35
Total Instrumentation/year	$147,143	$152,515	$158,105	$163,924	$169,982	$176,290
Total Operational & Laboratory Analysis	$2,993,831	$3,000,572	$3,007,515	$3,014,667	$3,022,033	$3,029,620
Total Personnel	$720,611	$742,229	$764,496	$787,431	$811,054	$835,385
Annual Total	**$3,861,584**	**$3,895,315**	**$3,930,116**	**$3,966,021**	**$4,003,068**	**$4,041,295**

Description	Year 13	Year 14	Year 15
New Sites Established	5	5	5
Total Sites Operational	35	35	35
Total Instrumentation/year	$182,860	$189,704	$196,835
Total Operational & Laboratory Analysis	$3,037,435	$3,045,484	$3,053,775
Total Personnel	$860,447	$886,260	$912,848
Annual Total	**$4,080,742**	**$4,121,448**	**$4,163,458**

The budget assumes that monitoring will be limited to the determination of VOCs, carbonyls, trace metals, and hexavalent chromium. Only six PAH sites are included in the budget. A standard 20 percent co-location factor was used to allow for quality assurance/precision measurements. Also, it was assumed that 10 percent of the total number of samples submitted for analysis will be blanks. A 10 percent monitor replacement/breakdown factor was used. The assumed sampling frequency is once every six (6) days. A three percent inflation rate is assumed for all costs. Greater detail is shown in **Table 6** and even more detail is in **Appendix E.**

Table 6: Budget Estimates to Implement Ambient Air Toxics Monitoring Network

			3% inflation rate assumed.					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**
New Sites Established	7	7	7	7	7	5	5	5
Total Sites Operational	7	14	21	28	35	35	35	35
Instrumentation & One Time Purchase Costs								
Instrumentation/site (PAH at 6 sites only)	$15,000	0	0	0	0	0	0	0
Instrumentation/site (VOC,Carb,TSP)	$10,500	$13,650	$17,745	$23,069	$29,989	0	0	0
Site Set up/site	$4,500	$4,770	$5,056	$5,360	$5,681	$6,022	$6,383	$6,766
Trailers	$12,000	$12,360	$12,731	$13,113	$13,506	$0	$0	$0
Met. Equip., Data Loggers, Strip Chart recorders	$10,000	$10,300	$10,609	$10,927	$11,255	$11,593	$11,941	$12,299
Total/site	$364,000	$287,560	$322,987	$367,276	$423,020	$88,074	$91,619	$95,325
Total Additional Equipment	$56,300	$78,648	$151,983	$238,310	$362,356	$57,384	$59,106	$60,879
Total Instrumentation/year	$417,300	$363,118	$471,787	$602,308	$781,999	$141,980	$147,143	$152,515
Operational Costs								
Total no. of sample sets, 1 in 6 day all sites total	626	1190	1755	2319	2883	2883	2883	2883
Sample collection $75/sample set, 3% inc/yr	$46,965	$91,958	$135,543	$179,127	$222,712	$229,393	$236,275	$236,275
Lab Costs, $713/set of samples, 3% inc/yr	$446,481	$874,218	$1,288,561	$1,702,904	$2,117,246	$2,180,764	$2,246,187	$2,246,187
Travel, avg 350mi/site Audit, 3% inc/yr	$808	$1,615	$2,423	$3,230	$4,038	$4,159	$4,283	$4,283
Shop Support, parts, 3% inc/yr	$43,750	$45,063	$46,414	$47,807	$49,241	$50,718	$52,240	$53,807
Power, $100/mo site, 3% inc/yr	$8,400	$17,304	$25,956	$34,608	$43,260	$44,558	$45,895	$45,895
Shipping, Nat'l Contract $500/site, 3% inc/yr	$3,500	$7,210	$10,815	$14,420	$18,025	$18,566	$18,566	$18,566
Total Hex. Cr, $150/sample, 3% inc per yr	$42,315	$87,169	$130,753	$174,338	$217,922	$217,922	$217,922	$217,922
Total PAH Costs, 6 sites 1 in 6 day, 3% inc /yr	$144,435	$148,768	$153,231	$157,828	$162,563	$167,440	$172,463	$177,637
Total Operational and Laboratory Analysis	$736,653	$1,273,305	$1,793,696	$2,314,262	$2,835,007	$2,913,520	$2,993,831	$3,000,572
Total Personnel	$355,000	$402,215	$564,929	$659,461	$679,245	$699,622	$720,611	$742,229
Annual Total	**$1,508,953**	**$2,038,638**	**$2,830,412**	**$3,576,031**	**$4,296,251**	**$3,755,122**	**$3,861,584**	**$3,895,315**

Table 6: Budget Estimates to Implement Ambient Air Toxics Monitoring Network, Continued

			3% inflation rate assumed.				
	Year 9	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**
New Sites Established	5	5	5	5	5	5	5
Total Sites Operational	35	35	35	35	35	35	35
Instrumentation & One Time Purchase Costs							
Instrumentation/site (PAH at 6 sites only)	0	0	0	0	0	0	0
Instrumentation/site (VOC,Carb,TSP)	0	0	0	0	0	0	0
Site Set up/site	$7,172	$7,603	$8,059	$8,542	$9,055	$9,598	$10,174
Trailers	$0	$0	$0	$0	$0	$0	$0
Met. Equip., Data Loggers, Strip Chart recorders	$12,668	$13,048	$13,439	$13,842	$14,258	$14,685	$15,126
Total/site	$99,200	$103,252	$107,490	$111,923	$116,562	$121,418	$126,500
Total Additional Equipment	$62,705	$64,586	$66,524	$68,520	$70,575	$72,692	$74,873
Total Instrumentation/year	$158,105	$163,924	$169,982	$176,290	$182,860	$189,704	$196,835
Operational Costs							
Total no. of sample sets, 1 in 6 day all sites total	2883	2883	2883	2883	2883	2883	2883
Sample collection $75/sample set, 3% inc/yr	$236,275	$236,275	$236,275	$236,275	$236,275	$236,275	$236,275
Lab Costs, $713/set of samples, 3% inc/yr	$2,246,187	$2,246,187	$2,246,187	$2,246,187	$2,246,187	$2,246,187	$2,246,187
Travel, avg 350mi/site Audit, 3% inc/yr	$4,283	$4,283	$4,283	$4,283	$4,283	$4,283	$4,283
Shop Support, parts, 3% inc/yr	$55,421	$57,084	$58,796	$60,560	$62,377	$64,248	$66,176
Power, $100/mo site, 3% inc/yr	$45,895	$45,895	$45,895	$45,895	$45,895	$45,895	$45,895
Shipping, Nat'l Contract $500/site, 3% inc/yr	$18,566	$18,566	$18,566	$18,566	$18,566	$18,566	$18,566
Total Hex. Cr, $150/sample, 3% inc per yr	$217,922	$217,922	$217,922	$217,922	$217,922	$217,922	$217,922
Total PAH Costs, 6 sites 1 in 6 day, 3% inc /yr	$182,966	$188,455	$194,109	$199,932	$205,930	$212,108	$218,471
Total Operational and Laboratory Analysis	$3,007,515	$3,014,667	$3,022,033	$3,029,620	$3,037,435	$3,045,484	$3,053,775
Total Personnel	$764,496	$787,431	$811,054	$835,385	$860,447	$886,260	$912,848
Annual Total	**$3,930,116**	**$3,966,021**	**$4,003,068**	**$4,041,295**	**$4,080,742**	**$4,121,448**	**$4,163,458**

5. AMBIENT NETWORK REVIEW

Section 58.20 of the Code of Federal Regulations (CFR), Title 40, Part 58 requires the states to review the criteria air monitoring networks on an annual basis to determine (**5,31**):

- How well the network is achieving it's monitoring objectives.
- How well it is meeting the data user's needs.
- How it should be modified, including closure of some sites, relocation of other sites or establishing new sites.

Although the CFR doesn't require a review of monitoring networks that measure compounds other than the priority pollutants, it is a valuable tool that can be used to improve the air toxics and atmospheric deposition networks and to ensure that the data generated by the both networks are adequate, representative, and meet the monitoring objectives. The magnitude of reviewing an air toxics network that will be measuring over a hundred compounds will be substantially greater than reviewing the criteria network, which only addresses six compounds. Therefore, the network and all data collected by it will be reviewed on only a biannual basis.

Some of the topics addressed by the review shall include:

- Adequacy of the network design to evaluate the accuracy of CEP/NATA results
- Frequency of monitoring
- Suitability of physical siting criteria (includes terrain changes such as building construction and tree growth) and representativeness of location
- Previous data generated by the site (relative frequency of non detected levels), purpose of the site and possible relocation
- Degree of homogeneity of concentrations of air toxics in the general area, redundancy with other sites
- Feasibility and review of monitoring technology and possible updates
- Assess site by site data completeness and address any data capture deficiencies
- Identify any deficiencies of the network (insufficient number of samples or sites) and determine corrective action
- If excessive data are being collected, a schedule of divestment actions will be developed and implemented
- Population changes and projected growth; changes in economic activity
- Roadway changes; commuting changes
- Modifications in neighborhood type of use etc.
- Adequacy of list of compounds measured, assess new compounds/methods, deletion of some compounds/methods

Assessment of the adequacy of the network will be conducted by staff and reviewed by management.

6. QUALITY CONTROL AND QUALITY ASSURANCE

The monitors will be audited by MDEQ staff once per quarter to insure proper flow rates, etc. Annual maintenance will be performed on all monitors and their sampling lines will be checked for contamination. To assess precision, co-located samplers will be placed at 20 percent of the sites. Blank sample media will be analyzed at the lab, accounting for 10 percent of the annual sample load to determine trip and field contamination.

The regional USEPA office supplies technical systems audits for monitoring networks annually. MDEQ and any laboratories that are used for subcontracting purposes will participate in USEPA's national performance evaluation samples and annual quality assurance reporting. The results will be attached to the network review as an appendix.

If funding is obtained to implement this strategy, a quality assurance project plan will be prepared which will describe quality control and quality assurance activities in greater detail.

7. DATA ANALYSIS AND INTERPRETATION

Laboratories providing data to support the Michigan Air Toxics Monitoring Strategy will not screen data and will report all data to minimize the number of non-detected quantities in the database. This policy is consistent with the recommendations provided by the Science Advisory Board (SAB) in their evaluation of USEPA's Pilot City Projects for FY 2000. The lab may flag data to indicate greater levels of uncertainty. This practice attempts to avoid the introduction of bias into the database caused by the necessity of various data handling practices associated with data substitution for non-detectable quantities (**18,31-34,30A**). One of the key issues that will be examined by Battelle's air toxics data analysis contract with USEPA will be data handling conventions associated with data bases that contain non-detected quantities. MDEQ will review Battelle's recommendations and adopt any or all appropriate data handling conventions.

Data analysis is an essential portion of this strategy. Adequate resources must be available to promote proper data management and reporting, as well as statistical quality assurance procedures. A detailed report providing data analysis and interpretation will be prepared every two years, due to the volume of data generated by the proposed network. Some of the topics that may be addressed in the bi-annual report include:

- Measured changes in air quality and estimated risks from exposure to air toxics.
- Simple descriptive statistics such as peak concentrations, seasonal, annual and multi-year averages.
- Air quality differences between major population areas as well as differences between rural, smaller cities and urban areas.
- Gradients across larger communities with a large number of monitors.
- Relationship between emissions and air quality. Does the data track changes in emissions, and efficacy of improvements in control technology?
- Graphics such as time series, fingerprint, scatter, box and regression plots as well as pollution roses.
- Long-term trends, seasonal fluctuations, day of the week variability in air toxics concentrations
- Quality control and quality assurance

A summary report will be prepared on alternate years to supply information to the stakeholders, staff, and citizens by providing trends in the concentrations of toxic air contaminants and drawing general conclusions about environmental quality.

The costs associated with data analysis and report generation are included in budget estimates provided in the preceding section and detailed in the **Appendix E**.

8. FUTURE PLANS

The primary goal of this strategy is to serve as the initial phase to further develop Michigan's monitoring network. Risk assessment as well as modeling, including trajectory analysis, source apportionment and receptor modeling are logical ultimate uses of the data that would become available after implementation of the plans outlined in this strategy. Detailed discussions of modeling and risk assessment techniques are beyond the scope of this document. Detailed descriptions for risk assessment procedures and modeling studies will be described in future documents once additional funding is secured.

This strategy is considered to be the first phase in the implementation of the expanded air toxics program. The strategy will be updated after the results from the Detroit Pilot Project become available, by approximately December 2003.

9. COORDINATION WITH OTHER LOCAL, STATE, REGIONAL, AND NATIONAL EFFORTS ADDRESSING LEVELS OF TOXIC AIR CONTAMINANTS

Over the previous year, there have been several initiatives that impact the measurement of ambient levels of air toxics in Michigan. On the federal level, the USEPA has drafted an air toxics monitoring concept paper intended to guide the formation of a nationwide monitoring network for air toxics. The USEPA is also developing pilot monitoring projects to address levels of air toxics in various cities nationwide. Wayne County and MDEQ, as well as an advisory panel, have been developing an air toxics study within Detroit. This document will briefly review these projects then describe their interrelationships.

A. USEPA's Air Toxics Concept Paper and Plans for a National Network

The most immediate initiative resulting from federal efforts are short-term projects designed to improve basic understanding of the ambient concentrations of toxic compounds. To better characterize the spatial distributions of air toxics and to evaluate existing databases of air toxics, during FY 2000, the USEPA and STAPPA/ALAPCO decided to distribute $3,000,000 in air toxics funding in the following manner. A portion ($500,000) will be used to analyze and assess air toxics data already collected by various state and local agencies across the country. The remaining funds will be used to better characterize levels in urban areas, small cities and assess background concentrations by performing 10 air toxic monitoring pilot projects (**1,2,18,19**).

The primary goal of the pilot projects (**17**) is to provide data to aid the design and implementation of a toxics monitoring network to supply trends in air quality. The national monitoring program will provide data that will be used to:

- characterize ambient concentrations and toxics deposition
- better understand the fate and transport of air toxics
- help evaluate atmospheric dispersion and deposition models
- establish trends and evaluate the effectiveness of reduction strategies for hazardous air pollutants.

Four large cities were selected as nationwide pilots, each to receive funding to support five to eight sites. One of the selection criteria for the pilot cities was the ability to leverage existing funds, infrastructure and projects. Detroit, along with Providence, Rhode Island; Seattle, Washington; and Tampa, Florida; are the urban pilot cities.

Fewer monitoring sites (two or three) will be set up in the smaller cities and rural areas, which include:

1. San Jacinto, California
2. Grand Junction, Colorado
3. Rio Rancho, New Mexico
4. Cedar Rapids, Iowa
5. San Jaun/Barcolenta, Puerto Rico
6. 60 miles west of Charleston, South Carolina

The areas were selected to provide data from diverse emission sources under different climatological conditions. The data generated by the pilot projects will be reviewed to assess the sources and magnitudes of variability of concentrations of air toxics across the nation. A similar study in other locations may be repeated during 2003. The data generated from these studies will be used in the design of a national air toxics network.

In the early planning stages, the USEPA created a series of draft papers that envisioned a nationwide air toxics network limited to 46 sites, less than 1 per state. The ability of such a sparse network to adequately characterize levels of air toxics was heavily criticized and resulted in the Pilot City approach. In addition, suggestions were made that the existing air toxics database, limited though it may be, should be "mined" for information useful in the design of a national network.

B. Detroit Pilot Project

Wayne County Department of the Environment, Air Quality Management Division (WCAQMD), along with stakeholders and MDEQ, were planning a 6-site air toxics study to commence during 2000 using the 2 existing MDEQ air toxic sites, along with $200,000 in special funds from WCAQMD. This study planned to leverage the existing infrastructure and expand monitoring at sites currently operational in Wayne County and upwind in Ypsilanti, located in Washtenaw County. The funds were insufficient to allow the measurement of a full suite of compounds at all of the proposed monitoring sites for the duration of a complete year. Towards the end of the planning year for this study, the USEPA began the selection process for their National Air Toxics Monitoring Pilot Program. In an effort to secure more funding, Detroit was nominated by MDEQ and WCAQMD as an urban pilot city, and subsequently, received $500,000 as part of the FY 2000 and FY 2001 air toxics 103 grant funding. The national funding will be used to supplement and expand the planned project.

The Detroit Pilot Study (**20**) will examine the levels of volatile organic compounds (VOCs), semi-volatile compounds, carbonyl compounds and trace metals at eight sites as well as hexavalent chromium at four sites within the Detroit metropolitan area. The additional funding received from USEPA will be used to expand the study from six to eight sites and add the following modifications:

- Extend duration of the study from 10 to 12 full months
- Provide duplicate sampling to assess both inter-laboratory and intra-laboratory precision
- Add a mobile source oriented site
- Add a maximum impact site
- Increase sampling frequency to every day at one site
- Add analysis of hexavalent chromium (Cr +6) at four sites

In general, monitoring will be conducted at population-oriented sites on the neighborhood scale. For most parameters, at most sites, a once every six-day sampling schedule is planned.

The goals behind the Detroit Pilot Project include:

- Determine the degree of spatial variability of levels of air toxics in a major urban area.
- Compare and contrast concentration differences between mobile source oriented sites, hot spots and upwind locations.
- Pending acquisition of fine particulate ($PM_{2.5}$) speciation monitors, collect elemental carbon, trace metal and particulate data to assess relative contributions from diesel emissions to air quality (subject to USEPA's release of funding for $PM_{2.5}$ speciation sites)
- Determine the optimal sampling frequency for collection of air toxics data.
- Provide data to support the design of the national air toxics network.
- Provide data to help evaluate the accuracy of emission inventories and dispersion models used in the National Air Toxics Assessment Project.

Monitoring for the Detroit Pilot Project began April 2001 and will be completed in April 2002. The Detroit Pilot Project will address not only the urban scale variability in levels of air toxics, but when the data are compared with measurements from other cities across the state; regional scale variability will be addressed. The data collected by the Detroit Pilot Study, as well as that collected by the statewide network, will be an invaluable tool to estimate population exposure, indicate environmental quality and assess the accuracy of emission estimates and modeled results. When data from the Detroit Pilot Study becomes available, it will be evaluated to determine if any changes in the proposed air toxics monitoring strategy are needed. The data from this study will also be used to help determine the optimal sampling frequency for the ambient network proposed in this air toxics monitoring strategy.

C. Regional Monitoring Strategy

During 1999, an attempt was made by the USEPA to review air monitoring priorities on a nationwide scale. The goal was to address the ever expanding air monitoring requirements coupled with the limited, flat lined federal budgets expected over the next decade and to resolve the problem of being asked to do more monitoring with less funding. The limited success of the federal project has prompted the Great Lakes States to undertake the project on a more limited regional scope.

Region 5 states across the Lake Michigan basin that include Illinois, Indiana, Michigan, Ohio, Wisconsin, and Minnesota, along with the USEPA Region 5 office, have been developing an approach to address:

- Funding Issues
- Monitoring Program Objectives and Priorities - Including the increased need for air toxics measurements
- A Review of Existing Programs
- Recommend Program and Regulation Modifications
- Address Quality Assurance Issues

- Summarize Data Handling Procedures
- Short and Long Term Monitoring Plans

A draft regional strategy has been developed through cooperative efforts between the Region 5 states, LADCO, and USEPA Region 5. Michigan's Air Toxic Monitoring Strategy will complement this effort.

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PART 2: Assessing Atmospheric Deposition

1. PURPOSE

The purpose of this part of the document is to develop a strategy that 1) provides an overview of atmospheric deposition and the air toxics most susceptible to deposition; 2) summarizes available data; and, 3) delineates future plans that address air monitoring costs, methodologies, and proposed site locations for a state-wide atmospheric monitoring network. This strategy will be used as a guide to potential funding entities in the future to fund an atmospheric deposition network in Michigan.

As discussed in **Section 2B.1** of this part of the strategy, many reports have been generated at the state, federal, and international levels that highlight the need for additional monitoring to further estimate atmospheric deposition of air toxics to the environment.

Air toxics data collected for use in assessing atmospheric deposition will be useful for the MDEQ's Air Quality and Surface Water Quality programs as well as efforts at both the federal and international level to better understand this issue.

This document is intended to serve as only a preliminary step toward the further development and expansion of a comprehensive atmospheric deposition monitoring program for the State of Michigan. Comprehensive site selection criteria, detailed human and ecological risk assessments, and specialized modeling applications are beyond the scope of this strategy.

2. BACKGROUND

A. Introduction

Air toxic pollutants of concern that may adversely impact the environment through atmospheric deposition share similar characteristics. These pollutants are:

- Persistent – the compounds do not naturally degrade in the environment,
- Bioaccumulative – the compounds build up in tissues of animals; as animals feed on other animals in the environment the pollutant levels will increase or biomagnify at the top of the food chain, and
- Toxic – the compounds are known to cause adverse health effects in humans and wildlife from exposure; effects can include cancer and/or developmental and reproductive effects.

Special concern is attached to such substances due to their propensity to persist and/or bioaccumulate in the environment which can lead to heightened exposure beyond inhalation. Some organic compounds and all metals have long-term environmental persistence. Because of these characteristics, the pollutants are often referred to as persistent, bioaccumulative toxic pollutants or PBTs. While ambient air concentrations of certain PBTs may not be high enough to cause a concern from direct inhalation, these pollutants can enter the environment through atmospheric deposition leading to potential environmental and health risk concerns through indirect exposure. Typically, PBTs can be deposited to the environment via three processes including:

Wet Deposition - refers to gases and particles carried in precipitation (rain, snow, fog, and sleet) which are deposited on land and water surfaces.

Dry Deposition - refers to pollutants bound to particulate matter that are deposited on water and land surfaces in the absence of precipitation, and

Gas Absorption or Exchange - refers to pollutants in a gaseous state that cross the air-water interface, and are absorbed in the water column by gas transfer.

Air deposition is one of the crucial elements largely responsible for contamination of lakes and streams by some types of pollutants including mercury and polychlorinated biphenyls (PCBs). Additionally, deposition of certain pollutants, like dioxins, can contribute to elevated levels in soils.

For a summary of data collected in Michigan and the Great Lakes Basin that assesses atmospheric deposition to the Great Lakes and within Michigan see **Appendix A**.

While several studies are included in **Appendix A** that address ambient levels and atmospheric deposition of PBTs over the past decade, only intermittent measurements for a limited set of pollutants have been collected. The fragmented nature of these studies demonstrates and supports the need for implementation of a comprehensive

atmospheric deposition network spanning a continuous time frame within the state and region.

B. Approach

In September 1999, a small AQD workgroup was created to guide the progress and direction of the project, form the initial monitoring objectives, design the network, create the budgets, and act as liaison to the Division Chiefs and management. Ms. Cathy Simon, Chief of the Toxics Unit, and Ms. Mary Ann Heindorf, Environmental Quality Specialist in the Air Monitoring Unit, acted as lead staff for the overall project. Ms. Joy Taylor Morgan, Environmental Quality Specialist in the Toxics Unit, provided the lead for the development of the atmospheric deposition monitoring network. Mr. Robert Sills, Toxicologist Specialist in the Toxics Unit, and the late Mr. Paul Shutt, Chief of the Air Quality Evaluation Section were also members of the workgroup. Several other AQD staff also provided assistance on an as needed basis. During each major stage of the project, feedback was solicited from AQD staff and members of the Air Advisory Group, consisting of representatives from industry, environmental groups, small businesses, local groups and state representatives. The atmospheric deposition strategy was also submitted to a panel for scientific peer review.

1) Initiatives Supporting the Development of the Strategy

In recent years, there have been several reports and recommendations urging the expansion of monitoring for PBTs, as summarized below:

- The Recommended Environmental Indicators Program for the State of Michigan prepared by the MESB and released July 2001 recommends that 20 environmental indicators be included into a statewide environmental indicators program. Rates of deposition of persistent and bioaccumulative air toxic pollutants and acidic components were recommended in this report for future indicators (**1**).

- The February 1999 report, Michigan's Relative Risk Task Force Report on Air Quality Issues stated the identification of sources and an understanding of the deposition, fate, and impact of PBTs found in the Great Lakes region should be a priority and that these PBTs are of concern now in Michigan and will continue to be in the future (**2**). The report also stated that, "There is sufficient scientific uncertainty about the role of persistent hazardous air pollutants to warrant consideration of an ecologically-based monitoring program to provide data on the transport and fate of these materials in urban as well as rural areas of the state."

- The International Joint Commission (IJC) in their 2000 10th Biennial Report on the Great Lakes Water Quality recommended that both dioxin and mercury be added to the Integrated Atmospheric Deposition Network (IADN) (**3**). The IJC also identified ambient monitoring of PBTs as a priority in their 1997-1999

Priorities and Progress under the Great Lakes Water Quality Agreement (GLWQA) (**4**).

- The USEPA's Mercury Research Strategy (**5**) describes USEPA-ORD's (Office of Research and Development) program to reduce the scientific uncertainties related to mercury and methylmercury risks. As stated by the strategy, "enhanced monitoring of atmospheric mercury deposition for model application" is a priority. The USEPA will begin development of a coordinated mercury monitoring program, in cooperation with the U.S. Geological Survey and other federal and state agencies, through the installation of comprehensive deposition monitoring stations in various areas, including the Midwest. These stations will obtain data on the temporal and spatial distribution of mercury deposition and the data will also be used for modeling source-receptor relationships. A recommendation was also made that was beyond the scope of the USEPA-ORD's mercury research strategy; that was to develop a statistically-representative monitoring data set that would provide a baseline against which progress in mercury risk management could be measured. The USEPA has also developed a Mercury Action Plan (**6)** that recommends a national mercury monitoring strategy that is intended to harmonize monitoring programs by federal and state agencies to achieve efficient and comprehensive mercury analysis on a national scale. Any monitoring implemented in Michigan would be coordinated with this effort.

- The Lake Michigan Forum, the Delta Institute, the International Air Quality Advisory Board, and the Science Advisory Board of the IJC in their briefing document titled, Using Models to Develop Air Toxics Reduction Strategies: Lake Michigan as A Test Case (**7**) recommended that "Environmental officials in the region should design and implement a comprehensive multimedia regional monitoring network." This network would help to fulfill the mandates in Annex 15 of the GLWQA, support regional air quality transport and deposition modeling needs and track both identified and emerging pollutants of concern.

- The recent Environmental Council of States (ECOS) resolution Number 01-1 approved on February 27, 2001 "urges the President and Congress to expand federal and state capacity for mercury-related environmental monitoring, pollution prevention programs, and health advisory efforts" (**8**).

- Environment Canada in their report that summarized monitoring of persistent toxic substances in Ontario from 1994-1999, recommended that "emphasis in future monitoring should be placed on PAHs and on dioxins and furans." Objectives should also include an effort to identify both spatially and more frequent sample collections (**9**).

- The Michigan Environmental Science Board also recommended that Michigan establish a regional mercury air and precipitation monitoring network to determine the spatial distribution of airborne concentrations and deposition by mercury species across the state (**10**).

3. MONITORING GOALS AND OBJECTIVES

A. Goal Statement

The goals of the atmospheric deposition component of the air toxics monitoring strategy are to assess ambient concentrations of certain PBTs in urban and remote areas and to estimate deposition to land and water bodies within the state.

Achieving these goals will aid in the statewide characterization of PBT compounds in the ambient air and precipitation and the amount of PBTs deposited within the state. This information will be used to support human exposure and health risk assessments, to determine temporal and spatial trends, to evaluate changes in environmental quality, and to assess impacts on the environment. This will be accomplished by measuring the levels of the PBTs at selected key locations across the state. The data collected will be useful in comparison of modeled values when multi-pathway risk assessments are conducted. While specific source identification is very important, estimates for source apportionment work will not be included in this strategy at this time.

B. Objectives

The specific objectives of this PBT monitoring include:

1) Assess Temporal Trends of PBTs in Urban and Rural Areas

Long-term monitoring occurring for at least ten years at fixed sites allows the determination of changes in concentrations of PBTs over time. The determination of temporal trends in the concentrations and subsequent deposition of PBTs can be used to verify actual improvements in environmental quality. Reductions in emissions inventories and improvements in control technologies must not be limited to what is calculated and reported in emission inventories , but must be linked to actual environmental measurements.

Added benefits arising from improved temporal coverage include the availability of more information to evaluate the efficacy of air toxics programs and facilitate better decisions about the future direction of these programs. Additionally, this information will be useful for prioritizing future work, which may include sampling in a more in-depth or source specific basis.

While the IADN (See **Appendix A**) has been in operation for approximately 10 years, no data have been collected on the levels of dioxins/furans or mercury in Michigan. Several years of mercury data have been collected for mercury by the University of Michigan (U of M), but these sites were limited and offer little urban temporal trend data.

2) Access Spatial Variability

Concentrations and deposition of PBTs can vary spatially across different areas of the state. These concentrations may be influenced by several factors including the type of sources located in an area, the number of sources, local meteorological conditions, varying terrain, etc. To adequately characterize the spatial variations in levels of PBTs, it is necessary to locate monitors in areas representative of these different environments. These monitors will be in operation for several years.

Improved spatial coverage will allow the determination of homogeneity or variability across distances that may be impacted by specific sources. It is also important to assess differences between background concentrations that are measured in urban, suburban, and rural locations.

To date, only a limited number of studies have been performed in urban and downwind areas impacted by sources. Background levels of mercury and PCBs have been collected in Michigan through the U of M's monitoring projects as mentioned in **Appendix A** or at the two IADN sites located in Michigan (for PCBs). Additional data however are needed to establish background dioxin and furan ambient levels in Michigan. All urban areas need PBT data, only limited data exist for mercury and PCBs in Detroit.

Preliminary studies in both Chicago and south Florida have found as much as two-thirds of the mercury wet deposition to be of local anthropogenic origin (**11,12**). Both of these studies were limited by not having the capability to measure reactive gaseous mercury (RGM). The RGM data are essential for estimating the dry deposition of mercury and for identifying the source or sources of the mercury deposited via both wet and dry processes.

3) Support and Evaluate Dispersion and Receptor Modeling

Establishing reliable PBT ambient concentrations and atmospheric deposition estimates will be helpful in comparing modeled values for current and future applications. The AQD is required to process air permits for new sources and to evaluate the release and impact of such PBT emissions as mercury, dioxins, and PCBs. Currently, the AQD lacks ambient data to compare the modeled values from such sources as municipal, medical, sewage sludge, and hazardous waste incinerators; automobile shredders; electric arc furnaces; fluorescent light recycling facilities; and tire and wood burning facilities. For several years, the AQD has conducted multi-pathway risk assessments routinely for municipal waste incinerators in the state. Many models used today lack ambient monitoring data to confirm that the modeling results represent actual levels in the environment (**13**). Due to the high costs associated with monitoring, reliable modeling systems and emission inventories are the best approach for assessing PBT release and deposition to the environment. However, before widespread application of these tools, it is important to validate their results under a wide range of conditions to provide a "reality check" with monitored values.

4) Environmental Indicators

The atmospheric deposition monitoring network should be designed so that the data collected may be used as an indicator of environmental quality. This objective is specifically mentioned in the AQD's Targets and Means for FY 2000. While other measures such as emissions inventory data may provide some information about the quality of the air, ambient monitoring data provides the most direct measure. It is anticipated that the monitoring locations that will be selected to address spatial and temporal trends objectives will also supply data to be used as an indicator of environmental quality.

The development and implementation of the atmospheric deposition monitoring network will also be coordinated with any efforts by the State of Michigan to establish Master Stations. The establishment of a system of Master Stations where environmental indicator data would be consistently and uniformly collected was recommended by the MESB in their report, Recommended Environmental Indicators Program for the State of Michigan (**1**). The MESB recommended establishing between 10-25 Master Stations in order to reasonably represent the major landscape/waterbody type and geographic regions across Michigan. A wide range of biological, physical, and chemical parameters would be monitored at the Master Stations to provide long term trend data.

4. ATMOSPHERIC DEPOSITION NETWORK TARGET COMPOUNDS

Rather than develop a new list of target compounds for this state strategy, **Table 1** summarizes those substances which have been identified through previous initiatives, to present substantial concerns for persistence and/or bioaccumulation, as well as toxicity, and are known to deposit through the atmosphere. These key initiatives are discussed below and include the USEPA Great Waters Study [112(m)] of the CAA (excluding nitrogen) (**14**); the CAA Section 112(c)(6) list (**15**); and the USEPA (1994) guidance for conducting risk assessments for indirect pathways of exposure.

A. CAA Section 112(m) Great Waters Pollutants

Under the 1990 amended Clean Air Act (CAA), USEPA was required in Section 112(m) to identify and assess the extent of atmospheric deposition of air pollutants to the Great Waters. The "Great Waters" are defined as the Great Lakes, Lake Champlain, Chesapeake Bay and coastal waters. The Great Waters report(s) identified 15 pollutants of concern to the Great Waters (**Table 1**). These pollutants were identified as being emitted into the air by a wide range of sources, are persistent in the environment and have known adverse environmental and/or health and wildlife impacts.

B. CAA Section 112(c)(6)

Also included in the 1990 CAA was Section 112(c)(6) requiring the USEPA to ensure that seven specific HAPs would be subject to standards(**Table 1**). The sources making up 90% of the aggregate emissions of these pollutants had to be listed by 1995 and had to be subject to standards under subsection 112(d)(2) or (d)(4) by the year 2000. These seven pollutants in Section 112(c)(6) were among the pollutants of concern identified by the IJC of the U.S. and Canada and USEPA's Great Waters Program due to their persistence and tendency to bioaccumulate, bioconcentrate, and biomagnify in the environment. These pollutants are also associated with adverse human effects that include neurotoxic, carcinogenic, reproductive, or endocrine system function effects.

C. USEPA Guidance on Risk Assessments for Indirect Pathways of Exposure

The USEPA (1994) Exposure Assessment Guidance for RCRA Hazardous Waste Combustion Facilities provides a list of compounds which have been judged to be of the greatest concern by routes of exposure other than direct inhalation (**16**). These substances were considered to be the most frequently detected during stack testing of combustion devices. This list has since been expanded in the 1998 USEPA Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (**17**).

Selection of Parameters for Network: The AQD's monitoring priority for this strategy is to focus on PBTs that are currently known to be released in significant quantities from atmospheric sources and where there exists a known environmental

problem within the state, such as fish advisories. Additionally, the three federal initiatives included in Table 1 were used as a guideline for selecting the key PBTs to emphasize for this strategy. Examination of the Table 1 list of PBTs indicates several of the pollutants are listed in all three columns including mercury, lead, dioxins/furans, hexachlorobenzene, POCs and PCBs. Lead will not be included in this strategy as it has been shown to decline in the environment and also, because lead is a criteria pollutant. As a criteria pollutant, monitoring for lead continues through the AQD's particulate matter monitoring sites. Hexachlorobenze (HCB) will also not be included in this strategy as there are currently no fish advisories in Michigan due to HCB and most sources have been eliminated. HCB was used as an agricultural fungicide up to the 1970s and is currently a byproduct of metal and chemical manufacturing. It can also be released as a product of incomplete combustion if chlorine and high temperatures are present. HCB will be considered in the future, if new data demonstrates it as an increased PBT of concern. This strategy will initially focus on the remaining three pollutants highlighted by all federal initiatives in **Table 1**, and includes mercury, dioxins, and PCB's. Also, as outlined in **Appendix A**, the most widespread fish advisories are due to PCBs, mercury, and dioxin. As other pollutants of concern emerge as problems due to air emissions and deposition, this strategy will be updated to incorporate those pollutants. For example, scientists are now finding elevated levels of polybrominated diphenyl ethers (PBDEs), a common chemical flame retardant in Lake Michigan salmon (**18**).

The following is a summary of the PBTs (potential sources, atmospheric forms measured, etc.) that will be monitored as part of this strategy.

Mercury

Mercury has been widely recognized as a pollutant of concern to the environment for decades. Mercury can be released naturally or emitted from industrial sources, and can enter aquatic systems via atmospheric deposition where it is converted by micro-organisms to methylmercury, a form that is persistent in the food chain. Through bioaccumulation, levels in fish, specifically predatory species, can be greatly elevated beyond surface water concentrations.

Atmospheric deposition has been shown to be a significant source of mercury to some of the Great Lakes (**19**). The atmospheric deposition of mercury is approximately seven times higher in the Great Lakes than other areas (**20**). Recent data collected from the Mercury Deposition Network (MDN) however, has found the Great Lakes region as not being significantly higher than other regions in the nation (http://nadp.sws.uiuc.edu/mdn/). It should be noted that the MDN program uses weekly composite samples and measures only wet deposition.

Historically, some sources, such as municipal waste incinerators, have been identified as contributors to ambient levels of mercury (**21**). Ambient elemental mercury data directly downwind of a sewage sludge incinerator in Detroit also demonstrates elevated urban levels (**22**). Data has shown that Chicago contributes up to 30 percent of the mercury loadings to Lake Michigan, and that atmospheric

deposition was responsible for 80 percent of the total mercury loadings (**23**). While atmospheric deposition is an important source to many lakes, other sources such as historical mining tailings are being investigated as being significant contributors to mercury loadings into Lake Superior (**24**). Sources of mercury in Michigan include coal fired electric utilities, municipal and medical waste incinerators, and disposal of mercury-containing products such as fluorescent lights (**25**).

Speciated measurements will be collected for mercury. Speciated measurements of ambient mercury include gaseous elemental mercury, RGM, and particulate phase mercury; mercury in precipitation will also be collected. Speciated measurements are critical for estimating total deposition impacts to urban areas on downwind ecosystems. Measurements of RGM are also important; the LMMBS model demonstrated that dry deposition of RGM resulted in mercury loadings to the lake approximately equal to the wet deposition loadings.

Dioxins and Furans

Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are byproducts of combustion and can be released from such sources as incinerators, burn barrels and forest fires. For the purposes of this report, the term "dioxins" refers to the class of compounds including all PCDDs and PCDFs. The USEPA's recent draft assessment of dioxin indicates a potential heightened concern for exposure to these compounds (**26**). The primary exposure route for dioxins is believed to come from the food chain due to atmospheric deposition to animal feed crops and subsequent uptake by livestock, poultry, etc.

Recent emission inventory work demonstrates that burning of residential trash can be a significant contributor of dioxin emissions in the state (**27**). Other sources of dioxins include medical and municipal waste incinerators, coal-fired utilities, cement kilns, and aluminum smelters. Emissions from sources in Michigan have been estimated to contribute the following percentage of dioxin loadings to the Great Lakes: Lake Superior-10 percent; Lake Huron-17 percent; Lake Michigan-7 percent; Lake Erie-11 percent; and Lake Ontario-4 percent (**28**). Dioxins will be collected as vapor and particulate matter following the protocol established in the National Dioxin Air Monitoring Network (**29**).

PCBs

PCBs do not occur naturally in the environment; they were manufactured for use as a fire-resistant, nonflammable insulating fluid in electrical and heat transfer equipment. The PCBs were used in capacitors, fluorescent lamp ballasts, televisions, and appliances. Other uses include plasticizers in paints, plastics, rubber products, pigments caulking compounds, and adhesives. The PCBs were banned for use in 1977 and are, for the most part, no longer used deliberately in product manufacturing. However, they are still in use in certain applications and can be released to the environment from several different sources, some of which include: transformers, capacitors, and other electrical equipment; combustion or incineration of materials containing PCBs; environmental sinks of past PCB

contamination, such as contaminated sediments; inadvertent generation during certain production processes; and storage and disposal facilities (**30**). PCBs have been shown to be highly elevated in such urban areas as Chicago as identified in the LMMBS. In Michigan, numerous fish advisories exist due to elevated PCBs in fish.

PCBs will be collected as vapor and particulate and in precipitation. The budget reflects using PUF samplers to monitor for PCBs, however this method may be revised to be consistent with IADN. The IADN sites use HI Vol monitors with glass fiber filters with XAD-2 resin. Typically, analysis for PCBs in particulate matter is not done, as the levels are usually nondetect (**31**). These methods appear to be somewhat controversial and will need to be further evaluated prior to implementing this strategy. The results of PCB analysis will be reported on a PCB congener-specific basis.

Polynuclear aromatic hydrocarbons (PAHs)

PAHs may be of concern from direct inhalation as well as atmospheric deposition. Given the concern from direct inhalation, this class of compounds will be monitored as part of the ambient monitoring network (see **Part 1: Ambient Monitoring Network, Section 3.C.2.**). Initially, PAHs will not be included at every site proposed in the ambient monitoring portion of this strategy as a cost containment measure. Instead, six sites will be established as part of a preliminary assessment and samples will be collected on a once every six day sampling frequency. Once data from the Detroit Pilot Project is evaluated, this number of sites and sampling frequency will be revisited.

TABLE 1: Pollutants of Concern

POLLUTANTS OF CONCERN	15 Great Waters [Section 112(m) CAA]	Section 112(c)(6) CAA	USEPA Guidance for Indirect Pathways
METALS			
Antimony			X
Arsenic			X
Barium			X
Beryllium			X
Cadmium and cadmium compounds	X		X
Chromium			X
Lead and lead compounds	X	X	X
Mercury and mercury compounds	X	X	X
Nickel			X
Selenium			X
Silver			X
Thallium			X
ORGANIC POLLUTANTS			
Chlordane	X		
DDT/DDE	X		
Dieldrin	X		
DIOXINS/FURANS (3 subsets) • Dioxin and Dioxin-like Compounds 2,3,7,8-substituted Polychlorinated dibenzo(p)dioxin congeners (2,3,7,8-PCDD's), 2,3,7,8-substituted Polychlorinated dibenzofuran congeners (2,3,7,8-PCDF's) • 2,3,7,8-TCDD and 2,3,7,8-TCDF • 2,3,7,8-tetrachlorodibenzofuran and 2,3,7,8-tetrachlorodibenzo-p-dioxin	X	X	X
α- Hexachlorocyclohexane (α - HCH)	X		
γ-hexachlorocyclohexane, or (γ-HCH Lindane)	X		
Hexachlorobenzene (HCB)	X	X	X
Nitroaromatics (1,3-dinitro benzene, 2,4-dinitro toluene, 2,6-dinitro toluene, nitrobenzene, pentachloronitrobenzene)			X
Nitrogen compounds	X		
POCs (2 subsets) • Polycyclic organic matter (POM) • Polycyclic aromatic hydrocarbons (PAH's) - benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene	X	X	X
Pentachlorophenol			X
Polychlorinated biphenyls (PCBs)	X	X	X
Phthalates (Bis (2-ethylhexyl) phthalate, di(n)octyl phthalate			X
Toxaphene	X		

5. ATMOSPHERIC DEPOSITION NETWORK DESIGN PRINCIPLES

A. Summary of Atmospheric Deposition Network

The atmospheric deposition portion of the strategy will focus upon the determination of isomer specific levels of PCBs, dioxins, furans, and speciated mercury. The atmospheric deposition network will consist of four to twelve sites, depending on the parameter measured. Monitors will be located in two background areas, four urban areas in the lower peninsula, one urban area in the upper peninsula, and two agricultural sites.

Table 2 provides a summary of pollutants monitored at each atmospheric deposition site. Unlike the ambient portion of this strategy, not all parameters are measured at every site as shown by the blank cells in **Table 2**. The high costs that are associated with many of these measurements was a motivating factor behind the restrictions in this sampling design.

TABLE 2: Parameters Measured at Atmospheric Deposition Sites

NUMBER OF MONITORING SITES			
Site	**Dioxins/Furans**	**PCBs**	**Mercury**
Background Sites			
Sleeping Bear Dunes	1	X (already being monitored by USEPA)	1
Keweenaw Peninsula	1	X (already being monitored by USEPA)	1
Urban Sites			
Grand Rapids	1	1	3
Detroit	1	1	3
Lansing	1	1	3
Sault St. Marie	1	1	1
Midland	1		
Agricultural Sites	2		
TOTAL SITES	**9**	**4**	**12**

Table 3 provides a more detailed description of what pollutants will be monitored at various sites over the years during strategy implementation.

Table 3: Summary of Atmospheric Deposition Measurements

NATA Years are shown in gray

"Dioxin" refers to PCDD's and PCDF's

		NATA Years:	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Site	Code	Param	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Sleeping	IA	Dioxin	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Bear	USEPA	PCBs															
Dunes		Hg	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Keewanaw	IK	Dioxin	x	x	x	x			x			x			x		
	USEPA	PCBs															
		Hg	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Detroit	D1	Dioxin	x	x	x	x			x			x			x		
Site 1		PCBs	x	x	x	x			x			x			x		
		Hg	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Detroit	D2	Dioxin															
Site 2		PCBs															
		Hg	x														
Detroit	D3	Dioxin															
Site 3		PCBs															
		Hg	x														
Grand	GR1	Dioxin		x	x	x			x			x			x		
Rapids		PCBs		x	x	x			x			x			x		
Site 1		Hg		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Grand	GR2	Dioxin															
Rapids		PCBs															
Site 2		Hg		x													
Grand	GR3	Dioxin															
Rapids		PCBs															
Site 3		Hg		x													
Lansing	L1	Dioxin			x	x			x			x			x		
Site 1		PCBs			x	x			x			x			x		
		Hg			x	x			x			x			x		
Lansing	L2	Dioxin															
Site 2		PCBs															
		Hg			x												
Lansing	L3	Dioxin															
Site 3		PCBs															
		Hg			x												
Midland	MD	Dioxin	x			x			x			x			x		
		PCBs															
		Hg															
Marquette	MQ	Dioxin				x			x			x			x		
		PCBs				x			x			x			x		
		Hg				x			x			x			x		
Ag Site 1	Ag	Dioxin	x	x	x												
		PCBs															
		Hg															
Ag Site 2	Ag	Dioxin	x	x	x												
		PCBs															
		Hg															

Figure 1 provides the general location for the atmospheric monitoring sites. For selecting some of the specific sites, the AQD will coordinate with other divisions or agencies as appropriate including USEPA, MDEQ's SWQD as well as research scientists that are experts in the field of ambient monitoring and modeling of PBTs.

Figure 1: Proposed Atmospheric Deposition Network

B. Atmospheric Deposition Network Design Considerations

Urban Sites

Population levels were used as an initial consideration in design of the network. In the Upper Peninsula Sault St. Marie was selected over Marquette (which is the largest city in the Upper Peninsula) because Sault St. Marie is a transnational site and is also a site that could be used as a source impacted and a background site. The top two urban areas in Michigan's Lower Peninsula were selected (Detroit and Grand Rapids) as well as Lansing for better spatial coverage across the state (**32**).

Dioxins, mercury, and PCB monitoring will take place at these urban sites. In the three larger urban areas, for mercury only, three sites will be established in a triangulation format in order to establish levels within the urban area. One site will be located in the urban center, one downwind and one upwind from the urban center, to help identify transport in the urban area. Several trace elements will also be collected at the urban

centers for use in future source apportionment work. However, at this time, the budget does not include costs for source apportionment and back trajectory modeling.

Midland was added as a fifth urban area to the network. Dioxins is the only PBT that will be monitored at this site. Soil samples analyzed by the DEQ and Dow have indicated elevated levels of dioxin. A site to measure atmospheric deposition of dioxin in Midland is proposed to provide further information on the contribution of this route to levels found in various environmental media.

Background Sites

Sleeping Bear Dunes and Keweenaw Peninsula were selected for background sites as these sites are currently operated as part of the IADN. Their proximity to the Great Lakes provides an ideal location to assess background levels of atmospheric deposition in the basin and to track temporal trends. The USEPA currently monitors for PCBs, certain pesticides, PAHs, and trace elements at these two IADN master stations. Dioxins and mercury are not routinely monitored.

This strategy will therefore add dioxins and furans (vapor and particulate) and mercury (speciated vapor, particulate, and in precipitation) to the existing IADN sites. Utilizing these sites will facilitate reductions of costs for site set up. The USEPA, as part of their National Dioxin Air Monitoring Network (NDAMN), may be able to fund analytical costs for dioxins and furans monitoring if equipment purchases are covered by the state.

Agricultural Sites

Two agricultural sites will be selected to monitor for dioxins and furans. These sites will be important for providing information on deposition to agricultural areas. The primary exposure route for dioxins is believed to come from the food chain due to atmospheric deposition to animal feed crops, and subsequent uptake by livestock, poultry, etc. Coordination with other studies or researchers on evaluating biological specimens that would indicate deposition, including cow's milk, breast milk, and fish tissue concentrations will be considered.

Based on feed crops grown in Michigan (**Figures 2-4**)and number of beef and dairy cattle (**Figures 5-7**), the agricultural sites will be established along the south central area of Michigan and in the "thumb" region of the state (**33,34**).

Figure 2: Corn For Grain

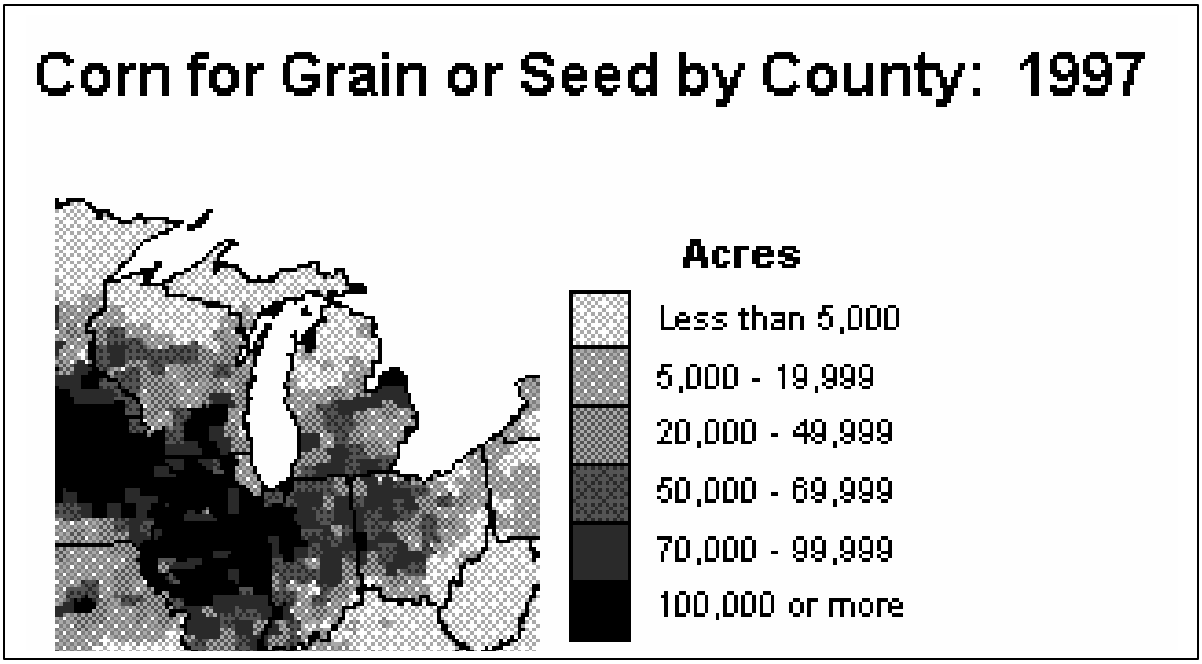


Figure 3: Wheat For Grain

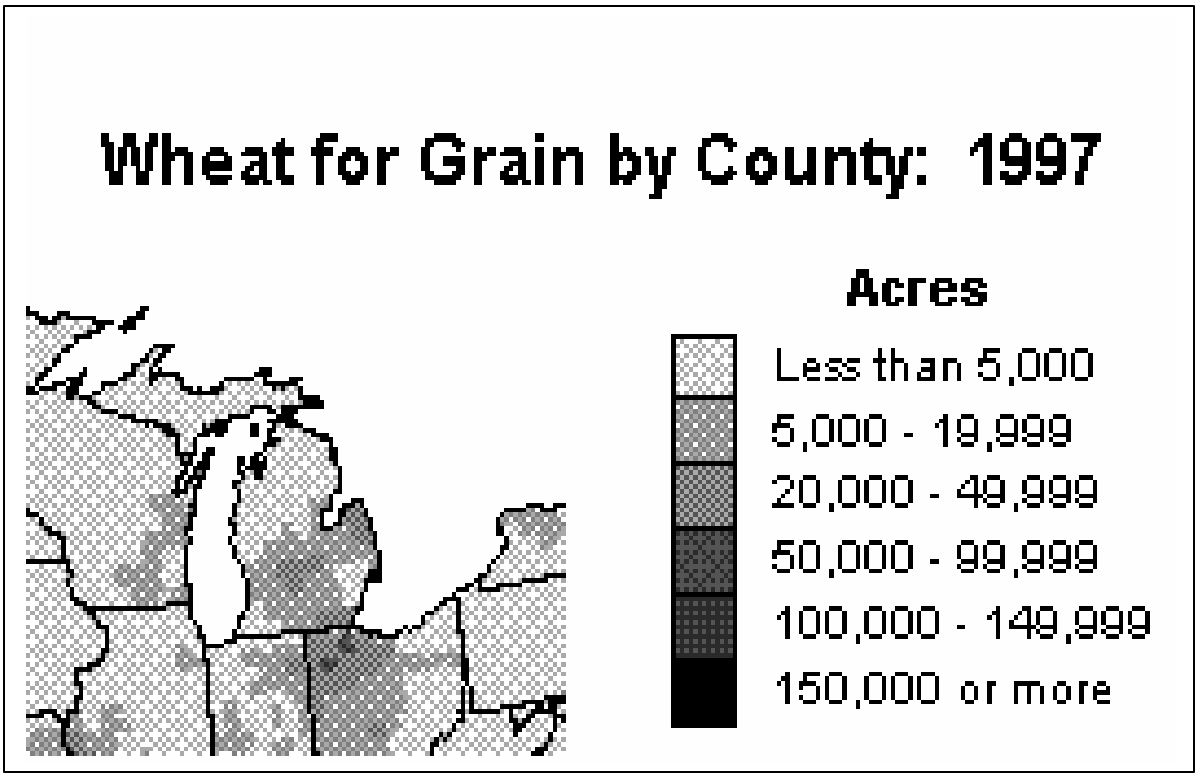


Figure 4: Alfalfa Hay

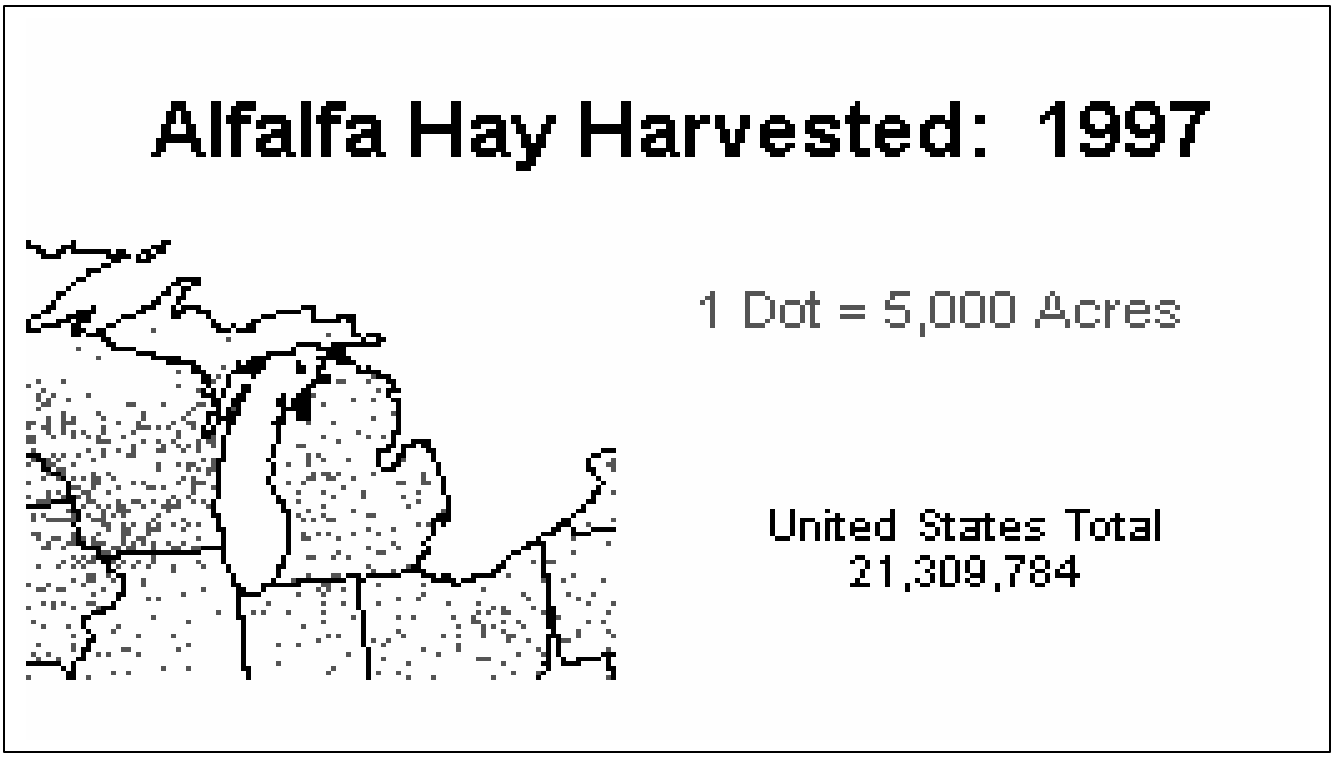


Figure 5: Dairy Cattle in Michigan

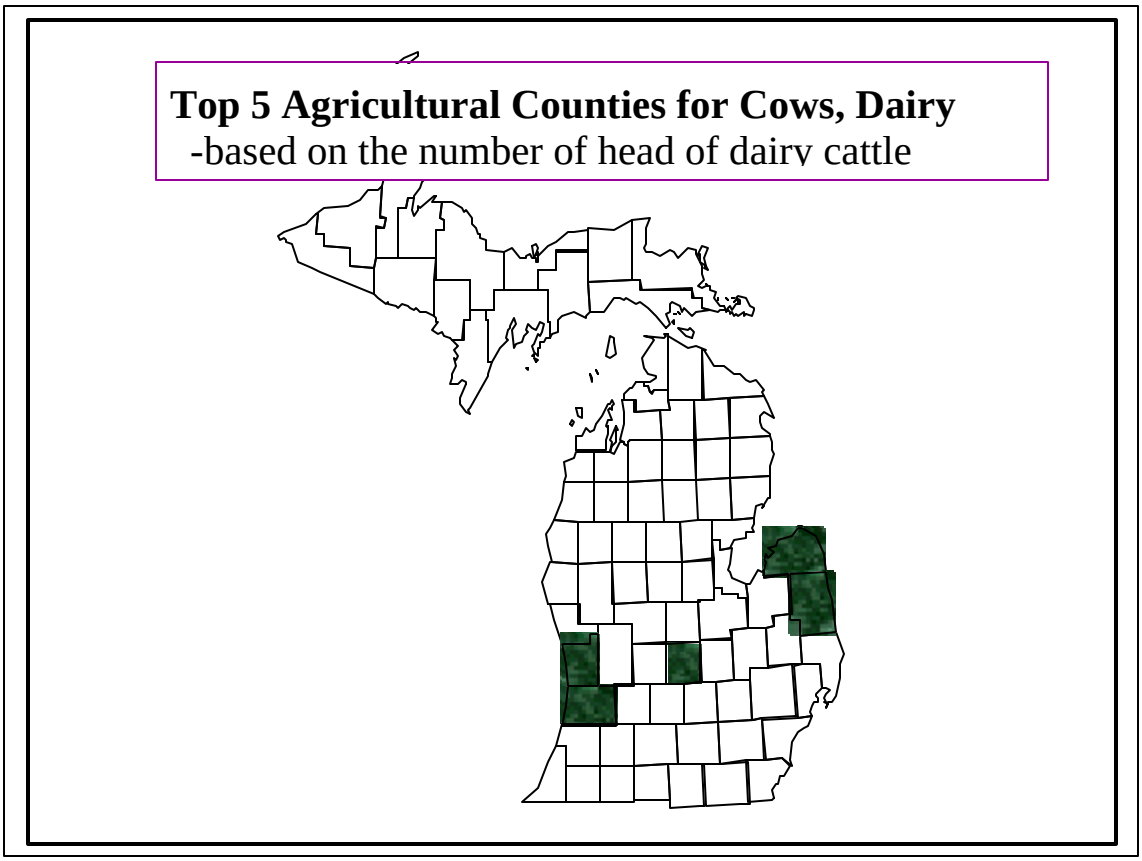


Figure 6: Beef Cattle in Michigan

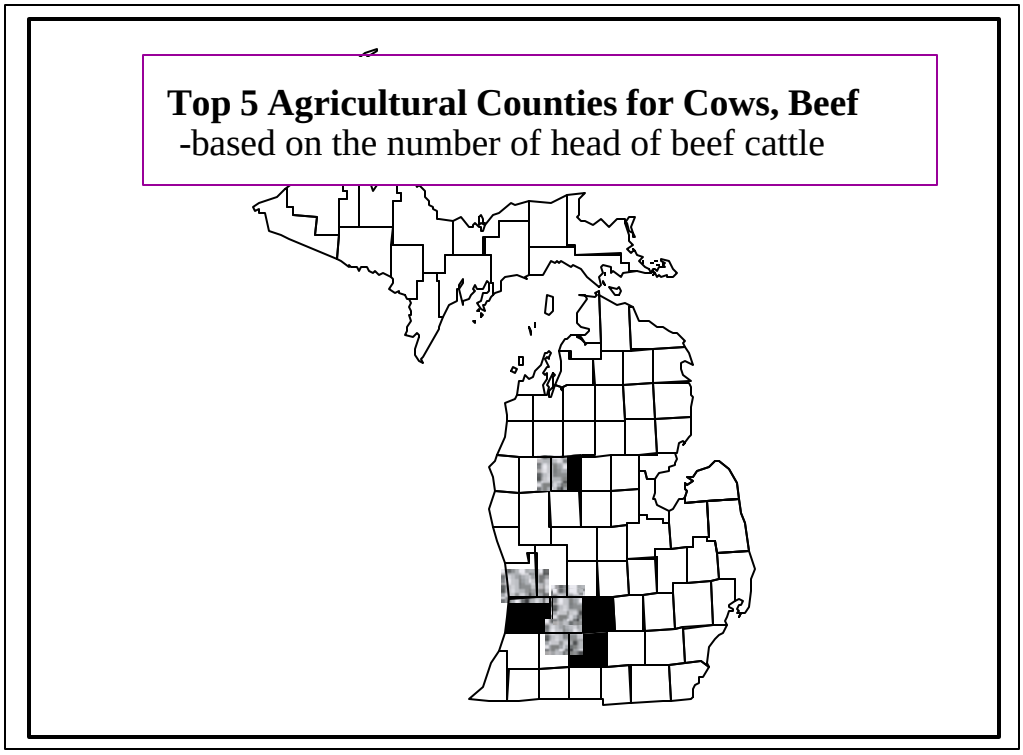
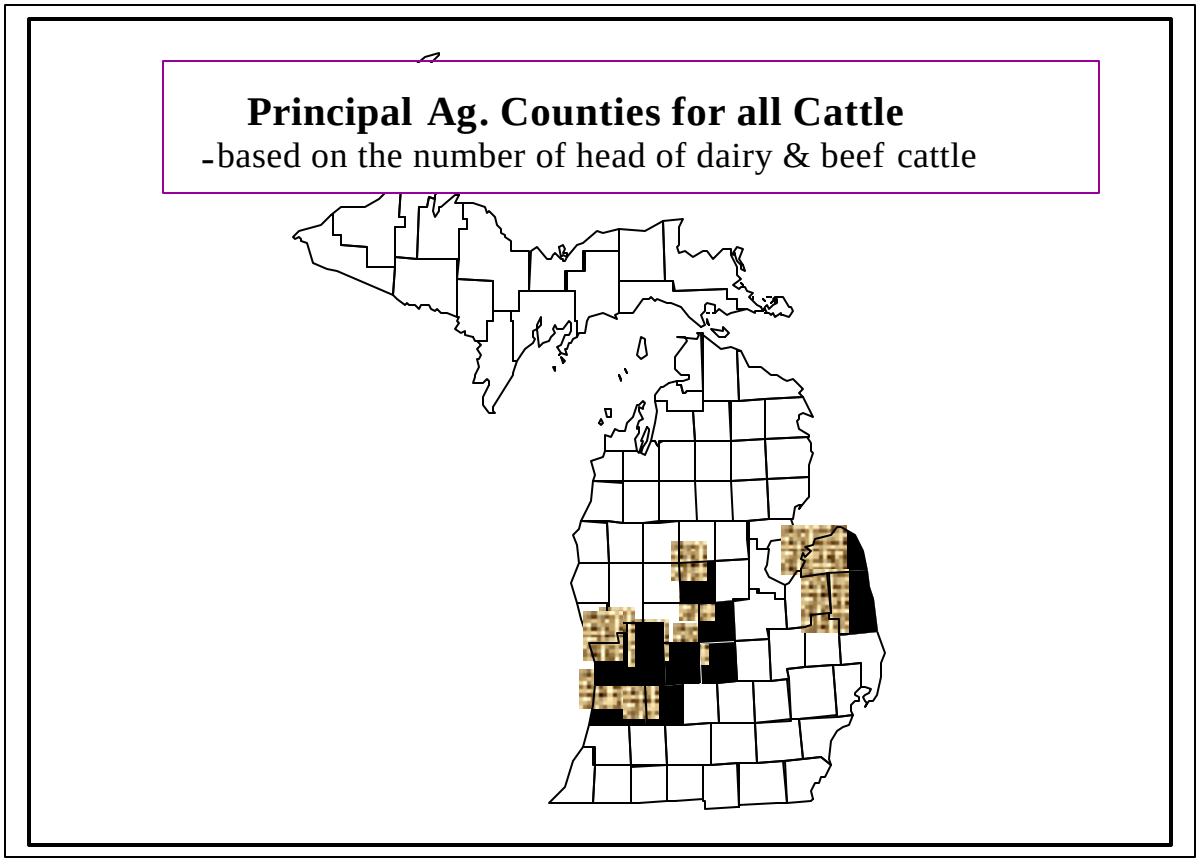


Figure 7: Total Cattle in Michigan



C. Additional Monitoring Considerations for the Atmospheric Deposition Network

1) Criteria for Site Selection

Monitoring locations will be selected to comply with established site guidelines which provide specifications about the set back requirements for distances from major roads, stationary sources, inlet heights, etc. The sampling inlets for the various types of monitors will be from three to fifteen meters above ground level. The probe should be more than one meter vertically or horizontally away from any supporting structure. All inlets should be 20 meters or more from the drip lines of trees. The distance between any obstacle and the probe is at least twice the height that the obstacle protrudes above the sampler. There should be at least 270 degrees of unrestricted air flow that includes the predominant and second most frequent dominant wind direction. If any monitors are located on a roof top, they should be two or more meters away from walls, parapets, penthouses, etc.

Collocating ambient, atmospheric deposition, criteria pollutant monitors as well as meteorological instruments will be implemented whenever possible. Collocating these instruments will save on resources and add value to the data that is collected.

2) Methods

Sampling

The air sampling instrumentation, sample handling protocols, analytical methods, laboratory techniques, and quality assurance protocols will all follow conventional procedures. Sampling handling will follow the AQD Standard Operating Procedures specific to each method (**35**). Chain of custody will be followed during all phases of sample collection and data generation.

For PCBs and dioxins/furans air sampling instrumentation will be commonly available equipment that includes Anderson Polyurethane Foam PS-1 Samplers (PUF), MIC-B automatic precipitation collectors, and HI Vol samplers. Dioxins/furans will not be collected in precipitation.

For mercury, automated continuous mercury analyzers, manufactured by Tekran, Inc. and MIC-B automatic precipitation collectors with teflon-coated funnels and teflon-covered pad/funnel covers adapted specifically for mercury collection will be employed.

Analysis

The analytical methods and laboratory techniques used by the laboratory to analyze samples generated by deposition network will adhere to standard methods set forth by the USEPA. Dioxins, and furans will be collected using polyurethane foam samplers and analyzed using the appropriate chromatographic method (**36**). A Hi Vol sampler with a glass fiber filter with XAD-2 resin or a PUF sampler will be used

for PCBs. Analysis will include isomer specific analysis for PCBs as well as dioxins and furans. The USEPA approved methods will be used for mercury sample collection and analysis (**37**). Efforts are underway by the University of Michigan researchers to evaluate the automated samplers against IO-5 EPA methods. The information from this study will be evaluated and considered when it becomes available.

The laboratory analysis of the dioxins, furans, PCBs, and mercury will be subcontracted. Good laboratory practices or good automated laboratory practices will be used to insure the generation of high quality data (**38**).

3) Sampling Frequency and Duration

For dioxins and furans, the sampling schedule used by the NDAMN will be followed to maximize data comparability with the national network that is designed to avoid non-detectable quantities (**39**). Over a 28-day period, sampling is conducted on 24 days. Each week, six days of continuous operation is followed by one day of inactivity which allows removal of the quartz fiber filter on the PS-1 PUF sampler. For each completed sampling event, the four quartz fiber filters will be composited and analyzed for particulate levels of dioxins and furans. The PUF will be collected once at the end of the sampling moment. This sampling plan allows for the collection of 13 particulate and vapor phase samples at each site per year. Dioxins/furans will not be collected in precipitation.

PCBs samples will be collected by sampling particulate and vapor phases for 24-hours, once every 12 days. The contribution of wet deposition to overall loading will be determined by the collection of monthly composite samples of precipitation events with a MIC-B collector.

To measure levels of vapor phase mercury, the Tekran units will provide continuous measurements of elemental mercury and RGM. Precipitation sampling will be event based, with 100 samples per year reflecting an annual estimate of the number of samples per site. This assumption was necessary to create the budget in **Section 6**. Finally, particulate levels of mercury will be assessed by collecting aerosol samples once every six days.

A target of 75 percent data capture per quarter and overall 75 percent data capture per year reflected the sample collection efficiency for the network.

6. BUDGET FOR ATMOSPHERIC DEPOSITION NETWORK

The overall total atmospheric deposition budget is summarized in **Table 4**. There are a few assumptions that impact the budget estimates. None of the atmospheric deposition sites are assumed to be co-located at the locations that will be used to assess ambient levels. It is assumed that dioxin, PCB's, and mercury will be measured at a single site according to **Table 2**. For the purposes of estimating this budget, the use of subcontractors was maximized for sample collection and analysis. The use of subcontractors will be re-evaluated upon implementation of this strategy.

Although deploying and operating a monitoring network of this nature will rely heavily on the use of subcontracted labor, it will be necessary to retain some functions within the AQD to insure the continued collection of high quality data. The AQD staff are needed to setup, audit, and oversee the network as well as keep the instrumentation in good repair to assure the collection of complete data. Data validation, review, interpretation, analysis, and report generation are other functions essential to retain within the AQD and these costs have been included in the budget. If additional staff as budgeted is not provided, dramatic shifts in priorities within the AQD will be necessary to deploy and operate the air toxics monitoring network proposed in this strategy.

TABLE 4: Budget Summary - Atmospheric Deposition

3% inflation rate assumed

Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
New Sites Established	4	1	3	1	0	0
Total Sites Operational	8	8	9	7	4	4
Total Instrumentation/year	$1,030,420	$225,457	$228,486	$48,069	$0	$0
Total Operational & Laboratory Analysis	$621,185	$725,082	$889,540	$888,354	$804,431	$816,130
Personnel	$319,500	$365,650	$527,267	$620,669	$639,289	$658,468
Annual Total	**$1,971,105**	**$1,316,189**	**$1,645,293**	**$1,557,092**	**$1,443,720**	**$1,474,597**

Description	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
New Sites Established	0	0	0	0	0	0
Total Sites Operational	7	4	4	7	4	4
Total Instrumentation/year	$0	$0	$0	$0	$0	$0
Total Operational & Laboratory Analysis	$843,810	$865,418	$891,177	$921,108	$945,035	$973,182
Personnel	$678,222	$698,568	$719,525	$741,111	$763,345	$786,245
Annual Total	**$1,522,031**	**$1,563,986**	**$1,610,702**	**$1,662,219**	**$1,708,380**	**$1,759,427**

Description	Year 13	Year 14	Year 15
New Sites Established	0	0	0
Total Sites Operational	7	4	4
Total Instrumentation/year	$0	$0	$0
Total Operational & Laboratory Analysis	$1,005,574	$1,032,035	$1,062,792
Personnel	$809,832	$834,127	$859,151
Annual Total	**$1,815,406**	**$1,866,162**	**$1,921,943**

Table 5 provides the detailed costs associated with the atmospheric deposition portion of the strategy. The budget assumes a staggered deployment and a sequential approach to monitoring. The budget is divided into two portions, one addresses the organic compounds and the other is for the determination of mercury.

Table 3 summarizes the parameters that will be measured at each site and the deployment plan. This table emphasizes the more intensive monitoring efforts every three years to coordinate with the USEPA's planned emission inventory and modeling being done under the NATA program.

For dixoins and furans, composite samples will be collected following NDAMN procedures discussed in **Section 5**. This results in 13 particulate and vapor samples per year. The budget assumes particulate and vapor are extracted together providing one sample.

For PCBs, there are four sites (two background sites are already being funded by USEPA) and for dioxin and furan there are nine sites. The budget assumes sampling for PCBs occurs on a once every 12 day schedule. Precipitation events are also composited to form monthly samples for PCBs.

For the mercury portion of the network, 12 sites are included in the budget. Aerosol mercury samples will be collected every six days and the collection of precipitation samples will be event-based with the budget assuming 100 precipitation events per year. The monitoring costs for the mercury sites include the purchase of a speciated Tekran unit at $80,000, a sequential precipitation sampler at $23,000, and an aerosol sequential sampler at $20,000. Sample analysis for each particulate and precipitation sample is $225 and includes the cost of bottle preparation and trace element analysis.

The sites monitoring organic pollutants will be equipped with a PUF or a Hi Vol sampler for PCBs containing a glass fiber filter and XAD-2 resin ($2,300/eachand a precipitation monitor (MIC-B) ($15,000 each). Analysis costs are estimated to be $500/sample for PCBs which includes analysis for the coplanar PCBs. The costs for the equipment for dioxin and furan monitoring is $2,500 for the PS-1 PUF. Analytical costs are estimated to be $1,400 per sample.

Table 5: Budget Estimates to Implement Atmospheric Deposition Monitoring Network

3% inflation rate assumed

Site setup costs are rolled into Dioxin numbers. If Dioxin sites are eliminated, site setup costs must be added back in.

"Dioxin" includes PCDD's and PCDF's

Parameter	Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Instrum. & Site	**Instrumentation & One Time Purchase Costs**								
set up	Site Set up/site	$4,500	$4,635	$4,774	$4,917	$5,065	$5,217	$5,373	$5,534
	Trailers	$12,000	$12,360	$12,731	$13,113	$13,506	$13,911	$14,329	$14,758
	Met. Equip., Data Loggers, Strip Chart recorders	$10,000	$10,300	$10,609	$10,927	$11,255	$11,593	$11,941	$12,299
organic	Instrumentation- PUF $2,490 each, 3% inflation	$2,490	$2,565	$2,642	$2,721	$2,803	$2,887	$2,973	$3,062
organic	Wet Dep. Instru. MICB, $15,000	$15,000	$15,450	$15,914	$16,391	$16,883	$17,389	$17,911	$18,448
Hg	Auto. Seq.Precip.Samplers, $23,000 3% inflation	$23,000	$23,690	$24,401	$25,133	$25,887	$26,663	$27,463	$28,287
Hg	Aerosol Sampler $20,000 3% inflation	$20,000	$20,600	$21,218	$21,855	$22,510	$23,185	$23,881	$24,597
Hg	Tekrans Vapor, Elemental & Gaseous $80,000	$80,000	$82,400	$84,872	$87,418	$90,041	$92,742	$95,524	$98,390
Dioxin	Number of New Sites	4	1	1	1	0	0	0	0
Dioxin	Total Dioxin Sites Operational	6	6	7	7	0	0	7	0
Dioxin Cost	Total Site Setup & instrumentation	$213,430	$27,295	$46,669	$28,957	$0	$0	$0	$0
Dioxin Sampling Costs	Sample Costs- Dioxin Total (no FTEs)	$285,000	$293,550	$356,781	$367,484	$378,509	$389,864	$401,560	$413,607
TOTAL DIOXIN		**$498,430**	**$320,845**	**$403,450**	**$396,441**	**$378,509**	**$389,864**	**$401,560**	**$413,607**
PCBs	Number of New Sites (Not Dioxin)-need setup	0	0	0	0	0	0	0	0
PCBs	Total PCB Sites Operational	1	2	3	4	0	0	4	0
PCB Costs	Total Site Setup & instrumentation	$17,490	$33,465	$21,197	$19,112	$0	$0	$0	$0
PCB Sampling Costs	Sample Costs- PCB Total (no FTEs)	$28,875	$59,483	$92,457	$126,784	$130,587	$134,505	$138,540	$142,696
TOTAL PCB		**$46,365**	**$92,947**	**$113,654**	**$145,895**	**$130,587**	**$134,505**	**$138,540**	**$142,696**
Hg	Number of New Sites (Not Dioxin)-need setup	0	0	2	0	0	0	0	0
Hg	Total Hg Sites Operational	5	6	7	6	4	4	6	4
Hg Cost	Total Site Setup & instrumentation	$799,500	$164,697	$160,620	$0	$0	$0	$0	$0
Hg Sampling Costs	Sample Costs- Hg Total (no FTEs)	$263,250	$325,223	$390,676	$345,029	$248,512	$243,737	$251,049	$258,581
TOTAL Hg		**$1,062,750**	**$489,920**	**$551,297**	**$345,029**	**$248,512**	**$243,737**	**$251,049**	**$258,581**
General Operational	Travel, avg 350mi/site Audit, 3% inc/yr	$560	$577	$594	$612	$630	$649	$669	$689
General Operational	Shop Support, parts, 3% inc/yr $35,000	$35,000	$36,050	$37,132	$38,245	$39,393	$40,575	$41,792	$43,046
General Operational	Power, $100/mo site, 3% inc/yr	$6,000	$7,200	$8,400	$7,200	$4,800	$4,800	$7,200	$4,800
General Operational	Shipping, National Contr. $500/site	$2,500	$3,000	$3,500	$3,000	$2,000	$2,000	$3,000	$2,000
General Operational	Personnel	$319,500	$365,650	$527,267	$620,669	$639,289	$658,468	$678,222	$698,568
Total General & Personnel		$363,560	$412,477	$576,893	$669,726	$686,112	$706,491	$730,882	$749,103
ANNUAL TOTAL ATM DEP.		**$1,971,105**	**$1,316,189**	**$1,645,293**	**$1,557,092**	**$1,443,720**	**$1,474,597**	**$1,522,031**	**$1,563,986**

Table 5: Budget Estimates to Implement Atmospheric Deposition Monitoring Network (Continued)

3% inflation rate assumed

"Dioxin" includes PCDD's and PCDF's

Parameter	Description	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Instrum. & Site	**Instrumentation & One Time Purchase Costs**							
set up	Site Set up/site	$5,700	$5,871	$6,048	$6,229	$6,416	$6,608	$6,807
	Trailers	$15,201	$15,657	$16,127	$16,611	$17,109	$17,622	$18,151
	Met. Equip., Data Loggers, Strip Chart recorders	$12,668	$13,048	$13,439	$13,842	$14,258	$14,685	$15,126
organic	Instrumentation- PUF $2,490 each, 3% inflation	$3,154	$3,249	$3,346	$3,447	$3,550	$3,657	$3,766
organic	Wet Dep. Instru. MICB, $15,000	$19,002	$19,572	$20,159	$20,764	$21,386	$22,028	$22,689
Hg	Auto. Seq.Precip.Samplers, $23,000 3% inflation	$29,136	$30,010	$30,910	$31,837	$32,793	$33,776	$34,790
Hg	Aerosol Sampler $20,000 3% inflation	$25,335	$26,095	$26,878	$27,685	$28,515	$29,371	$30,252
Hg	Tekrans Vapor, Elemental & Gaseous $80,000	$101,342	$104,382	$107,513	$110,739	$114,061	$117,483	$121,007
Dioxin	Number of New Sites	0	0	0	0	0	0	0
Dioxin	Total Dioxin Sites Operational	0	7	1	1	7	1	1
Dioxin Cost	Total Site Setup & instrumentation	$0	$0	$0	$0	$0	$0	$0
Dioxin Sampling Costs	Sample Costs- Dioxin Total (no FTEs)	$426,015	$438,795	$451,959	$465,518	$479,483	$493,868	$508,684
TOTAL DIOXIN		**$426,015**	**$438,795**	**$451,959**	**$465,518**	**$479,483**	**$493,868**	**$508,684**
PCBs	Number of New Sites (Not Dioxin)-need setup	0	0	0	0	0	0	0
PCBs	Total PCB Sites Operational	0	4	0	0	4	0	0
PCB Costs	Total Site Setup & instrumentation	$0	$0	$0	$0	$0	$0	$0
PCB Sampling Costs	Sample Costs- PCB Total (no FTEs)	$146,977	$151,386	$155,928	$160,606	$165,424	$170,387	$175,498
TOTAL PCB		**$146,977**	**$151,386**	**$155,928**	**$160,606**	**$165,424**	**$170,387**	**$175,498**
Hg	Number of New Sites (Not Dioxin)-need setup	0	0	0	0	0	0	0
Hg	Total Hg Sites Operational	4	6	4	4	6	4	4
Hg Cost	Total Site Setup & instrumentation	$0	$0	$0	$0	$0	$0	$0
Hg Sampling Costs	Sample Costs- Hg Total (no FTEs)	$266,338	$274,329	$282,558	$291,035	$299,766	$308,759	$318,022
TOTAL Hg		**$266,338**	**$274,329**	**$282,558**	**$291,035**	**$299,766**	**$308,759**	**$318,022**
General Operational	Travel, avg 350mi/site Audit, 3% inc/yr	$709	$731	$753	$775	$798	$822	$847
General Operational	Shop Support, parts, 3% inc/yr $35,000	$44,337	$45,667	$47,037	$48,448	$49,902	$51,399	$52,941
General Operational	Power, $100/mo site, 3% inc/yr	$4,800	$7,200	$4,800	$4,800	$7,200	$4,800	$4,800
General Operational	Shipping, National Contr. $500/site	$2,000	$3,000	$2,000	$2,000	$3,000	$2,000	$2,000
General Operational	Personnel	$719,525	$741,111	$763,345	$786,245	$809,832	$834,127	$859,151
Total General & Personnel		$771,372	$797,709	$817,934	$842,268	$870,732	$893,148	$919,739
ANNUAL TOTAL ATM DEP.		**$1,610,702**	**$1,662,219**	**$1,708,380**	**$1,759,427**	**$1,815,406**	**$1,866,162**	**$1,921,943**

7. ATMOSPHERIC DEPOSITION NETWORK REVIEW

Section 58.20 of the Code of Federal Regulations (CFR), Title 40, Part 58 requires the states to review the criteria air monitoring networks on an annual basis to determine (**40**).

- How well the network is achieving its monitoring objectives.
- How well it is meeting the data user's needs.
- How it should be modified, including closure of some sites, relocation of other sites or establishing new sites.

Although the CFR doesn't require a review of monitoring networks that measure compounds other than the priority pollutants, it is a valuable tool that can be used to improve the atmospheric deposition networks and to ensure that the data generated by the network are adequate, representative, and meet the monitoring objectives. The magnitude of reviewing an atmospheric deposition network that will be generating such a large database will be substantially greater than reviewing the criteria network. Therefore, the network and all data collected by it will be reviewed on only a biannual basis.

Some of the topics addressed by the review, in no particular order, shall include:

- Adequacy of the network design to evaluate the accuracy of CEP/NATA results
- Frequency of monitoring
- Monitoring locations
- Suitability of physical siting criteria (includes terrain changes such as building construction and tree growth) and representativeness of location
- Previous data generated by the site (relative frequency of non detected levels), purpose of the site and possible relocation
- Feasibility and review of monitoring technology and possible updates
- Assess site by site data completeness and address any data capture deficiencies
- Identify any deficiencies of the network (insufficient number of samples or sites) and determine corrective action
- Population changes and projected growth; changes in economic activity
- Adequacy of list of compounds measured, assess new compounds/methods, deletion of some compounds/methods

Assessment of the adequacy of the network will be conducted by staff and reviewed by management.

8. QUALITY CONTROL AND QUALITY ASSURANCE

The monitors will be audited by MDEQ staff once per quarter to insure proper flow rates, etc. Annual maintenance will be performed on all monitors and their sampling lines will be checked for contamination. Blank sample media will be analyzed at the lab, accounting for 10 percent of the annual sample load to determine trip and field contamination. If funding is obtained to implement this strategy, a quality assurance plan will be prepared which will describe quality control and quality assurance in more detail. Additionally, the appropriate agencies will be contacted on assistance with technical systems audits.

9. DATA ANALYSIS AND INTERPRETATION

Data analysis is an essential portion of this strategy and critical to the successful implementation of an atmospheric deposition monitoring program. Adequate resources must be available to promote proper data management and reporting, as well as statistical quality assurance procedures. A detailed report providing data analysis and interpretation will be prepared every two years, due to the volume of data generated by the proposed network. A briefer report will be prepared on alternate years. The purpose of the report is to supply information to the stakeholders, staff, and citizens by providing trends in the concentrations of PBTs and drawing conclusions about environmental quality.

Some of the topics that may be addressed in the bi-annual report include:

- Measured changes in PBTs.
- Simple descriptive statistics such as peak concentrations, seasonal, annual, and multi-year averages.
- Air quality differences between background, urban, and agricultural sites
- Gradients across larger communities with more than one monitor.
- Relationship between emissions and air quality. Does the data track changes in emissions and efficacy of improvements in control technology?
- Graphics such as time series, fingerprint, scatter, box, and regression plots as well as pollution roses.
- Long-term trends, seasonal fluctuations, day of the week variability in PBT concentrations.
- Qualitatively assess long term air quality trends with regulatory programs.
- Assess atmospheric deposition of PBTs.

The costs associated with data analysis and report generation are included in budget estimates provided in the preceding section and detailed in **Appendix B**.

10. FUTURE PLANS

The primary goal of this strategy is to serve as the initial phase to further develop Michigan's monitoring network. Risk assessment as well as modeling, including trajectory analysis, source apportionment, and receptor modeling are logical ultimate uses of the data that would become available after implementation of the plans outlined in this strategy. Detailed discussions of modeling and risk assessment techniques are beyond the scope of this document. Detailed descriptions for risk assessment procedures and modeling studies will be described in future documents once additional funding is secured.

Modeling experts both on the AQD staff and in outside agencies will be consulted about network design considerations. This strategy is considered to be the first phase in the implementation of the expanded air toxics program. The strategy will be updated after the results from the Detroit Pilot Project become available, approximately by December 2003.

11. COORDINATION WITH OTHER LOCAL, STATE, REGIONAL, AND NATIONAL EFFORTS ADDRESSING LEVELS OF TOXIC AIR CONTAMINANTS

There are several initiatives that have been implemented to obtain better information on ambient levels of PBTs and assessing deposition. Efforts will be made to coordinate efforts and share data to ensure data comparability. At the federal level, these efforts include the Integrated Atmospheric Deposition Network, the Mercury Research Strategy, the National Dioxin Atmospheric Monitoring Network and the Mercury Deposition Network. Coordination with also occur through the regional mercury monitoring workgroup and information will be shared with other states. This document will briefly review these projects then describe their interrelationships.

A. Integrated Atmospheric Deposition Network (IADN)

The IADN is an international monitoring network for the Great Lakes Basin that has been established to improve our understanding of atmospheric deposition of PBTs to the Great Lakes (also described in **Section 2.A.** of this document). The development of the IADN was first recommended in Annex 15 of the 1987 GLWQA. Development of the network was also required in Section 112(m) of the CAAA in 1990. Operation began in 1990, with five "master" monitoring stations located on the shores of each of the Great Lakes. The sites established for Lake Superior and Lake Michigan are located in Michigan and are at Eagle Harbor and Sleeping Bear Dunes, respectively. The PBTs that are collected and analyzed include trace metals including lead, arsenic and cadmium, PCBs, PAHs, and pesticides including lindane, dieldrin, endosulfan, and DDT. The IADN data will be utilized as background sites for comparison of PBT concentrations in urban areas. If mercury and dioxin monitoring is to be added to these IADN sites, coordination with USEPA-Great Lakes National Program Office that manages the sites located in the U.S. is essential. Additional information on the IADN can be found at the USEPA web site: http://www.epa.gov/glnpo/monitoring/air/iadn/iadn.html.

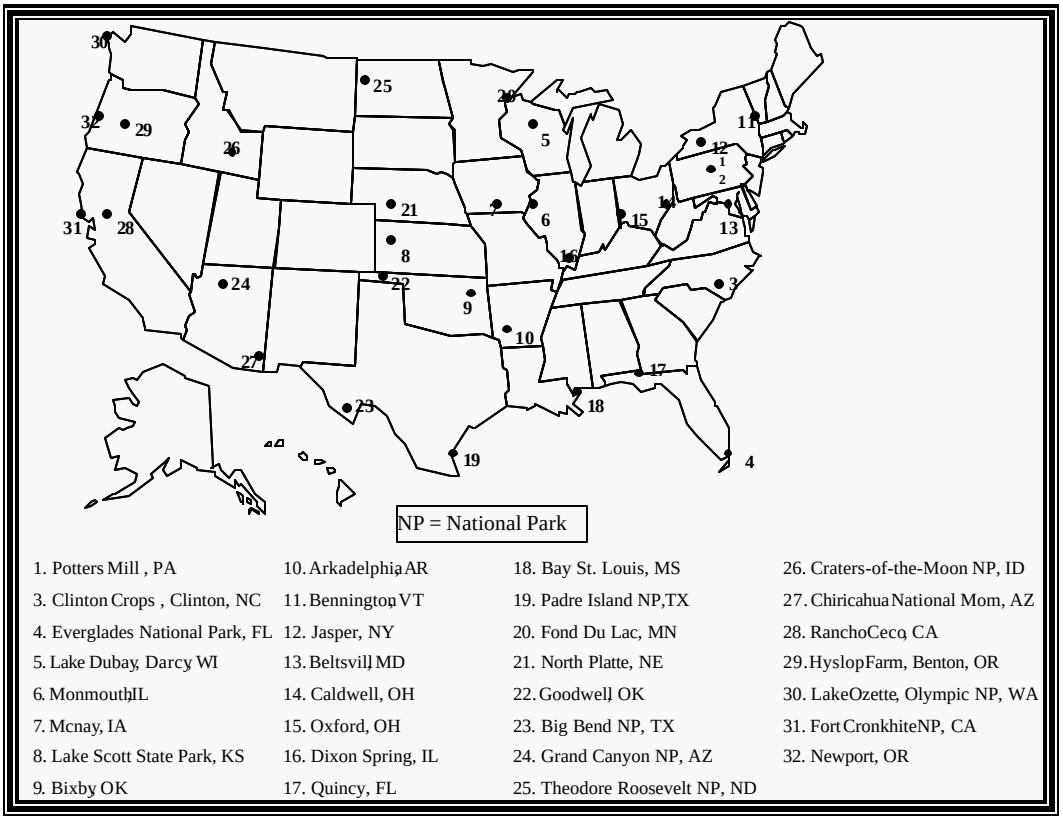
B. Mercury Research Strategy

Efforts will also be coordinated with the Mercury Research Strategy developed by USEPA's Office of Research Development. This Strategy uses the 1997 Mercury Study Report to Congress (**41**) as a technical foundation to address specific scientific questions raised in the Report. One of the recommendations in this Strategy is, "enhanced monitoring of atmospheric mercury deposition for model application." USEPA-National Exposure Research Laboratory has begun the development of a coordinated mercury monitoring program. Comprehensive deposition monitoring stations in highly sensitive geographic regions such as south Florida, the Northeast, the upper Midwest, and the Arctic will be established. Specialized platforms to sample all forms of mercury for assessing deposition and source attribution will be established. The site in Florida and the Arctic has already been set up and is operating (**42**). For additional information regarding this Strategy visit the USEPA web site:
http://www.epa.gov/ORD/NRMRL/mercury/600R00073%20front.pdf

C. National Dioxin Atmospheric Monitoring Network (NDAMN)

Efforts will also be coordinated with NDAMN. NDAMN was established by USEPA's National Center for Environmental Assessment-Office of Research Development. Its purpose is to provide measurements of background atmospheric levels of dioxin-like compounds across the U.S. including agricultural areas where animal feed crops are grown, and to provide data to evaluate results from long-range transport and deposition air models (**43**). To date, 29 sites have been established in the U.S., although no sites have yet been established in Michigan (**Figure 8**, Courtesy of Dave Cleverly, USEPA).

FIGURE 8: NDAMN Sites Established in the U.S.



The protocol established for NDAMN will be followed for the sites that are deployed in Michigan. Because USEPA is interested in obtaining wide spatial coverage in the U.S., there is a potential for resource sharing with USEPA if Michigan sites are established sites.

D. Mercury Deposition Network

The Mercury Deposition Network is part of the National Atmospheric Deposition Network which is a national precipitation network and is a cooperative effort with a variety of organization including the State Agricultural Experiment Stations, the U.S. Geological Survey, the U.S. Department of Agriculture, and numerous other governmental agencies. The Mercury Deposition Network began in 1995 and is a national mercury deposition network that consists of collection and analysis of weekly precipitation samples at 54 sites across the

nation and Canada (see **Figure 9**); the website is: http://nadp.sws.uiuc.edu/networks.html#mdn.

While there are currently no Mercury Deposition Network sites in Michigan, the USEPA plans to establish a site at the Sleeping Bear Dunes IADN site. This national network provides geographic spatial variability of wet deposition of mercury.

FIGURE 9

E. Regional Mercury Monitoring Workgroup

The USEPA has recently formed a Regional Mercury Monitoring Workgroup for the eight Great Lakes states to facilitate the sharing of mercury monitoring information and data. A meeting was held on January 18, 2001, at the USEPA offices in Chicago that brought in atmospheric mercury scientists to present the state-of-the-art knowledge on mercury monitoring equipment and methods to provide states and USEPA an overview of mercury research and monitoring efforts in the nation. Correspondence will continue with USEPA and the Great Lakes' states through this workgroup.

F. State Monitoring Efforts

Many other states such as Minnesota, Wisconsin, Connecticut, etc. monitor for mercury and/or dioxins. An effort will be made to share data for comparisons with these various states.

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APPENDICES

PART 1: Ambient Monitoring Network

APPENDIX A: Past and Current Air Toxic Monitoring Projects in Michigan

A1. MITAMP

The Michigan Toxic Air Monitoring Program (MITAMP) was established in January 1990. Since the program's inception, 40 toxic organic compounds and 13 trace metals have been monitored at various urban locations throughout the state. Carbonyl sampling (aldehydes and ketones) under the MITAMP began in June 1995[1]. To collect MITAMP data, the AQD operates additional monitors using sampling techniques that are specifically designed for pollutants of interest. High-volume sampler filters are used to collect toxic metals. Samplers using polyurethane foam (PUF) retain PAH's, PCB's etc., and evacuated canisters are used to sample for VOC's. Due to budgetary limitations, a "snapshot" approach was taken by alternating the sites that were operational during various years. The table below summarizes the sites and years each was in operation. Houghton Lake, which became operational in 1997, is located to assess background levels of air toxics.

Summary of MITAMP Monitoring Sites

O=measurements made for the Detroit Pilot Project, 2001

Location	AIRS ID	Years Operated															Carbonyls & VOC's	Trace Metals as TSP	Dioxins & Furans	Trace Metals as PM-10	Semi-Volatiles
		87	88	89	90	91	92	93	94	95	96	97	98	99	00	01					
Flint, City Market, 420 E. Blvd Dr.	260490011		x	x	x	x												x			
Flint, Whaley Park	260490021									x	x	x	x	x	x	x		x			
Alma, 6522 N. Jerome	260570001						x	x									x				
Lansing, Holy Cross School, 1514 W Saginaw	260650013	x	x														x	x			
Lansing, Fire Station #1, 120 E. Shiawassee	260651001		x	x	x	x												x			
Kalamazoo, 418 W. Kalamazoo	260770002		x	x	x	x	x											x			
Portage, Bishop Rd.	260770004				x	x	x	x									x	x			
Kalamazoo, Fairgrounds, 2500 Lake St	260770008																				
Grand Rapids, College & Cherry	260810010		x	x	x	x			x	x	x	x	x					x			
Grand Rapids, 1276 Randolph (Sprint)	260810021									x	x	x	x	x	x	x	x				
Wyoming, 521 28th Street	260812002		x	x	x	x			x	x	x	x	x					x			
Menominee	261090002							x										x			
Midland, 1100 Washington	261110007	x	x	x	x	x	x										x	x			x
Houghton Lake	261130001												x	x	x	x	x	x			
Muskegon, Marquette School, 480 Bennett	261210023		x	x	x	x			x	x	x	x						x			
Saginaw, Second Nat'l Bank, M-13 at M-81	261450002		x	x	x	x												x			
Pt. Huron, Nat'l Guard Armory, 2525 Dove Rd	261470005	x	x	x	x	x											x	x			
Deckerville	261510002						x	x	x											x	
Lawton, 880 2nd Street	261590004																				
Ann Arbor, 425 E. Washington	261610002		x	x	x	x												x			
Dexter	261618001						x	x	x											x	
Dearborn, Salina Jr. High School, 2623 Salina	261630002	x	x														x	x			
River Rouge, 315 S. Genesee	261630005							x	x	x	x	x	x	x	x	x	x	x			O
Detroit, Evergreen	261630014						x	x										x			
Detroit, 6921 W. Fort	261630015				x	x	x	x	x	x	x	x	x	x	x	x	x	x			O
Detroit, I-94 Service Dr. at Grande	261630032																				
Detroit, Linwood	261630016			x	x	x	x	x	x	x	x	x	x	x	x	x		x			
Detroit, E 7 Mile	261630019			x	x	x	x	x	x	x	x	x	x	x	x	x		x			O
Wayne Co: Kettering HS	261630030	x															x				
Wayne Co:Weston Trailer	261630032	x	x														x	x			x
Dearborn	261630033				x	x	x	x	x	x	x	x	x	x	x	x	O	x			O

A2.Kalamazoo Area Air Toxics Monitoring Project

Beginning in 1993, monitoring at five sites in and around Kalamazoo was performed to measure VOCs, carbonyls, and trace metals. The sites were located at the Kalamazoo Fairgrounds (260770905), East Shore Drive (260770903), Bishop Road East Site (260770902), Bishop

[1] *Annual Air Quality Report*, 1999. Michigan Department of Environmental Quality, Air Quality Division, P.O. Box 30260, Lansing, MI 48909.

Road North Site (260770901), and at Second Street in Lawton (261590901) as the upwind location. In 1996, all sites were shut down except Bishop Road North Site and the East Shore Drive site, which are still operational as of October 2000. The Aerometric Information Retrieval System (AIRS) IDs were modified to show the change in operator; the sites were taken over by MDEQ.

Summary of Monitoring for Toxic Air Contaminants in Kalamazoo

Location	AIRS ID	Years Operated															VOC's	Trace Metals as TSP	Dioxins & Furans	Trace Metals as PM-10	Semi-Volatiles
		87	88	89	90	91	92	93	94	95	96	97	98	99	00	01					
Kalamazoo, 418 W. Kalamazoo	260770002		x	x	x	x	x											x			
Portage, Bishop Rd.	260770004				x	x	x	x									x	x			
Kalamazoo, Fairgrounds, 2500 Lake St	**260770008**																				
Kalamazoo, North Site, Bishop Rd.	260770901					x	x	x	x	x	x	x	x	x			x				
Kalamazoo, East Site, Bishop Rd	260770902					x	x	x	x	x	x						x				
Kalamazoo, East Shore Dr.	260770903					x	x	x	x	x	x	x	x	x			x				
Kalamazoo, Fairgrounds, 2500 Lake St.	260770905					x	x	x	x	x	x						x	x		x	
Lawton, 880 2nd Street	**261590004**																				
Lawton, Upjohn, 880 2nd Street	261590901					x	x	x	x	x	x						x	x		x	

A3.Midland Area Air Toxics Monitoring Project

Beginning in 1991 a special project monitoring air toxics began in Midland. The sites and parameters measured are shown below.

Summary of Monitoring for Toxic Air Contaminants in Midland

Location	AIRS ID	Years Operated															VOC's	Trace Metals as TSP	Dioxins & Furans	Trace Metals as PM-10	Semi-Volatiles
		87	88	89	90	91	92	93	94	95	96	97	98	99	00	01					
Midland, 1100 Washington	261110007	x	x	x	x	x	x										x	x			x
Midland, 2514 S. Saginaw	261110951					x	x	x	x	x	x	x	x	x			x	x			
Midland, 500 E. Lyon	261110952					x	x	x	x								x	x			
Midland, 3900 S. Saginaw	261110953					x	x	x	x	x	x	x	x	x			x	x			
Midland, 1780 E. Hubert Rd.	261110954					x	x	x	x	x	x	x	x	x			x	x			
Midland, Nature Center	261110955					x	x	x	x	x	x	x	x	x			x	x			
Midland, 2001 George St	261110956					x	x	x	x								x	x			
Midland, 4103 Bay City Rd.	261110957					x	x	x	x								x	x			
Midland (co-located site)	261110958					x	x	x	x	x	x	x	x	x			x	x			

A4.Alpena Area Air Toxics Monitoring Project

Beginning in 1997, monitoring for VOCs and PAHs was initiated in Alpena at three locations: Besser School (260070901), North Point LaFarge (260070903), and the Sunrise Center (260070905).

In 1995 and 1996, Dioxins and furans were also measured. The table below summarizes the monitoring that was conducted.

Summary of Monitoring for Toxic Air Contaminants in Alpena

Location	AIRS ID	Years Operated															VOC's	Trace Metals as TSP	Dioxins & Furans	Trace Metals as PM-10	Semi-Volatiles
		87	88	89	90	91	92	93	94	95	96	97	98	99	00	01					
Alpena, Besser School	260070901									x			x				x	x			x
Alpena, Lincoln School	260070902									x			x				x	x	x		x
Alpena, North Point	260070903									x			x				x	x			x
Alpena, Sunrise Center	260070905												x								

APPENDIX B: Ambient Air Monitoring Stations Currently Operated by the MDEQ

Monitor Distribution throughout Michigan's 2002 Network

NAMS monitors are coded as ■. = to be closed 1/1/03.

◈ SPM was closed 12/31/01.

Site Name	AIRS ID	CO	Lead Only	O_3	NO_2	NOy	PM_{10}	$PM_{2.5}$	SO_2	TSP	Metals (TSP), Inc. Lead	VOCs	Carbonyls	Meteor-ological para-meters	Building or Trailer
Holland	260050003			x		x		x						x	T
Alpena	260070005							x							T
Bay City	260170014		▪					x							
Benzonia	260190003			x										x	T
Coloma	260210014			x				x						x	T
Cassopolis	260270003			x				Operated by the State of Indiana							?
Rose Lake	260370001			■											B
Flint	260490021			■			x	x	x	x	x			x	T
Otisville	260492001			■										x	T
Traverse City	260550003							x							
Harbor Beach	260630007			x										x	T
Lansing	260650012			■	◈			x						x	T
Kalamazoo	260770008			x				x						x	T
Wealthy St, GR	260810007						x								
Monroe St. GR	260810020	x		■			x	x	x					x	T
Randolph St (Sprint), GR	260810021									x	x	x	x	x	T
Evans	260810022			■											T
Tecumseh	260910007			x										x	T
New Haven	260990009			x				x						x	T
Warren	260991003	x		■					■						T
Marquette	261030012				Operated by the State of Wisconsin									x	
Scottville	261050007			x										x	T
Houghton Lake	261130001			x						x	x	x	x	x	T
Luna Pier	261150005							x							

Monitor Distribution throughout Michigan's 2002 Network (Continued)

NAMS monitors are coded as ■.

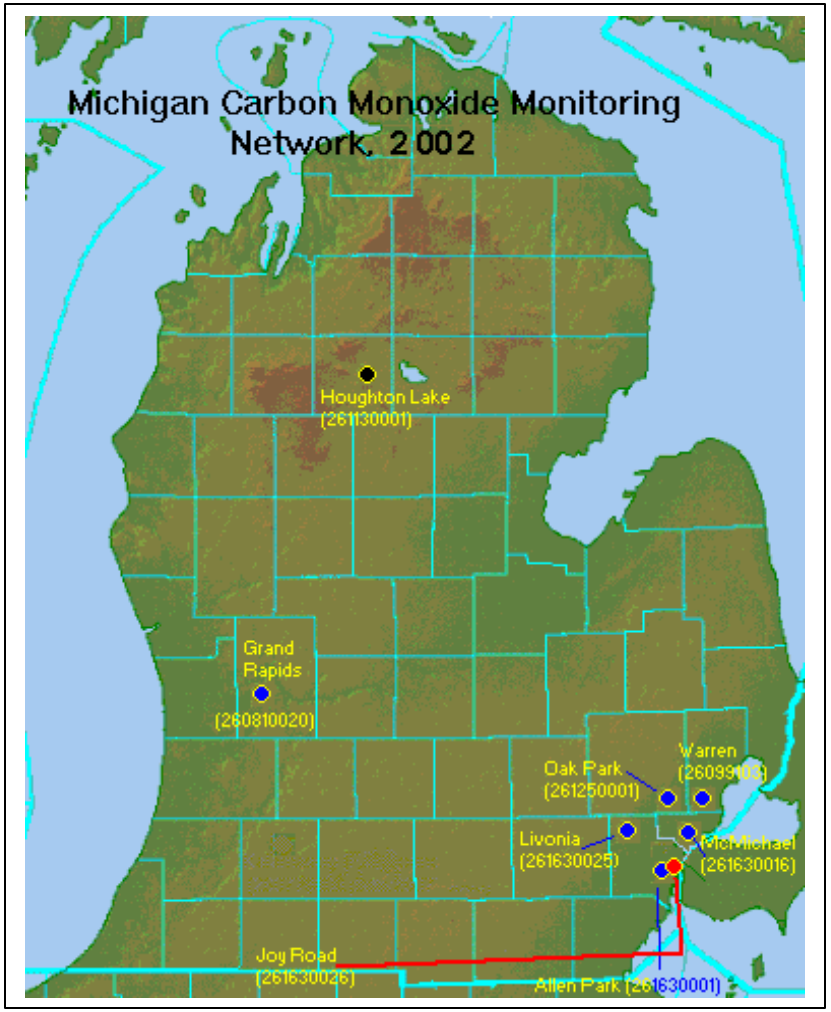
◈ SPM was closed 12/31/01.

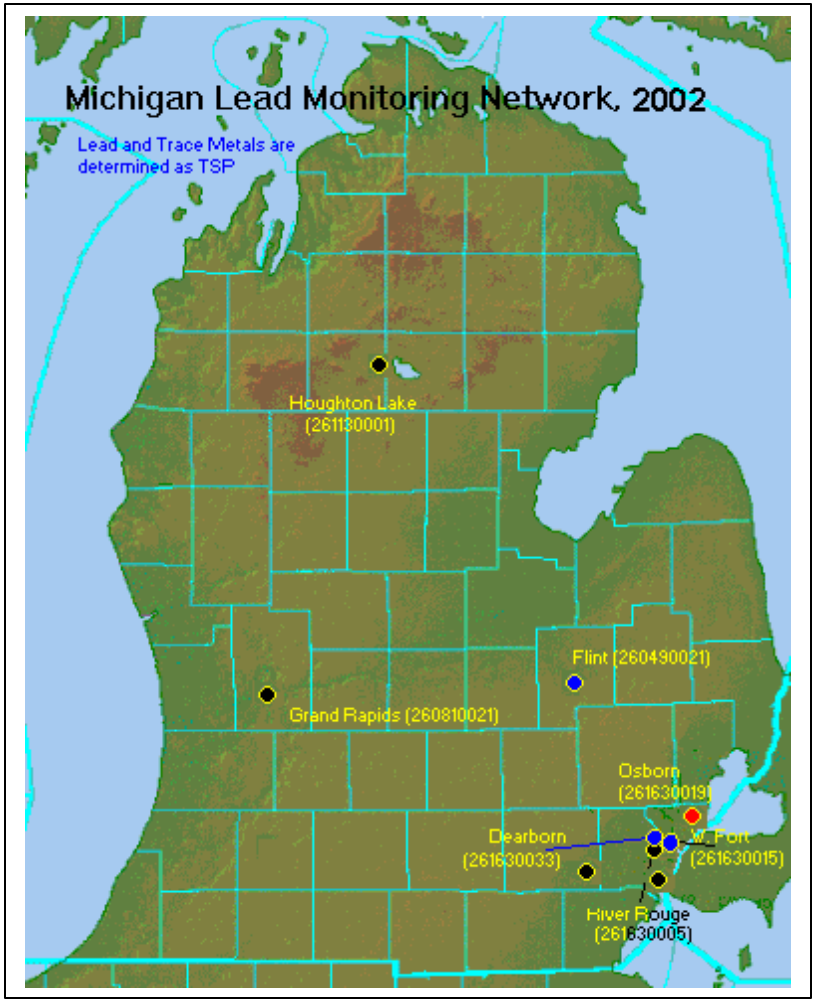
= to be closed 1/1/03.

Site Name	AIRS ID	CO	Lead Only	O_3	NO_2	NOy	PM_{10}	$PM_{2.5}$	SO_2	TSP	Metals (TSP), Inc. Lead	VOCs	Carbonyls	Meteor-ological para-meters	Building or Trailer
Muskegon, Green Ck Rd	261210039			x										x	T
Muskegon, Apple St	261210040							x							
Oak Park	261250001	x		■				x						x	T
Jenison	261390005			x				x						x	T
Saginaw	261450018							x							T
Port Huron	261470005			x				x	x					x	T
Ann Arbor (old U of M))	261610005							x							B
Ypsilanti	261610008			■				x				x			T
Allen Park	261630001	x	x	x			■	x							T
River Rouge	261630005						■			x	x	x	x		T
Fort St	261630015						■	x	■	x	x	x	x	x	T
Linwood	261630016	x	x	■	■			x	x						B
E. 7 Mile	261630019		■	x	■			x	■					x	T
Livonia	261630025	x					■	x							T
Dearborn	261630033		x				■	x				x			T
Wyandotte	261630036							x							

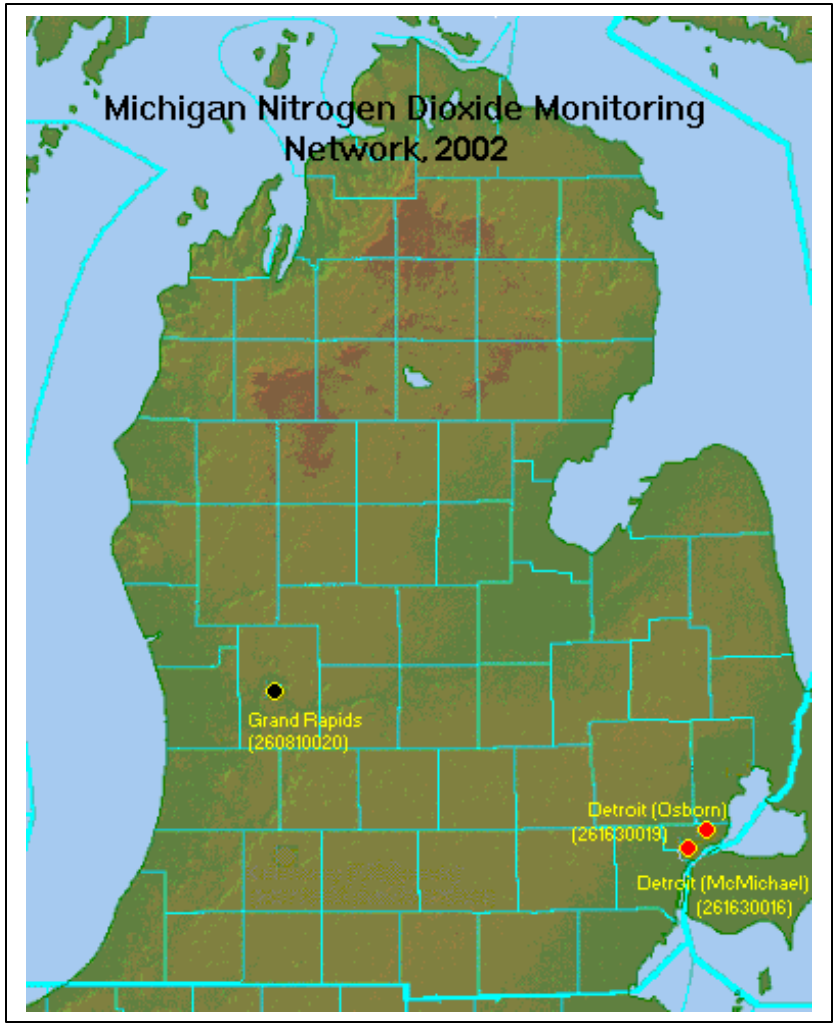
APPENDIX B (Continued): Ambient Air Monitoring Stations Currently Operated by the MDEQ

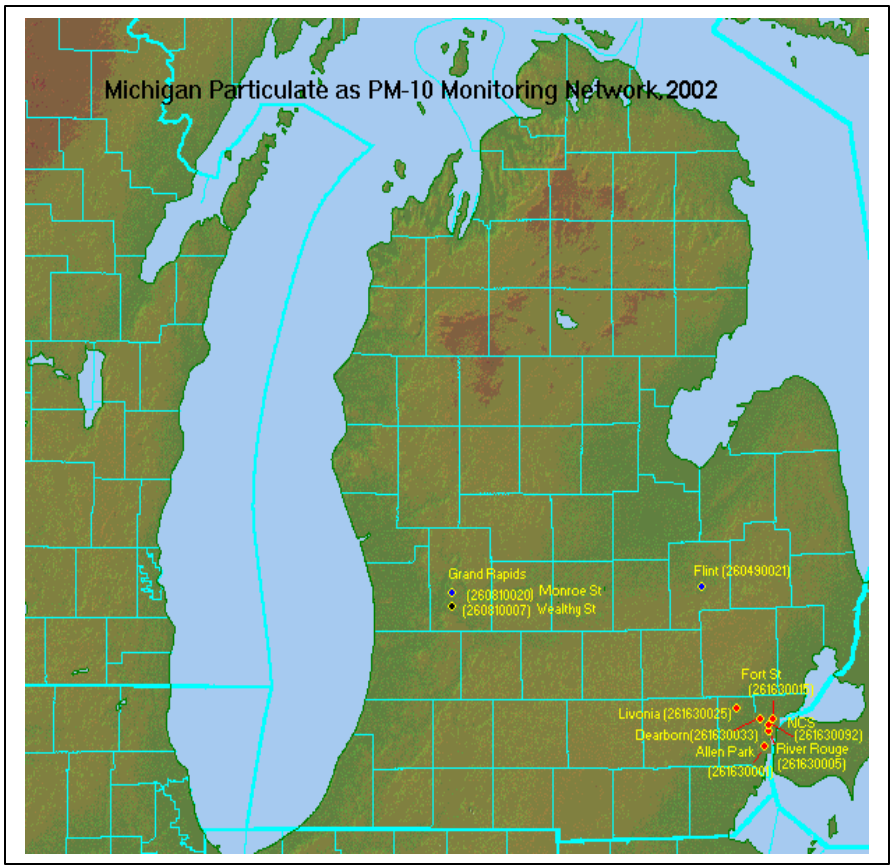
Most of the Federal monitoring requirements focus on population centers, which are located in Michigan's lower peninsula. Therefore, the following maps show only the lower peninsula to maximize legibility of the text. In the following maps, all NAMS stations are shown in red, SLAMS sites are blue and special purpose monitoring locations are black.

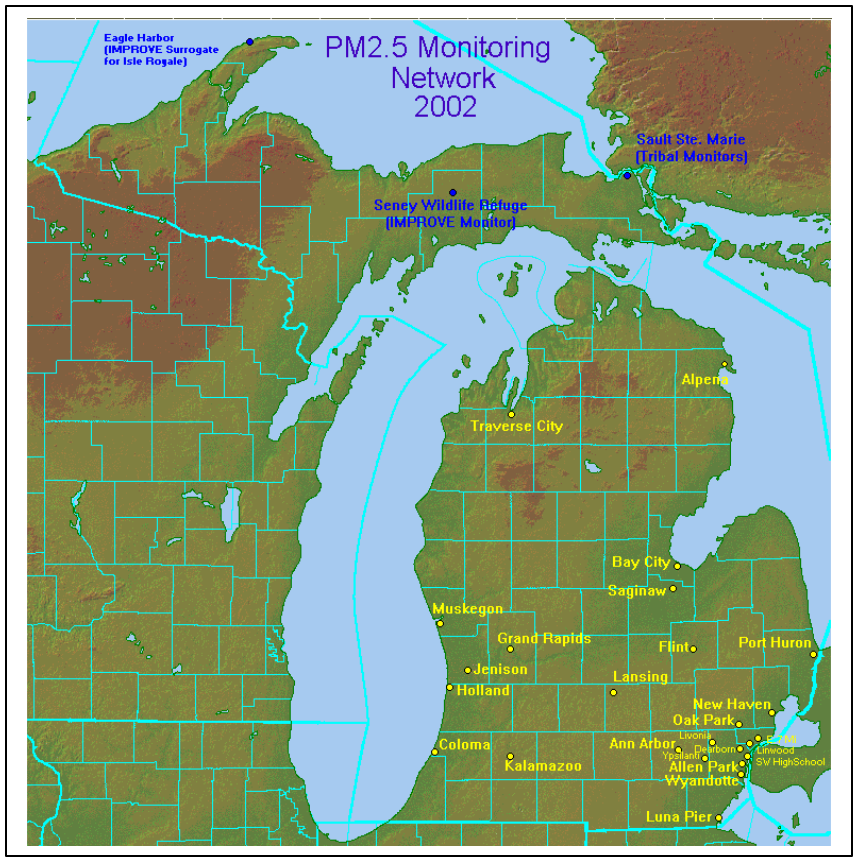


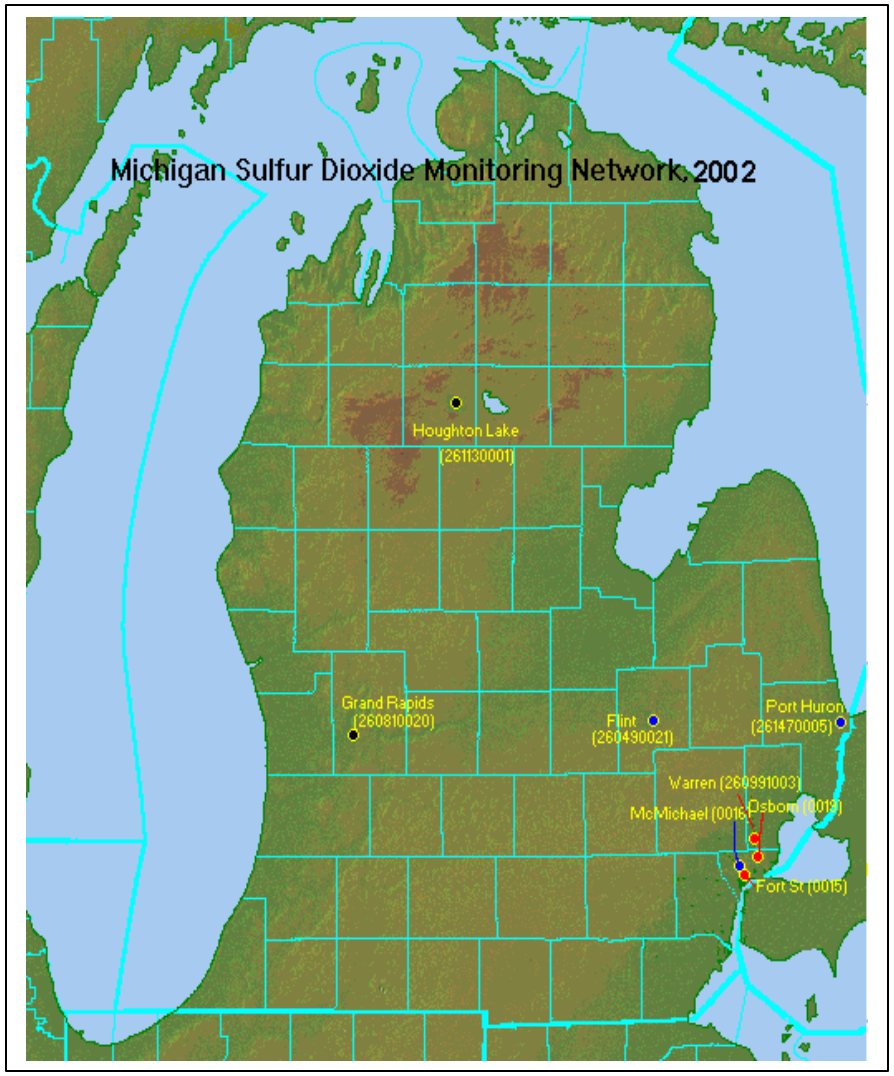


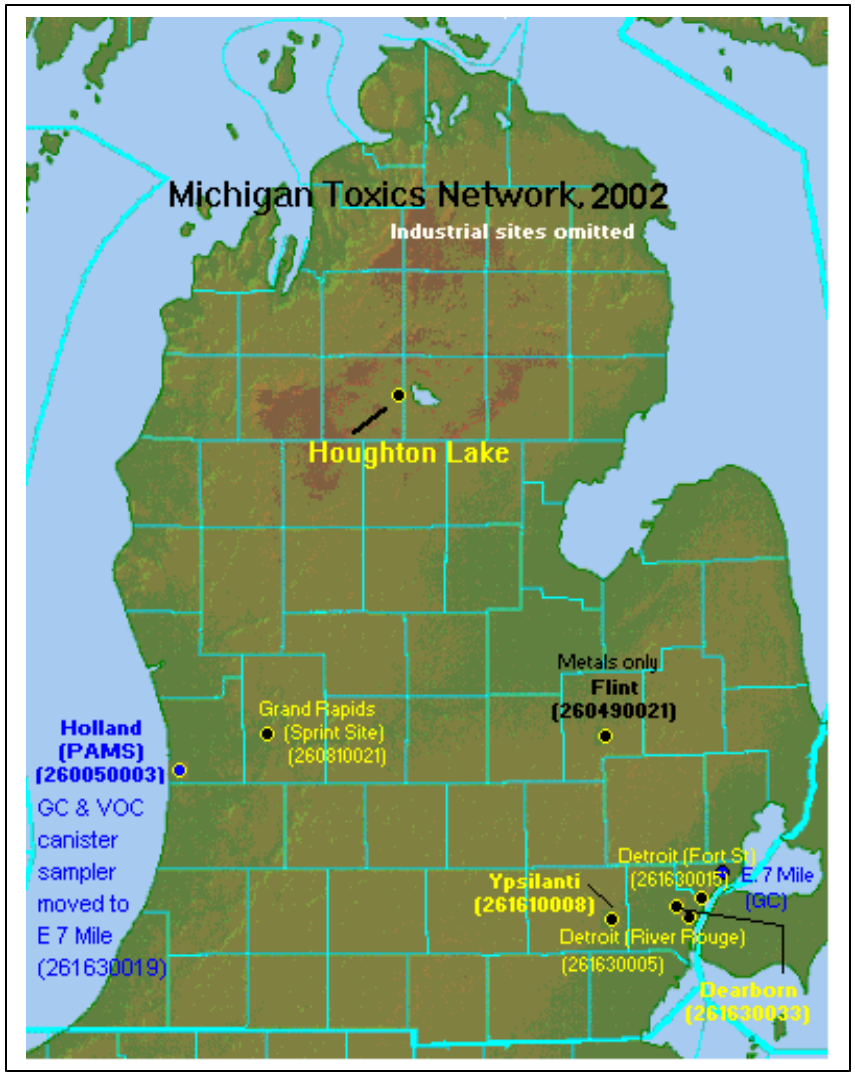
Michigan Ozone Monitoring Network, 2002
Frankfort
Houghton Lake
Scottville
Harbor Beach
Muskegon
Evans
Grand Rapids
Jenison
Holland
Otisville
Port Huron
Flint
Bath Twp (Rose Lake)
Lansing
New Haven
Warren
Oak Park
Osborn
McMichael
Ypsilanti
Allen Park
Coloma
Kalamazoo (Fairgrounds)
Tecumseh
Cassopolis


Michigan Nitrogen Dioxide Monitoring Network, 2002
Grand Rapids (260810020)
Detroit (Osborn) (261630019)
Detroit (McMichael) (261630016)


Michigan Particulate as PM-10 Monitoring Network,2002
Grand Rapids
(260810020) Monroe St
(260810007) Wealthy St
Flint (260490021)
Fort St
(261630001)
Livonia (261630025)
Dearborn(261630033)
Allen Park
(261630001)
NCS
(261630092)
River Rouge
(261630005)


PM2.5 Monitoring
Network
2002
Eagle Harbor
(IMPROVE Surrogate
for Isle Rosale)
Sault Ste. Marie
(Tribal Monitors)
Seney Wildlife Refuge
(IMPROVE Monitor)
Alpena
Traverse City
Bay City
Saginaw
Muskegon
Grand Rapids
Flint
Port Huron
Jenison
Lansing
Holland
New Haven
Oak Park
Coloma
Ann Arbor
Kalamazoo
Allen Park
Wyandotte
Luna Pier


Michigan Sulfur Dioxide Monitoring Network, 2002
Houghton Lake
(261130001)
Grand Rapids
(260810020)
Flint
(260490021)
Port Huron
(261470005)
Warren (260991003)
McMichael (0018)
Osborn (0019)
Fort St (0015)


Michigan Toxics Network, 2002
Industrial sites omitted
Houghton Lake
Metals only
Flint
(260490021)
Grand Rapids
(Sprint Site)
(260810021)
Holland
(PAMS)
(260050003)
GC & VOC
canister
sampler
moved to
E 7 Mile
(261630019)
Detroit (Fort St)
(261630015)
E. 7 Mile
(GC)
Ypsilanti
(261610008)
Detroit (River Rouge)
(261630005)
Dearborn
(261630033)

APPENDIX C: List of Compounds Determined Analytically by Various Methods

Although the Method Detection Limits (MDLs) vary over time, those below are provided as an example. These MDLs are the ones generated just prior to the Detroit Pilot Study, April 2001.

C1. VOCs Determined Using Method TO-15 by Eastern Research Group[1]

Parameter	MDL, ppbv	Parameter	MDL, ppbv
Acetylene	0.13	Carbon Tetrachloride	0.08
Propylene	0.05	Tert-Amyl Methyl Ether	0.12
Dichlorodifluoromethane	0.04	1,2-Dichloropropane	0.07
Chloromethane	0.06	Ethyl Acrylate	0.16
Dichlorotetrafluoroethane	0.05	Bromodichloromethane	0.06
Vinyl Chloride	0.06	Trichloroethylene	0.07
1,3-Butadiene	0.07	Methyl Methacrylate	0.18
Bromomethane	0.09	cis-1,3-Dichloropropene	0.10
Chloroethane	0.08	Methyl Isobutyl Ketone	0.15
Acetonitrile	0.25	trans-1,3-Dichloropropene	0.11
Acetone	0.26	1,1,2-Trichloroethane	0.06
Trichlorofluoromethane	0.04	Toluene	0.06
Acrylonitrile	0.21	Dibromochloromethane	0.08
1,1-Dichloroethene	0.10	1,2-Dibromoethane	0.08
Methylene Chloride	0.06	n-Octane	0.06
Trichlorotrifluoroethane	0.07	Tetrachloroethylene	0.06
trans-1,2-Dichloroethylene	0.06	Chlorobenzene	0.06
1,1-Dichloroethane	0.08	Ethylbenzene	0.04
Methyl Tert-Butyl Ether	0.18	m,p-Xylene	0.05
Methyl Ethyl Ketone	0.15	Bromoform	0.08
Chloroprene	0.10	Styrene	0.07
Cis-1,2-Dichloroethene	0.10	1,1,2,2-Tetrachloroethane	0.06
Bromochloromethane	0.12	o-Xylene	0.05
Chloroform	0.05	1,3,5-Trimethylbenzene	0.07
Ethyl Tert Butyl Ether	0.15	1,2,4-Trimethylbenzene	0.07
1,2-Dichloroethane	0.06	m-Dichlorobenzene	0.05
1,1,1-Trichloroethane	0.06	Chloromethylbenzene	0.07
Benzene	0.04	p-Dichlorobenzene	0.09
Hexachloro-1,3-Butadiene	0.06	o-Dichlorobenzene	0.06
1,2,4-Trichlorobenzene	0.06		

[1] Eastern Research Group. 1600 Perimeter Park, Morrisville NC 27560-8421. (919) 468-7800.

C2. Carbonyl Compounds Determined Using Method TO-11A by Eastern Research Group

Parameter	MDL, ppbv	Parameter	MDL, ppbv
Formaldehyde	0.0116	IsoValeraldehyde	0.0028
Acetaldehyde	0.0035	Valeraldehyde	0.0039
Acetone	0.0017	Hexanaldehyde	0.0020
Propionaldehyde	0.0033	2,5-Dimethylbenzaldehyde	0.0030
Crotonaldehyde	0.0037	Butra/iso butraldehyde	0.0078
Benzaldehyde	0.0023	Tolualdehydes	0.0065

C3. Trace Metals Determined Using Method 6010 by Eastern Research Group

Parameter	MDL, ug	Parameter	MDL, ug
Arsenic, As	1	Iron, Fe	8
Barium, Ba	8	Manganese, Mn	4
Beryllium, Be	0.1	Molybdenum, Mo	8
Cadmium, Cd	4	Nickel, Ni	4
Cobalt, Co	8	Lead, Pb	1
Chromium, Cr	2	Vanadium, V	8
Copper, Cu	5	Zinc, Zn	4

C4. Semi-Volatile Compounds Determined Using Method 8270 by Eastern Research Group

Parameter	MDL, ug
Acenaphthene	5.82
Acenaphthylene	8.87
Acetophenone	13.87
Aniline	16.2
Anthracene	17.06
4-aminobiphenyl	9.6
Benzidine	0
Benzoic Acid	12.31
benzo(a)anthracene	8.33
benzo(b)fluoranthene	17.34
benzo(k)fluoranthene	23.61
benzo(g,h,i)perylene	15.05
benzo(a)pyrene	18.17
benzyl alcohol	8.15
bis(2-chloroethoxy)methane	14.03
bis(2-chloroethyl)ether	11.66
bis(2-chloroisopropyl)ether	11.07
bis(2-ethylhexyl)phthalate	11.62
4-bromo phenyl phenyl ether	11.3
butyl benzyl phthalate	11.66
4-chloroaniline	16.83
1-chloronaphthalene	30.03
2-chloronaphthalene	18.48
4-chloro-3-methylphenol	16.8
2-chlorophenol	9.99
4-chlorophenyl phenyl ether	6.79
Chrysene	10.57
Dibenz(a,h) anthracene	15.85
Dibenzofuran	9.28
di-n-butyl phthalate	14.01
1,3-dichlorobenzene	12.05
1,4-dichlorobenzene	10.86
1,2-dichlorobenzene	10.96
3,3'-dichlorobenzidine	8.95
2,4-dichlorophenol	14.55
2,6-dichlorophenol	18.1
diethyl phthalate	7.2
p-dimethylaminoazo benzene	50
7-12-dimethylbenz(a)anthracene	19.04
a,a-dimethylphenethylamine	100
2,4-dimethyl phenol	17.64
dimethyl phthalate	9.15
4,6-dinitro-2-methyl phenol	11.31

Parameter	MDL, ug
3-nitroaniline	8.7
4-nitroaniline	10.4
nitrobenzene	24.86
2-nitrophenol	10.07
4-nitrophenol	7.36
N-nitroso-di-n-butyl amine	22.42
N-nitrosodiphenylamine	50
N-nitrosodipropylamine	21.48
N-nitrosopiperidine	17.32
pentachlorobenzene	9.74
pentachloronitro benzene	10.37
pentachlorophenol	14.74
phenanthrene	10.29
phenol	22.48
2-picoline	11.15
pyrene	10.54
1,2,4,5-tetrachlorobenzene	10.54
2-methyl phenol	9.44
4-methyl phenol	7.69
naphthalene	15.46
1-naphthylamine	5.42
2-naphthylamine	10.22
2-nitro aniline	12.3
2,3,4,6,-tetrachlorophenol	9.67
1,2,4-trichlorobenzene	13.62
2,4,5-trichlorophenol	6.9
2,4,6-trichlorophenol	8.35
diphenyl amine	25.39
1,2-diphenyl hydrazine	50
di-n-octyl phthalate	13.19
fluoranthene	14.49
fluorene	10.01
hexachlorobenzene	14.12
hexachlorobutadiene	13.23
hexachlorocyclopentadiene	21.74
hexachloroethane	5.65
indeno(1,2,3-cd) pyrene	14.56
isophorene	22.61
methyl methane sulfonate	16.5
2-methyl naphthalene	11.36
2,4-dinitro phenol	10.05
2,4-dinitro toluene	9.71
2,6-dinitro toluene	9.38

C5. VOCs Determined Using Method TO-15 by MDEQ

Parameter	MDL, ppbv
Freon-12	0.20
Chloromethane	0.20
Freon-114	0.25
1,3-Butadiene	NA
Vinyl Chloride	0.20
Bromomethane	0.20
Chloroethane	0.20
Acetonitrile	NA
Freon-11	0.25
Acrylonitrile	NA
1,1-Dichloroethene	0.20
Methylene Chloride	0.20
Freon-113	0.25
Trans-1,2-Dichloroethene	0.20
1,1-Dichloroethane	0.20
Methyl Tert-Butyl Ether	NA
Methyl Ethyl Ketone	NA
2-Chloro-1,3-Butadiene	NA
Cis-1,2-Dichloroethene	NA

Parameter	MDL, ppbv
Hexane	NA
Chloroform	0.20
1,2-Dichloroethane	0.20
1,1,1-Trichloroethane	0.20
Benzene	0.20
Carbontetrachloride	0.20
1,2-Dichloropropane	0.20
Bromodichloromethane	NA
Trichloroethene	0.20
2,2,4-Trimethylpentane	NA
cis-1,3-Dichloropropene	0.20
Methyl Isobutyl Ketone	NA
trans-1,3-Dichloropropene	0.20
1,1,2-Trichloroethane	0.20
Toluene	0.20
Dibromochloromethane	NA
1,2-Dibromoethane	0.20
Perchloroethene	0.20

C6. Carbonyls Determined Using Method TO-11A by MDEQ

Parameter	MDL, ppbv
Formaldehyde	0.0070
Acetaldehyde	0.0081
Acetone	0.0094
Acrolein	0.0187
Propionaldehyde	0.0722
Crotonaldehyde	0.0069
n-Butyraldehyde	0.0061

Parameter	MDL, ppbv
Benzaldehyde	0.0034
Isovaleraldehyde	0.0107
Valeraldehyde	0.0192
o-Tolualdehyde	0.0021
m,p-Tolualdehyde	0.0021
Hexanaldehyde	0.0044
2,5-Dimethylbenzaldehyde	0.0028

C7. Trace Metals Determined Using Method 6010 by MDEQ

Parameter	MDL, ng/m3
arsenic	0.016
beryllium	0.01
cadmium	0.024
chromium	0.014
lead	0.01

Parameter	MDL, ng/m3
manganese	0.01
nickel	0.01
antimony	
cobalt	
selenium	

APPENDIX D: Census Concepts & Calculation of Hazard Index

D1. Metropolitan Statistical Area (MSAs) - Background

Metropolitan areas are designated by the U.S. Office of Management and Budget. Conceptually, a metropolitan area is defined as "a core area containing a large population nucleus, together with adjacent communities having a high degree of economic and social integration with that core."[5] Areas that meet these definitions of a metropolitan area are based on the 1990 census.

The current standards provide that each MSA must include at least:

- One city with 50,000 or more inhabitants or
- A census bureau-defined urbanized area (of at least 50,000 inhabitants) and a total population of at least 100,000 (75,000 in New England).

"Under the standards the county (or counties) that contain the largest city becomes the central county (counties), along with any adjacent counties that have at least 50 percent of their population in the urbanized area surrounding the largest city. Additional "outlying counties" are included in the MSA if they meet specific requirements of commuting to the central counties or other selected requirements of metropolitan character (such as population density and percent urban)."

"An area that meets these requirements for recognition as an MSA and also has a population of one million or more may be recognized as a CMSA if:

- Separate component areas can be identified within the entire area by meeting statistical criteria specified in the standards.
- Local opinion indicates there is support for the component areas. If recognized, the component areas are designated as PMSAs and the entire area becomes a CMSA."

D2. CEP Index and County Rank

The CEP Index and County Rank were determined in the following manner:

At the census tract level, the ambient modeled concentration for each pollutant was determined from the USEPA CEP data. The ratio of this concentration to the ITSL or IRSL was determined for each pollutant. The ITSL and IRSL are health benchmark values used in the AQD's new source review permitting program. The ITSL represents a concentration of chemical in air that is protective for non-carcinogenic effects, and the IRSL represents a concentration that would result in an estimated increased cancer risk of one in one million (1 x 10-6). The above ratios are represented as follows:

CEP/ITSL
CEP/IRSL Where CEP represents the modeled ambient concentration of a pollutant in air.

[5] 1996 statistical abstract of the United States: 1996. February 1997 #1. Product Profile The National data book. US Census Bureau Appendix II

The individual ratios for each chemical were summed together to get a census tract total for the CEP/ITSL and CEP/IRSL. These summed ratios for each census tract within a county were then added together to determine a county total. The county total was then divided by the number of census tracts in the county to determine the county average sum of the ratios of CEP/ITSL and CEP/IRSL. These values represent the CEP $Index_{(ITSL)}$ and CEP $Index_{(IRSL)}$, respectively. The CEP Index values for each county in Michigan were then ranked from highest to lowest. There are 83 counties in Michigan. The highest CEP Index value was assigned a rank of 1, and the second highest received a rank of 2. The remaining counties were ranked in a similar fashion down to the county with the lowest CEP Index which received a rank of 83. **Table A1** provides these values for all the counties in Michigan.

TABLE D1: CEP Index and County Rank Values

COUNTY NAME	CEP $INDEX_{(IRSI)}$	COUNTY RANK- CEP $INDEX_{(IRSL)}$	CEP $INDEX_{(ITSL)}$	COUNTY RANK CEP $INDEX_{(ITSL)}$
ALCONA	41	79	2.9	23
ALGER	39	83	22.6	2
ALLEGAN	53	48	0.2	82
ALPENA	61	32	0.6	72
ANTRIM	47	60	0.4	79
ARENAC	45	68	1.2	56
BARAGA	40	80	2.1	37
BARRY	49	57	49.3	1
BAY	93	10	1.5	49
BENZIE	54	45	1.4	50
BERRIEN	75	19	1.3	54
BRANCH	63	30	1.3	52
CALHOUN	72	23	2.6	28
CASS	60	35	2.1	36
CHARLEVOIX	51	52	15.2	3
CHEBOYGAN	354	1	0.4	78
CHIPPEWA	54	46	2.3	32
CLARE	48	59	4.6	15
CLINTON	53	49	0.4	76
CRAWFORD	44	70	0.9	64
DELTA	65	27	0.8	66
DICKINSON	54	47	2.9	24
EATON	66	24	1.1	60
EMMET	56	42	2.2	35
GENESEE	106	6	1.3	55
GLADWIN	82	15	3.0	22
GOGEBIC	50	55	2.6	27
GRAND TRAVERSE	65	28	4.5	17
GRATIOT	60	34	0.8	69
HILLSDALE	51	50	1.1	59

TABLE D1: CEP Index and County Rank Values (Continued)

COUNTY NAME	CEP INDEX$_{(IRSL)}$	COUNTY RANK- CEP INDEX$_{(IRSL)}$	CEP INDEX$_{(ITSL)}$	COUNTY RANK CEP INDEX$_{(ITSL)}$
HOUGHTON	59	36	0.4	77
HURON	43	76	6.0	9
INGHAM	97	8	1.6	45
IONIA	61	33	5.3	11
IOSCO	47	62	5.4	10
IRON	42	77	0.4	74
ISABELLA	66	26	7.0	7
JACKSON	93	11	3.4	20
KALAMAZOO	95	9	7.2	6
KALKASKA	55	44	2.7	26
KENT	77	16	2.3	31
KEWEENAW	47	61	1.9	40
LAKE	43	75	3.4	19
LAPEER	56	43	4.5	16
LEELANAU	45	65	0.2	83
LENAWEE	56	41	0.8	65
LIVINGSTON	58	38	4.6	14
LUCE	40	81	5.2	12
MACKINAC	45	67	0.7	71
MACOMB	142	4	1.5	48
MANISTEE	51	51	2.2	34
MARQUETTE	87	12	2.0	39
MASON	62	31	1.3	53
MECOSTA	58	39	7.5	5
MENOMINEE	59	37	2.5	29
MIDLAND	235	2	0.3	81
MISSAUKEE	46	64	6.1	8
MONROE	75	20	2.0	38
MONTCALM	50	54	1.5	47
MONTMORENCY	41	78	1.8	42
MUSKEGON	76	17	1.0	63
NEWAYGO	50	53	1.4	51
OAKLAND	114	5	1.7	43
OCEANA	102	7	0.3	80
OGEMAW	45	66	0.4	75
ONTONAGON	39	82	2.3	33
OSCEOLA	44	72	3.6	18
OSCODA	43	74	2.8	25
OTSEGO	48	58	1.6	46
OTTAWA	75	18	0.7	70
PRESQUE ISLE	44	69	0.5	73
ROSCOMMON	47	63	11.5	4

TABLE D1: CEP Index and County Rank Values (Continued)

A high rank has a high CEP index. The highest rank value is 83.

COUNTY NAME	CEP INDEX$_{(IRSL)}$	COUNTY RANK- CEP INDEX$_{(IRSL)}$	CEP INDEX$_{(ITSL)}$	COUNTY RANK CEP INDEX$_{(ITSL)}$
SAGINAW	86	13	3.2	21
SAINT CLAIR	73	22	1.1	58
SAINT JOSEPH	64	9	1.9	41
SANILAC	43	73	0.8	68
SCHOOLCRAFT	44	71	1.2	57
SHIAWASSEE	66	24	4.8	13
TUSCOLA	49	56	1.0	62
VAN BUREN	56	40	0.8	67
WASHTENAW	82	14	1.0	61
WAYNE	183	3	2.3	30
WEXFORD	74	21	1.6	44

Appendix E: Budget Details: Ambient Air Toxics Network

3% inflation rate assumed.	SPM=Special Purpose Monitor					SPM Rotation	SPM Rotation	SPM Rotation	SPM Rotation	SPM Rotation	SPM Rotation	SPM Rotation	SPM Rotation	SPM Rotation	SPM Rotation
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**
New Sites Established	7	7	7	7	7	5	5	5	5	5	5	5	5	5	5
Total Sites Operational	7	14	21	28	35	35	35	35	35	35	35	35	35	35	35
Instrumentation& 1 Time Purchase Costs															
Instrumentation/site (VOC,Carb,TSP	$10,500	$13,650	$17,745	$23,069	$29,989	0	0	0	0	0	0	0	0	0	0
Site Set up/site	$4,500	$4,770	$5,056	$5,360	$5,681	$6,022	$6,383	$6,766	$7,172	$7,603	$8,059	$8,542	$9,055	$9,598	$10,174
Trailers	$12,000	$12,360	$12,731	$13,113	$13,506										
Met. Equip., Data Loggers, Strip Cha	$10,000	$10,300	$10,609	$10,927	$11,255	$11,593	$11,941	$12,299	$12,668	$13,048	$13,439	$13,842	$14,258	$14,685	$15,126
Total/site	$259,000	$287,560	$322,987	$367,276	$423,020	$88,074	$91,619	$95,325	$99,200	$103,252	$107,490	$111,923	$116,562	$121,418	$126,500
Co-Located Instrumentation 20%	$10,500	$27,300	$70,980	$115,343	$209,923	0	0	0	0	0	0	0	0	0	0
Spare Instrumentation 10%	$10,500	$13,650	$35,490	$69,206	$89,967	0	0	0	0	0	0	0	0	0	0
hexavalent Cr Instrument./site	$3,000	$3,090	$3,183	$3,278	$3,377	$3,478	$3,582	$3,690	$3,800	$3,914	$4,032	$4,153	$4,277	$4,406	$4,538
hexavalent Cr Instrument. All sites	$21,000	$21,630	$22,279	$22,947	$23,636	$17,389	$17,911	$18,448	$19,002	$19,572	$20,159	$20,764	$21,386	$22,028	$22,689
Hexa Cr Co-loc Instru. 20%	$4,200	$8,652	$13,367	$18,358	$23,636	$24,345	$25,075	$25,827	$26,602	$27,400	$28,222	$29,069	$29,941	$30,839	$31,764
Hexa Cr Spare Instru 10%	$2,100	$4,326	$6,684	$9,179	$11,818	$12,172	$12,538	$12,914	$13,301	$13,700	$14,111	$14,534	$14,970	$15,420	$15,882
Total Instrumentation/year	$307,300	$363,118	$471,787	$602,308	$781,999	$141,980	$147,143	$152,515	$158,105	$163,924	$169,982	$176,290	$182,860	$189,704	$196,835
Operational Costs															
Samples/site	31	31	31	31	31	31	31	32	33	34	35	36	37	38	39
Sample collected all sites/ year	217	434	651	868	1085	1085	1085	1120	1155	1190	1225	1260	1295	1330	1365
no. blanks, 10%	22	43	65	87	109	109	109	112	116	119	123	126	130	133	137
no. duplicates, 20%	43	87	130	174	217	217	217	224	231	238	245	252	259	266	273
Total number of samples	313	595	877	1159	1442	1442	1442	1488	1535	1581	1628	1674	1721	1767	1814
Sample collection $75/sample set, 3	$23,483	$45,979	$67,771	$89,564	$111,356	$114,697	$118,137	$121,948	$125,759	$129,570	$133,381	$137,192	$141,003	$144,814	$148,625
Lab Costs, $713/set of samples, 3%	$223,240	$437,109	$644,280	$851,452	$1,058,623	$1,090,382	$1,123,093	$1,159,322	$1,195,551	$1,231,780	$1,268,009	$1,304,237	$1,340,466	$1,376,695	$1,412,924
Travel, avg 350mi/site Audit, 3% inc/	$808	$1,615	$2,423	$3,230	$4,038	$4,159	$4,283	$4,283	$4,283	$4,283	$4,283	$4,283	$4,283	$4,283	$4,283
Shop Support, parts, 3% inc/yr	$43,750	$45,063	$46,414	$47,807	$49,241	$50,718	$52,240	$53,807	$55,421	$57,084	$58,796	$60,560	$62,377	$64,248	$66,176
Power, $100/mo site, 3% inc/yr	$8,400	$17,304	$25,956	$34,608	$43,260	$44,558	$45,895	$45,895	$45,895	$45,895	$45,895	$45,895	$45,895	$45,895	$45,895
Shipping, Nat'l Contract $500/site, 3	$3,500	$7,210	$10,815	$14,420	$18,025	$18,566	$18,566	$18,566	$18,566	$18,566	$18,566	$18,566	$18,566	$18,566	$18,566
HexaVal Cr. No samples/site	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
No samples per year, all sites	217	434	651	868	1,085	1,085	1,085	1,085	1,085	1,085	1,085	1,085	1,085	1,085	1,085
no blanks, 10%	22	43	65	87	109	109	109	109	109	109	109	109	109	109	109
no duplicates, 20%	43	87	130	174	217	217	217	217	217	217	217	217	217	217	217
total no. samples hex cr	282	564	846	1,128	1,411	1,411	1,411	1,411	1,411	1,411	1,411	1,411	1,411	1,411	1,411
Ltotal Lab Costs Hex. Cr, $150/samp	$42,315	$87,169	$130,753	$174,338	$217,922	$217,922	$217,922	$217,922	$217,922	$217,922	$217,922	$217,922	$217,922	$217,922	$217,922
Total Operational	$289,845	$571,872	$845,228	$1,118,583	$1,391,939	$1,427,159	$1,463,437	$1,503,476	$1,543,516	$1,583,556	$1,623,595	$1,663,635	$1,703,675	$1,743,714	$1,783,754
Personnel															
Total Personnel	$355,000	$402,215	$564,929	$659,461	$679,245	$699,622	$720,611	$742,229	$764,496	$787,431	$811,054	$835,385	$860,447	$886,260	$912,848
Annual Total	**$952,145**	**$1,337,205**	**$1,881,944**	**$2,380,352**	**$2,853,183**	**$2,268,761**	**$2,331,190**	**$2,398,220**	**$2,466,117**	**$2,534,910**	**$2,604,631**	**$2,675,310**	**$2,746,982**	**$2,819,679**	**$2,893,437**

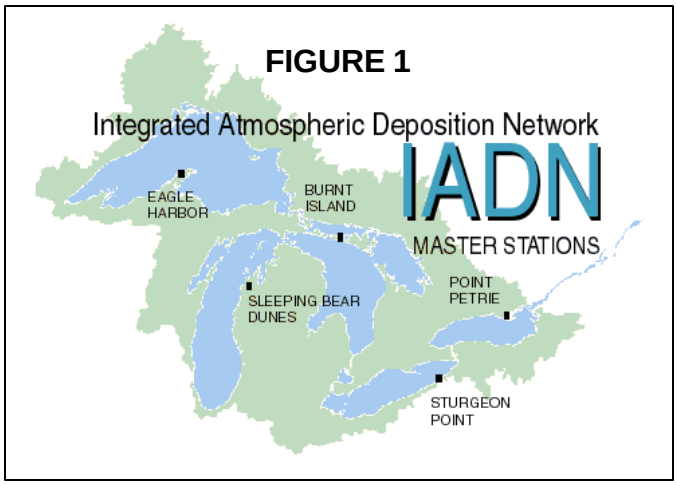
APPENDICES

PART 2: Assessing Atmospheric Deposition

APPENDIX A: Summary of Data Collected in Michigan

A1.Atmospheric Deposition Research on the Great Lakes

There has been significant research studying atmospheric deposition of PBTs to the Great Lakes. The Great Lakes are susceptible to atmospheric deposition of PBTs because of their large surface areas, long residence time, and proximity to large urban areas. An excellent summary of the milestones associated with atmospheric deposition of PBTs from the 1960s to present day can be found in a report published by the Delta Institute (**1**). The impetus behind much of the research conducted within the Great Lakes Basin in the last decade have arose from an international agreement with the U.S. and Canada known as the GLWQA - Annex 15 (**2**) and the Great Waters Program as required in Section 112(m) of the 1990 CAAA (**3**). The IADN was required by both Annex 15 of the GLWQA and the Clean Air Act and was established in 1990. The network was mandated to assess the extent of atmospheric deposition of HAPs to the Great Lakes.



Two sites were established in Michigan as part of the IADN. One of these sites is located at Sleeping Bear Dunes on the Lake Michigan shoreline in Leelanau County (latitude: 44 degree, 45' 40", longitude: 86 degree 03' 31") and the other is at Eagle Harbor on the Lake Superior shoreline on the Keweenaw Peninsula in Keweenaw County (latitude: 47degrees 27' 47", longitude: 88 degrees, 08' 59") in Michigan's Upper Peninsula.

At the IADN sites (**Figure 1**), precipitation and air samples are collected and analyzed for trace metals including lead, arsenic, and cadmium; PCBs; polycyclic aromatic hydrocarbons (PAHs); as well as pesticides including lindane, dieldrin, endosulfan, and dichlorodiphenyltrichloroethane (DDT).

The data obtained from the IADN has been summarized in published articles (**4-6**). Temporal trends or trends over the past decade show a gradual decline for PCBs and other organochlorines (like DDT), lead, and cadmium (**7**). Resource constraints have prevented routine sampling and analysis for mercury, dioxins, and furans at the IADN sites.

Although the suite of parameters that are measured is limited, the IADN serves as an important tool in establishing background concentrations of PBTs and in assessing temporal trends for atmospheric deposition of these PBTs.

Other studies that have been conducted in and around Michigan are listed below and include information on these environmentally important PBTs. Lake Michigan has been the most widely studied Great Lake. The UAT study collected and analyzed samples for PCBs, PAHs, pesticides, and trace metals over and around Lake Michigan (**8**). This study demonstrated that

Chicago was a significant source of PCBs and PAHs to Lake Michigan; however, southwest Michigan was identified as having the highest levels of DDT. The Atmospheric Exchange Over Lake and Oceans Study further identified Chicago as a significant source of PBTs to Lake Michigan (**9-11**). The Lake Michigan Mass Balance Study (LMMBS) that was initiated in 1994 and completed in 1998 focused on mercury, trans-nonochlor (a component of chlordane), PCBs, and atrazine to Lake Michigan (**12**). The study examined the loadings from all sources (air, run-off, tributaries, resuspended sediments), releases (volatilization), and sediment burial to establish baselines to better understand pollutant cycling in the lake, to target future load reductions, and to identify impacts to the ecosystem. This study found that Chicago was a significant source of PCBs and mercury to Lake Michigan via atmospheric deposition, and atrazine concentrations were found to have remained about constant which are consistent with the nearly constant sales rate of the herbicide (**13,14**).

While no mass balance study has been conducted on any other Great Lake, the University of Michigan (U of M) and Oak Ridge National Laboratory researchers are assessing mercury in the Lake Superior Basin[6] (**15**). This three-year project is examining the relationship between mercury emissions to the atmosphere and the impact in both dry and wet deposition to levels in Lake Superior. The project tasks include identifying the most important indirect sources of mercury to Lake Superior, identifying the air-water exchange of mercury from Lake Superior, and reconstruction of the history of mercury loading to the terrestrial ecosystem. Since the inception of the project, the following tasks have been completed and a final report is expected in spring 2001 (this is not an exhaustive list):

- soil sampling surrounding the smelter;
- ambient mercury samples for vapor, particulate, and precipitation at six locations around the southern shores of Lake Superior and on Isle Royale;
- sampled mercury in foliage and litterfall; U of M determined that concentrations increased throughout the growing season demonstrating that mercury can be taken up by leafs;
- sampled mercury in Tahquamenon River and Whitefish Bay; and
- developed a fog water collector and a flux chamber to measure the mercury evasion from Lake Superior and inland waterways.

Some of the Lake Superior work that has been published focuses on examining the role of sunlight and iron (III) on the formation of dissolved gaseous mercury in freshwater systems and its subsequent toxicity in the ecosystem (**16**).

Lake Superior is serving as a demonstration pilot project for virtual elimination of several PBTs. Under the auspices of the GLWQA, Canada and the U.S. in cooperation with Michigan, Minnesota, Wisconsin, and Ontario agreed to a “zero discharge demonstration area” for PBTs in 1991 (**17,18**).

Studies have also been conducted to estimate dioxin and furan loadings to the Great Lakes. Sediment core data identified the dominant source in Lake Superior of dioxins and furans is the atmosphere (**19**). Through modeling, Cohen found the contribution of sources from within the

[6] Funds were provided by the Lake Superior Trust that was set up by the MDEQ and Wisconsin Department of Natural Resources (DNR) as part of a settlement with a Copper Smelter facility located in Michigan’s Upper Peninsula that stopped operation in February of 1995.

Great Lakes Basin versus those contributing loadings from long-range transport vary (**20**). Lake Michigan was found to have the highest contribution of sources within 100 km contributing to atmospheric deposition, up to approximately 60 percent.

Atmospheric deposition of PBTs can contribute to elevated concentrations in fish. All five Great Lakes are under a fish advisory for PCBs and for dioxins in certain species of fish. Fish advisories in the Great Lakes are not as widespread for mercury as they are for PCBs. The fish advisories due to mercury contamination in the Great Lakes include Lake Michigan walleye and Lake Superior ciscowet (**Table 1**) (**21**).

TABLE A1: Great Lakes' Fish Advisories In Michigan

Pollutant	Lake Superior	Lake Michigan	Lake Huron	Lake Erie
PCBs	Many Species	Many Species	Many Species	Many Species
Mercury	Ciscowet Only	Walleye Only		
Dioxin	Ciscowet Only	Whitefish (entire lake) & Sturgeon for Southern Portion	Lake Trout, Rainbow Trout & Whitefish	Whitefish Only
Chlordane	Ciscowet & Lake Trout	Lake Trout (entire lake), Sturgeon & Whitefish for Southern Portion		

A2.Atmospheric Deposition Research Within Michigan

While atmospheric deposition loading estimates are available for the Great Lakes, little data is available within the state to estimate contributions of PBT loadings to any of Michigan's 11,000 inland lakes, or to determine if elevated concentrations in urban areas exist. Since 1988, Michigan has been under a statewide fish consumption advisory for mercury. Additionally, Michigan's inland lakes also are under numerous PCB and dioxin advisories in certain areas of the state and it is not known what contribution of these pollutant loadings originates from the atmosphere. The Surface Water Quality Division's (SWQD's) 303(d) report, required by the Clean Water Act, requires SWQD to identify waters not meeting water quality standards and to develop total maximum daily loads or (TMDLs); that is they need to identify the loadings from all sources including atmospheric deposition. The 303(d) report states, "TMDLs for problematic organic chemicals with atmospheric sources (PCB, chlordane, DDT, and dioxin), are generally scheduled in later years (starting in 2008) to allow the collection of additional information based on low level analysis and source determination" (**22**).

Because of this lack of Michigan specific PBT data, Michigan's AQD and academia have attempted to gather such information throughout the last decade, however, no comprehensive monitoring network has ever been developed due to lack of state resources. The following is a summary of the air monitoring projects for PBTs that have been collected in Michigan. The studies are summarized in chronological order of implementation.

In 1990, the MDEQ's AQD received a one year grant from the Great Lakes Protection Fund (GLPF) to establish baseline data for certain PBTs in background areas in Michigan. The air monitoring sites were located in Sault St. Marie , Traverse City, and Saginaw Bay. Ambient air samples were collected and analyzed for PCBs, PAHs, hexachlorobenzene, dieldrin, and 13

trace metals. The final report was released in 1993 (**23**). A follow-up grant was awarded to the AQD in conjunction with the U of M and was titled, "Assessing Atmospheric Levels and Transport of Toxic Contaminants in Michigan" with the final report being completed in 1998 (**24**). The sites included South Haven, Deckerville, and Dexter. This study sampled chlorinated organic compounds, PAHs, and chlorobenzenes. This study found elevated levels of DDT in South Haven and found that PCBs had higher average concentrations at the most southern Michigan sites in Dexter and South Haven compared to the northern sites of Deckerville and Pellston (which is a U of M site). Elevated levels of specific PCB congeners were identified at different sites at different times indicating possible impacts to the sites from different source regions. Numerous PAHs were also detected above the detection limit in these rural areas of Michigan. In the Great Lakes region the areas with elevated PAH deposition have been found to occur along the southern shores of Lake Michigan (by Gary, Indiana and Chicago, Illinois); deposition levels were found to be the lowest in Michigan's Upper Peninsula (**25,26**).

The U of M received a grant in 1992 to study mercury in precipitation to estimate wet deposition at three sites in Michigan (**27**). Wet deposition, total vapor-phase mercury, and total particulate-phase mercury samples were collected at three sites (Pellston, South Haven, and Dexter) for two years. This study identified a seasonal trend in wet deposition of mercury in Michigan (spring and summer comprises 66-71 percent) and also identified a spatial gradient with deposition increasing from the northern to the southern sites in Michigan's lower peninsula. The gradient in Michigan shows wet deposition of mercury in northern Michigan receiving half of the mercury that southern Michigan sites receive (**Table 2**).

TABLE A2: Deposition of Mercury in Precipitation, March 1992-May 1994 (µg/m^2)

SITE	n	EVENT AVERAGE	EVENT MAX	TOTAL MERCURY DEPOSITION	TOTAL cm OF PRECIPITATION
Pellston	**179**	**0.08**	**0.51**	**13.7**	**165**
South Haven	**216**	**0.12**	**0.85**	**24.6**	**221**
Ann Arbor	**210**	**0.10**	**0.98**	**20.9**	**201**

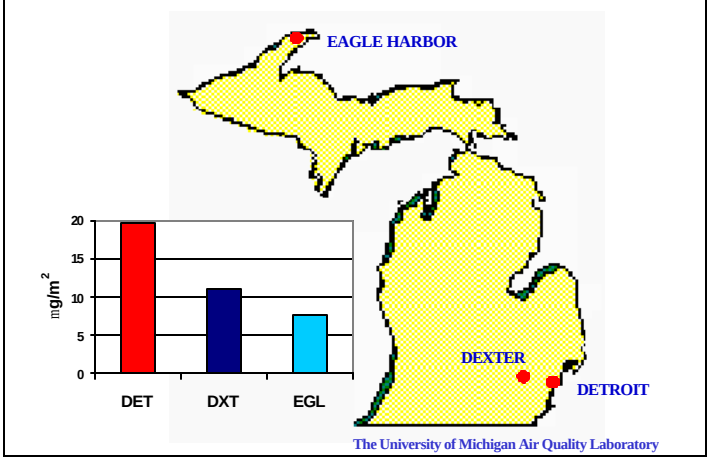
The U of M also conducted a two-year regional air monitoring network for mercury in particulate and gas-phase forms through a Regional GLPF grant and USEPA support (from December 1994 to December 1996). This Great Lakes Atmospheric Mercury Assessment Project had two primary objectives: 1) to establish a Great Lakes Basin atmospheric monitoring network to determine ambient levels of mercury and identify potential sources, and 2) facilitate coordination within the Great Lakes states and research groups to maintain this monitoring effort. Over ten sites were established within the eight Great Lakes states. The sites in Michigan were located at Dexter, Sleeping Bear Dunes, and Eagle Harbor. Preliminary data found that there is a variation in ambient concentration of vapor-phase mercury throughout the Basin. The concentrations of vapor-phase mercury in rural and remote areas range from 1-4 nanograms per cubic meter (ng/m^3). Data suggest that both vapor and particulate-phase mercury are higher in the eastern Great Lakes sites than the levels at the western and northern Great Lakes sites (**28**).

The U of M also performed the atmospheric mercury monitoring for the LMMBS (**29**). As part of the LMMBS, five sites were operated around the lake with two of the sites operated in Michigan (South Haven and Sleeping Bear Dunes) from July 1994 through October 1995. Elevated

concentrations of mercury in precipitation were observed at South Haven, and similar elevated wet deposition was observed at both Michigan shoreline sites (11.92 and 10.62 micrograms per squared meter (µg/m^2) per year at South Haven and Sleeping Bear Dunes, respectively, compared to 7-8 µg/m^2/per year at Pellston).

In 1996, an urban study to investigate the atmospheric contributions of mercury, cadmium, and PCBs in urban runoff and to the Detroit Wastewater Treatment Plant's headworks was conducted in Detroit[7]. Atmospheric deposition was not a significant source to this particular facility, other sources were more of an issue, such as contaminated sediments. However, this limited data set indicated that dry deposition of mercury bound to particulate matter significantly contributed to the total atmospheric deposition in Detroit and to levels of mercury in urban runoff. This study quantified mercury wet deposition for a nine-month period also allowed U of M's scientists to compare Detroit data to other areas in the state where mercury data was available (**30**). Wet deposition measured in the urban area was almost three times that measured at the Eagle Harbor site. **Figure 2** clearly demonstrates the urban influence of mercury in wet deposition and the need to further quantify the impact of urban areas on mercury deposition to downwind lakes and ecosystems.

FIGURE 2: Annual Mercury Wet Deposition 1996



Funding from USEPA's National Geographic Initiatives Great Lakes 105 Funds also was awarded to the U of M to support mercury deposition sites in Pellston and Dexter from 1997 to 1998. At this time, the data is not available from the principle investigator to provide a summary of mercury deposition at these sites.

The AQD received funding from USEPA's Great Lakes National Program Office to further study the elevated DDT levels in southwest Michigan from 1997 to 1999. The study confirms that the levels are still elevated in this area and the ratio of DDT to DDE demonstrates that this is a historical source of DDT. The final report for the first year study is expected to be completed in 2001 (**31, 32**).

In 2000, the AQD, Minnesota Pollution Control Agency, and Wisconsin Department of Natural Resources received a grant from USEPA's National Geographic Initiatives Great Lakes 105 Funds to purchase two mercury monitors and a trailer for transportation of the monitors. The monitors will be used to quantify fugitive releases of mercury in the three states (**33**).

The AQD, partnering with the U of M, applied to the GLPF in 2000 to develop a mercury monitoring network. A grant in the amount of $400,000 was received the summer of 2001 following the receipt of matching funds from the Lake Superior Trust. This project will establish sites in urban areas to help address the data deficiencies regarding long-term mercury

[7] Funded by the Detroit Water & Sewage Department.

monitoring data in Michigan's urban areas. This proposal will also continue the long-term event-based mercury deposition record at two rural sites in Michigan (Dexter and Pellston). This project will be coordinated with this atmospheric deposition strategy (**34**).

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Appendix B: Detailed Budget Estimates: Atmospheric Deposition by Parameter

Updated 4-28-01

Site setup costs are rolled into Dioxin numbers. If Dioxin sites are eliminated, site setup costs must be added back in.

Parameter		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
	Instrumentation& 1 Time Purchase Costs															
	Site Set up/site	$4,500	$4,635	$4,774	$4,917	$5,065	$5,217	$5,373	$5,534	$5,700	$5,871	$6,048	$6,229	$6,416	$6,608	$6,807
	Trailers	$12,000	$12,360	$12,731	$13,113	$13,506	$13,911	$14,329	$14,758	$15,201	$15,657	$16,127	$16,611	$17,109	$17,622	$18,151
	Met. Equip., Data Loggers, Strip Chart recorders	$10,000	$10,300	$10,609	$10,927	$11,255	$11,593	$11,941	$12,299	$12,668	$13,048	$13,439	$13,842	$14,258	$14,685	$15,126
	Instrumentation- PUF $2,490 each, 3% inflation	$2,490	$2,565	$2,642	$2,721	$2,803	$2,887	$2,973	$3,062	$3,154	$3,249	$3,346	$3,447	$3,550	$3,657	$3,766
	Wet Dep. Instru. MICB, $15,000	$15,000	$15,450	$15,914	$16,391	$16,883	$17,389	$17,911	$18,448	$19,002	$19,572	$20,159	$20,764	$21,386	$22,028	$22,689
Dioxin	Number of New Sites	4	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Dioxin	Existing sites	0	3	4	4	0	0	5	0	0	5	0	0	5	0	0
Dioxin	Co-locate w/ IADN	2	2	2	2	1	1	2	1	1	2	1	1	2	1	1
Dioxin	Total Dioxin Sites Operational	6	6	7	7	0	0	7	0	0	7	1	1	7	1	1
Dioxin	Sites needing monitors	6	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Dioxin	Co-Located PUF Instrumentation 20%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dioxin	Spare PUF Instrumentation 10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dioxin	# Add'l Monitors Required to meet Co-loc & Spare	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dioxin	Costs for Add'l PUF Instrumentation Req'd	$2,490	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total SiteSetup & Instru. Dioxin		**$213,430**	**$27,295**	**$46,669**	**$28,957**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Dioxin, vapor	Vapor Samples/site; Monthly Composites	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
	no. blanks, 10%	7	7	9	9	0	0	9	0	0	9	1	1	9	1	1
	no. duplicates, 20%	15	15	18	18	0	0	18	0	0	18	2	2	18	2	2
	Total number of Vapor samples	100	100	118	118	0	0	118	0	0	118	16	16	118	16	16
Dioxin, particulate	particulate Samples/site Monthly Composites	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
	no. blanks, 10%	7	7	9	9	0	0	9	0	0	9	1	1	9	1	1
	no. duplicates, 20%	15	15	18	18	0	0	18	0	0	18	2	2	18	2	2
	Total number of particulate samples	100	100	118	118	0	0	118	0	0	118	16	16	118	16	16
	Total Dioxin Samples	200	200	236	236	0	0	236	0	0	236	32	32	236	32	32
Dioxin	Sample collection $25/sample set, 3% inc/yr	$5,000	$5,150	$6,259	$6,447	$6,641	$6,840	$7,045	$7,256	$7,474	$7,698	$7,929	$8,167	$8,412	$8,664	$8,924
	Lab Cost: Dioxin/Furan $1400/sample	$280,000	$288,400	$350,521	$361,037	$371,868	$383,024	$394,515	$406,350	$418,541	$431,097	$444,030	$457,351	$471,071	$485,204	$499,760
	Sample Costs- Dioxin Total (NO FTEs)	**$285,000**	**$293,550**	**$356,781**	**$367,484**	**$378,509**	**$389,864**	**$401,560**	**$413,607**	**$426,015**	**$438,795**	**$451,959**	**$465,518**	**$479,483**	**$493,868**	**$508,684**
TOTAL DIOXIN ANNUAL		$498,430	$320,845	$403,450	$396,441	$378,509	$389,864	$401,560	$413,607	$426,015	$438,795	$451,959	$465,518	$479,483	$493,868	$508,684
PCBs	Number of New Sites (Not Dioxin)-need setup	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCBs	Existing PCB sites	0	1	2	3	0	0	4	0	0	4	0	0	4	0	0
PCBs	Sites needing Monitors only	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
PCBs	Total PCB Sites Operational	1	2	3	4	0	0	4	0	0	4	0	0	4	0	0
PCBs	Co-Located Instrumentation 20%	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
PCBs	Spare Instrumentation 10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCBs	# Add'l Monitors Required to meet Co-loc & Spare	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
PCBs	Costs for Add'l Instrumentation Req'd	$0	$0	$2,642	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
PCBs	Co-Located MICB Instrumentation 20%	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
PCBs	Spare MICB Instrumentation 10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCBs	# Add'l Monitors Required to meet Co-loc & Spare	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
PCBs	Costs for Add'l MICB Instrumentation Req'd	$0	$15,450	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total SiteSetup & Instru. PCB		**$17,490**	**$33,465**	**$21,197**	**$19,112**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**

Appendix B: Detailed Budget Estimates: Atmospheric Deposition by Parameter (Continued)

Updated 4-28-01

Site setup costs are rolled into Dioxin numbers. If Dioxin sites are eliminated, site setup costs must be added back in.

Parameter		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
PCB,	Vapor Samples/site; 1 in 12 days	31	31	31	31	31	31	31	31	31	31	31	31	31	31	31
vapor	no. blanks, 10%	3	6	9	12	0	0	12	0	0	12	0	0	12	0	0
	no. duplicates, 20%	6	12	18	24	0	0	24	0	0	24	0	0	24	0	0
	Total number of Vapor samples	40	80	120	160	0	0	160	0	0	160	0	0	160	0	0
PCB,	particulate Samples/site 1 in 12 days	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
particulate	no. blanks, 10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	no. duplicates, 20%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total number of particulate samples	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PCB,	precip.Samples/site MO COMPOSITE	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
wet dep.	no. blanks, 10%	1	2	3	4	0	0	4	0	0	4	0	0	4	0	0
	no. duplicates, 20%	2	4	7	9	0	0	9	0	0	9	0	0	9	0	0
	Total number of precip. Samples	15	30	46	61	0	0	61	0	0	61	0	0	61	0	0
	Total No. PCB Samples per year (vap. Ppt, wet dep)	55	110	166	221	0	0	221	0	0	221	0	0	221	0	0
PCB	Sample collection $25/sample set, 3% inc/yr	$1,375	$2,833	$4,403	$6,037	$6,218	$6,405	$6,597	$6,795	$6,999	$7,209	$7,425	$7,648	$7,877	$8,114	$8,357
	Lab Cost : PCB $500/sample	$27,500	$56,650	$88,055	$120,746	$124,369	$128,100	$131,943	$135,901	$139,978	$144,177	$148,503	$152,958	$157,547	$162,273	$167,141
PCB Sampling Costs		**$28,875**	**$59,483**	**$92,457**	**$126,784**	**$130,587**	**$134,505**	**$138,540**	**$142,696**	**$146,977**	**$151,386**	**$155,928**	**$160,606**	**$165,424**	**$170,387**	**$175,498**
TOTAL Annual PCB		$46,365	$92,947	$113,654	$145,895	$130,587	$134,505	$138,540	$142,696	$146,977	$151,386	$155,928	$160,606	$165,424	$170,387	$175,498
Hg	Sequential Precipitation Samplers, $23,000 3% inflation	$23,000	$23,690	$24,401	$25,133	$25,887	$26,663	$27,463	$28,287	$29,136	$30,010	$30,910	$31,837	$32,793	$33,776	$34,790
	Aerosol Sampler $20,000 3% inflation	$20,000	$20,600	$21,218	$21,855	$22,510	$23,185	$23,881	$24,597	$25,335	$26,095	$26,878	$27,685	$28,515	$29,371	$30,252
	Tekrans Vapor, Elemental & Gaseous $80,000	$80,000	$82,400	$84,872	$87,418	$90,041	$92,742	$95,524	$98,390	$101,342	$104,382	$107,513	$110,739	$114,061	$117,483	$121,007
	Total Instrumentation per site	$123,000	$126,690	$130,491	$134,405	$138,438	$142,591	$146,868	$151,274	$155,813	$160,487	$165,302	$170,261	$175,369	$180,630	$186,049
Hg	Number of New Sites (Not Dioxin)-need setup	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
	IADN	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	Sites needing Monitors	3	4	3	4	2	2	4	2	2	4	2	2	4	2	2
Hg	Total Hg Sites Operational	5	6	7	6	4	4	6	4	4	6	4	4	6	4	4
Hg	Co-Located Instrumentation, 20%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Spare Instrumentation, 10%	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total new Monitor Sets Req'd	7	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Hg	**Total SiteSetup & Instru. Hg**	**$799,500**	**$164,697**	**$160,620**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
vapor	Total number of Vapor samples	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg,	Continuous- TEKRAN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg,	aerosol Samples/site 1 in 6 day	62	62	62	62	62	62	62	62	62	62	62	62	62	62	62
aerosol	no. blanks, 10%	31	37	43	37	24	24	37	24	24	37	24	24	37	24	24
	no. duplicates, 20%	62	74	86	74	49	49	74	49	49	74	49	49	74	49	49
	Total number of aerosol samples	403	483	563	483	321	321	483	321	321	483	321	321	483	321	321
Hg,	precip.Samples/site 100 per year	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
wet dep.	no. blanks, 10%	50	60	70	60	40	40	60	40	40	60	40	40	60	40	40
	no. duplicates, 20%	100	120	140	120	80	80	120	80	80	120	80	80	120	80	80
	Total number of precip. Samples	650	780	910	780	520	520	780	520	520	780	520	520	780	520	520
	Total No. Hg Samples per year (aerosol. Ppt, wet dep)	1,053	1,263	1,473	1,263	841	841	1,263	841	841	1,263	841	841	1,263	841	841
Hg	Sample collection $25/sample set, 3% inc/yr	$26,325	$32,522	$39,068	$34,503	$35,537.94	$24,374	$25,105	$25,858	$26,634	$27,433	$28,256	$29,104	$29,977	$30,876	$31,802
	Lab Cost: Hg $225/sample	$236,925	$292,700	$351,609	$310,526	$212,974	$219,364	$225,945	$232,723	$239,705	$246,896	$254,303	$261,932	$269,790	$277,883	$286,220
Hg Sampling Costs		**$263,250**	**$325,223**	**$390,676**	**$345,029**	**$248,512**	**$243,737**	**$251,049**	**$258,581**	**$266,338**	**$274,329**	**$282,558**	**$291,035**	**$299,766**	**$308,759**	**$318,022**
TOTAL Hg Annual		$1,062,750	$489,920	$551,297	$345,029	$248,512	$243,737	$251,049	$258,581	$266,338	$274,329	$282,558	$291,035	$299,766	$308,759	$318,022

Appendix B: Detailed Budget Estimates: Atmospheric Deposition by Parameter (Continued)

Parameter		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
General Operational																
	Travel, avg 350mi/site Audit, 3% inc/yr	$560	$577	$594	$612	$630	$649	$669	$689	$709	$731	$753	$775	$798	$822	$847
	Shop Support, parts, 3% inc/yr $35,000	$35,000	$36,050	$37,132	$38,245	$39,393	$40,575	$41,792	$43,046	$44,337	$45,667	$47,037	$48,448	$49,902	$51,399	$52,941
	Power, $100/mo site, 3% inc/yr	$6,000	$7,200	$8,400	$7,200	$4,800	$4,800	$7,200	$4,800	$4,800	$7,200	$4,800	$4,800	$7,200	$4,800	$4,800
	Shipping, National Contr. $500/site	$2,500	$3,000	$3,500	$3,000	$2,000	$2,000	$3,000	$2,000	$2,000	$3,000	$2,000	$2,000	$3,000	$2,000	$2,000
Personnel 8 FTEs																
	Auditor 0.5 FTE	$35,500	$36,565	$37,662	$38,792	$39,956	$41,154	$42,389	$43,661	$44,970	$46,319	$47,709	$49,140	$50,615	$52,133	$53,697
	Program Oversight 1FTE	$71,000	$73,130	$75,324	$77,584	$79,911	$82,308	$84,778	$87,321	$89,941	$92,639	$95,418	$98,281	$101,229	$104,266	$107,394
	Site Setup/field support 1FTE	$71,000	$73,130	$75,324	$77,584	$79,911	$82,308	$84,778	$87,321	$89,941	$92,639	$95,418	$98,281	$101,229	$104,266	$107,394
	Data Validation/QA 1 to 2 FTE	$71,000	$73,130	$150,648	$155,167	$159,822	$164,617	$169,555	$174,642	$179,881	$185,278	$190,836	$196,561	$202,458	$208,532	$214,788
	Data Analysis & Interpretation 1 to 2 FTE			$75,324	$155,167	$159,822	$164,617	$169,555	$174,642	$179,881	$185,278	$190,836	$196,561	$202,458	$208,532	$214,788
	Shop Support 1 FTE	$71,000	$73,130	$75,324	$77,584	$79,911	$82,308	$84,778	$87,321	$89,941	$92,639	$95,418	$98,281	$101,229	$104,266	$107,394
	Administration, contract/bills 0.5 FTE		$36,565	$37,662	$38,792	$39,956	$41,154	$42,389	$43,661	$44,970	$46,319	$47,709	$49,140	$50,615	$52,133	$53,697
Total Personnel		$319,500	$365,650	$527,267	$620,669	$639,289	$658,468	$678,222	$698,568	$719,525	$741,111	$763,345	$786,245	$809,832	$834,127	$859,151
Total General & Personnel		$363,560	$412,477	$576,893	$669,726	$686,112	$706,491	$730,882	$749,103	$771,372	$797,709	$817,934	$842,268	$870,732	$893,148	$919,739
TOTAL	**ATM DEP**	**$1,971,105**	**$1,316,189**	**$1,645,293**	**$1,557,092**	**$1,443,720**	**$1,474,597**	**$1,522,031**	**$1,563,986**	**$1,610,702**	**$1,662,219**	**$1,708,380**	**$1,759,427**	**$1,815,406**	**$1,866,162**	**$1,921,943**