Developing a Local HAP Inventory and Reduction Strategy in New Haven, CT

Madeleine Weil, City of New Haven Community Clean Air Initiative
City Plan Department, 165 Church Street, New Haven CT, 06510, mweil@newhavenct.net

ABSTRACT

The New Haven Community Clean Air Initiative is a pilot project for EPA's Integrated Urban Air Toxics Strategy. 1999 National Air Toxics Assessment (NATA) data reflected that New Haven County had the second highest quantity of air toxic emissions of any county in New England. In response, EPA and the City of New Haven developed a plan to inventory hazardous air pollutant (HAP) emissions from point, area and mobile sources. New Haven has now completed the final inventory report and initiated work on Phase II of the project, reducing risk associated with air toxic emissions. The risk reduction strategy was devised with input from a focus group comprised of diverse community stakeholders. Because the strategy is a) premised on a reliable local inventory and b) community driven, it has been recognized as a model for community-based projects.

This paper addresses New Haven's experience in developing a local HAP emissions inventory and provides guidance intended to facilitate future community inventory initiatives. The project has demonstrated the potential for refining inventories through targeted data collection at the local level and methodological innovation. The paper also addresses some of the challenges and advantages of local inventory projects and provides insight concerning the resources and partnerships needed to achieve desired results. Finally, this paper reflects on the value of a local inventory to the effort of developing and implementing a comprehensive risk reduction strategy.

INTRODUCTION

New Haven is a small city with a land base of approximately 19 square miles. This area was fully built out before the City's current zoning ordinance was enacted in 1963. New Haven's industrial and residential zones closely abut one another and are in close proximity to highways, railways and the Port of New Haven, one of the largest petroleum shipping facilities along the northeast corridor. One of City's challenges is to balance New Haven's many economic roles – major port, transportation thoroughfare, central business district, bioscience cluster and industrial enclave – with its identity as a desirable place to live. The City has worked hard to develop an environmental agenda that is cognizant of intractable realities yet aggressive in its pursuit of environmental improvements.

In this context, in 2001, New Haven completed a local inventory of greenhouse gas emissions. Related to that study, the City became aware of the health risk posed by HAPs. NATA data identified New Haven County as having the second highest quantity of air toxic emissions of any county in New England. The City's previous experience with inventory development and the mix of point, area and mobile sources located within City boundaries qualified New Haven for a Community Air Toxics pilot project. Unlike the Cleveland air toxics project, which launched immediately into reduction strategies, the New Haven pilot emphasized the development of a local air toxics inventory. With funding (awarded in 2002) and technical assistance from EPA New England, the City has now completed this inventory. New Haven's Air Toxic Reduction Strategy, (funded by a 2003 Healthy Communities grant) is premised on the information contained in the inventory and input from a community-based stakeholder group.

Although the primary purpose of the air toxics inventory was to provide empirical support for the development of an air toxics reduction strategy, EPA also intended for the pilot to explore the appropriateness

of published methodology and the availability of local data. Apart from the greenhouse gas inventory, New Haven had not addressed the problem of air pollution at the local level in a quantitative nor qualitative way since 1969, when the State of Connecticut gained regulatory authority over air quality. The New Haven project, therefore, served to explore how a local government, lacking relevant regulatory capacity and inventory experience, would go about developing a local air program. Specifically, EPA wanted to probe the following questions:

1) How accessible is air toxics data to local government staff lacking inventory expertise?
2) Where would the technical and systemic challenges lie in gathering inventory data?
3) What innovative methods would emerge from a community-based, "rookie" project?
4) How would emissions estimates compare with emissions data recorded in the 1999 NEI?

This last question was explored by McConnell, Smuts and Weil (2003) in *Comparison of HAP Emission Estimates Using Top-Down and Bottom-Up Techniques for New Haven, CT* and has been revisited here.

Because of the strategic purpose of the inventory, New Haven sought to obtain the most current emissions information available and strove for a high degree of clarity and accuracy. Also, the City felt that, intuitively, the stakes for accuracy were high because of the small geographic scale of project design. The results of this inventory, when publicized, would have real meaning to City residents because of their proximity to and familiarity with sources of air toxics.

PROJECT METHODOLOGY

As the New Haven inventory development process began, EPA had recently released the 1999 National Emissions Inventory (NEI) Draft Version 2 data and documentation. It was the City's primary reference document for an initial scoping study in which emissions sources were identified. As the inventory progressed, many other reference documents and data sources were used, principally EPA publications and material developed by the Connecticut Department of Environmental Protection (DEP). At different points in the project, the City consulted with government agencies including EPA OTAQ and OAQPS, CARB, Connecticut state agencies including the Connecticut Department of Transportation, the Department of Revenue Services, the Office of Policy and Management, and the Department of Labor. Several industry associations provided information and data. Local business owners and corporate representatives provided the City with essential information about facilities and operations. Members of the City's focus group, including representatives of environmental and public health organizations, local businesses, elected officials, government staff and community members provided expertise and assisted with community outreach.

Emissions data for 116 pollutants and pollutant groups were inventoried. Direct air toxic emission values were collected when available or calculated using emission profiles and activity data. All available HAP emissions data and PM_{10} emissions from diesel engines were included in the inventory. In the end, several iterations of emissions data and methodology were integrated into what became the final inventory. In summary, the following steps summarize New Haven's approach to estimating emissions from each emissions category.

1) Define the category;
2) Canvass NEI and DEP's Ozone Inventory for methodological direction;
3) Explore data availability and appropriateness of methodology for local conditions;
4) Calculate local emission estimate;
5) "Sniff Test" estimate in consultation with EPA, DEP, other experts; and
6) Consider improvements to calculation methodology or data inputs.

Point Sources

In the New Haven inventory, point sources were defined as industrial and commercial stationary sources that were inventoried as individual facilities. In some local inventories, only major sources as defined by the Clean Air Act are inventoried individually. In New Haven, only one facility meets EPA's threshold definition for a "major" source of HAPs.

The New Haven focus group felt that the City should investigate emissions from point sources close enough to impact air quality, even if they weren't located within the city. In consultations with EPA's modeling group, the City decided to include point sources within a 5-mile buffer of city boundaries. This five-mile buffer, in effect, encompasses towns adjacent to New Haven. While not included in the main inventory, emissions from adjacent-town sources may be considered in future air quality and health risk modeling efforts as well as stationary source emission reduction initiatives.

Initially, New Haven intended to use the NEI as the principle source for point source emission data. Technical issues prevented a quick distillation of relevant data for sources in New Haven. Difficulties were encountered in navigating the NEI data files: making sense of the NEI input format and codes, identifying New Haven sources, determining what data were necessary to meet EPA's and the City's needs. For the City's purposes, it was important that the information be organized in a format that could be easily interpreted and accessible to staff and ultimately, the public. For this reason, the New Haven point source inventory includes only information of concern to these audiences: facility name and address, principle business, emissions source category, names and amounts of emitted pollutants.

Although the NEI was used as a starting point for point source data, the need to supplement with other emissions sources was quickly determined. EPA's NEI Draft Version 2 reported incorrect lead emissions mistakenly submitted by the DEP (these were corrected in Version 3). Furthermore, several sources included in the NEI no longer existed and others had changed hands in previous years. There was uncertainty regarding the date of reported releases and therefore how accurately they characterized current local emissions.

The 2000 Toxic Release Inventory (TRI) and the DEP's 2000 Air Emissions Inventory were reviewed for potentially supplemental and corrective data, taking into account the additional limitations of these sources. TRI, for instance, does not cover the same scope of chemicals reported in the NEI. Also, TRI releases are reported as category averages rather than specific emission estimates. The DEP's 2000 Air Emissions Inventory only contained criteria pollutant emissions. The DEP Air Bureau does not yet inventory HAP emissions. An attempt was made to speciate reported VOC emissions with EPA tools, (*AP-42, Speciate, FIRE).* However, the City lacked the expertise and input data necessary to achieve a high degree of confidence in speciated results.

After the first round of data were collected, on the advice of a focus group member from the business community, the City released the draft point source emissions data to the facilities included in the inventory. Corrected or updated information was requested. With some follow-up, managers from 16 of 33 New Haven sources and 8 of 23 adjacent town sources submitted responses. Managers either confirmed that estimates were correct or provided revisions reflecting more recent or more accurate emissions data. Managers commonly reported that NEI estimates were out-of-date or that the range averages reported in TRI did not precisely reflect actual emissions.

The final point source inventory reflects emissions data from the thirty-three point source facilities in New Haven gathered from the following hierarchy of data sources:

1) Reported Emission Values: Sixteen facility managers provided emissions data in response to the City's request. Emissions from non-responding facilities were estimated using data sources listed below.
2) 2001 Toxic Release Inventory (TRI): Provided emissions data for five point sources. 2000 TRI data was used for the initial scoping study.
3) 1999 National Emissions Inventory (NEI): Provided emissions data for eight point sources. Most of these were commercial heating combustion sources for which emissions were not documented elsewhere.
4) Connecticut DEP, Air Bureau: Provided lead emissions data for six fossil fuel combustion sources. This data was, in some cases, used to supplement data reported in other inventories.

Table 1 shows summaries of the thirteen individual facilities with the greatest quantity of air toxic emissions and compares the results of the New Haven Inventory to the NEI. Cumulative emissions from these thirteen facilities account for approximately 96% of total point source emissions.

Discussion

The City felt that the process of assembling a legible and current point source inventory was more difficult and time consuming than it might have been. The fact that the state of Connecticut lacked reporting requirements for air toxics and therefore lacked an air toxics inventory hampered the City's efforts. This experience highlighted the dependence of local efforts on record-keeping staff at regulatory agencies. In addition, a training session for local staff regarding how to read NEI data files would be worth the up-front investment.

Area Sources

In the New Haven Inventory, stationary sources that were either too small or too numerous to inventory individually were inventoried as area sources. The City's first task was to determine which area source categories to include. NEI Documentation was consulted and categories were selected on the basis of their presumed importance in New Haven. Some additional categories were suggested by the focus group (scrap metal yards and fireworks, for instance) but lack of emissions estimation methodology made it impractical to develop estimates for these categories. The following area source categories were selected for inclusion in the inventory and are listed in no particular order:

1) Architectural Surface Coating
2) Auto Body Shops
3) Consumer Product Usage
4) Dry Cleaners
5) Gasoline Refueling Stations
6) Residential Heating
7) Structure Fires
8) Residential Wood Burning
9) Traffic Markings
10) Solvent Cleaning
11) Industrial Surface Coating
12) Graphic Arts

Methodology was approached separately for each category. New Haven strove to develop emission estimates from local activity data wherever possible. Table 2 outlines methodology and data sources used for area source categories.

.

Table 1. Top Thirteen Emitting New Haven Facilities.

Facility Name	Process	HAP Emissions (TPY)	Data Source	Largest Chemical Release	1999 NEI Estimate (TPY)
St. Gobain Performance Plastics*	Surface Coating (Fabric Coating)	33.53	2001 TRI	Toluene, Xylenes, Ethylbenzene, Methyl Ethyl Ketone	46.8
Gulf Oil, LP	Petroleum Bulk Terminals	19.09	2001 TRI	Napthalene, MTBE, Benzene, Tert-Butyl-Alcohol, Toluene, Cyclohexane	16.8
Von Roll Isola	Surface Coating (Fabric Coating)	14.52	Facility Submission	Methyl Ethyl Ketone, Xylenes, Toluene, 1,2,4-Trimethylbenzene, Methanol	20.1
Uretek, Inc.	Surface Coating (Fabric Coating)	8.15	Facility Submission	Methyl Ethyl Ketone, Toluene, N-Methyl-2-Pyrrolidone	12.3
Motiva Enterprises	Petroleum Bulk Terminals	7.50	2001 TRI	MTBE, Xylenes, Toluene, Benzene, n-Hexane, Ethyl Benzene	Not in 1999 NEI
Magellan Terminals	Petroleum Bulk Terminals	5.64	Facility Submission	MTBE, Hexane, Toluene, 2,2,4-Trimethylpentane, Xylenes, Benzene	Not in 1999 NEI
Sargent Manufacturing Co.	Surface Coating- Misc. Metal Parts / Solvent Cleaning	5.36	Facility Submission	Trichloroethylene, Methylene Chloride, Copper Comp, Zinc Comp	0.01
H.B. Ives Co.	Surface Coating / Solvent Cleaning	4.80	Facility Submission	Copper Comp, Glycol Ethers, Nitric Acid, Ethyl Benzene, Ethylene Glycol, Xylenes	Not in 1999 NEI
Magellan Terminals	Petroleum Bulk Terminals	5.91	Facility Submission	MTBE, Hexane, Toluene, 2,2,4-Trimethylpentane, Xylenes, Benzene	Not in 1999 NEI
Yale University Central Plant	Fossil Fuel Combustion – Combined Heat & Power	2.56	Facility Submission	Hexane, Formaldehyde, Toluene, Xylenes, Acetaldehyde, Manganese Comp	1.04
New Haven Terminal, Inc.	Bulk Terminals – Storage and Transport	2.08	Facility Submission	Styrene	32.7
PSE&G Harbor Station	Fossil Fuel Combustion – Electric Utilities	2.01	Facility Submission	Formaldehyde, Toluene, Nickel, Vanadium, POM	2.9
Getty Terminals	Petroleum Bulk Terminals	1.39	2001 TRI	MTBE, N-Hexane, Benzene, Toluene, Cyclo Hexane, Xylenes	1.1

* St. Gobain left New Haven summer 2003.

Table 2. Area Source Emission Estimation Methodology

Area Source Category	Methodology	VOC Emission Factor Source	Activity Data Source	Speciation Profile Source
Architectural Surface Coating	Per-Capita HAP Emission Factors	1999 NEI Area Source Documentation	U.S. Census	1999 NEI Area Source Documentation
Auto Body Shops	Per-Auto Refinishing Employee VOC Factor	CT DEP Inspections	Telephone Survey of Local Auto Body Shops	1999 NEI Area Source Documentation
Consumer Product Usage	Per-Capita HAP Emission Factors	1999 NEI Area Source Documentation	U.S. Census	1999 NEI Area Source Documentation
Dry Cleaners	Per-Ton Clothes Cleaned Perc Emission Factor	AP-42	Survey of Local Dry Cleaners	AP-42
Gasoline Refueling	Per Gallons Gasoline Sold VOC Emission Factor	CT DEP Ozone Inventory, AP-42, EIIP Technical Reports	Survey of Local Gas Stations	1999 NEI Area Source Documentation
Residential Heating	Per MMBtu Heating Fuel HAP Emission Factors	NA	Local Gas Company and Local Heating Oil Vendors	1999 NEI Area Source Documentation
Structure Fires	Tons of Burned Material HAP Emission Factors	NA	Local Fire Department and CARB Fuel Loading Factor	EIIP Technical Reports
Residential Wood Burning	Tons of Wood Burned HAP Emission Factors	NA	DEP Survey and EIA Data	AP-42
Traffic Markings	Paint Volume Emission Factor	NA	New Haven and CT DOT Traffic Agencies	MSDS
Solvent Cleaning	Per Employee VOC Emission Factor	CT DEP Ozone Inventory	CT DOL	*Speciate*
Industrial Surface Coating	Per Employee VOC Emission Factor	EIIP Technical Reports	*ReferenceUSA:* Employees by SIC	*Speciate*
Graphic Arts	See section below	NA	NA	NA

The following sections detail several area source categories for which locally-collected data were used to estimate HAP emissions.

Auto Body Shops

Emissions were estimated using a per-employee VOC emission factor developed in 1998 by the Connecticut DEP Bureau of Air Management. After conducting 450 inspections and analyzing data from 273 refinishers in Connecticut, the DEP arrived at an emission factor of 0.216 tons of VOC per auto body refinishing employee.

The estimate number of refinishing employees in New Haven was determined through a telephone survey conducted in October 2002 by the City of New Haven. All auto body shops in the New Haven phonebook were contacted by phone. It was determined that 16 facilities in New Haven offer automobile refinishing services with an equivalent of 51.5 full time employees. VOC emissions were calculated and speciated using profiles published in documentation for the 1999 NEI Area Source Inventory.

This method produced an estimate of 6.2 tons of HAP emissions (primarily Xylene, Toluene and MEK). Compiling employment statistics via phone survey risks underestimating total auto refinishing emissions because it does not capture emissions from unlisted/illegal shops or backyard activities. Further study in New Haven could involve an investigation of these activities.

Dry Cleaners

The dry cleaner category went through several iterations of emissions estimates, calculated according to the three different methods listed below.

1) The DEP's 1990 state-level estimate of perchloroethylene emissions was enlarged to account for population growth between 1990 and 2000 and then reduced to account for technology improvements required by Connecticut standards. This adjusted state-level estimate was apportioned to New Haven by the number of dry cleaners in the city versus the state as a whole. This method produced an estimate of 18 tons of perc;
2) EPA's per-employee emission factor from EIIP Technical Reports was applied to New Haven dry cleaner employment data from the *ReferenceUSA* business database. This method produced an estimate of 48.9 tons of perc; and
3) Because the results produced by these two methods differed so dramatically, New Haven sent out a survey to local dry cleaners, identified through the phone book. Twenty of twenty-six identified facilities responded. Nine were drop-only locations (no cleaning operations take place on-site) and eleven facilities reported the weight of clothes cleaned and the technology used. Survey responses indicated that approximately 425,336 lbs of clothing are cleaned per year in New Haven (includes non-responders). All respondents used perc as the cleaning agent and all but one used dry-to-dry technology. This amount was multiplied by an AP-42 emission factor (perc per amount clothes cleaned) for dry-to-dry technology to produce an estimate of 8 tons of perc emissions.

Ultimately, the estimate produced by Method 3 was included in the New Haven inventory. It is notable that the emission factor used in this calculation was developed in 1981 yet yielded a lower estimate than the factor used in Method 2, developed in 1996. This result is contrary to expectations.

Gasoline Refueling

The CT Office of Policy & Management conducted a fuel sales survey of gas stations in 1990. A driving tour of New Haven gas stations revealed that by 2002, OPM's 1990 list was no longer representative of actual conditions and could not serve as an accurate assessment of local fuel sales. A survey requesting annual gasoline sales was addressed to all existing gas stations. Gasoline sales were obtained from 32 of 44 service stations in New Haven. Several non-responders cited proprietary privilege in withholding sales data. Sales from non-responsive stations were estimated in the following three ways, using tank capacity and gas nozzle data, gathered from the New Haven Health Department Weights & Measures Division and Connecticut Department of Revenue Services:

4) The average gallons sold per tank capacity ratio among responders was applied to tank capacity of non-responders. This method produced an estimated total of 31.9 million gallons;
5) The average gallons sold per gas nozzle ratio among responders was applied to gas nozzles of non-responders. This method calculated an estimated total of 32.2 million gallons; and
6) The average number of gallons sold per facility among responders was attributed to non-responders. This method calculated an estimated total of 35.2 million gallons.

Since none of the above methods was judged to be any more or less valid than the others, the results were averaged (33.1 million gallons) and this number was multiplied by a per-gallon VOC emission factor to produce a VOC estimate. VOC emissions were speciated with chemical profiles published in the documentation for the 1999 NEI Area Source Inventory. Profiles were adapted to match Connecticut's blend of gasoline: 50% winter oxygenated with MTBE and 50% reformulated with MTBE.

Subcategories of gasoline refueling emissions calculated in the New Haven Inventory include tank truck unloading, underground tank breathing, vehicle refueling, tank trucks in transit, and aircraft refueling. This last category was based on fuel sales information provided by the staff of New Haven's local airport. Total HAP emissions from gasoline refueling are estimated to be 15 tons per year.

Graphic Arts

Because emissions from area source printing facilities primarily depend upon the contents of the materials used, it is possible to develop emission estimates using material-based factors. In the New Haven inventory, EPA's ink sales data method was initially used to develop an emission estimate for area source printing facilities. The dollar value of inks sold in New Haven County was obtained from an industry association and U.S. census data was used to relate these dollar values to volumes. Employment data were used to apportion county estimates to the city level. From there, fountain and cleaning solution volumes were extrapolated from ink volumes, using EIIP factors. VOC emissions were estimated and speciated into chemical components using a general graphic arts profile in EPA's *Speciate.*

According to this method, cumulative emissions from small graphic arts facilities in New Haven amount to more than 970 tons. After comparing this result with county and state estimates from the NEI and consulting EPA and industry professionals, it was determined that this method likely grossly overstated local emissions from this category. In an effort to estimate graphic arts emissions as accurately as possible, a survey was developed and addressed to twenty-four local printing facilities. The survey was designed with the help of environmental specialists within the graphic arts industry, EPA and DEP. Industry professionals provided direction on several rounds of pre-distribution revisions in an attempt to make it as easy as possible for facility managers to respond.

Unfortunately, the survey did not successfully capture the information necessary to develop an emission estimate. Out of the twenty-four facilities that received the survey, eight reported that their operations do not generated air emissions. Most of these were copy shops rather than commercial printers. Eight did not respond at all, despite several follow-up phone calls. The final eight facilities completed and returned the survey, but the information they supplied was not sufficient to develop quantitative assessments of HAP emissions. It was apparent that because small graphic arts facilities are not regulated and have no reporting requirements, most facility owners and managers are not prepared to provide emissions-related information.

Despite these shortfalls, survey responses showed that HAP-containing materials are being used by small commercial printing facilities in New Haven. The eight responding facilities (all sheetfed lithographic presses) reported using a combined total of 12,248 gallons of HAP-containing materials. Toluene, n-Hexane, Ethylene Glycol, Xylene, Ethyl Benzene, Methyl Ethyl Ketone, Formaldehyde and Methanol are contained in reported blanket washes, fountain solutions and other materials used by New Haven businesses. But because the percentage of HAPs found in reported materials is low (1-5%), it is unlikely that the printing industry is a significant source of HAPs.

Discussion

In retrospect, New Haven feels that the area source component of a local inventory is the section to which locally derived data can add the most value. In a city the size of New Haven, it was quite possible to collect accurate, ground level activity data for a number of different area source categories through surveys and phone calls. Although the City has a high degree of confidence in the accuracy of activity data used in emissions calculations, it has less confidence in the accuracy in the emissions calculations themselves. In most cases, it was not feasible for the City to develop local HAP emission factors. Emissions estimates for most categories, therefore, assume that EPA's national-level factors are applicable to local conditions. New Haven's experience with the graphic arts ink sales methodology calls this assumption into question.

On-Road Mobile Sources

Initially, New Haven intended to use the Mobile 6.2 model to develop New Haven specific emission factors for on-road vehicles. After experimenting with the model and input parameters, the effort was abandoned. New Haven would have been the first organization to attempt a sub-county run – a task that the City decided it could not efficiently accomplish.

Instead, New Haven initially apportioned county-level emissions reported in the 1999 NEI to the City level by multiplying them by a VMT ratio:

Equation (2) $e_{city} = e_{county}(VMT_{city} / VMT_{county})$

where

e = HAP emissions
VMT = vehicle miles traveled

This method assumed that emissions at the city and county levels are proportionate to one another with respect to VMT. Intuitively, New Haven felt that by ignoring other potential variables - vehicle mix, traffic patterns and speed, for example - the inventory might underestimate New Haven's vehicle emissions. New Haven's role as the physical and economic hub of New Haven County means that this variability could be significant. For instance, because lower speeds cause higher levels of exhaust emissions, rush hour congestion in New Haven is likely to result in emissions per VMT out of proportion with the rest of New Haven County.

Without running Mobile 6.2, the City was unable to identify a method for quantifying the emission impacts of New Haven's congestion problem. It was possible, however, to refine the emissions estimate with respect to vehicle mix.

In the 1999 NEI, county-level emissions were calculated by applying emission factors generated by Mobile 6.2 to county-level VMT data apportioned by vehicle category. The City found that the proportions of VMT attributed to different vehicle categories in the 1999 NEI did not conform to local vehicle classification data, as reported by the Connecticut Department of Transportation. Therefore, the City adjusted these proportions to better reflect local conditions by allocating New Haven VMT by vehicle category according to traffic count data reported by the DOT.

Table 3. Comparison of Vehicle Classifications and VMT Allocations – County vs. City

Vehicle Type	NEI County Vehicle Classifications (% of VMT)	NEI County VMT Assumptions (millions)	New Haven Vehicle Classifications (% of VMT)	New Haven VMT Assumptions (millions)
HDDV	6.60%	437.571	10.7%	82.300
LDDV	0.32%	21.0607	3.96%	30.510
HDGV	3.01%	199.650	1.32%	10.170
LDGV	59.36%	3933.08	55.59%	428.37
LDGT	30.32%	2009.12	28.48%	218.82
MOTO	0.38%	25.4512	0.05%	0.3900
TOTAL	100%	6,625.94	100%	770.56

To apportion NEI county level emissions to the city level, county emissions for each pollutant per vehicle category were divided by the NEI VMT input for that category. This calculation yielded the underlying emission factor (originally calculated by Mobile 6.2). Then, this emission factor was multiplied by the New Haven VMT input for that vehicle category. This calculation produced city-level emissions estimates, tailored to New Haven's particular vehicle classification mix as reported by the DOT. PM_{10} emissions from diesel vehicles, reported in the 1999 NEI Criteria Pollutant Inventory, were apportioned from county to city by VMT.

Heavy Duty Diesel Vehicles

Shipping activities associated with the port bring a greater proportion of truck traffic through New Haven, compared to the rest of the county. Trucks idle as they load and unload and they move at slow speeds on local roads and on and off exit ramps. The City felt that these patterns associated with local truck movements in and out of the port should have the effect of increasing emissions per vehicle mile traveled within the city of New Haven – an increase that is not accounted for in the emissions estimates above.

The effect on emissions of port-related truck traffic has been documented by monitoring data. The air monitor located between Interstate 95 and the Port of New Haven is the only monitor in the state that has recorded levels of $PM_{2.5}$ in exceedance of National Ambient Air Quality Standards. The DEP believes that the high volume of truck movements around the port is in part responsible for this exceedance. Taking this evidence into account, the City believes that on-road heavy-duty diesel emissions may be underestimated in the New Haven inventory.

Non-Road Mobile Sources

The New Haven inventory contains emission estimates for aircraft, commercial marine vessels, locomotives and other non-road equipment used for construction, recreational, landscape and industrial applications – the range of vehicle and equipment types in operation in New Haven.

Aircraft, Commercial Marine Vessels and Locomotives

HAP emissions for these vehicle types were calculated largely from the bottom-up. Aircraft emissions were calculated by applying EPA emission factors to landing and take-off data for Tweed New Haven Airport, as reported by the Federal Aviation Administration (FAA). Emissions for commercial marine vessels were based on the U.S. Military's Waterborne Commerce Statistics, the Energy Information Association's fuel consumption statistics and EPA emission factors. Diesel PM emissions for commercial marine vessels in New Haven County (reported in the 1999 NEI) were attributed to the Port of New Haven. The locomotive emissions estimate was based on fuel consumption reports requested from three railroad companies operating in New Haven. Railroad engineers were asked to estimate the amount of fuel consumed by locomotives while in New Haven. Results were multiplied by EPA emission factors. In the inventory, total HAP emissions from locomotives appear misleadingly low because the 1999 NEI Criteria Pollutant Inventory lacked a locomotive PM_{10} estimate in New Haven County.

Other Non-Road Vehicles and Equipment

The non-road category includes construction equipment, commercial and industrial equipment, golf carts, landscaping equipment and recreational boats. Emissions from these categories were calculated from the top-down: county-level emissions data from the 1999 NEI were apportioned to New Haven using a variety of indicators (see Table 4).

Table 4. Other Non-road Equipment Activity Indicators

Non-road Category	Activity Indicator
Industrial Equipment	Manufacturing Employees
Personal Landscaping Equipment	Single/Duplex Housing Units
Commercial Landscaping Equipment	Land Area (square miles)
Golf Equipment	Equipment Population
Construction Equipment	$ Spent in Construction
Commercial Equipment	# Wholesale Establishments
Recreational Boats	Surface Water Area
Railway Maintenance Equipment	Population

Health Risk Prioritization

The inventory presented information in terms of tons of pollutants emitted per source category per year. Because New Haven's goal was to develop an emissions reduction strategy based on health risk, and quantities emitted do not necessarily correlate with health risk, additional analysis was necessary. In national studies, EPA determines health risk by modeling pollutant concentrations in the effected airshed and analyzing the toxicity and concentration of chemicals to which populations are exposed. This process was beyond the scope of the New Haven project. However, with assistance from EPA New England, a toxicity analysis of local emissions was conducted, using the toxicity weight screening approach outlined in EPA's draft *Air Toxics Risk Assessment Reference Library, Volume 2 Site-Specific Risk Assessment Technical Resource Document.* This method evaluates relative risk, taking into account both the emissions and toxicity of a chemical. In this way,

the City was able to order the chemicals in the inventory by toxicity weighted factors and focus a reduction strategy on risk-based lists.

Table 5 compares the top ten pollutants in New Haven measured by quantity versus the top ten pollutants ranked by cancer, chronic and acute risk. The differences between the emission list and the three health-based lists highlight the need for local inventory efforts to be accompanied by health-risk analysis. In other words, basing a reduction strategy on inventory results alone might prompt a local project to prioritize a source category emitting higher volumes of less toxic chemicals over a less-emitting, but more hazardous source. The expertise of toxicologists and seasoned air pollution experts is essential at this stage in a local project.

New Haven Air Toxics Risk Reduction Strategy

In October of 2003, EPA New England awarded the City of New Haven a Healthy Communities grant to implement an air toxics emission reduction strategy in collaboration with community stakeholders. The Strategy targets source categories identified as health risk drivers. Prioritization of these source categories was based on the following criteria:

1) The volume of emissions reported in the New Haven Air Toxics Inventory;
2) The toxicity of the chemicals released;
3) The geographic locations of emission sources and their proximity to population locations; and
4) The City's ability to implement effective risk reduction strategies.

New Haven designed a three-tiered strategy, intended to reduce emissions from mobile, indoor and stationary sources of air toxic emissions (see Table 6). Given the City's limited regulatory authority over air pollution, New Haven's strategy is based on voluntary initiatives and is designed to engage stakeholders with diverse concerns. Several of the components of New Haven's Air Toxic Risk Reduction Strategy dove-tail with actions intended to produce alternative but complementary results – greenhouse gas emissions reductions, for example. Because of this overlap, there is a pre-existing constituency for adopting the CAL LEV II standards in Connecticut, for example. The diesel issue is another example. Recent concern over New Haven's non-compliant levels of fine particulate matter has added a legal component to the already compelling list of reasons to work towards diesel reductions. In New Haven and across the State of Connecticut, there are different but overlapping constituencies for health-based, environmental justice and climate-based emissions reduction programs. This coincidence of goals strengthens constituent support for these initiatives. The Community Clean Air Initiative's "Big-Tent" approach to air pollution outreach is intended to leverage the City's power to catalyze change.

Table 5. New Haven Air Toxic Emissions – Top Ten Quantity vs. Top Ten Health Risk

Rank	Top Ten Chemicals – Quantity of Emissions (Emissions in tons)	Top Ten Chemicals – Cancer Risk (Emissions in tons)	Top Ten Chemicals – Chronic Risk (Emissions in tons)	Top Ten Chemicals – Acute Risk (Emissions in tons)
1	Diesel PM = 230	POM = 0.69	Acrolein = 2	2,2,4-Trimethylpentane = 49
2	Toluene = 166	Diesel PM = 230	Napthalene = 8	Ethylene = 7
3	Xylenes = 110	Formaldehyde = 42	Hydrogen cyanide = 5	Propionaldehyde = 3
4	Methyl Tert-Butyl Ether = 85	Dioxin and compounds = 1.32E-05	Manganese compounds = 0.06	n-Methyl-2-pyrrolididone = 1
5	Benzene = 52	Benzene = 52	Xylenes = 110	Acetylene = 2
6	2,2,4-Trimethylpentane = 49	Chromium Compounds = 0.03	Phospherous compounds = 0.04	2-Methylfuran = 1
7	n-Hexane = 48	1,3-Butadiene = 8	Toluene = 166	Ethane = 2
8	Formaldehyde = 42	Arsenic compounds = 0.04	Mercury compounds = 0.04	Furfural = 1
9	Methyl Chloroform = 30	Nickel compounds = 0.60	Cobalt compounds = 0.03	Tert Butyl Alcohol = 2
10	Ethylbenzene = 27	Tetrachloroethylene = 11	n-Hexane = 48	Nitric Acid = 1

Table 6. New Haven's Three-Tiered Risk Reduction Strategy

Source Category	Target Area	Goal	Implementation	Partners / Venues
Mobile Source Air Toxic Emissions	Passenger Vehicles	Reduce VMT	Smart growth, transit, and enhancement of in-town non-motorized transportation opportunities	Connecticut Climate Change Stakeholders, Blue Ribbon Commission on Smart Growth and Property Tax Reform
		Reduce emissions per vehicle mile driven	Support the adoption of the CAL LEV II standards by the CT Legislature.	Connecticut Clean Cars Alliance, Connecticut Fund for the Environment
	Heavy Duty Diesel Vehicles	Reduce diesel exhaust emissions and exposure	Create ultra-low sulfur diesel buying group, retrofit school bus fleet & other municipal vehicles, require emissions control equipment through construction specifications, promote voluntary retrofits and retirements for private fleets.	EPA New England, Connecticut DEP, Connecticut DOT, Environment Northeast, New Haven Environmental Justice Network, Northeast States for Coordinated Air Use Management (NESCAUM)
Indoor Air Toxins	Tobacco Smoke	Reduce children's exposure to second-hand smoke	Distribute EPA's Smoke-Free Home campaign materials to families through day-care and pre-school centers.	New Haven School Readiness Program
	Hazardous Consumer Products	Decrease use of products containing air toxins in New Haven households	Distribute materials about toxic consumer products and hazardous waste recycling.	EPA New England, New Haven Health Department, New Haven Asthma Initiative
	Indoor Air Toxins / Asthmagens in Schools	Improve or maintain indoor air quality in school environments	EPA Tools for Schools pilot program in New Haven school. Safe cleaning product recommendations to school board.	EPA New England, New Haven Health Department, New Haven Asthma Initiative
Stationary Source Emissions	Surface Coating / Solvent Cleaning Operations	Reduce emissions from local facilities	Compliance and pollution prevention outreach through inspections and workshops	Connecticut DEP, NESCAUM
	Gasoline Refueling Emissions	Reduce emissions from gasoline refueling	Develop and/or distribute pump safety sticker to local fueling stations	TBD: EPA New England, CT DEP, New Haven Environmental Justice Network

CONCLUSIONS

The New Haven Air Toxics Project demonstrates the ability of a local agency, largely lacking inventory expertise and air pollution regulatory authority, to develop a credible inventory of air toxic emissions from local sources. The City considers the inventory development process a success for the following reasons:

1) It raised awareness of toxic air pollution both in the community and at City Hall;
2) It helped to establish the City as an authority and stakeholder on issues of air pollution at the state and local level;
3) It bestowed legitimacy on the resulting risk reduction strategies;
4) It established a baseline from which emissions reductions can be measured and future inventories can be compared;
5) The issue of emissions source clusters was recognized as a zoning concern; and
6) It has leveraged, and is leveraged by, complementary campaigns addressing a variety of air quality issues.

As a pilot, the New Haven project was intended to highlight the challenges and advantages to developing air toxics inventories at the local level. Several general observations about the inventory development process are listed below.

1) Local inventory development staff should receive training in accessing, decoding and working with the NEI database in advance of collecting emissions data;
2) The development of local air toxics inventories (particularly for point sources) is likely to be easier in states with air toxics reporting requirements;
3) EPA's methodologies and emission factors, based on national inventories, will not always produce accurate results at the local level. Local inventory staff should be prepared to think analytically and creatively about local conditions;
4) Inventory focus groups should include one toxicologist, one inventory staff person from a regulatory and record-keeping agency, and one well-established member of the business community;
5) Without modeling results and monitoring data, it can not be conclusively established that New Haven's bottom-up results are more accurate than those that would have been developed through a top-down process;
6) Although individuals were very helpful, the City found it difficult to engage the focus group, as such, in the technical aspects of inventory development. In New Haven's experience, the value of the community focus group was primarily in the development and implementation of risk reduction strategies. In this stage of the process, focus group members could engage their own organizations in the areas in which they have expertise and reach out to the sectors of the community to which they have access. Inventory development, in contrast, is not an equally accessible nor democratic process;
7) Although the Cleveland Project by-passed the assessment phase and went directly to implementation, Cleveland's risk reduction strategy targets largely the same sources as New Haven's. This is interpreted to reveal a) a certain degree of commonality in the emissions profile of urban areas and b) limitations to the realm of implementation strategies feasible at the local level.

Regarding this final point: As New Haven moved from inventory development to toxicity analysis to risk reduction, a disconnect emerged between the causes of health risk and the City's ability to make a difference. Many of the most serious threats to public health in New Haven can not effectively be addressed through voluntary measures at the local level. Regulation and technology diffusion at the federal and state levels are necessary. For this reason, the City's long-term strategic objectives now include advocacy efforts and coalition building on issues previously considered outside of the municipal purview.

REFERENCES

1) *1996 National Air Toxics Assessment,* U.S. Environmental Protection Agency, Research Triangle Park, NC.
2) *Cleveland Clean Air Century Campaign*, online, http://www.ohiolung.org/ccacc.htm, Accessed 2004.
3) McConnell, Robert, Mary Beth Smuts and Madeleine Weil; *Comparison of HAP Emission Estimates Using Top-Down and Bottom-Up Techniques for New Haven, CT,* U.S. Environmental Protection Agency Region 1, Boston, MA, 2003.
4) *Greenhouse Gas Inventory & Forecast Report*, New Haven Department of City Plan, New Haven, CT, 2001.
5) *1999 National Emissions Inventory Version 2 for Hazardous Air Pollutants*, U.S. Environmental Protection Agency, Research Triangle Park, NC, 2002.
6) *2000 and 2001 Toxic Release Inventory*, U.S. Environmental Protection Agency, Washington, DC.
7) *Connecticut Department of Environmental Protection Air Emissions Inventory of 2000*, Hartford, CT, 2000.
8) *Compilation of Air Pollutant Emission Factors,* U.S. Environmental Protection Agency, Research Triangle Park, NC, AP-42, Various Sections.
9) *Speciate Version 3.2,* U.S. Environmental Protection Agency, Research Triangle Park, NC.
10) *Factor Emission Retrieval (FIRE) Data System Version 6.23*, U.S. Environmental Protection Agency, Research Triangle Park, NC.
11) Eastern Research Group; Documentation for the 1999 Base Year Nonpoint Source National Emission Inventory for Hazardous Air Pollutants; prepared for the Emission Factors and Inventory Group, U.S. EPA, Research Triangle Park, NC, 2001. Prepared by Eastern Research Group, In., Morrisville, NC, 2001.
12) Mulcahy, Christopher; *Auto-Body Refinishers Emission Factor*, Connecticut Department of Environmental Protection, Hartford, CT, interoffice memo, November 18, 1998.
13) *1996 Periodic Ozone and Carbon Monoxide Emissions Inventory*, Connecticut Department of Environmental Protection, Hartford, CT, 2000.
14) Emissions Inventory Improvement Program; *Volume III, Area Sources Preferred and Alternative Methods,* U.S. Environmental Protection Agency, Research triangle Park, NC, 1997*ReferenceU.S.A. Version 2004.4*, InfoUSA, Inc., Omaha, NE, 2004.
15) *Listing of Gas Stations in 1990,* Connecticut Office of Policy and Management, Hartford, CT, 1990.
16) *1999 National Emissions Inventory Final Version 3.0 for Criteria Pollutants*, U.S. Environmental Protection Agency, Research Triangle Park, NC, 2003.
17) *APO Terminal Area Forecast Report for Tweed New Haven*, Aviation Policy and Plans, Federal Aviation Administration, U.S. Department of Transportation, Washington, DC, Accessed 2002.
18) *Waterborne Commerce of the United States, 2000, Part 1: Waterways and Harbors of the Atlantic Coast,* U.S. Institute for Water Resources, U.S. Army Corps of Engineers, Alexandria, VA, 2000.
19) Draft Air Toxics Risk Assessment Reference Library, Volume 2, Site Specific Risk Assessment Technical Resource Document, Research Triangle Park, NC, 2003.

KEYWORDS

Emissions Inventories
Air Toxics
New Haven
Risk Reduction

ACKNOWLEDGEMENTS

The author wishes to acknowledge the assistance of Michael Piscitelli and Paul Kowalski, City of New Haven, Mary Beth Smuts and Bob McConnell, EPA Region 1, and Tracy Babbidge, CT DEP.