An aerial photograph of Pittsburgh, Pennsylvania, showing the city skyline with numerous skyscrapers and buildings. The Allegheny River flows through the city, with several bridges crossing it, including the prominent yellow arch bridge in the foreground. The sky is a mix of blue and light orange, suggesting a sunset or sunrise. The overall scene is a panoramic view of the city from an elevated perspective.

PITTSBURGH REGIONAL ENVIRONMENTAL THREATS ANALYSIS (PRETA) REPORT

PRETA AIR: HAZARDOUS AIR POLLUTANTS

**UNIVERSITY OF PITTSBURGH GRADUATE SCHOOL OF PUBLIC HEALTH
CENTER FOR HEALTHY ENVIRONMENTS AND COMMUNITIES**

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PRETA AIR: HAZARDOUS AIR POLLUTANTS (HAPs)/AIR TOXICS

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The Center for Healthy Environments and Communities (CHEC), part of the University of Pittsburgh Graduate School of Public Health's Department of Environmental and Occupational Health, was founded in 2004 under a grant from The Heinz Endowments. CHEC's mission is to improve environmental health in Western Pennsylvania through community-based research.

www.chec.pitt.edu

This Pittsburgh Regional Environmental Threats Analysis (PRETA) report was developed by CHEC with generous support from The Heinz Endowments.

THE PURPOSE OF PRETA

The Pittsburgh Regional Environmental Threats Analysis (PRETA) project puts together information about the major threats to human health and the environment within Southwestern Pennsylvania. PRETA is intended to cover the core public health functions—assessment, policy development, and assurance—and relies heavily on figures, maps, and other visuals. PRETA is meant to encourage stakeholders to take into account scientific analysis and public values for sound policy development and remedial action against environmental threats. PRETA also is meant to be informative, highlighting the populations most at risk to those threats. Ideally, PRETA will inspire initiatives to address the highest risks to human health and the environment in Southwestern Pennsylvania. The preliminary assessments employed in the project identified air quality as the number one current environmental threat to the welfare of the greater Pittsburgh region. The third part in the *PRETA Air* series focuses on hazardous air pollutants (HAPs) or air toxics and their various environmental and public health impacts within the Southwestern Pennsylvania area.

PRETA STUDY AREA 10 Southwestern Pennsylvania counties:

- Allegheny
- Armstrong
- Beaver
- Butler
- Fayette
- Greene
- Indiana
- Lawrence
- Washington
- Westmoreland

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EXECUTIVE SUMMARY

The Pittsburgh Regional Environmental Threats Analysis (PRETA), conducted by the Center for Healthy Environments and Communities (CHEC) at the University of Pittsburgh Graduate School of Public Health, seeks to collect, analyze, and inform the public regarding data concerning various threats relevant to environmental quality and human health in the Southwestern Pennsylvania area. This third edition of the PRETA Air series discusses a broad class of air pollutants termed hazardous air pollutants (HAPs), otherwise known as air toxics, and some of their specific issues pertinent to Southwestern Pennsylvania. HAPs are a category of approximately 200 unique pollutants specifically identified by the U.S. Environmental Protection Agency (EPA) that are known or suspected to cause cancer or other serious health effects and have a tendency to reach significant concentrations in the air we breathe. Most HAPs are released directly into the environment by a variety of human activities in our area, many of which have commercial significance, including chemical production and manufacturing, energy production, coke processing, and automobile and diesel engine emissions. While the PRETA region as a whole experiences a constant burden of certain ambient air toxics derived from secondary and background sources, certain communities experience added risk simply by living close to unique emissions sources and/or high traffic areas.

Ambient air quality standards do not exist for HAPs. Rather, they are regulated nationally by permitting how much an industry can emit, driven by the most effective technological controls available. The Allegheny County Health Department, in cooperation with many concerned stakeholders, recently updated its air permitting guidelines to address local air quality issues. These guidelines include a more stringent criterion for HAP emissions by considering actual risk to human health prior to issuing site permits and are applicable to Allegheny County only, not to other counties in the PRETA area or Pennsylvania. These updates allow for easier incorporation of human health risk estimates into the framework of sustainable development in the county and go beyond the protection afforded at the national level.

In this report, we used the latest available EPA National Air Toxics Assessment (NATA) from

2005 to explore the estimated risks of HAPs in the PRETA area. NATA assesses the risk posed by individual pollutants based on projected emission inventories from a variety of sources in the area and estimated concentrations in the air. It is clear that HAPs pose a cancer risk within our area that is greater than the “one-in-a-million” level set as the lower-limit criterion for concern by the EPA. When the total cancer risk from these air toxics is summed across the 10-county region, the median risk is more than 120 per million. When diesel particulate matter (DPM) is not included in the total assessment, the median lifetime cancer risk attributable to HAPs is just more than 50 per million. Moreover, people residing in Allegheny County have a cancer risk more than twice that of those within surrounding rural areas. A maximum cancer risk estimate as predicted by NATA is located in West Elizabeth (1,314 per million), which is located just south of Clairton (1,155 per million)—the second highest area of predicted lifetime cancer risk in the region. Individuals living in these areas are predicted to be about 20 times more likely to develop cancer from air toxics



People residing in Allegheny County have a cancer risk more than twice that of those within surrounding rural areas.

The photographs of facilities and their locations published in this document are representational of typical industries that may emit hazardous air pollutants.

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than those living in many other areas surrounding Allegheny County. An analysis from more than 7,500 census tracts in a four-state region, sorted by cancer risk from all HAPs (excluding DPM), showed that five out of the top seven, including the highest risk area (Clairton, Pa.), are within the PRETA region—and all are within Allegheny County. Allegheny County ranks 63rd out of 3,225 U.S. counties in terms of cancer risk from HAPs, placing it in the top 2 percent nationally. This lifetime risk estimate is comparable to many other major urban centers in the United States; however, areas within Allegheny County exhibit a unique contribution from numerous source types. While many urban areas face air quality challenges, in our region, the number of nearby electric power-generating facilities and other industrial point sources such as coke processing plants within a complex topography present unique obstacles.

The top cancer drivers within the region identified by NATA include formaldehyde, benzene, coke oven emissions, and carbon tetrachloride. Diesel particulate matter (DPM) also must be considered in this assessment; potential risk estimates by NATA and Allegheny County research indicate that DPM could be the highest priority air toxic in our region. Among noncancer end points, significant risks to the respiratory system were predicted, primarily driven by the chemical acrolein, which is formed as a secondary pollutant from multiple HAP precursors. Thus, residents with respiratory ailments such as asthma or chronic obstructive lung disease may be adversely affected.

We next sought to analyze what limited data were available through direct monitoring of pollutant concentrations in specific areas in Allegheny County to determine how accurate the NATA predictions were. Overall, reasonably good agreement was observed between NATA predictions and air monitoring data in terms of overall cancer risks and the individual priority pollutants identified. One exception was the identification of high levels of various chlorinated organic compounds in the downtown Pittsburgh area, such as trichloroethene, tetrachloroethene, dichlorobenzene, and vinyl chloride, which were significantly underpredicted by NATA.

In addition, direct air monitoring studies suggested that contributions from several large stationary point sources, such as the two coke works located in Clairton and on Neville Island, may impact nearby communities to a greater extent than was predicted by NATA. These emissions may even extend to the downtown area and other more distant sites. NATA predictions also appeared to slightly overestimate the contributions from mobile traffic sources.

In recent years, there has been an unprecedented expansion of unconventional natural gas development in Western Pennsylvania, Ohio, and West Virginia driven in part by the recent feasibility of hydraulic fracturing, which is part of a drilling procedure that allows for the tapping of the vast methane deposits contained in the Marcellus and Utica shales. To support the refining of wet gas condensates, Shell Chemicals plans to build an ethane “cracker” facility in Monaca, Pa. (Beaver County), which would replace the aging Horsehead, Inc., zinc smelter. It would appear that the replacement of the existing zinc smelter with the proposed ethane cracker has the potential to significantly transform the current pollutant mixture in the region. Such a plant would likely become the largest single emitter of volatile organic compounds (VOCs) in the PRETA region and could potentially increase ozone production in an urban VOC-limiting regime. Elimination of lead and other heavy metal emissions from the zinc smelter would clearly be beneficial and lower the risk of toxicity from these agents. In addition, it does not appear that the proposed ethane cracker alone would increase any of the National Ambient Air Quality Standards (NAAQS) criteria air pollutants, with the possible exception of ozone. On the other hand, the rather large releases of several known cancer drivers, such as formaldehyde and acetaldehyde, from the proposed cracker could increase cancer risk in the immediate proximity. In addition, the large influx of VOCs and fugitive emissions from these operations warrants further predictive analysis, especially with regard to current pollution-mitigating strategies that may not be anticipating a transforming pollutant mix.

INTRODUCTION

This report marks the third in a series of monographs prepared as part of the Pittsburgh Regional Environmental Threats Analysis (PRETA) initiative concerning various environmental issues relevant to the Southwestern Pennsylvania area. The first two PRETA reports about ozone and particulate matter dealt with two of the most recognizable threats to human health and the environment in this region. These pollutants are widely acknowledged by health care professionals, scientists, and regulatory agencies as high priority toxic agents, enough to mandate their inclusion as criteria air pollutants whose ambient concentrations in the atmosphere are monitored and regulated at the national level. This third edition in the series will discuss a much broader class of air pollutants termed hazardous air pollutants (HAPs), otherwise known as air toxics. Approximately 200 different chemicals are considered HAPs, and while exposure to them may not be as widespread as the specific criteria air pollutants routinely monitored in ambient air, their large variations in spatial and temporal distributions in the air and their association with serious adverse effects such as cancer warrant consideration here.

HISTORY

In the Clean Air Act Amendments of 1990, the U.S. Congress specified a list of 189 hazardous chemicals with known or suspected serious adverse health effects, such as cancer, birth

defects, reproductive effects, respiratory toxicity, and neurological dysfunction, and charged the U.S. Environmental Protection Agency (EPA) with regulating the emission of these chemicals to protect human health¹. The extensive list made routine and widespread monitoring of all specified agents impractical. Moreover, the precise level required to completely eliminate risk from each chemical often is unclear. Because the sources of various HAPs are often industry specific, EPA regulates these agents by applying the “maximum achievable control technology” (MACT) standards for each source category. These standards are based primarily on best available control technologies (pollution control equipment) that are available in the respective industrial categories. While this approach does not initially consider the human health risk associated with exposure, the Residual Risk Program of EPA is mandated to conduct a risk assessment at a specific period of time (usually eight years) after the adoption of the MACT standards to determine whether those measures adequately protect human health and, if not, propose additional regulations to mitigate those risks.

WHAT ARE HAPs?

Air toxics, or HAPs, are those pollutants that are known or suspected to cause cancer or other serious health effects and have a propensity to reach significant concentrations in the air we breathe. As mentioned above, the original list compiled in 1990 contained 189 compounds², and



Not all hazardous air pollutants are created equal, and they can produce differing health effects from varying chemical properties. Some produce cancer in regions of the body; others are respiratory irritants, while others may affect the nervous system, reproduction, or neurological development.

only three (hydrogen sulfide, caprolactam, and methyl ethyl ketone) have been withdrawn from the list since then. A table listing all of the specific chemicals contained on the list of HAPs is included in Appendix A of this document.

The HAPs list is a diverse group of chemical entities emitted by a wide array of predominantly human-made sources, including chemical production and manufacturing, energy production, automobiles, and even dry cleaners. An examination of the list reveals a large variety of volatile organic compounds (VOCs; about 50 percent of the regulated HAPs), with the remainder characterized as semivolatiles (35 percent) and nonvolatiles (16 percent). The term “volatile” refers to the ability of these compounds to evaporate, or move into the atmosphere as a gas or vapor. HAPs as a group contain chemicals of very diverse molecular structure, from those based on simple linear chains of carbon atoms such as acrolein, formaldehyde, and ethylene oxide to more complex chemicals that possess one or more aromatic rings, such as benzene, naphthalene, and other polycyclic aromatic hydrocarbons. Some of these chemicals also may contain atoms of chloride and fluoride—trichloroethylene, bromobenzene, and fluoranthene, for example. Also included on the list are several metals, such as nickel, chromium, beryllium, and mercury, as well as inorganic chemicals like asbestos, ammonia, hydrochloric acid, and hydrogen fluoride.

While some HAPs are immediately dangerous to health even in small amounts, others become problematic only after chronic exposure over a prolonged period of time. Moreover, the significant number of chemicals on the HAPs list means that many different types of toxicity

can be produced in a chemical-specific manner. Each of the chemicals possesses a unique profile of target organ(s) and toxic effect(s) as well as a characteristic dose-response relationship that determines the magnitude of those effects. In other words, not all HAPs are created equal, and they can produce differing health effects from varying chemical properties. Some produce cancer in regions of the body; others are respiratory irritants, while others may affect the nervous system, reproduction, or neurological development. It is this diversity in chemical species, adverse effects, and effective concentrations that makes analyzing the overall risk of HAPs so challenging.

SOURCES OF HAPs

Most HAPs are released into the atmosphere as the result of human activity, which often has substantial industrial and commercial significance. Releases occur via fugitive emissions that arise during routine use, accidental spillage into the environment, and/or direct injection into the atmosphere as part of a waste disposal process. Numerous indoor and household pollutant sources also exist (e.g., building materials and cleaning products). Some HAPs also can be released in significant amounts as the result of natural events such as forest fires. HAPs can appear in the air from direct vaporization of highly volatile compounds (gas phase) or as the result of chemical transformations and physical formations of small particulate aerosols. Some of the HAPs are considered secondary pollutants in that they often are formed in the atmosphere by chemical reactions that occur with other chemicals that are directly released into the atmosphere (primary pollutants). Gaseous hydrocarbons (e.g., methane, hexanes, and

Table 1. Definitions of specific sources of HAPs as defined by the National Air Toxics Assessment

SOURCE TYPE	DEFINITION
POINT (stationary)	Large industrial stacks, power plants, incinerators, factories
NONPOINT (stationary)	Smaller facilities—dry cleaners, gas stations, minor manufacturing (less than 10 tons per year of one HAP or less than 25 tons total of a mixture of all HAPs)
ON-ROAD (mobile)	Vehicles, including cars and trucks, that travel along roadways
NONROAD (mobile)	Construction machinery, marine vessels, trains, etc.
SECONDARY (formation)	Point, nonpoint, and mobile source types that emit compounds that are readily transformed in the atmosphere into HAP compounds
BACKGROUND	Anthropogenic and natural sources that persist in the environment or sources that are emitted from distances greater than 50 km



propane) and nitrogen oxides (e.g., nitric oxide and nitrogen dioxide) can transform into air toxics by photochemical reactions catalyzed by sunlight³. Common products of these reactions are formaldehyde and acetaldehyde⁴, and it is estimated that as much as 70–90 percent of formaldehyde in the air is formed as a secondary reaction product^{4–6}. Secondary formation sources include numerous stationary and mobile source types that emit large amounts of hydrocarbons and nitrogen oxides (primary pollutants) that are readily transformed in the atmosphere into other compounds⁷. Therefore, all source types listed in Table 1 contribute significantly to both local and regional HAP concentrations and subsequent health effects.

As shown in Table 1, there are many source types for HAPs, and they can first be classified as stationary or mobile. Mobile sources of HAPs can be further divided into either “on-road” (e.g., interstate car and truck traffic) or “nonroad” (e.g., construction equipment) sources. Routine emissions from stationary sources account for about 50 percent of all man-made emissions of HAPs. Examples of stationary sources include power generation plants, chemical factories, metal smelting facilities, waste incinerators, gasoline stations, and dry cleaners. EPA classifies stationary sources into two types: A major point source is defined as a facility that emits either 10 or more tons per year (TPY) of a single HAP compound or 25 or more TPY of an aggregate mixture of HAPs. An area stationary source (also referred to as nonpoint stationary source) is a smaller source and is defined by the release of

less than 10 TPY of any single HAP or less than 25 TPY of a HAP mixture. Typically, the closer one lives to a stationary source, the greater the magnitude of exposure to any chemicals released by that source will be, especially for locations immediately downwind at the time of release. Therefore, it is important for people to be informed of the location of various stationary point sources in their communities as well as the amount and types of chemicals released from those sources. Background source concentrations are considered to be from natural sources, emissions of persistent HAPs that occurred in previous years, and long-range transport from sources beyond 50 kilometers. The majority of background contribution in the PRETA region is from distant sources across the northeast and midwest United States. Ambient air concentrations modeled from known emissions are combined with monitored ambient concentrations to derive an estimated background concentration average over a year.

Major point sources of HAPs (as well as other industries that release ground and water pollutants) are required by law to report their annual release of HAPs to EPA⁸. EPA maintains this Toxic Release Inventory as a publicly accessible database through the National Library of Medicine’s Toxicology Data Network, available online (toxnet.nlm.nih.gov). This inventory forms an important part of the overall emissions inventory used to estimate possible health risks associated with HAPs in various areas throughout the country, as described on pages 8 and 9.

Because these [emission] values are usually self-reported by the industry and not actually measured as part of the regulatory process, accuracy of total emissions and rates comes with a degree of uncertainty.



HOW ARE HAPs REGULATED?

With the exception of Allegheny County, the jurisdiction for regulating HAPs in the PRETA region falls upon the Pennsylvania government. The Pennsylvania Department of Environmental Protection implements and enforces the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) federally mandated by EPA. Unlike the six NAAQS criteria pollutants (particulate matter, ozone, carbon monoxide, sulfur and nitrogen oxides, and lead), ambient air standards do not exist for HAPs. Rather, they are regulated through the permitting of allowable emissions. When an industry plans to install a new source of emissions or modify or add new equipment to an existing source, they are required to first obtain an installation permit (IP). The facility's IP clearly defines the maximum allowable amount of emissions that can be produced. This way, the regulator can keep track of the amount, or mass, of emissions entering the air, known cumulatively as an emissions inventory. However, because these values are usually self-reported by the industry and not actually measured as part of the regulatory process, accuracy of total emissions and rates comes with a degree of uncertainty.

EPA does not limit the total mass of HAPs emitted into the atmosphere. Instead, federal regulations require companies to use BACT (best available control technology) and MACT (maximum achievable control technology) engineering standards to reduce emissions. As long as an emission source adheres to these standards, it will be granted a federal permit. State and county governments also retain the right to establish their

own requirements for permitting, as was enacted by the Allegheny County Health Department (ACHD) first in 1988 and recently updated in 2012. Concurrently, Pennsylvania chooses to enforce the MACT standards and also has elected to regulate 12 additional source categories of HAPs not explicitly covered by NESHAPs. Furthermore, Pennsylvania has defined ambient air quality standards for two additional HAP compounds: beryllium and hydrogen fluoride.

In Allegheny County, the list of regulated HAPs includes a total of 204 chemical compounds or classes. Because Allegheny County and Southwestern Pennsylvania have such a strong legacy of industrial activity, ACHD promulgated its own air permitting guidelines to tailor regulations to address local air quality issues. These guidelines take a different approach to permitting from NESHAPs. With an understanding of the impact of emissions on public health and the environment, the guidelines go beyond the engineering standards approach and actually evaluate risk associated with each pollutant. Additionally, the county's inventory of regulated air toxics includes 24 pollutants that are not included in the NESHAPs list.

In November of 2012, ACHD updated this policy with a more comprehensive permitting process, including revised risk values based on new information on health effects of air toxics. The guidelines had not been updated since 1988. The new guidelines were achieved through a multistep process that included input from academic scientists, industry representatives,

and environmental and public interest groups. Adoption of these measures will result in several improvements to the permitting process that will benefit air quality. First, the cumulative impact of air toxics will be considered by requiring IPs to include risk models for emissions from their facility, as well as from neighboring sources up to 0.5 miles from the facility fence line. For carcinogens, the risk estimate will be comprehensive, meaning the guidelines require the summation of risks from individual carcinogens to calculate total risk. For noncarcinogenic effects of air toxics, the additive risk will be summed individually for independent organs/organ systems. Secondly, the guidelines define cumulative risk thresholds for both cancer and noncancer health effects. This means that the cumulative risk in an airshed will not be allowed to exceed a specific amount. For cancer risk, the threshold is set at one cancer case for every 10,000 people. For noncancer risk, a hazard index (HI) of two was adopted. (The calculation of risk estimates is discussed in greater detail in the next section.) Lastly, an offsetting program was established to reduce preexisting risk. The offsetting ratios favor reductions in pollution "hot spots," such as Clairton, Pa., but also can target mobile sources to reduce diesel emissions in metropolitan areas.

Environmental critics of the guidelines, although overwhelmingly in favor of the update, cite several shortcomings. First, some critics consider the 0.5-mile radius for the inclusion of neighboring sources to be too small an area for large sources. In addition, some think the thresholds set for cancer risks and noncancer effects may be too lax. Consider, for example, EPA's acceptable risk level of no greater than one case for every 1 million⁹, while the risk in our region is already

considerably larger. Lastly, rather than modeling risk at the "fence line" (property line) of the facility, risk will be modeled at a "public exposure boundary," defined as the nearest habitable structure. The boundary allows industries that border rivers, public parks, publicly or privately owned forest land, parking lots, recreational fields, or other large tracts of open land to emit more air toxics without exceeding the thresholds, as the emissions will have a larger area in which to dissipate. This creates a potential discrepancy in allowable emissions between similarly sized industries depending on their location relative to a "public exposure boundary." Ambiguity in defining this boundary creates potential problems in the future, such as the creation of potential high-risk areas beyond the fence line that may limit future residential or economic development in these areas.

Several other states and counties of the United States elect to manage their own air quality programs. Some, like Tennessee and several counties within it, are essentially identical to the federally mandated standards. The most progressive and comprehensive is the State of California, which is split into 35 local air districts, each with oversight from the California Resources Board (CARB). CARB has adopted many pollution prevention techniques, called air toxic control measures, that focus on individual HAPs and sources. CARB estimates that there has been a 45 percent statewide reduction of cancer risk between 1990 and 2003. Minnesota, North Carolina, and South Carolina all require modeling of emissions, with all but South Carolina using a risk-based standard and all but North Carolina including the contributions of neighboring facilities. New Jersey's permitting guidelines are the most similar to those of Allegheny County. Both require modeling of cumulative risk, including the contribution of background (neighboring) sources, and use an upper risk threshold of one in 10,000 for cancer risk. New Jersey has successfully reduced toxic air emissions from 32.4 million pounds in 1988 to 3.3 million pounds in 2003, a decrease of almost 90 percent¹⁰. Comparatively, ACHD's update to the HAPs permitting guidelines are not the most progressive but are more comprehensive than the majority of other state programs and have the potential for Allegheny County to see a reduction similar to New Jersey's.



WHAT ARE THE RISKS OF HAPs?

CARCINOGENIC EFFECTS

As mentioned previously, the adverse health effects associated with exposure to HAPs can be diverse. Many HAPs are established or highly suspected to be carcinogens (cancer-causing chemicals). This is perhaps one of the best studied effects of these pollutants. Most HAPs have been tested for carcinogenesis in animals, and some have sufficient human data that relate exposure to cancer incidence in occupational or epidemiological studies. Approximately half of the HAPs have been classified by EPA as “known,” “probable,” or “possible” human carcinogens. Known human carcinogens are those that have been demonstrated to cause cancer in humans. Examples of these include benzene, which has been shown to cause leukemia in occupational exposure settings, and arsenic, which has been associated with lung cancer in workers at metal smelters. Probable human carcinogens are those chemicals for which testing in at least two animal species indicates cancer-causing potential, and yet human cancer cases are either sparse or lacking. Possible human carcinogens include chemicals about which we are less certain as to their potential to cause cancer in people, yet laboratory testing has demonstrated some type of cancer response. When it comes to hazardous air pollutants, the greatest concern is for lung cancer, followed by nasal cancer and perhaps cancer in other areas of the upper respiratory tract. Some HAPs, however, have the potential to produce cancer in other organs besides those in the respiratory system, such as the case with benzene and its potential to cause leukemia.

The carcinogenic potential and potency of a chemical is derived assuming that even the smallest dose of a cancer-causing chemical has some theoretical risk of producing cancer (although, at very low doses, risk is usually too small to be discerned against the background rate of cancer from other causes in the population) and that risk linearly increases as a function of dose at a chemical-specific rate¹¹. In other words, the more potent the carcinogenic effect of a chemical, the more rapid the rise in cancer incidence as dose is increased. The cancer risk of a chemical often is expressed using a term called unit risk estimate (URE) and represents the upper-bound excess lifetime cancer risk

(70-year lifetime) estimated to result from continuous exposure to an agent at a concentration of 1 µg/m³ in air. Each chemical has been assigned a URE based on rigorous reviews by scientific panels commissioned by regulatory and research agencies such as the EPA Integrated Risk Information System (IRIS)¹². For example, the IRIS-assigned URE values for benzene (7.8 x 10⁻⁶) and chloroform (2.3 x 10⁻⁵) mean that 7.8 cases of benzene-induced cancer and 23 cases of chloroform-induced cancer would be expected for every 1 million people breathing each chemical present in the atmosphere at an equivalent concentration of 1 µg/m³ over their lifetime. Therefore, chloroform possesses a greater cancer risk than benzene when present at equivalent concentrations. Knowing the approximate long-term ambient concentration of any HAP in the air allows researchers to predict the cancer risk from that compound in that area as follows:

LIR = URE x C, where:

LIR = Lifetime incidence rate (lifetime cancer incidence per 1 million people)

C = Concentration of HAP in µg/m³

URE = Unit risk estimate [(mg/m³)⁻¹]

For example, the atmospheric concentration of benzene in Vanport Township (Beaver County) predicted by NATA in 2005 was 1.67 µg/m³. The chemical-specific URE for benzene is 7.8 x 10⁻⁶ per 1 µg/m³ (7.8 cancer cases per 1 million people). Therefore, we might predict the benzene-specific cancer risk to be about 13 per million (7.8 x 10⁻⁶ X 1.67 = 13 x 10⁻⁵) for those breathing this concentration of benzene every day over a projected 70-year life span. While this risk may not be detectable in a community of only a few hundred to a few thousand residents, little comfort can be taken if you happen to be one of those 13 individuals affected by what is likely a preventable exposure. Moreover, it is rare for a person to be exposed to a single chemical alone, and therefore one's cumulative cancer risk from HAPs must be, at best, considered as the sum of the LIRs calculated for each chemical in the environment.

NONCANCEROUS EFFECTS

Risk for noncancer end points, such as respiratory toxicity, are assessed in a somewhat different manner. In contrast to the dose-response model for carcinogens, most non-cancer effects arise at some threshold dose below which toxicity is not observed. In other words, these chemicals can exist in the atmosphere at “safe” levels that fail to produce adverse effects. Once the threshold is exceeded, however, toxicity can then be produced as concentrations increase. Because many chemicals may produce different effects at varying concentrations, effects that occur at the lowest concentrations are the most relevant for assessing risk to exposed communities. Similar to the URE used to describe cancer-related end points, noncancer effects of HAPs are characterized by a specific reference concentration (RFC) unique for each HAP and its most recognized toxicity. Again, this is a chemical-specific value selected by panels of scientific experts arrived at by analyzing the available scientific data compiled for each chemical and serves as the best estimate of the threshold concentration above which human health effects are expected to be observed¹³. A good source of available information of individual air toxics, including their RFCs and UREs, is the Air Toxics Health Effects Database^{14, 15}. In order to evaluate the various risks that different communities may face as a function of HAP exposure, one can derive a hazard quotient (HQ) that depends on the ambient concentration (C) of the specific HAP and its RFC as follows¹⁶:

HQ = C/RFC, where:

RFC = Reference concentration assigned to a specific HAP for toxicity

C = Ambient concentration of a specific HAP (µg/m³)

If HQ is greater than one, then the ambient concentration of the HAP exceeds the RFC and risk of toxicity exists. The larger the magnitude of the hazard quotient, the greater the risk presented. A hazard index (HI) is frequently used to characterize the cumulative risk of mixtures of chemicals that affect the same target organ. HI is calculated as the sum of the individual HQs (HQ less than 0.2 are considered negligible) that affect the same organ system. However, this is probably more valid for chemicals that possess the same cellular/molecular mechanism of action, which is rarely

the case. Because detailed information on toxic mechanisms is lacking for many substances, there is some degree of uncertainty in this approach.

USING EPA'S NATIONAL AIR TOXICS ASSESSMENT (NATA) TO CHARACTERIZE RISK FROM HAPs

EPA currently studies air toxics around the country by aggregating and publishing the National Air Toxics Assessment (NATA)^{16, 17}, accessible at www.epa.gov/nata. NATA is a periodic screening assessment that estimates cancer and noncancer risks posed by specific HAPs. Although EPA reports these data at the level of individual census tracts within the United States, it is quick to point out that the data do not accurately quantify the precise exposure and risk of individuals or small geographic areas. NATA provides information to better holistically examine and prioritize pollutant emissions, monitoring, exposure, and further characterizations depending on pollutant. The average ambient concentrations for HAPs are estimated over each census tract in the United States using a complex computer modeling program that incorporates specific emissions data such as that reported to Toxic Release Inventory (TRI) from major point sources, approximations of contributions from area and mobile sources, and meteorological data. Using these concentrations, specific exposures to the population are then estimated. By applying the chemical-specific URE or RFC described above, the relative risk of the population is obtained. A detailed description of this process is available online¹⁸. It is important to realize that these estimates are based on many assumptions, and the concentration data are rarely derived from specific measurements of HAPs at monitoring stations. EPA acknowledges that such model predictions are likely overestimations of risk from individual pollutants but overall are underestimations of total risk, as estimates do not consider indoor exposures or nonrespiratory routes. This approach should not be used to determine the exact magnitude of personal exposure of various individuals within a specific area but rather is useful to identify geographic areas, specific pollutants, and types of emission sources that might need closer investigation to more fully characterize potential risks and determine if actions need to be taken to protect public health.

HAPs RISK CHARACTERIZATION WITHIN THE PRETA REGION

It is beyond the scope of this report to analyze each specific chemical and its attendant risk within the PRETA region. Instead, our goal is to address several questions relevant to HAPs within the Southwestern Pennsylvania area. First, what are the specific HAPs of concern in the region? Second, are there specific regions and communities within the PRETA area that potentially shoulder a disproportionate health risk from HAP exposure compared to other regions? If so, what are the most important health effects, and what are the specific chemicals and their sources that contribute to this risk? We first seek to explore the existing emissions inventories, literature, and NATA database to assess the scope and geographical representation of risk across the PRETA area for both cancer and noncancer health effects. We dissect the factors responsible for increased risk in terms of the specific contributing chemicals and their probable sources. Next, we examine the limited data available from specific monitoring stations to assess the validity of the previously modeled assumptions of risk. Such approaches rely on historical data regarding emissions and air quality measurements and, therefore, are an estimate of the present situation but not necessarily the future.

Southwestern Pennsylvania is currently undergoing considerable commercial transition, especially in the field of energy resources. For example, the proposed construction of an ethane “cracker” facility in Monaca, Pa. (Beaver

County), to support the growing unconventional natural gas extraction industry represents the potential for significant change in HAP emissions within the area. This proposed facility will replace the country’s largest zinc smelter. HAPs produced by the original (and aging) facility will be replaced by those from the new cracker. In addition, the ethane cracker also will likely facilitate the future influx of other industries, such as chemical and plastic manufacturers that use the cracker products as raw materials. The expansion of shale gas extraction and related industries undoubtedly has begun and will certainly continue to change the emission profile of specific HAPs within the immediate region, but to date, no systematic investigation as to how this may impact health risk has been undertaken. Therefore, our final goal is to attempt a broad estimation comparing the possible HAP profile of the new facility to those of the old plant and whether it might be expected to produce any change in risk to the nearby population.

What is the risk of cancer associated with HAPs in the PRETA area?

Risk characterization results from the NATA database provide a snapshot of the risk to human health from outdoor air quality based on current emissions inventories. When determining whether or not an environmental factor poses a significant risk of cancer, EPA uses a threshold level of “one-in-a-million” probability of lifetime (70 years) cancer risk above which it deems to be unacceptable or cause for concern. The geographical distribution of total cancer risk within the PRETA area from all HAPs is shown in Figure 1.

From Figure 1, even those areas showing the lowest risk (yellow) exceed EPA’s recommended limit by more than 25-fold. The entire 10-county region is estimated to have a lower limit lifetime cancer risk from HAPs in excess of 28 per million. The map also shows that there is considerable variability across the PRETA region. Moreover, nearly all of Allegheny County has twice the cancer risk compared to other more rural areas, if not more. Even within the other PRETA counties, a higher cancer risk can be noted in the more

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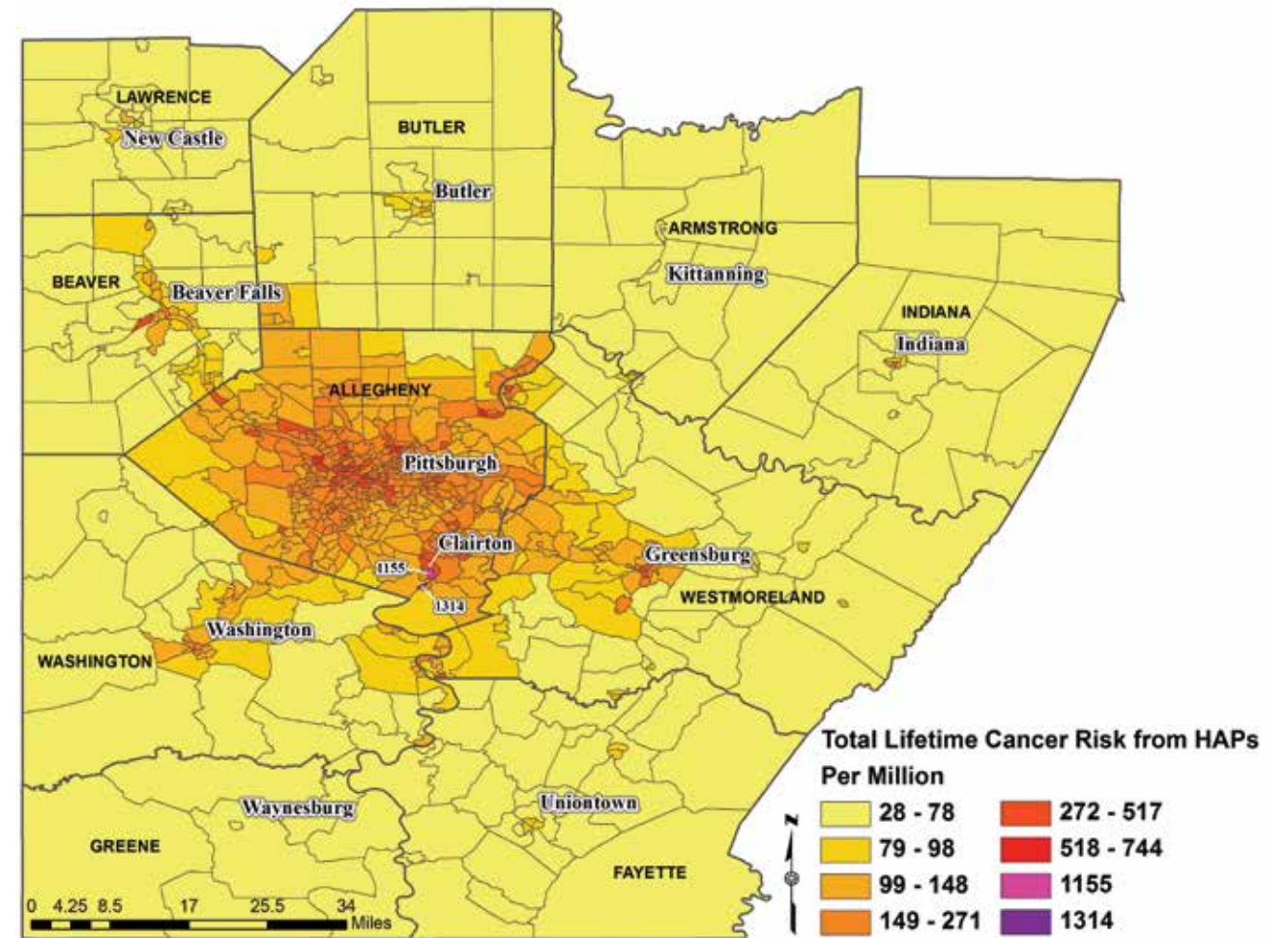


Figure 1. Total lifetime cancer risk from all hazardous air pollutants (HAPs) within the PRETA region as predicted by NATA (2005)

WHAT DOES THIS MAP SHOW?

Figure 1 shows that the entire PRETA area experiences some significant cancer risk above EPA’s target of one in a million from hazardous air pollutants. Overall risk is greater in areas containing greater population, such as downtown Pittsburgh and other city centers. The two census tracts with the highest risk are located in or near Clairton and reflect the contribution from the nearby USX Clairton Coke Works and other facilities.

populated regions. Note the small concentrations of orange regions that colocalize with such populated centers as Indiana, Washington, Greensburg, New Castle, and other small cities. Increased HAPs in these areas probably arise through a concentration of small nonpoint stationary sources (e.g., dry cleaners and gas stations) and increased vehicular traffic.

A maximum cancer risk estimate as predicted by NATA is located in West Elizabeth (1,314 per million), just south of Clairton (1,155 per million)—

the second highest area of predicted lifetime cancer risk (Figure 1). Individuals living in this area are predicted to be 20 times more likely to develop cancer from air toxics compared to many other areas surrounding Allegheny County. Similar overall average HAP-dependent cancer risks are observed in other urbanized industrial regions of the country, such as areas surrounding Fresno, Calif.; Cleveland, Ohio; Seattle, Wash.; Birmingham, Ala.; Richmond, Va.; St. Paul, Minn.; and St. Louis, Mo., among others¹⁹. However, the Pittsburgh region has been uniquely burdened by

point sources compared to the cities listed above, which are more driven by nonpoint and on-road sources. This distinction can be seen when diesel is removed from the equation by comparing Tables 2 and 3.

Table 2. The 10 highest census tracts in Pennsylvania, Ohio, West Virginia, and Maryland for cancer risk from total HAPs (red shaded areas represent those within the 10-county PRETA area)

RANK	STATE	COUNTY	TRACT NUMBER	TOTAL CANCER PER MILLION	MAJOR CONTRIBUTING SOURCE TYPE	LOCATION
1	Ohio	Hamilton	0112	2,377	Nonroad	Cincinnati (Central Business District)
2	Ohio	Hamilton	0007	1,548	Nonroad	Cincinnati (Central Business District)
3	Ohio	Cuyahoga	1071	1,414	Nonroad	Cleveland (East Bank)
4	Ohio	Cuyahoga	1076	1,372	Nonroad	Cleveland (Warehouse District)
5	Ohio	Cuyahoga	1042	1,335	Nonroad	Cleveland (Scranton Peninsula)
6	Pennsylvania	Allegheny	4930	1,314	Nonroad	West Elizabeth
7	Maryland	Baltimore City	2001	1,282	On-road	Baltimore (Lexington)
8	Ohio	Hamilton	0006	1,217	On-road	Cincinnati (Riverfront)
9	Ohio	Hamilton	0004	1,183	On-road	Cincinnati (Riverfront)
10	Pennsylvania	Delaware	4066	1,174	Nonroad	Philadelphia (Marcus Hook)

Table 3. The 10 highest census tracts in Pennsylvania, Ohio, West Virginia, and Maryland for cancer risk from HAPs when diesel particulate matter is excluded (red shaded areas represent those within the 10-county PRETA area)

RANK	STATE	COUNTY	TRACT NUMBER	TOTAL CANCER PER MILLION	MAJOR CONTRIBUTING SOURCE TYPE	LOCATION
1	Pennsylvania	Allegheny	4927	289	Point	Clairton
2	West Virginia	Brooke	0312	243	Point	Follansbee (Weirton-Steubenville)
3	Ohio	Hamilton	0007	199	Nonpoint	Cincinnati (Central Business District.)
4	Pennsylvania	Allegheny	4928	184	Point	Clairton
5	Pennsylvania	Allegheny	4970	156	Point	Lincoln
6	Pennsylvania	Allegheny	4980	143	Point	Liberty
7	Pennsylvania	Allegheny	4994	142	Point	Glassport
8	Ohio	Cuyahoga	1024	142	Point	Cleveland (West Boulevard)
9	Ohio	Cuyahoga	1132	128	Nonpoint	Cleveland (Fairfax)
10	Ohio	Hamilton	0006	125	On-road	Cincinnati (Central Business District)

WHAT DO THESE TABLES TELL US?

Diesel exhaust is an important driver of cancer risk in urban settings. Table 2 lists those census tracts with the highest estimated cancer risk posed from all HAPs, including diesel exhaust. Cancer risk over the four state region ranges from 1,174 to 2,377 expected cases per million people with the highest risk areas located within the largest cities. If diesel is removed from consideration, the projected cancer rates fall by about tenfold; however, half of the highest risk locations are now within the PRETA area and indicate that point sources, such as the USX Clairton Coke Works, pose a unique challenge for air quality in our region.

If one compares the overall cancer risk from all HAPs, including diesel particulate matter (DPM), within the PRETA region to other areas in Pennsylvania and surrounding states (West Virginia, Ohio, and Maryland), it appears that other areas also have considerable risk of cancer from air pollution. Table 2 lists the top 10 census tracts for cancer risk in Pennsylvania, West Virginia, Ohio, and Maryland when including DPM. Only one of the top 10 census tracts is located within the PRETA region, the same West Elizabeth census tract noted above. (This is discussed in more detail below.) Other cities such as Cincinnati, Cleveland, Baltimore, and Philadelphia also contain tracts of similar or even higher risk. Of interest is the fact that the contributing source types noted in this table are mobile sources, specifically “nonroad” sources, suggesting the importance of parking areas, heavy-duty vehicles, and machinery-derived DPM. These areas include major transloading terminals and ports along waterways, large parking areas for stadiums, and major highway intersections for on-road contributing source areas. As will become apparent below, DPM emerges as an overwhelming driver of these total cancer risks in urban areas. Because this particular pollutant is common to many urban environments as well as high-traffic density sites and is responsible for such a large percentage of the risk, it makes it difficult to assess the contribution of other pollutants and to determine how the PRETA region compares in risk from these other sources.

Therefore, we performed a similar comparison of cancer risk after excluding the contribution of DPM. Indeed, within Pennsylvania and the surrounding three states (Ohio, West Virginia, and Maryland), the PRETA area stands out in terms of increased cancer risk from point source HAPs. Table 3 shows a listing of the top 10 census tracts with the highest HAP-dependent residual cancer risk within all of Pennsylvania, West Virginia, Ohio, and Maryland after the exclusion of DPM. Note that when DPM is not considered in the overall cancer risk from HAPs, the contribution from all other HAPs accounts for only about 10–15 percent of the total cancer risk. However, when excluding DPM, five of the top seven census tracts in Table 3, including the tract with the highest risk, are within the PRETA region.

The tracts within the PRETA region with the highest cancer risk are all clustered within an

area located in southeastern Allegheny County and whose high burden of HAPs likely arises from the large-scale coke oven (USX Clairton Works) and other industries operating in the vicinity. It is interesting to note that the highest cancer risk area when including DPM is in West Elizabeth, not downtown Pittsburgh (Table 2), where the heaviest traffic exists. Also, this specific census tract is not in the top 10 list with DPM excluded (Table 3), though it is in the same location of southeastern Allegheny County that is heavily burdened by point sources. This finding highlights the cancer-driving combination of both point sources and nonroad heavy diesel machinery in this area.

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While these lifetime risks are indeed significant, it is important to put them into perspective. For example, much greater levels of cancer risk are usually considered “acceptable” for occupational/workplace exposures to chemicals (3,000–4,000 per 1 million individuals)^{20, 21}. Importantly, though, smaller risks from ambient exposures are ubiquitous and spread across a much larger population, which includes sensitive groups such as children and the elderly. In addition, the lifetime risk of developing cancer from smoking cigarettes is on the order of 150,000 per million smokers²² and about 650 per 1 million nonsmokers exposed to tobacco smoke in the home²³. The overall lifetime risk of developing cancer from any cause within the United States is about one in three²⁴. Lastly, the above discussion focused only on cancer end points. Risks posed by certain types of pollutants such as particulate matter and cigarette smoke to cardiovascular and respiratory health and mortality are profound and significant at low doses but much less studied in terms of HAPs.

Table 4. EPA National Air Toxics Assessments 2005 top additive cancer risk air toxics within PRETA counties

RANK	AIR TOXIC NAME	CANCER RISK (LIFETIME RISK, PER 1 MILLION) ^A
1	Diesel particulate matter (DPM) ^B	93.43
2	Formaldehyde	16.37
3	Benzene (including benzene from gasoline)	7.49
4	Coke oven emissions	7.05
5	Carbon tetrachloride	2.86
6	Acetaldehyde	2.75
7	Arsenic compounds (inorganic, including arsine)	2.71
8	Chromium compounds	2.13
9	1, 3-Butadiene	1.99
10	Naphthalene	1.44
11	*Polycyclic aromatic hydrocarbons	1.30

What specific HAPs are most associated with cancer risk in our area, and what are their sources?

Within the PRETA region, 11 specific air toxic pollutants have a cancer risk level above one per million (Table 4) and therefore are considered by NATA to be a regional or local cancer driver. When the total cancer risk from these air toxics is summed across the 10 counties, the median risk is more than 120 per million. When DPM is not included in the total assessment, the median lifetime cancer risk attributable to HAPs is just more than 50 per million. The top cancer drivers within the region are diesel particulate matter, formaldehyde, benzene, coke oven emissions, and carbon tetrachloride. Potential risk estimates indicate that DPM should be the highest priority air toxic according to both NATA and supplemental research performed in Allegheny County²⁵.

As described in detail above, sources of air toxics emissions that are included in NATA are characterized as stationary (point and nonpoint sources), mobile (on-road and nonroad), and background sources. Figure 2 shows total air toxics cancer risk by source sector (excluding that by DPM, which arises primarily from road and nonroad mobile sources) for the PRETA region. The top three categories of HAP sources that contribute to cancer risk were secondary, background, and point sources.

^A Cancer risks are upper-bound lifetime cancer risks—that is, a cancer risk is a plausible upper limit to the true probability that an individual will contract cancer over a 70-year lifetime as a result of a given exposure. This risk can be measured or estimated in numerical terms (e.g., one chance in a million).

^B A unit risk estimate of 3×10^{-4} was used, as established by the California Air Resources Review Board as a reasonable estimate²⁷.

AIR TOXICS CANCER RISK BY SOURCE

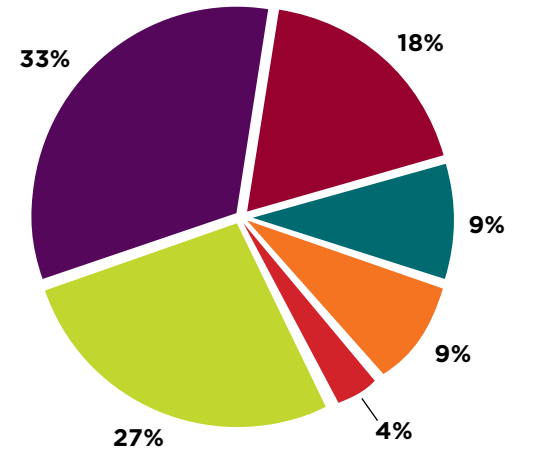


Figure 2. Total air toxics (excluding DPM) cancer risk by source sector within the PRETA region in 2005.

The top three sources of air toxics that contribute to cancer risk in the PRETA region are secondary sources (33%), background sources (27%) and point sources (18%)

- POINT CANCER RISK SOURCES
- NONPOINT CANCER RISK SOURCES
- ON-ROAD CANCER RISK SOURCES
- NONROAD CANCER RISK SOURCES
- BACKGROUND CANCER RISK SOURCES
- SECONDARY CANCER RISK SOURCES

Exposure and risk characterizations are limited by the data available in regulatory emissions inventories. Risk contributions from secondary and background sources do not show significant spatial variability across the PRETA region, further verifying that the whole region experiences a constant burden of certain ambient air toxics and that ground-level stationary and mobile sources drive spatial variability and hot spots. For further discussion, we decided to focus on those HAPs predicted to have cancer risks equal to more than 2 per million, which are the top eight listed in Table 3.

DIESEL PARTICULATE MATTER (DPM)

While it is clear that DPM represents the greatest single cancer risk among the individual pollutants in this area, estimation of the true cancer risk through NATA does have a caveat. To date, not enough data exist to develop a federal carcinogenic unit risk estimate necessary to quantify risk for DPM. However, EPA's 2002 Diesel Health Assessment concluded that diesel exhaust is "likely" to be carcinogenic to humans through inhalation, expressing the unit risk estimate of diesel not as a specific value but as a range: 10^{-3} – 10^{-5} (1 in 1,000 to 1 in 100,000) risk at $1 \mu\text{g}/\text{m}^3$ over their lifetime²⁶. To calculate cancer risk attributable to DPM for this report, a unit risk estimate of 3×10^{-4} was used, as also established by the California Air Resources Board as a "reasonable estimate"²⁷.

Figure 3 shows the regional distribution of cancer risk attributed to DPM within the PRETA area. There are no major point sources for the DPM emissions noted, indicating the major contributing sources are mobile. Therefore, it is not surprising that the greatest risk is concentrated in places of high traffic volume. The risk is high in Allegheny County, reflecting the larger volume of bus and truck traffic compared to other counties. The downtown area appears to be especially problematic because emissions from buses and trucks can become trapped in the "canyons" formed by tall buildings, limiting dispersion and mixing with the upper atmosphere. The contributing diesel risk is apparent from darker blue shades that seem to parallel the major roadways connecting Pittsburgh to the Washington, Greensburg, and Beaver metropolitan areas.

There also are several small census tracts highlighted in dark blue in the southeastern corner of Allegheny County. One of these

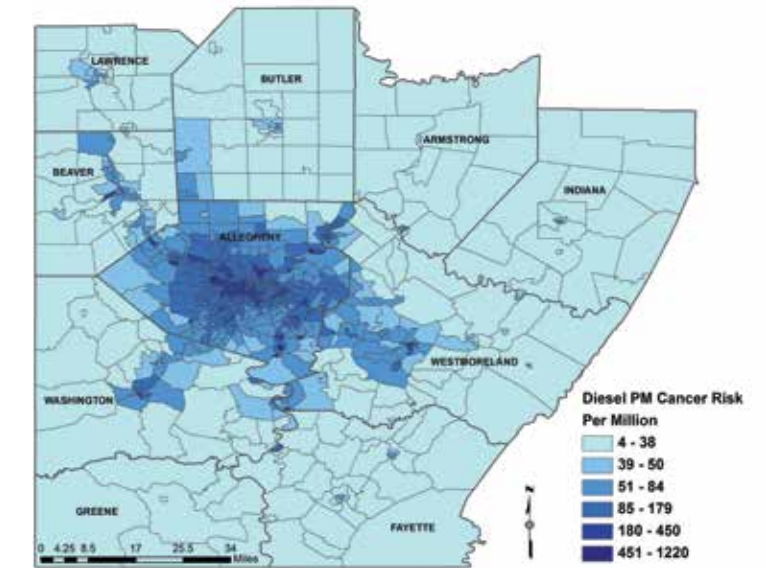


Figure 3. Spatial distribution of cancer risk attributed to diesel particulate matter (DPM) in the PRETA region

WHAT DO THESE MAPS TELL US?

The maps illustrated in this section represent the spatial distributions of the number of lifetime cancer cases expected in an area (census tract) per 1 million people over a lifetime (70 years) of inhalation exposure. Certainly, 1 million people do not reside in any of these small areas. However, to better interpret these cancer risks, the data have been normalized to cases per million to more easily compare to EPA's one-in-a-million recommended cancer threshold. The data represented in each map are grouped into six classes by a natural breaks method. The natural breaks method maximizes the differences between the six data classes within the distribution of the individual pollutant's cancer risk. As a result, the shades of blue color on each of the multiple maps do not coincide with equivalent levels of risk between each map. Therefore, spatial comparisons by color should not be made between multiple maps. They also do not represent intervals of equal sizes, although in all cases the transition from light to dark blue represents progressively increasing levels of risk.



DPM, continued

is West Elizabeth, where the highest overall rate of total cancer risk from HAPs was noted above. NATA predicted a DPM concentration in West Elizabeth of 8.29 µg/m³, of which 8.11 µg/m³ was attributed to nonroad sources. Further investigation of this area revealed the presence of a facility formerly known as Clairton Slag Inc., which produced asphalt and paving mixtures. In January 2010, this facility was converted to a multimodal loading terminal where approximately 2,500 tons of coke per day are transported from the Clairton Coke Works to river barges on the Monongahela River via 12 special dump trucks (coke had previously been transported via railcar). Emission inventories are not yet available for 2011, and it is beyond the scope of this analysis to estimate the current diesel concentrations in this area. It appears that this facility continues to operate in a similar capacity and currently experiences heavy-duty truck activity similar to 2005 levels.

FORMALDEHYDE

For the majority of the PRETA region population, most of the cancer risk from air toxics does not originate directly from point sources. The second and third leading drivers of cancer risk in the PRETA area are formaldehyde and benzene (Table 4). Figure 4 shows cancer risk attributed to airborne formaldehyde along with any major point sources as reported by the Toxic Release Inventory for 2010. Only two point sources of formaldehyde are noted: one in Butler County (INDSPEC Chemical Corporation) and the other in Beaver County (Engineered Polymer Solutions Inc.). The largest point source of release fails to modify cancer risk in the immediate area, suggesting that point sources of formaldehyde per se are of little consequence in determining cancer risk. Note that the risk of cancer, however, is elevated throughout Allegheny County and especially in high traffic areas such as downtown Pittsburgh. The role of vehicular traffic is again pointed out by the region extending southwest from Pittsburgh toward Washington, Pa., which probably relates to the I-79 Interstate corridor that connects these two regions. Because formaldehyde

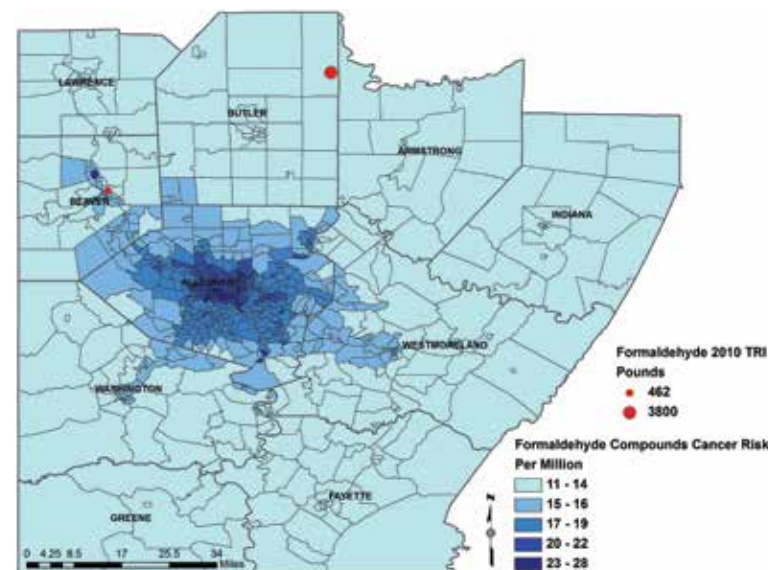


Figure 4. Spatial distribution of cancer risk attributed to formaldehyde and major point source releases within the PRETA region

can be formed by photochemical oxidation of many naturally occurring compounds, including methane and isoprene, as well as many man-made pollutants (a vast array of hydrocarbons), secondary formation greatly exceeds direct emissions from combustion sources and may account for up to 70-90 percent of total atmospheric formaldehyde⁴⁻⁶.

BENZENE

Figure 5 shows a similar map for benzene. Several more point sources of benzene release are significant compared to formaldehyde, but again the risk appears to be focused more on population centers (Pittsburgh and other urban hubs) rather than on the major point sources of release. The two largest point sources of benzene in Allegheny County are the Shenango Inc. Coke Battery on Neville Island and the USX Clairton Coke Works. These two sources released 28,862 and 33,000 pounds of benzene in 2010, respectively. These levels are approximately three times greater than the next biggest source (INDSPEC Chemical Corporation, Butler County). While overall cancer risk from HAPs around these areas is clearly elevated (Figure 1), it also is driven by other chemicals released in these processes. Major sources of benzene considered in the analysis are exhaust from motor vehicles, smoke from wood burning, and off-gassing from petroleum-based refueling stations. One should be aware that benzene also can be frequently encountered at much higher levels than in ambient air via cigarette smoke, household gasoline storage, and petroleum-based household products

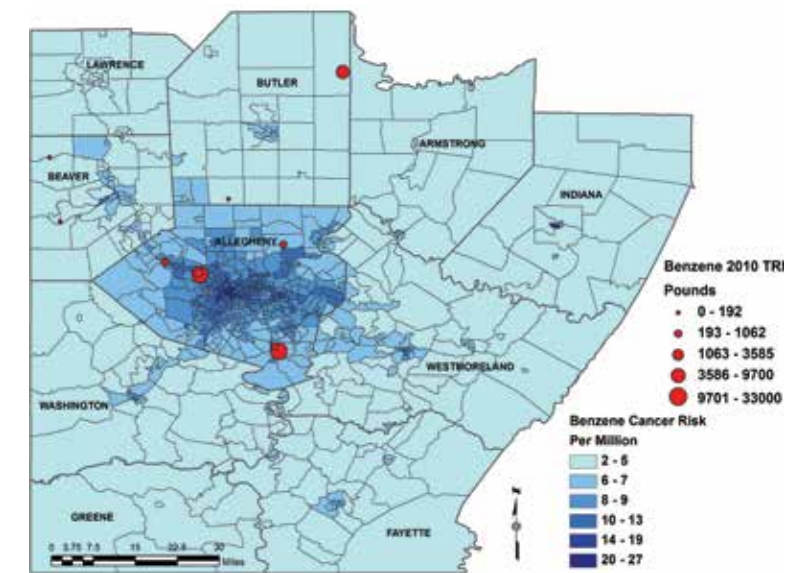


Figure 5. Spatial distribution of cancer risk attributed to benzene and major point source releases within the PRETA region

(glues, paints, furniture wax, and lubricants)⁸. The areas that predict the highest cancer risk contribution from on-road emissions follow the major traffic routes within the 10-county region. The highest prediction is found in the downtown corridor. The most significant agents driving the cancer risk from on-road emissions are formaldehyde and benzene. Not considering DPM, these same two chemicals contribute the largest share of risk concentrated in the downtown Pittsburgh area.

COKE OVEN EMISSIONS

It is noteworthy that localized high-cancer prevalent areas are apparent through NATA predictions. The area with the largest cancer risk attributable to point sources is the Liberty/Clairton/Glassport area of southern Allegheny County. Of the 289 per million predicted lifetime cancer cases in this area (not considering DPM), 245 are attributable to point sources and 138 per million are attributable to coke oven emissions (COEs). COEs are the third largest overall driver of cancer risk in the area. Figure 6 shows the major sources of COE and corresponding areas of cancer risk in the PRETA region. COEs are a species of air toxics unique to only a few airsheds: those that are home to coke batteries, which cook coal in ovens to burn off impurities and produce pure carbon (coke) for steel production.

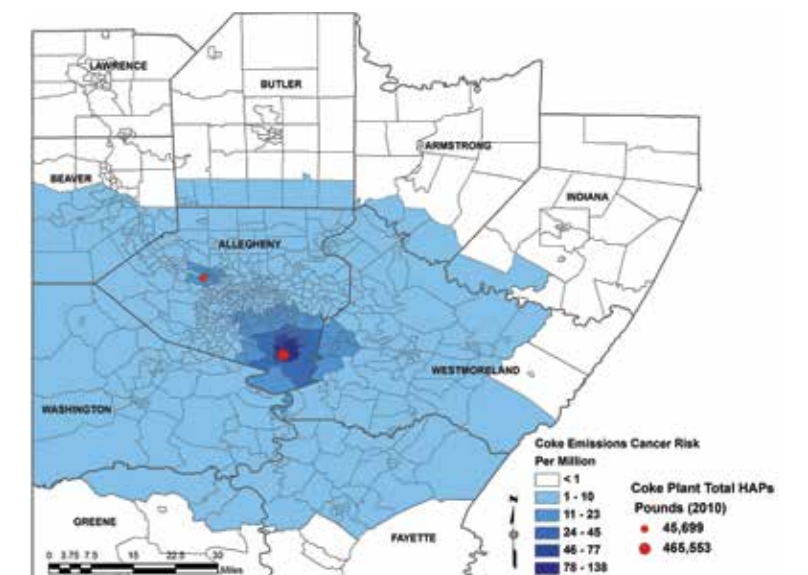


Figure 6. Spatial distribution of cancer risk attributed to coke oven emissions and major point source releases within the PRETA region

COKE OVEN EMISSIONS, continued

When the U.S. Steel facility was built in Clairton, Pa., it was the largest coke plant in the world. Now, the facility's emissions are a predominant source of cancer risk in the Clairton airshed, located just south of Pittsburgh in the Monongahela River valley (Figure 6). The second major point source represents Shenango Inc., located on Neville Island. In contrast to pure compounds like formaldehyde and benzene, COEs are a mixture of gases, vapors, and particulates containing upwards of 10,000 compounds²⁹. The mixture includes many known carcinogens and cocarcinogens, including polycyclic organic matter from coal tar pitch volatiles, beta-naphthylamine, benzene, arsenic, beryllium, cadmium, chromate, lead, nickel subsulfide, nitric oxide, and sulfur dioxide^{30, 31}. Because the emissions contain such a heterogeneous mixture of constituents, correlating exposure risks with sampling data is difficult. Regulatory monitoring of COEs relies on using surrogate measures, such as ambient hydrogen sulfide and benzene concentrations and the amount of benzo(a)pyrene in PM₁₀ filters to estimate overall release. The Allegheny County Health Department is studying more efficient methods to monitor the emissions and risk, such as testing new analytical methods to measure these surrogate markers for estimating COEs.

Exposure and risk characterizations are limited by the data available in regulatory emissions inventories. Risk contributions from secondary and background sources do not show significant spatial variability across the PRETA region, further verifying that the whole region experiences a constant burden of certain ambient air toxics.

CARBON TETRACHLORIDE

Next on the priority list is carbon tetrachloride (Figure 7). While small releases into the environment occur from chemical companies or hazardous waste/solvent recovery stations, carbon tetrachloride serves a good example of legacy pollution³². At one time, carbon tetrachloride was widely used in the dry cleaning industry; however, its use was dramatically curtailed around 1948 with its replacement by perchloroethylene. Until 1986, carbon tetrachloride was used as a pesticide. Because of its volatility, it quickly evaporates into the atmosphere, where it has an estimated life span of 50 years. That means that much of the carbon tetrachloride to which we are currently exposed is the result of historical use and release from many years ago. Figure 7 shows that the cancer risk from carbon tetrachloride is relatively uniformly spread over the region, but only one point source emission of carbon tetrachloride exists within the PRETA area; the Siemens Water Technologies Corp. Darlington Facility in Beaver County specializing in wastewater

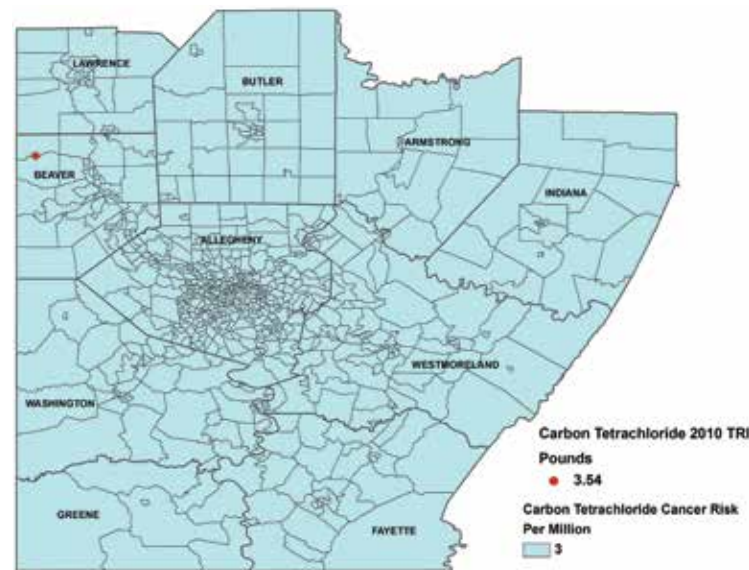


Figure 7. Spatial distribution of cancer risk attributed to carbon tetrachloride and major point source releases within the PRETA region

treatment. The fact that the model predicts risk to be uniformly spread spatially throughout the PRETA area speaks to the opportunity for prolonged mixing to achieve what are best considered global background levels of this once commonly used chemical.

ACETALDEHYDE

No major point sources currently exist for acetaldehyde (Figure 8), the next priority pollutant within the PRETA region. Acetaldehyde is ubiquitous in the environment^{33, 34} and can be released into the atmosphere during combustion of almost any material. A major source of release into the air is wood combustion from residential fireplaces and woodstoves. Other sources include burning tobacco, combustion of organic fuels, coal refining, and incineration of plastic waste. Because sources are primarily a large variety of small stationary nonpoint sources and motor vehicles, the overall risk appears to generally follow areas of higher population density, most likely an artifact of the models' inputs. Acetaldehyde also can be formed as a secondary pollutant by photo-oxidation of other hydrocarbons similar to formaldehyde.

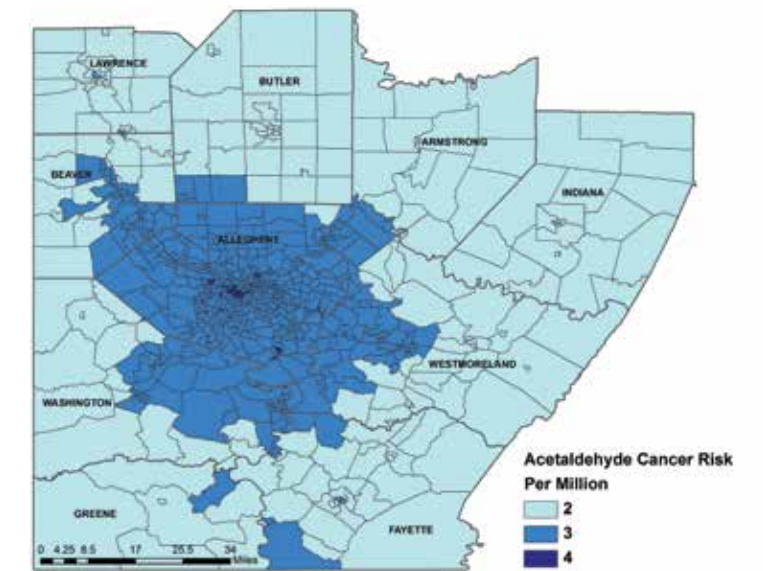


Figure 8. Spatial distribution of cancer risk attributed to acetaldehyde within the PRETA region

ARSENIC

While most of the concern over arsenic (seventh on the priority list) arises from potential contamination of water and food, it also needs to be considered as a hazardous air pollutant^{35, 36}. Arsenic can be released into the air both naturally (e.g., by volcanoes and crustal dust) and through human activity. Many different chemical forms of arsenic exist, but the inorganic form found in air is the most hazardous to human health. Man-made emissions come mainly from nonferrous metal smelting and refining plants; the use of pesticides; and combustion of fuels, especially low-grade lignite coal. Use of arsenical pesticides has been banned in the United States for some time, and very few arsenic-emitting metal foundries are found in our region. The primary point source emitters of arsenic in the PRETA region noted in Figure 9 are all coal-fired power plants. The four largest emitters of arsenic in the PRETA region are Homer City Generation LP (Indiana County), the Keystone Power Plant (Armstrong County), the Conemaugh Power Plant (Indiana County), and the Bruce Mansfield Power Plant (Beaver County). All four of these facilities were among the top 20 emitters of airborne arsenic in the nation

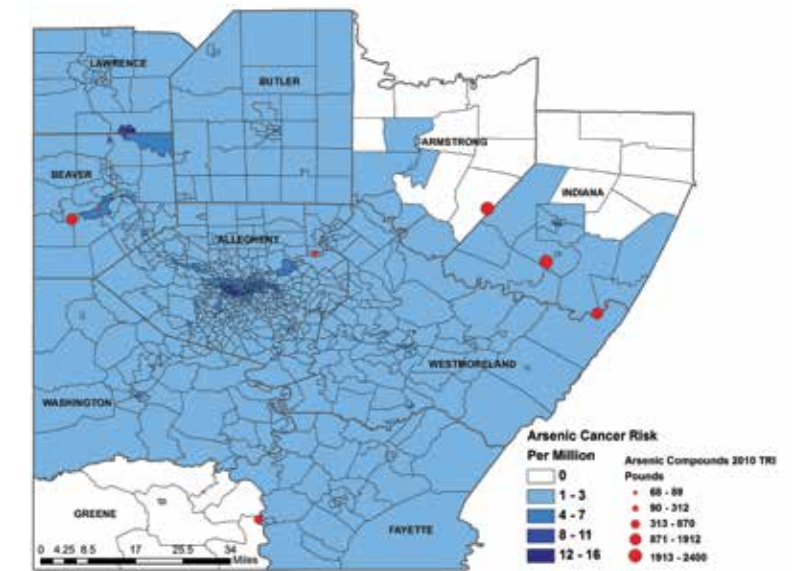


Figure 9. Spatial distribution of cancer risk attributed to arsenic and major point source releases within the PRETA region

in 2009³⁷. Annual emissions in 2010 ranged from 1,600 to 2,400 pounds. However, it should be noted that these levels of release do not appear to influence local cancer risk in nearby communities according to NATA results, as minimal increased risk is observed in their immediate vicinity, perhaps because of the large stack heights and opportunity for sufficient mixing and dilution in the atmosphere. Instead, areas of increased cancer risk appear primarily in the area of

ARSENIC, continued

downtown Pittsburgh (Allegheny County) and other relatively populated urban centers in other counties. Arsenic also is released via motor vehicle exhaust, especially when derived from diesel fuel. Thus, by these NATA predictions, it appears that urban centers in general produce a greater cancer risk from arsenic than areas located near coal-fired power plants. Average levels of arsenic in the United States range from less than 1–3 ng/m³ in remote areas and from 20 to 30 µg/m³ in urban areas. A study from Japan showed that a substantial amount of arsenic was associated with diesel particulate matter and that regional variations were dependent on traffic density³⁸. As an aside, arsenic is frequently used as a component of antifungal wood preservatives, so people should be warned against using pressure-treated lumber in wood-burning fireplaces and woodstoves.

CHROMIUM

Chromium, the eighth-ranked cancer driver in the PRETA region, is a metallic element found in particulate form similar to arsenic. Chromium is primarily associated with cancer risk in occupational settings, where high concentrations are present in the workplace such as metal foundry-produced stainless steel, chrome plating fixtures, and other metal alloys^{39, 40}. Such plants also can emit chromium into the ambient atmosphere as part of the industrial process. Figure 10 shows the various point sources in the PRETA region with reported chromium release inventories. Eighty-four point sources of chromium emissions exist here, and approximately 70 percent of those are listed as primary metals or fabricated metals facilities. In addition, the same power plants responsible for arsenic release also emit chromium. Other industries associated with chromium are various chemical companies; cement plants, and again, pressure-treated lumber companies. In general, chromium poses only a minor cancer risk in the PRETA area, the overall rate being only about double the “background” rate of one per million. Downtown Pittsburgh again shows an increase in risk, suggesting that chromium, like arsenic, could be a product of motor vehicle exhaust, although this is not well studied. There also appear to be several small pockets of increased risk within the PRETA area. Note the darker blue regions in Figure 10 located in central Westmoreland County and on the border of Westmoreland and Fayette counties. These regions are located

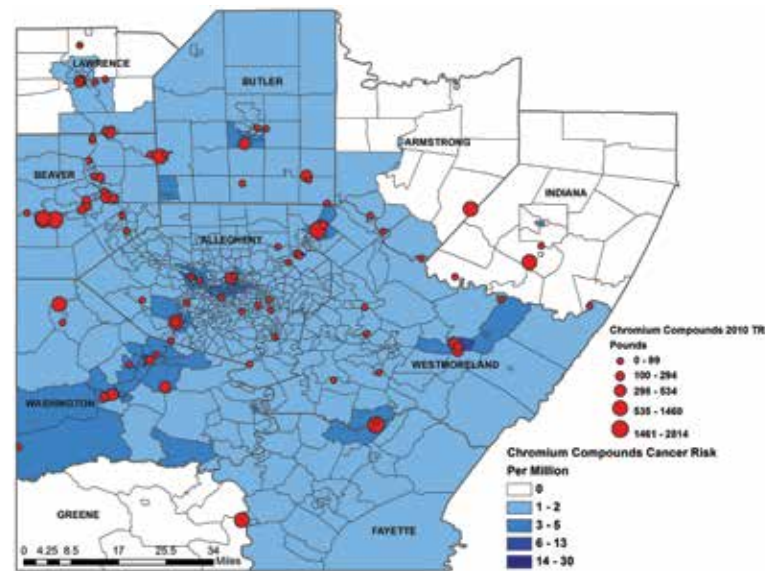


Figure 10. Spatial distribution of cancer risk attributed to chromium and major point source releases within the PRETA region

in close proximity to multiple point sources in each area that likely contribute to the cancer risk. The section along the Westmoreland/Fayette border is dominated by Duraloy Technologies in Scottsdale, Pa., which is the second largest releaser of chromium in the PRETA area (2,310 pounds in 2010). The higher risk area in the middle of Westmoreland County is centered on Latrobe, Pa., and contains chromium releases from Latrobe Specialty Steel Company; Lehigh Specialty Melting, Inc.; and ATI Allvac, each of which released 264–469 pounds of chromium in 2010. Again, without monitoring data in these areas, it remains difficult to determine the exact chromium concentrations present in ambient air, keeping in mind that the NATA risk estimates are calculated using reported emissions and atmospheric modeling only and can be rather imprecise.

Noncancer respiratory risk

The primary noncancer health effects of concern with HAPs are respiratory, neurological, and reproductive disorders. Risks for these types of effects can be presented as noncancer hazard indices (HIs) representing the sum of hazard quotients (HQs) for pollutants that affect the same target region (respiratory, neurological, or reproductive). The HIs for neurological and reproductive dysfunction for all summed HAPs in the PRETA region were less than one. In contrast, a respiratory risk hazard index of 1.52 exists for all HAPs when all hazard quotients are combined and averaged across the 10 counties, indicating the possibility of potential noncancer adverse effects. The largest contributing source types for respiratory risk are from secondary and nonpoint sources. No sectors alone have a combined average HI above one. The only single pollutant that shows an HQ above one is acrolein, which has an average HQ of 1.52 across the 10 counties. This makes it the primary driver of respiratory risk among all HAPs. Within the 10 counties, 377 census tracts had an HI above 1.0 for acrolein, with the maximum of 4.91 located in the heart of downtown Pittsburgh.

Figure 11 shows the total noncancer respiratory risk for PRETA's 10 counties. The majority of Allegheny County is predicted to have an HI above one, indicating the potential for adverse irritation to the respiratory system. (An HI above one cannot be translated directly to the probability that an adverse effect will occur and is not linearly proportional to risk. However, it does suggest that adverse respiratory effects are possible and are more likely the higher the index number.)

Noncancer risk to the respiratory system from air toxics is concentrated in the downtown Pittsburgh area, with acrolein being the primary driving agent. Acrolein is formed primarily through secondary photo-oxidation reactions of existing hydrocarbon pollutants and by combustion. As such, the burning of wood and other organic fuels contributes significantly to the amount of acrolein in the air. Secondary formation and nonpoint stationary emissions make up 43 percent and 27 percent of this airborne pollutant, respectively. Acrolein emissions for NATA were estimated using a highway vehicle emissions simulator model called MOVES (Motor Vehicle Emissions Simulator), the same model used to estimate both benzene and formaldehyde⁸.

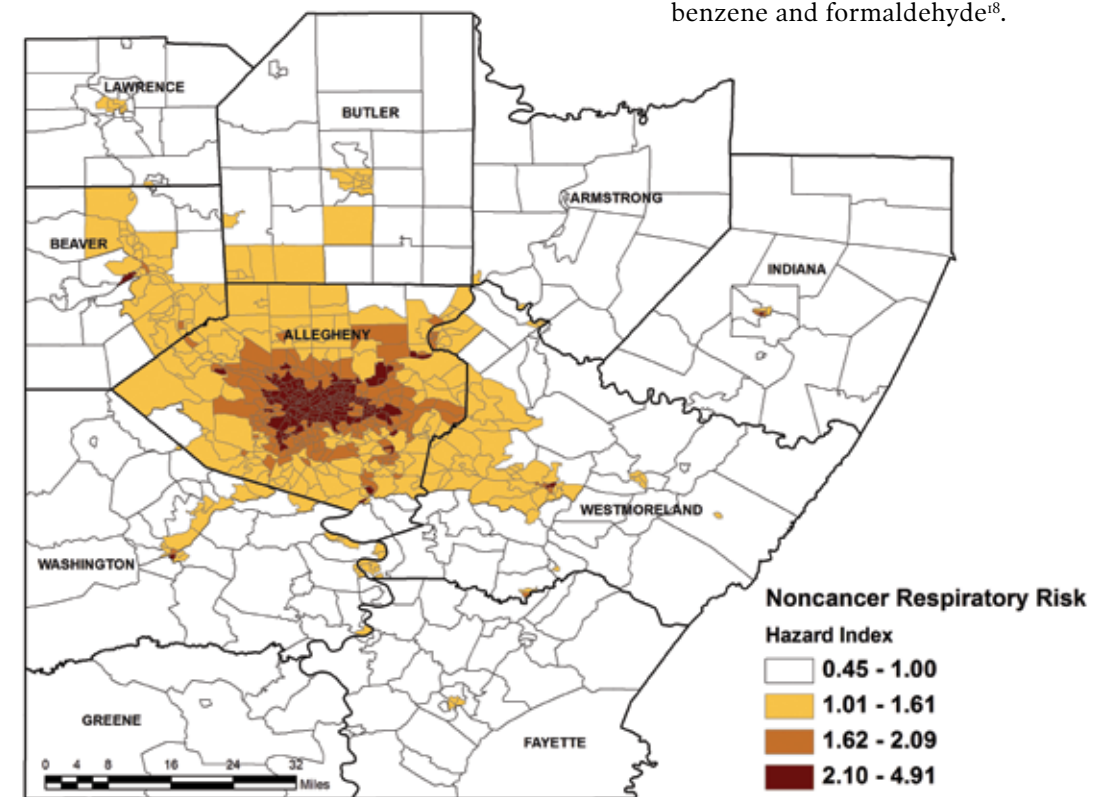


Figure 11. Total noncancer risk to respiratory end point from all air toxics combined as predicted by NATA (2005). A hazard index above one is associated with an increased chance of adverse health effects.

NATA appeared to overestimate the contribution from mobile sources and underestimate that from large point sources. This suggests that risks may indeed be greater than predicted at sites located near major industrial activities, such as Avalon and Stowe near Neville Island and in the communities downwind of coal-fired power plants.



EVALUATION OF NATA USING AIR MONITORING DATA

Again, it should be emphasized that the risk characterizations provided by NATA described above are based primarily on reported and predicted emissions inventories along with computational modeling to assume atmospheric concentrations of individual pollutants over time. It is therefore useful to review actual air monitoring data to validate its accuracy and predictions. However, the existing monitoring system is geared primarily toward monitoring the limited number of National Ambient Air Quality Standards (NAAQS) criteria air pollutants—particulate matter less than 2.5 microns (PM_{2.5}), ozone (O₃), sulfur dioxide (SO₂), oxides of nitrogen (NO_x), carbon monoxide (CO), and lead (Pb)—and not the extensive HAPs list. Limited resources preclude the monitoring of all the individual HAPs over the wide PRETA area on a routine basis, and, therefore, validation of NATA predictions is challenging. Limited air monitoring data do exist from the Pittsburgh Air Toxics Study and are discussed below. Currently, University of Pittsburgh researchers, in collaboration with Allegheny County Health Department, are monitoring volatile organic compounds (VOCs) and markers for diesel exhaust in the downtown Pittsburgh area to help understand the state of HAPs in the region.

PITTSBURGH AIR TOXICS STUDY

Sources of cancer risks have been tracked by researchers at Carnegie Mellon University as part of the Pittsburgh Air Toxics Study, whose data are reported in a series of studies published by Logue and colleagues. In their first study⁴¹, they compared high-time resolution (instantaneous) measurements of toxics collected at different locations in order to quantify the levels of a panel

of various gas-phase pollutants (formaldehyde and carbon tetrachloride were not considered) and estimated individual and additive cancer risks at these locations. Data were collected from downtown Pittsburgh; on the Carnegie Mellon campus; and in Avalon, Pa. Using positive matrix factorization (PMF), a process that groups like chemicals emitted by specific sources in space and time to assess the contributions of various sources, the authors then assigned this risk to specific source factors, such as the “coke works factor” and the “chemical plant factor” referenced below. As in NATA, benzene was found to be an important cancer risk driver at all locations and was above the 75th percentile compared to other U.S. cities. Benzene dominated the risk present at the Avalon site, which is in close proximity to numerous chemical and manufacturing facilities, including a large coke production facility. NATA data rely on emission inventories for their predictions, and both the Shenango Coke Works and the nearby Neville Chemical Company reported similar yearly releases for benzene: 3 and 3.6 tons, respectively. However, PMF revealed that the “coke works factor” contributed about seven times more benzene than the “chemical plant factor” compared to the actual monitored values, suggesting variations in model predictions based on total emissions released. In addition, a significant “coke works factor” also was noted for the downtown and Carnegie Mellon locations, suggesting perhaps a wider effect of the Clairton Coke Works over time than was predicted by NATA. Contributions from mobile sources also were substantial in all regions. However, the Avalon and Carnegie Mellon sites were dominated by gasoline vehicle sources, whereas diesel-powered sources more strongly influenced the

downtown site. In contrast to NATA, chlorinated compounds such as tetrachloroethene and 1,4-dichlorobenzene emerged as significant cancer drivers in the downtown area, probably from local stationary nonpoint sources such as dry cleaners, an inconsistency that is currently being investigated by University of Pittsburgh researchers.

In a second study, Logue et al confirmed acrolein as the only major contributor to noncancer risk²⁵. In terms of cancer risk, overall additive cancer risk estimated by monitoring at urban (downtown, Flag Plaza), residential/industrial (Avalon, Stowe), and rural (South Fayette) sites were similar to NATA predictions²⁵. More than half of the overall risk at all these sites could be attributed to two regionally distributed toxics, formaldehyde and carbon tetrachloride, similar to NATA. Higher-than-predicted levels of tetrachloroethene and 1,4-dichlorobenzene were again confirmed in the downtown Pittsburgh area at a monitor located at a different site from the first study, suggesting that further work is necessary to fully evaluate the sources and risks posed by these previously unrecognized pollutants. Trichloroethene was 41 times higher in downtown Pittsburgh than at the rural South Fayette site and in the 95th percentile nationally. In general, however, the overall additive cancer risk was similar to that seen in other U.S. cities.

More recently, this same research group has directly compared its findings to those of NATA⁴². For most of the high-risk air toxins identified in Pittsburgh (Table 4), the measured concentrations

were within a factor of two of those predicted by NATA. Regarding the longer list of 29 HAPs measured in the study, NATA generally tended to underpredict more compounds than it overestimated but was within a factor of 10 for 88 percent of the measured chemicals. The biggest discrepancies were found for a variety of chlorinated species and other chemicals associated with stationary, nonmobile source emissions. For example, NATA underpredicted 1,2-dichloroethane, vinyl chloride, chlorobenzene, and other chlorinated hydrocarbons by more than a factor of 10 at multiple sites. Using the measured values of trichloroethene and 1,4-dichlorobenzene, these chemicals emerge as the second and fifth strongest cancer drivers in downtown Pittsburgh, where they fail to make the top 10 identified by NATA. NATA performed better here than in other areas in the nation at predicting the concentrations of the important risk drivers. The authors also report that while overall pollutant concentrations and risks within the area were fairly congruent between both approaches, NATA appeared to overestimate the contribution from mobile sources and underestimate that from large point sources. This suggests that risks may indeed be greater than predicted at sites located near major industrial activities, such as Avalon and Stowe near Neville Island and in the communities downwind of coal-fired power plants. In addition, it is possible that areas of Allegheny County affected by the Clairton Coke Works are larger than was previously estimated.

FAQ REGARDING AIR TOXICS IN THE PRETA REGION

Q. Which air toxics pose the greatest potential risk of cancer across the PRETA region?

A. Diesel particulate matter, formaldehyde, benzene, and coke oven emissions are among the highest priority air toxics.

Q. Which air toxics pose lesser, but still significant, potential risk of cancer across the PRETA region?

A. Carbon tetrachloride, acetaldehyde, arsenic, and chromium. Limited monitoring data also suggest that several chlorinated organics (e.g., chloroethenes and chlorobenzenes) and 1,3-butadiene also may be of concern.

Q. When risks from all air toxics are combined, how many people have the potential for an upper-bound lifetime cancer risk greater than one in a million?

A. The entire PRETA population. A median risk of 120 per million cancer risk is estimated for the PRETA region, with a lower limit estimate of 28 per million.

Q. Which areas of the PRETA region have the highest potential cancer risk from air toxics?

A. West Elizabeth/Clairton/Liberty/Glassport, Avalon, and downtown Pittsburgh

FUTURE TRENDS: NEW SOURCES OF HAPs IN WESTERN PENNSYLVANIA?

THE PROPOSED MONACA, Pa., ETHANE CRACKER

All of the previous risk analyses and data discussed above were drawn using historical data collected in previous years. There is considerable delay around emissions inventory collection, air monitoring data collection, atmospheric modeling, and the calculated risk estimates' being made public. Hence, these analyses speak best toward past and present trends. They often are less useful in predicting future risks, especially when sources and technologies are constantly changing. For example, better pollution mitigation and retrofitting processes should curtail future emissions from present levels. In addition, changing the profile of various industries within a region also will alter atmospheric chemistry and subsequent risks in future scenarios.

In recent years, there has been an unprecedented expansion of unconventional natural gas development (UNGD) in Western Pennsylvania, Ohio, and West Virginia driven in part by the recent feasibility of hydraulic fracturing, which is part of a drilling procedure that allows for the tapping of the vast methane deposits contained in the Marcellus and Utica shales beneath Pennsylvania and surrounding states. Primarily, drillers are seeking to extract methane (CH₄), the primary component of natural gas. However, a portion of the natural gas present in our area is considered "wet gas," which includes heavier hydrocarbons like ethane, propane, and butane that are typically dissolved in a liquid phase or condensate. These compounds are separated from the methane to be marketed as such products as liquid propane or used as feedstock in numerous other chemical processes. Therefore, a high demand remains for wet gas deposits regardless of fluctuating natural gas (methane) market prices. Thus, a large-scale expansion in other industries (e.g., chemical manufacturing) is anticipated to follow UNGD; new industrial facilities are needed to support the refining of wet gas condensates. For example, an ethane cracker converts or "cracks" ethane, a by-product of natural gas, into ethylene so that it can be used in the production of plastics.



Located in Monaca, Pa. (Beaver County), about 12 miles east of the West Virginia border, is an aging zinc smelter owned by the Horsehead Corporation. The present Horsehead facility is currently the largest zinc refining site in the United States, producing metallic zinc and zinc oxide from recycled material and steelmaking waste. The plant opened in the 1920s to take advantage of the by-products of steel manufacturing and has expanded and modernized over time. It employed about 600 workers until recently, when the company announced its relocation to a new state-of-the-art facility in North Carolina in the near future. The scope of this metal-refining operation was such that it was a significant source of metals and criteria air pollutants.

Recently, Shell Chemical, U.S. subsidiary of Royal Dutch Shell PLC, announced plans to build an ethane cracker in the northeast to take advantage of UNGD. Lured by substantial tax benefits and other economic incentives, Shell chose the former zinc smelting site in Monaca as its proposed new location for such a facility and, in March 2012,

received the approval from Pennsylvania officials to build this petrochemical complex. The cracker, according to industry representatives, will be a multibillion-dollar structure and provide thousands of jobs for Pennsylvanians^{43, 44}. However, many of these jobs depend on the influx of concurrent industries and technologies, which are projected to follow in the wake of sufficient petrochemical refining facilities like the ethane cracker. Thus, it is not likely to be the sole source of pollutants in the area once constructed. Though plant construction remains years away, regional air pollutant composition and chemistry are poised to change as well. Adding to the issue is the fact that the zinc smelter, ranked as one of the worst air polluters in the country in 2002⁴⁵, will be decommissioned and have its operations moved to North Carolina.

Here, we will attempt to compare the pollutant profiles of the old and new air pollution sources in order to deduce potential air pollutant changes to existing air quality in the region. Previous emission inventories are available for the Horsehead zinc smelter (EPA Toxic Release Inventory for 2008)⁴⁶. Although the proposed cracker facility's engineering specifics are not available yet, using the records of a similar existing wet gas processing plant, we can approximate the proposed cracker's yearly emissions. In this case, we have chosen the similarly sized Williams Olefins Cracker Facility currently operating in Geismar, La., whose emissions profiles for 2008 also were available⁴⁶. This plant, owned by Williams Partners, L.P., processes approximately 37,000 barrels of ethane and 3,000 barrels of propane per day and annually produces 1.35 billion pounds of ethylene.

In assessing the emission inventories at the two sites, we first sought to compare those pollutants that were common to both facilities. Table 5 compares the annual release of criteria pollutants for which National Ambient Air Quality Standards (NAAQS) exist. These include ozone, sulfur dioxide, nitrogen oxides, particulate matter (PM₁₀, PM_{2.5}), lead, and carbon monoxide, for which health-based regulatory standards exist for their concentration in ambient air¹. Not surprisingly, the zinc smelter released large amounts of lead into the air (five tons per year). The proposed ethane cracker, on the other hand, would release only trace amounts of lead into the air and about 0.1 percent of the sulfur dioxide, 3 percent of the carbon monoxide, and 50 percent of the nitrogen oxides of the zinc smelter. Overall, release of PM would be of a similar order of magnitude at the two sites. Thus, the representative cracker facility by itself emits less NAAQS criteria pollutants than the smelter facility.

In recent years, there has been an unprecedented expansion of unconventional natural gas development in Western Pennsylvania, Ohio, and West Virginia driven in part by the recent feasibility of hydraulic fracturing.

Table 5. Comparison of the 2008 annual release of NAAQS criteria pollutants at the Horsehead zinc smelter and a surrogate to the newly proposed ethane cracker

POLLUTANT (measured in tons)	HORSEHEAD SMELTER (amount released)	GEISMAR CRACKER FACILITY (amount released)	PERCENT OF CURRENT EMISSIONS
Lead	5	0.004	0.1%
Nitrogen oxides	1,176	553	47%
Sulfur dioxide	3,320	4.5	0.1%
Carbon monoxide	25,735	800	3.1%
PM ₁₀ primary	334	215	64.4%
PM _{2.5} primary	239	212	88.7%

¹For more information, readers are referred to our previous reports, *PRETA Air: Ozone* and *PRETA Air: Particulate Matter*.

Table 6. Comparison of the 2008 annual release of HAPs between the Horsehead zinc smelter and a surrogate to the newly proposed ethane cracker.

POLLUTANT	HORSEHEAD SMELTER (amount released)	GEISMAR CRACKER FACILITY (amount released)	PERCENT OF CURRENT EMISSIONS
Acrolein (lbs.)	91	191	209.9%
Benzene (lbs.)	404	49	12.1%
Ethyl Benzene (lbs.)	37	0.3	0.8%
VOCs (tons)	66	481	728.8%
Xylenes (lbs.)	26	0.02	0.1%

WHAT DOES THIS TABLE TELL US?

Data are from the 2008 EPA Toxic Release Inventory (TRI) for total releases to air for the Horsehead zinc smelter (Monaca, Pa.) and Williams Ethane Cracker Facility (Geismar, La.). Percent of current emissions corresponds to probable increases or decreases in releases if the Horsehead smelter is replaced with an ethylene cracker of similar size to the Geismar facility. Green indicates a decrease from current emission levels, while red indicates increased emissions from the proposed ethane cracker.

Similarly, Table 6 examines similarly reported HAPs released from both of the facilities in question. A comparison of available emissions inventories of HAPs reveals a list of common pollutants, including acrolein, benzene, ethylbenzene, xylene, and volatile organic compounds (VOCs). Note the projected increase in release of acrolein and VOCs by the proposed ethane cracker. The latter are a rather broad class of organic chemicals that have high vapor pressure (low boiling point), allowing appreciable concentrations in the air as a gaseous phase⁴⁷.⁴⁸ Examples of VOCs include formaldehyde, d-limonene, toluene, acetone, ethanol (ethyl alcohol), 2-propanol (isopropyl alcohol), and hexanal, among others. They are common components of paints, paint strippers, and other solvents; wood preservatives; aerosol sprays; cleansers and disinfectants; moth repellents and air fresheners; stored fuels and automotive products; hobby supplies; and dry-cleaned clothing. They also possess a diverse range of health effects, including, but not limited to, eye and throat irritation, nausea, headaches, nosebleeds, and skin rashes at low doses, and kidney, liver, and central nervous system damage at high doses. Some are known or suspected carcinogens. These chemicals are more often known for their role in indoor air pollution and have been linked to allergies and asthma⁴⁹. Recall that acrolein is already the primary driver of noncancer respiratory risk in the PRETA area,

and releases from the proposed cracker would theoretically add to that burden.

Table 7 shows a compiled list of HAPs that were released from the Geismar plant in 2008 but not from the zinc smelter, highlighting the potential change in the pollutant mixture. For comparison, the pollutants highlighted in yellow represent those that are several orders of magnitude greater than those emitted by the Clairton Coke Works in 2008. Note the rather large emissions of formaldehyde and acetaldehyde that were discussed above as the number one and number five existing cancer drivers in the area.

Other VOCs of note include ethylene glycol, ethylene oxide, methyl-tert-butyl ether and propionaldehyde. While all these pollutants may have toxic effects on their own, one of the primary concerns, especially in outdoor air, should be their ability to form secondary pollutants. For example, we have noted previously that both acetaldehyde and formaldehyde can be formed via photo-oxidation reactions of other hydrocarbons and VOCs. Thus, the direct emissions reported in the table are likely to be significant underestimations of the true burden of acetaldehyde and formaldehyde in the area near the cracker. It also should be mentioned that a complex nonlinear sensitivity exists among VOCs, NO_x, and the production rate of ozone (O₃). Most urban areas are considered NO_x saturated or VOC sensitive and therefore have low VOC/



It would appear that the replacement of the existing zinc smelter with the proposed ethane cracker has the potential to significantly transform the current pollutant mixture in the region. The elimination of lead and other heavy metal emissions would be replaced by increases in formaldehyde and acetaldehyde.

NO_x ratios. In these environments, ozone actually decreases with increasing NO_x and increases with increasing VOCs—a potentially likely situation within the urban areas of Southwestern Pennsylvania.

In conclusion, it would appear that the replacement of the existing zinc smelter with the proposed ethane cracker has the potential to significantly transform the current pollutant mixture in the region. The elimination of lead and other heavy metal emissions would be replaced by increases in formaldehyde and acetaldehyde. In addition, it does not appear that the proposed ethane cracker alone would increase any of the NAAQS criteria air pollutants, with the possible exception of ozone. On the other hand, the rather large releases of several known cancer drivers, such as formaldehyde and acetaldehyde, from the proposed cracker could increase cancer risk in the immediate proximity. In addition, the large influx of VOCs and fugitive emissions from these operations warrants further predictive analysis, especially with regard to current pollution-mitigating strategies that may not be anticipating a transforming pollutant mix.

Table 7. Analysis of the 2008 annual release of HAPs unique to a surrogate to the proposed ethane cracker

POLLUTANT	ANNUAL RELEASE (lbs.)
Acetaldehyde	7,018
Ammonia	42,000
Cadmium	30
Chlorine	360
Chloroform	1,400
Chromium (III)	25
Cobalt	30
Ethylene Glycol	19,616
Ethylene Oxide	10,024
Formaldehyde	6,020
Hexane	1,057
Methanol	203
Methyl-Tert-Butyl Ether	4,921
Propionaldehyde	324

WHAT CAN I DO TO LIMIT MY EXPOSURE TO HAPs?

Probably the most important step one can take to minimize exposure to HAPs is to be aware of the source(s) in the nearby area. You should determine whether any major point sources that release air toxics into the atmosphere are close to your home, school, workplace, or any other location where you spend a lot of time. Large industrial facilities are relatively easy to identify, and the EPA Toxic Release Inventory can be accessed to determine what specific chemicals may be associated with a site. However, it also is important to realize that just because they appear in the inventory, such emissions may still be below a critical threshold for risk of adverse effects. Notify the Allegheny County Health Department (ACHD) or Pennsylvania Department of Environmental Protection if you have questions about a facility or especially if you smell something “funny,” experience unexplained health effects, or notice some change in the activities associated with that facility. ACHD maintains an air quality complaint hotline at 412-687-ACHD (2243).

HAPs also can be encountered in a variety of nonindustrial/noncommercial settings. For example, numerous household products such as paints, solvents, cleaners, and glues, among others, contain a variety of VOCs and other chemicals that can enter the atmosphere. Care should be taken to store these products in well-sealed containers and to use them in well-ventilated locations. Gasoline is a significant



source of exposure for benzene, as well as other hydrocarbons, and should be kept only in approved containers and preferably in garages or sheds that are not attached your home. Pressure-treated lumber treated with chromated copper arsenate should not be burned in or near residential areas, as these metals can become airborne during combustion.

Another way that community members can impact air quality in our region is to become involved with citizen advocacy efforts that strive to tighten air quality standards in their area. People can stay informed of air quality issues using publicly accessible data available in EPA's periodic NATA assessments and annual Toxic Release Inventory, as well as from ACHD and other air quality groups. Citizens should get involved with local environmental groups and local governments and initiate community-driven projects to work with industry and reduce air toxics.

Where can I obtain additional information?

Technology Transfer Network Air Toxics Web site: www.epa.gov/nata

Toxic Air Pollutants: www.epa.gov/oar/toxicair/newtoxics.html

Scorecard: The Pollution Information Site: scorecard.goodguide.com/env-releases/hap

Toxic Air: The Case for Cleaning Up Coal-fired Power Plants: www.lung.org/assets/documents/healthy-air/toxic-air-report.pdf

Air Quality and Toxic Air Pollutants: www.fhwa.dot.gov/environment/air_quality/air_toxics

Health Effects Notebook for Hazardous Air Pollutants: www.epa.gov/ttnatwo1/hlthef/hapindex.html

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APPENDIX

List of specific hazardous air pollutants (HAPs) recognized by EPA and the Allegheny County Health Department

ACETALDEHYDE	BIS (2-ETHYLHEXYL) PHTHALATE (DEHP)	CHROMIUM (TSP)
ACETAMIDE		CHROMIUM VI (TSP)
ACETONITRILE	BIS (CHLOROMETHYL) ETHER	COBALT (TSP)
ACETOPHENONE	BROMOFORM	COKE OVEN EMISSIONS
2-ACETYLAMINOFLUORENE	1,3-BUTADIENE	M-CRESOL
ACROLEIN	CADMIUM (PM ₁₀)	O-CRESOL
ACRYLAMIDE	CADMIUM (PM _{2.5})	P-CRESOL
ACRYLIC ACID	CADMIUM (TSP)	CRESOL/CRESYLIC ACID (MIXED ISOMERS)
ACRYLONITRILE	CALCIUM CYANAMIDE	CUMENE
ALLYL CHLORIDE	CAPTAN	CYANIDE COMPOUNDS
4-AMINOBIIPHENYL	CARBARYL	2,4-D (SALTS AND ESTERS)
ANILINE	CARBON DISULFIDE	DDE (1, 1-DICHLORO-2,2-BIS (P-CHLOROPHENYL) ETHYLENE
O-ANISIDINE	CARBON TETRACHLORIDE	DIAZOMETHANE
ANTIMONY (TSP)	CARBONYL SULFIDE	DIBENZOFURANS
ARSENIC (PM ₁₀)	CATECHOL	1,2-DIBROMO-3-CHLOROPROPANE
ARSENIC (PM _{2.5})	CHLORAMBEN	DIBUTYL PHTHALATE
ARSENIC (TSP)	CHLORDANE	1,4-DICHLOROETHYLENE (P)
ASBESTOS	CHLORINE	3,3-DICHLOROBENZIDINE
BENZENE (INCLUDING BENZENE FROM GASOLINE)	CHLOROACETIC ACID	DICHLOROETHYL ETHER (BIS [2-CHLOROETHYL] ETHER)
BENZIDINE	2-CHLOROACETOPHENONE	1,3-DICHLOROPROPENE
BENZOTRICHLORIDE	CHLOROBENZENE	DICHLORVOS
BENZYL CHLORIDE	CHLOROBENZILATE	DIETHANOLAMINE
BERYLLIUM (PM ₁₀)	CHLOROFORM	N, N-DIETHYL ANILINE (N, N-DIMETHYLANILINE)
BERYLLIUM (PM _{2.5})	CHLOROMETHYL METHYL ETHER	DIETHYL SULFATE
BERYLLIUM (TSP)	CHLOROPRENE	
BIPHENYL	CHROMIUM (PM ₁₀)	
	CHROMIUM (PM _{2.5})	

TSP-the measurement of level of that specific pollutant in total suspended particulates.
ACHD-Allegheny County Health Department

3,3-DIMETHOXYBENZIDINE	MERCURY (PM _{2.5})	QUINOLINE
DIMETHYL AMINOAZOBENZENE	MERCURY (TSP)	QUINONE
DIMETHYL CARBAMOYL CHLORIDE	MERCURY COMPOUNDS	RADIONUCLIDES (INCLUDING RADON)
DIMETHYL FORMAMIDE	METHANOL	SELENIUM (TSP)
DIMETHYL PHTHALATE	METHOXYCHLOR	STYRENE
DIMETHYL SULFATE	METHYL BROMIDE (BROMOMETHANE)	STYRENE OXIDE
3,3-DIMETHYLBENZIDINE	METHYL CHLORIDE (CHLOROMETHANE)	2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN
1,1-DIMETHYLHYDRAZINE	METHYL CHLOROFORM (1,1,1-TRICHLOROETHANE)	1,1,2,2-TETRACHLOROETHANE
4,6-DINITRO-O-CRESOL (AND SALTS)	METHYL ETHYL KETONE (2-BUTANONE)	TETRACHLOROETHYLENE (PERCHLOROETHYLENE)
2,4-DINITROPHENOL	METHYL HYDRAZINE	TITANIUM TETRACHLORIDE
2,4-DINITROTOLUENE	METHYL IODIDE (IODOMETHANE)	TOLUENE
1,4-DIOXANE	METHYL ISOBUTYL KETONE (HEXONE)	2,4-TOLUENE DIAMINE
1,2-DIPHENYLHYDRAZINE	METHYL ISOCYANATE	2,4-TOLUENE DIISOCYANATE
EPICHLOROHYDRIN	METHYL METHACRYLATE	O-TOLUIDINE
1,2-EPOXYBUTANE	METHYL TERT-BUTYL ETHER	TOXAPHENE (CHLORINATED CAMPHENE)
ETHYL ACRYLATE	METHYLENE CHLORIDE (DICHLOROMETHANE)	1,2,4-TRICHLOROBENZENE
ETHYL CARBAMATE (URETHANE)	METHYLENE DIPHENYL DIISOCYANATE (MDI)	1,1,2-TRICHLOROETHANE
ETHYL CHLORIDE (CHLOROETHANE)	4,4-METHYLENEBIS (2-CHLOROANILINE)	TRICHLOROETHYLENE
ETHYLBENZENE	4,4-METHYLENEDIANILINE	2,4,5-TRICHLOROPHENOL
ETHYLENE DIBROMIDE (DIBROMOETHANE)	NAPHTHALENE	2,4,6-TRICHLOROPHENOL
ETHYLENE DICHLORIDE (1,2-DICHLOROETHANE)	NICKEL (PM ₁₀)	TRIETHYLAMINE
ETHYLENE GLYCOL	NICKEL (PM _{2.5})	TRIFLURALIN
ETHYLENE IMINE (AZIRIDINE)	NICKEL (TSP)	2,2,4-TRIMETHYLPENTANE
ETHYLENE OXIDE	NITROBENZENE	VINYL ACETATE
ETHYLENE THIOUREA	4-NITROBIPHENYL	VINYL BROMIDE
ETHYLIDENE DICHLORIDE (1,1-DICHLOROETHANE)	4-NITROPHENOL	VINYL CHLORIDE
FINE MINERAL FIBERS	2-NITROPROPANE	VINYLDENE CHLORIDE (1,1-DICHLOROETHYLENE)
FORMALDEHYDE	N-NITROSO-N-METHYLUREA	M-XYLENE
GLYCOL ETHERS	N-NITROSODIMETHYLAMINE	O-XYLENE
HEPTACHLOR	N-NITROSOMORPHOLINE	P-XYLENE
HEXACHLOROETHYLENE	PARATHION	XYLENES (MIXED ISOMERS)
HEXACHLOROBUTADIENE	PENTACHLORONITROBENZENE (QUINTOBENZENE)	
HEXACHLOROCYCLOPENTADIENE	PENTACHLOROPHENOL	
HEXACHLOROETHANE	PHENOL	
HEXAMETHYLENE-1,6-DIISOCYANATE	P-PHENYLENEDIAMINE	
HEXAMETHYLPHOSPHORAMIDE	PHOSGENE	
HEXANE	PHOSPHINE	
HYDRAZINE	PHOSPHOROUS	
HYDROCHLORIC ACID	PHTHALIC ANHYDRIDE	
HYDROGEN FLUORIDE (HYDROFLUORIC ACID)	POLYCHLORINATED BIPHENYLS (AROCLORS)	
HYDROQUINONE	POLYCYCLIC ORGANIC MATTER	
ISOPHORONE	1,3-PROPANE SULTONE	
LEAD (PM ₁₀)	BETA-PROPIOLACTONE	
LEAD (PM _{2.5})	PROPIONALDEHYDE	
LEAD (TSP)	PROPOXUR (BAYGON)	
LINDANE (ALL ISOMERS)	PROPYLENE DICHLORIDE (1,2-DICHLOROPROPANE)	
MALEIC ANHYDRIDE	PROPYLENE OXIDE	
MANGANESE (PM ₁₀)	1,2-PROPYLENIMINE (2-METHYLAZIRIDINE)	
MANGANESE (PM _{2.5})		
MANGANESE (TSP)		
MERCURY (PM ₁₀)		

TSP-the measurement of level of that specific pollutant in total suspended particulates.
ACHD-Allegheny County Health Department

ACHD Regulated Pollutants

ANTIMONY COMPOUNDS (ACHD)
ARSENIC COMPOUNDS (INORGANIC INCLUDING ARSINE) (ACHD)
BERYLLIUM COMPOUNDS (ACHD)
CADMIUM COMPOUNDS (ACHD)
CHROMIUM COMPOUNDS (ACHD)
COBALT COMPOUNDS (ACHD)
COKE OVEN EMISSIONS (ACHD)
CYANIDE COMPOUNDS (ACHD)
GLYCOL ETHERS (ACHD)
LEAD COMPOUNDS (ACHD)
MANGANESE COMPOUNDS (ACHD)
MERCURY COMPOUNDS (ACHD)
FINE MINERAL FIBERS (ACHD)
NICKEL COMPOUNDS (ACHD)
POLYCYCLIC ORGANIC MATTER (ACHD)
RADIONUCLIDES (INCLUDING RADON) (ACHD)
SELENIUM COMPOUNDS (ACHD)

GLOSSARY

AMBIENT AIR—Air found in the outdoors to which the general population is exposed

AREA STATIONARY SOURCE—A stationary source of hazardous air pollutants (HAPs) that releases less than 10 tons per year (TPY) of any single HAP or less than 25 TPY of a HAPs mixture

AROMATICS—Organic compounds with one or more planar ring systems of six carbon atoms. Benzene and toluene are typical examples. In contrast to aliphatics, which are linear carbon chains containing discrete single, double, or triple bonds

BEST ACHIEVABLE CONTROL TECHNOLOGY (BACT)—A pollution control standard that applies, for any specific emission source, the currently available technology producing the greatest reduction of air pollutant emissions, taking into account energy, environmental, economic, and other costs

CARCINOGEN—A cancer-causing chemical

HAZARD INDEX (HI)—A term frequently used to characterize the cumulative noncancer risk of mixtures of chemicals that adversely affect the same target organ. HI is calculated as the sum of the individual HQs for each chemical. HIs greater than one imply a significant risk toxicity.

HAZARD QUOTIENT (HQ)—An index of toxicity given by the ratio of the ambient concentration (C) of the specific HAP to its reference concentration (RFC; i.e., $HQ = C/RFC$). If HQ is less than one, then the ambient concentration of the HAP exceeds the RFC and risk of toxicity exists. The greater the number of above one, the greater the risk presented. If HQ is calculated as less than one, then one can assume that little risk is posed under those conditions of exposure.

HAZARDOUS AIR POLLUTANTS (HAPS)

Also known as air toxics, these 189 air pollutants are known or suspected to cause cancer or other serious health effects and have a propensity to reach significant concentrations in the air we breathe. EPA is charged with regulating the emission of these chemicals to the end of protecting human health.

HYDROCARBONS—Simplest organic compounds, containing only carbon and hydrogen. Hydrocarbons can be gases, liquids, waxes, low-melting solids, or polymers. Their main use is as a combustible fuel source.

LEUKEMIA—A type of cancer that affects the white blood cells and originates in the bone marrow

LIFETIME CANCER RISK—The probability (expressed as number per million people) of developing cancer when exposed to a specific concentration of a chemical in the air continuously over a projected lifetime of 70 years

LIFETIME INCIDENCE RATE (LIR)—Lifetime cancer incidence per million people, calculated by multiplying the ambient concentration of a chemical by a chemical-specific value of its carcinogenic potency (unit risk estimate)

MAJOR POINT SOURCE—A facility that emits either 10 tons per year (TPY) or more of a single HAP compound, or 25 TPY or more of an aggregate mixture of hazardous air pollutants

MAXIMUM ACHIEVABLE CONTROL TECHNOLOGY (MACT)

—The emission standard for sources of air pollution requiring the maximum reduction of hazardous emissions, taking cost and feasibility into account. Under the Clean Air Act Amendments of 1990, MACT must not be less than the average emission level achieved by controls on the best performing 12 percent of existing sources, by category, of industrial and utility sources.

NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)—The Clean Air Act, last amended in 1990, requires EPA to set NAAQS for pollutants considered harmful to public health and the environment. The six common NAAQS air pollutants, or “criteria pollutants,” are ozone, fine particulates, nitrogen dioxide, sulfur dioxide, carbon monoxide, and lead. These standards indicate specific concentrations of these pollutants that cannot be exceeded in ambient air.

NATIONAL AIR TOXICS ASSESSMENT (NATA)

A periodic screening assessment conducted by EPA that estimates cancer and noncancer risk posed by specific hazardous air pollutants throughout the United States

NATIONAL EMISSIONS STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHAP)

Emission standards set by EPA for an air pollutant not covered by NAAQS that may cause death or serious, irreversible, or incapacitating illness. As authorized under the Clean Air Act, the standards require application of the maximal achievable control technology to control emissions.

PITTSBURGH REGIONAL ENVIRONMENTAL THREATS ANALYSIS (PRETA)

—Environmental assessment project developed by the Center for Healthy Environments and Communities in the Department of Environmental and Occupational Health at the University of Pittsburgh Graduate School of Public Health, with generous support from The Heinz Endowments. The 10-county region in which this project was conducted includes the following counties in Southwestern Pennsylvania: Allegheny, Armstrong, Beaver, Butler, Fayette, Greene, Lawrence, Indiana, Washington, and Westmoreland.

POSITIVE MATRIX FACTORIZATION

A computational process used to assign risk to specific source types based on knowledge of multichemical profiles typically emitted by those industries

REFERENCE CONCENTRATION (RFC)

—Characterization of the potency of a chemical to produce non-cancer effects using a defined chemical-specific value arrived at by analyzing the available scientific data compiled for each chemical. The RFC serves as the best estimate of the threshold concentration above which human health effects are expected to be observed.

SECONDARY POLLUTANTS—Toxins formed in the atmosphere by chemical reactions that occur with other chemicals that are released as primary pollutants

TONS PER YEAR (TPY)—A measure of pollutant release in terms of tons per year

TOXICITY—Degree to which a substance can cause damage to an organism

TOXIC RELEASE INVENTORY (TRI)—A compilation of amounts of hazardous air pollutants emitted by major point sources (as well as other industries that release ground and water pollutants), which companies are required by law to report to EPA annually

UNIT RISK ESTIMATE (URE)—the upper-bound excess lifetime cancer risk (expressed as cases per million in the population) estimated to result from continuous exposure to an agent at a concentration of $1 \mu\text{g}/\text{m}^3$ in air over a projected lifetime of 70 years

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)—Federal agency whose mission is to protect human health and the environment

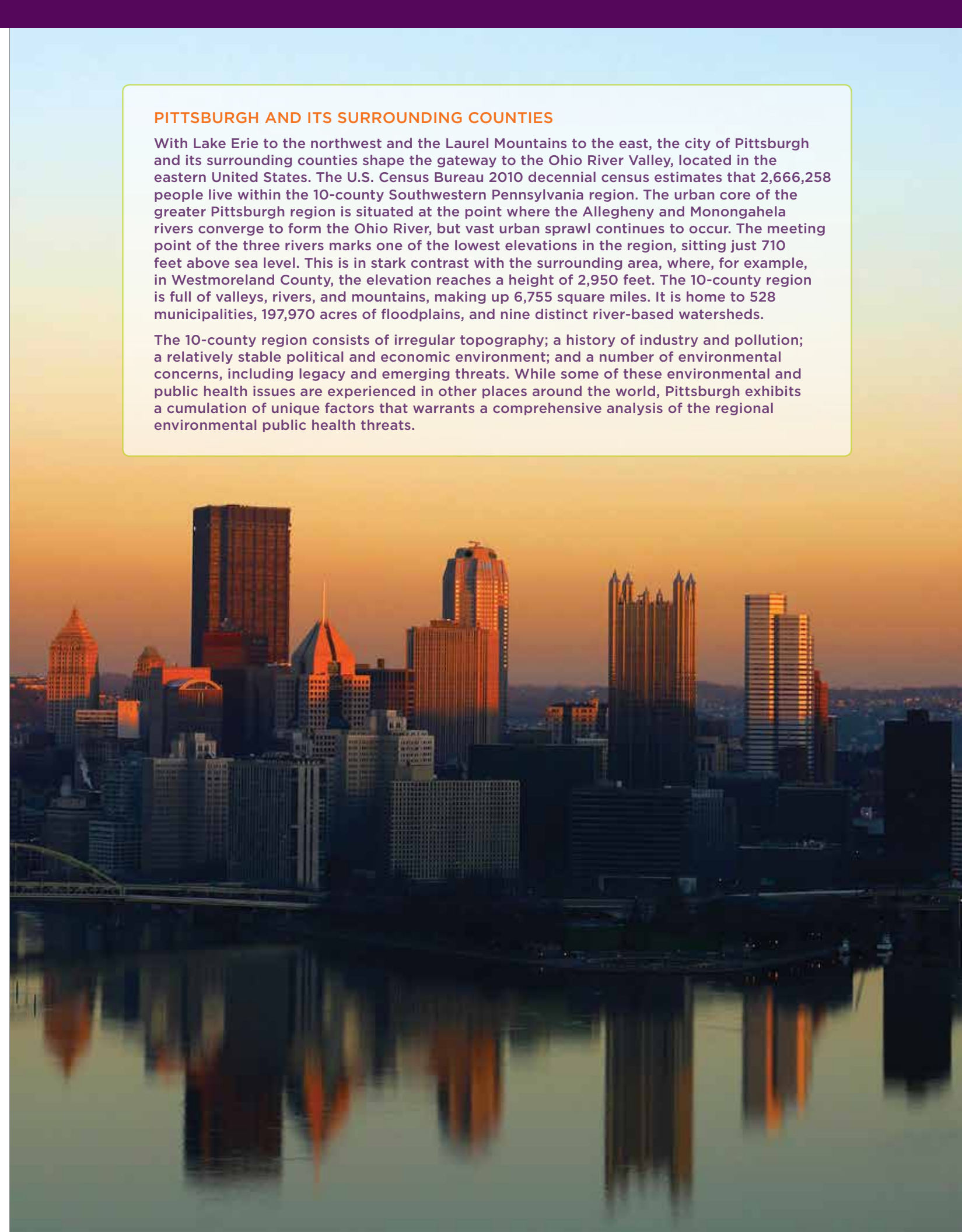
VOLATILE ORGANIC COMPOUND (VOC)

Chemical or compound that contains such vapor pressure that it does not require excessive heat to vaporize the compound into a gaseous form

PITTSBURGH AND ITS SURROUNDING COUNTIES

With Lake Erie to the northwest and the Laurel Mountains to the east, the city of Pittsburgh and its surrounding counties shape the gateway to the Ohio River Valley, located in the eastern United States. The U.S. Census Bureau 2010 decennial census estimates that 2,666,258 people live within the 10-county Southwestern Pennsylvania region. The urban core of the greater Pittsburgh region is situated at the point where the Allegheny and Monongahela rivers converge to form the Ohio River, but vast urban sprawl continues to occur. The meeting point of the three rivers marks one of the lowest elevations in the region, sitting just 710 feet above sea level. This is in stark contrast with the surrounding area, where, for example, in Westmoreland County, the elevation reaches a height of 2,950 feet. The 10-county region is full of valleys, rivers, and mountains, making up 6,755 square miles. It is home to 528 municipalities, 197,970 acres of floodplains, and nine distinct river-based watersheds.

The 10-county region consists of irregular topography; a history of industry and pollution; a relatively stable political and economic environment; and a number of environmental concerns, including legacy and emerging threats. While some of these environmental and public health issues are experienced in other places around the world, Pittsburgh exhibits a cumulation of unique factors that warrants a comprehensive analysis of the regional environmental public health threats.





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