Identifying Priority Hazardous Air Pollutants of Potential Concern: A Comparison of Toxicity-Weighted Emissions and Ambient Risk Screening Results

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ABSTRACT

The identification of the most important individual emission sources and/or source categories significantly contributing to potential health risks is challenging for many air quality managers. Large reductions in emissions of hazardous air pollutants (HAP) may not necessarily translate into significant reductions in health risk because toxicity varies by pollutant. For example, acetaldehyde mass emissions are more than double than acrolein emissions on a national basis, according to EPA's 2002 National Emissions Inventory (NEI). However, according to the Integrated Risk Information System (IRIS), acrolein is 450 times more toxic in terms of respiratory noncancer risk than acetaldehyde. Thus, it is important to account for the toxicity as well as the mass of the targeted emissions when designing reduction strategies to maximize health benefits.

This paper uses the anthropogenic portion of the 2002 NEI, which is comprised of stationary and mobile sources for every county in the United States, to explore a toxicity-weighting approach for identifying pollutants that pose the greatest potential health risk. In addition, the results of this toxicity weighted emissions approach are compared to those from ambient monitoring risk screening results for select areas across the country.

INTRODUCTION

Acute and chronic exposure to specific hazardous air pollutants (HAPs) can lead to cancer and/or noncancer effects. Since the passage of the 1990 Clean Air Act Amendments (CAAA),[1] EPA has spent considerable time and resources establishing federal regulations, primarily through maximum achievable control technology (MACT) standards, to reduce emissions for HAPs. Atmospheric models, such as those executed for the National Air Toxics Assessment (NATA), are often used to characterize the nation's air toxics problem both in absolute as well as relative senses by area and pollutant. In addition, ambient monitoring data can help identify pollutants and specific emission sources impacting an area's air quality, and track changes or identify trends in ambient concentrations.

HAP modeling may not be feasible for many state, local, and tribal agencies to perform on their own due to time, resource, and expertise constraints. Additionally, due to the complexity and time required for developing national emissions inventories and subsequently modeling the entire U.S., NATA results are often available only years after the actual time of the emissions (e.g., NATA 1999 was not publicly available until 2006). An alternative approach may help air quality managers screen for pollutants that may contribute most significantly to health risks in their area by toxicity-weighting their emissions inventory using an analytic method developed by EPA.[2] This paper demonstrates the approach for the toxicity-weighting process, as well as comparing "pollutants of concern" based on actual mass emissions, toxicity-weighted HAP emissions, and with those priority pollutants indentified by screening ambient monitoring data based on cancer and/or noncancer toxicity factors.

DATA SOURCES

National Emissions Inventory (NEI)

EPA compiles the National Emissions Inventory (NEI), consisting of stationary (point and nonpoint area), mobile (onroad and nonroad), and biogenic source emissions for the entire United States.[3] This study focuses on anthropogenic sources and does not include emissions information for biogenic sources. Pollutants in the NEI consist of emissions of HAPs and criteria air pollutants (CO, NH_3, NO_x, PM, SO_2, and VOCs). The NEI base year inventories are developed every three years, and the latest publicly available NEI is for base year 2002. Although point source emissions are typically available down to the process-level within an individual facility, nonpoint area, onroad, and nonroad are available only the county-level. As a result, the toxicity-weighting approach used in this study is at the county-level.

Urban Air Toxics Monitoring Program (UATMP)

EPA sponsors the Urban Air Toxics Monitoring Program (UATMP), which began in 1987,[4] to characterize the composition and magnitude of urban air pollution through ambient monitoring. Data collected within the UATMP has been considered by EPA as the most representative data available for air toxics monitoring. Pollutant groups measured in the UATMP include: volatile organic compounds (VOCs); carbonyl compounds; metals (including hexavalent chromium); semi-volatile organic compounds (SVOCs); and speciated nonmethane organic compounds (SNMOCs). Table 1 presents the more than 50 HAPs that can be measured at any given UATMP location based on the program's above pollutant groups. It is important to note that some HAPs have cancer effects, some noncancer effects, and some both. The national and regional cancer and noncancer pollutant drivers from the 1999 NATA assessment are also presented in Table 1. National pollutant drivers are those that affect more than 25 million people, whereas regional driver pollutants affect more than 10 million people. From a national perspective, benzene is the national cancer driver, while acrolein is the noncancer national driver.

In 2006, 59 sites participated in the UATMP. Four sites collected samples for most of the above pollutant groups. Information on these sites is presented in Table 2. The ambient monitoring sites, with their associated counties are: 1) Northbrook (NBIL) in Cook County, IL; Dearborn (DEMI) in Wayne County, MI; the St. Louis Supersite (S4MO) in St. Louis City, MO; and Bountiful (BTUT) in Davis County, UT. Figure 1 presents these study locations.

METHODOLOGY

Toxicity-Weighted Emissions Approach

The toxicity-weighted emissions approach consists of four basic steps:

1. Obtain HAP emissions data for all anthropogenic sectors. For point sources, sum the process-level emissions to the county-level.
2. Apply the mass extraction speciation profiles to extract metal and cyanide mass. Non-metals are multiplied by 1. The only exception is for two chromium species: chromium and chromium compounds.
3. For chromium and chromium compounds, it is important to separate trivalent chromium (non-toxic) vs. hexavalent chromium (toxic). To do this, apply the chromium speciation profile to extract the hexavalent chromium mass by industry group.
4. Weight the emissions derived in Step 2 and 3 above by their toxicity.
   a. To weight by cancer toxicity, multiply the emissions of each pollutant by its cancer URE.[5]

b. To weight by noncancer toxicity, divide the emissions of each pollutant by its noncancer RfC.[5]

While the absolute magnitude of the pollutant-specific toxicity-weighted emissions is not meaningful, the relevant magnitude of toxicity-weighted emissions is useful in identifying the order of potential priority or pollutants of interest. For example, higher values suggest greater priority; however, even the highest values may not reflect potential cancer effects greater than a level of concern (1 in 1 million) or potential noncancer effects above levels of concern (e.g., HQ = 1).

Ambient Monitoring Predicted Risk Calculations

In the 2006, sampling at S4MO, BTUT, DEMI, and NBIL took place all year (January through December). As presented in Table 2, measurements were made at each of these sites every sixth day, yielding 60 samples over the course of the year. To translate predicted cancer and/or noncancer risk, a valid annual average is required. The definition of a "valid annual average", as defined in the UATMP, is the average of all detected concentrations and ½ minimum detection limit (MDL)-substituted surrogate values for non-detects for the pollutants of interest. Additionally, samples must be collected for a minimum of ten consecutive months, typically beginning no later than February and ending no earlier than November in a typical calendar year.

Pollutants of interest are site-specific, and they are identified using a modified EPA-approved risk screening approach that takes into account the number of concentrations exceeding a risk screening value.[6] Applicable cancer URE and/or noncancer RfC factors are applied to the annual average concentration to screen the pollutants in the context of predicted cancer and/or noncancer risks. In this assessment, "predicted" cancer and noncancer risks do not reflect true human inhalation exposure, as no human activity patterns are considered. Consequently, results presented in this paper only represent a relative and initial sense of the pollutants of potential concern.

RESULTS

The more toxic the pollutant, the more risk associated with its emissions in ambient air. However, a pollutant emitted in high quantities does not necessarily present a higher risk to human health than a pollutant emitted in very low quantities. The total mass emissions and the associated toxicity-weighted emissions top 10 priority pollutants are presented in Tables 3 through 10. For comparative purposes, each table also includes the priority pollutants identified from the risk screening performed using the ambient monitoring data from the UATMP.

Toxicity-Weighted Emissions vs. Mass Emissions Comparison

<u>Cook County, IL</u>

The 10 priority pollutants determined by mass emissions and toxicity-weighted emissions for Cook County, IL are presented in Tables 3 and 4 for cancer and noncancer, respectively. Among the cancer-causing pollutants, benzene ranks highest using a mass basis, followed by formaldehyde and tetrachloroethylene. Using the toxicity-weighting approach, benzene also ranked highest, followed closely by arsenic and coke oven emissions, both of which did not rank in the 10 highest mass emissions. Arsenic emissions ranked 20th in Cook County, IL at 2.9 tons per year (tpy), while coke oven emissions ranked 12th at 16.7 tpy. Five pollutants are in the top 10 for both mass emissions and toxicity-weighted emissions (benzene, naphthalene, 1,3-butadiene, tetrachloroethylene, and *p*-dichlorobenzene).

Among the noncancer pollutants, toluene, xylenes (total), and methanol were the top 3 pollutants by mass emissions in Cook County, IL. Using the toxicity-weighting approach, acrolein and manganese are ranked highest, despite having their mass emissions ranked 29th and 38th, respectively (63.7 tpy for acrolein and 7.7 tpy for manganese). Only formaldehyde ranked in the top 10 for both mass emissions and toxicity-weighted emissions.

Wayne County, MI

The 10 priority pollutants determined by mass emissions and toxicity-weighted emissions for Wayne County, MI are presented in Tables 5 and 6 for cancer and noncancer, respectively. Among the cancer-causing pollutants, benzene ranked highest using a mass basis, followed by formaldehyde and tetrachloroethylene. Using the toxicity-weighting approach, coke oven emissions ranked highest, followed by benzene and 1,3-butadiene. Coke oven emissions ranked 11th in Wayne County, MI at 40.3 tpy. Four pollutants were in the top 10 for both mass emissions and toxicity-weighted emissions (benzene, naphthalene, 1,3-butadiene, and tetrachloroethylene).

Among the noncancer pollutants, toluene, xylenes (total), and benzene were the top 3 pollutants by mass emissions in Wayne County, MI. Using the toxicity-weighting approach, acrolein and manganese ranked highest, despite having their mass emissions ranked 27th and 30th, respectively (40.9 tpy for acrolein and 16.5 tpy for manganese). Hydrochloric acid, formaldehyde, and benzene were on both lists for mass emissions and toxicity-weighted emissions.

St. Louis City, MO

The 10 priority pollutants determined by mass emissions and toxicity-weighted emissions for St. Louis City, MO are presented in Tables 7 and 8 for cancer and noncancer, respectively. Among the cancer-causing pollutants, benzene ranked highest using a mass basis, followed by formaldehyde and acetaldehyde. Using the toxicity-weighting approach, benzene also ranked highest, followed by 1,3-butadiene and arsenic. Arsenic emissions ranked 17th in St. Louis City at 0.09 tpy. Five pollutants were in the top 10 for both mass emissions and toxicity-weighted emissions (benzene, 1,3-butadiene, naphthalene, acetaldehyde, and tetrachloroethylene).

Among the noncancer pollutants, toluene, xylenes (total), and methanol were the top 3 pollutants by mass emissions in St. Louis City, MO. Using the toxicity-weighting approach, acrolein and chlorine were ranked highest, despite having their mass emissions ranked 25th and 27th, respectively (7.8 tpy for acrolein and 4.8 tpy for chlorine). Hydrochloric acid, formaldehyde, and benzene ranked in the top 10 for both mass emissions and toxicity-weighted emissions.

Davis County, UT

The 10 priority pollutants determined by mass emissions and toxicity-weighted emissions for Davis County, UT are presented in Tables 9 and 10 for cancer and noncancer, respectively. Among the cancer-causing pollutants, benzene ranked highest using a mass basis, followed by formaldehyde and dichloromethane. Using the toxicity-weighting approach, benzene also ranked highest, followed by 1,3-butadiene and naphthalene. Although polycyclic organic compounds as 7-PAH (POM as 7-PAH) emissions were 0.24 tpy (ranked 14th by mass emissions), its associated toxicity-weighting ranked 8th. Seven pollutants were in the top 10 for both mass emissions and toxicity-weighted emissions (acetaldehyde, benzene, 1,3-butadiene, *p*-dichlorobenzene, naphthalene, POM as 15-PAH, and tetrachloroethylene).

Among the noncancer pollutants, toluene, xylenes (total), and benzene were the top 3 pollutants by mass emissions in Davis County, UT. Using the toxicity-weighting approach, acrolein and hexamethylene diisocyanate ranked highest, despite having their mass emissions ranked 22nd and 39th, respectively (4.6 tpy for acrolein and 0.1 tpy for hexamethylene diisocyante). Benzene, formaldehyde, and xylenes (total) ranked in the top 10 for both mass emissions and toxicity-weighted emissions.

Toxicity-Weighted Emissions vs. Ambient Monitoring Screening Comparison

Cook County, IL vs. NBIL Monitoring Site

The 10 priority pollutants determined by ambient monitoring screening of measurements taken at the NBIL monitoring site are also presented in Tables 3 and 4 for cancer and noncancer, respectively. Among the cancer-causing pollutants, carbon tetrachloride ranks highest for predicted cancer risk, followed by benzene and acrylonitrile. By comparison, the toxicity-weighted approach for emissions ranked benzene, arsenic, and coke oven emissions among the top 3 cancer-causing pollutants. Coke oven emissions are not measured for the UATMP; thus, no comparison can be made. When comparing the top 10 priority cancer-causing pollutants for the ambient monitoring screening and the toxicity-weighted approach, five pollutants were common to both lists (arsenic, benzene, *p*-dichlorobenzene, 1,3-butadiene, and tetrachloroethylene).

County-level emissions from carbon tetrachloride according to the NEI were low (1.26 tpy), and are comparable to cadmium emissions (1.40 tpy). Yet, its cancer URE factor is 120 times more toxic than cadmium. Although carbon tetrachloride was phased out as a refrigerant and dry cleaning solvent in the mid-1990s under the Montreal Protocol, the presence of this chemical in ambient air is attributed to its long lifetime in the atmosphere from 30-100 years.[7,8]

Among the noncancer-causing pollutants, acrolein ranked the highest based on the ambient data screening, followed by bromomethane and formaldehyde. By comparison, the toxicity-weighted approach for emissions ranked acrolein, bromomethane, and formaldehyde among the top 3 noncancer-causing pollutants. When comparing the top 10 priority noncancer-causing pollutants for the ambient monitoring screening and the toxicity-weighted approaches, eight pollutants were common to both lists (acrolein, bromomethane, formaldehyde, manganese, acetaldehyde, arsenic, 1,3-butadiene, and nickel).

Wayne County, MI vs. DEMI Monitoring Site

The 10 priority pollutants determined by ambient monitoring screening of measurements taken at the DEMI monitoring site are also presented in Tables 5 and 6 for cancer and noncancer, respectively. Among the cancer-causing pollutants, carbon tetrachloride ranks highest for predicted cancer risk, followed by benzene and tetrachloroethylene. By comparison, the toxicity-weighted approach for emissions ranked coke oven emissions, benzene, and 1,3-butadiene among the top 3 cancer-causing pollutants. As previously noted, coke oven emissions are not measured for the UATMP; thus, no comparison can be made. When comparing the top 10 priority cancer-causing pollutants for the ambient monitoring screening and the toxicity-weighted approaches, three pollutants were common to both lists (benzene, 1,3-butadiene, and tetrachloroethylene).

Among the noncancer-causing pollutants, acrolein ranked the highest based on the ambient data screening, followed by formaldehyde and acetaldehyde. By comparison, the toxicity-weighted approach for emissions ranked acrolein, manganese, and 1,3-butadiene among the top 3 noncancer-causing pollutants. When comparing the top 10 priority noncancer-causing pollutants for the ambient monitoring screening and the toxicity-weighted approaches, four pollutants were common to both lists (acrolein, formaldehyde, 1,3-butadiene, and benzene).

St. Louis City, MO vs. S4MO Monitoring Site

The 10 priority pollutants determined by ambient monitoring screening of measurements taken at the S4MO monitoring site are also presented in Tables 7 and 8 for cancer and noncancer, respectively.

Among the cancer-causing pollutants, carbon tetrachloride ranked highest for predicted cancer risk, followed by benzene and acetaldehyde. By comparison, the toxicity-weighted approach for emissions ranked benzene, 1,3-butadiene, and arsenic among the top 3 cancer-causing pollutants. When comparing the top 10 priority cancer-causing pollutants for the ambient monitoring screening and the toxicity-weighted approach, four pollutants were common to both lists (benzene, acetaldehyde, arsenic, and 1,3-butadiene).

Among the noncancer-causing pollutants, acrolein ranked the highest based on the ambient data screening, followed by manganese and acetaldehyde. By comparison, the toxicity-weighted approach for emissions ranked acrolein, chlorine, and hydrochloric acid among the top 3 noncancer-causing pollutants. Chlorine and hydrochloric acid are not pollutants that are measured for the UATMP; thus, no comparison can be made. When comparing the top 10 priority noncancer-causing pollutants for the ambient monitoring screening and the toxicity-weighted approach, seven pollutants were common to both lists (acrolein, manganese, acetaldehyde, formaldehyde, 1,3-butadiene, benzene, and nickel).

Davis County, UT vs. BTUT Monitoring Site

The 10 priority pollutants determined by ambient monitoring screening of measurements taken at the BTUT monitoring site are also presented in Tables 9 and 10 for cancer and noncancer, respectively. Among the cancer-causing pollutants, benzene ranked highest for predicted cancer risk, followed by carbon tetrachloride and acetaldehyde. By comparison, the toxicity-weighted approach for emissions ranked benzene, 1,3-butadiene, and naphthalene among the top 3 cancer-causing pollutants. When comparing the top 10 priority cancer-causing pollutants for the ambient monitoring screening and the toxicity-weighted approach, five pollutants were common to both lists (benzene, acetaldehyde, acrylonitrile, 1,3-butadiene, and tetrachloroethylene).

Among the noncancer-causing pollutants, acrolein ranked the highest based on the ambient data screening, followed by formaldehyde and acetaldehyde. By comparison, the toxicity-weighted approach for emissions ranked acrolein, hexamethylene diisocyanate, and 1,3-butadiene among the top 3 noncancer-causing pollutants. Hexamethylene diisocyanate is not a pollutant that is measured for the UATMP; thus, no comparison can be made. When comparing the top 10 priority noncancer-causing pollutants for the ambient monitoring screening and the toxicity-weighted approach, seven pollutants were common to both lists (acrolein, formaldehyde, acetaldehyde, manganese, 1,3-butadiene, benzene, and xylenes).

Observations

A number of observations can be made as a result of this study:

1) Certain pollutants exhibited similar behavior. Benzene, 1,3-butadiene, and tetrachloroethylene were identified as priority cancer-causing pollutants for both mass emissions and toxicity-weighted emissions. Conversely, noncancer-causing pollutants rarely appeared in both mass emissions and toxicity-weighted emissions priority.
2) Acrolein was consistently ranked highest in noncancer toxicity-weighting for all study locations. This is similar to acrolein being identified as a NATA 1999 national noncancer driver HAP.
3) Metal HAPs did not emerge as priorities based on mass emissions, but were often priority ranked for toxicity-weighted emissions. Manganese was priority identified for all four study locations.
4) Among the ambient monitoring results for the cancer-causing HAPs, carbon tetrachloride, benzene, acrylonitrile, acetaldehyde, and 1,3-butadiene were consistently priority-ranked for all study locations.
5) The priority of carbon tetrachloride from the ambient monitoring results cancer risk along with its low mass and toxicity-weighted emissions total at each study location comports with the

common understanding of this compound as a background pollutant, and not from direct emission sources.

6) Among the ambient monitoring priorities for the noncancer-causing HAPs, acrolein, formaldehyde, acetaldehyde, acrylonitrile, 1,3-butadiene, and benzene were consistently priority-ranked for all study locations.
7) The emissions used for this study represent baseyear 2002. The HAP priority rankings due to the toxicity-weighted emissions approach may change if applied to base year 2005 emissions, which is currently not publicly available.

CONCLUSIONS

Mass emissions, toxicity-weighted emissions, and ambient monitoring-based cancer and/or noncancer screening results were compared to one another for four locations to determine if the same pollutants would be identified as the top 10 of their respective lists. The following observations were made:

- Toxicity-weighting data from an emissions inventory can be useful in prioritizing pollutants based on risk potential.
- There was fairly good agreement between the priority ranking of pollutants by mass emissions and cancer toxicity-weighting in Davis County, UT with seven common pollutants in the top 10. Conversely, there was not as strong agreement in Wayne County, MI with only four common pollutants in the top 10.
- There was very little agreement between the priority ranking of pollutants by mass emissions and noncancer toxicity-weighting in all four study locations. Davis County, UT, Wayne County, MI, and St. Louis City, MO had the most pollutants in common on both top 10 lists.
- There was some agreement in priority ranking when comparing Cook County, IL and Davis County, UT county-level cancer toxicity-weighted emissions and the NBIL and BTUT ambient monitoring-based cancer screening results; both priority rankings shared five common pollutants in the top 10. Conversely, there was poor agreement in Wayne County, MI and DEMI with three common pollutants in the top 10.
- There was very good agreement between the priority ranking of pollutants when comparing noncancer county-level toxicity-weighted emissions and ambient monitoring-based noncancer risk screening for: Cook County, IL and NBIL (eight common top 10 pollutants); St. Louis City, MO and S4MO (seven common top 10 pollutants); and Davis County, UT and BTUT (seven common top 10 pollutants).

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KEYWORDS

Hazardous Air Pollutants (HAPs)
Toxicity-Weighting
NATA
NEI
UATMP

Table 1. Pollutant Information – UATMP HAPs

Pollutant	Cancer HAP	Noncancer HAP	Pollutant	Cancer HAP	Noncancer HAP
Acetaldehyde	X	X	Ethylbenzene		X
Acetonitrile		X	*Formaldehyde*[1]	X	X
Acrolein		X	Hexachlorobutadiene	X	X
Acrylonitrile	X	X	*Hexavalent Chromium*[1,2]	X	X
Antimony[1]		X	Lead		X
Arsenic[1,2]	X	X	*Manganese*[1]		X
Benzene	X	X	Mercury		X
Beryllium	X	X	Methyl Ethyl Ketone (delisted)		X
Bromomethane		X	Methyl Isobutyl Ketone		X
Butadiene, 1,3-[1,2]	X	X	Methyl Methacrylate		X
Cadmium[1,2]	X	X	Methyl *tert*-Butyl Ether		X
Carbon Tetrachloride[2]	X	X	*Naphthalene*[2]	X	X
Chlorobenzene		X	*Nickel*[1]	X	X
Chloroethane		X	*POM as 7-PAH*[2]	X	
Chloroform		X	*POM as 15-PAH*[2]	X	
Chloromethane		X	*POM as non 15-PAH*[2]	X	
Chloroprene		X	Propionaldehyde	NA	NA
Cobalt		X	Selenium		X
Dibromomethane, 1,2-	X	X	Styrene		X
Dichlorobenzene, *p-*	X	X	Tetrachloroethane, 1,1,2,2-	X	
Dichloroethane, 1,1-	**X**	**X**	*Tetrachloroethylene*[2]	X	X
Dichloroethane, 1,2-	**X**	**X**	Toluene		X
Dichloroethene, 1,1-		**X**	Trichloroethane, 1,1,1-		X
Dichloromethane	X	X	Trichloroethane, 1,1,2-	X	X
Dichloropropane, 1,2-	X	X	Trichloroethylene	X	X
Dichloropropene, *cis*-1,3-	X	X	Vinyl Chloride	X	X
Dichloropropene, *trans*-1,3-	X	X	Xylenes (total)		X
Ethyl Acrylate	X				

NA = no designation of cancer or noncancer in IRIS
BOLD = NATA national driver pollutant; benzene = cancer; acrolein = noncancer
Italic = NATA regional driver pollutant
[1] = Identified by NATA as a regional pollutant driver for noncancer
[2] = Identified by NATA as a regional pollutant driver for cancer

Table 2. Site Information

UATMP Site	Location	County	AQS Site ID	Census Tract ID	Latitude (degrees)	Longitude (degrees)	Sampling Frequency
NBIL	Northbrook, IL	Cook County, IL	17-031-4201	17031801500	42.139996	-87.799167	1 in 6 days
DEMI	Dearborn, MI	Wayne County, MI	26-163-0033	26163573500	42.30754	-83.14961	1 in 6 days
S4MO	St. Louis, MO	St. Louis City, MO	29-510-0085	29510109700	38.65556	-90.198333	1 in 6 days
BTUT	Bountiful, UT	Davis County, UT	49-011-0004	49011126600	40.90297	-111.88447	1 in 6 days

Table 3. Cancer Toxicity-Weighted Analysis for Cook County, IL and NBIL.

Top 10 Priority Cancer-causing Pollutants Based on Mass Emissions (County-Level)		Top 10 Priority Cancer-causing Pollutants Based on Toxicity-Weighted Emissions (County-Level)		Top 10 Priority Cancer-causing Pollutants Based on Ambient Monitoring Screenings	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Screening (in-a-million)**
Benzene	1,923.92	Benzene	1.50E-02	Carbon Tetrachloride	10.58
Formaldehyde	1,311.52	Arsenic	1.25E-02	Benzene	4.58
Tetrachloroethylene	1,167.21	Coke Oven Emissions	1.04E-02	Acrylonitrile	4.39
Acetaldehyde	634.98	Naphthalene	7.45E-03	Arsenic	3.68
p-Dichlorobenzene	523.44	1,3-Butadiene	7.10E-03	1,1,2,2-Tetrachloroethane	2.69
Trichloroethylene	420.87	Tetrachloroethylene	6.89E-03	Hexachloro-1,3-butadiene	2.21
Dichloromethane	316.79	*p*-Dichlorobenzene	5.76E-03	Acetaldehyde	2.16
1,3-Butadiene	236.69	Hexavalent Chromium	5.66E-03	Tetrachloroethylene	2.00
Naphthalene	219.02	Cadmium	2.51E-03	1,3-Butadiene	1.68
1,3-Dichloropropene	89.84	Lead	2.15E-03	*p*-Dichlorobenzene	1.20

Table 4. Noncancer Toxicity-Weighted Analysis for Cook County, IL and NBIL.

Top 10 Priority Noncancer-causing Pollutants Based on Mass Emissions (County-Level)		Top 10 Priority Noncancer-causing Pollutants Based on Toxicity-Weighted Emissions (County-Level)		Top 10 Priority Noncancer-causing Pollutants Based on Ambient Monitoring Screenings	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Risk Screening (HQ)**
Toluene	7,837.72	Acrolein	3,193,594.06	Acrolein	12.46
Xylenes	5,082.62	Manganese	153,628.02	Bromomethane	0.41
Methanol	3,404.01	Formaldehyde	133,828.14	Formaldehyde	0.28
Methyl Ethyl Ketone	3,215.93	1,3-Butadiene	118,344.25	Manganese	0.12
Benzene	1,923.92	Bromomethane	113,356.00	Acetaldehyde	0.11
Methyl Isobutyl Ketone	1,483.77	Nickel	100,856.60	Acrylonitrile	0.03
Hexane	1,332.45	Arsenic	96,523.58	Arsenic	0.03
Formaldehyde	1,311.52	Naphthalene	73,005.50	1,3-Butadiene	0.03
Tetrachloroethylene	1,167.21	Acetaldehyde	70,553.24	Benzene	0.02
1,1,1-Trichloroethane	1,137.26	Cadmium	69,789.79	Nickel	0.02

Table 5. Cancer Toxicity-Weighted Analysis for Wayne County, MI and DEMI.

Top 10 Priority Cancer-causing Pollutants Based on Mass Emissions (County-Level)		Top 10 Priority Cancer-causing Pollutants Based on Toxicity-Weighted Emissions (County-Level)		Top 10 Priority Cancer-causing Pollutants Based on Ambient Monitoring Screenings	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Screening (in-a-million)**
Benzene	1,901.76	Coke Oven Emissions	2.50E-02	Carbon Tetrachloride	10.04
Formaldehyde	740.64	Benzene	1.48E-02	Benzene	9.77
Tetrachloroethylene	388.05	1,3-Butadiene	5.76E-03	Tetrachloroethylene	5.05
Dichloromethane	290.39	Quinoline	4.83E-03	Acrylonitrile	4.80
Acetaldehyde	272.58	POM as 7-PAH	4.25E-03	1,3-Butadiene	3.71
1,3-Butadiene	192.12	Naphthalene	3.85E-03	Acetaldehyde	3.63
1,3-Dichloropropene	147.66	Cadmium	3.16E-03	1,2-Dichloroethane	2.40
Naphthalene	113.19	Tetrachloroethylene	2.29E-03	Hexachloro-1,3-butadiene	1.92
p-Dichlorobenzene	76.63	Lead	2.15E-03	*p*-Dichlorobenzene	1.10
Trichloroethylene	47.80	POM and 15-PAH	1.04E-03	Hexavalent Chromium	0.82

Table 6. Noncancer Toxicity-Weighted Analysis for Wayne County, MI and DEMI.

Top 10 Priority Noncancer-causing Pollutants Based on Mass Emissions (County-Level)		Top 10 Priority Noncancer-causing Pollutants Based on Toxicity-Weighted Emissions (County-Level)		Top 10 Priority Noncancer-causing Pollutants Based on Ambient Monitoring Screenings	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Risk Screening (HQ)**
Toluene	4,966.63	Acrolein	2,046,078.60	Acrolein	22.68
Xylenes	3,339.72	Manganese	330,598.26	Formaldehyde	0.30
Benzene	1,901.76	1,3-Butadiene	96,059.90	Acetaldehyde	0.18
Hydrochloric Acid	1,627.79	Cadmium	87,737.35	1,3-Butadiene	0.06
Methanol	907.55	Hydrochloric Acid	81,389.73	Benzene	0.04
Ethylbenzene	748.25	Formaldehyde	75,575.59	Acrylonitrile	0.04
Formaldehyde	740.64	Benzene	63,391.91	Xylenes	0.03
Hexane	720.40	Bromomethane	41,215.89	Carbon Tetrachloride	0.02
Methyl Ethyl Ketone	575.03	Nickel	40,571.14	Tetrachloroethylene	<0.01
Glycol Ethers	476.52	Naphthalene	37,730.55	Hexachloro-1,3-Butadiene	<0.01

Table 7. Cancer Toxicity-Weighted Analysis for St. Louis City, MO and S4MO.

Top 10 Priority Cancer-causing Pollutants Based on Mass Emissions (County-Level)		**Top 10 Priority Cancer-causing Pollutants Based on Toxicity-Weighted Emissions (County-Level)**		**Top 10 Priority Cancer-causing Pollutants Based on Ambient Monitoring Screenings**	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Screening (in-a-million)**
Benzene	252.44	Benzene	1.97E-03	Carbon Tetrachloride	9.38
Formaldehyde	160.07	1,3-Butadiene	9.00E-04	Benzene	7.09
Acetaldehyde	62.89	Arsenic	3.76E-04	Acetaldehyde	6.49
1,3-Butadiene	29.99	Hydrazine	3.19E-04	Arsenic	4.53
Trichloroethylene	27.61	Naphthalene	2.64E-04	Acrylonitrile	4.48
Tetrachloroethylene	18.28	Acetaldehyde	1.38E-04	1,3-Butadiene	2.88
Dichloromethane	13.23	Nickel	1.12E-04	1,1,2,2-Tetrachloroethylene	2.66
Naphthalene	7.76	Tetrachloroethylene	1.08E-04	*p*-Dichlorobenzene	2.48
POM as 15-PAH	1.15	POM as 7-PAH	9.38E-05	Hexachloro-1,3-butadiene	1.92
Nickel Compounds	0.70	Chromium (VI)	9.34E-05	Cadmium	1.18

Table 8. Noncancer Toxicity-Weighted Analysis for St. Louis City, MO and S4MO.

Top 10 Priority Noncancer-causing Pollutants Based on Mass Emissions (County-Level)		**Top 10 Priority Noncancer-causing Pollutants Based on Toxicity-Weighted Emissions (County-Level)**		**Top 10 Priority Noncancer-causing Pollutants Based on Ambient Monitoring Screenings**	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Risk Screening (HQ)**
Toluene	688.46	Acrolein	386,409.41	Acrolein	28.83
Xylenes	453.77	Chlorine	23,771.26	Manganese	0.33
Methanol	445.40	Hydrochloric Acid	17,433.37	Acetaldehyde	0.33
Hydrochloric Acid	348.67	Formaldehyde	16,333.56	Formaldehyde	0.33
Methyl Tert-Butyl Ether	307.77	1,3-Butadiene	14,995.08	1,3-Butadiene	0.05
Methyl Ethyl Ketone	278.82	Nickel	10,815.37	Arsenic	0.04
Ethylene Glycol	254.91	Maleic Anhydride	9,645.64	Acrylonitrile	0.03
Benzene	252.44	Benzene	8,414.77	Cadmium	0.03
Formaldehyde	160.07	Acetaldehyde	6,987.50	Benzene	0.03
Methyl Isobutyl Ketone	142.97	Manganese	5,315.48	Nickel	0.02

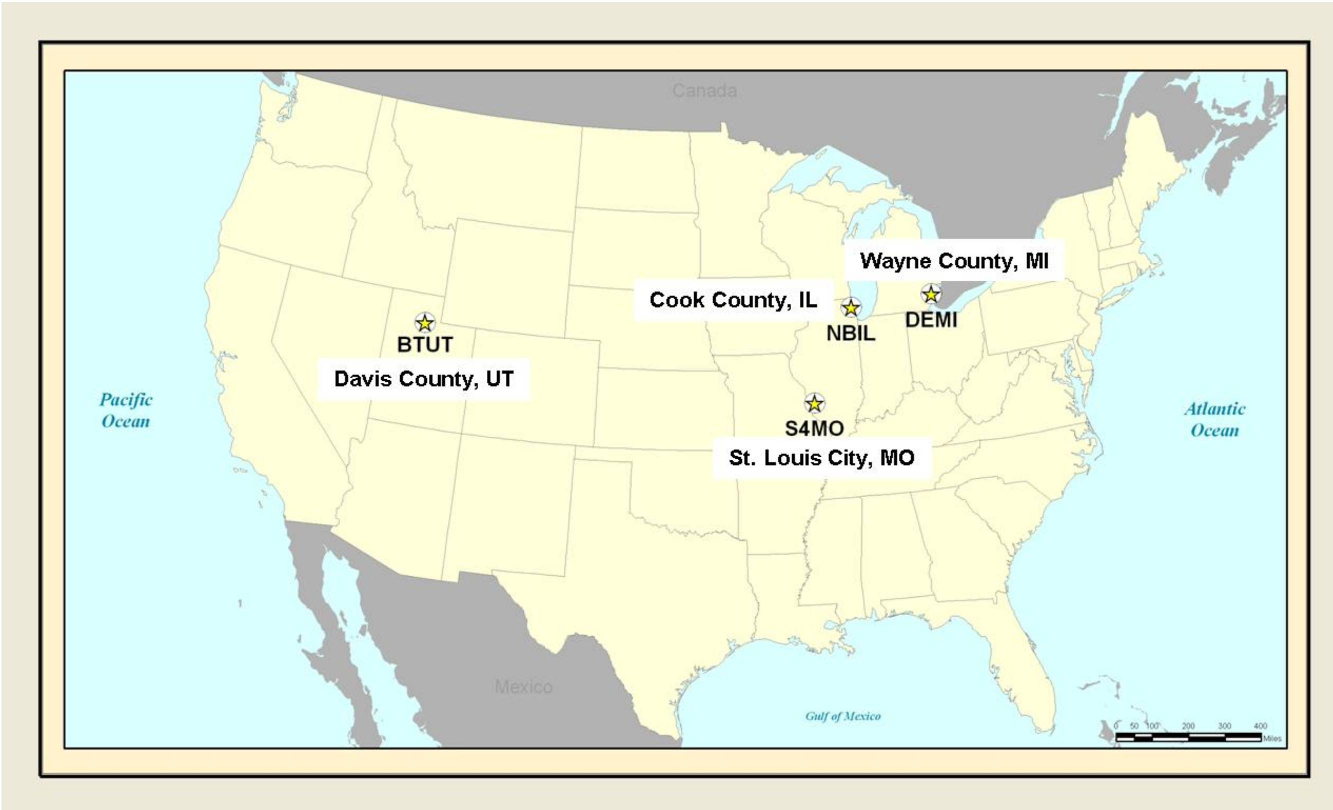
Table 9. Cancer Toxicity-Weighted Analysis for Bountiful, UT and BTUT.

Top 10 Priority Cancer-causing Pollutants Based on Mass Emissions (County-Level)		Top 10 Priority Cancer-causing Pollutants Based on Toxicity-Weighted Emissions (County-Level)		Top 10 Priority Cancer-causing Pollutants Based on Ambient Monitoring Screenings	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Cancer Toxicity Weight**	**Pollutant**	**Cancer Risk Screening (in-a-million)**
Benzene	227.11	Benzene	1.77E-03	Benzene	9.09
Formaldehyde	71.13	1,3-Butadiene	6.26E-04	Carbon Tetrachloride	9.08
Dichloromethane	29.21	Naphthalene	1.52E-04	Acetaldehyde	7.41
Acetaldehyde	27.74	Tetrachloroethylene	7.95E-05	Acrylonitrile	4.88
1,3-Butadiene	20.87	Acetaldehyde	6.10E-05	1,3-Butadiene	3.21
Tetrachloroethylene	13.48	POM as 15-PAH	6.02E-05	Arsenic	3.07
1,4-Dichlorobenzene	5.36	1,4-Dichlorobenzene	5.89E-05	Hexachloro-1,3-Butadiene	1.63
Naphthalene	4.48	POM as 7-PAH	4.90E-05	Cadmium	1.41
Trichloroethylene	2.92	Acrylonitrile	3.05E-05	Tetrachloroethylene	1.05
POM as 15-PAH	1.09	POM as non-15 PAH	2.34E-05	1,2-Dichloroethane	0.83

Table 10. Noncancer Toxicity-Weighted Analysis for Bountiful, UT and BTUT.

Top 10 Priority Noncancer-causing Pollutants Based on Mass Emissions (County-Level)		Top 10 Priority Noncancer-causing Pollutants Based on Toxicity-Weighted Emissions (County-Level)		Top 10 Priority Noncancer-causing Pollutants Based on Ambient Monitoring Screenings	
Pollutant	**Emissions (tpy)**	**Pollutant**	**Noncancer Toxicity Weight**	**Pollutant**	**Noncancer Risk Screening (HQ)**
Toluene	681.49	Acrolein	231,458.77	Acrolein	28.77
Xylenes	489.16	Hexamethylene Diisocyanate	12,645.00	Formaldehyde	0.57
Benzene	227.11	1,3-Butadiene	10,436.73	Acetaldehyde	0.37
Hexane	113.93	Manganese	9,087.72	Manganese	0.16
Ethylbenzene	106.11	Benzene	7,570.43	1,3-Butadiene	0.05
Methanol	93.65	Formaldehyde	7,258.18	Cadmium	0.04
Methyl Ethyl Ketone	89.92	Xylenes	4,891.56	Benzene	0.04
Methyl Isobutyl Ketone	87.13	Chlorine	4,710.00	Acrylonitrile	0.04
Formaldehyde	71.13	Cyanide	3,915.00	Xylenes	0.03
1,1,1-Trichloroethane	51.76	Acetaldehyde	3,082.11	Arsenic	0.02

Figure 1. Sites of Interest



* = UATMP Monitoring Site