

Chapter 4 Air Toxics: Chemicals, Sources, and Emissions Inventories

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4.1 Introduction

This chapter identifies the set of chemicals broadly, and most commonly, considered “air toxics.” This section also describes the general categories of air toxics sources that emit these chemicals as well as the primary places where air toxics emissions information (e.g., databases that contain information on the location and nature of emissions released from various types of sources) used in air toxics risk assessments can be found. Section 4.2 discusses air toxics; Section 4.3 describes air toxics sources; and Section 4.4 describes air toxics emissions data sources.

The exhaustive lists of air toxics discussed in this section do not include all of the hazardous chemicals of public health concern. Note also that other forms of air pollution (e.g., odors) are not addressed in this Reference Library.

4.2 Air Toxics

Chapter 2 of this Volume introduced Hazardous Air Pollutants (HAPs), criteria air pollutants, Toxic Release Inventory (TRI) chemicals, and persistent, bioaccumulative, and toxic (PBT) chemicals and discussed the relationships among these various groupings. This section will revisit each of these groups to provide more detailed information related to the chemicals on each of those lists. A thorough understanding of the different types of chemicals that may be of interest for an assessment, as well as the nuances of the various ways chemicals are written into those lists, will be important for the risk assessment team to comprehend before the assessment begins in earnest.

The term “air toxics” is a generic term that could conceivably encompass literally anything in the air that poses harm to people or the environment. This Volume uses the term “air toxics” in this general sense. Thus, while the focus of most air toxics risk assessments will be on the 188 chemicals and chemical compounds listed as HAPs in the Clean Air Act (CAA) section 112(b), some assessment teams may wish to have a broader focus. The use of the term “air toxics” in this general sense is meant to provide for this flexibility. Ultimately, the scope of any assessment must clearly identify the chemicals that will be evaluated and the reason for their inclusion or exclusion in the evaluation.

4.2.1 Introduction to Air Toxics Chemical Lists

The various lists that are the focus of this volume were all derived directly from the Clean Air Act, the Emergency Planning and Community Right to Know Act, or a specific EPA initiative (e.g., the PBT initiative list of chemicals). It is important to understand that there is not always consistency among these various lists in either the naming of chemicals or the meaning of the names. For example, as noted in Chapter 2, “glycol ethers” are defined differently for the TRI and as HAPs (see box in Section 2.4.4).

Lists of toxic chemicals commonly provide the chemical identity by both a name and a unique identifying number, called a **Chemical Abstracts Registry Number**.^(a) However, most

^aCAS (Chemical Abstracts Service) is a division of the American Chemical Society. A CAS Registry Number (CAS number or CASRN) is assigned in sequential order to unique, new substances identified by CAS scientists for inclusion in the CAS REGISTRY database. Each CAS Registry Number is a unique numeric identifier; designates only one substance; and has no chemical significance. A CAS Registry Number is a numeric

chemicals have multiple synonyms (sometimes dozens). Fortunately, every unique chemical has only one unique CAS number and one can always refer to this unique number to identify the compound in question. For example, toluene and methylbenzene are synonyms for the same compound (which is normally referred to as toluene). However, there is only one CAS number for the compound: 108-88-3. No matter where one is in the world or what name is attached to a chemical, there is unanimity of identity through the CAS numbering system.

When there is any question about what a particular chemical name means, it is always advisable to try to pinpoint the identity through use of the CAS number. For example, a risk assessment team may ask for air sampling analysis for the HAP acetaldehyde (CAS number 75-07-0); however, when they receive the analytical lab report, acetaldehyde is not reported. A quick scan of the CAS numbers reported by the lab lists the CAS number 75-07-0 next to the name “ethanal.” Ethanal is a synonym for acetaldehyde and, hence, has the same CAS number. EPA’s *Handbook for Air Toxics Emission Inventory Development* includes a list (Appendix C) of synonyms and CAS numbers for HAPs that is helpful in overcoming the nomenclature obstacle.⁽¹⁾ (Note, however, that there are nuances even beyond this simplistic description. For example, some chemicals have one CAS number for their pure form and a different CAS number for a technical grade. A knowledgeable chemist can usually identify and clarify these issues.)

Some of the entries on chemical lists are for large groups of compounds and not just one single substance. For example, one of the HAPs is listed in the CAA as “polychlorinated biphenyls (aroclor)s” and is most commonly referred to as PCBs. This listing is not for one single substance but, rather, for any one or a mixture of any of the 209 possible chemicals that are themselves PCBs. As another example, the pesticide “2,4-D” is written into the list of HAPs as “2,4-D (salts and esters).” This listing includes any possible salt of 2,4-D and any possible ester of 2,4-D. In our earlier lead example, the lead compound listing includes any compound known to exist in or be emitted to the environment that contains a lead molecule as part of the compound’s molecular structure (a potentially huge number of possibilities). Another important group of chemicals is called “POM” for polycyclic organic matter. This includes organic compounds with more than one benzene ring, and which have a boiling point greater than or equal to 100° C (e.g., polycyclic aromatic hydrocarbons (PAHs) such as benzo(a)pyrene).

In reality, most risk assessments will deal with a relatively small number of chemicals because either the sources in a given place are releasing only a limited number of chemicals or the ability to model or monitor the numerous chemicals present is limited by the available inventories or monitoring/analytical methods, respectively.

In the initial stages of the assessment, risk assessors often sort the chemicals of interest into groups that, generally, have similar physical and/or chemical properties. This is a helpful thing to do as a way of making some educated guesses about how chemicals are likely to behave in the environment. The groupings also help an assessment team to plan for the types of sampling and analysis methods that will be needed, because the sampling and analytical methods tend to be broken out along these same lines. In general, all air toxics can be broadly categorized into three main groups, organic chemicals, inorganic chemicals, and organometallic compounds as follows:

identifier that can contain up to nine digits, sometimes divided by hyphens into three parts. See <http://www.cas.org/faq.html> for more information.

Organic Chemicals

Organic chemical compounds are composed of carbon in combination with other elements such as hydrogen, oxygen, nitrogen, phosphorous, chlorine, and sulfur (not including carbonic acid or ammonium carbonate). Organic compounds can generally be split into two different groups, based on their propensity to evaporate. The following such groupings are commonly employed by analytical chemistry laboratories for purposes of sample analysis.

- **Volatile Organic Compounds (VOCs).** These are organic chemicals that have a high vapor pressure and tend to have low water solubility.^(b) Simply put, VOCs have a high propensity to evaporate and remain airborne. Many VOCs are human-made chemicals that are used and produced in the manufacture of paints, pharmaceuticals, and refrigerants, as industrial solvents, such as trichloroethylene, or produced as by-products, such as chloroform produced by chlorination in water treatment. VOCs are often also components of petroleum fuels (e.g., benzene), hydraulic fluids, paint thinners, and dry cleaning agents.^(c)

A subgroup of VOCs is termed **Carbonyl Compounds** and includes chemicals such as formaldehyde and acetaldehyde. While such chemicals are themselves VOCs due to their high vapor pressure, they are often grouped as a separate class from the VOCs because of the special sampling and analytical methods necessary to measure them in air.

- **Semivolatile Organic Compounds (SVOCs).** SVOCs are organic chemicals that have a lower vapor pressure than VOCs and, thus, have a lower propensity to evaporate from the liquid or solid form. Once airborne, they also tend to more readily condense out of the gas phase. Examples of SVOCs include most organic pesticides (e.g., chlordane), and certain components of petroleum, such as polycyclic aromatic hydrocarbons. Note that the demarcation between SVOCs and VOCs is not exact. For example, the two separate air sampling and analytical methods for VOCs and SVOCs will both usually detect naphthalene when present, indicating that this chemical is on the lower end of the VOC scale of volatility and on the higher end of the SVOC scale of volatility. In general, as chemicals increase in molecular weight and/or polarity, they become more SVOC-like.

Inorganic Chemicals

This group includes all substances that do not contain carbon and includes a wide array of substances such as:

- Metals (e.g., mercury, lead, and cadmium) and their various salts (e.g., mercury chloride);
- Halogens (e.g, chlorine and bromine);
- Inorganic bases (e.g., ammonia); and
- Inorganic acids (e.g., hydrogen chloride, sulfuric acid).

^bThe regulatory definition of VOC does not identify vapor pressure as a consideration. See 40 CFR 51.100(s).

^c“VOC” refers to volatile organic compounds that contribute to ozone formation as defined by 40 CFR 50.100(s) as ozone precursors. VOC is a subset of VOCs. VOC emissions inventory information is sometimes used to derive estimates for specific chemicals; when this is done, the VOC number is said to have been speciated.

Organometallic Compounds

This group is comprised of compounds that are both organic and metallic in nature. The alkyl lead compounds that were added to gasoline to enhance its properties can be used for illustration. “Alkyl” refers to the organic portion of a compound which is attached to the inorganic metal lead. The result is a so-called “organometallic” material, a hybrid of both metallic and organic. (Note that salts, such as sodium benzoate, are usually classified as an organic chemical, rather than an organometallic compound.)

An understanding of the general characteristics of organic chemicals, inorganic chemicals and organometallic compounds will aid in planning a risk assessment and developing an appropriate analysis strategy. For example, most VOCs tend to remain airborne and also do not tend to bioaccumulate to the same extent as some of the non-volatile chemicals. Thus, if an assessment were being planned to evaluate the impact of a source from which only VOCs were released, it becomes less likely that a multipathway risk analysis will be necessary (since VOCs do not tend to migrate into soil or water and do not tend to bioaccumulate as strongly in living tissue).

In addition, the sampling and analytical methods available to test for chemicals in environmental media are generally broken out along the same chemical groupings noted above. Thus, if one were interested in testing for airborne chlordane (an SVOC), a VOC monitoring method would not be used. Detailed information on available monitoring methods and the chemicals for which they have been validated is provided in Chapter 10.

In air toxics studies, both individual substances and mixtures of substances are of interest. Particulate matter (PM), for example, is almost never comprised of just one substance; instead, PM is usually made up of numerous individual substances (sometimes in the hundreds). Both the physical and chemical nature of a mixture will influence the fate and transport of the chemicals in the environment as well as the potential for the mixture to cause harm. For example, a toxic chemical adsorbed onto the surface of a relatively large particle (> 10 microns in diameter) will usually be trapped in the upper portion of the respiratory system and either coughed/sneezed out of the body or swallowed. The same chemical adsorbed onto a very small particle (< 2.5 microns in diameter) has a much higher likelihood of being inhaled into the deep lung. As we will see in later chapters, both the route of exposure (in this example, ingestion or inhalation) as well as the toxic properties of the chemical in question are important determinants of potential harm.

4.2.2 Hazardous Air Pollutants (HAPs)

The HAPs are a group of 188 specific chemicals and chemical compounds and are identified in Section 112(b) of the CAA. The Agency provides additional information on the HAPs online.⁽²⁾ HAPs are pollutants known to cause or suspected of causing cancer or other serious human health effects or ecosystem damage. They include individual organic and inorganic compounds and pollutant groups closely related by chemical structure (e.g., arsenic compounds, cyanide compounds, glycol ethers, polycyclic organic matter) or emission sources (e.g., coke oven emissions). EPA may add or remove pollutants from the HAP list as new information becomes available. A full list of the HAPs is provided in Appendix A.

When people talk about “air toxics risk assessment,” they generally mean assessments of risks associated with one or more of the HAPs. This is largely because of the CAA listing of 188

HAPs and its requirement under Section 112(f)(2) (Residual Risk) that EPA assess the risks associated with HAPs that remain after the application of the Maximum Achievable Control Technology (MACT) standards (Section 112(d) of the Act). However, given that this is a relatively short list of chemicals, many communities may want to go beyond this list when assessing risk. It is for this reason, that assessors and other stakeholders must clearly identify why they are conducting an “air toxics” risk assessment and what they want to include in that assessment.

In its Integrated Urban Air Toxics Strategy, EPA identified a subset of 33 HAPs as those posing the greatest risk in urban areas (see Section 2.2.1). These 33 HAPs were selected based on a number of factors, including toxicity-weighted emissions, monitoring data, past air quality modeling analysis, and a review of existing risk assessment literature.

The national-scale assessment for 1996 (see Section 2.3.2) focused on 32 of these 33 Urban HAPs (dioxin was omitted) and also includes diesel particulate matter, which is used as a surrogate measure of diesel exhaust. EPA recently concluded that diesel exhaust is likely to be carcinogenic to humans by inhalation at environmental levels of exposure. Diesel exhaust is addressed in several regulatory actions and diesel particulate matter plus diesel organic gases are listed by EPA as a mobile source air toxic (see Section 4.3.3 below).

4.2.3 Criteria Air Pollutants

The “criteria air pollutants” are six substances regulated pursuant to Title I of the CAA, for which “criteria documents” are developed by the Agency prior to national standard setting decisions. There are already national ambient air quality standards (NAAQS) in place for each of these pollutants as well as established regulatory programs and activities in place to meet those standards. However, they are discussed here because there is some crossover between the realm of HAPs and criteria pollutants. The more important crossover issues are discussed below.

- **Particulate matter.** NAAQS have been established for particles with an aerodynamic diameter less than or equal to 10 microns (called PM₁₀) and particulate matter with an aerodynamic diameter less than or equal to 2.5 microns (called PM_{2.5}). As noted above, however, PM can be made up of as little as one or a few, or many hundreds of individual chemicals. In many cases (and depending on the source of the PM), any number of specifically listed HAPs may be a part of the PM mix. It is for this reason that risk assessors may opt to evaluate the composition of PM and to include the identified chemicals in risk calculations.

For example, it is possible to collect samples of PM₁₀ for purposes of determining the types and amounts of individual substances contained in the particles. The risks posed by those individual chemicals may then be estimated for the inhalation route of exposure. Because particles with diameters greater than 10 microns are not generally respirable, analysts usually select a PM₁₀ monitor to capture samples for risk assessment purposes rather than a total suspended particulate (TSP) sampler, because TSP would capture larger particles that do not penetrate very far into the respiratory tract (thus leading to an overestimate in inhalation risk associated with the specific pollutants studied). Note that this would not be true for particle-bound chemicals that exert their toxic effects on the nasal passages.

- **Ozone and other criteria pollutants.** Certain other criteria pollutants are not specifically listed as HAPs, but HAPs may lead to their formation or they may lead to HAP formation. For example, ozone is produced by the interaction of certain VOCs, oxides of nitrogen (called NO_x), and sunlight. As noted previously, many of the HAPs are VOCs and may play a role in ozone formation. In contrast, sulfur dioxide is a criteria pollutant that can be transformed in the environment into sulfuric acid which, in turn, may become part of a listed HAP (e.g., cadmium sulfate). In general, the criteria pollutants ozone, nitrogen dioxide, sulfur dioxide, carbon monoxide are not usually considered in air toxics risk assessments.

4.2.4 Toxics Release Inventory (TRI) Chemicals

Data on TRI chemicals are reported pursuant to Section 313 of the Emergency Planning and Community Right-To-Know Act (EPCRA) of 1986 and Section 6607 of the Pollution Prevention Act of 1990 (PPA). EPCRA and the PPA are intended to inform communities and citizens about chemical hazards in their areas. EPA and states are required to collect data annually on releases (to each environmental medium) and waste management methods (e.g., recycling) of certain toxic chemicals from industrial facilities, and to make the data available to the public in the TRI.⁽³⁾ EPCRA Section 313(d) permits EPA to list or delist chemicals based on certain criteria. In a 1994 rulemaking, EPA added 286 chemical categories to the TRI chemical list. The TRI chemicals are listed in 40 CFR Section 372.65, and information about the 667 currently-listed TRI chemicals is provided online.⁽⁴⁾

The current TRI chemical list contains 582 individually listed chemicals and 30 chemical categories (including three delimited categories containing 58 chemicals), for a total of 612 separate chemicals. If the members of the three delimited categories are counted as separate chemicals then the total number of chemicals and chemical categories is 667 (i.e., 582 + 27 + 58). The TRI list of toxic chemicals includes most (180) of the HAPs. Similar to the HAPs, the TRI chemicals include VOCs, SVOCs, inorganic compounds, and organometallic compounds.

The utility of the TRI for air toxics risk assessment is two fold. First, it provides a broader perspective of industrial emissions than the HAP list because it includes information on air releases of many hundreds of additional chemicals. Second, accessing TRI information is extremely quick and easy. Using the TRI Explorer search engine (<http://www.epa.gov/tri/tridata/index.htm>), one may quickly identify the location of emissions sources and the identity and quantity of chemicals released to the air. The data is also updated annually (as opposed to the National Emissions Inventory (NEI), a nationwide inventory of emissions developed by EPA, which is only updated triennially). However, other characteristics of the TRI data may limit their use for risk assessments (see Section 4.4.2).

4.2.5 Toxic Chemicals That Persist and Which Also May Bioaccumulate

Some toxic compounds have the ability to persist in the environment for long periods of time and may also have the ability to build up in the food chain to levels that are harmful to human health and the environment. For example, releases of metals from a source may deposit out of the air onto the ground where they remain in surface soils for long periods of time. Children playing in the area may ingest this contaminated dirt through hand-to-mouth behaviors. The chemicals in the dirt may also be taken up into plants through the roots and accumulate in foraging animals.

EPA's challenge in reducing risks from this category of toxic air pollutants stems from this ability to transfer from air, to sediments, water, land, and food; to linger for long periods of time in the environment; and for some substances, their ability to travel long distances. Many of these chemicals (e.g., DDT) have been banned for use in the U.S. As such, there should be no active air emissions of these chemicals (although releases into the air are still possible, e.g., by resuspension of previously contaminated soil). However some, such as mercury, are still in use today. A number of lists of these persistent and bioaccumulative chemicals have been developed through international and internal EPA efforts (see Exhibit 4-1). A number of the HAPs appear on one or more of these lists.

Exposure to persistent and bioaccumulative air toxics through a pathway other than inhalation of contaminated air is termed **an indirect exposure pathway** because contact with the chemical occurs in a medium that is not the original medium to which the chemical was released (i.e., air). In contrast, a **direct exposure pathway** is one in which contact occurs with the chemical in the medium to which it was originally released. When exposure of a person to a chemical (or chemicals) occurs through more than one pathway, a **multipathway analysis** may be considered.

In air toxics risk assessment, the inhalation pathway is commonly assessed (i.e., the release of a chemical to air and human exposure through breathing that air). However, indirect exposure pathways are usually assessed for a limited set of chemicals released to the air. EPA has identified a preliminary set of HAPs for which indirect exposure pathway analyses should generally be conducted for situations involving significant emissions of these chemicals in a study area. This new list of chemicals is termed **Persistent Bioaccumulative HAP Compounds (PB-HAP Compounds)** (Exhibit 4-2); however, all of the PB-HAP compounds occur on one or more of EPA's existing lists of PBT chemicals. The designation "PB-HAP" was developed to distinguish this list from the existing lists of PBT chemicals (Exhibit 4-1) and specifically to clarify that chemicals on this new list are:

- HAPs;
- Relatively persistent in the environment; and
- For some chemicals, have a strong propensity to bioaccumulate and/or biomagnify.^(d)

This preliminary list of PB-HAPs was derived primarily on the basis of human health concerns. It does not consider direct contact by plants or inhalation by animals. Additional HAPs may be identified as EPA gains more familiarity with ecological risk assessments for air toxics. Appendix D describes the process by which EPA identified the list of PB-HAPs.

^dBiomagnification is the process whereby certain substances transfer up the food chain and increase in concentration. Chemicals that biomagnify tend to accumulate to higher concentration levels with each successive food chain level. Biomagnification is a particular concern for ecological risk assessment.

Exhibit 4-1. "Lists" of Toxic Chemicals that Persist and Which Also May Bioaccumulate

LRTAP chemicals – The United States signed protocols on Persistent Organic Pollutants (POPs) and heavy metals pursuant to the Convention on Long-Range Transboundary Air Pollution (LRTAP) in June 1998 at a ministerial meeting in Aarhus, Denmark. Sixteen POPs and three metals are regulated (<http://www.epa.gov/oppfead1/international/lrtap2pg.htm>):

- aldrin
- cadmium
- chlordane
- dieldrin
- endrin
- hexabromobiphenyl
- kepone (chlordecone)
- mirex
- toxaphene
- hexachlorobenzene
- heptachlor
- lead
- mercury
- polychlorinated biphenyls (PCBs)
- dichlorodiphenyltrichloroethane (DDT)
- lindanedioxins (polychlorinated dibenzo-p-dioxins)
- furans (polychlorinated dibenzofurans)
- hexachlorobenzene
- polycyclic aromatic hydrocarbons

PBT Chemicals – EPA has identified the following priority persistent, bioaccumulative, and toxic (PBT) chemicals and has developed the PBT program to address the cross-media issues associated with these chemicals (<http://www.epa.gov/opptintr/pbt/>):

- aldrin/dieldrin
- mercury and its compounds
- benzo(a)pyrene
- mirex
- chlordane
- octachlorostyrene
- DDT
- dichlorodiphenyldichloroethane (DDD)
- dichlorodiphenyldichloroethylene (DDE)
- PCBs
- hexachlorobenzene
- dioxins and furans
- alkyl-lead
- toxaphene

Great Lakes Priority Substances. In keeping with the obligations of the Great Lakes Water Quality Agreement, Canada and the United States on April 7, 1997, signed the "Great Lakes Binational Toxics Strategy: Canada-United States Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes" (<http://www.epa.gov/glnpo/p2/bns.html>). This Strategy seeks percentage reductions in targeted persistent toxic substances so as to protect and ensure the health and integrity of the Great Lakes ecosystem. The list of "Level 1" substances is identical to EPA's priority PBT pollutants.

Great Waters Pollutants of Concern. The 1990 Clean Air Act Amendments established research and reporting requirements related to the deposition of hazardous air pollutants to the Great Lakes, Lake Champlain, Chesapeake Bay, and certain other "Great Waters." The Program has identified the following pollutants of concern (<http://www.epa.gov/airprog/oar/oaqps/gr8water/index.html>):

- cadmium and cadmium compounds
- chlordane
- DDT/DDE
- dieldrin
- hexachlorobenzene
- α -hexachlorocyclohexane
- lindane (γ -hexachlorocyclohexane)
- lead and lead compounds
- mercury and mercury compounds
- PCBs
- polycyclic organic matter
- tetrachlorodibenzo-p-dioxin (dioxins)
- tetrachlorodibenzofuran (furans)
- toxaphene
- nitrogen compounds

Exhibit 4-1 (continued)

TRI PBT chemicals. EPA has published two final rules that lowered the Toxics Release Inventory (TRI) reporting thresholds for certain persistent bioaccumulative and toxic (PBT) chemicals and added certain other PBT chemicals to the TRI list of toxic chemicals (<http://www.epa.gov/tri/lawsandregs/pbt/pbtrule.htm>). The following PBT chemicals are subject to reporting at lowered thresholds:

- dioxin and dioxin-like compounds
- lead compounds
- mercury compounds
- polycyclic aromatic compounds
- aldrin
- benzo(g,h,i)perylene
- chlordane
- heptachlor
- hexachlorobenzene
- isodrin
- lead
- mercury
- methoxychlor
- octachlorostyrene
- pendimethalin
- pentachlorobenzene
- PCBs
- tetrabromobisphenol A
- toxaphene
- trifluralin

Waste Minimization Priority Chemicals. EPA's National Waste Minimization Partnership Program focuses on reducing or eliminating the generation of hazardous waste containing any of 30 Waste Minimization Priority Chemicals (WMPCs). This list replaces the list of 53 chemicals EPA identified in 1998 (*Notice of Availability: Draft RCRA Waste Minimization Persistent, Bioaccumulative and Toxic (PBT) Chemical List*, Federal Register 63(216): 60332-60343, November 9, 1998). Twenty six of the chemicals in the current list were also in the draft list published in 1998. The remaining four chemicals on the current list were added in response to comments and new information EPA received from the public regarding the Agency's methodology for selecting the 53 chemicals in the draft list (<http://www.epa.gov/epaoswer/hazwaste/minimize/chemlist.htm>).

- 1,2,4-trichlorobenzene
- 1,2,4,5-tetrachlorobenzene
- 2,4,5-trichlorophenol
- 4-bromophenyl phenyl ether
- acenaphthene
- acenaphthylene
- anthracene
- benzo(g,h,i)perylene
- dibenzofuran
- dioxins/furans
- endosulfan, alpha and endosulfan, beta
- fluorene
- heptachlor and heptachlor epoxide
- hexachlorobenzene
- hexachlorobutadiene
- hexachlorocyclohexane, gamma-
- hexachloroethane
- methoxychlor
- naphthalene
- PAH group (as defined in TRI)
- pendimethalin
- pentachlorobenzene
- pentachloronitrobenzene
- pentachlorophenol
- phenanthrene
- pyrene
- trifluralin
- cadmium and cadmium compounds
- lead and lead compounds
- mercury and mercury compounds

Exhibit 4-2. PB-HAP Compounds			
PB-HAP Compound	Pollution Prevention Priority PBTs	Great Waters Pollutants of Concern	TRI PBT Chemicals
Cadmium compounds		X	
Chlordane	X	X	X
Chlorinated dibenzodioxins and furans	X ^(a)	X	X ^(b)
DDE	X	X	
Heptachlor			X
Hexachlorobenzene	X	X	X
Hexachlorocyclohexane (all isomers)		X	
Lead compounds	X ^(c)	X	X
Mercury compounds	X	X	X
Methoxychlor			X
Polychlorinated biphenyls	X	X	X
Polycyclic organic matter	X ^(d)	X	X ^(e)
Toxaphene	X	X	X
Trifluralin			X
<p>^(a) "Dioxins and furans" (" " denotes the phraseology of the source list)</p> <p>^(b) "Dioxin and dioxin-like compounds"</p> <p>^(c) Alkyl lead</p> <p>^(d) Benzo[a]pyrene</p> <p>^(e) "Polycyclic aromatic compounds" and benzo[g,h,i]perylene</p>			

4.2.6 Other Chemicals

The chemicals included in the various lists of air toxics described above – HAPs, criteria pollutants, TRI chemicals, and toxic chemicals that persist and which also may bioaccumulate – do *not* represent all of the chemicals potentially emitted to air in a given place. EPA is required to maintain an inventory, known as the “Toxic Substances Control Act (TSCA) Inventory,” of each chemical substance which may be legally manufactured, processed, or imported in the U.S. The TSCA inventory currently contains over 75,000 chemicals (see: “enforcement programs” at <http://www.epa.gov/compliance/civil/programs/tsc/>). At best, we have the capability to assess only a few hundred in detail. As noted previously, this does not imply that risk assessments are always missing important information. To the contrary, the actual number of chemicals used in significant amounts and released to air are relatively small compared to the number of chemicals known. Nevertheless, it is important to keep in mind that the ability to evaluate air toxics releases is limited by current technology, the lack of toxicity information for all but a relatively small number of chemicals and, in some cases, costs (e.g., a single sample for certain analytes such as dioxin can cost upwards of \$1,000 per sample, making multiple sampling events cost prohibitive).

The HPV Challenge Program

EPA, in partnership with industry and environmental groups, recently created a voluntary chemical testing effort, the high production volume (HPV) Challenge Program. This program was developed to make publicly available a complete set of baseline health and environmental effects data on HPV chemicals (those manufactured in, or imported into, the United States in amounts equal to or exceeding 1 million pounds per year). Information on HPV chemicals is available at <http://www.epa.gov/chemrtk/rtkfacts.htm>.

4.3 Sources of Air Toxics

Many anthropogenic and natural activities are sources of air pollutants. Examples of human activities that result in the release of air toxics include:

- Fuel combustion activities in power plants, factories, automobiles, and homes;
- Biomass burning and other agricultural activities;
- Use of consumer products, such as pesticides and cleaning agents;
- Commercial activities, such as dry cleaning; and
- Industrial activities, such as petroleum refining, chemical manufacture, and metal plating.

Sources of air toxics can be categorized in various ways – whether they occur indoors or out, whether they are stationary or mobile, by the amount of chemicals they release, or by other approaches. For the purposes of this discussion, air toxics have been placed into several major groupings that track EPA’s programs and emissions inventories. Note that some differences in terminology exist between the CAA and the NEI (Exhibit 4-3).

- Point sources;
- Nonpoint sources;
- On-road mobile sources;
- Nonroad mobile sources;
- Indoor sources;
- Natural sources; and
- Exempt sources.

The first four categories are groupings of emission sources of HAPs and criteria air pollutants in EPA's **National Emissions Inventory (NEI)**. The NEI is a nationwide inventory of emissions that has been developed by EPA with input from numerous state, local, and tribal (S/L/T) air agencies. The NEI is discussed in more detail as a source of quantitative emissions release data in Section 4.4.1 below. For detailed information on NEI, refer to EPA's main NEI web page.⁽⁵⁾ NEI summaries were posted in October 2003.

Exhibit 4-3. Terminology Related to Groupings of Source Types		
Source Type	How Defined in CAA	How Reported in NEI
Point source – Major	Point source – Major	Point source
Point source – Area	Point source – Area	Point source if location coordinates reported Area source if coordinates not reported
Nonpoint source	Nonpoint source	Area
Mobile source – On-road	Mobile source – On-road	Modeled
Mobile source – Nonroad	Mobile source – Nonroad	Modeled or estimated
Indoor	Not defined	Not reported
Natural	Not defined	Not reported
Exempt	Not defined	Not reported

4.3.1 Point Sources

Point sources of air toxics are stationary sources (i.e., sources that remain in one place) that can be located on a map. A large facility that houses an industrial process is an example of a point source – the facility and its emission release points (e.g., stacks, vents, fugitive emissions from valves) are stationary, and the emission rates of air toxics can be characterized, either through direct measurements, such as stack monitoring, or indirect methods, such as engineering estimates based on throughput, process information, and other data. The CAA divides point sources into two main categories primarily on the basis of annual emissions rates:

- **Major sources** are defined in Section 112(a)(1) as “any source or group of stationary sources located within a contiguous area and under common control that emits or has the potential to emit, considering controls, in the aggregate, 10 tons per year (tpy) or more of any hazardous air pollutant or 25 tpy or more of any combination of hazardous air pollutants.”
- **Area sources** are defined in Section 112(a)(2) as “any stationary source of hazardous air pollutants that is not a major source. For purposes of this section, the term ‘area source’ shall not include motor vehicles or nonroad vehicles subject to regulation under Title II.” Examples of area sources include dry cleaners, gas stations, chrome electroplaters, and print shops. Though emissions from individual area sources may be relatively insignificant in human health terms, collectively their emissions can be quite significant, particularly where large numbers of sources are located in heavily populated areas. Note that sources that are classified as “area sources” pursuant to the CAA may be reported in the NEI as “point sources” if they can be located on a map.

Many sources of HAPs are subject to **National Emission Standards for Hazardous Air Pollutants (NESHAPs)** pursuant to Section 112 of the CAA. This Section of the CAA directs EPA to issue regulations listing categories and subcategories (commonly referred to collectively as **source categories**) of major sources and area sources of HAPs and to develop standards for each listed category and subcategory.⁽⁶⁾ EPA periodically updates the list of source categories (see Appendix E).⁽⁷⁾

Physical Forms of Emissions	
<i>Gas</i>	Emissions that are distinguished from solid and liquid states
<i>Fume</i>	Tiny particles trapped in vapor in a gas stream
<i>Mist</i>	Liquid particles measuring 40 to 500 micrometers that are formed by condensation of vapor
<i>Particulate Matter (and Aerosols)</i>	Fine liquid or solid particles

Air pollutants can be found in all three physical phases: solid, liquid, or gaseous. The distinct chemical and physical attributes of each phase contribute to the pollutant's transport and fate. For example, as reported in the *Mercury Study Report to Congress*,⁽⁸⁾ elemental mercury vapor is not thought to be susceptible to any major process of direct deposition to the earth's surface due to its relatively high vapor pressure and low water solubility. Therefore, it is carried by the wind and subsequently dispersed throughout the atmosphere. However, divalent mercury, in either vapor or particulate phase, is thought to be subject to much faster atmospheric removal, and is expected to be deposited near its source. For further details on fate and transport analysis, see Chapter 8.

As noted in Chapter 2, EPA regulates stationary sources in a two-phase process. First, EPA issues technology-based MACT standards that require sources to meet specific emissions limits. The emission limits are typically expressed as maximum emission rates, or minimum percent emission reductions, for specific pollutants from specific processes. In the second phase, EPA applies a risk-based approach to assess how well MACT emissions limits reduce health and environmental risks. Based on these **residual risk assessments**, EPA may implement additional standards to address any significant remaining, or residual, health or environmental risks (see Chapter 2 for a more detailed discussion of the MACT and residual risk programs).

Area sources may be subject to either MACT or **Generally Available Control Technology (GACT)** standards. GACT standards are generally less stringent than MACT standards. Area sources subject to MACT standards include Commercial Sterilizers using Ethylene Oxide, Chromium Electroplaters and Anodizers, Halogenated Solvents Users, and Asbestos Processors.

4.3.2 Nonpoint Sources

The term nonpoint source refers to smaller and more diffuse sources within a relatively small geographic area. In the context of EPA's NEI, nonpoint sources of air toxics are stationary sources for which emissions estimates are provided as an aggregate amount of emissions for all similar sources within a specific local geographic area, such as counties or cities, rather than on a facility- or source-specific basis. Emission estimates for nonpoint sources are generated using "top-down" methods, when detailed information at the local level is lacking. Instead, the total emissions over a large geographic area (e.g., n tons in the northeastern states) are allocated to the

local level (e.g., x percent is assigned to locality 1, y percent is assigned to locality 2, and so on). Note that for the purposes of this discussion, the nonpoint source category includes only stationary sources and does *not* include mobile sources.

Source-specific information may be available for *some* (but not all) of the specific facilities within a certain nonpoint source type. Area sources may be reported as either point or nonpoint sources in the NEI. If a state or local agency reports an area source emission as a point source, then the NEI retains the area source emission as a point source. The NEI does not aggregate point area sources as nonpoint sources, and **EPA has taken steps to avoid “double-counting” of emissions in the point and nonpoint source inventories.**

To compile nonpoint estimates for a category, the EPA first estimates county level emissions for nonpoint source categories. Then EPA replaces nonpoint EPA generated estimates with state and local agency and tribal estimates. If a state or local agency or tribe includes point source estimates for an EPA generated nonpoint source category, EPA removes the nonpoint estimate that it had generated and the point source inventory contains the S/L/T estimate. For example, in the Denver area, the State of Colorado inventories dry cleaners and service stations as point sources. The NEI contains point sources estimates for these two categories in the six county area of Denver and the NEI does not contain nonpoint estimates for these two categories. Dry cleaners and service station emissions are contained in the NEI nonpoint inventory for the other fifty counties on Colorado.

A variety of sources are categorized as nonpoint sources in the NEI, including some small industrial/commercial processes (e.g., small dry cleaning facilities, hospital sterilization facilities, and dental offices). Additional nonpoint sources that contribute to air pollution are agricultural activities, residential trash and yard-waste burning, wood stoves and fireplaces, releases from spills and other accidents, and volatilization and resuspension of pollutants from contaminated sites. Examples of agricultural activities contributing to air pollution are biomass burning (e.g., for land clearing) and the application of fertilizers and pesticides. The open burning of forests (including wildfires) are also categorized as nonpoint sources. (Note that forest fires are generally considered for the purposes of the NEI to be an anthropogenic source of air toxics because they are assumed to be directly or indirectly, for purposes of the NEI, caused by man.)

Some nonpoint sources emit HAPs and are subject to NESHAPs pursuant to Section 112 of the CAA (see Section 4.3.1 above for more information on NESHAPs). These nonpoint sources are area sources in that they emit less than 10 tpy of a single air toxic or less than 25 tpy of a mixture of air toxics. For example, facilities that perform perchloroethylene dry cleaning belong to a source category that is subject to NESHAPs.

4.3.3 On-Road and Nonroad Mobile Sources

Mobile sources pollute the air with fuel combustion products and evaporated fuel. These sources contribute greatly to air pollution nationwide and are the primary cause of air pollution in many urban areas. Section 202(l) of the CAA gives EPA the authority to regulate air toxics from motor vehicles. Based on 1996 National Toxics Inventory data (the NTI is the former name of the air toxics portion of the current NEI), mobile sources contributed 2.3 million tpy or about half of all air toxics emissions in the U.S. Mobile sources emit hundreds of air pollutants – for example, exhaust and evaporative emissions from mobile sources contain more than 700

compounds. EPA's Final Rule, *Control of Emissions of Hazardous Air Pollutants from Mobile Sources*, commonly known as the "Mobile Source Air Toxics" (MSAT) rule,⁽⁹⁾ identified 21 compounds as HAPs emitted by mobile sources (see Chapter 2). All of these compounds except diesel particulate matter and diesel exhaust organic gases (DPM + DEOG) are included on the CAA Section 112 HAPs list. Although some mobile source air toxics are TRI chemicals, mobile sources are not generally subject to TRI reporting. Other mobile source regulations address emissions of criteria pollutants and their precursors, including carbon monoxide (CO), nitrogen dioxide (NO₂), particulate matter (PM), volatile organic compounds (VOCs), and sulfur dioxide (SO₂). These criteria air pollutant control programs for mobile sources have and will continue to result in substantial reduction of HAP releases.

Mobile sources include a wide variety of vehicles, engines, and equipment that generate air pollution and that move, or can be moved, from place to place. In the NEI, EPA divides mobile sources into two broad categories. **On-road mobile sources** include motorized vehicles that are normally operated on public roadways for transportation of passengers or freight. This includes passenger cars, motorcycles, minivans, sport-utility vehicles, light-duty trucks, heavy-duty trucks, and buses. **Nonroad mobile sources**, (sometimes also called "off-road") include aircraft, commercial marine vessels (CMVs), locomotives, and other nonroad engines and equipment. The other nonroad engines and equipment included in NEI comprise a diverse list of portable equipment, such as lawn and garden equipment; construction equipment; engines used in recreational activities; and portable industrial, commercial, and agricultural engines.

EPA's National Air Pollutant Trends Report, 1900–1998⁽¹⁰⁾ indicates that about 60 percent of mobile source air toxics emissions in the U.S. are from on-road sources, and 40 percent of mobile source air toxics emissions are from nonroad sources. The emissions distribution between on- and off-road sources emitting criteria pollutants depends on the chemical. CO comprises the majority of criteria pollutants emitted, with over 100 million tons per year emitted in the U.S. Releases of CO are *primarily* the result of mobile sources – like HAPs, these emissions are split approximately 60/40 between on-road and off-road sources. (The use of CO as a monitoring surrogate for mobile source emissions is discussed in Section 4.4.1.)

Within the two broader categories of mobile sources, EPA further distinguishes on-road and nonroad sources by size, weight, use, horsepower and/or fuel type. For example, categories of on-road vehicles include light-duty gasoline vehicles (i.e., passenger cars), light-duty gasoline trucks, heavy-duty gasoline vehicles, and diesel vehicles. Examples of nonroad sources include nonroad *gasoline* engines and vehicles, (e.g., recreational off-road vehicles, construction equipment, lawn and garden equipment, and recreational marine vessels that use gasoline), nonroad *diesel* engines and vehicles (including the vehicles and equipment listed above, *except* those that use diesel fuel), aircraft, non-recreational marine vessels, and locomotives. An additional category covers all nonroad sources that use liquified petroleum gas or compressed natural gas.

4.3.4 Sources Not Included in the NEI or TRI

In addition to the four primary categories used in compiling the NEI, five other sources of air toxics which are not captured by either the NEI or TRI are described below: Indoor sources, natural sources, secondary formation of air toxics, exempt sources, and international transport.

4.3.4.1 Indoor Sources

Indoor pollution sources that release gases or particles into the air are the primary cause of indoor air quality problems in homes (Exhibit 4-4). Inadequate ventilation can increase indoor pollutant levels by not bringing in enough outdoor air to dilute emissions from indoor sources and by not carrying indoor air pollutants out of the home. High temperature and humidity levels indoors can increase the uptake of some pollutants, thereby magnifying negative health effects.

There are many sources of indoor air pollution in any home. These include combustion sources such as oil, gas, kerosene, coal, wood, and tobacco products; building materials and furnishings as diverse as deteriorated, asbestos-containing insulation, wet or damp carpet, and cabinetry or furniture made of certain pressed wood products; products for household cleaning and maintenance, personal care, or hobbies; central heating and cooling systems and humidification devices; and outdoor sources such as radon, pesticides, and outdoor air pollution.

The relative importance of any single source depends on how much of a given pollutant it emits and how hazardous those emissions are. In some cases, factors such as how old the source is and whether it is properly maintained are significant. For example, an improperly adjusted gas stove can emit significantly more carbon monoxide than one that is properly adjusted.

Some sources, such as building materials, furnishings, and household products like air fresheners, release pollutants more or less continuously. Other sources, related to activities carried out in the home, release pollutants intermittently. These include smoking, the use of unvented or malfunctioning stoves, furnaces, or space heaters, the use of solvents in cleaning and hobby activities, the use of paint strippers in redecorating activities, and the use of cleaning products and pesticides in housekeeping. High pollutant concentrations can remain in the air for long periods after some of these activities.

In addition to the same indoor air problems as single-family homes, apartments can have indoor air problems similar to those in offices, which are caused by sources such as contaminated ventilation systems, improperly placed outdoor air intakes, or maintenance activities.

One particularly important indoor air toxics problem actually results from an outdoor natural source. In fact, radon gas, a HAP, is one of the leading causes of lung cancer in the U.S. The most common source of indoor radon is uranium in the soil or rock on which homes are built (thus, a natural source becomes an indoor air quality problem). As uranium naturally breaks down, it releases radon as a colorless, odorless, radioactive gas. Radon gas enters homes through dirt floors, cracks in concrete walls and floors, floor drains, and sumps. When radon becomes trapped in buildings and indoor concentrations build up, exposure to radon becomes a concern.

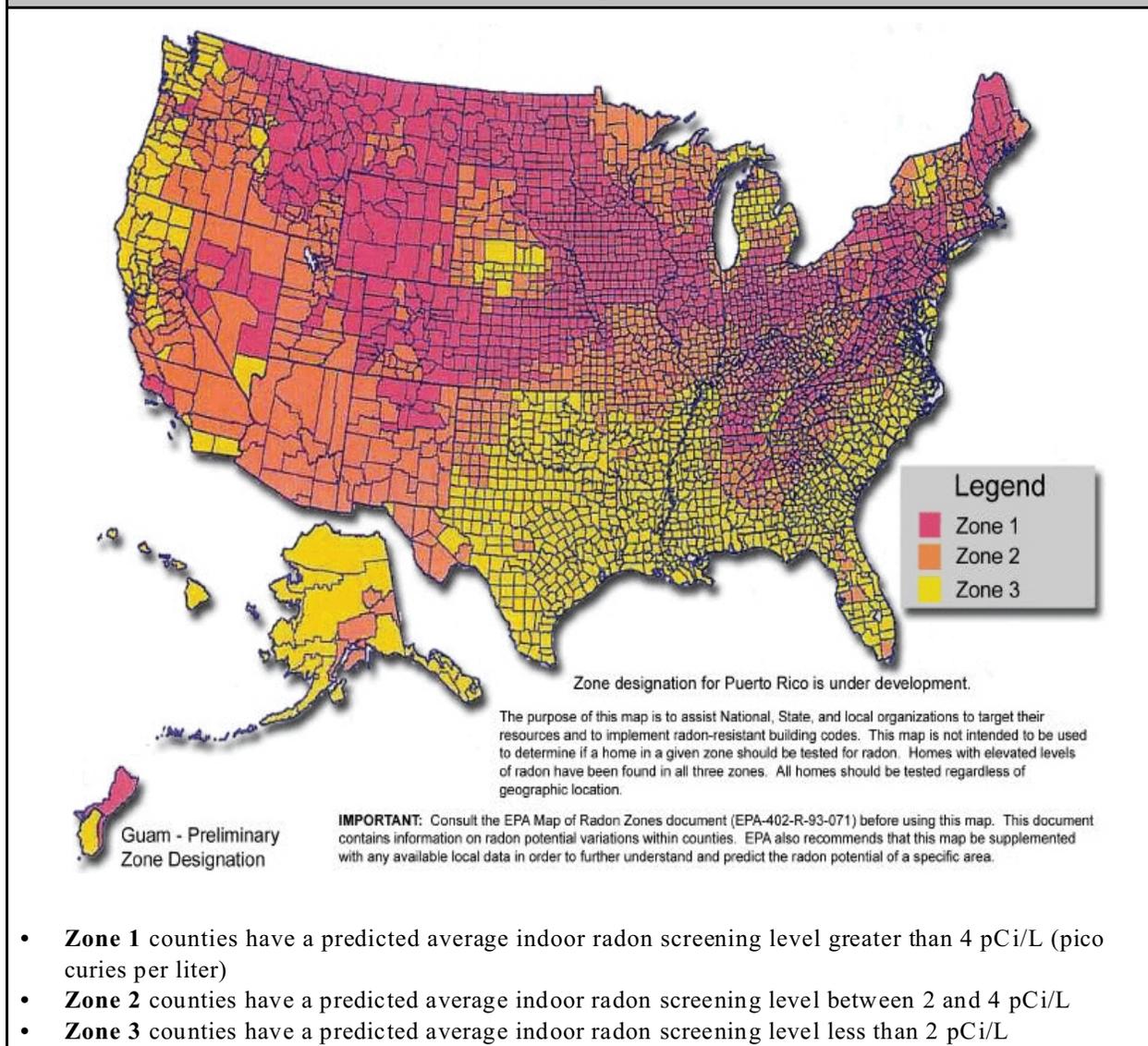
Sometimes radon enters the home through well water. In a small number of homes, the building materials can give off radon, too. However, building materials alone rarely cause radon levels of concern (see http://www.epa.gov/radon/risk_assessment.html for more information on radon risks). Exhibit 4-5 shows EPA's map of radon zones in the U.S.

Exhibit 4-4. Major Indoor Air Pollutants and their Sources

Major Indoor Air Pollutants	Sources
Radon (Rn)	Earth and rock beneath home; well water; building materials
Environmental Tobacco Smoke (includes carbon monoxide, nitrogen dioxide, and respirable particles)	Cigarette, pipe, and cigar smoking
Biologicals (e.g., pollen, mold, animal dander, and fungi)	Wet or moist walls, ceilings, carpets, and furniture; poorly maintained humidifiers, dehumidifiers, and air conditioners; bedding; household pets
Carbon Monoxide	Unvented kerosene and gas space heaters; leaking chimneys and furnaces; back-drafting from furnaces, gas water heaters, woodstoves, and fireplaces; gas stoves. Automobile exhaust from attached garages
Nitrogen Dioxide (NO ₂)	Kerosene heaters, unvented gas stoves and heaters. Environmental tobacco smoke
Volatile Organic Compounds (such as xylene)	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; dry-cleaned clothing
Respirable Particles	Fireplaces, wood stoves, and kerosene heaters. Environmental tobacco smoke
Formaldehyde	Pressed wood products (hardwood plywood wall paneling, particle board, fiberboard) and furniture made with these pressed wood products. Urea-formaldehyde foam insulation (UFFI). Combustion sources and environmental tobacco smoke. Durable press drapes, other textiles, and glues
Pesticides	Products used to kill household pests (insecticides, termiticides, and disinfectants). Also, products used on lawns and gardens that drift or are tracked inside the house
Asbestos	Deteriorating, damaged, or disturbed insulation, fireproofing, acoustical materials, and floor tiles
Lead	Lead-based paint, contaminated soil, dust, and drinking water

Source: U.S. Environmental Protection Agency and the United States Consumer Product Safety Commission. 1995. Office of Radiation and Indoor Air (6604J) EPA/402/K/93/007, April 1995. Available at: <http://www.epa.gov/iaq/pubs/insidest.html>.

Exhibit 4-5. EPA Map of Radon Zones



4.3.4.2 Natural Sources

Natural processes are significant sources of some air pollutants, including VOCs, NO_x, O₃, PM and other pollutants (Exhibit 4-6). Examples of natural sources of air pollutants that are *not* covered by the four main categories described above include natural processes occurring in vegetation and soils (e.g., emissions from trees), in marine ecosystems, as a result of geological activity in the form of geysers or volcanoes, as a result of meteorological activity such as lightning, and from fauna, such as ruminants and termites. Sources associated with biological activity are called biogenic sources.

Natural pollutants contribute significantly to air pollution. For example, biogenic emission estimates for the United States were 28.2 million tons of VOC and 1.53 million tons of NO_x in 1997.⁽¹⁰⁾

Exhibit 4-6. Categories of Natural Sources		
Category	Examples of Emissions	Sources
Geological	<ul style="list-style-type: none"> • Sulphuric, hydrofluoric and hydrochloric acids • Radon • Nitrogen oxides 	<ul style="list-style-type: none"> • Volcanic gases • Radioactive decay of rock • Soils, lightning
Biogenic	<ul style="list-style-type: none"> • Ammonia • Methane • VOCs 	<ul style="list-style-type: none"> • Animals wastes • Animal wastes, plant decay • Vegetation
Marine	<ul style="list-style-type: none"> • Dimethyl sulfide, ammonia, chlorides, sulfates, alkyl halides, nitrous oxides 	<ul style="list-style-type: none"> • Sea spray released by breaking waves

Source: International Fertilizer Industry Association. 2001. Food and Agriculture Organization of the United Nations. *Global estimates of gaseous emissions of NH₃, NO and N₂O from agricultural land*. ISBN 92-5-104698-1. Available at: www.fao.org/DOCREP/004/Y2780E/y2780e01.htm.

4.3.4.3 Formation of Secondary Pollutants

Some air pollutants, in addition to being directly emitted to the atmosphere by identifiable sources, are generated in the atmosphere by the chemical transformation of precursor compounds (a process called **secondary formation**). For example, under some meteorological conditions, up to 90 percent of ambient formaldehyde originates from secondary formation from a variety of precursor compounds in the presence of light (i.e., via a **photochemical reaction**). Some of the precursor compounds include isoprene (an organic compound released from trees), isobutene, and propene. The secondary formation of pollutants like formaldehyde and acetaldehyde is a complex process but can be estimated by some photochemical models (e.g., UAM-Tox, a special version of the Urban Airshed Model (UAM)). Other available models also address secondary formation but in a much more limited way (see Chapter 9 for a more detailed discussion of air models).

The NEI and other emission inventories generally do not include estimates of pollutants formed through secondary formation – only the initially emitted species are included. Because the formation of secondary pollutants depends on the meteorological conditions and the presence or absence of other compounds and/or light, a model that incorporates chemical transformation algorithms is required to estimate how much secondary product is formed from precursor compounds once they enter the atmosphere. EPA has in some instances developed estimates of secondarily formed chemicals to better inform the assessment of exposure of people to toxic air pollutants. For example, for the 1996 NATA, National-scale Air Toxics Assessment, risk characterization exercise, EPA developed a special inventory of precursor compounds to supplement the NTI, which was used in conjunction with the Assessment System for Population Exposure Nationwide (ASPEN) model to calculate ambient concentrations (see <http://www.epa.gov/ttn/atw/nata/>). Formation of secondary pollutants is discussed in greater detail in Chapter 8.

4.3.4.4 Other Sources Not Included in NEI or TRI

Many air toxics sources, usually relatively small ones, may not be covered or are exempt from various emissions control, reporting, and other requirements, and in some cases the number or stringency of requirements is tiered according to source size or other criteria. For example, air pollution regulations for municipal waste combustors (MWCs) promulgated pursuant to Section 129 of the CAA include separate rules for large MWCs (i.e., with capacities greater than 250 tons per day) and small MWCs (i.e., with capacities between 35 and 250 tons per day). However, there are no rules for MWCs with capacities less than 35 tons per day.

Other miscellaneous sources of air pollution (e.g., agricultural and residential burning) are controlled primarily by other S/L/T requirements. However, EPA conducts research, provides information, and pursues other non-regulatory means of addressing some of these pollution sources. For example, EPA, in conjunction with the Consumer Product Safety Commission and the American Lung Association, has published a guide for reducing pollution from residential wood combustion, including design information for less-polluting stoves and fireplaces.⁽¹¹⁾ Some local areas have ordinances that require new fireplace and wood stove installations to comply with the certification program, and others have ordinances that prohibit the use of a wood stove or fireplace on days that are conducive to the concentration of wood smoke emissions.

International Transport of Air Toxics

As noted earlier in Chapter 2 and Section 4.2.5, certain air toxics may be transported over long distances, sometimes across international borders. International sources may be an important contributor to local pollutant levels in some study areas.

Ultimately, there is no single comprehensive source of information on all sources of air toxics in a given area. The NEI and TRI are good places to start an investigation of what is being released in a study area, but as noted above, in any given place, there are probably a number of air toxics sources that are not accounted for in these inventories. Nonregulated sources, natural sources, and material moving into a study area from distant sources all have an impact on overall air quality. Assessors need to clearly understand what these limitations are as they move into the planning and scoping stage of the risk assessment (see Chapter 6). (A description of how EPA addressed background concentrations for the NATA national-scale assessment is provided at <http://www.epa.gov/ttn/atw/nata/natsa2.html>.)

4.4 Emissions Inventories

As mentioned previously, information on releases of air toxics is primarily compiled and maintained in **emissions inventories**. The primary emission inventory for HAPs and criteria pollutants is EPA's NEI. EPA's TRI is a second inventory that has some utility for planning and scoping an air toxics risk assessment, but is of limited use for risk assessment because of the nature of the way the data are reported. In addition to the NEI and the TRI, S/L/T air agency permit files and, in some instances, S/L/T inventories that have been developed, but not submitted to the NEI, can also provide information on the location, identity, magnitude, and source characteristics of air toxics releases.

The best inventory data are collected near the ground, literally at the source. For example, an urban scale study might opt to do a "drive by" or "windshield" verification of the number and

location of dry cleaners and gas stations in the study area rather than rely on an aggregate county-level estimate. Ultimately, the needs of the assessment (e.g., screening level or more refined) will determine the level of accuracy needed in the emissions inventory. This section will describe the NEI and the TRI. Other potential sources of air toxics data are described in Chapter 7. The process of developing an emissions inventory is also described in Chapter 7.

4.4.1 National Emissions Inventory (NEI)

EPA's Office of Air and Radiation compiles and maintains the **National Emissions Inventory (NEI)** that includes quantitative data on anthropogenic emissions of criteria pollutants and HAPs and characteristics of the sources of these air toxics.⁽⁵⁾ It includes point, non-point, and mobile sources for all 50 states, Washington, D.C., and U.S. territories.

Previously, emissions of criteria pollutants and HAPs were tracked separately by EPA in databases that preceded the NEI. Criteria pollutant emissions data for 1985 through 1998 are available in the National Emission Trends (NET) database. Hazardous air pollutant (HAP) emissions data are available for 1993 and 1996 in the National Toxics Inventory (NTI) database. For 1999 (the most recent year for which data are available), criteria and HAP emissions data have been prepared separately but in a more integrated fashion. The final version of both the criteria and HAP inventories (for 1999) are available at <http://www.epa.gov/ttn/chief/net/1999inventory.html>. Note that the data collection and processing requirements for this undertaking are significant. As such, EPA plans to update the NEI every three years.

The NEI inventories are developed by EPA's Emission Factors and Inventories Group with input from S/L/T agencies, industry, and a number of EPA offices. In some cases, if a S/L/T agency does not submit data, EPA may use data from an earlier year and "grow" the emissions (e.g., for criteria stationary sources) or use only data available from other sources (e.g., HAP collected by EPA as part of the development of emission standards, or data submitted by sources under the Toxics Release Inventory program). Separate inventory documentation files have been prepared for each part of NEI (i.e., for criteria pollutants and HAPs, and for point, nonpoint, and mobile sources). These detailed documentation files are available online for criteria pollutants⁽¹²⁾ and HAPs.⁽¹³⁾ The reader should refer to these documentation files for detailed information on NEI. Summaries of data sources for the components of the current version of NEI are also provided below.

An important fact to keep in mind about the NEI is that it includes data on HAPs from both small and large stationary sources and both on- and off-road mobile sources. Equally important, it is much more likely to include the data necessary for modeling (although many of the data fields needed for modeling are not "mandatory," and thus states are not required to provide this information to the NEI). Information such as stack height, emission rate, and temperature are critical to developing reasonably accurate estimates of human exposure in the areas surrounding a source. It is for this reason that the NEI can be of more use than other databases, for example, for getting a better handle on realistic exposure and risk estimates in an actual study.

NEI for HAPs – Point Sources. For the NEI for HAP emissions from point sources, S/L/T agencies are asked to supply HAP emission inventory data to EPA. If they do not provide HAP emission inventory data to EPA, then EPA prepares default emission inventory data (this has been done for the 1993, 1996, and 1999 inventory years). As discussed previously, EPA uses a variety of methods to develop data and fill in gaps, where necessary (for point sources of HAPs,

EPA uses S/L/T data, EPA estimates for MACT and source categories, and TRI data; all the TRI facilities are in the NEI). This is one reason why the NEI provides, for some sources, data that may not accurately reflect actual emissions in any given place. Depending on a study's specific data quality objectives, closer inspection and verification of emissions estimates may be necessary.

The target area for the NEI includes every state and territory in the United States and every county within a State. There are no boundary limitations pertaining to traditional criteria pollutant nonattainment areas or to designated urban areas. If a facility was included in a S/L/T database, it is included in the NEI regardless of where in the state it was located. The pollutants inventoried included all 188 HAPs identified in Section 112(b) of the CAA. Some S/L/T agencies collect information on more than just these HAPs, but only the 188 are included in the HAP NEI. In addition to numerous specific chemical species and compounds, the list of 188 HAPs includes several compound groups (e.g., individual metals and their compounds, polycyclic organic matter [POM], and glycol ethers); the NEI includes emission estimates for the individual compounds within these groups wherever possible. Appendix F lists all of the specific pollutants and compound groups included in the 1999 NEI along with their Chemical Abstract Services (CAS) numbers (for individual compounds).

NEI for Criteria Pollutants – Point Sources. For the NEI for criteria emissions from point sources, EPA solicits point source data from S/L/T governments. EPA uses S/L/T point source data preferentially, except for NO_x and SO₂ emissions from utilities. For utilities, EPA uses NO_x and SO₂ emissions that facilities report to the Emissions Tracking System/Continuous Emissions Monitoring (ETS/CEM) Scorecard database. Some other criteria pollutant emissions data in the most recent version of NEI have been supplemented by EPA based on submissions to other emissions databases. In addition, emissions of ammonia (NH₃) (which is not a criteria pollutant, but is a precursor for PM) have been added to NEI based on reports submitted by S/L/T offices, TRI data, and (for locations where reports were not submitted) also based on EPA estimation methods.

Nonpoint Sources (Both HAPs and Criteria Pollutants). Much of the nonpoint source data in NEI for HAPs was initially compiled as a national-level inventory. National-level emission estimates are spatially allocated to the county-level using a number of allocation factors, such as population and employment within certain industries. For example, aggregate amounts of dry cleaner emissions for a county might be estimated from the number of people living within a county. For HAPs, EPA uses MACT data and S/L/T data, where available.

When S/L/T- or locality-specific emissions data are available, those data are substituted for data that had been allocated from national emission estimates. EPA prepares emissions for several area source categories for the NEI each year using the most current activity and emission factor data available. Emissions for other area source categories for which methodologies were not prepared in a given year are extrapolated (and assumed to increase some percentage each year) from the most recent S/L/T inventory submitted previously to EPA. For example, if an inventory was submitted in the past 3 years to EPA for the 1996 base year, the 1999 NEI emissions are extrapolated from the 1996 inventory. In some cases, criteria air emissions may also be extrapolated from other inventories (e.g., the 1985 National Air Pollutant Assessment Program inventories). A more detailed discussion of emissions estimation routines for source categories with national-level emission estimates are described in the documents referenced above.

EPA uses an emissions estimation model known as the **Biogenic Emissions Inventory System (BEIS)** to predict emissions of VOC and NO_x from forests, crop lands, and fertilized lands. Emission rates are dependent on several meteorological factors. VOC emissions are dependent on temperature and sunlight, and NO_x emissions from fertilized soils are dependent on temperature and soil moisture. The BEIS model is used to predict emissions that are included in the NEI inventory for criteria pollutants. (Keep in mind that VOCs, as a group, are inventoried, but not speciated, to help evaluate an area's potential for ozone production. Non-speciated VOC data are of limited use for performing air toxics risk assessments.)^(e)

On-road Mobile Sources. In the final Version (V 3.0) of the 1999 NEI, EPA used the most recent version of the MOBILE6 (Version 6.2) model to calculate emission factors for criteria pollutants and 36 HAPs. On-road emissions inventories for CO, NO_x, VOC, PM₁₀, PM_{2.5}, SO₂, NH₃, and the 36 HAPs are calculated by multiplying an appropriate emission factor in grams emitted per mile by the corresponding vehicle miles traveled (VMT) in millions of miles, and then converting the product to units of tons of emissions. Emission estimates include calculations by month, county, road type, and vehicle type, with VOC broken down by exhaust and evaporative emissions and PM₁₀ and PM_{2.5} broken down by exhaust, brake wear, and tire wear emissions. The MOBILE6 model used is the publicly available version from EPA's Office of Transportation Air Quality's (OTAQ) Website (<http://www.epa.gov/otaq/m6.htm>). This model incorporates both MOBILE6.0, which is used to estimate emission factors of VOC, CO, and NO_x, and MOBILE6.1, which is used to calculate emission factors of PM₁₀, PM_{2.5}, SO₂ and NH₃ and MOBTOX, which is used to calculate certain HAPs. The particulate and SO₂ emission factors were previously calculated using EPA's PART5 model.

Nonroad Mobile Sources. To develop this component of the NEI, data were compiled on criteria and HAP emissions data for aircraft, commercial marine vessels, and locomotives. HAP emissions for other nonroad engines operating in the United States were estimated using the latest nonroad model. S/L/T data are used when provided. In this effort, national emission estimates were often developed for each of the above types of nonroad sources and allocated to counties based on available Geographic Information System (GIS) data. For some pollutants associated with the nonroad category, county-level (instead of national) data were used to estimate emissions. The methodologies used to estimate emissions and the procedures used to spatially allocate them to the county level vary by source category and pollutant. For some pollutants and categories, the NONROAD model was utilized to estimate emissions (see <http://www.epa.gov/otaq/nonrdmdl.htm>).

Concurrent with the development of the national emission estimates, S/L/T agencies developed and provided to EPA emissions inventory data for their areas based on local knowledge and activity information. These S/L/T agency data replaced the national emission estimates when the pollutant, source type, and emission type matched with the national estimates. Submitted S/L/T data that did not match the nationally-derived data were retained along with the national estimates. S/L/T data were used as provided and not adjusted to better match the national data. Some S/L/T inventories did not provide estimates for all of the pollutants included in the

^eVolatile Organic Compound means any organic compound which participates in atmospheric photochemical reactions; or which is measured by a reference method, an equivalent method, an alternative method, or which is determined by procedures specified under any subpart (40 CFR Part 60).

nationally-derived emission estimates; in these cases, the submitted S/L/T data were used and the national estimates were included only for the missing pollutants.

Although the current NEI data files represent a valuable source of emissions data, there are numerous uncertainties associated with the current versions of these inventories that should be considered when using the data in a risk assessment. Sources of uncertainty include the following:

- The emission data included in NEI are of variable, and in some cases, undocumented derivation. Many of the emission estimates were submitted by the sources of the emissions to S/L/T air agencies, and then to EPA, without full explanations of how the emissions were estimated.
- Not all sources are accounted for. In some S/L/T data sets, very small sources have been reported, while in others only the largest sources in certain types of industry are included.
- Not all S/L/T agencies have submitted data. Specifically, for the NEI for criteria pollutants, 35 out of 50 states submitted data to EPA for the 1999 version of NEI. For the other states, EPA extrapolated the affected portions of the inventory from an earlier year. This omits sources that came online in the target year and erroneously include sources that have shut down. For more information on which S/L/T governments submitted data and for which states the inventory is extrapolated, the user can refer to the documentation for the respective inventory sector and the respective pollutant type (see website addresses above). Some of the states for which 1999 data were not available when these inventory versions were compiled have now provided EPA with their data, and EPA is working to incorporate this data into the next versions. For HAPs, 46 states have participated in the development of the 1999 NEI (with some revisions from states still under way).
- Duplicate facilities may be present, but most of the duplicates have been removed. Facility identification (ID) codes are a potential source of confusion. The NEI Unique Facility ID is the ID for the entire facility, while the state IDs are usually for individual processes; therefore an NEI Unique Facility ID can have multiple state facility IDs.
- The primary source of uncertainty associated with the inventory is the methodology used to generate the emission estimates. The emission estimation methodology is often poorly documented in the NEI Input Format - this data field is not mandatory. Data in the 1999 NEI for HAPs are made using different estimation methods. Future versions of the NEI will include a data quality rating to each emissions record, which should help characterize the quality of the emissions estimate.

Emissions data in the NEI are submitted to EPA according to the **NEI Input Format (NIF) Shell** (see <http://www.epa.gov/ttn/chief/nif/index.html>). This format consists of data fields grouped into tables that provide the basic structure of NEI. The NIF shell consists of eight tables for point sources, five tables for area sources, three tables for mobile sources, and two tables for biogenic sources. EPA has developed data element descriptions and data element validation rules to enforce mandatory data fields and relationships between the various tables and records of the NIF. As the NEI has evolved (and continues to be improved and developed), the NIF shell has evolved as well. Version 3.0 of the NIF shell was released in May 2003 and updated in November 2003.

In June 2002, EPA promulgated the final Consolidated Emissions Reporting Rule,⁽¹⁴⁾ which simplifies and consolidates emission inventory reporting requirements (for criteria air pollutants only) to a single location within the *Code of Federal Regulations* (CFR), establishes new reporting requirements related to PM_{2.5} and regional haze, and establishes new requirements for the statewide reporting of area source and mobile source emissions. Many state and local agencies asked EPA to take this action to consolidate reporting requirements; improve reporting efficiency; provide flexibility for data gathering and reporting; and better explain to program managers and the public the need for a consistent inventory program. Consolidated reporting should increase the efficiency of the emission inventory program and provide more consistent and uniform data.

In conjunction with the NIF shell, EPA has developed an automated software program to help NIF users perform **quality assurance/quality control (QA/QC) checks** on their files to ensure correct format specification. This software, available for download from the NIF shell web page, separates QA/QC checks into format and content. Format checks ensure that the submitted information includes the minimum data elements required for Emission Factor and Inventory Group (EFIG) to accept the submitted data. Content checks are provided for the user as a way to highlight possible errors in the submitted data. The latest version of the software allows the user to choose whether to perform QA/QC checks on the data for format, the minimum standards required to put the data in the database, or the more resource intensive content or reasonableness checks. When checking for content, the format is also checked as the format must be correct in order for content checks to be performed at all.

4.4.2 Toxics Release Inventory (TRI)

The **Toxics Release Inventory (TRI)** is a publicly available EPA database that contains information about releases and other waste management activities reported annually by certain covered industry groups as well as federal facilities for over 650 toxic chemicals (see <http://www.epa.gov/tri/>). This inventory was established under the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA) and expanded by the Pollution Prevention Act of 1990.

TRI reporting is required only for facilities that meet all of the following three criteria:

- They have ten or more full-time employees or the equivalent (i.e., a total of 20,000 hours or greater; see 40 CFR 372.3);
- They are included in specified industrial sectors (see Exhibit 4-7); and
- They exceed any one reporting threshold for manufacturing, processing, or otherwise using a TRI chemical (see Exhibit 4-8).

If a facility meets these criteria, then it must report releases to environmental media as well as waste management data. In 2001 (the latest year for which data are publicly available), air emissions of toxic chemicals totaled 1.7 billion pounds (over a quarter of all releases of TRI chemicals to the environment).

Exhibit 4-7. Standard Industrial Classification (SIC) Codes in TRI Reporting

Original Industries			
SIC Code	Industry Group	SIC Code	Industry Group
20	Food	30	Rubber and Plastics
21	Tobacco	31	Leather
22	Textiles	32	Stone, Clay, and Glass
23	Apparel	33	Primary Metal
24	Lumber and Wood	34	Fabricated Metals
25	Furniture	35	Machinery (excluding electrical)
26	Paper	36	Electrical and Electronic Equipment
27	Printing and Publishing	37	Transportation Equipment
28	Chemicals	38	Instruments
29	Petroleum and Coal	39	Miscellaneous Manufacturing
New Industries Reporting to TRI as of the 1998 Reporting Year			
SIC Code	Industry Group		
10	Metal mining (except for SIC codes 1011,1081, and 1094)		
12	Coal mining (except for 1241 and extraction activities)		
4911, 4931, and 4939	Limited to electrical utilities that combust coal and/or oil for distribution in commerce (SIC codes 4911, 4931, and 4939)		
4953	Limited to hazardous waste treatment and disposal facilities regulated under the Resource Conservation and Recovery Act (RCRA) Subtitle C		
5169	Chemicals and allied products wholesale distributors		
5171	Petroleum bulk plants and terminals		
7389	Solvent recovery services primarily engaged on a contract or fee basis		
<p><i>Source:</i> U.S. Environmental Protection Agency. 2004. Toxic Release Inventory (TRI) Program. <i>Standard Industrial Classification (SIC) Codes in TRI Reporting</i>. Updated March 2, 2004. Available at: http://www.epa.gov/tri/report/siccode.htm. (Last accessed April 2004.)</p>			

Exhibit 4-8. Thresholds for Reporting to the TRI

EPCRA Section 313 non-PBT chemicals (Section 372.25). A facility meeting the SIC code (or Federal facility) and employee criteria must file a TRI report for a non-PBT Section 313 chemical if the facility:

- Manufactured (including imported) more than 25,000 pounds per year; or
- Processed more than 25,000 pounds per year; or
- Otherwise used more than 10,000 pounds per year.

EPCRA Section 313 PBT chemicals (40 CFR372.28). If a facility manufactures, processes, or otherwise uses any chemicals that are listed as persistent, bioaccumulative, and toxic (PBT), the threshold quantity is one of the following (per Section 313 chemical or category per year):

Type of Chemical	Reporting Threshold by Activity		
	Manufacture	Process	Otherwise Used
Highly persistent and bioaccumulative compounds	10 pounds	10 pounds	10 pounds
Dioxin and dioxin-like compounds	0.1 grams	0.1 grams	0.1 grams
Other persistent and bioaccumulative compounds (lead and lead compounds)	100 pounds	100 pounds	100 pounds

Activity thresholds are calculated independently of each other based on cumulative quantities per Section 313 chemical over the reporting year.

Current list of Section 313 PBT Chemicals

<ul style="list-style-type: none"> • aldrin • benzo(g,h,i)perylene • chlordane • dioxin and dioxin-like compounds • heptachlor • hexachlorobenzene • isodrin • lead • lead compounds • mercury 	<ul style="list-style-type: none"> • mercury compounds • methoxychlor • octachlorostyrene • pendimethalin • pentachlorobenzene • polychlorinated biphenyl • polycyclic aromatic compounds • tetrabromobisphenol A • toxaphene • trifluralin
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Note in Exhibit 4-7 that additional industries have been added to the TRI over time. Thus, some industries were not required to report in the past and, as such, no records will exist for these facilities in the historical TRI files. The list of covered chemicals has also grown over time. Thus, the ability to track trends for more recently added industries and chemicals is more limited than for industries and chemicals that have been covered throughout the history of the TRI.

Industrial sectors subject to TRI reporting are identified by Standard Industrial Classification (SIC) codes. SIC codes are numerical codes developed by the U.S. government as a means of consistently classifying the primary business of business establishments. A full list of the industry groups that are required to report can be found at <http://www.epa.gov/tri/report/siccode.htm>.

Although most of the existing emissions data in the TRI system are organized according to SIC codes, EPA has proposed regulations that would result in the use of the North American Industry Classification System (NAICS) rather than SIC codes (see <http://www.census.gov/epcd/www/naics.html>). Rather than classifying industries on the basis of several different economic concepts (as the SIC structure does), NAICS classifies establishments according to similarities in the processes used to produce goods and services. The TRI program issued a proposed rule to implement the NAICS system classification on March 21, 2003. (See 66 *Fed. Reg.* 13872.) It is expected that the use of NAICS in the TRI system will allow EPA to more accurately characterize the current state of the national economy (including new and emerging industries not adequately covered by SIC codes). The existing SIC structure will not be updated in the future because the Office of Management and Budget has adopted NAICS as the United States' new industry classification system. In addition, using NAICS for TRI reporting purposes will enable more efficient database integration and will promote public access to commonly defined data from disparate sources. This change will not affect the universe of facilities that is currently required to report to TRI.

EPCRA requires only that facilities report their releases of the listed chemicals. There are no additional control or mitigation actions required. The information collected through the TRI program is made public, however, and pressure from local citizen groups has been an incentive to many industries to reduce the quantity of pollutants they release.

While the TRI data have utility for the scoping out of an air toxics risk assessment project, they have several limitations that assessors must understand. Importantly for risk assessors, the TRI program requires only that one single annual value representing total releases to the air (segregated only by stack releases and fugitive releases) be reported by the individual affected facilities. So while annual average emissions may be useful in screening-level assessments for chronic exposures, it may be difficult to assess acute noncancer hazard associated with short-term, peak emission levels. Source-specific information within the facility is not routinely reported through the TRI. Likewise, no information is reported on release parameters critical to air dispersion modeling (e.g., location of release on the facility property, release rates, stack height, stack diameter, release temperature). (See Chapter 9, for more information on modeling parameters used in air quality and exposure modeling.)

As discussed in Section 4.2, the list of TRI pollutants is organized differently than the list of HAPs in CAA Section 112, causing some complications in interpreting emission data. It is difficult to correctly relate some of the SIC codes (under which TRI emissions are grouped) to specific air emission processes. Because quantities are only reported if a statutory threshold is

met, a facility may report emissions for one year but not the next, even though the facility is still in operation. Similarly, individual pollutants may not be reported consistently from year to year due to the thresholds that apply to individual pollutants (e.g., a facility may report releases of 10 pollutants one year and releases of only five pollutants the next year because the others dropped below the reporting threshold).

Furthermore, for some facilities, it is possible that, for a variety of releases, the data included for a facility's emissions in the TRI do not match the same data reported to the NEI, indicating a potential problem with either or both data sets. The risk assessor should apply care and discretion when using TRI information to estimate exposures and risk from individual facilities. Ultimately, the TRI provides information about the location, identity, and amount of air toxics emissions in a community. However, due to the nature of the way the data are developed and reported, TRI data should generally be considered a source of limited information about a facility and should not be used in risk assessments involving modeling (as noted above, S/L/T and NEI data are more likely to be useful for modeling). For robust analysis, it should generally be considered a starting point, not an end.

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