Sonoma Technology, Inc.
Air Quality Research and Innovative Solutions

A Synthesis of Completed Community-Scale Air Toxics Ambient Monitoring Projects

Final Report

U.S. EPA
Research Triangle Park, NC
April 2013

A Synthesis of Completed Community-Scale Air Toxics Ambient Monitoring Projects

Final Report
STI-910313-5469-FR

Prepared for

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Cover image illustrates sampling of particulate metals from the study “Toxics Monitoring Around a Kraft Pulp and Paper Mill in Lewiston, Idaho.” Image courtesy Nez Perce Tribe; used with permission.

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1. Introduction

1.1 Community-Scale Air Toxics Monitoring Projects

1.1.1 Background

The U.S. EPA's Community-Scale Air Toxics Ambient Monitoring (CSATAM) Program is comprised of a series of grants[1] issued from 2003 to 2012. The program supports projects by state, local, and tribal communities that identify and profile air toxics sources, characterize local air toxics problems, and track progress of air toxics reduction activities. These projects are intended to enhance the ability of state, local, and tribal agencies to characterize sources and local-scale distribution of air toxics and assess human exposure and risk at a local scale. As part of these projects, state, local, and tribal agencies were required to file a final report with the EPA Office of Air Quality Planning and Standards (OAQPS) to document the projects' key findings and lessons learned. A summary report was prepared in 2009[2] to document overall findings from studies completed by that time. This report builds on the prior report and examines final reports from CSATAM projects available as of July 2012.

The EPA has conducted four requests for applications: 2003/2004 – 16 projects/15 reports; 2005/2006 – 19 projects/17 reports; 2007/2008 – 13 projects/5 reports; and 2011/2012 – 7 projects. A total of 37 reports are available for review at this time. All awarded projects are shown in **Table 1-1**, listed by primary awardee. Studies summarized in this report are included in **Figure 1-1**.

Table 1-1. List of awarded community-scale air toxics monitoring grants by award date and primary awardee. Studies listed in **bold** do not have a report available for review as of July 2012, are not included in Figure 1-1, and are discussed separately in Section 5 of the report.

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2003/2004	2005/2006	2007/2008	2011/2012
Allegheny County Health Dept. – Pittsburgh, PA	Boulder Co. PHD – Boulder, CO	**Anchorage, AK**	**Broward County, FL**
Arizona DEQ – Phoenix, AZ	Cherokee Nation – Cherokee Heights, OK	Arizona DEQ – Phoenix, AZ	**City of Philadelphia, PA**
Capital Area Council of Governments – Austin, TX	City of Albuquerque EHD – Albuquerque, NM	**Delaware DNR**	**Linn Co. PH, IA**
Chicago, IL	City of Los Angeles EMD – Los Angeles, CA	Houston DHHS – Houston, TX	**Minnesota PCA**
Delaware DNREC – Wilmington, DE	Connecticut DEP	**Massachusetts DEP**	**Municipality of Anchorage, AK**

[1] Under Section 103(b) of the Clean Air Act, EPA is authorized to award grants for research, investigations, experiments, demonstrations, surveys, and studies related to the causes, effects, extent, prevention, and control of air pollution.
[2] http://www.epa.gov/ttnamti1/files/ambient/airtox/CSATAMSummaryReport2009.pdf.

Table 1-1. List of awarded community-scale air toxics monitoring grants by award date and primary awardee. Studies listed in **bold** do not have a report available for review as of July 2012, are not included in Figure 1-1, and are discussed separately in Section 5 of the report.

2003/2004	2005/2006	2007/2008	2011/2012
Denver DEH – Denver, CO	Houston DOH – Houston, TX	**Michigan DEQ**	**Shelby County HD, TN**
Hillsborough Co. EPC – Port of Tampa, FL	Idaho DEQ – Treasure Valley, ID	Missouri DNR – St. Louis, MO	**Virginia DEQ**
Jefferson Co. DOH, AL	Indiana DEM – Indianapolis, IN	**New Jersey DEP**	
Louisville, KY	**Nevada DEP**	**Pennsylvania DEP**	
Michigan DEQ – Delray, Detroit, MI	New Jersey DEP	Puget Sound CAA – Seattle, WA	
New Jersey DEP – Paterson City, NJ	New Jersey Meadowlands Commission	Puget Sound CAA – Tacoma and Seattle, WA	
Nez Perce Tribe – Lewiston, ID	New York DEC	**South Coast AQMD, CA**	
Oregon DEQ – Portland, OR	New York State DEC – Tonawanda, NY	**Wisconsin DNR**	
RI DEM – TF Green Airport, RI	Placer Co. APCD – Roseville, CA		
SCAQMD – Sun Valley, CA	**San Diego APCD, CA**		
Washington State Univ. – Spokane, WA	St. Regis Mohawk Tribe – Akwasasne, NY		
	Vermont DEC – Burlington, VT		
	Virginia DEQ – Hopewell, VA		
	Wisconsin DNR – Milwaukee, WI		

DEQ = Dept. of Environmental Quality; DEH = Dept. of Environmental Health; DOH = Dept. of Health; DEP = Dept. of Environmental Protection; EPC = Environmental Protection Commission; SCAQMD = South Coast Air Quality Management District; DEM = Dept. of Environmental Management; DNREC = Dept. of Natural Resources and Environmental Control; EHD = Environmental Health Dept.; PHD = Public Health Dept.; DOH = Dept. of Health; APCD = Air Pollution Control District; EMD – Environmental Management Division; DHHS = Dept. of Health and Human Services; PCA = Pollution Control Agency.

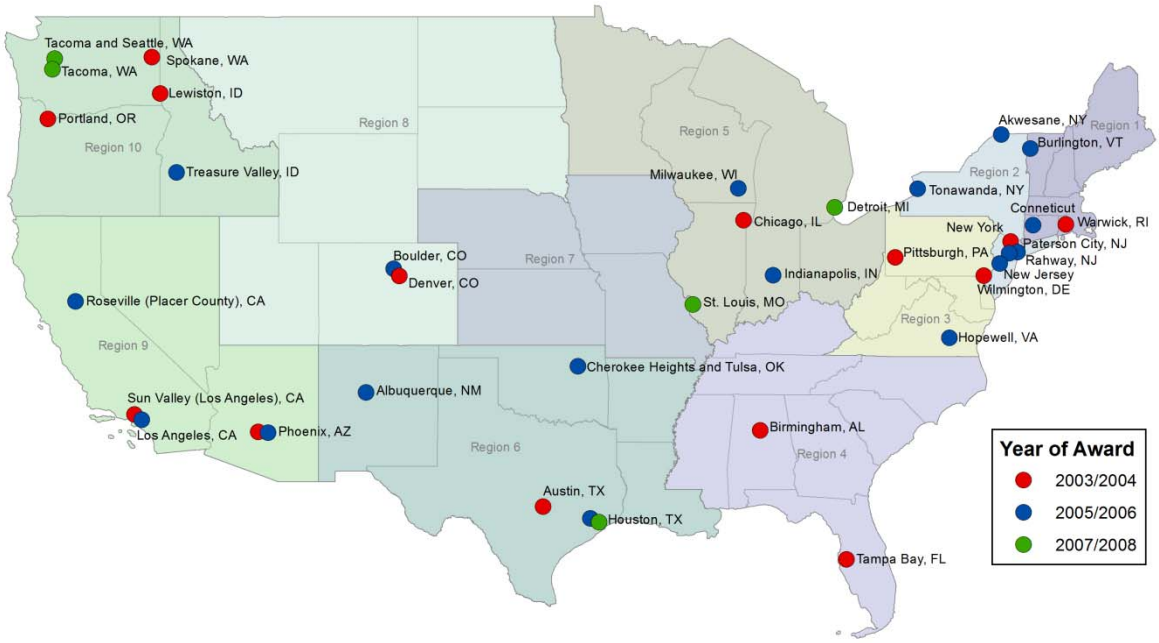

Figure 1-1. Location, EPA region, and year of award for CSATAM projects discussed in this report. Note that Alaska, Hawaii, and U.S. territories have no awarded projects with final reports available.

1.1.2 Community-Scale Air Toxics Ambient Monitoring Overview

Beginning in 2003/2004, EPA began conducting periodic CSATAM grant competitions. These grants support projects of one-and-a-half to three years in duration. Grants were awarded in three categories:

- Community Monitoring
  - Risk/health/baseline characterization – 29 studies
  - Emissions source characterization – 13 studies
  - Model validation and evaluation – 11 studies
- Methods development – 18 studies
- Analysis of existing data – 8 studies

Many studies addressed multiple categories and objectives, so the total here is greater than the actual number of studies. Individual studies are described and categorized in Sections 3 and 4.

The CSATAM project categories and objectives broadly support the larger air toxics monitoring program objectives. The goal of the air toxics monitoring program is to support reduction of public exposure to hazardous air pollutants (HAPs, generally referred to as air

toxics in this report).[3] Air toxics data from monitoring support three very basic monitoring objectives and several sub-objectives. These objectives are:

1. **Trends** - Measurements of key air toxics in representative areas of the nation provide a basic measure of air quality differences across cities and regions and over time in specific areas. Trends measurements provide one basis for assessing program progress. Trends analysis falls under the *analysis of existing data* category within the CSATAM program.
2. **Exposure Assessments** - Ambient measurements may serve as a surrogate for actual human exposure. However, understanding relationships between ambient concentrations and personal exposure and how human activities impact these relationships is critical for true exposure assessments. Ambient measurements support exposure assessments by providing ambient concentration levels for comparison with personal measurements. In addition, ambient measurements may also provide direct input into detailed human exposure models that can be used to estimate actual human exposures. Both the *risk/health/baseline characterization* and the *emissions characterization* categories of the CSATAM program support the exposure assessment goal.
3. **Air Quality Model Evaluation** - Measurements provide basic ground truthing of models, which, in turn, are used to develop exposure assessments, emissions control strategies, and related assessments of program effectiveness. In addition, measurements provide direct input into source-receptor models, which provide relatively direct linkage between emissions sources and receptor locations. The *air quality model evaluation* category of the CSATAM program directly corresponds to this objective.

Additionally, the CSATAM program fits within the broader Office of Air and Radiation (OAR) ambient measurement program goals including:

- Identifying data gaps
- Developing monitoring protocols
- Analyzing data
- Assessing risks
- Developing control strategies
- Developing regulations

For example, the *methods development* category directly correlates with the OAR goal to develop monitoring protocols. The *data analysis* category fits with the OAR's goal to identify data gaps and analyze data goals, and the data can also be used to examine trends. Finally, the monitoring category of the CSATAM program includes data gathering for identifying data gaps, assessing risks, evaluating air quality models, and assessing emissions categories that may be important for control strategies or regulations.

[3] http://www.epa.gov/ttnamti1/airtoxpg.html.

1.1.3 Objective and Guide to the Report

The objective of this report is to summarize key findings and lessons learned from the CSATAM program to date. Information summarized in this report will be helpful to agencies planning similar projects in the future. Additionally, we summarize and synthesize findings that are broadly applicable to the OAR and air toxics program monitoring objectives including risk characterization, emissions characterization, model evaluation, methods development and evaluation, and data analysis.

Key findings and lessons learned are discussed in Section 2. An overview of the community monitoring program is provided in Section 3. In Section 4, individual projects are summarized. Section 5 provides a summary of project plans for projects that have not been reported on to date. The Appendix guides the reader to key resources on air toxics.

2. Key Findings and Lessons Learned

This section summarizes the findings from available CSATAM projects regarding monitoring, measurement methods evaluation, and data analysis. Monitoring projects covered a range of goals including risk characterization and screening, emissions characterization, and baseline concentration characterization. This section explores the common themes found in study results and concludes with overall lessons learned.

2.1 Risk Characterization

The National-Scale Air Toxics Assessment (NATA)[4] provides a list of the most important air toxic pollutants with highest cancer risk and chronic noncancer hazard. The 2005 NATA provides information on 177 of the 187 Clean Air Act air toxics plus diesel particulate matter (DPM was assessed for chronic noncancer hazard only). **Table 2-1** lists the key air toxics for cancer risk and noncancer hazard for the United States for NATA 2005. Note that throughout the CSATAM program, NATA 1996, 1999, and 2002 have all been recently available assessments; in this document we list all comparisons of studies to the NATA release year. Many of the priority pollutants on this list have been on the target list in previous releases of NATA, but there have been some changes as our understanding has evolved. Changes from the 2002 NATA were minimal; formaldehyde and ethylbenzene risk is higher for 2005 and benzene is a bit lower. The 1999 NATA was very similar to the 2002 NATA; only arsenic ranked higher in the 1999 NATA than in the 2002 and 2005 NATA. The 1996 NATA was significantly different from later iterations, as it did not include three of the key air toxics on the list: naphthalene, 1,4-dichlorobenzene, and ethylbenzene. Additionally, the 1996 NATA showed chromium VI and formaldehyde as being national risk drivers alongside benzene.

In NATA 2005, which was released in 2011, secondary formation was the largest contributor to cancer risk, while stationary, mobile, and background sources contributed almost equal portions of the remaining cancer risk. Note that pollutants formed from secondary production in the atmosphere are a result of photo-oxidation of hydrocarbons emitted from other anthropogenic and biogenic sources. Acrolein, which can affect the lungs, contributes the most to noncancer risks, nationwide. Risk from fires was not included in NATA 2005 and would likely be a significant source of risk because fires are a key emissions source for many of the air toxics listed in Table 2-1.

Ambient monitoring data has been used to validate NATA model results. Monitor-to-model concentrations that are within a factor of two are considered within acceptable agreement. Most studies noted good agreement for mobile source air toxics and poorer agreement for other air toxics such as chlorinated volatile organic compounds (VOCs), trace metals, and acrolein.

All the air toxics listed in Table 2-1 were targeted in at least one measurement study, with the notable exception of ethylene oxide; this air toxic was not measured in any study. VOCs and carbonyls were monitored most frequently, in 22 of the 34 monitoring studies.

[4] http://www.epa.gov/ttn/atw/nata2005/.

Semi-volatile organic compounds (SVOCs)/polycyclic aromatic hydrocarbons (PAHs) were the least targeted group of pollutants with measurements in 8 of the 34 studies. Among those eight studies, only a few had speciated measurements capable of quantifying naphthalene. Several studies noted problems with the quality of acrolein measurements, an ongoing measurement problem throughout the CSATAM program history. EPA is currently working on improving the method for measuring acrolein.

Table 2-1. Key air toxics driving cancer risk and noncancer hazard nationally from NATA 2005.

Pollutant	% National Average Cancer Risk	Key Emissions Sources
Formaldehyde	45.1	Secondary, Fires, On-road, Nonroad,
Benzene	14.9	On-road, Nonroad, Fires, Energy/Combustion
Acetaldehyde	6.7	Secondary, On-road, Fires, Nonroad, Energy/Combustion
Carbon Tetrachloride	5.7	Background, Forest Products, Waste Treatment, Chemical Production
Naphthalene	4.6	On-road, Solvent Use, Nonroad, Energy/Combustion, Boilers and Process Heaters
1,3-Butadiene	3.9	Fires, On-road, Nonroad
Polycyclic Aromatic Hydrocarbons (PAHs) and Polycyclic Organic Matter (POM)	3.0	Fires, Energy/Combustion, Nonroad, On-road, Boilers and Process Heaters
Chromium Compounds	2.8	Electric Utilities, Iron/Steel production, Boilers and Process Heaters, Metal Fabrication, On-road, Iron/Steel Foundries, Incineration
Arsenic Compounds	2.7	Electric Utilities, Boilers and Process Heaters
Tetrachloroethylene	2.2	Dry Cleaning, Solvent Use
1,4-Dichlorobenzene	1.7	Solvent Use
Ethylbenzene	1.3	On-road, Nonroad, Asphalt
Ethylene Oxide	1.1	Sterilization, Solvent Use, Chemical Production
Acrolein	Noncancer	Fires, Secondary, Nonroad, On-road, Waste Operations

2.1.1 Emissions Sources with Potentially High Risk for a Local Community

This characterization question was considered in the least number of studies deliberately characterizing or identifying sources with high risk (chronic or acute; cancer or noncancer). Given the available reports, sources were identified as high risk or potentially high risk only if the study report characterized risk and listed the emissions source. Additionally, pollutants and emissions sources were characterized as “high risk” only if the study report mentioned that the risk levels were considered high. Given that different chronic cancer and noncancer benchmarks can be used in these types of studies, and that the definition of “high risk” is subjective, there is significant imprecision in comparing results from one study to another. For

example, coke smelter emissions may be characterized with a 1-in-1,000 cancer risk, while carbon tetrachloride is associated with a 1-in-100,000 cancer risk, but both may be listed in the following table (**Table 2-2**). In addition, we note in the table if a risk is likely a local issue only, or may be ascribed to a regional or national risk characterized in NATA 2005.

Table 2-2 lists monitoring results. Two studies determined that mobile sources were high contributors to local risk. This result is consistent with NATA 2005 and national studies of air pollution. These results are applicable nationally, not just for those local studies. One study found a high noncancer hazard from acrolein; this is also true nationally, although the concentrations in that study may have been higher than other places (as noted in the report). Similarly, multiple studies found high formaldehyde and acetaldehyde contributions to risk. This is also true nationally, but may be a result of high local contributions as well as high regional concentrations (also as noted in several reports). Of truly local sources, the Roseville rail yard, industrial facilities, and nonpoint sources are all specific emissions sources that would not be found in all cities and are not ubiquitous in the urban environment. All of these source types are identified in NATA 2005 as high risk emissions sources.

Table 2-2. Emissions sources and pollutants identified in the CSATAM study reports as potentially high risk for a local community.

On-Road vehicles	Transportation Facilities (e.g., ports, airports, depots)	Large Stationary Sources	Small Stationary Sources	Other
• Akwasasne, NY • Indianapolis, IN • Milwaukee, WI • Phoenix, AZ • Tacoma/ Seattle, WA	• Roseville, CA (Rail yard DPM, PAHs, metals)	• Birmingham, AL (coke by-product plant) • Louisville, KY (rubber plant) • Pittsburgh, PA (coke facility) • Tonawanda, NY (coke oven facility)	• Sun Valley, CA (chrome plating)	• Austin, TX (acrolein, unknown source) • Detroit, MI (unknown carbonyl, manganese, and chlorinated solvent sources) • Lewiston, ID (formaldehyde and acetaldehyde, possibly background) • Pittsburgh, PA (background, unidentified sources of chlorinated compounds) • Tacoma/Seattle, WA (wood smoke)

2.2 Source Characterization Findings

The goal of many CSATAM projects was to characterize air toxics concentrations in a community with an underlying goal of evaluating potential sources of high concentrations of air toxics. This section summarizes emissions sources that CSATAM investigators considered (1) well-characterized, and (2) in need of more research (inconclusive results from community monitoring). Note that emissions sources that are both well-characterized and in need of more research may still be identified as high risk; these groupings are not mutually exclusive.

2.2.1 Well-Characterized Emissions Sources

The table (Table 2-3) below lists studies that reported successful characterization of an emissions source within broad emissions categories. On-road vehicle sources were the most common source characterized. Sources emitting metals were the most common target in the stationary sources categories. Several studies investigated residential wood smoke and wood-fueled boilers.

On-Road Vehicles	Transportation Facilities (e.g., ports, airports, depots)	Large Stationary Sources	Small Stationary or Area Sources
• Akwasasne, NY • Albuquerque, NM • Boulder, CO • Chicago, IL • Denver, CO • Detroit, MI (but not MSATs) • Indianapolis, IN • Lewiston, ID • New Jersey Turnpike • Phoenix, AZ • Pittsburgh, PA • Portland, OR • Spokane, WA • St. Louis, MO (regional transport) • Tacoma/Seattle, WA • Treasure Valley, ID • Warwick, RI	• Roseville, CA (rail yard, but not MSATs) • Tacoma, WA (fueling/port operations) • Wilmington, DE (bus depot, port)	• Birmingham, AL (coke by-product plant) • Denver, CO (industrial facilities) • Houston, TX (refinery fugitive emissions) • Lewiston, ID (pulp and paper mill) • Pittsburgh, PA (metallurgical-coke facility) • Portland, OR (metal foundry/facilities) • St. Louis, MO (smelter) • Sun Valley, CA (landfill) • Tonawanda, NY (coke oven facility) • Wilmington, DE (industrial facilities)	• Boulder, CO (natural gas production) • Connecticut (wood smoke) • Lewiston, ID (pesticide application) • Paterson, NJ (fluorescent light bulb disposal) • Spokane, WA (auto repair shops, industrial park) • Sun Valley, CA (chrome plating facility) • Tacoma/Seattle, WA (wood smoke) • Tacoma, WA (wood smoke) • Tampa, FL (crematory, spa manufacture) • Treasure Valley, ID (wood smoke) • Warwick, RI (dry cleaners)

2.2.2 Emissions Source Characterization – Indistinguishable and Unknown Sources

In many studies, difficulties were encountered identifying or characterizing emissions sources. Typical difficulties included discriminating between emissions sources with similar chemical characteristics and identifying unknown/unexpected emissions sources not noted in the emissions inventory. For unknown sources, many of the studies identified high concentrations of a particular air toxic or set of air toxics, and were unable to identify the exact source responsible for the pollutants. This was particularly true for point sources of metals or chlorinated solvents and for unidentified sources of a single air toxic. Given that standard air toxics measurements have a typical sampling duration of 24 hours, correlating high concentrations with wind directions to identify potential source direction was shown as problematic. Additionally, single-pollutant emissions sources not identified in the EPA National Emissions Inventory (NEI) or Toxics Release Inventory (TRI) may be located in industrial areas with many potential sources. Positive identification of specific air toxic sources in these cases was shown to be extremely difficult.

Table 2-4 lists the emissions sources and pollutants that were indistinguishable from other emissions or unidentified in the monitoring studies. The most common emissions source types that were insufficiently characterized, as noted in the study reports, included transportation facilities, metals from point and nonpoint sources, chlorinated solvents, and mobile source facilities such as airports, ports, and roads. Additionally, there were a number of studies that listed difficulties identifying or characterizing the fraction of emissions attributable to regional/global background and identifying the sources of pollutants with secondary formation (i.e., formaldehyde, acetaldehyde, and acrolein).

Table 2-4. Emissions sources and pollutants that were reported as indistinguishable or unidentified sources in CSATAM projects with reports available.

	On-Road Vehicles	Transportation Facilities (e.g., ports, airports, depots)	Large Stationary Sources	Small Stationary Sources	Other
Indistinguishable Characterization	• New Jersey Turnpike (metals by particle size) • Milwaukee, WI (BTEX near-road) • Phoenix, AZ (carbonyls near-road)	• Detroit, MI (bridge, rail yard) • Los Angeles, CA (port) • Roseville, CA (rail yard VOCs and carbonyls) • Tampa, FL (port DPM) • Warwick, RI (airport)	• Louisville, KY (rubber plant)		• Connecticut (outdoor wood furnaces)
Unknown Source		• Chicago, IL (airport)	• Cherokee Heights, OK (industrial metals) • Chicago, IL (steel mill) • Detroit, MI (chlorinated solvents, manganese, carbonyls) • Indianapolis, IN (industrial sources) • Paterson, NJ (dichlorobenzene source, area and point sources for arsenic and chlorinated compounds)	• Detroit, MI (chlorinated solvents, manganese, carbonyls) • Paterson, NJ (dichlorobenzene, area and point sources for arsenic and chlorinated compounds) • Phoenix, AZ (solvents) • Portland, OR (hexavalent Cr) • St. Louis, MO (nearby intermittent emitter) • Treasure Valley, ID (solvents)	• Austin, TX (acrolein) • Cherokee Heights, OK (background) • Detroit, MI (background) • Tonawanda, NY (background) • Indianapolis, IN (background) • Lewiston, ID (carbonyls, metals, chlorobenzene • Pittsburgh, PA (chlorinated compounds, substituted aromatics) • Warwick, RI (formaldehyde)

2.3 Measurement Method Development

Standard methods for air toxics measurements include TO-15 24-hr duration canister measurements for VOCs, TO-11 24-hr dinitrophenylhydrazine (DNPH) cartridge measurements for carbonyls, filter-based 24-hr inductively coupled plasma mass spectrometry (ICP-MS, IO-3.5) or x-ray fluorescence (XRF) measurements of metals. In a number of studies, nonstandard methods were used to measure air toxics concentrations. **Table 2-5** lists the less common measurement methods and gives a brief comment on the limitations of each method. Some of the methods were relatively novel applications that are rarely used for air toxics measurements specifically. For example, the Aerosol Mass Spectrometer (AMS) is commonly used in the research community to characterize particulate matter at the single-particle level, but it is rarely used to characterize air toxics components. Similarly, the Proton Transfer Reaction Mass Spectrometry (PTR-MS) is occasionally used by the research community to characterize VOC concentrations, but its use for air toxics studies has been rare to this date. The AMS, PTR-MS, and Xact metals methods are all relatively new techniques developed in recent years.

For the VOCs, the PTR-MS is the only novel approach; passive sampling and gas chromatography-flame ionization detector (GC-FID) measurements of VOCs have been made for years as part of the Photochemical Assessment Monitoring Stations (PAMS) program and other applications. GC-FID measurements are described in TO-14A and examples of passive sampling techniques are described in TO-1 and TO-2. Automated GC-FID techniques offer considerable advantages in time-resolution relative to canister collection and subsequent analysis, but require additional capital outlay, have more difficulty measuring some important air toxics (e.g., 1,3-butadiene and acrolein), and often have higher detection limits than gas chromatography-mass spectrometry (GC-MS*)* techniques. Passive sampling methods are cheap and easy to deploy, but have a limited range of compounds (e.g., benzene, toluene, ethyl benzene, and xylenes, or BTEX) and require longer sampling times (typically days to weeks rather than hours). The PTR-MS instrument has the capability to measure any pollutant with a proton affinity greater than H_2O, which includes pollutants like aromatics (e.g., benzene, toluene), aldehydes and ketones (e.g., acetaldehyde, acrolein), and some gas-phase PAHs (e.g., naphthalene, anthracene) at 1- to 5-minute time resolution. Unfortunately, the instrument is quite expensive and finicky and requires a skilled operator to oversee it during operations.

Table 2-5. Monitoring methods applied in CSATAM projects and their *limitations* (if applicable).

VOCs	Metals	Carbonyls	Other
• Albuquerque, NM (auto-GC) • Chicago, IL (passive sampling, *poor time resolution, biased relative to routine*) • Denver, CO (auto-GC) • Houston, TX (thermal desorption GC-FID/MS) • Houston, TX (DIAL, FTIR, UV-DOAS, *siting issues*) • Milwaukee, WI (passive BTEX, *poor time resolution*) • Pittsburgh, PA (Auto-GC) • Portland, OR (pneumatic focusing GC, *efficacy was not reported*) • Spokane, WA (PTR-MS, *operationally intensive*) • Tacoma, WA (auto-GC) • Tacoma, WA (OP-FTIR, *detection limit and specificity*)	• Paterson, NJ (EOSHI Cr6+, *inconclusive results*) • Rahway, NJ (Cr6+, *expensive*), • St. Louis, MO (Xact semi-continuous metals, *expensive*) • Wilmington, DE (Cr6+, *wet chemistry)*	• Detroit, MI (continuous formaldehyde, *operationally intensive)* • Lewiston, ID (DOAS, PTR-MS) • Paterson, NJ (PAKS, *precision was good for acrolein; formaldehyde, acetaldehyde biased high*) • Spokane, WA (PTR-MS, *operationally intensive*) • Warwick, RI (Cerex open-path optical system) • Wilmington, DE (formaldehyde, *wet chemistry*)	• Detroit, MI (Aethalometer for BC) • Hopewell, VA (Aethalometer for BC) • Los Angeles, CA (particle-bound PAH) • Pittsburgh, PA (thermal desorption for SVOCs, PAHs) • Spokane, WA (particle bound PAH) • Tacoma/Seattle, WA (levoglucosan, particle bound PAH) • Tacoma, WA (LIDAR for ship emissions, *siting issues*) • Tampa, FL (open path ozone and SO_2 monitoring) • Wilmington, DE (real-time single particle composition)

For the metals, three projects focused on improving hexavalent chromium measurement methods. In the Wilmington, DE study, a Steam-Jet Aerosol Collector–Long Pathlength Absorbance Spectroscopy (SJAC-LPAS) instrument was tested. Detection limits for Cr(VI) were as low as 0.19 ng/m^3 in a laboratory setting. Cr(III) can also be analyzed using the system, but has an order of magnitude higher detection limits. A new method developed at the Environmental and Occupational Health Sciences Institute (EOHSI) at Rutgers uses IC/ICPMS to assess both Cr(VI) and Cr(III) concentrations. This method is more expensive than the EPA approved Cr(VI) method, but may be helpful for developing a standard Cr(III):Cr(VI) ratio and validating Cr(VI) concentrations measured using the IC/UV method.

Additionally, one project tested a prototype semi-continuous method for analyzing metals using XRF (Xact instrument). The Xact metals monitor can measure a suite of up to 20 metals for durations ranging between 15 minutes and 4 hours, depending on necessary detection limits. The method was deemed suitable by the project researchers, requiring little oversight and proving quite robust in the field. The capital cost of this instrument is much higher than capital costs associated with standard air toxics methods, but the amount of data that can be collected and the utility of that data may override the cost considerations. Details on the Xact Metals Monitor and its cost and reliability in the field were not available in the St. Louis report.[5] This instrument has already been applied in other air toxics monitoring applications, for example, in EPA Region 5 (Caudill, 2012).

For carbonyls, at least six methods were tested that were non-standard. For the Delaware method, a wet chemical separation technique called the Passive Aldehydes and Ketones Sampler (PAKS) method was found to have good precision for acrolein, but was biased high relative to DNPH cartridges for both formaldehyde and acetaldehyde. Study researchers in Rhode Island noted that the open-path measurement study applied to carbonyls did not work well. The PTR-MS method is capable of measurement of some aldehydes and ketones, but formaldehyde is quite complicated because its proton-affinity is very close to that of water. As noted earlier, the PTR-MS technology is expensive and operator intensive. The continuous formaldehyde sampler from the Wilmington study had high sample throughput (~20 s) with detection limits of ~0.78 µg/m^3, but required significant wet chemistry. Cost and operational intensity were not described. The Delray, Michigan, monitoring study tested a commercially available wet chemistry continuous formaldehyde monitor. The continuous monitor operated on a similar principle to that of the Wilmington monitor, but had a large number of technical issues that resulted in operational problems. Reagent leaks and crushed tubing were common issues. The continuous formaldehyde samplers required intense oversight by an operator and were deemed not robust enough for independent operation.

The Aethalometer measurement method uses optical absorption as a means of characterizing black carbon concentrations; black carbon can be used as a proxy for DPM in situations where other emissions sources such as wood smoke are uncommon. The monitoring methodology/sampling approach used to isolate the Roseville/Placer County railroad facility

[5] http://www.epa.gov/ttnamti1/files/20072008csatam/20100331stlouisfinal.pdf.

could be applied to other sampling situations. Aethalometer measurement methods are now routinely applied at National Air Toxics Trends Stations (NATTS) monitoring locations and are no longer a novel method. This monitoring methodology/sampling approach could easily be applied at other locations.

Open-path optical methods were generally deemed ineffective by study participants. Ambient concentrations were too low to be reliably detected using the open-path methods.

Of the key pollutants from the toxics list in Table 2-1, some are not routinely measured or have problems with the standard methods. Acrolein is the obvious example, as most data in EPA's Air Quality System (AQS) is considered unverified and potentially invalid. Methods development for acrolein is ongoing. No measurements of ethylene oxide were made and only limited measurements of individual PAHs and naphthalene were made.

2.4 Data Analysis

Many studies provided thorough documentation of data analyses conducted including data validation, statistical methods, graphic depictions, and discussion of findings useful to future researchers. Data analysis was the primary objective in four studies. In two of these studies, receptor modeling of air toxics data was performed to identify emissions sources. When source apportionment was discussed, findings were more specific and useful when additional pollutants were included beyond the list of air toxics because a broader range of pollutants provides the possibility of additional markers that are useful in identifying sources. Source apportionment was also best conducted with continuous, highly time-resolved data. For these highly time-resolved data sets, meteorological information is very useful in source identification. The two Phoenix Joint Air Toxics Assessment Project (JATAP) data analysis projects examined the spatial distribution of risk, assessed sources of that risk, and performed air quality modeling that used the ambient monitoring data to validate the results.

2.5 Lessons Learned in Designing CSATAM Studies

In evaluating the studies, talking with some of the study participants, and preparing training material for a workshop on conducting successful future community-scale air toxics studies, the following lessons learned were compiled for project goal setting, monitoring strategy, project planning, data collection and validation, data analysis, and taking action.

Project Goal Setting

- Goals need to be specific (and should not be too broad).
- It is hard to meet everyone's expectations (i.e., project leaders need to manage expectations, especially from the public, from the beginning).
- "Watch how large your project is, it's always more work than you envision."
- "Working with collaborators can be tricky."

Monitoring Strategy

- Understand the area to be monitored. For example, complete an emissions inventory, conduct site visits, and perform screening modeling and/or monitoring before finalizing monitoring locations and targeting which air toxics to monitor.
- Ensure the laboratory and/or sampling and analytical method can give you the detection limits you need (i.e., below levels of concern).
- Get the right people together to develop the monitoring strategy (e.g., local knowledge, monitoring experience).

Project Planning

- Budget enough time and resources to complete the project.
- In setting up the schedule and budget, be realistic, account for siting and setup issues, and consider data processing and analysis requirements.

Monitoring

- Assess laboratory detection limits, data reporting methods, and comparability early on in the project (or preferably, before the project starts) to ensure the data collected are useful to meet project goals.
- If using more than one laboratory, perform a comparability study up front. Experience has shown that there can be considerable differences in results (e.g., detection limits, precision) across laboratories.
- Consider security measures for monitoring. Vandalism was a problem in a few of the studies.
- If the project is NOT testing new sampling or analysis methods, use methods with a proven “track record.”
- Consider meteorology and geography in monitor location placement to ensure that measurements routinely capture air parcels from the direction of the sources of interest.

Data Collection and Validation

- Look at your data early in the project to correct problems before the study is over.
- There is no substitute for local knowledge about monitoring sites; operators or those who have extensive knowledge of the area are a unique resource for data analysts.
- Always validate data prior to analysis. Data visualization is essential.
- Inter-laboratory precision data indicated that laboratory selection could be a major factor influencing data comparability nationwide; however, comparability between laboratories is improving as a result of the performance evaluation program.

Data Analysis

- Plan for enough time and resources to be able to conduct data analysis.
- Isolating a particular source impact on pollutant concentrations is tricky with common measurement methods such as 24-hr average samples. Higher time resolution with local meteorological data provided better source identification.
- Analyses do not always lead to the answer you anticipated.
- Getting a similar result using different analysis approaches, similar to a weight of evidence approach, gives you more confidence in your results.
- Show uncertainty in results to demonstrate statistical significance of findings.

Taking Action

- Communicating results.
  - Leave adequate time and funds for reporting.
  - "Should have used a different group for communication" – project researchers should consider engaging outreach professionals or communications people to help shape communications with stakeholders and community groups.
  - "Write a less technical paper and get it out first (i.e., communicate early), then focus on the larger document."
- Working with community/industry groups.
  - "Should have engaged community groups earlier."
  - "Providing quarterly reports to community leaders was effective."
- Taking action.
  - Initiate anti-idling programs.
  - Initiate litigation against a source.
  - Use results to help with permitting new facilities.
  - Evaluate existing permits.
  - Establish a mobile monitoring program to help address future concerns.

3. Projects Completed to Date

This section summarizes the projects completed to date with the primary and secondary goals identified. As of July 2012, 37 reports were available for review; the reports are listed in **Table 3-1**. The reports are organized by EPA region and then the city and/or state in which the study was conducted and by the primary purpose of the study—monitoring, method development, or data analysis. If there were secondary objectives, those objectives are noted. A very brief project description is provided as well. Figure 1-1 shows a map of the areas studied.

Table 3-1. Community-scale air toxics monitoring projects conducted that were granted in 2003/2004, 2005/2006, or 2007/2008 solicitations. Projects are organized by primary (P) focus of the study: community monitoring, method development, or data analysis. Secondary (S) objectives are also noted.

Region	State	Community	Project Title and Brief Description	Risk/Health/Baseline Characterization	Emissions Characterization	Model Evaluation	Develop Methods	Analyze Existing Data
1	Connecticut	Connecticut	Evaluation of Wood Smoke Contribution to Particle Matter. Conducted ambient air monitoring to characterize the contribution of particulate matter from wood burning sources.	S	P			
1	Rhode Island	Warwick	Characterization of Ambient Air Toxics in Neighborhoods Abutting T. F. Green Airport and Comparison Sites. Evaluated impact of airport operation emissions on community concentrations.	P	S	S	S	
1	Vermont	Burlington	Spatial And Temporal Concentrations Of Benzene In Two Northern New England Communities - A Modeling Validation Study. Conducted monitoring to provide data for a model evaluation.	S		P	S	
2	New Jersey	New Jersey Turnpike	Results of Targeted PM2.5, Total Suspended Particles (TSP) and PAHs Monitored at a Heavily Trafficked Turnpike Location. Conducted monitoring to identify ambient air quality gradients of particulate matter (fine, TSP) and associated PAHs at three different distances (50 m, 100 m and 500 m) from the New Jersey Turnpike (NJTPK).	P				

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Region	State	Community	Project Title and Brief Description	Risk/Health/Baseline Characterization	Emissions Characterization	Model Evaluation	Develop Methods	Analyze Existing Data
2	New Jersey	Paterson City	*Urban Community Air Toxics Monitoring Project.* Tested passive sampling method for aldehydes and ketones, evaluated hexavalent chromium method, and performed data analysis (characterization and modeling).				P	S
2	New Jersey	Rahway	*Development and Optimization of a Sampling and Analytical Method to Measure Hexavalent Chromium in Ambient Air.* Conducted laboratory development and field testing. Obtained good method sensitivity with a method detection limit of 0.09 ng/m^3.				P	
2	New York	Akwesasne	*Characterization of Benzene and Other Air Toxics to Better Understand the Impact of Nearby Industrial Sources and Mobile Sources.* In addition to typical air toxics monitoring, conducted emissions measurements and personal sampling.	P	S			
2	New York	Tonawanda	*Community Air Quality Study.* Conducted monitoring to provide data for comparison to models and to better understand coke oven emissions impact on the community.	P				
2	New York	New York State	*Air Monitoring Plan for Establishing an Ambient Mercury Baseline. Conducted Hg monitoring and developed guidance for instrument operation.*	P			S	

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Region	State	Community	Project Title and Brief Description	Risk/Health/Baseline Characterization	Emissions Characterization	Model Evaluation	Develop Methods	Analyze Existing Data
3	Delaware	Wilmington	*Enhanced Delaware Air Toxics Assessment Study (E-DATAS).* Conducted fixed site and mobile monitoring of air toxics. Compared to data collected earlier in the same area. Tested particle measurement method.	S	P		S	
3	Virginia	Hopewell	*Risk Assessment for Air Toxics Measured in Three Cities.* Monitoring conducted to provide data for a risk screening.	P				
4	Alabama	Birmingham	*Air Toxics Study and Risk Assessment.* Monitored air toxics and conducted risk assessment screening.	P	S			
4	Florida	Tampa Bay	*Inhalation Risk Posed by Toxic Emissions from the Port of Tampa.* Explored open path monitoring systems. Compared open path measurements to fixed sites.	S	S		P	
5	Illinois	Chicago	*Large Area Monitoring Program (LAMP II) – BTEX Characterization of Chicago and O'Hare Airport Areas.* Tested new passive sampling technology for benzene, toluene, ethyl benzene, and xylenes (BTEX) and performed saturation study to characterize air toxics in the area.	S	S		P	
5	Indiana	Indianapolis	*Community-Scale Air Toxics Study*. Conducted monitoring to provide data for a risk screening and comparison to National Air Toxics Assessment (NATA).	P	S	S		S

Table 3-1. Community-scale air toxics monitoring projects conducted that were granted in 2003/2004, 2005/2006, or 2007/2008 solicitations. Projects are organized by primary (P) focus of the study: community monitoring, method development, or data analysis. Secondary (S) objectives are also noted.

Region	State	Community	Project Title and Brief Description	Risk/Health/Baseline Characterization	Emissions Characterization	Model Evaluation	Develop Methods	Analyze Existing Data
5	Michigan	Detroit	*Community Monitoring Project – Studying the Impact of Border Crossing Traffic.* Conducted monitoring in Del Ray (Newberry School) and at the Ambassador Bridge. Also investigated continuous formaldehyde samplers. Complement to Detroit Exposure Aerosol Research Study (DEARS).	P	S		S	
5	Wisconsin	Milwaukee	*Evaluation of Passive Sampling Techniques for Monitoring Roadway and Neighborhood Exposures to Benzene and Other Mobile Source VOCs.* Compared modeled and monitored concentrations.				P	S
6	New Mexico	Albuquerque	*Air Toxics Risk Assessment.* Monitored air toxics to characterize concentrations and support development of control strategies. Conducted risk assessment modeling.	P	S	S		S
6	Oklahoma	Cherokee Heights and Tulsa	*Cherokee Nation Air Quality Monitoring Report.* Monitored air toxics in three communities and performed health risk screening.	P				
6	Texas	Austin	*Austin-Round Rock Toxics Study (ARTS).* Conducted monitoring to identify ambient air toxics of highest risk. Compared monitored to modeled data.	P		S		
6	Texas	Houston	*Mobile Laboratory Deployed To Measure Air Toxics In The Houston Ship Channel Area. Tested feasibility of mobile monitoring in industrialized area to identify and characterize point source emissions in near real time.*	S			P	

Table 3-1. Community-scale air toxics monitoring projects conducted that were granted in 2003/2004, 2005/2006, or 2007/2008 solicitations. Projects are organized by primary (P) focus of the study: community monitoring, method development, or data analysis. Secondary (S) objectives are also noted.

Region	State	Community	Project Title and Brief Description	Risk/Health/Baseline Characterization	Emissions Characterization	Model Evaluation	Develop Methods	Analyze Existing Data
6	Texas	Houston	*Measurement and Analysis of Benzene and Volatile Organic Compound (VOC) Emissions in the Houston Ship Channel Area and Selected Surrounding Major Stationary Sources Using DIAL (Differential Absorption Light Detection and Ranging) Technology to Support Ambient Hazardous Air Pollutant (HAP) Concentrations Reductions in the Community.* Comprehensive survey project regarding emissions from a combined petroleum refinery and chemical plant complex in the Houston Ship Channel area.	S			P	
7	Missouri	St. Louis	*Advanced Sampling and Data Analysis for Source Attribution of Ambient Particulate Arsenic and Other Air Toxics Metals in St. Louis.* Monitoring was conducted in urban residential areas. Included high time resolution metals sampling, analysis of previously collected data, and comparison of annual average arsenic concentrations to cancer risk benchmarks.	P	S	S	S	S
8	Colorado	Boulder	*Understanding Air Toxics and Carbonyl Pollutant Sources in Boulder County, Colorado.* Conducted air toxics monitoring to understand spatial and temporal characteristics in the area.	P		S	S	
8	Colorado	Denver	*Community-Scale Air Dispersion Modeling in Denver. Measurements made using new sampling methods to better understand spatial variability, compare to standard methods, and evaluate monitor vs. model results.*	P		S	S	
9	Arizona	Phoenix	*Analysis of Air Toxics Collected as Part of the Joint Air Toxics Assessment Project (JATAP). Analyzed air toxics data collected during JATAP and communicated findings.*					P

Table 3-1. Community-scale air toxics monitoring projects conducted that were granted in 2003/2004, 2005/2006, or 2007/2008 solicitations. Projects are organized by primary (P) focus of the study: community monitoring, method development, or data analysis. Secondary (S) objectives are also noted.

Region	State	Community	Project Title and Brief Description	Risk/Health/Baseline Characterization	Emissions Characterization	Model Evaluation	Develop Methods	Analyze Existing Data
9	Arizona	Phoenix	*Phoenix Arizona Air Toxics Assessment.* Final report for JATAP project. Performed risk assessment and emissions, meteorological, and air quality modeling.					P
9	California	Los Angeles	*The Port of Los Angeles Community-Based Air Toxics Exposure Study.* Conducted monitoring to understand the polycyclic aromatic hydrocarbon (PAH) levels in the area on a real-time basis and to more accurately estimate health risk using direct PAH measurements rather than surrogates.	P				
9	California	Sun Valley (Los Angeles)	*Air Toxics Study*. Sub-regional air toxics study conducted as a complement to the Multiple Air Toxics Exposure Study (MATES III). Monitoring conducted in population centers surrounded by various industrial sources.	P	S			
9	California	Roseville (Placer County)	*Placer County Roseville Rail Yard Air Toxics Monitoring Project. Conducted monitoring to characterize the magnitude of diesel particulate matter (DPM) emissions from a rail yard.*		P			
10	Idaho	Lewiston	*Nez Perce National Air Toxics Program Characterization of Air Toxics Concentrations around a Kraft Pulp and Paper Mill Facility. Conducted monitoring to characterize air toxics concentrations, assess contributions to ambient air toxics concentrations from paper mill emissions, and perform risk screening.*	P	S	S	S	

Table 3-1. Community-scale air toxics monitoring projects conducted that were granted in 2003/2004, 2005/2006, or 2007/2008 solicitations. Projects are organized by primary (P) focus of the study: community monitoring, method development, or data analysis. Secondary (S) objectives are also noted.

Region	State	Community	Project Title and Brief Description	Risk/Health/Baseline Characterization	Emissions Characterization	Model Evaluation	Develop Methods	Analyze Existing Data
10	Idaho	Treasure Valley	*Air Toxics Study.* Monitored air toxics at sites in the Boise area. Characterized the spatial and seasonal trends of air toxics and identified sources of the pollutants. Performed source apportionment, model-to-monitor comparison, and risk screening.	P				
10	Oregon	Portland	*Air Toxics Community Assessment Monitoring Project.* Characterized air toxics in areas of concern. Performed modeling and compared to measured data. Tested a new instrument.	P		S	S	
10	Washington	Spokane	*Air Toxics Study 2005.* Conducted monitoring of air toxics to characterize levels, compared to modeled data, and performed source-receptor modeling.	P	S	S	S	
10	Washington	Tacoma	*Evaluation of New Methods for Source Apportionment Using Real-Time Continuous Monitoring Instruments.* Evaluated a number of novel methods to estimate diesel emissions and to characterize diesel sources, including vehicles and marine vessels.					P
10	Washington	Tacoma and Seattle	*Air Toxics Evaluation – Comparison of Key Risk Drivers Across Sites in Two Cities.* Monitoring conducted to identify key risk drivers and compare concentrations across sites.	P				

4. Individual Project Summaries – Completed

This section provides a brief summary of each project to date. Project summaries provide the pollutants monitored, project goals, key findings by topic area, and a generalized list of lessons learned (if available) that may be applicable to community-scale or other monitoring efforts in the future. Projects are grouped by primary type: community-scale monitoring, methods development, and data analysis. Within each subsection, the studies are listed by EPA Region, State, metropolitan area, then chronologically. EPA regions are displayed in Figure 1-1.

The pollutants listed include those identified in Table 2-1 as national key risk drivers. The term VOCs typically includes benzene, 1,3-butadiene, carbon tetrachloride, and tetrachloroethylene. When acrolein is measured using TO-15 or similar canister collection and analysis technique, it is listed. Carbonyls typically include formaldehyde and acetaldehyde; we note when acrolein is reported as measured from cartridge collection and analysis. Naphthalene is listed with PAHs if collection includes both gaseous and particulate collection. Particle-bound PAHs typically refers to species such as benzo-a-pyrene, pyrenes, phenanthrene, and others. Total chromium and arsenic are typically reported with PM_{10} or total suspended particulate (TSP) metals analyses. Hexavalent chromium is reported from a different collection and analysis technique and thus is listed separately.

4.1 EPA Region 1: New England

4.1.1 State of Connecticut: Evaluation of Wood Smoke Contribution to Particulate Matter

The Connecticut Department of Environmental Protection conducted an ambient air monitoring study to characterize the contribution of particulate matter from wood burning sources. Monitoring was conducted at one core site and six satellite sites. Sampling was conducted using continuous measurements of black carbon (BC), organic carbon/elemental carbon (OC/EC), and particle-bound PAHs from September 2006 through April 2008. Additionally, trace metals measurements were collected, but were not yet analyzed or discussed in the study report. Modeling was applied to the data collected to apportion the sources and quantify wood smoke PM. A project summary is provided in **Table 4-1**.

Table 4-1. Connecticut State: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
$PM_{2.5}$ OC, EC Sulfate CO, SO_2, NO_y Trace metals PAHs Optical absorption of PM at two wavelengths	• Characterize the contribution of wood smoke to ambient $PM_{2.5}$ concentrations in Connecticut. • Conduct monitoring and testing to characterize the emissions for outdoor wood furnaces (OWFs), outdoor wood boilers (OWBs), or hydronic heaters. • Investigate control options for reducing wood smoke emissions from outdoor wood furnaces.
Risk Characterization	
• The annual average contribution of wood smoke PM to $PM_{2.5}$ mass ranged from 1.7% to 17.3% across the sites. • As expected, wood smoke PM contributions were greatest during the colder, winter months. For all sites, maximum monthly average wood smoke contributions in the winter ranged from 10.8 to 41.3%, while maximum monthly summertime averages ranged from zero to 6.1%. • Wood smoke contributions were significant (more than 25%) on cold days when $PM_{2.5}$ concentrations were above 15 $\mu g/m^3$.	
Emissions Characterization	
• A study-wide scaling factor, used to scale the Delta-C wood smoke signal from the Aethalometer to wood smoke PM concentrations at all sites was 7.8. • Wood smoke PM and PAH measurements sometimes correlated and sometimes did not. This finding is consistent with the fact that PAHs are emitted by both wood smoke and mobile sources. • High time resolution source apportionment using Unmix showed the morning rush-hour peak for mobile sources, the steady contribution from oil-burning sources and decrease in the wood burning sources during the traditional workday hours. • The Delta-C measurement provides a consistent indicator of wood smoke for local wood burning sources, but was found to be much less reliable for wood smoke that has undergone significant transport, particularly when exposed to UV radiation.	
Lessons Learned	
• EPA test methods for outdoor wood boilers may under-represent real-world emissions by a factor of four.	

4.1.2 Warwick, RI: Characterization of Ambient Air Toxics in Neighborhoods Abutting T.F. Green Airport and Comparison Sites

The Rhode Island Department of Environmental Management Office of Air Resources conducted a study to characterize ambient air toxics in neighborhoods abutting T. F. Green Airport. The study was designed to address local concerns by providing data to characterize current health risks from inhalation of air toxics in Warwick and, to the extent possible, identify the contribution of the airport and other stationary and mobile sources to those risks. Five ambient monitoring sites were deployed—four near the airport and one comparison neighborhood site. Sampling included 24-hr integrated samples, short-duration samples during peak emissions periods and real-time instruments. The 24-hr integrated air toxics samples

were collected on a one-in-six day schedule from April 2005 to June 2006. Additionally, 3-hr samples were collected from 6 a.m. to 9 a.m. EDT from June 2006 through September 2006 on a one-in-six day schedule to characterize heavy airport and roadway traffic conditions. Aethalometer measurements of BC were collected at 1-minute, 5-minute, and 1-hr averaging periods from May 2005 through August 2006. A project summary is provided in **Table 4-2**.

Table 4-2. Warwick, RI: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls BC $PM_{2.5}$	• Characterize the ambient air toxics levels in neighborhoods around the airport and a comparison Warwick neighborhood. • Determine the impacts of various source types on air toxics levels at the monitoring locations. • Compare monitored-to-modeled concentrations. • Establish a baseline that can be used to evaluate the air quality impacts of planned changes in airport operations.
Risk Characterization	
• For all of the measured pollutants with benchmarks, the maximum concentrations observed were substantially lower than the corresponding acute health benchmarks. • Annual average concentrations of all the VOCs and carbonyls measured were substantially lower than the corresponding chronic noncancer health benchmarks. • Concentrations of formaldehyde, carbon tetrachloride, benzene, chloroform, acetaldehyde, and 1,3-butadiene were above the corresponding cancer health benchmarks at all of the Warwick sites.	
Emissions Characterization	
• The source of elevated formaldehyde concentrations at one site relative to others was not identified; sampling errors were likely not the cause of the high concentrations. • Elevated concentrations of benzene and 1,3-butadiene were associated with motor vehicle emissions. • Elevated concentrations of tetrachloroethylene were likely due to dry cleaning facilities. • Elevated concentrations of BC were influenced by airport activities and meteorology. • $PM_{2.5}$ levels were not clearly influenced by airport actives.	
Model Evaluation	
• Modeled values from NATA 1999 were within 50% of the monitored values for many of the pollutants.	
Methods Development and Evaluation	
• The CEREX open-path optical system failed to produce reliable data. The system was costly to maintain and the associated software was problematic.	
Outcomes	
• The study resulted in the requirement of long-term monitoring for selected pollutants to assess air toxics exposure impacts from the airport. In addition, diesel-powered ground support equipment used by the airport is to be phased out.	
Lessons Learned	
• Higher time resolution of VOC and carbonyl sampling, such as was available for BC, would aid in source identification. • Communication of results/progress to the community was problematic and may have been better handled by a different agency.	

4.1.3 Burlington, VT: Spatial and Temporal Concentrations of Benzene in Two Northern New England Communities

The Vermont Air Pollution Control Division conducted monitoring to provide data for model evaluation. A combination of multiple sites were employed: sites with 24-hr canisters over the study year (one-in-twelve day), multiple sites with 6-hr samples collected during intensive periods, and one site with a semi-continuous sampling system for benzene. Sampling was conducted at urban, source-impacted, and rural site types. A project summary is provided in **Table 4-3**.

Table 4-3. Burlington, VT: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
Benzene	• Characterize risk due to ambient benzene concentrations. • Validate a modeling tool.
Risk Characterization	
• Results from the expanded monitoring network indicated that the existing routine monitoring location measured a higher annual average benzene concentration than other monitoring locations in Burlington. Therefore, the risk within and across Burlington due to benzene exposure may be less than previously indicated based on data solely from one monitoring location.	
Model Evaluation	
• California Puff model (CALPUFF) model was able to reasonably predict ambient air concentrations throughout Burlington. Model performance was improved over longer time scales. • The CALPUFF model was not able to capture short-term peaks in benzene concentrations.	

4.2 EPA Region 2: New Jersey, New York, Puerto Rico, and the Virgin Islands

4.2.1 Paterson City, NJ: Urban Community Air Toxics Monitoring Project

Monitoring was conducted by the New Jersey Department of Environmental Protection (NJDEP) in Paterson City, a highly industrialized urban area. Overall, the project sought to provide information and develop tools and methods to better address exposure and risk issues related to air toxics. Four sites represented industrial, commercial, and mobile source dominated emissions and background (rural). Sampling was performed on a one-in-six day schedule from November 2005 through December 2006. A project summary is provided in **Table 4-4**.

Table 4-4. Paterson City, NJ: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls PM_{10} species PM_{10} mass Hexavalent chromium EC and OC PAHs	• Characterize the spatial resolution of local air toxics including gradients. • Identify source signatures from various land uses. • Evaluate modeling results using monitoring data. • Field test new sampling and analytical techniques for air toxics that are currently difficult to quantify. • Characterize the concerns of an Environmental Justice (EJ) type community. • Identify risk reduction strategies and implement feasible strategies.

Risk Characterization

- One air toxic, p-dichlorobenzene, showed a significant increase in concentration during two months (mid-October through mid-December) of the 14-month monitoring period in which concentrations increased by up to three orders of magnitude over the levels observed during the other months of monitoring. A source was not found.
- Cancer risks above the NJDEP air program guideline value of one-in-a-million cancer risk included arsenic, 1,3-butadiene, benzene, carbon tetrachloride, chloroform, chloromethane, ethylbenzene, p-dichlorobenzene, and tetrachloroethylene.

  Concentrations at the commercial site indicated that the site was impacted by stationary emissions more than the industrial designated site.

Methods Development and Evaluation

- Environmental and Occupational Health Sciences Institute (EOHSI) developed new techniques to measure carbonyls, acrolein, and hexavalent chromium; the techniques were used in this study.
- PAKS, a passive sampler, was tested for carbonyls and acrolein. Acrolein precision was good while formaldehyde, acetaldehyde, and propionaldehyde concentrations were overestimated.
- Hexavalent chromium measurement evaluation was inconclusive and is undergoing further testing.

Model Evaluation

- Monitored and modeled NATA 2002 concentrations were within a factor of two for most air toxics with the exception of manganese, p-dichlorobenzene, formaldehyde, acetaldehyde, and acrolein (monitored much higher than modeled). However, note that the carbonyl measurements may have been biased high.
- The comparison of the CALPUFF model with monitoring data showed very good agreement for some compounds but not for others. The model over-predicted the mobile source related VOCs.

Outcomes

- Three facilities installed anti-idling signs.
- One facility ceased the practice of crushing fluorescent bulbs onsite (reduced mercury vapor).

Lessons Learned

- Complete emissions inventory, site visits, and screening of modeling/monitoring before finalizing monitoring locations and targeting air toxics.
- Local meteorological measurements should be collected at every site.
- More detailed information on actual emissions in permits and emissions statements would have been helpful when compiling the emissions inventory.
- A more timely assessment of the data would have been helpful to enforcement if there were issues that required attention.
- Projects of this scope require the cooperation of many program areas in a state agency.
- It is difficult to form a community group “from scratch.”

4.2.2 New Jersey: Results of Targeted $PM_{2.5}$, TSP, and PAHs Monitored at a Heavily Trafficked New Jersey Turnpike Location

The New Jersey Meadowlands Commission Meadowlands Environmental Research Institute conducted a near-road monitoring study to identify ambient air quality gradients at three different distances (50 m, 100 m, and 150 m) from the New Jersey Turnpike (NJTPK). Samples were collected on a one-in-six day schedule between September 2007 and September 2008. A project summary is provided in **Table 4-5**.

Table 4-5. New Jersey Turnpike: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
$PM_{2.5}$ TSPs PAHs	• Examine the spatial and seasonal patterns of $PM_{2.5}$, TSP, and PAH concentration gradients. • Investigate the influence of the traffic density/pattern and meteorological conditions on airborne-contaminant levels.
Baseline Characterization	
• The PAH and TSP average concentrations decreased significantly with increasing distance from the highway over the year but there are no significant differences in $PM_{2.5}$ concentrations. • $PM_{2.5}$ levels were not significantly influenced by total traffic count. Moderate correlations of PAHs and TSP with total traffic counts were found and higher concentrations were observed on weekdays than weekends.	

4.2.3 Rahway, NJ: Development and Optimization of a Sampling and Analytical Method to Measure Hexavalent Chromium in Ambient Air

The Environmental and Occupational Health Sciences Institute (EOSHI) at Rutgers and NJDEP collaborated to develop a sensitive and reliable method for measuring ambient hexavalent chromium. Field evaluations were conducted in week-long intensives in summer (August-September 2008) and winter (February-March 2009). Sample durations were 24-hr and collected daily during the intensives. Filters were spiked with isotopes of Cr during sampling as an internal standard to monitor conversion of hexavalent chromium to trivalent chromium. A project summary is provided in **Table 4-6**.

Table 4-6. Rahway, NJ: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
Hexavalent chromium	• Develop a reliable method for the measurement of hexavalent chromium. • Optimize the ion chromatography (IC) combined with the inductively coupled plasma mass spectrometry (ICP-MS) method for Cr(VI) analysis to lower the detection limit to the one-in-a-million risk level. • Reduce Cr(VI) on blank filter. • Determine recovery and conversion rate of Cr(VI) and Cr(III) during sampling, storage, and extraction. • Characterize factors that potentially affect the stability of Cr(VI). • Evaluate the method in a field study.

Table 4-6 cont'd – Rahway NJ

Methods Development and Evaluation
• Good method sensitivity was attained with a method detection limit very close to the study goal. Good precision was obtained as well. • Cr(VI) collected during the winter was found to be relatively stable during the entire measurement process, with an average recovery greater than 69%; however, recovery was lower in summer than in winter. Thus, to reduce the potential Cr transformation during sample collection, a cooling system is needed. • The conversion from Cr(VI) to Cr(III) was negligible.
Lessons Learned
• It would be very helpful to develop a certified Cr(VI) ambient PM standard reference material so the recovery and inter-conversion rates could be verified.

4.2.4 Akwesasne, NY: Characterization of Benzene and Other Air Toxics

The St. Regis Mohawk Tribe Environment Division assessed the impact of benzene and other air toxics on the Akwesasne Community with the Center for Air Resources Engineering and Science at Clarkson University. One-in-six day 24-hr duration ambient air sampling was conducted at nine locations throughout the community over one year from May 2007 through May 2008. Vehicle exhaust, whole gasoline, and personal sampling were also conducted. Emissions sampling was instant, while personal samples lasted 6 to 8 hours, depending on individual activity patterns. A project summary is provided in **Table 4-7**.

Table 4-7. Akwesasne, NY: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
Benzene, toluene, ethylbenzene, xylenes (BTEX)	• Conduct monitoring to understand the impacts of industrial emissions on air quality on the Community.
Risk Characterization	
• Ambient benzene concentrations at sites in the community were 60% higher than concentrations found at rural sampling sites in NY state; concentrations were above the cancer benchmark. • Benzene concentrations showed expected seasonal pattern with concentrations highest during fall and winter (low ambient temperatures and mixing heights reduced mixing).	
Emissions Characterization	
• Sources of benzene in Akwesasne were vehicle exhaust and evaporation losses from gasoline. • Benzene emissions from the neighboring aluminum smelting plant did not impact the reservation. • Personal sampling revealed the highest exposure to BTEX concentrations was found for a gasoline station attendant.	
Lessons Learned	
• Community involvement helped make the project a success.	

4.2.5 Tonawanda, NY: Community Air Quality Study

The New York State Department of Environmental Conservation conducted a monitoring study to determine the ambient concentrations of selected air toxics and criteria pollutants at four locations (including coke oven facility perimeter and upwind background sites) in Tonawanda, New York. Sampling of air toxics occurred on a one-in-six day schedule from July 2007 through June 2008. A risk characterization was performed and concentrations were used to evaluate the Regional Air Impact Modeling Initiative (RAIMI), American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC) Dispersion Model (AERMOD), and NATA 2002 predictions. A project summary is provided in **Table 4-8**.

Table 4-8. Tonawanda, NY: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls $PM_{2.5}$ SO_2 CO	• Evaluate influence of wind direction on monitored concentrations. • Compare annual average concentrations to health-based guidelines and characterize risk. • Assess emissions and potential contribution to monitored concentrations for mobile sources, large (major) and small (area) industrial and manufacturing sources. • Compare model and monitor results.
Risk Characterization	
• The annual average concentration for five air toxics (1,3-butadiene, acetaldehyde, benzene, carbon tetrachloride, formaldehyde) exceeded the cancer risk screening level of one-in-a-million and acrolein exceeded the noncancer health-based comparison value. • Benzene concentrations were highest at the site closest to the coke facility. Concentrations at this site were above the 95th percentile nationally. • In the study area, the concentrations of benzene and formaldehyde were much higher, as compared to other industrial and urban monitors in the state.	
Model Evaluation	
• Monitor-to-model results compared well for ten air toxics using RAIMI and AERMOD. • The comparisons of the monitoring data to the preliminary 2002 NATA predictions were good for many air toxics. However, the NEI under-reported acrolein emissions for the entire Tonawanda area and under-reported 1,3-butadiene, benzene, ethylbenzene, formaldehyde, and propionaldehyde emissions for sources near one of the monitors.	
Outcomes	
• Monitoring was continued to further understand impacts on benzene, formaldehyde, and PAH concentrations near the industrial facilities.	
Lessons Learned	
• Acrolein results should be viewed with caution because of known (now) sampling and analysis issues. The analytical laboratory found many validation comparisons exceeding the acceptable limit. • The weight of evidence technique used to assess impacts from the coking facility on monitored concentrations could be applied to other similar data sets. • Communicating technical results to the public proved to be challenging.	

4.2.6 New York State: Air Monitoring plan for Establishing an Ambient Mercury Baseline

The New York State Department of Environmental Conservation (NYSDEC) conducted monitoring of ambient mercury to establish baseline concentrations and characterize ambient elemental, divalent, and particle-bound mercury. NYSDEC operated Tekran Mercury Speciation Units at two urban locations in New York—Rochester and Bronx—to characterize ambient air concentrations of particle-bound mercury (PBM), reactive gaseous mercury (RGM), and elemental mercury [Hg(0)]. Sampling occurred at a 2-hr frequency from August 2008 through September 2010. NYSDEC also measured wet Hg deposition. A project summary is provided in **Table 4-9**.

Table 4-9. State of New York: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
Particle bound mercury (PBM) Reactive gaseous mercury (RGM) Elemental mercury [Hg(0)]	• Establish a reference baseline for mercury air concentrations and wet deposition in urban areas. • Compare urban concentrations to rural concentrations. • Use data, with other mercury monitoring measurements within New York and the surrounding states, to track progress of mercury reduction efforts for the two largest source categories: municipal waste combustors and coal-fired electric utilities.
Baseline Characterization	
• Urban monitors measured slightly higher average mercury concentrations than rural monitors. • Average RGM and PBM concentrations were three times higher at urban sites than at rural sites. • RGM has a springtime maximum in concentration. PBM has a wintertime maximum. The seasonal patterns are associated with meteorological temperatures and mixing heights.	
Methods Development and Evaluation	
• SOPs for the Tekran mercury samplers were developed.	
Lessons Learned	
• Budget sufficient lead time and resources to begin operational deployment of new instruments for monitoring.	

4.3 EPA Region 3: Mid-Atlantic

4.3.1 Wilmington, DE: Enhanced Delaware Air Toxics Assessment Study

The Delaware Department of Natural Resources and Environmental Control Division of Air and Waste Management conducted monitoring to augment previously collected data. Collaborators included University of Delaware and Duke University researchers. Both fixed and mobile monitoring were conducted. The fixed site was in an urban setting surrounded by a mix of emissions sources. Mobile monitoring focused on industrial sources. In both the fixed and mobile monitoring, a series of short intensive operating periods constituted the bulk of the

monitoring; sampling occurred in May-June 2005, July-August 2005, November 2005, and January-February 2006. A project summary is provided in **Table 4-10**.

Table 4-10. Wilmington, DE: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
Formaldehyde Ultrafine PM Ozone CO NO_x $PM_{2.5}$ hexavalent and trivalent chromium	• Use mobile monitoring to characterize PM near industrial sources. • Characterize seasonal and spatial variability of ultrafine particles using a new method. • Collect pollutant concentrations with routine and new methods for comparison. • Develop long-term partnerships with the research community.
Risk Characterization	
• Hexavalent chromium concentrations varied significantly spatially. • As expected, formaldehyde concentrations were highest in spring and summer compared to winter. • At the central site, formaldehyde concentrations correlated with $PM_{2.5}$ and PM_{10} mass, indicating the influence of long range transport on formaldehyde concentrations. • Consistent with secondary formation, ozone and formaldehyde concentrations showed lower variability than aerosol concentrations (which were influenced by local source emissions). • Internal capabilities were developed for making real-time VOC measurements.	
Emissions Characterization	
• PM less than 1 micron was comprised of secondary aerosol of regional (38%) and local (27%) origin and biomass burning (14%). • Some source sampling was conducted (landfill, steel processing, coal fired power plant). • Local industrial combustion sources, diesel vehicle exhaust, and ships were identified in particle signatures.	
Methods Development and Evaluation	
• Steam-Jet Aerosol Collector–Long Pathlength Absorbance Spectroscopy (SJACLPAS), a high time resolution, automated instrument for 1) mobile measurements of spatial distribution of hexavalent and water-soluble trivalent chromium in ambient aerosols ($PM_{2.5}$) and 2) continuous formaldehyde measurements, was specifically developed for this study. • Real-Time Single Particle Mass Spectrometer (RSMS-3) was used to characterize aerosol size distribution and composition in real time.	
Outcomes	
• Data will be useful to improve strategic planning and monitoring, which, in turn, will help reduce emissions.	
Lessons Learned	
• Budget sufficient time and resources for the project. For example, the study authors would have preferred sufficient funding to use the Public Affairs Department to continue outreach efforts. • In hindsight, the authors would have potentially collaborated with different partners because of the proprietary nature of the sampling technology that arose during the study.	

4.3.2 Pittsburgh, PA: Air Toxics in Allegheny County

Allegheny County Health Department and Carnegie Mellon University collaborated to monitor air toxics in the Pittsburgh area, assess risk, and evaluate emissions sources. Sites included residential areas near a heavily industrialized area, downtown Pittsburgh, and a rural background site. Measurements were made on a one-in-six day schedule during 2006 at all sites to collect baseline data. Additionally, hourly measurements were made using a GC/MS/FID for four intensive operating periods lasting a few months in 2002, 2007, and 2008. A project summary is provided in **Table 4-11**.

Table 4-11. Pittsburgh, PA: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls BC SVOCs PAHs	• Measure airborne concentrations of gaseous and particulate air toxics around Neville Island (industrial), in downtown Pittsburgh, and at a background site. • Estimate human exposure and health risks. • Quantify the contribution of different sources (regional background, industrial, mobile) to airborne concentrations and estimated health risks. • Establish the relative importance of regional transport versus local sources to air toxics exposures in the county. • Compare air toxics concentrations and estimated health risks to other areas of the country where adequate data exist.
Risk Characterization	
• Concentrations of benzene, toluene, propionaldehyde, tetrachloroethene, ethyl benzene, methylene chloride, styrene, 1,4-dichlorobenzene, trichloroethene, and hydrogen sulfide were greater than the national 75th percentile at all of the sites. • The air toxics contributing most to risk were formaldehyde, benzene, and carbon tetrachloride. Trichloroethene and 1,4-dichlorobenzene also added substantial risks at the downtown site. Only acrolein is predicted to pose a noncancer health risk.	
Emissions Characterization	
• Source apportionment indicated benzene from metallurgical coke production impacted residential sites adjacent to Neville Island. • Sources of elevated concentrations of 1,4-dichlorobenzene and trichloroethene at the downtown site were unknown. • Mobile source tracers, hopanes and stearanes, were used with BC to identify gasoline and diesel activity. • Plume strikes on monitoring sites were identified using the hourly data.	
Model Evaluation	
• Comparison of monitored data to NATA 1999 showed that the model systematically under-predicted concentrations. The worst model performance was for styrene and other pollutants specific to point sources.	

Methods Development and Evaluation
• An auto-GC was used to measure a number of air toxics and other hydrocarbons. Good agreement with 24-hr canister results was found for most compounds; those that did not agree were excluded from data analysis. • Thermal Desorption Aerosol GC-MS based system (TAG) provided a large suite of semi-volatile organic molecular markers and air toxics.
Lessons Learned
• Highly time resolved measurements aided in source identification and provided more statistical power to data analysis (including source apportionment).

4.3.3 Hopewell, VA: Risk Assessment for Air Toxics Measured in Three Cities

The Virginia Department of Environmental Quality Office of Air Quality Monitoring conducted monitoring at three sites to obtain data for a risk characterization. Sampling occurred at a one-in-six day frequency from December 2006 through September 2008. Risk characterization was performed to identify key compounds of concern for cancer and noncancer chronic effects. A project summary is provided in **Table 4-12**.

Table 4-12. Hopewell, VA: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls BC PM_{10} metals Hexavalent chromium	• Conduct monitoring to obtain data for risk characterization. • Identify potential existence of hot spots. • Compare monitored data to NATA.
Risk Characterization	
• Concentrations and risks were very similar to those in other urban areas in Virginia. Excess cancer risks for each of the sites exceed the 1×10^{-4} benchmark at both the 50^{th} and 90^{th} percentile concentrations. Hazard indices at each site exceeded 1.0. • Chemicals of concern for cancer risk included carbon tetrachloride and formaldehyde, and to a lesser degree, benzene and arsenic. Noncancer chemicals of concern were acrolein and formaldehyde.	
Model Evaluation	
• NATA 1999 over-predicted the concentrations of benzene, chloroform, toluene, and chromium VI and under-predicted concentrations of acrolein, acetaldehyde, carbon tetrachloride, formaldehyde, methylene chloride, and hexane relative to measured values. Estimates of the other available compounds compare favorably to the observed values.	
Lessons Learned	
• Information obtained assisted in the development of residual risk standards.	

4.4 EPA Region 4: Southeast

4.4.1 Birmingham, AL: Air Toxics Study and Risk Assessment

The Jefferson County Department of Health (JCDH) conducted an air toxics monitoring study at four locations in Jefferson County, Alabama. The purpose of this study, called the Birmingham Air Toxics Study (BATS), was to assess the potential health effects resulting from the local population's exposure to chemicals in ambient air. Two monitoring locations were selected for their proximity to industrial facilities including two coke plants, a mineral wool plant, quarrying operations, a large pipe mill, and a steel mini-mill; there are also adjacent neighborhoods. The third site was selected for its proximity to mobile sources and the fourth site was in a rural setting. Sampling was performed on a one-in-twelve day schedule from July 2005 through July 2006. A project summary is provided in **Table 4-13**.

Table 4-13. Birmingham, AL: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs (incl. 1,4-dichlorobenzene) PAHs (incl. naphthalene) Carbonyls TSP and PM_{10} metals Hexavalent chromium	• Investigate the potential cancer risk and noncancer hazard posed by chemicals present in ambient air. • Identify potential sources of chemicals with greatest risk.
Risk Characterization	
• Cumulative cancer risks were highest at the site closest to industrial sources and lowest at the rural site. • Of the 14 different chemicals identified as potential cancer risk drivers, six were listed at all four sites, including the rural monitor: 1,3-butadiene, acetaldehyde, arsenic, benzene, carbon tetrachloride, and p-dichlorobenzene. At the urban sites, an additional two chemicals (naphthalene and tetrachloroethylene) were potential risk drivers. • Benzene was among the top three contributors, percentage-wise, to risk at all four monitoring sites. Carbon tetrachloride was among the top four contributors to risk at all sites.	
Outcomes	
• The JCDH is working with a coke by-products plant to reduce concentrations of several chemicals that were found to be risk drivers, including benzene.	
Lessons Learned	
• More frequent sampling than one-in-twelve day is needed to increase the certainty in a risk assessment.	

4.4.2 Port of Tampa, FL: Inhalation Risk Posed by Toxic Emissions from the Port of Tampa

This project, conducted by the Environmental Protection Commission of Hillsborough County, was designed to perform additional sampling, analysis, and characterization of air toxics to supplement findings from the 1996 NATA, a 2001 monitoring study, and routine

monitoring efforts. The project assessed new open-path measurement methods. One mobile site and three fixed sites (commercial, port, and neighborhood) in Tampa were deployed. Integrated samples of air toxics were measured on a one-in-six day schedule for one year beginning in 2004. Measurements of BC, SO_2, and ozone were collected hourly during the study. A project summary is provided in **Table 4-14**.

Table 4-14. Port of Tampa, FL: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls PM_{10} metals BC SO_2 Ozone	• Monitor air toxics emissions using open path monitoring systems – CEREX ultraviolet (UV), OPSIS Differential Optical Absorption Spectroscopy (DOAS), and Fourier Transform Infrared Spectroscopy (FTIR). • Compare open path monitoring results between methods and to fixed point measurement results. • Characterize spatial and temporal variations in pollutant concentrations and risk. • Distinguish between highway and marine DPM. • Establish baseline concentrations for future studies. • Perform QA/QC and define precision and accuracy of the data.
Emissions Characterization	
• Measurements were inadequate to distinguish between highway and marine DPM sources. • Air toxics concentrations attributed to impacts from crematory emissions were above noncancer and cancer health effects levels for metals and above cancer health effects levels for benzene. • Methods used were developed in this study to perform additional monitoring near a styrene-emitting facility (spa manufacturing). • Monitoring results were used to help evaluate new and existing facility permitting.	
Methods Development and Evaluation	
• Comparison of fixed-point monitors with open path UV measurements showed that ozone and SO_2 measurements were comparable. • Different monitoring methods were not as intercomparable for air toxics as anticipated. • An EPA Region 4 workgroup was established to evaluate and set method detection limits (MDLs) for analytical methods.	
Lessons Learned	
• Large differences in the detection limits and reporting levels of air toxics data were found for different laboratories.	

4.5 EPA Region 5: Great Lakes

4.5.1 Chicago, IL: LAMP II-BTEX Characterization of Chicago and O'Hare Airport Areas

The Larger Area Monitoring Program (LAMP) was designed to test an innovative diffusion tube (passive sampling) technology to measure and characterize ambient air

concentrations of BTEX throughout the greater Chicago area in a saturation study (i.e., sampling at many sites). The project was conducted in two phases with a year-long study comparing sampling methodology to routine measurements in Phase I (not a part of CSATAM) and the saturation study in Phase II. Duplicate passive sampling occurred at all sites for month-long durations for a twelve month period during the 2005 calendar year. A project summary is provided in **Table 4-15**.

Table 4-15. Chicago, IL: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs	• Obtain annual average BTEX concentrations for risk screening. • Provide baseline concentrations to assess effectiveness of future emissions reduction strategies. • Compare diffusion tube results to those obtained from VOC canisters and field GCs. • Determine spatial variability in BTEX concentrations including identification of "hot spots." • Characterize air toxics concentrations near significant point sources (O'Hare Airport, expressways).
Risk Characterization	
• BTEX concentrations varied significantly by month. • Concentrations were highest at sites near roadways and in densely populated areas. • A second air monitoring site was added to the airport for routine measurements.	
Emissions Characterization	
• BTEX concentrations near O'Hare Airport were 50% higher than concentrations observed at routine monitoring sites (Northbrook, Chicago-Jardine). The higher concentrations were likely associated with expressway/arterial traffic and airport traffic.	
Method Development and Evaluation	
• Diffusion tube results generally over-predicted BTEX concentrations measured by the field GCs.	
Outcomes	
• The study recommended to the Federal Aviation Administration (FAA) that air toxic emissions be included in a future Environmental Impact Statement (EIS) if and when the airport is expanded.	
Lessons Learned	
• The study authors noted that they would have benefited from more sites (more data leading to more statistical power) and additional duplicative analysis (improved understanding of data quality and data capture).	

4.5.2 Indianapolis, IN: Community-Scale Air Toxics Study

The Indiana Department of Environmental Management worked with a diverse group of stakeholders to conduct air toxics monitoring at two sites in Southwest Indianapolis. Monitoring sites were in areas of high population. Both sites followed a one-in-six day monitoring schedule from October 2006 through October 2008. Additionally, an emissions inventory assessment

and an evaluation of air quality modeling were performed. A project summary is provided in **Table 4-16**.

Table 4-16. Indianapolis, IN: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls PM_{10} metals Hexavalent chromium	• Collect air toxics monitoring data within the study area. • Develop a detailed emissions inventory of all industrial and business sources in the area. • Conduct community-scale detailed air toxics modeling. • Assess and characterize potential health risks from air toxics to the community. • Communicate results of the study.
Risk Characterization	
• Concentrations measured were similar to those found throughout Indiana and other Midwestern cities. • Mobile sources were identified as the largest contributor to risk. • Benzene was the most important air toxic with respect to risk. • Acrolein concentrations were above health protective benchmarks at both monitoring locations. Acrolein appears to be a non-localized pollutant.	
Emissions Characterization	
• No industry-caused hot spots were observed in residential areas of the study.	
Model Evaluation	
• Measured air toxics concentrations were lower than those predicted by the NATA 1999.	
Data Analysis	
• Extensive documentation was provided of the statistical approach used in the study and data validation.	
Outcomes	
• Two pollution prevention measures were begun as a result of this study: 1) promoting the use of the Green Steps environmental management program at local schools, and 2) encouraging local trucking companies to join the Voluntary Idling Program	
Lessons Learned	
• In comparing measured concentrations to other cities, the public was most interested in comparison to other Midwestern cities rather than the entire U.S.	

4.5.3 Detroit, MI: Delray Community Monitoring

The Michigan Department of Environmental Quality (MDEQ) community monitoring project was multi-faceted including monitoring, method evaluation, and data analysis. MDEQ assessed data from two new monitoring sites to further investigate the impact of air toxics emissions from mobile and stationary sources on the air quality in the Del Ray area of Detroit and near the international border crossing at the Ambassador Bridge. Continuous formaldehyde samplers were also tested. Measurements of BC, EC, OC, NO_x, and formaldehyde were made hourly. Measurements of speciated OC, $PM_{2.5}$ metals, and PM_{10}

metals were sampled on a one-in-six day schedule. This study complemented the Detroit Exposure Aerosol Research Study (DEARS). A project summary is provided in **Table 4-17**.

Table 4-17. Detroit, MI: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
Carbonyls (formaldehyde) $PM_{2.5}$ $PM_{2.5}$ metals PM_{10} metals EC and OC BC Speciated OC NO_x CO	• Characterize air quality at two new sites and establish baseline concentrations. • Assess impact of border crossing traffic emissions on neighborhood. • Investigate middle- and micro-scale variability in air toxics concentrations. • Field test continuous formaldehyde and trace level carbon monoxide monitors. • Provide data for source apportionment with a focus on mobile sources including DPM tracers.
Risk Characterization	
• A communication strategy was developed to inform the public about results. • Monitoring was continued at new sites based on results of this study and the DEARS study.	
Emissions Characterization	
• The Ambassador Bridge and Detroit Intermodal Freight Terminal (DIFT) emissions were targeted in the study, but not characterized. The impacts of these source areas were identified using BC (specifically 1-minute data) and nonparametric linear regression, but not quantified.	
Methods Development and Evaluation	
• Continuous formaldehyde instruments were not reliable enough for unattended operation in the field. • Optimization of the continuous samplers, such as Aethalometer measurements of BC, needed to be done to improve precision. • Operating techniques were improved and standard operating procedures (SOP) were updated for the EC/OC samplers.	
Lessons Learned	
• Security measures needed to be improved at monitoring sites to prevent vandalism. Vandalism at the school site reduced data capture during 2005. • The grant provided the opportunity for the agency to build in-house knowledge of source apportionment modeling and statistical analysis. • Back up instruments (for replacement upon primary instrument failure) would have increased data capture.	

4.5.4 Milwaukee, WI: Evaluation of Passive Sampling Techniques for Monitoring Roadway and Neighborhood Exposures to Benzene and Other Mobile Source VOCs

The Wisconsin Department of Natural Resources conducted an evaluation of passive sampling to monitor roadway and neighborhood exposures to benzene and other mobile source VOCs. Two passive sampling methods were tested: passive adsorbent samplers for week-long measurements and passive canister samplers for short-term peak measurements. Measurements were compared to existing routine VOC measurements. Sampling occurred

next to two urban highway segments and a rural highway. Nine to eleven sites were deployed in each of the three measurement campaigns. Sampling times for the passive samplers were approximately one week. Three intensive studies were performed: a five-week study beginning in November 2006, a four-week study beginning in March of 2007, and a four-week study beginning in April of 2007. A project summary is provided in **Table 4-18**.

Table 4-18. Milwaukee, WI: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
Benzene	• Evaluate efficacy of passive sampling to understand near-road concentrations and gradients.
Risk Characterization	
• Benzene concentrations at all study sites were higher than the one-in-a-million risk concentration up to 600 meters from a heavily trafficked highway in contrast to model predictions of 150 meters. • Measured concentrations were more uniform across transects than suggested by the model. • Weekly average concentrations were more variable between weeks than between sites.	
Emissions Characterization	
• Study peak concentrations were measured along a roadway parallel to the highway indicating that urban non-highway traffic routes may also have significant mobile source emissions (compared to highways with higher traffic volumes).	
Model Evaluation	
• Benzene concentrations measured near-road were higher than those estimated by the RAIMI model. Either the model underestimated mobile source emissions or missed an unknown benzene source.	
Methods Development and Evaluation	
• Passive adsorbent sampling method generates data comparable to established methods, but data were biased low relative to those methods. • Blank corrections need to be made (i.e., blank levels were significant but not high enough to invalidate the method). • Precision of the passive adsorbent was good. • They study showed that literature diffusive uptake rate constants were needed to calculate all ambient concentrations.	
Lessons Learned	
• Vandalism resulted in lost samples.	

4.6 EPA Region 6: South Central

4.6.1 Albuquerque, NM: Air Toxics Risk Assessment

The City of Albuquerque Environmental Health Department contracted with Desert Research Institute (DRI) to conduct a monitoring, risk characterization, and modeling study. Monitoring was conducted at three sites on a one-in-six day schedule within specific community settings and geographic and demographic regions in the city from September 2007 through March 2009. A project summary is provided in **Table 4-19**.

Table 4-19. Albuquerque, NM: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs (incl. 1,4-dichlorobenzene) Carbonyls PAHs (incl. naphthalene) PM_{10} Metals OC/EC (organic carbon/elemental carbon)	• Conduct air toxics monitoring. • Assess spatial variations in air toxics concentrations. • Identify and evaluate the impact of local air toxics sources. • Quantify the relative contributions from local sources and long-range transport. • Determine the impact of meteorological conditions on diurnal, daily, and seasonal time scales. • Assess adverse health impacts from exposure using risk assessment models.
Risk Characterization	
• The levels of VOC concentrations in Albuquerque were similar to those measured nationally in NATTS, while heavy metals concentrations were significantly lower. • Carbonyl concentrations measured in Albuquerque were a factor of ten times higher than those reported in NATTS. • Typical seasonal patterns were observed for aromatic hydrocarbons and 1,3-butadiene with concentrations highest in the cold season. • Noncancer and cancer risks associated with exposures to air toxics in Albuquerque were typical for urban communities dominated by traffic emissions and similar to those estimated for other urban communities.	
Emissions Characterization	
• Day-of-week patterns were similar to those seen elsewhere with the lowest concentrations measured on Sundays and highest on Mondays for VOCs, OC, and EC; these findings are consistent with mobile source emissions and known activity patterns.	
Model Evaluation	
• For VOCs primarily emitted by mobile sources (e.g., BTEX), monitored concentrations compared well to NATA 2002 model results. Concentrations did not compare well between monitors and model results for most of the other air toxics.	
Lessons Learned	
• More highly time resolved data (in this case, hourly VOC measurements) allowed for exploration of diurnal variation in concentrations, which aided emissions source characterization.	

4.6.2 Cherokee Heights, OK: Cherokee Nation Air Quality Monitoring Report

The Cherokee Nation Environmental Program conducted VOC monitoring at four sites (three in Tulsa and one in Cherokee Heights) on a one-in-six day schedule for 18 months from September 2006 through March 2008. The Cherokee Heights site was in a rural setting. Tulsa sites were in an industrial area, near a major freeway interchange, and in the city center. A project summary is provided in **Table 4-20**.

Table 4-20. Cherokee Heights, OK: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls	• Monitor air toxics to understand spatial and temporal characteristics. • Understand the link between emissions, meteorology, and monitored concentrations. • Characterize risk.
Risk Characterization	
• Air toxics present at all four monitoring sites at concentrations of interest for health risk included acrolein, benzene, 1,3-butadiene, and carbon tetrachloride. • Seasonal averages of acrolein were consistently higher than the intermediate health benchmark risk factor at all four sites. An MRL is a concentration of a hazardous substance that is "without appreciable risk of adverse noncancer health effects over a specified duration of exposure". MRLs are intended to be used as screening tools. No acute MRLs were exceeded by any VOC measurement taken at the Oklahoma monitoring sites. The same is true for the chronic MRLs. • At the Cherokee Heights site (rural), carbon tetrachloride was the top chronic cancer risk driver while acrolein was the top noncancer risk driver. At this site, the most important metals from a toxicity-weighted perspective were lead, cadmium, arsenic, and manganese. • Toxicity-weighting (cancer) of emissions inventory data for the study counties showed that arsenic, hexavalent chromium, benzene, 1,3-butadiene, and lead were most important. Acrolein was most important from a noncancer perspective. • Additional monitoring of metals was added to respond to public concerns about industrial emissions and to prepare for the 2008 change in the lead National Ambient Air Quality Standards (NAAQS).	
Lessons Learned	
• Budget sufficient lead time and resources.	

4.6.3 Austin, TX: Austin-Round Rock Toxics Study

The Capital Area Council of Governments (CAPCOG), a regional planning commission that serves a ten-county area in central Texas including the Austin-Round Rock Area, conducted a monitoring study to better characterize air toxics levels in the area. Five sites collected samples on a one-in-twelve day schedule in Austin from June 2005 through June 2006. A project summary is provided in **Table 4-21**.

Table 4-21. Austin, TX: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs (incl. acrolein) Carbonyls PM_{10} metals Hexavalent chromium	• Identify air toxics above levels of concern for health risk. • Assess cancer and noncancer risk. • Establish baseline concentrations. • Compare monitored results to model predictions. • Compare monitored concentrations to concentrations in other similar sized cities.

Risk Characterization
• Concentrations for all air toxics monitored, except for acrolein, were similar to or lower than concentrations observed in other similar-sized cities. • Acrolein concentrations were much higher than measured at other cities; the source of the pollutant is unknown. Acrolein data quality in this study was deemed questionable. • As expected for a globally distributed pollutant, between-site variability of carbon tetrachloride was low. Formaldehyde and acetaldehyde also had low between-site variability, suggesting that sources are either uniformly distributed or concentrations are driven by background levels (i.e., more regional than local). • Benzene and other mobile source air toxics concentrations were similar to national levels except at one site where concentrations were nearly twice national median levels.
Model Evaluation
• Measurements agreed well with results of the NATA 1999 with respect to total excess cancer risk estimates and noncancer hazard. Modeled to monitored concentrations compared well for most VOCs and carbonyls and poorer for trace metals, acrolein, and trichloroethylene.
Lessons Learned
• Additional resources were needed to facilitate sampling, analysis, and data analysis.

4.6.4 Houston, TX: Mobile Laboratory Deployed to Measure Air Toxics in the Houston Ship Channel Area

The Houston Department of Health and Human Services constructed a Mobile Ambient Air Quality Monitoring Laboratory (MAAML) to identify and characterize point source emissions in near real time from petrochemical facilities in Houston. The instrument used was a thermal-desorption flami-ionization detection gas chromatograph. This instrument was capable of hourly resolution measurement of hydrocarbons. It was deployed in a series of monitoring intensives from August 2007 through December 2008. A project summary is provided in **Table 4-22**.

Table 4-22. Houston, TX: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs	• Develop analytical platform capable of identifying and characterizing 1,3-butadiene point source emissions. • Build capability to identify and characterize other air toxics. • Obtain detection limit of 1 ppb. • Provide measurement mobility.
Method Development and Evaluation	
• The platform exceeded goals and objectives. • The platform provided the ability to monitor concentrations downwind of emissions sources. Because the laboratory is operated by a skilled chemist in real time, a more immediate response is available when high concentrations occur. • The system employed a Thermal Desorber followed by GC with FID and MS.	

4.6.5 Houston, TX: Measurement and Analysis of Benzene and VOC Emissions in the Houston Ship Channel Area and Selected Surrounding Major Stationary Sources using DIAL Technology to Support Ambient HAP Concentration Reductions in the Community

The Houston Department of Health and Human Services conducted a survey project of emissions from a combined petroleum refinery and chemical plant complex in the Houston Ship Channel area. The project used Differential Absorption Light Detection and Ranging (DIAL) to remotely sense air pollutants. DIAL measurements were compared to an open path Fourier transform infrared (FTIR) instrument and a fixed point monitor on the MAAML. Measurements were made during daylight hours at large facilities; DIAL measurements were sub-hourly, although actual integration times are not explicitly described. Measurements took place January through March of 2010. A project summary is provided in **Table 4-23**.

Table 4-23. Houston, TX: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs (benzene key target pollutant)	• Develop, improve, and demonstrate DIAL measurement method for estimating mass flux of benzene and other VOCs. • Evaluate and verify DIAL benzene and VOC measurements using the MAAML, canister sampling, and other open path monitoring techniques. • Identify unanticipated/underestimated benzene and VOC sources. • Compare DIAL emission factor estimates to estimated emissions. • Assess feasibility of emissions reduction strategies based on the measured impact from the most significant individual benzene emissions sources. • Assess cost effectiveness of DIAL system.
Emissions Characterization	
• Emission factors estimated using data collected during the survey were significantly higher than reported (i.e., emissions may be underestimated for the processes studied).	
Method Development and Evaluation	
• DIAL was shown to be effective for the measurement of mass flux from fugitive, non-point emissions sources. • DIAL is limited in that it can only measure the mass flux of a single compound or class of compounds that absorb energy at a defined wavelength during a scan. DIAL cannot directly provide information on the chemical composition of a plume of pollutants. • DIAL compared well to FTIR and UV-DOAS but did not compare well to the mobile laboratory measurements. Recommendations were made to improve comparability and usability including using the same sample duration, improved detection limits (FTIR), and ability to sample at plume height.	

4.7 EPA Region 7: Midwest

4.7.1 St. Louis, MO: Advance Sampling and Data Analysis for Source Attribution of Ambient Particulate Arsenic and Other Air Toxics Metals

Missouri Department of Natural Resources and Washington University, St. Louis partnered to conduct monitoring in urban residential areas in St. Louis. This project included high time resolution metals sampling, analysis of previously collected data, and comparison of annual average arsenic concentrations to cancer risk benchmarks. Monitors the first year included two urban and two suburban sites. In the second year, high time resolution (2-hr) sampling was conducted at six sites for about one month each. This project built upon sampling conducted in 2001-2003 and also used data from the Chemical Speciation Network (CSN) and NATTS in the area. A project summary is provided in **Table 4-24**.

Table 4-24. St. Louis, MO: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
PM_{10} metals	• Describe the climatology of and develop a conceptual model (including identifying sources) for ambient particle arsenic and selected other air toxics metals. • Understand the temporal and spatial variability of arsenic and other air toxic metals with the use of new monitoring and data analysis methods.
Risk Characterization	
• 24-hr sampling showed significant spatial gradients over relatively short distances along the industrial Mississippi Riverfront north of the urban core. • Annual average PM_{10} arsenic was below the 2 ng/m^3 benchmark established in the St. Louis Community Air Project study as a level of concern.	
Emissions Characterization	
• At most sites, PM_{10} lead plumes were observed for winds from the south; consistent with the location of a large primary lead smelter 20-50 km from the sites. • A high arsenic spike (2,345 ng/m^3, 2-hr average) at the East St. Louis site was indicative of a source of extreme emission rates, possibly under upset conditions. • Arsenic data collected with high time resolution measurements at the Blair Street NATTS site showed high variability with notable plume impacts from the west/northwest, not seen in the 24-hour samples; these plumes are consistent with an industrial source operating during the daytime on weekdays.	
Model Evaluation	
• Mean PM_{10} arsenic concentrations from the NATTS site compared well to the Assessment System for Population Exposure Nationwide (ASPEN) computer air dispersion model estimates for arsenic and arsenic compounds for the 2002 and draft 2005 NATA.	
Method Development and Evaluation	
• An Ambient Metals Monitor (Xact 620) was used successfully to obtain 2-hr time resolution of PM_{10} metals.	

Data Analysis
• More than one month of high time resolution sampling is needed at a site to obtain better statistical power over a wider range of wind directions for improved source identification.
Lessons Learned
• The study showed the value of higher time resolution sampling and identified issues with the national emissions inventory for arsenic and lead in the area that should be addressed.

4.8 EPA Region 8: Mountains and Plains

4.8.1 Denver, CO: Community-Scale Air Dispersion Modeling

The City and County of Denver Department of Environmental Health, in collaboration with the University of Colorado at Denver Department of Chemistry, conducted a monitoring project to verify the spatial and temporal characteristics of air toxics concentrations across Denver County that were observed in previous monitoring campaigns. Sampling sites included business areas heavily influenced by vehicle traffic, neighborhood residential areas influenced by multiple air pollution sources, neighborhood residential areas reflective of urban background, and areas affected by industrial sources and truck traffic. For base sampling, a one-in-six day 24-hr duration schedule was kept at four sites from June 2005 through May 2006. Additionally, six 4-hr average samples were collected on the same dates as the 24-hr sampling. Finally, 1-hr average data was collected with an auto-GC. A project summary is provided in **Table 4-25**.

Table 4-25. Denver, CO: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls BC CO Ozone	• Characterize spatial and temporal variability of air toxics concentrations. • Establish baseline concentrations to assess efficacy of emissions reduction strategies. • Evaluate innovative sampling techniques. • Compare monitored results to model predictions (NATA 1996 and local AERMOD runs). • Investigate relationship of air toxics and source categories.
Risk Characterization	
• TEX and carbonyl compound concentrations varied significantly in time and space indicating that a single site does not adequately capture the potential exposure of the population to air toxics. • Outreach to schools about anti-idling laws already in place resulted in additional schools complying with the laws.	
Emissions Characterization	
• Diurnal patterns in CO, BTEX, and BC concentrations were relatable to emissions sources near the monitoring sites and to driving patterns. • BTEX concentrations varied by season, day of week, and time of day. Day of week and time of day variations were consistent with mobile source emissions impacts. CO concentrations showed similar variations also consistent with mobile source emissions. • Short term spikes in concentrations could be tied back to specific emissions events. These short-term spikes were shown to influence 24-hr average concentrations.	

Model Evaluation
• AERMOD generally under-predicted ambient air toxic concentrations but correctly predicted spatial distributions. Toluene and xylenes were underestimated in the emissions inventory.
Methods Development and Evaluation
• Continuous sampling of VOCs using an auto-GC was shown to be reliable, practical, and feasible and provided 1-hr time resolution.
Lessons Learned
• Interlaboratory sample analyses and proficiency tests should be performed before, during, and after the project when labs other than the EPA contract lab are used. • Budget sufficient time and resources to validate and analyze the data.

4.8.2 Boulder, CO: Understanding Air Toxics and Carbonyl Pollutant Sources

The Boulder County Public Health Department (BCPH) and the University of Colorado at Boulder (CU) teamed to conduct sampling at five monitoring sites in the Boulder area to assess spatial and temporal variability in air toxics. The sampling sites included an urban area heavily influenced by vehicle traffic, three suburban areas influenced by multiple air pollution sources, and a remote background location. Sampling occurred on a one-in-six day schedule from March 2007 to February 2008. A project summary is provided in **Table 4-26**.

Table 4-26. Boulder, CO: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls Ozone	• Understand spatial and temporal variability in air toxics. • Evaluate a community-scale air dispersion model. • Compare monitored concentrations with NATA 1996 and 1999 results for Denver and Boulder. • Develop a baseline for longer-term monitoring. • Guide air quality management strategies in Boulder County.
Risk Characterization	
• Spatial variation of air toxics generally met expectations. Concentrations of mobile source air toxics were highest at the urban site and lowest at the remote site. Concentrations of evaporative emissions were highest closest to oil and gas operations. • Seasonally, findings also met expectations with formaldehyde highest in the summer and most other air toxics highest in the winter or with little seasonal variation. • Concentrations of formaldehyde and acetaldehyde measured in the Boulder study were generally lower than those observed in earlier monitoring studies, especially for acetaldehyde.	
Model Evaluation	
• easured median concentrations of VOCs fell within the range of the NATA 1996 and 1999 results. • For most pollutants, AERMOD-predicted spatial distribution of emissions seems to match the distribution of observed concentrations. However, for butane and pentane (oil and gas production emissions), AERMOD under-predicted concentrations and did not match spatial patterns when these pollutants were assumed to be exclusively emitted by the oil and gas sector and have zero background concentrations.	

Emissions Characterization
• Principal component analysis indicated that a factor with light alkanes, toluene, and octane was associated with evaporative emissions of gasoline vapor and natural gas condensate consistent with emissions sources near the monitor. • A factor with aromatic compounds including toluene and xylenes was likely associated with motor vehicle exhaust.
Lessons Learned
• The study would have benefited from additional pollutants monitored continuously. • Increased sampling frequency (one-in-three day instead of one-in-six day) would provide greater insight into weekday versus weekend trends and more accurately capture the ambient conditions. • The authors noted difficulty in getting data into AQS and suggested additional pollutants could be added to the NATTS performance testing to improve accuracy and precision for a wider range of air toxics.

4.9 EPA Region 9: Pacific Southwest

4.9.1 Phoenix, AZ: Analysis of Air Toxics Collected as Part of JATAP

JATAP was a three-year project to assess cancer and noncancer risks from air toxics in the greater Phoenix area. JATAP was a consortium of federal, state, local, and tribal air pollution control officials from EPA Region 9, EPA's OAQPS, Arizona Department of Environmental Quality (ADEQ), Maricopa County Environmental Services Division, Pinal County Air Quality Control District, Intertribal Council of Arizona, Gila River Indian Community, Salt River-Pima Maricopa Indian Community, and Fort McDowell Yavapai Nation. Data assessed included air toxics measured at a near-road site, urban sites, and rural sites. Pollutants measured in the previous phase of the project were collected on a one-in-six day schedule in 2005. A project summary is provided in **Table 4-27**.

Table 4-27. Phoenix, AZ: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls PAHs PM_{10} metals	• Validate gaseous air toxics data. • Characterize spatial and temporal variations in air toxics concentrations. • Perform risk screening using annual average concentrations. • Communicate findings to the stakeholder communities.
Risk Characterization	
• Spatial variation in pollutant concentrations was consistent with the conceptual model of higher concentrations closer to the urban core and lower concentrations at suburban and rural sites. • Phoenix urban concentrations of 1,3-butadiene, acetaldehyde, formaldehyde, chloroform, benzene, and tetrachloroethylene were above the 75th percentile of national urban scale data. Concentrations of these air toxics were typically above the one-in-a-million cancer risk level. • Benzene concentrations at the long-term supersite decreased from 1995 to 2005 by more than a factor of three, consistent with emissions reduction efforts. In contrast, formaldehyde concentrations were similar between the two time periods. • The project helped raise awareness of anti-idling programs for school buses and spurred additional bus retrofits.	

Emissions Characterization
• Carbonyl compound concentrations were highest at an urban site closest to a heavily trafficked road, likely from mobile source emissions. • ADEQ assisted in developing an emissions inventory for the tribes.
Model Evaluation
• Concentrations were compared to NATA 1999 results showing modest to good comparisons for the gaseous pollutants (within a factor of two).
Outcomes
• Plans were made to investigate tribal land emissions such as dust from unpaved roads and smoke from agricultural burning.
Lessons Learned
• Detection limits were too high for some air toxics, which reduced the usefulness of the data. • The ambitious scope of the project needed to be scaled back because of insufficient funds. • The collaborative nature of the study resulted in better communication of study results to a wider range of stakeholders.

4.9.2 Phoenix, AZ: Air Toxics Assessment

On behalf of JATAP, a comprehensive final report was compiled by researchers at Arizona State University and the University of Notre Dame. Building on the measurements made in 2005-2006, this report summarizes the risk assessment made based on emissions, meteorological, and air quality modeling. Monitoring was initially conducted at one freeway corridor site, several urban core sites, two tribal sites on the urban perimeter, and two background sites. Pollutants measured in the previous phases of the project were collected on a one-in-six day schedule in 2005. A project summary is provided in **Table 4-28**.

Table 4-28. Phoenix, AZ: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls PAHs PM_{10} metals	• Summarize annual average air toxics concentrations, air toxics emissions inventory, meteorological modeling, air quality modeling, and assessment of risk.
Risk Characterization	
• Based on modeling, the risk estimate from both gaseous and particulate air toxics in metropolitan Phoenix is 300-700 excess lifetime cancer cases per one million people from DPM, arsenic, cadmium, and nine gaseous species. The range of risk reflects spatial variation in air toxics pollutants and concentrations. DPM is the risk driver (90% of total risk). • This degree of risk places Phoenix above the national average, lower than Houston or Los Angeles, but similar to Detroit and Seattle. • Including organic carbon (assigning risk similar to DPM) in the risk estimate would double the lifetime cancer risk estimates. • Urban particulate species concentrations were enriched from 3 to 40 times above background levels. • The emissions sources of gaseous air toxics posing the greatest risk are vehicle exhaust, fuel combustion, secondary formation, and solvent use.	

Model Evaluation
• CAMx air quality modeling results for air toxics did not compare well to measurements. The model estimates under-predicted ambient measured concentrations.
Lessons Learned
• The JATAP project provided an opportunity for cross-cultural cooperative efforts.

4.9.3 Sun Valley, CA: Air Toxics Study

The South Coast Air Quality Management District (SCAQMD) conducted air toxics monitoring in Sun Valley to complement the Multiple Air Toxics Exposure Study III (MATES III) and to better understand sub-regional concentration distributions. Five monitoring sites were deployed in the area at local schools, on Los Angeles County property, and at a fire department. Sampling occurred on a one-in-three day basis at all sites. The overall study took place from June 2005 through June 2006; only one site operated during the entire study and the durations of other sites were limited (ranging from 4 to 10 months). A project summary is provided in **Table 4-29**.

Table 4-29. Sun Valley, CA: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls PM_{10} metals EC and OC Hexavalent chromium	• Identify pollutant "hot spots" within the Sun Valley region. • Characterize seasonal or spatial trends of pollutants. • Determine the impact of air toxics exposure to Sun Valley residents near the Bradley landfill and other industrial sources.
Risk Characterization	
• Concentrations of air toxics other than hexavalent chromium were similar across the Sun Valley region.	
Emissions Characterization	
• A "hot spot" source of hexavalent chromium was identified with measurable concentrations detected immediately downwind of a chrome plating facility. Concentrations declined a short distance (i.e., within 500 meters) from the source to background levels found at other monitoring sites. The source is no longer in operation. • Concentrations of pollutants measured did not seem to be affected by the landfill.	
Lessons Learned	
• The study authors noted that they would have used more real-time measurements of the air toxics if the technology was available and economically feasible.	

4.9.4 Los Angeles, CA: Port of Los Angeles Community-Based Air Toxics Exposure Study

The Port augmented an existing monitoring study to enhance the measurements. Real-time particle-bound PAH measurements were added to four sites: a coastal boundary station, a source-dominant station, and two community stations. Existing measurements included $PM_{2.5}$, ultrafine particles, BC, SO_2, NO_x, OC/EC, and CO. The goal of this study was to take results from the real-time PAH measurements combined with meteorological, PM, and chemical measurements from the existing Port-wide air monitoring network to characterize emissions sources and potential air quality impacts from the Port's operations (particularly DPM). Sampling was conducted from April 2008 through April 2009 on an hourly basis. A project summary is provided in **Table 4-30**.

Table 4-30. Los Angeles, CA: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
Particle-bound polycyclic aromatic hydrocarbon (pPAH)	• Understand impacts of Port PAH emissions on the surrounding community.
Emissions Characterization	
• Real-time PAH data strongly correlated with NO_x and EC (24-hr average) at all four sites suggesting a common source. PAH data did not correlate well with BC (1-hr average); however, results were preliminary. • On average, the concentrations at the source-dominant site were highest, up to five times higher than the one background and two community sites. • The diurnal profile of the PAHs, with morning and evening peaks, was a function of emissions activity and meteorology (as expected). Also as expected, concentration decline with increased wind speed (enhanced dispersion).	
Lessons Learned	
• Activity data from the port operations would have aided in analyzing relationships of ambient PAH concentrations with port equipment and activities.	

4.9.5 Roseville (Placer County), CA: Rail Yard Air Toxics Monitoring Project

The Roseville Rail Yard Ambient Monitoring Program (RRAMP) was designed to characterize the magnitude of DPM emissions emanating from the Union Pacific Rail Road (UPRR) facility located in Placer County. The rail yard is one of the largest in the western United States, operates around the clock, and services over 30,000 locomotives per year. This community-scale monitoring project was performed as a follow-on to a study conducted in 2000-2003, which identified increased risk for the Roseville community. Two pairs of upwind/downwind sites were used. The report provided to EPA covered the first two years of the three-year study. Additional results are now available online.[6] The study was conducted by the Placer County Air Pollution Control District. All data discussed in the report were collected

[6] http://www.placer.ca.gov/Departments/Air/railroad.aspx.

continuously; a description of the VOC and carbonyl sampling schedule and duration were not in the available reports. A project summary is provided in **Table 4-31**.

Table 4-31. Placer County, CA: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls $PM_{2.5}$ EC BC NO_x	• Obtain ambient DPM concentrations (using BC as a surrogate) for three intensive periods. • Share concentration information with the public. • Determine impact of air toxics and other pollutant concentrations from the UPRR facility on the nearby community. • Monitor (verify) effectiveness of implemented emissions reductions actions. • Provide data to further improve health risk assessment.
Emissions Characterization	
• Screening criteria were established to aid analysts in determining the conditions for which upwind vs. downwind analyses were appropriate. Criteria included wind direction (45 to 225 degrees), wind speed (0.5 to 4 m/s), and hours (10 p.m. to 5 a.m.). • Upwind vs. downwind site concentration differences were shown to represent rail yard emissions contributions. BC, $PM_{2.5}$, NO, and NO_x concentrations were higher downwind of the rail yard. Findings for VOCs and carbonyls were inconclusive.	
Outcomes	
• Monitoring project results were shared with the public, UPRR emissions mitigation measures were developed (e.g., reduced idling time), and community meetings were conducted. Other actions included city planning to 1) develop a "greenbelt" around the rail yard and 2) redevelop land near the rail yard from residential to commercial to reduce exposure. • A risk assessment has now been conducted at every major rail yard in California based on the Roseville Rail Yard model.	
Lessons Learned	
• Data analysis led to an adjustment of the monitoring approach after one year of sampling to better capture upwind and downwind conditions for the monitoring locations.	

4.10 EPA Region 10: Pacific Northwest

4.10.1 Lewiston, ID: Nez Perce National Air Toxics Program Characterization of Air Toxics Concentrations around a Kraft Pulp and Paper Mill Facility

The Nez Perce Tribe Environmental Restoration and Waste Management Air Quality Program in cooperation with the Idaho Department of Environmental Quality conducted an air toxics monitoring study in the Lewiston valley and northwestern portion of the Nez Perce Reservation. This study built upon two previous measurement campaigns. Five monitoring sites covered a variety of land use types and provided spatial resolution. Two sites were on tribal lands, one site was close to the paper mill, one was in the urban center, and the final site was in a residential area. Measurements at the five sites were collected on a one-in-six day

schedule from May 2006 through April 2007. Two short-term measurement periods included a DOAS (for formaldehyde) and PTR-MS (for VOCs) mobile laboratory system. A project summary is provided in **Table 4-32**.

Table 4-32. Lewiston, ID: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls PM_{10} metals	• Characterize air toxics concentrations. • Characterize emissions from Clearwater Paper (formerly Potlatch) with a determination of spatial patterns and gradients in air toxics concentrations. • Evaluate the relative contributions of paper mill emissions by species to concentrations in the valley. • Characterize air toxics risks, with an emphasis on risks posed by the paper mill.
Risk Characterization	
• Concentrations of formaldehyde and acetaldehyde were much higher than expected for an area of Lewiston's size. • Formaldehyde was the largest contributor to cancer risk among the pollutants measured and acetaldehyde was a significant contributor.	
Emissions Characterization	
• Ambient concentrations of chloroform, tetrachloroethylene, and trichloroethylene were determined to be a result of emissions from Clearwater Paper. The weight-of-evidence consensus from spatial, temporal, and chemical analysis was consistent with mill emissions.	
Model Evaluation	
• Comparison of the modeled (Community Multiscale Air Quality model [CMAQ]) to measured air toxic concentrations (24-hr averages) showed that formaldehyde, acetaldehyde, and benzene were underestimated by as much as a factor of five. Modeled concentrations were sensitive to uncertainties in chemical boundary conditions. • CALPUFF demonstrated its potential for accurate dispersion modeling by predicting chloroform (from industrial emissions) concentrations generally within a factor of 2 relative to observations.	
Methods Development and Evaluation	
• DOAS measurements of formaldehyde were conducted for a week, but wind directions were not conducive for evaluation of formaldehyde emissions from the mill. Concentrations compared well to routine measurements. • A PTR-MS mobile laboratory system was deployed for a few days to measure VOCs. Comparison of the high time resolved PTR-MS with 24-hr average canister data was limited, but the utility of highly time resolved data was high.	
Lessons Learned	
• Analytical laboratory measurements of benzene and 1,3-butadiene concentrations reported in this study did not meet expectations for data quality. • High time resolution measurements are more useful for source identification than 24-hr samples.	

4.10.2 Treasure Valley, ID: Air Toxics Study

The Idaho Department of Environmental Quality conducted a monitoring study to characterize air toxics in the Treasure Valley airshed (which includes Boise). Monitoring was conducted at five sites. Sites included urban core and rural background locations. Sampling was conducted on a one-in-six day schedule from February 2007 through February 2008. Ambient data were used to evaluate the NATA 2002 and CMAQ 2007 summer model results. Source apportionment was used to identify potential emissions sources. A project summary is provided in **Table 4-33**.

Table 4-33. Treasure Valley, ID: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls PM_{10} metals	• Explore spatial and seasonal trends in air toxics. • Identify sources of the air toxics.
Risk Characterization	
• Pollutants above the chronic health screening benchmarks included acetaldehyde, arsenic, benzene, cadmium, dichloropropene, ethylbenzene, formaldehyde, manganese, and methylene chloride. • Arsenic and selenium concentrations were lower than national mean values while manganese concentrations were between the 50^{th} and 75^{th} percentiles nationally. • Spatial patterns in most of the air toxics concentrations met expectations. Concentrations of the mobile source air toxics, for example, were highest at the urban core site and lowest at the rural site. Benzene levels were in the 75^{th} to 95^{th} percentile nationally at the urban core site. • Concentrations of 1,3-dichloropropene were highest at the rural site likely due to soil fumigant use.	
Emissions Characterization	
• Formaldehyde and acetaldehyde concentrations in summer may have been increased by regional wildfires, but there were insufficient data to confirm this hypothesis. • Source apportionment indicated the following sources contributing to air toxics: mobile sources, photochemical production, geologic materials, biomass burning, isopropanol solvent use, other solvents, and a mixed group of sources including coal combustion, chlorinated solvents, and refrigerants.	
Model Evaluation	
• NATA 2002 model results agreed within a factor of two to monitored concentrations at all sites for toluene and the aldehydes. NATA 2002 was found to generally overestimate air toxics concentrations relative to monitored data. • CMAQ model results were found to generally underestimate measured concentrations and most pollutants were off by more than a factor of two.	

4.10.3 Portland, OR: Air Toxics Community Assessment Monitoring Project

The Oregon Department of Environmental Quality conducted a monitoring project to obtain additional data at several sites in Portland for model evaluation. Monitoring was conducted at six neighborhood-scale sites spread throughout the city with a mix of surrounding land uses. Monitoring for all compounds except PAHs occurred on a one-in-six day schedule

beginning in January 2005 and running through the calendar year; PAHs were on a one-in-twelve day schedule. The project built upon sampling and modeling conducted in 1999-2000 and on NATA 1996 results. A project summary is provided in **Table 4-34**.

Table 4-34. Portland, OR: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls PAHs BC $PM_{2.5}$ speciation PM_{10} metals Hexavalent chromium	• Measure air toxics concentrations at several sites. • Characterize spatial variability of air toxics concentrations across the urban airshed and in predicted problem areas. • Compare monitored results to model predictions. • Field test a continuous Pneumatic Focusing GC (PFGC). • Estimate BC emissions from woodstoves.
Risk Characterization	
• Annual average concentrations of arsenic, cadmium, and acetaldehyde were above Oregon's Ambient Benchmark Concentrations (ABC), while benzene and PAHs were suspected to be above the ABC. • Some compounds of concern were below the analytical minimum reporting limit. • Sampling problems included high minimum reporting limits for the PFGC relative to ambient concentrations, contamination of VOC canister sampling hardware (resulting in invalidation of more than 25% of benzene data), and QC problems for PAHs.	
Emissions Characterization	
• Data showed mobile sources were the primary source of air toxics in the Portland area; concentrations were similar across the area. • Manganese and nickel concentrations were higher at a site near a foundry and metal working facilities. • Hexavalent chromium was found at one site; the source is unknown.	
Methods Development and Evaluation	
• PFGC was tested during this study. Problems were noted but results of the efficacy of the PFGC measurements were not included in the report.	
Outcomes	
• A local advisory committee was tasked with reducing air toxics emissions in the Portland area within 10 years.	
Lessons Learned	
• Earlier review of data would have been beneficial. While laboratory QA/QC procedures resulted in identification of problems with the canister benzene data, the finding was too late in the study to result in any changes that could have improved data completeness.	

4.10.4 Spokane, WA: Air Toxics Study

Washington State University and RJ Lee Group, Inc. Center for Laboratory Sciences conducted a year-long monitoring study in Spokane. The goal of this study was to provide data

that could be used to characterize human exposure levels to air toxics, better understand temporal and spatial trends of the air toxics, and provide measurement data for air quality model evaluation. Four monitoring sites were deployed including a site in a commercial/industrial zone and the other three sites spread throughout Spokane. Sampling occurred on a one-in-six day schedule for the 2005 calendar year. A mobile monitor was also used. A project summary is provided in **Table 4-35**.

Table 4-35. Spokane, WA: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls PM_{10} metals	• Investigate spatial and temporal trends. • Provide measurement data for the AIRPACT air quality model and compare modeled to monitored data. • Explore source-receptor relationships. • Assess exposure risk using Hazardous Air Pollutant Exposure Model (HAPEM).
Risk Characterization	
• Average annual concentrations of many of the air toxics were similar to those reported in other U.S. cities. The highest average concentrations were observed at the commercial/industrial site. • Many air toxics exhibited elevated levels in the wintertime and lower ambient concentrations during the summertime as expected. Carbonyl concentrations were higher in summer, consistent with secondary formation. • Initial screening showed that concentrations of most of the 15 air toxics studied were above levels of concern. HAPEM showed benzene, 1,3-butadiene, carbon tetrachloride, tetrachloroethylene, trichloroethylene, acetaldehyde, formaldehyde, arsenic, chromium, and manganese exceeded the health screening value in Spokane neighborhoods.	
Emissions Characterization	
• Correlation analyses of data collected at all sites suggested common sources for benzene and 1,3-butadiene; acetaldehyde and formaldehyde; arsenic, cadmium, and lead; and chromium and nickel (only at the commercial/industrial site). • Lead was found to be from a 50:50 mix of crustal and combustion sources in Spokane based on lead isotope analysis. • Several hot spots were identified, indicating auto repair shops emitted high concentrations of acetone and xylenes while a large source of styrene was found in an industrial park.	
Model Evaluation	
• The AIRPACT model was found to overpredict benzene concentrations because of problems with the emissions inventory and underpredict carbonyl concentrations because of poor initial/boundary conditions.	
Methods Development and Evaluation	
• A PTR-MS was used to locate emissions sources of benzene, acetaldehyde, several low molecular weight oxygenated solvents, and BTEX. • pPAH concentrations and surface areas were measured along roadways.	
Lessons Learned	
• Budget sufficient time to conduct the project.	

4.10.5 Tacoma and Seattle, WA: Air Toxics Evaluation

The Puget Sound Clean Air Agency, Washington State Department of Ecology, and the University of Washington collaborated to conduct monitoring in Tacoma and Seattle to characterize the similarities and differences in air toxics between the cities. The study included four sites in Tacoma and two in Seattle; all sites were urban with two sites in heavily industrialized areas. Sampling of air toxics occurred on a one-in-six day schedule from November 2008 through October 2009. A project summary is provided in **Table 4-36**.

Table 4-36. Tacoma and Seattle, WA: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs Carbonyls BC PAHs pPAH $PM_{2.5}$ mass and speciation Levoglucosan (wood burning marker)	• Determine baseline air toxics concentrations for the Tacoma area and provide information at select sites in the Seattle area for comparison. • Investigate spatial gradients in selected pollutants.
Risk Characterization	
• The following pollutants/pollutant types were the highest contributors to potential cancer risk, in order: DPM, wood smoke PM, carbon tetrachloride, benzene, 1,3-butadiene, formaldehyde, naphthalene, acetaldehyde, chloroform, and tetrachloroethene. • Air toxics concentrations have decreased since 2000 with the exception of carbon tetrachloride, which has slightly increased. The source of increased carbon tetrachloride is unknown.	
Emissions Characterization	
• In the study cities, the two key emissions sources of many of the risk drivers listed above are motor vehicles and residential wood burning. • Wood smoke was found to be a significant contributor to ambient benzene concentrations.	
Model Evaluation	
• Monitored concentrations were compared to NATA 2002 model estimates. Overall, the model performance was within a factor of 2 for carbon tetrachloride, chloroform, tetrachloroethylene, and acrolein. The remaining compounds were generally overestimated, including diesel emissions, benzene, 1,3-butadiene, acetaldehyde, and formaldehyde. Naphthalene was overestimated at the Seattle sites, but underestimated at the Tacoma sites.	
Methods Development and Evaluation	
• Mobile monitoring included a Membrane Introduced Mass Spectrometer (MIMS) for gaseous pollutants and an instrument for pPAH. Both instruments showed very high time resolution (30 seconds). For pPAH, individual truck plumes could be seen in the data set. • Filters placed upstream of the MIMS system were analyzed and used to track markers for wood smoke, diesel fuel combustion, and secondary formation.	

4.10.6 Tacoma, WA: Evaluation of New Methods for Source Apportionment Using Real-time Continuous Monitoring Instruments

The Puget Sound Clean Air Agency and the University of Washington evaluated a number of novel methods to estimate diesel emissions and to characterize diesel sources, including vehicles and marine vessels. Data collected at the Seattle Duwamish site were used including measurements of 1-hr $PM_{2.5}$, VOCs, and Aethalometer BC. Measurements were collected in four intensive operating periods of a few weeks each in 2009; the earliest intensive was in January-February and the final intensive ended in August. A project summary is provided in **Table 4-37**.

Table 4-37. Tacoma, WA: Pollutants measured, project goals, and results summary.

Pollutants	Project Goals
VOCs BC $PM_{2.5}$	• Develop source apportionment methodology for VOCs targeting mobile sources. • Combine VOC apportionment with traditional $PM_{2.5}$ filter data. • Monitor maritime activities
Emissions Characterization	
• Source apportionment using positive matrix factorization indicated the following factors: high-load diesel, gasoline/liquefied petroleum gas, idling/crankcase diesel, fueling/port operations, two wood smoke factors, and "other $PM_{2.5}$." • A diesel exhaust marker, 1-nitropyrene, was successfully linked to both truck traffic and the high load diesel factor. • The highly time-resolved (1-hr) VOC data aided in the apportionment of $PM_{2.5}$. • The data analysis illustrated the superiority of hourly data relative to traditional, every sixth day, 24-hr measurements.	
Methods Development and Evaluation	
• Remote monitoring of marine traffic was useful in estimating diesel impacts from this source. LIDAR was used to measure emissions while ships were docked. A logging system was successful in obtaining activity information from which emissions could be estimated. • A new method for processing auto-GC chromatographs reduced analyst time and improved data quality. • Open path Fourier transform infrared spectroscopy (OP-FTIR) use for resolving gasoline and diesel emissions was not successful (detection limit and specificity issues).	

5. Individual Project Summaries – Ongoing

This section provides a brief summary of each awarded project for which a final report has not yet been submitted to EPA. Information from these projects was obtained from project plans and may not reflect the final project design. Project summaries provide the pollutants monitored and project goals. Only categories that are listed pertain to that community monitoring study—categories not pertaining to a given study are not listed.

The pollutants listed include those identified in Table 2-1 as key risk drivers nationally. As in Section 4, the term VOCs typically includes benzene, 1,3-butadiene, carbon tetrachloride, and tetrachloroethylene. Carbonyls typically include formaldehyde and acetaldehyde. Total chromium and arsenic are typically reported with PM_{10} or TSP metals analyses while hexavalent chromium is reported from an entirely different collection and analysis technique.

Projects are listed by EPA Region, then state, metropolitan area, then chronologically.

5.1 EPA Region 1: New England

5.1.1 Massachusetts Department of Environmental Protection: Evaluation of Spatial Gradients and Temporal Trends of Black Carbon in Boston

This project was awarded in the 2007/2008 grant years A project overview is provided in **Table 5-1**.

Table 5-1. Boston, MA: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
BC	• Analyze spatial and temporal trends in existing BC data in Boston.
Project Category	
• Analysis of existing data	

5.2 EPA Region 2: New Jersey, New York, Puerto Rico, and the Virgin Islands

5.2.1 New Jersey Department of Environmental Protection: Evaluation of Two Sampling and Analytical Methods for the Measurement of Hexavalent Chromium in Ambient Air

This project was awarded in the 2007/2008 grant years. A project overview is provided in **Table 5-2**.

Table 5-2. New Jersey: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
Total, hexavalent, and trivalent chromium	• Evaluate two sampling and analytical methods for the measurement of hexavalent chromium in ambient PM. • Evaluate two sampling trains. • Evaluate two analytical methods. • Compare inter-laboratory analysis variability.
Project Category	
• Methods development	

5.3 EPA Region 3: Mid-Atlantic

5.3.1 Delaware Community Air Toxics Study (CATS)

This project was awarded in the 2007/2008 grant years. A project overview is provided in **Table 5-3**.

Table 5-3. Wilmington, DE: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
VOCs	• Establish an enhanced VOC monitoring program to investigate areas identified as hot spots. • Identify temporal and spatial variability. • Create a data set for validation and evaluation of modeling efforts. • Investigate changes in VOC concentrations following Delaware's switch to E_{10} gasoline. • Evaluate risk associated with VOCs.
Project Categories	
• Baseline characterization • Emissions characterization • Risk characterization	

5.3.2 Pennsylvania Department of Environmental Protection: Ambient Sampling Project for Trichloroethylene and other Air Toxic Compounds in the Collegeville Area

This project was awarded in the 2007/2008 grant years. A project overview is provided in **Table 5-4**.

Table 5-4. Collegeville, PA: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
VOCs	• Assess health risk to residents in the Collegeville area from exposure to air toxics. • Compare emissions from steel tube manufacturing facilities to monitoring data to assess relationship, focusing on voluntary trichloroethylene emissions reductions. • Conduct perimeter monitoring of the steel tube facilities. • Evaluate the contribution of air strippers in the area to ambient trichloroethylene concentrations.
Project Categories	
• Baseline characterization • Risk characterization • Emissions characterization	

5.3.3 Philadelphia, PA: South Philadelphia Community Continuous Air Toxics Monitoring Project

This project was awarded in the 2011/2012 grant years. A project overview is provided in **Table 5-5**.

Table 5-5. Philadelphia, PA: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
VOCs Carbonyls H_2S CS_2 NO_x Ozone NH_3 SO_2 HF Cl_2 ClO_2 Hg Naphthalene HNO_2	• Assess the degree and extent to which air toxics from an oil refinery and other manufacturing activities impact the local community. • Purchase and deploy the Cerex UV Sentry DOAS air monitoring system and Cerex SPECTRA-1 TDL gas analyzer. • Assess risk from pollutants in this community.
Project Categories	
• Methods evaluation • Risk characterization • Emissions characterization	

5.3.4 Virginia Department of Environmental Quality: Community-Scale Methyl Bromide Monitoring Project for Suffolk, VA

This project was awarded in the 2011/2012 grant years. A project summary is provided in **Table 5-6**.

Table 5-6. Suffolk, Virginia: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
VOCs Methyl bromide	• Assess the degree and extent to which emissions from methyl bromide from fumigation operations in Suffolk, VA, impact the local community. • Evaluate air quality dispersion modeling for dense gases dispersion. • Test ppbRAE 3000 PID monitoring for portable monitoring. • Use an infrared camera to map plume dispersion during the aeration portion of the venting process. • Determine whether methyl bromide concentrations are elevated around the facilities.
Project Categories	
• Emissions characterization • Risk characterization • Methods evaluation	

5.4 EPA Region 4: Southeast

5.4.1 Broward County, FL: Evaluation of Alternate Methods for the Quantification of Carbonyl and PAH Concentrations in Ambient Air

This project was awarded in the 2011/2012 grant years. A project overview is provided in **Table 5-7**.

Table 5-7. Broward County, FL: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
PAHs Carbonyls	• Test alternative methods for carbonyls and PAH measurements in ambient air versus established EPA methods TO-11 and TO-13. • Test methods for feasibility of analyzing VOCs and PCBs on these alternate methods. • Present results through conferences, informational materials, SOPs, and QAPPs. • Potentially prepare the local air toxics laboratory to analyze.
Project Category	
• Methods evaluation	

5.4.2 Louisville Air Pollution Control District, KY: Emissions and Risk Characterization around Rubbertown

This project was awarded in the 2003/2004 grant years. A project overview is provided in **Table 5-8**.

Table 5-8. Louisville, KY: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
VOCs Metals Formaldehyde	• Perform risk assessment and spatial and temporal analysis on monitoring data for 18 chemicals collected since the fall of 2001. • Establish four fence line monitors and two background monitors around a rubber facility for the 18 target chemicals. • Develop a model-to-monitor relationship based on the existing risk assessment. • Demonstrate the use of an optical-based measurement technology for fence line monitoring around the facility. • Analyze and compare speciated $PM_{2.5}$ analytical measurements with the risk assessment. Leverage the $PM_{2.5}$ speciation data to assist with interpreting toxics source-receptor relationships.
Project Categories	
• Risk characterization • Emissions characterization • Method evaluation	

5.4.3 Shelby County Health Department, TN: Reducing Exposure to Airborne Chemical Toxics (REACT)—A Community-Scale Air Monitoring Project in Memphis

This project was awarded in the 2011/2012 grant years.

Table 5-9. Memphis, TN: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
VOCs	• Measure ambient concentrations of air toxics in communities with varying degrees of urbanization and industrialization, and estimate the health risks. • Assess the impact of seasons and industrial/urban/suburban environments on air toxics concentrations. • Identify socioeconomic and racial determinants of individual exposure to air toxics and priority air toxic mixtures. • Identify hot spots or major sources of contribution to air toxics pollution. • Evaluate the ability of dispersion models to predict concentrations measured. • Identify common mixtures, estimate probabilities of priority mixtures selected on the basis of toxicity and/or interest, and develop multivariate models of exposure distributions using copulas that efficiently and accurately represent tail dependencies.

Project Categories
• Community baseline • Health risk characterization • Air quality model evaluation

5.5 EPA Region 5: Great Lakes

5.5.1 Michigan Department of Environmental Quality: Analysis of Air Toxics Data—QA Implication, Source Apportionment Uncertainty Analysis, and Updated Risk Assessment

This project was awarded in the 2007/2008 grant years. A project overview is provided in **Table 5-10**.

Table 5-10. Detroit, MI: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
VOCs PAHs Carbonyls Metals Hexavalent chromium OC/EC	• Determine the impact of changes in MDLs and assess accuracy of reported MDLs. • Place air toxics measurements in historical and national perspective. • Quantify impact of source changes on air toxic ambient concentrations. • Compare risk in Detroit and Grand Rapids. • Assess uncertainty in source apportionment model results. • Communicate results to shareholders and populations at risk.
Project Category	
• Analysis of existing data	

5.5.2 Minnesota Pollution Control Authority: Calibrating Concern about PAHs in Urban Air Using Monitoring and Modeling

This project was awarded in the 2011/2012 grant years. A project overview is provided in **Table 5-11**.

Table 5-11. Minnesota: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
Speciated PAHs, including naphthalene	• Measure gas- and particle-phase PAHs using three monitors. • Rotate measurement sites to areas of concern. • Use 10 passive PAH samplers to assess spatial gradients in central Minneapolis. • Use the data to verify source contributions, emissions estimates, and model predictions of concentrations and risk.

Project Categories
• Community baseline monitoring • Risk characterization • Emissions characterization • Air quality model evaluation

5.5.3 Wisconsin Department of Natural Resources: Development and Testing of a Mobile Monitoring Trailer for Improved VOCs and Particulate Carbon Monitoring Near Roadways

This project was awarded in the 2007/2008 grant years. A project overview is provided in **Table 5-12**.

Table 5-12. Wisconsin: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
VOCs BC	• Purchase and equip a trailer to function as a mobile monitoring platform. • Install a Perkin Elmer Automated Ozone Precursor Analysis System and develop methods for use in the mobile platform. • Install an Aethalometer on the mobile platform and develop methods for use. • Field test the system. • Deploy the mobile platform in field studies and use data collected to aid in the validation of modeling results and to improve risk assessments.
Project Category	
• Methods development	

5.6 EPA Region 6: South Central

There are no ongoing projects.

5.7 EPA Region 7: Midwest

5.7.1 Linn County Public Health, IA: Community-Scale Acetaldehyde Air Toxics Phase 2 Project

This project was awarded in the 2011/2012 grant years. A project overview is provided in **Table 5-13**.

Table 5-13. Linn County, IA: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
Carbonyls	• Characterize acetaldehyde in targeted modeled locations, determined during previous phase of this project. • Measure and track progress of planned emissions reduction strategies with point source industries. • Determine how planned new and expanding industrial sources of acetaldehyde will affect concentrations. • Measure the risk reduction from acetaldehyde concentrations in the near-source Time Check neighborhood, which is undergoing redevelopment and revitalization after a 2008 flood.
Project Categories	
• Emissions characterization • Risk characterization • Air quality model evaluation	

5.8 EPA Region 8: Mountains and Plains

There are no ongoing projects.

5.9 EPA Region 9: Pacific Southwest

5.9.1 San Diego Air Pollution Control District: Community Measurements

This project was awarded in the 2005/2006 grant years. A project overview is provided in **Table 5-14**.

Table 5-14. San Diego, CA: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
VOCs Metals Carbonyls Hexavalent chromium OC/EC	• Supplement ongoing monitoring activities with capital improvements in order to measure industrial- and mobile-source related impacts of toxic pollutants along the U.S.-Mexico border, within the northern inland valley region of the San Diego Air Basin, and within the community of Barrio Logan. • Characterize spatial gradients. • Perform a simple health risk assessment.
Project Categories	
• Community baseline monitoring • Risk characterization	

5.9.2 South Coast Air Quality Management District: The Impacts of Commercial Airport Operations on Air Toxics Levels in Surrounding Communities

This project was awarded in the 2007/2008 grant years. A project overview is provided in **Table 5-15**.

Table 5-15. Los Angeles and Long Beach, CA: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
VOCs Metals Carbonyls OC/EC Hexavalent chromium Acrolein	• Enhance the Los Angeles World Airports air monitoring and source apportionment study at Los Angeles International Airport (LAX). • Add monitoring sites at LAX and Long Beach Airport. • Perform mobile monitoring around airports.
Project Categories	
• Emissions characterization • Community baseline	

5.9.3 Nevada Department of Environmental Protection: Development of Methods for Quantifying Speciated Mercury in Nevada

This project was awarded in the 2005/2006 grant years. A project overview is provided in **Table 5-16**.

Table 5-16. Nevada DEP: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
Speciated Hg	• Develop a passive sampling system for measurement of total and reactive gaseous Hg in ambient air.
Project Category	
• Methods development	

5.10 EPA Region 10: Pacific Northwest

5.10.1 Anchorage, AK Department of Health and Human Services: Assessment of New MSAT Regulation to Reduce Ambient Concentrations of Benzene and other MSATs

This project was awarded in the 2007/2008 grant years. A project overview is provided in **Table 5-17**.

T**able 5-17.** Anchorage, AK: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
VOCs Speciated PAHs Naphthalene CO	• Measure ambient baseline concentrations of benzene, MSATs, speciated PAHs, and CO prior to implementation of the new MSAT rule to reduce benzene content in Anchorage gasoline. • Measure gasoline BTEX content.
Project Categories	
• Baseline characterization • Emissions characterization	

5.10.2 Anchorage, AK Department of Health and Human Services: Assessment of New MSAT Regulation to Reduce Ambient Concentrations of Benzene and other MSATs – Phase 2

This project was awarded in the 2011/2012 grant years. A project overview is provided in **Table 5-18**.

T**able 5-18.** Anchorage, AK: Pollutants targeted, project goals, and project type.

Pollutants	Project Goals
VOCs Speciated PAHs Naphthalene CO	• Measure ambient baseline concentrations of benzene, MSATs, speciated PAHs, and CO prior to implementation of the new MSAT rule to reduce benzene content in Anchorage gasoline. • Measure gasoline BTEX content.
Project Categories	
• Trends characterization • Emissions characterization	

6. Conclusions

EPA's CSATAM Program grants have supported projects by state, local, and tribal communities to characterize sources and ambient concentrations of air toxics and assess human exposure and risk at a local scale. Projects were awarded in three categories: community monitoring (risk/health/baseline characterization, emissions source characterization, model evaluation), methods development, and data analysis. A total of 37 reports are available for review at this time.

6.1 Community Monitoring

As noted by the researchers, sources categorized well included:

- On-road vehicle sources, which was the most common source characterized.
- Large stationary sources, small stationary sources, and area sources. Sources emitting metals were the most common target in the stationary source categories.
- Residential wood smoke and wood-fueled boilers.

Some of the monitoring studies noted emissions sources and pollutants that were indistinguishable from other emissions or unidentified. The most common emissions source types and pollutants that were insufficiently characterized, as noted in the study reports, included:

- Transportation facilities (rail yard, intermodal facility)
- Metals from point and nonpoint sources
- Chlorinated solvents
- Mobile source facilities such as airports, ports, and roads

Additionally, there were a number of studies that listed difficulties identifying or characterizing the fraction of emissions attributable to regional/global background and identifying the sources of pollutants with secondary formation (i.e., formaldehyde, acetaldehyde, acrolein).

6.2 Methods Development

Methods development studies included novel application of existing measurement technology and development of new or improved methods. For the VOCs, PTR-MS was the only novel approach. The PTR-MS instrument has the capability to measure any pollutant with a proton affinity greater than H_2O, which includes pollutants like aromatics (e.g., benzene, toluene), aldehydes and ketones (e.g., acetaldehyde, acrolein), and some gas-phase PAHs (e.g., naphthalene, anthracene) at 1- to 5-minute time resolution. Unfortunately, the instrument is quite expensive and finicky and requires a skilled operator to oversee it during operations.

For the metals, three projects focused on improving hexavalent chromium measurement methods. Additionally, one project tested a prototype semi-continuous method for analyzing metals using XRF (Xact instrument). The Xact metals monitor can measure a suite of up to 20 metals for durations ranging between 15 minutes and 4 hours, depending on necessary detection limits. The method was deemed a suitable method by the project researchers, requiring little oversight and proving quite robust in the field.

For carbonyls, some methods were tested that were non-standard:

- The wet chemical separation technique, PAKS, was found to have good precision for acrolein, but was biased high relative to DNPH cartridges for both formaldehyde and acetaldehyde.
- The PTR-MS method is capable of measurement of some aldehydes and ketones, but formaldehyde is quite complicated as its proton-affinity is very close to that of water.
- The continuous formaldehyde sampler from the Wilmington study showed high sample throughput (~20 s) with detection limits of ~0.78 $\mu g/m^3$, but required significant wet chemistry.
- A commercially available wet chemistry continuous formaldehyde monitor was tested in Delray, Michigan; the monitor had a large number of technical issues that resulted in operational problems.

Open-path optical methods were generally deemed ineffective by study participants. Ambient concentrations were too low to be reliably detected using the open path methods.

6.3 Data Analysis

Many studies provided thorough documentation of data analyses conducted including data validation, statistical methods, graphic depictions, and discussion of findings useful to future researchers. Two data analysis focused studies performed receptor modeling of air toxics data to identify emissions sources. Findings were more specific and useful when additional pollutants were included beyond the list of air toxics because a broader range of pollutants provides the possibility of additional markers that are useful in identifying sources. Source apportionment was also most effective with continuous, highly time resolved data. For these highly time-resolved data sets, meteorological information becomes very useful in source identification.

6.4 Lessons Learned

In evaluating the studies, talking with some of the study participants, and preparing training material for a workshop on conducting successful future community-scale air toxics studies, lessons learned were compiled for project goal setting, monitoring strategy, project planning, data collection and validation, data analysis, and taking action. A key lesson learned across many studies was the need for better initial planning, including visiting proposed monitoring sites, identifying concentrations of concern, and confirming that the

measurement/analytical method can achieve the required level, balancing scope and budget, and setting a realistic schedule.

The grantees all noted that they gained valuable knowledge and experience from their studies.

7. References

Caudill M. (2012) Semi-continuous metals monitoring in Ohio industrial communities. Presented at the *National Air Quality Conference, Ambient Air Monitoring, Denver, CO, May 14-17* by the U.S. Environmental Protection Agency, Region 5, Chicago, IL. Available on the Internet at http://www.epa.gov/ttn/amtic/files/2012conference/3BCaudill.pdf.

Appendix: Resources Available to Agencies Conducting Air Toxics Monitoring Projects

EPA has funded a series of national-scale air toxics data analyses to characterize spatial and temporal variability in air toxics concentrations. A product of these extensive analyses was an Air Toxics Data Analysis workbook (Hafner et al., 2009), which presented guidance on preparing data for analysis, characterizing air toxics, quantifying and interpreting trends, and discussion of advanced topics (e.g., source apportionment). While a key limitation to these large-scale studies is a lack of local information about emissions sources, local regulations, and site operations, for example, the workbook provides data analysis approaches and observations that are relevant and useful to local-scale applications.

EPA also sponsored development of training material for "How to Create a Successful Air Toxics Monitoring Project" (Hafner and McCarthy, 2011). **Figure A-1** illustrates the underlying structure of the training, which provided steps to develop a successful project. Lessons learned from community-scale air toxics monitoring projects were woven into the training material.

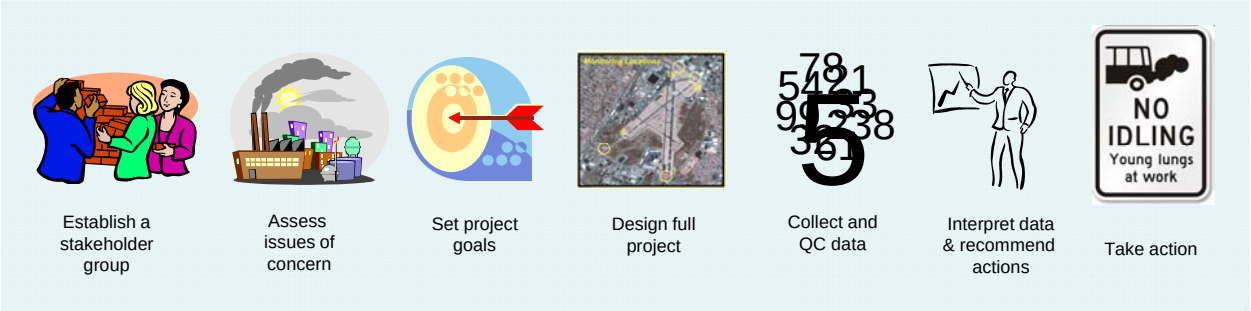

Figure A-1. Process recommended for development of a successful community-scale air toxics project.

The workbook, webinars, and presentations are available through this web portal: http://www.epa.gov/ttn/amtic/airtoxpg.html.

References

Hafner H.R., Charrier J.G., and McCarthy M.C. (2009) Air toxics data analysis workbook. Prepared for the U.S. Environmental Protection Agency, Research Triangle Park, NC, by Sonoma Technology, Inc., Petaluma, CA, STI-908304-3651-WB, June. Available on the Internet at http://www.epa.gov/ttnamti1/files/ambient/airtox/workbook/AirToxicsWorkbook6-09.pdf.

Hafner H. and McCarthy M. (2011) How to create a successful air toxics monitoring project. Training prepared for the U.S. Environmental Protection Agency, Research Triangle Park, NC, by Sonoma Technology, Inc., Petaluma, CA, STI-910219-4112, April.