# Spatial Distribution of Air Toxics near a U.S. Border Crossing

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## Project Overview

An exposure assessment of ambient air toxics from vehicular emissions was conducted in West Buffalo, a neighborhood adjacent to the Peace Bridge, a major US-Canada border crossing. The findings and methods implemented in this study should be relevant to other similar mobile-source hot spots, such as those along the U.S. borders with Mexico, and other locations of intense vehicle traffic, such as ports.

Understanding the spatial distribution of the concentration profile for pollutant levels in and around a highly trafficked area should provide insights into estimating exposures on an individual household scale around "hot spots". Our objective is to develop neighborhood scale maps showing statistically estimated pollutant concentration profiles, and to characterize the extent and severity of air toxics exposure in Buffalo neighborhoods adjacent to the Peace Bridge Plaza.

We chose ultrafine particle count measurements and total particle bound polycyclic aromatic hydrocarbons (pPAHs) for our maps. These contaminants serve well as traffic indicators, represent exposures of interest, and provide the ability to detail spatial and temporal patterns within local neighborhoods.

**Aerial photo of Peace Bridge Complex within West Buffalo. Study area is 1 km² x 2 km²**

**Data Collection along "Birdwalk Pier". This location represents background levels under the predominant winds from the southwest.**

## Methods and Materials

Measurements were taken during
•July 18-31, 2005
•January 9-21, 2006

Sampling measurements included speciated 12-hour integrated (VOCs, elements, PAHs) and continuous real-time monitors at three fixed sites. Small scale variations in concentrations across space were measured using four sets of mobile, portable continuous monitors carried in a backpack.

Our study captures temporal and spatial variations in air toxins and pollutants within the community though a combination of three (3) fixed sites established along the dominant wind vector (southwesterlies), and four (4) mobile sites. We chose to use portable sampling monitors that detect ultrafine particle counts and total particle bound polycyclic aromatic hydrocarbons (pPAHs).

**Data Collection:**
*Four backpack systems (see below) were used to measure the following throughout the study area:*
•$PM_{2.5}$ particle concentrations were collected using a P-Trak Ultrafine Particle Counter, Model 8525, for particle sizes between 0.02 µm to >1 µm (TSI, Inc., St. Paul, MN).
•Particle-bound PAHs were measured using PAS2000CE (Ecochem, League City, TX) with a sensitivity level of 10 ng/m³.
•Garmin Etrex Vista GPS recorded locations of researchers.
•SKC 10 lpm PEM with BGI pump. Sampling media is acid washed Teflo filter. For elements, mass, and reflectance.

**Prediction Maps:**
Estimated surface concentration profiles for particle counts and pPAHs were produced using a generalized additive model (GAM) in R (R: A Language and Environment for Statistical Computing). ARCGIS™ (ESRI, Inc.) was used to produce surface maps.

**Data Management and Analysis:**
SASv9.1™ PROC GLM was used to test differences on air toxin concentrations between sites, and also was the primary tool for data management. GPS locations were validated and assigned to the nearest street using ARCGIS™ (ESRI, Inc.).

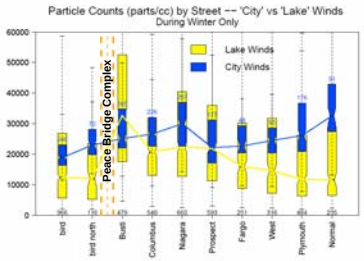
## Results

•Contributions of air toxics from vehicle emissions at the Peace Bridge/I-190 complex from volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs) over the entire sampling period were well in excess of locally measured background levels. The relative proportions of these levels vary over time and meteorology, and across species
•Distributions of pPAHs and particle counts exhibited similar dispersal patterns across the community. Particles penetrate up to 300 m and pPAHs to 400 m downwind of the PBC.
•Measurements of particles appear more affected by local sources than do pPAHs.
•Both the PAS2000CE and the P-TRAK appear to respond well to combustion products. Elevated levels of both were observed in the winter, possibly due to meteorology or home heating.

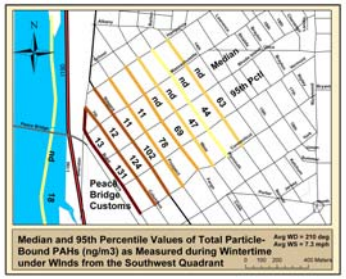
**A partial listing of air toxins at the downwind site that were significantly elevated above background**

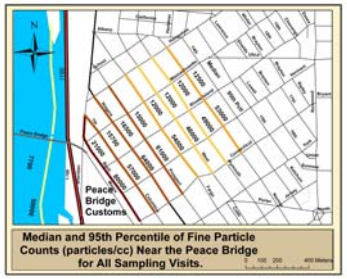
| Compound | Mean Difference (µg/m³) | Obs | (P-value) |
|---|---|---|---|
| Benzene | 0.46 | 36 | 0.0063 |
| Toulene | 1.3 | 36 | 0.0004 |
| Styrene | 0.062 | 36 | 0.0018 |
| Formaldehyde | 1.39 | 36 | 0.0026 |
| Black Carbon | 1.38 | 21 | <0.0001 |
| Manganese | 0.84 ng/m³ | 21 | 0.0033 |
| Acenapthalene | 1.13 pg/m³ | 21 | 0.0009 |
| Napthalene | 36.7 pg/m³ | 21 | 0.0171 |

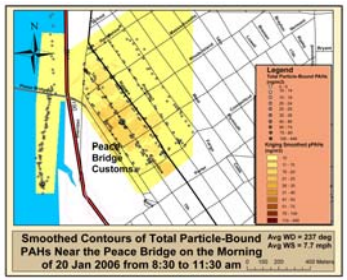
**Effect of wind direction on particle distributions by street.**




**Below: reporting street-level exposures under various conditions may reduce misclassification.**



**Above maps of smoothed predictions of measured pPAH and particle count levels. Note they exhibit a similar pattern during the same period.**

## Discussion

•We were able to capture differences across the Peace Bridge Complex in many mobile-sources related air toxins using 12-hour integrated measurements conditioned on truck counts and wind speed.

•On the community scale, a mobile monitoring approach for investigating spatial trends provides the required 'saturation sampling' for refined spatial analysis.

•The difference in the measured average behavior of particle counts and pPAHs is likely due to the fact that ultrafine particles are a near-field phenomena and the PAS2000CE measures pPAHs in the 1 – 2 um size fraction which is stable over greater distances thus reducing the impact of local traffic to the measurement.

•Over shorter times and conditioned on meteorological parameters, both instruments are good surrogates of spatial variations of traffic emissions.

•As measured concentrations drop off rapidly from a large source such as a border crossing, we would conclude that many fixed-site urban monitoring systems will not characterize mobile-sources related air toxic exposures that have substantial heterogeneity.

## Future Work

•Apply statistical method to incorporate predictors such as traffic counts and measures of surrogate compounds as well as controlling for meteorological conditions

•Develop exposure factors for use in local epidemiologic-related asthma research

•Perform factor analysis on air toxin data from fixed sites

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