

## Chapter 4

# Pollutant Sources

**T**oxic chemicals that accumulate in sediment and are associated with contamination problems enter the environment from a variety of sources. These sources can be broadly differentiated as point sources and nonpoint sources. The term “point source” is defined in the Clean Water Act (CWA) and generally refers to any specific conveyance, such as a pipe or ditch, from which pollutants are discharged. In contrast, nonpoint sources do not have a single point of origin and generally include diffuse sources, such as urban areas or agricultural fields, that tend to deliver pollutants to surface water during and after rainfall events. Some sources, such as landfills and mining sites, are difficult to categorize as either a point or nonpoint source. Although these land areas represent discrete sources, pollution from such areas tends to result from rainfall runoff and leaching. Likewise, atmospheric deposition of pollutants, generally considered to be a nonpoint source of water pollution, arises from the emission of chemicals from discrete stationary and mobile source points of origin. The CWA specifies water vessels and other floating craft as point sources although, taken as a whole, they function as a diffuse source.

Many point and nonpoint pollutant sources have been the subject of federal and other action over the past 25 years. The direct discharge of pollutants to waterways from municipal sewage treatment and industrial facilities requires a permit under the CWA. Many states have been authorized to issue permits in lieu of EPA. These permits contain technology-based and water quality-based pollutant discharge limits and monitoring requirements. More recently, replacement of aging combined sewer systems and other storm water control measures has addressed the discharge of pollutants from urban areas through municipal facilities. The disposal of sediment dredged to maintain navigation channels is managed under both the CWA and the Marine Protection, Research, and Sanctuaries Act (MPRSA) to ensure that unacceptable degradation from chemical pollutants in the dredged material does not occur at the disposal location. Emission standards and controls on stationary and mobile sources of air pollutants have also been established in federal regulations promulgated under the authority of the Clean Air Act (CAA). These actions have reduced emissions of gaseous compounds such as inorganic oxides, as well as pollutants that eventually enter water bod-

ies and accumulate in sediment. The Toxic Substances Control Act (TSCA) and Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) have greatly reduced the toxic pollutant input to the environment through bans and use restrictions on many pesticides and industrial-use chemicals.

Federal, state, and local laws have also addressed land-based pollutant sources. Under the Resource Conservation and Recovery Act (RCRA), the transport, storage, and disposal of pollutants in landfills and other repositories of hazardous waste are tracked and controlled. At sites where past disposal practices, either purposeful or accidental, have resulted in severe contamination, remediation has been undertaken under the federal Superfund laws. Where applicable, land development projects may be subject to an assessment of the environmental impact conducted under National Environmental Policy Act (NEPA) authority. Under the authority of the Coastal Zone Management Act (CZMA), EPA has developed nonregulatory management measures to reduce pollutant delivery via nonpoint sources, such as runoff from urban and agricultural areas.

The combined impact of these actions has yielded improvements in water quality. In at least some documented cases, pollutant levels in sediment are also decreasing. (For example, see the discussion of the Palos Verdes case study presented in Chapter 5.) However, improvement in sediment quality might lag behind improvement in overlying water because of the persistent nature of many pollutants, as well as the storage and sink functions of sediment, and because the most toxic bioaccumulative pollutants are difficult to monitor and regulate. It is beyond the scope of this baseline assessment to determine the temporal trends of pollutant concentrations in sediment on a national scale. Future reports to Congress will address that issue.

Natural recovery of contaminated sediment can occur through source reduction, contaminant degradation, and continuing deposition of clean sediment. The feasibility of natural recovery, as well as the long-term success of remediation projects, depends on the effective control of pollutant sources. For some classes of sediment contaminants, such as PCBs and organochlorine

pesticides, use and manufacture bans or severe restrictions have been in place for many years. Past disposal and use of PCBs continue to result in evaporation of these contaminants from some landfills and leaching from soils, but most active PCB sources have been controlled. The predominant sources of organochlorine pesticides are runoff and atmospheric deposition from past applications on agricultural land, and occasional discharge from municipal treatment facilities. For other classes of sediment contaminants, active sources continue to contribute substantial environmental releases. For example, liberation of inorganic mercury from fuel burning and other incineration operations continues, as do urban runoff and atmospheric deposition of metals and PAHs. In addition, discharge limits for municipal and industrial point sources are based on technology-based limits and state-adopted standards for protection of the water column, not necessarily for downstream protection of sediment quality. Determining the local and far-field effects of individual point and nonpoint sources on sediment quality usually requires site-specific study.

The purposes of this chapter are to:

- Present the extent of sediment contamination by chemical class in the 96 watersheds identified as areas of probable concern for sediment contamination (APCs).
- Identify the major source categories of these chemical classes and summarize key studies that link these source categories to sediment contamination.
- Analyze land use patterns and the extent of sediment contamination by chemical class in the 96 APCs.
- Briefly describe current EPA efforts to further characterize point and nonpoint sources of sediment contaminants.

## Extent of Sediment Contamination by Chemical Class

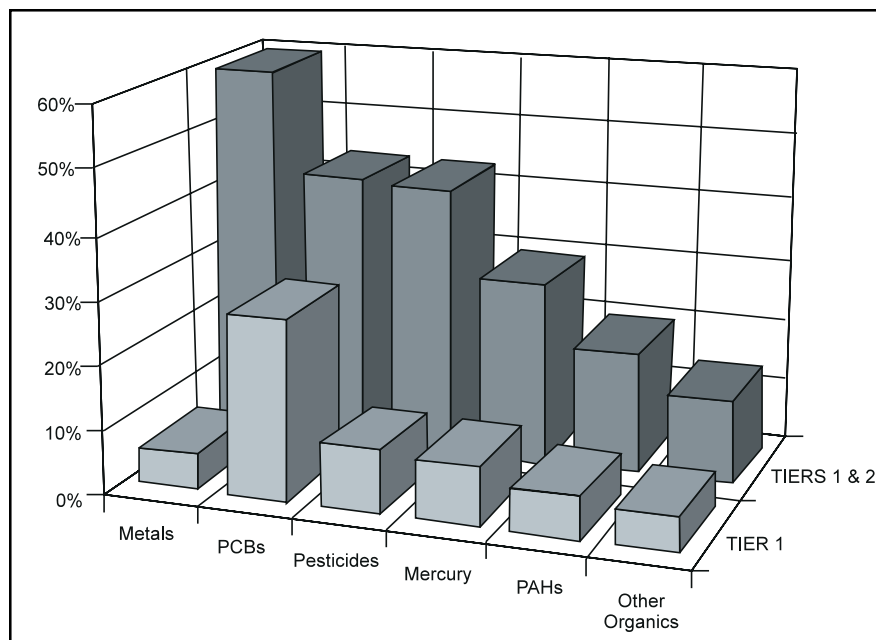
The individual chemicals evaluated for this report can be grouped into six chemical classes: metals, PCBs, pesticides, mercury, PAHs, and other organic chemicals. Pesticides include the organochlorine pesticide compounds assessed in this report, such as DDT and metabolites, dieldrin, and chlordane. PAHs include both low- and high-molecular-weight polynuclear aromatic hydrocarbons, and other organ-

ics include all organics not otherwise classified. Mercury is grouped separately from other metals because of its unique behavior in the environment (e.g., methylation and bioaccumulation potential) and because of recent attention focused on its impact as a primary sediment and fish contaminant of concern.

Figure 4-1 presents, by chemical class, the average percent of stations that are contaminated in the 96 APCs. For this analysis, the percent contamination is derived by taking the number of stations where an individual chemical constituent of a particular chemical class places a station into Tier 1 or Tier 2 and dividing by the total number of stations in the watershed. Each constituent, or any constituent representative of a chemical class, might not have been measured at all stations in the watershed. In addition, the total number of stations in each watershed varies extensively, as does the spatial extent of sampling within the watershed. The resulting percent contamination by chemical class varies a great deal—from 0 percent to 100 percent for each class—among the watersheds. Figure 4-1 presents the average value at both Tier 1 and combined Tier 1 and Tier 2 contamination levels.

Figure 4-1 indicates that at the Tier 1 level of contamination, PCBs are the dominant chemical class with an average extent of contamination of 29 percent. Among Tier 1 stations, all other classes of contaminants account for contamination at a lower percent of the stations on the average (6 to 10 percent). The relative importance of PCBs reflects, in part, the fact that a station can be designated Tier 1 for human health effects based on elevated fish tissue concentrations alone for this chemical class, whereas elevated levels in fish tissue and corresponding elevated levels in sediment are required for all other classes. At the combined Tier 1 and Tier 2 level of contamination, metals are the dominant chemical class measured by average extent of contamination (59 percent), followed by PCBs and pesticides (both at 43 percent), mercury (29 percent), and PAHs and other organics (19 and 14 percent, respectively). The very large increase in the relative importance of metals from Tier 1 to combined Tier 1 and Tier 2 also reflects the evaluation methodology because a divalent transition metal concentration cannot place a station into Tier 1 without an accompanying acid-volatile sulfide concentration ([AVS]) measurement, which is typically not available.

Figure 4-1 graphically displays the relative differences in certainty of assessing the probable effects of metals versus assessing the effects of PCBs. More confidence can be placed in the assertion that PCBs exhibit “probable association with adverse effects” than in mak-



**Figure 4-1. Average Percent Contamination in Watersheds Containing APCs by Chemical Class.**

ing this assertion for metals. The relatively high percent of PCB contamination at the Tier 1 level reflects the relative certainty that elevated PCB levels in fish are associated with elevated levels in sediment. The relatively low percent of metal contamination at the Tier 1 level primarily reflects the lack of confirming data (i.e., AVS) regarding important binding phases and bioavailability, not necessarily the lack of significance of metal contamination. In fact, the very high percent contamination indicated at the combined Tier 1 and Tier 2 level demonstrates the potential importance of this chemical class. It should also be noted, however, that correlative screening values such as ERM<sub>s</sub> do not indicate causality, rather they are concentrations *associated* with effects.

This analysis does not imply that certain chemical classes are always dominant, nor that other chemical classes can be dismissed altogether. In fact, contamination from constituents in any class may be of paramount importance in a given watershed or location. The differences in extent of chemical class contamination on the average in the 96 APCs is intended to provide some perspective to the ensuing sections of this chapter.

## Major Sediment Contaminant Source Categories

To identify the important sources of sediment contaminants, EPA searched the scientific and technical literature for studies that link specific pollutant sources to

evidence of sediment contamination. EPA focused this review on studies appearing in peer-reviewed journals and government reports published after 1980. The majority of studies related sediment contamination to a source through qualitative means, including associations of land use or specific activity with the types of contaminants detected, and spatial analyses. For example, organochlorine pesticide contamination is associated with agricultural land use where past application practices and hydrologic routes of rainfall runoff are known. Some researchers made the association with contamination source by more quantitative means such as loadings measurements, runoff or deposition estimates, or mass balance

models of contaminant inputs. Most research has focused on the chemicals or chemical classes listed above. The studies reviewed attributed sediment contamination from the six classes of chemicals to four general nonpoint source categories and two general point source categories. Table 4-1 summarizes the correlations of source category to chemical class documented in literature.

Table 4-1 does not specifically list some important sources that are difficult to categorize as a point or nonpoint source. These sources include leachate from landfills, direct inputs from recreational and commercial boating, and disposal of contaminated dredged material. As mentioned at the beginning of this chapter, landfills are not easily classified as a point or nonpoint source. Evaporation and subsequent deposition of moderately volatile contaminants from landfills represent an atmospheric source, yet leachate is typically considered as neither “urban runoff” nor a controlled point source. Nonetheless, leachate from landfills is an important documented source of sediment contaminants. For example, landfill leachate and past effluent discharges from electronics manufacturers have contaminated New Bedford Harbor in Massachusetts with PCBs and heavy metals (Garton et al., 1996). Boating and shipping activities can be important sources of a variety of contaminants, including PAHs and antifouling paint additives such as tributyl tin and copper. As for dredged material disposal, past dredging operations to maintain navigation channels could be responsible for contaminated sediment at specifically designated dump sites. Dredging

**Table 4-1. Correlations of Sources to Chemical Classes of Sediment Contaminants**

Source/Chemical Class	Mercury	PCBs	PAHs	Metals	Pesticides	Other Organics
Harvested Croplands					★	
Inactive and Abandoned Mine Sites	●			●		
Atmospheric Deposition	●	●	●	●	●	●
Urban Sources	●		●	●	★	●
Industrial Discharges	●	★	●	●	★	●
Municipal Discharges	●	●	●	●	●	●

★ Source from past activities

● Ongoing source

practices are currently managed under federal, state, and local authority to ensure that appropriate testing and safe disposal occur. In addition to these sources, uncontrollable and accidental point source releases, such as improper disposal practices and spills, have occurred and continue to occur.

A notable feature of Table 4-1 is the extent to which multiple sources can be associated with each chemical class. This is the primary factor in making source assessment and effective source control such difficult tasks. The table does not provide any indication of which sources are the most significant. The significance of any given source depends on the areal extent of the source and intensity of the activity in the watershed. Because a variety of sources are present (or were present in the past) in most watersheds, and the extent and intensity of each source vary, the most important source of a particular chemical or class of chemical contaminants at a given location also varies. In addition, there is typically overlap among source categories. The most obvious overlap is between atmospheric deposition and urban sources. For example, fuel combustion in urban areas releases PAHs to the atmosphere, which are subsequently deposited in various parts of the watershed or transported to other areas.

Despite these cautions, the results of EPA's literature review allow some broad assertions regarding source associations. For harvested croplands, organochlorine pesticides are the major contaminants of concern. Inactive and abandoned mine sites contribute mercury and other heavy metals to sediment. Atmospheric deposition is a primary contributor of mercury, PCBs, and PAHs. Urban sources are most closely associated with metals and PAHs. Although permit monitoring records

and industry-supplied release estimates, as well as specific spatial analysis studies, indicate that municipal and industrial discharges of sediment contaminants (particularly metals and other organics) continue, the relative contribution compared to nonpoint sources is an open question and undoubtedly varies substantially by watershed. A brief summary of the literature review for major source categories follows.

At many sites, elevated levels of pesticides in the Nation's sediment can be attributed to past

agricultural practices. Crop growers deliberately apply pesticides to protect their yield from insects, fungus, and weeds. In the past, organochlorine compounds such as DDT and chlordane were used without restriction to rid harvested croplands of a broad range of unwanted species. These compounds tend to be persistent in the environment, adsorptive to soil and sediment particles, highly bioaccumulative in living tissue, and lethal to many non-target organisms. As these effects became apparent and regulatory authorities began restricting or banning the use of persistent pesticides in the United States, chemical manufacturers developed newer organophosphate pesticides that might be more easily degradable and, in some cases, more narrowly targeted to specific organisms. In addition, modern pesticides must undergo federal registration procedures designed to protect human health and the environment before they can be approved for intended new uses.

Although the current-use pesticides are applied throughout the country in large amounts, they are not frequently analyzed in routine sediment monitoring, nor are they frequently detected in sediment when included in monitoring studies (Pereira et al., 1994). Because of the lack of monitoring data, and the absence of available levels of concern in sediment, current-use pesticides were not included in this evaluation of sediment quality. However, these compounds exhibit toxicity to non-target organisms. Furthermore, although these compounds have shorter half-lives and greater water solubility than organochlorines in general, the chemical and physical properties of some of these compounds indicate significant bioconcentration potential (Willis and McDowell, 1983). Thus, further assessment of the presence of current-use pesticides in fish and sediment is warranted.

The discharge of pollutants from agricultural lands to surface water is largely driven by precipitation. Contaminants also reach the aquatic ecosystem via irrigation return flows through interflow or ground water seepage. Most of the literature reviewed identifies agriculture as the source of pesticides in sediment because of upstream land use, chemical use, and the nature of the chemicals detected in sediments. Contamination of sediment associated with major agricultural areas of the United States has been reported in numerous studies. For example, the San Joaquin River, in the highly agricultural central valley of California, has bed-sediment concentrations of the pesticides DDT and dieldrin among the highest of all major rivers in the United States (Gilliom and Clifton, 1990). Researchers have also found continued elevated levels of highly persistent organochlorines in bottom-feeding fish, a condition that is often a consequence of sediment contamination. In the Yakima River in Washington, which drains a largely agricultural region, concentrations of DDT in fish for the years 1989-90 were found to be similar to concentrations for the years 1970-76 (USGS, 1993).

Contaminant contributions from past mining activities are so significant that several former mining sites in the United States have been included on the EPA Superfund Program's National Priorities List of sites for remediation, including the Clark Fork River Basin in Montana, the Bunker Hill Complex in Idaho, White-wood Creek and the Belle Fourche River in South Dakota, Tar Creek in Oklahoma, Iron Mountain in California, and the Arkansas River and tributaries near Leadville, Colorado. The persistence and mobility of heavy metals have resulted in concentrations in sediments up to 65 miles downstream of discharge similar to the elevated concentrations found in the mine tailings themselves (Henny et al., 1994). Based on information provided by the states, the Bureau of Mines estimated that abandoned coal and metal mines and their associated wastes adversely affect more than 12,000 miles of rivers and streams and more than 180,000 acres of lakes and reservoirs (Kleinman, 1989).

The primary sediment contaminants of concern associated with mining are heavy metals such as lead, mercury, zinc, cadmium, copper, manganese, and silver. These metals are primarily associated with historical mining of silver, gold, lead, and zinc. A literature review of studies related to mining pollution provided publications describing the effects of mining on water quality; however, few researchers have directly addressed the effects of mining on sediments. A monitoring study performed on Idaho's Lake Coeur d'Alene surface sediment found that ores and wastes from a mining district

were the source of elevated sediment concentrations of several heavy metals via transport down the Coeur d'Alene River (Horowitz et al., 1993). Moore et al. (1991) performed an integrated sediment-water-biota monitoring study on the effects of acid mine effluent on the Blackfoot River in Montana. These researchers found elevated levels of heavy metals in sediment from tributaries with known historical mine effluent input that were higher than levels in nonaffected tributaries. In another study from the gold mining region of northern Georgia, elevated mercury concentrations decreased as distance of the sampling sites from the mining district increased (Leigh, 1994). The author further suggests that similar occurrences of mercury contamination could exist throughout the gold mining region of the Southern Piedmont because of the historical amalgamation processes used by gold miners.

Atmospheric deposition is often identified as a major source of mercury, PCBs, and PAHs to aquatic systems. Studies have also implicated atmospheric sources as an important contributor of metals. Sources that emit large amounts of many toxic chemicals to the atmosphere include industrial point sources, fuel combustion in motor vehicles, volatilization of compounds from landfills and open water, combustion of wood and other fuels to produce heat, and waste incineration. In addition, long-range atmospheric transport of organochlorine pesticides from countries where their use is still permitted contributes these compounds to aquatic environments in this country (Keeler et al., 1993).

Atmospheric sources of mercury include coal combustion, waste incineration, and paint application. Sorensen et al. (1990) compared mercury levels in sediment cores from lakes in northern Minnesota with precipitation loadings from monitoring and concluded that, on the average, direct wet atmospheric deposition accounts for 60 percent of the mercury in lake sediment. A 1994 EPA report to Congress entitled *Deposition of Air Pollutants to the Great Waters* also describes mass balance studies from Wisconsin and Sweden indicating that atmospheric deposition is responsible for most of the mercury in lakes (USEPA, 1994a). The Swedish study also points out that mercury deposited onto forest soils is stored, for potentially long periods of time, before it enters the lake through storm water runoff. This further illustrates the relationship between atmospheric deposition and runoff.

Sources of PCBs to the atmosphere include municipal and hazardous waste landfills, refuse and sewage sludge incinerators, and occasional leakage from electrical transformers and capacitors (Keeler et al., 1993).

Researchers have developed a mass balance for PCBs in Lake Superior that indicates that approximately 77 to 89 percent of the annual PCB input to the lake is from atmospheric deposition (Baker et al., 1993, cited in USEPA, 1994a). These researchers have also estimated the percent contribution of PCBs from atmospheric deposition for other Great Lakes, keeping track of the fraction contributed from atmospheric deposition to upstream lakes. For example, about 63 percent of PCB input to Lake Huron is from direct atmospheric deposition, an additional 15 percent is from atmospheric deposition to the upstream Lakes Superior and Michigan, and the remaining 22 percent is from other sources. Lakes Erie and Ontario receive only about 13 percent and 7 percent, respectively, of their annual PCB load from atmospheric sources.

Sources of atmospheric PAHs include stationary fuel combustion, industrial production facilities, transportation, solid waste incineration, and forest and prairie fires. Routine installation of catalytic converters in motor vehicles, as well as other combustion emission controls, have decreased PAH releases to the atmosphere. Atmospheric transport of PAHs generated during fuel combustion has often been inferred to account for the appearance of PAHs in soils and sediments in regions distant from known combustion sources, but quantification of this process is scarce in the literature (Prahl et al., 1984). Researchers typically state that the types of PAHs detected in sediments at a particular study site are indicative of combustion sources, thereby implying that atmospheric deposition is probably the primary source to the aquatic environment (Helfrich and Armstrong, 1986; Rice et al., 1993). In a rare attempt to quantify this contribution, Prahl et al. (1984) studied atmospheric particulate matter and surface sediment in Washington State coastal sediments and estimated that atmospheric transport accounted for about 10 percent of the PAHs in sediment. However, unlike the examination of PCBs in the Great Lakes described above, the authors did not account for the atmospheric contribution to upstream waterborne inputs.

Metals are released to the atmosphere from sources such as primary and secondary metal production and, in the past, use of leaded gasoline. Mass balance studies of metal inputs to the aquatic environment have identified atmospheric deposition as an important contributor, but less significant than riverine and upstream sources. As was the case with the PAH mass balance in Washington, these studies do not identify the atmospheric portion of riverine or upstream sources. In one study, estimates of loadings to Narragansett Bay, Rhode Island, indicated that atmospheric deposition contributes 2 per-

cent of copper and zinc and 33 percent of lead in sediment (Bricker, 1993). Based on a mass balance study on Delaware Bay, direct atmospheric deposition accounts for 7 percent of the cadmium loading to the bay; rivers (72 percent) and salt marshes (21 percent) account for the remaining cadmium input. Some portion of the riverine input originates from the air (USEPA, 1994a).

Atmospheric deposition is a significant source of dioxins and furans found in sediment. These highly persistent compounds are grouped with "other organics" in Figure 4-1. Municipal and industrial waste incineration and residential and industrial wood combustion were both listed as important sources of dioxins and furans to the environment in two recent reviews (Voldner and Smith, 1989 and Johnson et al., 1992, cited in Keeler et al., 1993).

The category "urban sources" refers broadly to runoff from roadways, residential and commercial areas, construction sites, and marinas and shipyards. According to EPA's National Urban Runoff Program (NURP) studies, the principal toxic pollutants found in urban runoff are metals, oil and grease, PAHs, and petroleum hydrocarbons (USEPA, 1992b). Much of the pollution in urban runoff is associated with atmospheric deposition, particularly for mercury and PAHs. Other classes of chemicals, such as metals and petroleum hydrocarbons, have many land-based sources. Lead was formerly contributed by car exhaust, but most contributions now come from exterior paints and industrial runoff. Cadmium is also associated with paints. Zinc is associated with weathering and abrasion of galvanized iron and steel. Car brake linings and leaching and abrasion of copper pipes and brass fittings contribute copper to runoff. Chromium is contributed to runoff through car and machinery corrosion (Cohn-Lee and Cameron, 1991). Sources of petroleum hydrocarbons include disposal of automobile and industrial lubricants, spillage from oil storage facilities, and leakage from motor vehicles (Brown et al., 1985). In addition to agricultural uses, organochlorine pesticides were also used extensively in urban and residential areas for a variety of pest control purposes.

The association of urban sources and metal enrichment of sediment is well documented in the literature. For example, a study of storm water detention ponds in Florida, Virginia, Maryland, and Minnesota found that metal concentrations in surface sediments were typically 5 to 30 times higher than those in the parent soils (Schueler, 1994). This study also reported the highest metal concentrations in ponds associated with industrial land use, followed by those associated with roads

and commercial land use, then those associated with residential land use. In contrast to atmospheric transport, which can carry pollutants far from their original source, runoff of metals tends to affect areas in close proximity to the source. For example, Yousef et al. (1985) sampled water and sediments in detention ponds in Florida and found that metals from highway runoff are retained by bottom sediments close to the point of entry to the waterway.

Hydrocarbons, PAHs, and mercury are also frequently associated with urban sources. Using analytical chemistry techniques, Brown et al. (1985) discovered that crankcase oil was a primary contributor to sediment hydrocarbon contamination in Tampa, Florida. Gas chromatograms of used crankcase oil, storm water runoff, and sediment samples all showed similar peaks, indicating that the type of petroleum found in sediment very closely resembled that found in storm water runoff. Sources of PAHs that are concentrated in urban areas include emissions from commercial and residential fuel-burning furnaces and vehicular emissions. An inventory of sediment contamination in Casco Bay, Maine, showed that the highest PAH concentrations occurred at locations closest to the city of Portland (Kennicutt et al., 1994). Mastran et al. (1994) found that sediments from urban areas tend to have lower fluoranthene/pyrene ratios than those from remote areas. These ratios are indicative of pollution caused by gas exhaust residues in urban runoff. A study of ambient air in the southern Lake Michigan basin revealed that concentrations of mercury, both gaseous and particulate, are significantly higher (approximately 5 times higher) in the Chicago urban/industrial area than levels measured at the same time in surrounding areas (Keeler, 1994, as reported in USEPA, 1994a).

In addition to the nonpoint source categories discussed above, municipal and industrial point sources have been associated with sediment contaminated by each of the chemical classes examined in this report. Much of this contamination has been caused by past industrial and municipal discharges. For example, sediment core samples from southwestern Long Island, New York, revealed levels of metals that increased to several times the preindustrial concentrations, then decreased approximately 50 percent between the mid-1960s and late 1980s. PCBs, chlordane, and other chlorinated organics in sediment also decreased between the late 1960s and the late 1980s. Local improvements in wastewater treatment and national efforts to restrict the use of specific chemicals are cited as explanations for the declines (Bopp et al., 1993). As previously mentioned, past ef-

fluent discharges from electronics manufacturers are linked to PCB contamination in New Bedford Harbor, Massachusetts (Garton et al., 1996; Lake et al., 1992). Perhaps the best example of pesticide contamination in sediment from past industrial activity is kepone in the James River, Virginia. Kepone escaped undetected from a manufacturing site for over 9 years and contaminated miles of the James (Nichols, 1990).

A well-documented case of the effects of point sources on sediment quality is the Newark Bay estuary in New Jersey, which encompasses the Passaic River, Hackensack River, Kill van Kull, and Arthur Kill. Wenning et al. (1994) examined sediment core samples from the lower Passaic River in New Jersey and concluded that the sediment is heavily contaminated with PCBs, PAHs, and metals from recent and historical municipal and industrial discharges from local and upstream sources. The authors identify industrial effluent, either directly discharged or released through combined sewer overflows, as the most likely primary source. Researchers have also measured high levels of dioxin in sediment in the estuary adjacent to an industrial site in Newark where chlorinated phenols had been produced (Bopp et al., 1991). In a recent study, researchers determined that the magnitude of current loading estimates for metals and organics from major sources, such as industrial and municipal discharges and combined sewer overflows, likely exceeds the capacity of the Newark Bay estuary to absorb and dilute the various waste streams (Crawford et al., 1995).

EPA has conducted an inventory and analysis of point source releases of sediment contaminants in the United States. This inventory includes examination of data from effluent monitoring required by discharge permits and chemical release estimates provided by industry under the community right-to-know provision of the Superfund Amendments and Reauthorization Act of 1986 (SARA). Permit monitoring data indicate that municipal sewage treatment plants and major industrial facilities discharge all chemical classes of sediment contaminants. Metals are monitored at the greatest number of facilities and released in the largest amounts. Mercury, PAHs, and other organics are also released from many facilities. PCBs and pesticides are less frequently monitored, and a relatively small number of records indicate positive detections. Industry-supplied release estimates provided under SARA indicate that manufacturing facilities transfer the majority of their sediment contaminants, primarily metals and other organics, to municipal sewage treatment plants. The analysis of these data addresses the potential to adversely affect

sediment quality, but does not indicate whether these discharges actively contribute to documented cases of sediment contamination.

## Land Use Patterns and Sediment Contamination

The characteristics of local sediment contamination are usually related to the types of land use activities that take place or have taken place within the area that drains into the water body (the watershed). The previous section of this chapter provided numerous examples of these relationships from published studies. For this report, EPA examined the relationship between the extent of sediment contamination by chemical class and patterns of land use in the 96 APCs. EPA identified individual watersheds where land use appears to provide important information concerning the types of contaminants present, and summarized general trends that emerge by looking at the percent of urban and agricultural land areas in watersheds.

This analysis was based on a comparison of the extent of contamination by chemical class (described earlier in this chapter) within each watershed to the percent of land area developed for certain uses within the watershed. EPA used the Agency's modeling tool, Better Assessment Science Integrating Point and Nonpoint Sources (BASINS), for spatial analysis to quickly obtain land use data originally compiled by the U.S. Geological Survey (USGS) on a watershed basis. Although these land use data might be as much as 20 years old, the data compiled for the NSI have also been collected over the past 15 years. The original land use data are divided into 10 categories. EPA combined residential, commercial/industrial, and other urban land uses in the "total urban" land use category for this analysis. EPA also combined cropland and other agricultural land/rangeland in a "total agricultural" land use category. This allowed comparison of attributes such as the percent of stations with pesticide contamination and the percent total agricultural land use.

Several difficulties are associated with this approach to comparing land use to the evaluation of NSI sampling stations. First, the frequency and spatial extent of sampling data in the NSI vary by watershed. Second, the acreage of a land use activity is not indicative of the *intensity* of that use. For example, a small amount of land in a watershed might be devoted to an industrial activity that contributes a large amount of pollution. Most watersheds contain at least a small fraction of each

land use activity. There are also problems of scale. Localized problems in specific reaches might be caused by land use activity in the immediate vicinity of the reach rather than the overall land use in the watershed. Lastly, many individual pollutants and chemical classes are associated with multiple types of sources. Some classes of pollutants, like the highly persistent PCBs, have been cycled in the environment for many years and transported far from their original source. These chemicals would not be expected to be associated with any general land use category.

Table 4-2 lists each of the 96 APCs with the number of Tier 1 and Tier 2 stations by chemical class and the percent land use information. In general, EPA found that a diversified set of land uses yields a diversified set of pollutants. However, in some cases a preponderance of one land use type is associated with expected chemical classes of sediment contaminants. For example, the Lower Yakima watershed in Washington, an intensive fruit and vegetable growing region, is approximately 81 percent agricultural and only 2 percent urban. In this watershed, nearly 90 percent of the sampling stations were contaminated with pesticides, whereas no stations exhibited mercury contamination and less than 10 percent exhibited contamination from metals or PAHs. These percentages were substantially different from the average values presented in Figure 4-1. Similar findings were evident in other highly agricultural watersheds, such as the Tulare-Buena Vista Lakes in California.

In some cases, the absence of a particular land use in a watershed can provide clues about the source of in-place contaminants. Some watersheds, such as the Lower Mississippi-New Orleans in Louisiana and the Hackensack-Passaic in New Jersey, have very low agricultural land usage, yet a high percentage of contamination from pesticides. High levels of contaminants in recent sediment deposition may indicate upstream delivery of contaminants, whereas high levels in buried sediment may be indicative of pesticide manufacture/formulation or urban applications in the past. In the Coeur D'Alene watershed in Idaho, there is very little agricultural land use and almost no urban land use. In this watershed, where mining is a known source of contamination, over 90 percent of the stations exhibited metal contamination, whereas none indicated PAH or pesticide contamination. In other watersheds with very low percent urbanization, there was substantial contamination from all chemical classes except PAHs. This phenomenon was evident in several nonurbanized watersheds in the Southeast and upper Midwest, such as Pickwick Lake and Guntersville Lake. Further ex-



**Table 4-2. Tier 1 and Tier 2 Station Classification by Chemical Class and Land Uses in Watersheds Containing Areas of Probable Concern for Sediment Contamination (APCs)**

EPA Reg.	Cataloging Unit #	Name	Number of Stations With a Probability of Adverse Effects									Percent of Total Area in Each Watershed									
			Tier	Mercury	Other Metals	PCBs	Pesticides	PAHs	Other	All Chemicals <sup>a</sup>	Total # of Stations	Residential	Commercial/Industrial	Other Urban	Cropland	Other Agricultural	Forestland	Bays & Estuaries	Other Water	Other	Missing/Unknown
1	01090001	Charles	1	146	68	35	8	11	1	195	708	25.43%	5.95%	4.56%	3.06%	0.04%	39.57%	7.82%	5.86%	1.47%	6.23%
			2	216	486	54	50	50	0	402											
1	01090004	Narragansett	1	8	18	4	3	2	0	28	48	13.74%	3.58%	4.61%	7.41%	0.86%	51.56%	9.96%	6.27%	1.14%	0.88%
			2	20	27	17	18	22	0	20											
1	01090002	Cape Cod	1	6	3	8	1	5	0	15	108	5.90%	0.81%	1.77%	1.84%	4.12%	22.90%	35.05%	4.26%	1.37%	21.98%
			2	27	60	33	33	34	0	73											
2	04120103	Buffalo-Eighteenmile	1	20	7	29	29	43	29	59	101	8.27%	3.54%	3.20%	42.85%	0.10%	30.94%	10.31%	0.35%	0.43%	0.02%
			2	45	79	31	31	17	15	33											
2	02030103	Hackensack-Passaic	1	21	12	13	23	10	4	43	103	33.33%	7.24%	5.65%	2.62%	0.26%	38.99%	0.00%	6.94%	1.33%	3.64%
			2	39	75	34	42	15	19	58											
2	04130001	Oak Orchard-Twelve mile	1	10	20	4	8	4	2	39	86	2.25%	44.43%	1.25%	10.48%	3.29%	8.42%	26.77%	2.78%	0.29%	0.04%
			2	30	61	15	20	12	13	46											
2	02030104	Sandy Hook-Statens Island	1	53	40	19	17	12	20	60	100	30.58%	10.23%	7.70%	6.99%	0.49%	7.83%	13.66%	7.27%	2.22%	13.03%
			2	11	30	9	19	29	5	21											
2	04120104	Niagara	1	5	0	17	13	19	16	24	41	9.35%	32.02%	3.91%	31.59%	0.24%	17.47%	0.02%	3.61%	0.92%	0.87%
			2	16	29	9	11	9	16	16											
2	04150301	Upper St. Lawrence	1	5	0	21	3	8	9	21	31	1.51%	0.85%	1.29%	36.31%	0.75%	28.47%	0.06%	26.73%	0.21%	3.82%
			2	8	17	5	11	6	5	5											
2	02030105	Raritan	1	1	1	4	5	1	1	13	65	15.15%	4.87%	2.99%	25.86%	0.49%	26.55%	0.00%	2.65%	1.01%	20.43%
			2	11	39	25	27	4	3	37											
2	02040301	Mullica-Toms	1	2	0	2	2	1	5	10	42	8.54%	1.71%	1.18%	6.04%	0.52%	43.11%	7.97%	20.75%	2.32%	7.86%
			2	10	24	10	11	15	4	22											
2	02040105	Middle Delaware-Musconetcong	1	1	1	8	1	1	0	11	48	5.49%	1.53%	1.26%	38.02%	0.16%	33.98%	0.00%	2.68%	0.67%	16.22%
			2	3	19	13	20	2	0	26											
2	02030202	Southern Long Island	1	7	4	1	4	1	2	11	43	23.38%	5.03%	5.06%	4.29%	0.74%	10.73%	19.75%	3.26%	1.88%	25.88%
			2	12	25	8	8	14	2	24											
3	02060003	Gunpowder-Patapsco	1	2	3	15	0	1	0	17	29	13.47%	5.10%	4.32%	40.80%	0.11%	26.70%	4.62%	4.11%	0.76%	0.01%
			2	6	19	4	21	7	4	7											
3	02040203	Schuylkill	1	0	1	11	0	0	2	12	44	9.17%	2.68%	2.78%	41.37%	0.26%	25.81%	0.00%	0.65%	2.46%	14.82%
			2	5	16	6	14	0	0	23											
3	05030101	Upper Ohio	1	0	0	12	0	0	0	12	53	13.08%	2.52%	2.18%	35.26%	0.34%	43.13%	0.00%	1.07%	2.42%	0.00%
			2	0	29	0	9	0	1	29											
3	02070004	Conococheague-Opequon	1	0	0	11	0	0	1	11	29	1.88%	0.98%	0.89%	50.58%	1.55%	43.24%	0.00%	0.51%	0.34%	0.02%
			2	2	17	1	13	0	0	12											
3	02040202	Lower Delaware	1	1	1	12	5	1	5	18	57	26.68%	13.51%	6.47%	21.76%	1.90%	18.45%	0.18%	9.61%	1.17%	0.27%
			2	7	23	20	33	2	0	29											
3	05030102	Shenango	1	0	0	11	0	0	0	11	15	3.93%	0.76%	2.20%	74.41%	0.02%	12.85%	0.00%	5.36%	0.44%	0.02%
			2	0	2	0	8	0	0	1											
3	04120101	Chautauqua-Connectaut	1	1	0	18	0	3	4	21	110	4.07%	1.13%	2.05%	38.07%	0.21%	21.58%	31.10%	0.18%	0.21%	1.40%
			2	22	101	15	20	29	13	86											
4	06010201	Watts Bar Lake	1	5	0	58	0	0	1	63	89	9.71%	1.84%	1.29%	27.72%	0.06%	52.32%	0.00%	5.20%	1.87%	0.01%
			2	5	10	2	14	0	1	7											
4	06010207	Lower Clinch	1	46	19	24	0	4	3	61	79	11.76%	1.74%	1.24%	24.98%	0.04%	56.28%	0.00%	2.16%	1.63%	0.16%
			2	11	33	0	7	14	20	14											
4	06030005	Pickwick Lake	1	8	1	45	1	0	0	49	69	1.93%	0.60%	0.33%	40.73%	0.07%	44.51%	0.00%	4.07%	1.35%	6.41%
			2	11	24	2	23	0	2	9											
4	06020001	Middle Tennessee-Chickamauga	1	14	1	16	1	26	7	47	94	8.14%	1.58%	1.19%	19.50%	0.04%	64.76%	0.00%	3.34%	1.44%	0.00%
			2	15	57	1	12	0	9	29											
4	03080103	Lower St. Johns	1	7	0	5	3	22	2	32	188	6.99%	1.71%	1.57%	9.03%	1.72%	51.60%	0.00%	25.04%	1.98%	0.36%
			2	35	76	18	48	57	1	111											

Table 4-2. (Continued)

			Number of Stations With a Probability of Adverse Effects										Percent of Total Area in Each Watershed									
EPA Reg.	Cataloging Unit #	Name	Tier	Mercury	Other Metals	PCBs	Pesticides	PAHs	Other	All Chemicals*	Total # of Stations	Residential	Commercial/ Industrial	Other Urban	Cropland	Other Agricultural	Forestland	Bays & Estuaries	Other Water	Other	Missing/ Unknown	
4	06030001	Guntersville Lake	1	7	1	15	3	0	0	25	92	0.97%	0.33%	0.23%	40.41%	0.05%	52.24%	0.00%	5.18%	0.55%	0.05%	
			2	36	60	0	11	0	0	46												
4	03130002	Middle Chattahoochee-Lake Harding	1	0	1	19	4	0	7	21	27	4.86%	0.77%	0.95%	15.41%	0.12%	75.59%	0.00%	0.98%	1.27%	0.05%	
			2	3	8	3	14	2	2	4												
4	03060106	Middle Savannah	1	11	11	19	3	2	6	20	36	3.75%	1.78%	0.81%	16.90%	0.18%	62.67%	0.00%	12.10%	1.80%	0.00%	
			2	6	10	3	13	2	2	11												
4	03140102	Choctawhatchee Bay	1	0	7	2	9	2	0	19	51	3.04%	4.94%	1.10%	3.03%	0.01%	61.80%	17.57%	3.14%	1.25%	4.13%	
			2	14	32	9	11	15	0	23												
4	06040005	Kentucky Lake	1	0	0	14	0	0	1	15	30	1.25%	0.33%	0.26%	25.78%	0.00%	58.59%	0.00%	13.00%	0.76%	0.03%	
			2	9	25	0	2	0	2	14												
4	06040001	Lower Tennessee-Beech	1	1	0	14	0	0	1	15	25	0.38%	0.12%	0.20%	28.06%	0.01%	65.47%	0.00%	3.01%	1.82%	0.94%	
			2	1	11	0	13	0	0	6												
4	06020002	Hiwassee	1	1	0	12	0	0	2	13	33	2.65%	0.51%	0.58%	18.99%	0.11%	58.13%	0.00%	1.63%	1.77%	15.63%	
			2	6	18	0	6	0	0	17												
4	08010100	Lower Mississippi-Memphis	1	1	1	12	0	0	4	14	20	0.57%	0.88%	0.35%	49.87%	0.06%	21.07%	0.00%	25.08%	2.09%	0.03%	
			2	0	3	2	15	0	0	3												
4	06010104	Holston	1	3	1	10	0	0	2	12	15	4.73%	1.14%	0.45%	44.35%	0.01%	43.72%	0.00%	5.29%	0.30%	0.00%	
			2	3	6	1	4	0	0	2												
4	03040201	Lower Pee Dee	1	1	0	7	5	0	2	11	34	2.02%	0.55%	0.47%	32.03%	0.20%	54.90%	0.01%	9.43%	0.38%	0.01%	
			2	16	16	1	16	1	0	20												
4	03160205	Mobile Bay	1	11	13	2	1	4	0	31	81	4.22%	0.91%	0.97%	2.68%	0.43%	9.60%	18.20%	1.97%	0.33%	60.70%	
			2	14	38	6	16	21	0	43												
4	08030209	Deer-Steele	1	0	0	0	11	0	0	11	21	1.29%	0.57%	0.77%	74.35%	0.91%	18.66%	0.00%	3.34%	0.03%	0.08%	
			2	0	7	0	10	0	0	10												
4	03140107	Perdido Bay	1	8	0	1	0	1	1	10	38	8.04%	2.35%	1.12%	2.59%	0.16%	14.87%	8.08%	4.77%	1.61%	56.39%	
			2	8	15	3	0	9	0	24												
4	03060101	Seneca	1	1	1	9	3	0	0	10	16	0.54%	0.02%	0.02%	0.12%	0.00%	13.24%	0.00%	0.58%	0.36%	85.13%	
			2	1	8	2	1	0	0	3												
5	04090004	Detroit	1	42	21	74	42	53	38	85	115	42.87%	12.65%	8.99%	24.55%	0.18%	5.95%	0.78%	2.29%	1.74%	0.00%	
			2	27	90	31	7	19	17	29												
5	07120003	Chicago	1	21	23	34	18	0	0	64	103	36.16%	19.12%	8.10%	20.63%	0.00%	4.45%	8.76%	1.14%	1.63%	0.00%	
			2	27	52	16	37	0	0	36												
5	07120004	Des Plaines	1	12	4	54	11	0	1	61	110	21.71%	9.97%	6.61%	48.40%	0.31%	7.47%	0.00%	2.04%	3.48%	0.00%	
			2	18	53	24	76	0	0	43												
5	04040003	Milwaukee	1	5	6	43	6	20	14	60	90	11.83%	5.78%	4.20%	66.30%	0.08%	6.64%	0.10%	4.68%	0.41%	0.00%	
			2	22	38	3	32	6	15	16												
5	04030204	Lower Fox	1	21	3	41	8	5	5	49	51	8.94%	5.28%	2.88%	76.15%	0.04%	3.43%	0.11%	2.19%	0.98%	0.00%	
			2	5	27	1	16	14	19	2												
5	04040001	Little Calumet-Galien	1	10	14	40	9	7	10	45	89	7.34%	6.16%	2.59%	37.11%	0.22%	12.87%	30.51%	2.12%	1.08%	0.00%	
			2	24	48	6	12	0	3	26												
5	04040002	Pike-Root	1	5	4	28	3	1	1	34	72	12.02%	5.19%	4.10%	33.68%	0.04%	0.93%	43.58%	0.18%	0.29%	0.00%	
			2	16	40	11	16	3	3	30												
5	07140201	Upper Kaskaskia	1	0	0	23	14	0	0	31	55	1.19%	0.39%	0.69%	90.79%	0.02%	5.83%	0.00%	1.05%	0.04%	0.00%	
			2	4	8	6	38	0	0	24												
5	07010206	Twin Cities	1	0	0	26	0	0	0	26	35	21.99%	5.24%	5.12%	48.03%	0.03%	4.39%	0.00%	14.24%	0.95%	0.00%	
			2	1	2	0	5	0	1	2												
5	07140106	Big Muddy	1	2	2	20	0	0	0	23	94	1.96%	0.91%	0.66%	70.37%	0.51%	20.43%	0.00%	3.60%	1.56%	0.00%	
			2	14	61	13	39	0	0	65												
5	07070003	Castle Rock	1	0	0	20	0	0	2	20	22	1.05%	0.53%	0.55%	40.77%	0.05%	37.43%	0.00%	18.97%	0.64%	0.00%	
			2	2	1	0	5	0	0	0												

Table 4-2. (Continued)

			Number of Stations With a Probability of Adverse Effects									Percent of Total Area in Each Watershed									
EPA Reg.	Cataloging Unit #	Name	Tier	Mercury	Other Metals	PCBs	Pesticides	PAHs	Other	All Chemicals <sup>a</sup>	Total # of Stations	Residential	Commercial/ Industrial	Other Urban	Cropland	Other Agricultural	Forestland	Bays & Estuaries	Other Water	Other	Missing/ Unknown
5	04100002	Raisin	1 2	1 2	0 7	17 17	7 13	1 2	0 6	18 19	38	2.25%	1.00%	0.74%	87.13%	0.15%	5.46%	0.01%	2.90%	0.35%	0.00%
5	04050001	St. Joseph	1 2	0 0	1 18	3 0	7 5	7 2	3 6	17 9	32	3.08%	1.42%	1.02%	79.21%	1.25%	9.23%	0.03%	4.45%	0.31%	0.00%
5	07040003	Buffalo-Whitewater	1 2	0 1	0 2	17 0	0 6	0 0	0 0	17 3	26	0.74%	0.29%	0.40%	54.93%	0.05%	37.00%	0.00%	6.50%	0.08%	0.00%
5	04110001	Black-Rocky	1 2	2 23	0 54	12 7	7 4	21 2	9 1	24 31	59	11.18%	2.79%	4.40%	66.45%	0.20%	11.11%	3.20%	0.38%	0.29%	0.00%
5	07120006	Upper Fox	1 2	0 12	0 37	15 14	0 27	0 0	0 0	15 40	60	10.36%	2.44%	2.38%	63.18%	0.61%	10.84%	0.00%	7.42%	2.77%	0.00%
5	05120111	Middle Wabash-Busseron	1 2	7 9	0 23	9 8	0 30	0 0	0 0	15 17	33	2.49%	0.92%	1.02%	79.64%	0.09%	13.31%	0.00%	1.50%	1.03%	0.00%
5	07140202	Middle Kaskaskia	1 2	1 4	0 16	5 6	8 22	0 0	0 0	13 22	38	1.21%	0.40%	0.60%	78.52%	0.09%	16.06%	0.00%	3.01%	0.10%	0.00%
5	07040001	Rush-Vermilion	1 2	0 2	0 3	13 0	0 3	0 0	1 0	13 1	14	1.38%	0.59%	0.44%	80.68%	0.06%	9.43%	0.00%	7.07%	0.34%	0.00%
5	05120109	Vermilion	1 2	8 2	0 19	4 1	0 26	0 0	0 0	12 16	28	3.92%	1.00%	0.73%	90.08%	0.10%	3.51%	0.00%	0.15%	0.50%	0.00%
5	04030108	Menominee	1 2	5 8	4 7	5 1	0 2	2 7	1 0	12 6	21	0.55%	0.17%	0.29%	10.13%	0.01%	67.58%	0.01%	20.94%	0.31%	0.01%
5	04090002	Lake St. Clair	1 2	1 10	2 13	10 6	8 8	5 8	9 5	13 5	19	18.44%	3.81%	2.35%	28.70%	0.00%	3.60%	38.06%	4.87%	0.17%	0.00%
5	07140101	Cahokia-Joachim	1 2	4 8	1 25	11 11	2 41	0 0	5 0	18 34	56	10.64%	4.50%	4.32%	42.42%	0.11%	33.25%	0.00%	3.85%	0.92%	0.00%
5	04100010	Cedar-Portage	1 2	3 24	0 46	3 0	3 4	3 15	3 9	13 39	56	1.85%	1.28%	1.44%	73.80%	0.07%	1.56%	17.41%	2.10%	0.49%	0.00%
5	04100001	Ottawa-Stony	1 2	0 5	1 16	12 3	3 10	4 3	3 7	13 15	29	6.73%	2.43%	2.93%	75.57%	0.30%	6.19%	3.84%	1.12%	0.89%	0.00%
5	07130001	Lower Illinois-Senachwine Lake	1 2	3 6	0 12	8 9	0 15	0 0	0 0	11 10	21	2.04%	1.04%	0.51%	82.55%	0.04%	8.96%	0.00%	4.04%	0.82%	0.00%
5	04030102	Door-Kewaunee	1 2	0 0	0 8	12 0	0 6	0 2	0 0	12 5	20	0.77%	0.35%	0.46%	38.47%	0.87%	10.63%	42.55%	5.63%	0.25%	0.00%
5	04060103	Manistee	1 2	2 7	1 11	3 11	2 12	10 4	0 7	11 3	14	0.45%	0.20%	0.30%	17.77%	0.14%	73.75%	0.00%	6.82%	0.57%	0.00%
5	05040001	Tuscarawas	1 2	0 0	8 55	1 0	2 4	0 2	0 4	10 53	78	10.00%	1.64%	1.71%	53.74%	0.04%	30.05%	0.00%	0.97%	1.85%	0.00%
5	07090006	Kishwaukee	1 2	0 1	0 12	10 4	0 34	0 0	0 0	10 24	34	2.25%	1.05%	0.99%	91.45%	0.38%	2.99%	0.00%	0.30%	0.58%	0.00%
5	04100012	Huron-Vermilion	1 2	0 21	0 45	5 3	0 0	0 17	5 5	10 35	45	1.63%	0.54%	0.91%	85.38%	0.17%	6.86%	3.93%	0.27%	0.27%	0.04%
5	04110003	Ashtabula-Chagrin	1 2	5 5	5 23	9 5	1 5	2 6	7 7	10 18	31	18.31%	3.14%	5.37%	39.91%	0.06%	27.41%	4.86%	0.63%	0.30%	0.01%
6	08080206	Lower Calcasieu	1 2	12 18	2 35	4 5	2 6	11 15	10 13	26 52	100	2.75%	2.01%	0.44%	30.87%	0.21%	4.37%	0.00%	54.19%	0.50%	4.67%
6	08090100	Lower Mississippi-New Orleans	1 2	3 11	0 48	9 30	1 40	3 34	1 1	16 34	51	3.09%	2.26%	0.73%	1.70%	0.03%	1.54%	16.26%	39.49%	0.53%	34.37%
6	11070209	Lower Neosho	1 2	0 0	0 2	13 0	0 13	0 0	0 0	13 3	20	0.34%	0.02%	0.05%	4.48%	0.01%	3.35%	0.00%	1.08%	0.02%	90.65%
6	08040207	Lower Ouachita	1 2	0 5	0 11	1 0	11 0	0 0	1 0	12 0	12	3.38%	0.53%	0.51%	30.43%	0.12%	52.72%	0.00%	8.96%	3.36%	0.00%

Table 4-2. (Continued)

EPA Reg.	Cataloging Unit #	Name	Number of Stations With a Probability of Adverse Effects									Percent of Total Area in Each Watershed									
			Tier	Mercury	Other Metals	PCBs	Pesticides	PAHs	Other	All Chemicals <sup>a</sup>	Total # of Stations	Residential	Commercial/Industrial	Other Urban	Cropland	Other Agricultural	Forestland	Bays & Estuaries	Other Water	Other	Missing/Unknown
6	12040104	Buffalo-San Jacinto	1	0	1	9	3	1	3	10	36	23.31%	7.07%	6.32%	45.96%	0.06%	13.38%	0.04%	2.97%	0.80%	0.08%
			2	14	26	15	14	11	3	23											
7	10270104	Lower Kansas	1	0	1	11	0	0	1	12	29	3.70%	1.82%	1.83%	82.75%	0.91%	7.67%	0.00%	0.92%	0.40%	0.00%
			2	1	14	0	22	1	3	15											
7	11070207	Spring	1	0	0	8	0	1	2	10	41	1.84%	0.67%	0.79%	80.42%	0.12%	14.27%	0.00%	0.19%	1.70%	0.01%
			2	1	29	1	7	0	1	25											
7	07080101	Copperas-Duck	1	1	1	17	0	0	1	17	27	5.40%	2.53%	1.58%	68.60%	0.18%	9.58%	0.00%	9.04%	0.54%	2.55%
			2	1	7	0	18	1	2	5											
9	18070304	San Diego	1	18	4	33	13	7	2	53	107	11.02%	4.09%	2.72%	6.92%	54.85%	9.62%	1.36%	0.86%	1.98%	6.60%
			2	26	93	45	47	39	4	51											
9	18070104	Santa Monica Bay	1	15	6	22	66	4	1	79	132	17.03%	7.90%	2.86%	1.18%	20.81%	0.68%	0.41%	0.20%	0.96%	47.95%
			2	33	94	34	22	18	3	31											
9	18070201	Seal Beach	1	5	0	8	23	2	32	63	442	41.18%	22.80%	4.68%	4.98%	0.12%	0.00%	0.75%	1.15%	1.27%	23.05%
			2	38	211	142	288	30	182	339											
9	18050003	Coyote	1	14	8	0	0	0	0	18	24	20.29%	9.69%	9.13%	6.07%	23.27%	27.93%	1.58%	1.38%	0.66%	0.01%
			2	8	12	1	0	1	0	6											
9	18070204	Newport Bay	1	10	0	1	11	0	2	24	108	19.51%	13.49%	6.60%	18.96%	28.16%	0.25%	1.09%	0.91%	3.33%	7.69%
			2	13	62	19	48	8	25	68											
9	18050004	San Francisco Bay	1	10	9	1	0	5	0	19	64	12.06%	7.21%	3.48%	4.43%	27.36%	28.64%	14.20%	1.98%	0.65%	0.00%
			2	33	41	18	19	21	0	37											
9	18070105	Los Angeles	1	4	0	2	8	3	0	14	37	38.36%	13.78%	6.51%	1.31%	31.59%	6.65%	0.02%	0.30%	1.46%	0.01%
			2	16	33	4	10	5	1	19											
9	18030012	Tulare-Buena Vista Lake s	1	0	0	1	10	1	1	10	20	1.76%	1.53%	0.70%	55.36%	38.72%	0.90%	0.00%	0.74%	0.26%	0.03%
			2	1	5	4	5	0	0	5											
9	18070107	San Pedro Channel Islands	1	7	2	2	10	0	0	14	25	0.00%	0.08%	0.01%	0.00%	2.59%	0.00%	0.02%	0.00%	0.18%	97.12%
			2	3	22	6	3	4	3	10											
9	18070301	Aliso-San Onofre	1	5	2	0	5	0	0	10	32	3.18%	1.26%	1.22%	4.37%	60.80%	5.39%	0.03%	0.26%	1.49%	22.01%
			2	7	29	9	7	2	0	22											
10	17110019	Puget Sound	1	98	52	146	37	296	32	418	1383	12.36%	2.12%	2.05%	3.75%	0.32%	41.35%	34.95%	2.62%	0.48%	0.00%
			2	449	1116	317	106	490	317	851											
10	17110013	Duwamish	1	0	3	34	3	12	6	48	127	12.99%	2.97%	4.23%	6.82%	0.55%	70.85%	0.00%	0.96%	0.63%	0.00%
			2	27	107	10	17	58	23	69											
10	17110002	Strait of Georgia	1	16	1	1	4	12	4	32	263	4.22%	0.75%	1.22%	10.95%	0.46%	28.13%	51.38%	2.61%	0.20%	0.07%
			2	51	180	15	34	73	28	168											
10	17030003	Lower Yakima	1	0	0	5	19	0	1	23	47	1.13%	0.52%	0.26%	25.97%	55.06%	15.65%	0.00%	1.23%	0.17%	0.01%
			2	0	4	0	23	1	10	19											
10	17090012	Lower Willamette	1	1	0	13	10	5	4	21	76	31.21%	6.41%	4.69%	13.32%	0.97%	39.03%	0.00%	3.77%	0.61%	0.00%
			2	12	51	24	18	11	15	51											
10	17110014	Puyallup	1	0	3	1	0	8	1	12	19	5.85%	0.55%	0.79%	3.78%	4.44%	81.43%	0.00%	0.68%	2.47%	0.01%
			2	0	8	6	1	9	6	6											
10	17010303	Coeur D'Alene Lake	1	1	8	2	0	0	0	10	23	0.73%	0.13%	0.42%	12.68%	0.65%	75.10%	0.00%	10.14%	0.14%	0.00%
			2	1	13	0	0	0	0	13											

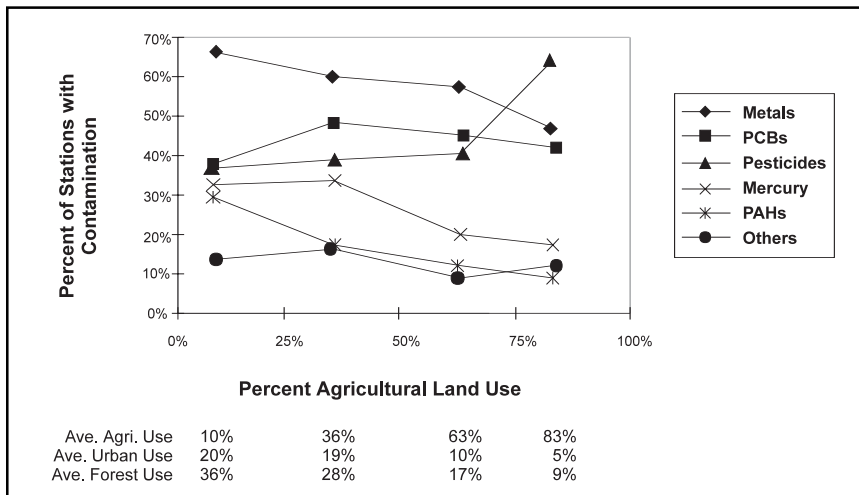
<sup>a</sup>Because of the numerous chemicals monitored at each station, the total in this column is not equal to the sum of the numbers in the columns for the different chemical classes.

<sup>b</sup>Adapted from USGS land use and land cover classification system for use with remote sensor data.

amination of percent agricultural and urban land use revealed some general trends that are illustrated by these examples.

A high percentage of agricultural land use in a watershed tended to correspond with a markedly higher percent contamination from pesticides and lower percent contamination from metals, mercury, and PAHs. This phenomenon is presented graphically in Figure 4-2 and in tabular form on Table 4-3. For this analysis, EPA grouped watersheds into quartiles based on percent total agricultural land use and calculated the average percent of sampling stations with contamination by chemical class. Some general trends that would be expected were clearly evident. In watersheds with greater than 75 percent of the land devoted to agriculture, pesticide contamination jumped from under 40 percent of all stations to 64 percent. In contrast, metal, mercury, and PAH contamination all steadily decreased, with all three classes exhibiting a percent contamination in the over 75 percent agriculture group at least 10 percentage points under the overall average for each class. PCBs and other organics did not exhibit any trend and never varied more than 5 percentage points from the overall average.

In contrast, increasingly higher percentages of urban land use in watersheds correlated with steadily increasing contamination from most chemical classes. Figure 4-3 and Table 4-4 present the results of a trend analysis for total urban land use. For this analysis, EPA placed watersheds into groups of under 5 percent urban area, 5 to 10 percent urban area, 10 to 20 percent urban area, and greater than 20 percent urban area to best illustrate trends. The percent PAH and metal contamination were both 10 percentage points under the overall average for the least urbanized watershed group, then rose sharply as the proportion of urban area crossed the 5 percent threshold. The extent of metal contamination rose to an average of 71 percent, more than 10 percentage points above the overall average of 59 percent, in



**Figure 4-2. Percent Tier 1 and Tier 2 Stations vs. Agricultural Land Use in APCs.**

**Table 4-3. Comparison of Percent Agricultural Land Use in Watersheds Containing APCs to Percent of Tier 1 and Tier 2 Stations by Chemical Class**

	Percent Total Agricultural Land Area				
	<25%	25-50%	50-75%	>75%	Overall Average
Average Percent Agricultural Land Area in Group	10%	36%	63%	83%	39%
Number of Watersheds in Group	32	34	13	17	
Metals	66%	60%	58%	47%	59%
PCBs	38%	48%	45%	42%	43%
Pesticides	37%	39%	40%	64%	43%
Mercury	32%	34%	20%	18%	29%
PAHs	30%	17%	12%	9%	19%
Others	13%	16%	9%	12%	14%

watersheds with more than 20 percent total urban land use. Mercury contamination rose steadily and reached a peak of 40 percent in the most heavily urbanized watersheds. The mercury and PAH trends perhaps illustrate the effect of atmospheric deposition from local urban sources. Contamination from other organics also rose steadily, but never varied more than 6 percentage points from the overall average. Pesticide contamination initially decreased as percent urbanization increased, but it rose more than 10 percentage points from the 10 to 20 percent urban group to the over 20 percent urban group. As mentioned previously, this may reflect upstream delivery of contaminants, pesticide manufacture or formulation, or urban applications in the past. As was the case with the agriculture analysis, the average percent PCB contamination for the urban groups showed no trend and never varied substantially from the overall average.

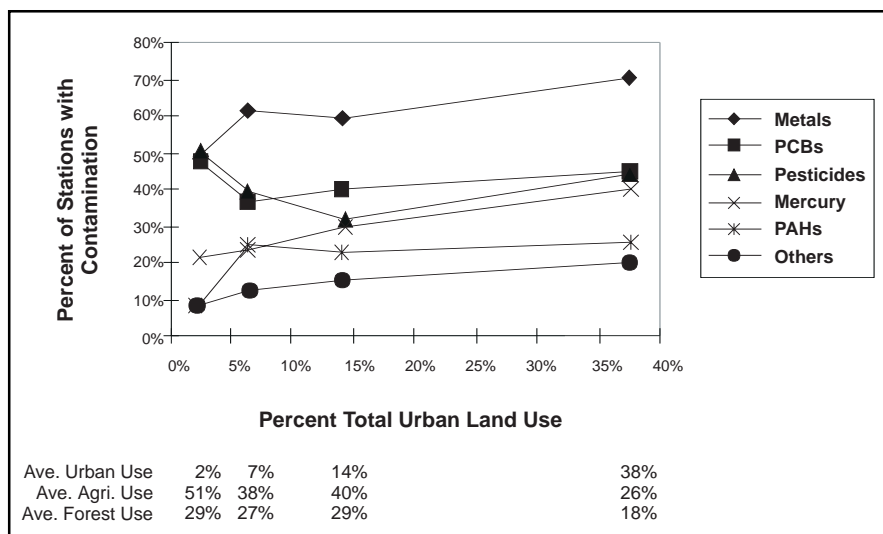


Figure 4-3. Percent Tier 1 and Tier 2 Stations vs. Urban Land Use in APCs.

Table 4-4. Comparison of Percent Urban Land Use in Watersheds Containing APCs to Percent of Tier 1 and Tier 2 Stations by Chemical Class

	Percent Total Urban Land Area				
	<5%	5-10%	10-20%	>20%	Overall Average
Average Percent Urban Land Area in Group	2%	7%	14%	38%	16%
Number of Watersheds in Group	32	18	19	27	
Metals	49%	61%	59%	71%	59%
PCBs	47%	37%	40%	45%	43%
Pesticides	50%	39%	32%	44%	43%
Mercury	21%	24%	30%	40%	29%
PAHs	9%	25%	23%	25%	19%
Others	8%	12%	15%	20%	14%

## EPA's Point and Nonpoint Source Sediment Contaminant Inventories

As part of the National Sediment Inventory (NSI) and mandate under the Water Resources Development Act (WRDA) of 1992, EPA is conducting inventories of point and nonpoint sources of sediment contaminants.

The objective of the point source assessment component of the NSI is to compile available data regarding the purposeful discharge of sediment contaminants from industrial facilities and municipal sewage treatment plants and to determine the potential to adversely affect sediment quality by chemical class, watershed, and industrial category. EPA has produced the *National Sediment Contaminant Point Source Inventory*

based on 1994 permit monitoring records in EPA's Permit Compliance System (PCS) and chemical release estimates in the 1993 Toxic Release Inventory (TRI). The report presents a screening analysis to identify probable point source contributors of sediment pollutants based on release amount, chemical toxicity, and inherent physical/chemical properties of the contaminant. The report serves as Volume 3 of the complete report to Congress on the incidence and severity of sediment contamination in surface waters of the United States. As previously stated, discharge limits for point sources are not necessarily protective of downstream sediment quality. The Agency believes an effective source control strategy should focus on areas at greatest risk on a watershed scale. The report identifies 29 watersheds among the 96 APCs where the potential for point source contribution to sediment contamination is the greatest.

The objective of the non-point source assessment component of the NSI is to prepare a nationwide assessment of annual nonpoint source contributions of selected sediment

contaminants on a watershed basis. Given the number and diversity of nonpoint sources, the Agency is focusing its initial efforts on four major categories: harvested croplands, urban areas, atmospheric deposition, and inactive and abandoned mine sites (where information is available). Although these nonpoint sources do not constitute the full range of sediment contaminant sources, they are frequently cited in the scientific literature as significant sources of mercury, PCBs, PAHs, metals, pesticides, and other organic compounds.

The nonpoint source assessment is intended to be a screening-level study that begins to correlate contaminated sediment locations with suspected sources of these contaminants. As part of this assessment, EPA is compiling data from the Bureau of the Census, the U.S.

Department of Agriculture, the U.S. Department of the Interior's U.S. Geological Survey and Bureau of Mines, and others. EPA will compile information and data concerning these nonpoint source activities to identify watersheds for further investigation and assessment.

Given the breadth of nonpoint sources, EPA anticipates that the process of conducting future assessments

will be iterative. Additional nonpoint sources will be added to the inventory to discriminate more fully between contaminant types and known sources and to characterize their proximity to known or suspected contaminated sediment sites. This iterative process will allow EPA to identify regions of the country where nonpoint sources are known to exist, but data on sediment quality are either limited or lacking.

