

January 2013

WATER QUALITY

EPA Faces Challenges in Addressing Damage Caused by Airborne Pollutants



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Why GAO Did This Study

Atmospheric deposition, a process that transfers pollutants, including NO_x, SO₂, and mercury, from the air to the earth's surface, can significantly impair the quality of the nation's waters. EPA can potentially address atmospheric deposition through the CWA and the CAA, but concerns have been raised about its ability to do so. GAO was asked to examine EPA's efforts to address atmospheric deposition of pollutants that impair waterbodies. This report examines (1) the extent to which atmospheric deposition of NO_x, SO₂, and mercury contributes to the impairment of the nation's waters and identify the key sources of these pollutants; (2) the regulatory tools that EPA uses under the CWA to address the effects of atmospheric deposition, and the challenges, if any, that it faces in doing so; and (3) the regulatory tools that EPA uses under the CAA to address the effects of atmospheric deposition, and the challenges, if any, that it faces in doing so. To conduct this work, GAO reviewed EPA data, reports, and activities and interviewed agency officials and other experts.

What GAO Recommends

GAO recommends that EPA determine whether EPA can obtain in a timely manner the data it needs to establish secondary NAAQS adequate to protect against the effects of acid rain and, if not, identify alternative strategies to do so. EPA agreed with GAO's recommendation.

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What GAO Found

Atmospheric deposition of nitrogen oxides (NO_x), sulfur dioxide (SO₂), and mercury contributes to the impairment of the nation's waters, but the full extent is not known. For example, states provide EPA with data on the extent to which their waterbodies do not meet water quality standards, and some states have reported that some of their waterbodies are polluted because of atmospheric deposition. However, the states have not assessed all of their waterbodies and are not required to report on the sources of pollution. Similarly, federal studies show that atmospheric deposition of NO_x, SO₂, and mercury is polluting waterbodies but have data for only some waters. The main sources of NO_x and SO₂ are cars and other forms of transportation and coal-burning power plants. Power plants are also the largest U.S. source of mercury emissions, but international sources also contribute to the mercury deposited in U.S. waters.

EPA has sought to address atmospheric deposition through Clean Water Act (CWA) programs but faces challenges in doing so. Specifically, states typically establish water quality standards—considering EPA recommended criteria—for each waterbody. If a waterbody does not meet standards, CWA generally requires the state to set a Total Maximum Daily Load (TMDL) that identifies the maximum amount of pollutant that can enter the waterbody and still meet standards. States are responsible for taking actions to ensure the TMDL is met. For point sources of pollution, such as a pipe from a sewer treatment plant, CWA requires new or renewed permits to be consistent with the TMDL. However, there is no similar statutory requirement for nonpoint sources of pollution, such as atmospheric deposition. States may take actions, such as providing technical or financial assistance to limit pollution from nonpoint sources, but face a challenge when atmospheric deposition pollution affecting their waters originates in emissions from a different state.

EPA has also sought to address atmospheric deposition through Clean Air Act (CAA) regulations but faces challenges in doing so. EPA issued regulations that reduced emissions of NO_x, SO₂, and mercury and in turn the amount of pollution in waterbodies. Even with reduced emissions, NO_x, SO₂, and mercury continue to pollute the nation's waterbodies. EPA's recent attempt to address atmospheric deposition by establishing secondary National Ambient Air Quality Standards (NAAQS)—standards to protect public welfare—targeting the effects of acid rain caused by NO_x and SO₂ on water bodies was not successful. EPA stated that uncertainty regarding atmospheric modeling and limitations in available data prevented determination of secondary NAAQS adequate to protect against the effects of acid rain, and the agency has not identified alternative strategies. EPA has begun a 5-year pilot program to gather additional scientific data, but it is unclear whether or when the agency will be able to address scientific uncertainties to enable adoption of a protective secondary NAAQS. EPA also did not set secondary NAAQS to address nutrient over-enrichment in aquatic ecosystems caused by NO_x because of the limited available scientific data. Many sources of nitrogen can contribute to nutrient over-enrichment in a waterbody, including sources of nitrogen unrelated to atmospheric deposition. EPA recently announced an effort that is to lead to the development of an integrated nitrogen research strategy that includes approaches to reducing atmospheric deposition of NO_x into waters impaired because of nutrient over-enrichment by nitrogen.

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Abbreviations

ATTAINS	Assessment, TMDL Tracking, and Implementation System
EPA	Environmental Protection Agency
CAA	Clean Air Act
CENRS	Committee on Environment, Natural Resources, and Sustainability
CWA	Clean Water Act
MACT	maximum achievable control technology
MATS	Mercury and Air Toxics Standards
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NAPAP	National Acid Precipitation Assessment Program
NEIWPC	New England Interstate Water Pollution Control Commission
NESCAUM	Northeast States for Coordinated Air Use Management
NLFA	National Listing of Fish Advisories
NOAA	National Oceanic and Atmospheric Administration
NO _x	nitrogen oxides
NPDES	National Pollution Discharge Elimination System
NSTC	National Science and Technology Council
NYSDEC	New York State Department of Environmental Conservation
PCBs	polychlorinated biphenyls
SO ₂	sulfur dioxide
SO ₄	sulfate
TMDL	Total Maximum Daily Load
UNEP	United Nations Environment Programme

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United States Government Accountability Office
Washington, DC 20548

January 24, 2013

The Honorable Timothy H. Bishop
Ranking Member
Subcommittee on Water Resources and the Environment
Committee on Transportation and Infrastructure
House of Representatives

The Honorable Eddie Bernice Johnson
House of Representatives

Atmospheric deposition—a process that transfers pollutants from the air to the earth’s surface—can significantly impair water quality in the nation’s rivers, lakes, bays, and estuaries, and harm human health and aquatic ecosystems. In particular, airborne pollutants can fall to the ground in precipitation or as a gas or particle and be deposited either directly onto the surface of a waterbody or onto land and then transported into a waterbody through runoff. Three airborne pollutants commonly associated with atmospheric deposition are nitrogen oxides (NO_x), sulfur dioxide (SO₂), and mercury. NO_x and SO₂—which cause acid rain—threaten certain aquatic ecosystems, especially in lakes and streams in higher altitudes. In addition, NO_x contributes to nutrient over-enrichment in estuaries, which can result in oxygen depleted areas known as “dead zones,” where fish and other organisms cannot survive. Once in water, mercury becomes concentrated in fish and can harm the health of individuals who consume these fish, particularly children.

Because these pollutants are transferred from air to water, the Environmental Protection Agency (EPA), whose mission is to protect human health and the environment, can potentially address atmospheric deposition through the Clean Water Act (CWA) and the Clean Air Act (CAA).¹ The CWA provides EPA with responsibilities aimed at maintaining and improving the quality of the nation’s waters, including the

¹The Federal Water Pollution Control Act Amendments of 1972, Pub. L. No. 92-500, § 2, 86 Stat. 816 (amending the Act of June 30, 1948, ch. 758, 62 Stat. 1155) (*codified as further amended at* 33 U.S.C. ch. 26 §§ 1251-1387 (2012) and commonly referred to as the Clean Water Act); Clean Air Act Amendments of 1970, Pub. L. No. 91-604, 84 Stat. 1676 (1970) (*codified as amended at* 42 U.S.C. §§ 7401-7671q (2011) (commonly referred to as the Clean Air Act).

responsibility to establish recommended water quality criteria for specific pollutants. Authorized states, territories, and tribes—collectively referred to as states in this report—then use these recommended criteria along with designated uses and antidegradation provisions to establish state-specific water quality standards. States then apply these standards to individual waterbodies.² If a waterbody does not meet water quality standards, these entities are to establish a pollutant “budget”—or a total maximum daily load (TMDL)—at a level that ensures that applicable water quality standards can be met and maintained.³ Once a TMDL is established, states are generally responsible for implementation, while EPA and states share responsibility to ensure that permitted discharges to a waterbody do not exceed the level established by the TMDL. Analogous to the CWA, the CAA provides EPA with tools for regulating the emissions of pollutants into the air. Among the pollutants that EPA regulates in certain emissions are NO_x, SO₂, and mercury.

EPA and others have recognized atmospheric deposition as a contributing factor to degraded water quality for several decades. However, congressional concerns have been raised about EPA’s ability to address atmospheric deposition. In this context, you asked us to review EPA’s efforts to address the atmospheric deposition of pollutants that impair the water quality and aquatic ecosystems of the nation’s rivers, lakes, and bays. Specifically, our objectives were to examine (1) the extent to which atmospheric deposition of NO_x, SO₂, and mercury contributes to the impairment of the nation’s waters and identify the key sources of these pollutants; (2) the regulatory tools that EPA uses under CWA to address the effects of atmospheric deposition, and the challenges, if any, that it faces in doing so; and (3) the regulatory tools that EPA uses under the CAA to address the effects of atmospheric deposition, and the challenges, if any, that it faces in doing so.

To examine the extent to which atmospheric deposition of NO_x, SO₂, and mercury impairs waters, we analyzed the most recently available data from EPA’s Assessment, TMDL Tracking, and Implementation System

²The water quality standard for a water body consists of three components: criteria, designated uses, and antidegradation provisions.

³TMDL is a calculation of the maximum amount of a pollutant that a body of water can receive and still meet water quality standards. TMDLs allocate or apportion the “budget” among the various sources, including permitted dischargers as well as nonpoint sources of pollution, or polluted runoff.

(ATTAINS), a database containing state-reported information on the extent to which waterbodies meet water quality standards. To assess the reliability of its data, we interviewed knowledgeable agency officials and conducted electronic testing of the data. We determined that although the data have limitations, they were sufficiently reliable to present reported atmospheric deposition impairment on assessed waters for selected categories of water bodies. We also reviewed studies from EPA and others to further examine the extent to which atmospheric deposition is contributing to the impairment of the nation's waters. We assessed the reliability and methodology of these studies, including limitations and assumptions, and determined that they were sufficiently reliable for the purposes of examining the extent to which atmospheric deposition is contributing to the impairment of the nation's waters. To identify key sources of NO_x, SO₂, and mercury emissions, we used estimates from EPA's 2008 National Emissions Inventory (version 2)—a national database of sources and amounts of pollution emissions. We also interviewed officials and scientists from EPA and the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA); and academic, state, and private sector scientists.

To examine tools EPA uses under the CWA to address atmospheric deposition and the challenges it faces, we reviewed the law, relevant EPA regulations and guidance, and other pertinent documents and interviewed relevant EPA and state officials. We chose to examine a nonprobability sample of three TMDLs in greater detail—the Northeast Regional TMDL for mercury atmospheric deposition, a New York State TMDL for acid rain in the Adirondacks, and the Chesapeake Bay TMDL for nitrogen atmospheric deposition—to illustrate challenges.⁴ We selected each TMDL to represent a different effect caused by the atmospheric deposition of the three pollutants on which we are focusing. The three effects are acid rain, nutrient over-enrichment, and mercury contamination. We examined key documents about these TMDLs and interviewed EPA and state and regional officials responsible for developing and implementing them.

⁴Because we selected a nonprobability sample, our analysis is not generalizable to all TMDLs but can illustrate the challenges faced by EPA in using this tool.

Likewise, to examine the tools EPA uses under the CAA to address atmospheric deposition and the challenges it faces, we reviewed the law, relevant EPA regulations and guidance, and other pertinent documents and interviewed relevant EPA officials. We used data from the 2008 National Emissions Inventory (version 2), a 2011 peer-reviewed EPA study that estimates the benefits and costs of the CAA amendments of 1990,⁵ and other information to identify reductions in NO_x, SO₂, and mercury that EPA has attributed to the CAA and the associated beneficial effects on water quality. We assessed the reliability and methodology of these sources of information, including limitations and assumptions, and determined that they were sufficiently reliable for the purposes of attributing estimates of some reductions in NO_x, SO₂, and mercury to the CAA. To understand the challenges that EPA faced in trying to develop an air quality standard to protect ecosystems sensitive to the effects of acid rain, we reviewed documentation developed as part of the rule making process and interviewed knowledgeable officials responsible for the rulemaking. To understand EPA's integrated nitrogen research strategy, we reviewed pertinent documents and interviewed relevant EPA officials. Appendix I presents a more detailed description of our scope and methodology.

We conducted this performance audit from September 2011 to January 2013 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

⁵U.S. Environmental Protection Agency, Office of Air and Radiation, *The Benefits and Costs of the Clean Air Act from 1990 to 2020*, Final Report (Washington, D.C.: March 2011).

Background

This section discusses atmospheric deposition, its effect on waterbodies, and how the CWA and the CAA address it.⁶

Atmospheric Deposition Is the Transfer of Air Pollution to the Earth's Surface

Air pollution can be carried through the atmosphere and deposited on land, water, or man-made structures in a process known as atmospheric deposition. The pollutants can get into waterbodies through either direct deposition or indirect deposition as follows:

- Direct deposition occurs when air pollutants are deposited directly onto a waterbody; and
- indirect deposition occurs when air pollutants are deposited onto the watershed—the area of land surrounding the waterbody—and are transported to the waterbody through runoff, rivers, streams, and groundwater.

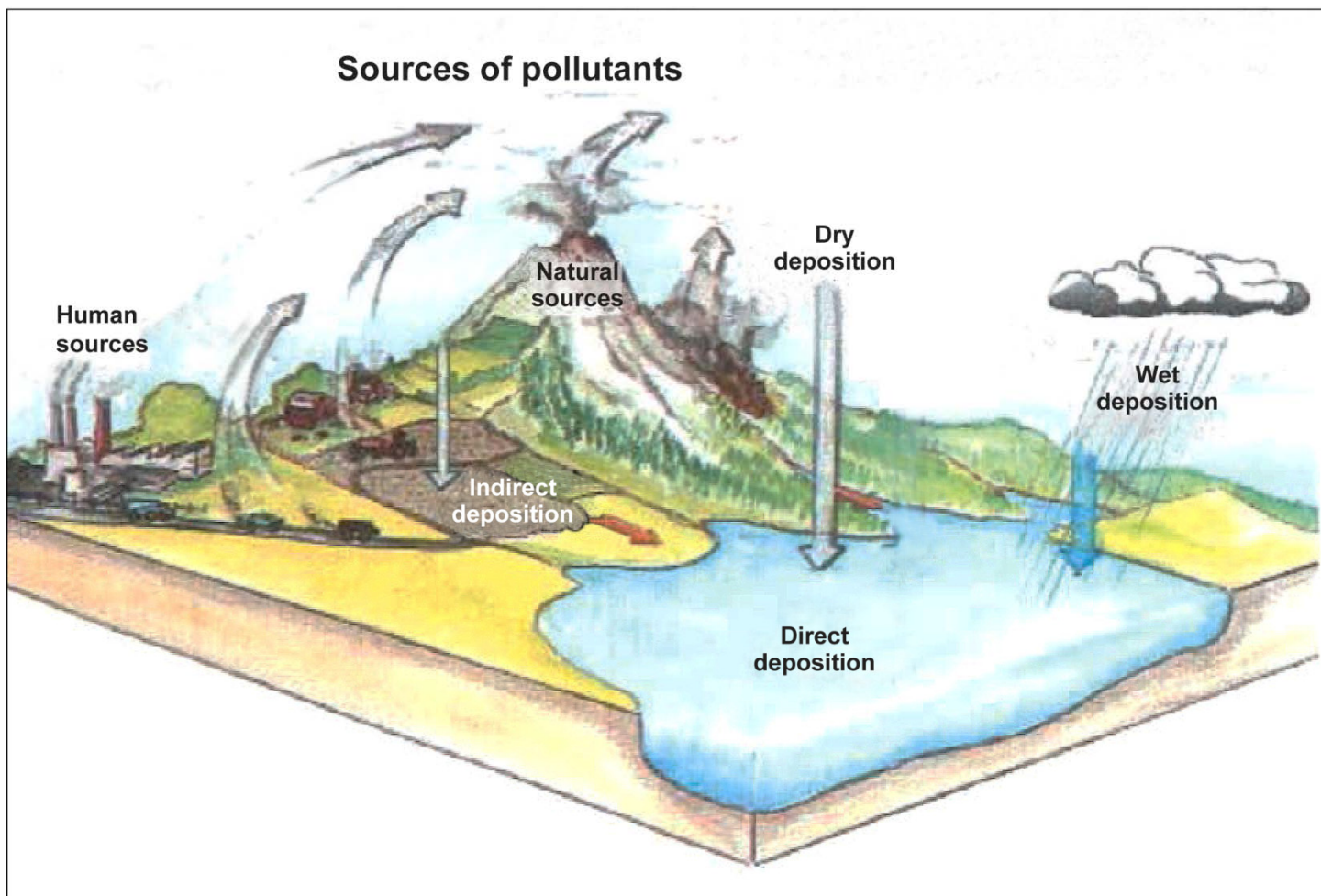
Additionally, atmospheric deposition can be either wet or dry as follows:

- Wet deposition occurs when pollutants are removed from the air and deposited via rain, snow, fog, or mist; and
- dry deposition occurs when air pollutants are deposited in the absence of rain or snow as falling particles or as the gas form of the pollutant.

The pollution deposited through atmospheric deposition can come from human-caused sources, such as power plants, or natural sources, such as volcanoes. Figure 1 depicts this process.

⁶This report focuses on the atmospheric deposition of pollutants and their effects on waterbodies, but atmospheric deposition of pollutants can also harm land-based ecosystems such as forests.

Figure 1: Atmospheric Deposition



Source: EPA's 2001 *Frequently Asked Questions About Atmospheric Deposition: Handbook for Watershed Managers*.

Three airborne pollutants commonly associated with atmospheric deposition are NO_x , SO_2 , and mercury but there are other pollutants. Examples include ammonia, which contributes to nutrient over-enrichment; and lead, polychlorinated biphenyls (PCBs), and other toxic substances, which can harm human health.

Effects of Atmospheric Deposition on Waterbodies

NO_x and SO₂ cause acid rain, and NO_x contributes to nutrient over-enrichment of waterbodies. Once in water, mercury becomes concentrated in fish and can harm individuals who consume contaminated fish.

NO_x and SO₂

NO_x and SO₂ cause acid rain, which can threaten certain aquatic ecosystems.⁷ NO_x reacts chemically in the atmosphere to form nitric acid. SO₂ reacts chemically in the atmosphere to form sulfuric acid.⁸ When these chemicals fall to the ground, they are known as acid rain. Some aquatic ecosystems are sensitive to acid rain. They are often at higher elevations and have underlying geologic conditions that limit their ability to neutralize or buffer acid. Acid rain in these ecosystems can cause a range of harmful effects. For example, acidification of lakes and streams can reduce or eliminate fish populations and decrease the numbers and types of aquatic plants and animals.

NO_x can also contribute to the nutrient over-enrichment of waterbodies, which can harm or kill aquatic species. NO_x is one of several sources of nitrogen that can contribute to nutrient over-enrichment. Other sources of nitrogen, such as runoff from agricultural and urban landscapes, do not enter water bodies through atmospheric deposition. Bays and estuaries are susceptible to the overabundance of nutrients, including an overabundance of nitrogen, because the growth of algae and plankton in these waters is generally limited by the availability of nitrogen. As nitrogen levels in the water increase, the growth of algae and plankton increases. When these organisms die, they are decomposed by bacteria that use the dissolved oxygen in the water. Dead zones characterized by low levels of dissolved oxygen in the water may result, harming or killing fish, crabs, shrimp, and other organisms. Benthic (bottom-dwelling) organisms such as oysters that are unable to move to more oxygenated waters are particularly susceptible.

Mercury

Mercury is toxic to humans and animals. Exposure to mercury can affect neurological development, especially in children and developing fetuses, which are especially susceptible to mercury exposure. Mercury exposure at high levels can also harm the brain, heart, kidneys, lungs, and immune systems of all ages. Eating contaminated fish and shellfish is the primary

⁷Acid rain is also known as acidic deposition.

⁸SO₂ is a component of sulfur oxide, commonly referred to as "SO_x".

way humans are exposed to mercury. In mercury contaminated waterbodies, bacteria in soils and sediments convert mercury into methylmercury, a highly toxic form of mercury. It can then be taken up by tiny aquatic plants and animals. Fish that eat these plants and animals build up methylmercury in their tissue through a process known as bioaccumulation. According to EPA, large predatory fish may have mercury concentrations many times higher than the concentrations in the waterbody in which they live. Thus, a relatively small concentration of mercury in a waterbody can harm humans who eat fish from these waterbodies.

Atmospheric deposition is the primary pathway for mercury to reach many waterbodies, although nonatmospheric sources of mercury, such as legacy gold mining, can be a significant source of mercury to some waterbodies. Once airborne, mercury can travel long distances or be deposited close to its source—depending in part on its chemical form. Elemental mercury is the most prevalent form of mercury in the atmosphere. Because it does not readily react with other chemicals in the atmosphere, elemental mercury generally stays aloft for longer periods of time and can travel around the globe as part of the “global pool” of mercury. Other forms of mercury more readily react with chemicals in the atmosphere and travel shorter distances before they deposit. Unlike NO_x and SO₂, mercury persists in the environment indefinitely. Mercury that has been deposited on land, water, and other surfaces can repeatedly be reemitted into the atmosphere.

The Clean Water Act and the Clean Air Act Address Water and Air Pollution

The CWA establishes the basic structure for establishing water quality standards for surface waters of the United States and for regulating discharges of pollutants into those waters. Among other things, CWA requires EPA to establish criteria that are then to be used by states to establish water quality standards for individual waterbodies. These standards consist of three key components: the designated uses that a given waterbody is intended to serve, such as recreation, water supply, or industrial; the qualitative (narrative) or numeric standards in order for a waterbody to be suitable for its designated uses; and antidegradation requirements. Where water quality standards are not being met, the waterbody is identified as impaired. States are required to identify and report a list of waterbodies that do not meet water quality standards, and for which pollution controls are not stringent enough to meet such

standards.⁹ In such cases, the CWA generally requires states to establish a TMDL for each pollutant causing a given waterbody to be impaired. The TMDL must identify allocations, i.e., the amount of the pollutant that will come from point sources (e.g., a pipe from sewage treatment plant) and nonpoint sources (e.g., atmospheric deposition or agricultural and urban runoff). The total amount of pollution from both types of sources must be at a level that ensures that applicable water quality standards for that waterbody can be met and maintained. States are generally responsible for developing and implementing TMDLs, but their TMDLs must be approved by EPA. As of August 2012, EPA has approved more than 48,000 TMDLs ranging in size from a small segment of a river to a multistate region. Additionally, the CWA authorizes EPA or, if approved by EPA, the states to issue National Pollution Discharge Elimination System (NPDES) permits to a facility that discharges a pollutant from a point source into U.S. waters.¹⁰ Generally, the discharge restrictions established by NPDES permits must be consistent with the allocations in applicable TMDLs. The CAA establishes the basic structure for regulating the emissions of pollutants into the air. It requires that EPA develop National Ambient Air Quality Standards (NAAQS) for certain pollutants, including NO_x and SO₂.¹¹ These standards include primary standards intended to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly, and secondary standards intended to protect public welfare from adverse effects such as decreased visibility and damage to animals, crops, vegetation, and buildings. EPA has developed primary and secondary standards for NO_x

⁹Pollution controls include technology-based and water quality-based effluent limitations contained in discharge permits, as well as any required best management practices.

¹⁰According to EPA, the agency has authorized 46 states to issue and enforce NPDES permit requirements under their state laws. For those states that are not so authorized (Idaho, Massachusetts, New Hampshire, New Mexico, the District of Columbia, American Samoa, the Commonwealth of Northern Mariana Islands, Guam, and Puerto Rico), EPA retains the authority to issue permits and enforce permit requirements. EPA may also issue a compliance order or bring a civil suit in U.S. district court against persons who violate the terms of a permit. Those responsible for point sources are required to maintain records and to carry out effluent monitoring activities. Permits are effective for up to 5 years by which time permittees must apply for permit renewal.

¹¹EPA has set NAAQS for six pollutants, termed "criteria" pollutants: carbon monoxide, lead, NO_x, ozone, particulate matter, and sulfur dioxides. EPA's NAAQS for SO₂ is designed to protect against exposure to all the components of sulfur oxide. Other components of sulfur oxide, such as sulfate (SO₄), are found in the atmosphere but at concentrations much lower than SO₂.

and SO₂. Through its regulatory process, EPA designed the current secondary NO_x and SO₂ standards to protect land-based ecosystems, not water quality or aquatic ecosystems. EPA is required, at 5-year intervals, to review current NAAQS and make revisions and promulgate new standards as appropriate. In addition, the CAA authorizes EPA to set certain limits on emissions of “air toxics”—such as mercury—which are certain pollutants that may present, through inhalation or other exposures, a threat to human health, such as cancer and birth defects, or cause adverse environmental effects. EPA has issued regulations that limit mercury emissions from certain industries.

Air Pollution Affects U.S. Waterbodies and Transportation and Power Plants Are Its Key Sources

Atmospheric deposition associated with NO_x, SO₂, and mercury contributes to the impairment of many waters in the United States, but the full extent is not completely known. Emissions from transportation and domestic power plants are key sources of NO_x, SO₂, and mercury, but international sources also contribute to mercury deposition in the United States.

Atmospheric Deposition Pollutes Many U.S. Waterbodies, but the Full Extent is Not Known

Atmospheric deposition, including from NO_x, SO₂, and mercury, is a contributing source of pollution to many waterbodies that the states have identified as impaired—that is, do not meet CWA water quality standards—according to our analysis of EPA’s ATTAINS database.¹² For example, about 53,300 square miles of the Great Lakes are reported to be impaired, in part, because of atmospheric deposition.¹³ Table 1 shows for select waterbody types the percentage of waterbodies assessed, the percentage of assessed waterbodies that are reported as impaired, and the percentage of impaired waterbodies for which atmospheric deposition, including from NO_x, SO₂, and mercury, is identified as a source of pollution. However, the ATTAINS database likely underestimates the extent of the problem because the states have not assessed all of their

¹²As described earlier, ATTAINS is an EPA database containing state reported information on the extent to which waterbodies meet water quality standards, among other things.

¹³This reference is to Great Lakes open water. ATTAINS collects separate data on Great Lakes shoreline, inland lake shoreline, and connecting channels. According to ATTAINS, there are about 60,500 square miles of Great Lakes open water.

waterbodies.¹⁴ The percentage of waterbodies assessed varies by waterbody type and ranges from about 1 percent of wetlands to about 88 percent of the Great Lakes. Additionally, states may, but are not required, to report on the sources of a pollutant to a waterbody, including whether atmospheric deposition is a reason why water quality standards are not being met or the extent to which atmospheric deposition is contributing to the problem.

Table 1: Waterbodies Reported by States as Impaired by Atmospheric Deposition by Waterbody Type

Type of waterbody	Percentage of waterbodies assessed	Percentage of assessed waterbodies that are reported as impaired	Percentage of impaired waterbodies for which atmospheric deposition was identified as a contributing source
Rivers and streams	28	53	20
Lakes and reservoirs	46	69	37
Bays and estuaries	37	66	36
The Great Lakes	88	100	100

Source: GAO analysis of ATTAINS database.

Notes: GAO’s analysis of ATTAINS database includes data on the 50 states, the District of Columbia, American Samoa, the Commonwealth of Northern Mariana Islands, Guam, Puerto Rico, and the Virgin Islands. The most recently available state data are the most current year that each state reported. These years varied from 2002 to 2010 because some states reported more recently than others.

The table includes the percentage of assessed waterbodies that are reported as impaired by any pollutant, including NO_x, SO₂, and mercury and the percentage of impaired waterbodies for which atmospheric deposition of any pollutant, including NO_x, SO₂, and mercury, was identified as a contributing source.

Federal studies also show that atmospheric deposition associated with NO_x, SO₂, and mercury is polluting waters in the United States. For example, a 2011 report from the National Acid Precipitation Assessment Program (NAPAP)—a federal interagency program that coordinates acid rain research—summarized the most recent studies on acid rain and identified waters in several acid-sensitive ecosystems that are most

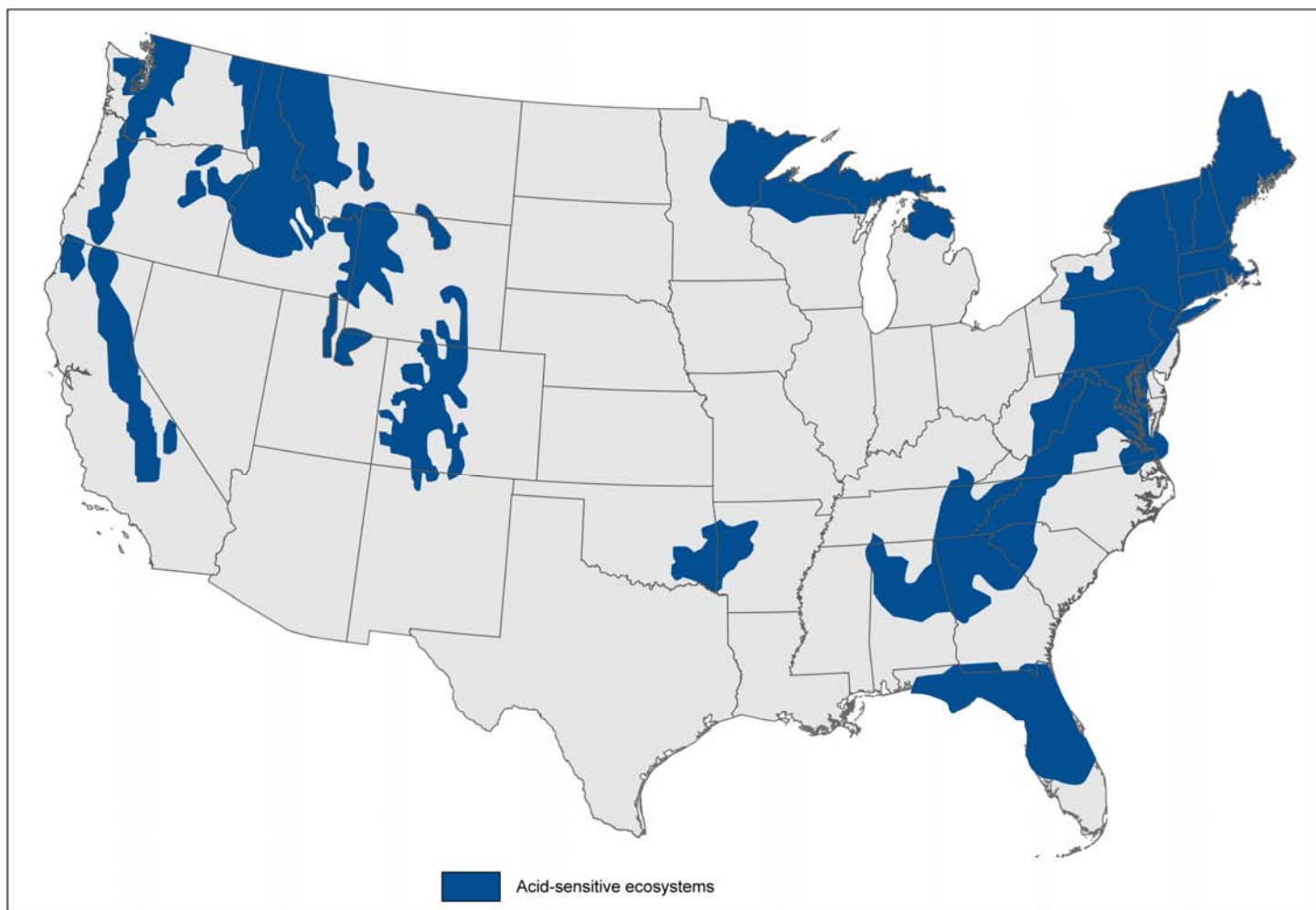
¹⁴States are required to identify those waters that are impaired—that is, waters for which pollution controls are insufficient to meet water quality standards—and report this list to EPA every 2 years. According to EPA, states have not assessed all their waterbodies because of limited resources, but many states target their limited resources to waterbodies that they suspect are impaired.

vulnerable and that continue to receive harmful levels of acid rain.¹⁵ According to the report, from 2006 through 2008, over 550 lakes in the Adirondack Mountains and approximately 21,000 miles of streams in the Central Appalachian Mountains continued to experience levels of acid rain that exceeded their ability to neutralize the acid. However, according to an EPA document, there is relatively sparse data coverage in mountainous western areas where a number of sensitive ecosystems are located.¹⁶ Figure 2 shows acid-sensitive ecosystems in the United States.

¹⁵National Science and Technology Council, *National Acid Precipitation Assessment Program Report to Congress 2011: An Integrated Assessment* (Washington, D.C.: 2011). The CAA Amendments of 1990 authorized NAPAP to, among other things, periodically assess the effectiveness of the Acid Rain Program and report its findings to Congress. NAPAP operates under the auspices of the National Science and Technology Council (NSTC) Committee on Environment, Natural Resources, and Sustainability (CENRS). The NAPAP member agencies are the EPA, the U.S. Department of Energy, the U.S. Department of Interior/U.S. Geological Survey, the U.S. Department of Interior/National Park Service, the National Aeronautics and Space Administration, and NOAA.

¹⁶See EPA, Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Sulfur; Proposed Rule, 76 Fed. Reg. 46,084, 46,134 (Aug. 1, 2011).

Figure 2: Location of Acid-Sensitive Ecosystems in the United States



Sources: 2011 National Precipitation Assessment Program Report (Map prepared by EPA); Map Resources (map).

A 2007 study by NOAA assessed the extent to which 99 estuaries across the country experienced symptoms associated with nutrient over-enrichment, such as algal blooms.¹⁷ The study found that 29 of the

¹⁷Bricker, S., B. Longstaff, W. Dennison, A. Jones, K. Boicourt, C. Wicks, and J. Woerner. *Effects of Nutrient Enrichment In the Nation's Estuaries: A Decade of Change*. NOAA Coastal Ocean Program Decision Analysis Series No. 26. National Centers for Coastal Ocean Science (Silver Spring, MD: 2007). The study initially chose 141 estuaries to assess but did not have sufficient data to assess 42 of them.

estuaries experienced symptoms that affected at least 50 percent of the estuary and/or were persistent and that another 35 estuaries periodically experienced symptoms that affected a smaller portion of the estuary. The study identified atmospheric deposition as contributing source of nutrients for all coastal regions—except the Pacific coast, for which there were insufficient data—but did not quantify the relative amount of nitrogen, including NO_x coming from atmospheric deposition. A 2011 NAPAP report did quantify the relative amount of nitrogen coming from atmospheric deposition.¹⁸ Summarizing other scientific studies, the report stated that the relative amount of nitrogen entering estuaries that comes from atmospheric deposition varied from about 15 percent to 25 percent in the Mississippi Delta region of the Gulf of Mexico, to 20 percent to 50 percent from the Chesapeake Bay to Tampa Bay, and as much as 60 percent to 80 percent in some coastal river estuaries of northern New England.¹⁹ The report did not provide any data about West Coast estuaries.

Similarly, studies show that mercury is contaminating waters in the United States, but the extent of the contamination is less well understood. According to the National Atmospheric Deposition Program (NADP)—a public-private cooperative program that monitors atmospheric deposition of mercury, among other pollutants—atmospheric deposition is the primary pathway by which mercury reaches waters in many parts of the

¹⁸National Science and Technology Council, National Acid Precipitation Assessment Program Report to Congress 2011: An Integrated Assessment (Washington, D.C.: 2011).

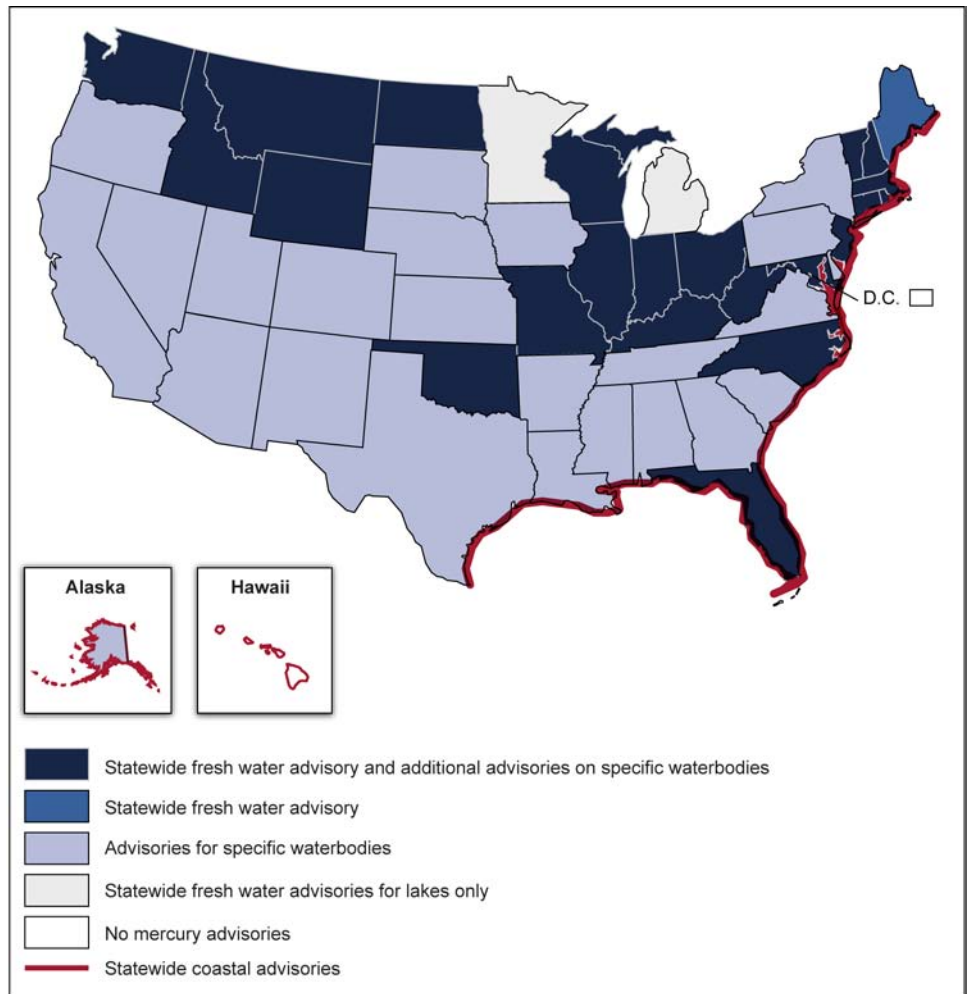
¹⁹The report summarized the following studies: Mclsaac, G.F., M.B. David, G.Z. Gertner, and D.A. Goolsby, “Eutrophication: Nitrate flux in the Mississippi River,” *Nature* 414 (2001):166–167; Boyer, E.W., C.L. Goodale, N.A. Jaworski, and R.W. Howarth, “Anthropogenic nitrogen sources and relationships to riverine nitrogen export in the northeastern U.S.A.” *Biogeochemistry* 57/58(2002):137–169.; Poor, N., C. Pollman, P. Tate, M. Begum, M. Evans, and S. Campbell, “Nature and magnitude of total inorganic nitrogen and other inorganic species to the Tampa Bay watershed, FL, USA,” *Water, Air, & Soil Pollution* 170(2006):267–83; Whitall, D., S. Bricker, J. Ferreira, A.M. Nobre, T. Simas, and M. Silva, “Assessment of eutrophication in estuaries: Pressure-state-response and nitrogen source apportionment,” *Environmental Management* 40(2007):678–690; Alexander, R.B., R.A. Smith, G.E. Schwarz, E.W. Boyer, J.V. Nolan, and J.W. Brakebill, “Differences in phosphorus and nitrogen delivery to the Gulf of Mexico from the Mississippi River,” *Environmental Science & Technology* 42(2008):822–830; and Howarth, R.W., “Estimating atmospheric nitrogen deposition in the northeastern United States: Relevance to Narragansett Bay,” ch. 3, in A. Desbonnet and B. A. Costa-Pierce, eds. *Science for Ecosystem based Management: Narragansett Bay in the 21st Century*, Springer Series on Environmental Management (New York: Springer) 47-65.

United States.²⁰ Other studies report similar results. For example, a 2007 report to Congress by NOAA concludes that atmospheric deposition of mercury is a significant source of mercury in the Great Lakes.²¹ However, measuring mercury atmospheric deposition, especially dry deposition, is scientifically challenging, and representatives from NADP told us that there are significant data gaps on the amount of dry deposition across the country. Additionally, there are factors other than the amount of mercury in a waterbody that affect the amount of mercury in fish tissue. For example, the amount of mercury that has been converted to methylmercury—the form of mercury that bioaccumulates in fish—is influenced by various factors such as the chemical composition of the water. The amount of mercury in fish tissue also varies by the size and species of fish present in the waterbody. Nevertheless, according to EPA's 2010 National Listing of Fish Advisories, all 50 states reported mercury-related fish consumption advisories, and 25 states reported statewide freshwater advisories. Additionally, Alaska, Hawaii, all of the Gulf states, and most of the East Coast states, reported statewide coastal advisories. Figure 3 shows the extent of mercury-related fish consumption advisories in 2010. Statewide advisories are precautionary and warn the public of the potential contamination of certain fish types in specific waterbodies, resulting in a designated fish advisory for all rivers or lakes in the state.

²⁰NADP is a cooperative effort among groups— including federal, state, tribal, and local governmental agencies, educational institutions, private companies, and nongovernmental agencies—that monitor atmospheric deposition of mercury, among other pollutants. The federal agencies involved in NADP include the Agricultural Research Service and the Forest Service within the Department of Agriculture; the Bureau of Land Management, the Fish and Wildlife Service, the Geological Survey, and the National Park Service within the Department of the Interior; the National Aeronautics and Space Administration; the National Science Foundation; NOAA; EPA; and the Tennessee Valley Authority.

²¹Cohen, M., R. Artz, and R. Draxler. *Report to Congress: Mercury Contamination in the Great Lakes*. NOAA Air Resources Laboratory (Silver Spring, MD: 2007).

Figure 3: Mercury-related Fish Consumption Advisories, 2010



Sources: 2010 National Listing of Fish Advisories from EPA's National Fish and Wildlife Contamination Program; Map Resources (map).

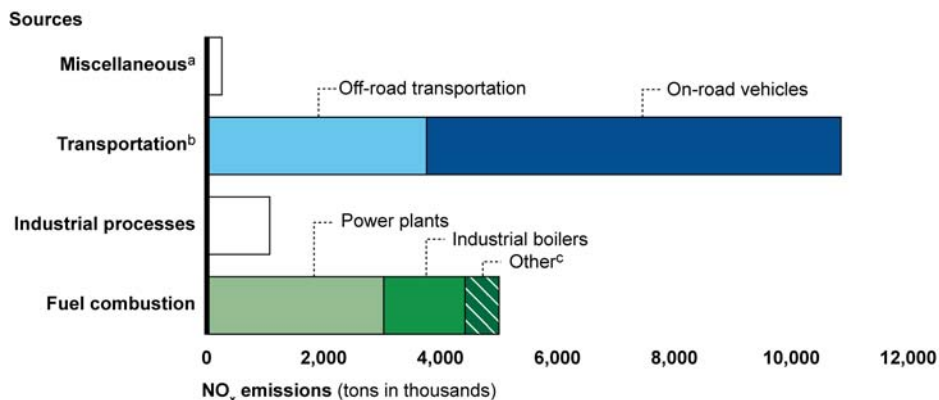
Domestic Transportation and Power Plants Are Sources of NO_x and SO₂, and Other Countries Contribute to Mercury Deposition

According to 2008 data, domestic transportation is the largest source of NO_x, and domestic power plants are the primary source of SO₂ and the largest source of U.S. mercury emissions, but international sources of mercury are a significant contributor to mercury atmospheric deposition in the United States.

Domestic Transportation Is the Largest Source of NO_x Emissions

Domestic transportation is the largest source of NO_x emissions in the United States, according to EPA's 2008 National Emissions Inventory.²² Figure 4 shows that on-road vehicles, such as cars and trucks, and off-road transportation, such as commercial fishing vessels, passenger trains, and commercial aircraft, contributed approximately 63 percent of the total estimated 17.4 million tons of NO_x emissions in the United States. Other sources of NO_x emissions include fuel combustion, mainly from power plants and industrial boilers,²³ which accounted for an estimated 28 percent of total estimated NO_x emissions. According to an EPA official, the only international sources of NO_x emissions of any note that reach the United States are in Canada and Mexico and, in general, emissions from these sources do not impact U.S. waters.

Figure 4: Estimated Contributions of NO_x Emissions from Domestic Sources in 2008



Source: 2008 National Emissions Inventory.

^aMiscellaneous includes sources such as gas stations, bulk gasoline terminals, and commercial cooking.

^bSome military aircraft are not included in the transportation category but are instead included in the fuel combustion category.

^cOther fuel combustion sources include residential, commercial, and institutional biomass and fossil-fuel burning units.

Ammonia emissions, like NO_x, can contribute to the atmospheric deposition of nitrogen. When nitrogen in fertilizers and animal waste

²²The 2008 National Emissions Inventory (version 2) provides the most complete collection of emissions data. EPA is currently collaborating with state, local, and tribal agencies in preparing the 2011 inventory.

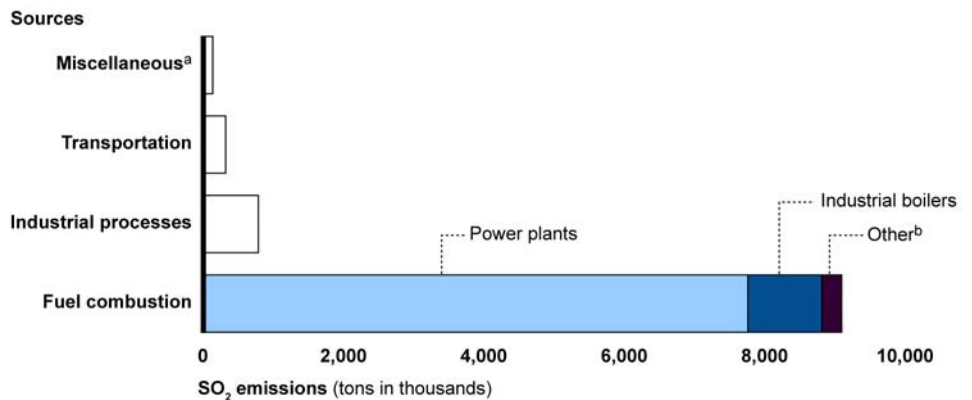
²³Industrial boilers are a type of electrical generating unit that burns fossil fuels.

Domestic Power Plants Are the Primary Source of SO₂ Emissions

breaks down, it is converted to ammonia gas and released into the air, where it can deposit on land and water. Agriculture accounted for approximately 83 percent of the total estimated 4.4 million tons of ammonia emissions, according to the 2008 National Emissions Inventory. Ammonia emissions can contribute to nutrient over-enrichment in waterbodies and, in some areas of the country, ammonia can be the dominant source of atmospheric nitrogen, especially those areas with abundant agricultural land, according to the 2011 NAPAP report.

Domestic power plants are the primary source of SO₂ emissions in the United States, according to the 2008 National Emissions Inventory. Figure 5 shows that fuel combustion, mainly from power plants, contributed approximately 87 percent of the total estimated 10.4 million tons of SO₂ emissions in the United States.²⁴ Industrial processes and transportation contributed approximately 8 percent and 3 percent, respectively. According to an EPA official, the only international sources of SO₂ emissions of any note that reach the United States are in Canada and Mexico and, in general, emissions from these sources do not impact U.S. waters.

Figure 5: Estimated Contributions of Sulfur Dioxide Emissions from Domestic Sources in 2008



Source: 2008 National Emissions Inventory.

Note: These power plants are primarily coal-fired.

^aMiscellaneous includes sources such as gas stations, bulk gasoline terminals and commercial cooking.

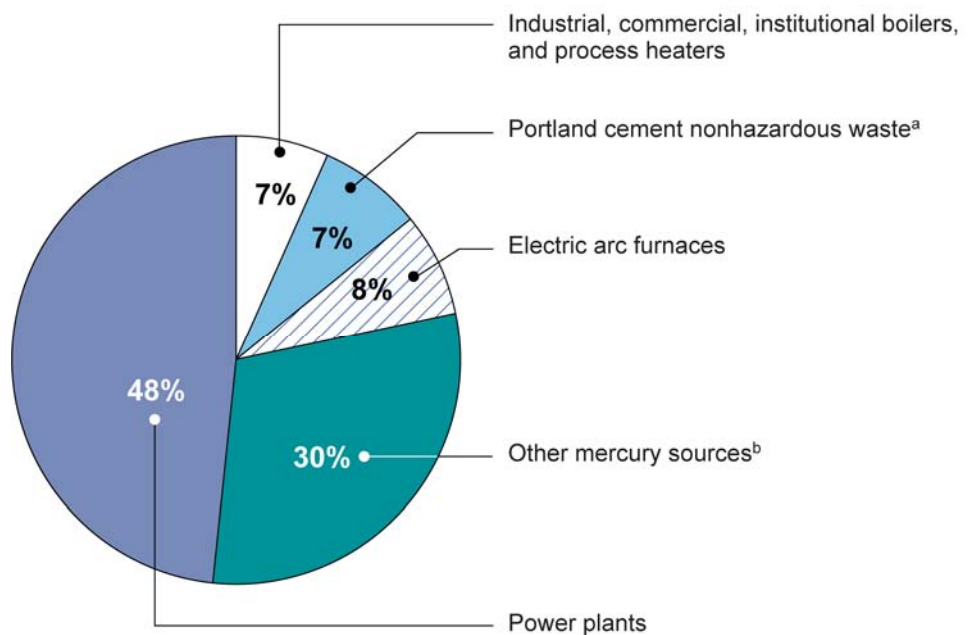
^bOther fuel combustion sources include residential, commercial and institutional biomass and fossil-fuel burning units.

²⁴Power plants contributed approximately 7.8 million tons of SO₂, or about 75 percent of the total estimated 10.4 million tons of SO₂ emissions.

Domestic Power Plants Are the Largest Source of U.S. Mercury Emissions, but International Sources Contribute to Deposition

Domestic sources emitted about 61 tons of mercury, according to the 2008 National Emissions Inventory. Figure 6 shows that fuel combustion from domestic power plants—mostly coal-burning power plants—contributed approximately half of these emissions. The next three largest sources were electric arc furnaces, industrial, commercial, and institutional boilers and process heaters, and Portland cement nonhazardous waste.²⁵

Figure 6: Estimated Contributions of Mercury Emissions from Domestic Sources in 2008



Source: 2008 National Emissions Inventory.

^aPortland cement is the most common type of cement produced around the world. Portland cement kilns emit mercury, among other pollutants.

^bOther sources of mercury emissions include gold mining, transportation, municipal waste combustors, medical waste incineration, and other types of incineration.

²⁵Electric arc furnaces are heating devices that produce highly luminous and intensely hot electrical currents that jump between electrical conductors in the form of an arc and are used for melting metals such as steel. Portland cement nonhazardous waste is waste produced from cement kilns that produce the most common cement around the world known as Portland cement. Industrial, commercial, and institutional boilers and process heaters are types of electrical generating units that burn fossil fuels.

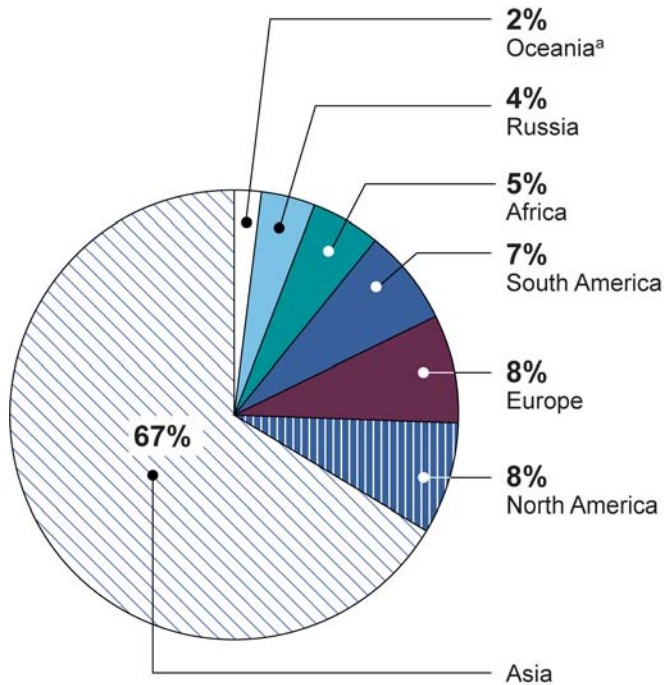
While most of the NO_x and SO₂ that affects U.S. waters originates from human-caused domestic sources, this is not the case for mercury. Some of the mercury deposited in the United States comes from international and natural sources, such as volcanoes, and not all mercury emissions from domestic sources are deposited in the United States. According to a 2010 EPA report, human-caused mercury emissions from the United States, southern Canada, and northern Mexico contribute about 20 to 30 percent of the total mercury atmospheric deposition in the continental United States.²⁶ The remainder comes from other foreign sources and natural sources. However, according to a 2008 EPA report, local sources can be the dominant contributor of mercury atmospheric deposition in areas where there are sources that emit large amounts of mercury.²⁷ A 2008 United Nations Environment Programme (UNEP) report estimated that human-caused mercury emissions from North America contributed about 8 percent of global human-caused mercury emissions in 2005 (see fig. 7).²⁸ Asia, on the other hand, contributed about 67 percent of global mercury emissions. According to the report, in 2005 about 46 percent of global mercury emissions came from burning fossil fuels, primarily coal, to produce electricity and heat. Another 24 percent of global mercury emissions came from gold production. Other global sources of mercury emissions include metal production (excluding gold) and cement production.

²⁶The Environmental Protection Agency, *Effects of Air Pollutants on Ecological Resources: Literature Review and Case Studies*, Draft Report (Washington, D.C.: February 2010). In its literature review, EPA cited two studies: (1) Seigneur, C., K. Vijayaraghavan, K. Lohman, P. Karamchandani, and C. Scott, "Global Source Attribution for Mercury Deposition in the United States" *Environmental, Science and Technology*, 38 (2004), 555-569, and (2) Selin, N.E., D.J. Jacob, R.J. Park, R.M. Yantosca, S. Strode, L. Jaegle, and D. Jaffe, "Chemical cycling of atmospheric mercury," *Journal of Geophysical Research* (January 2007). Reemissions of mercury also contribute to mercury deposition in the United States, but the two studies that EPA reviewed either did not cite reemission contributions or included reemission contributions in the emission contributions from natural or human-caused sources.

²⁷The Environmental Protection Agency, *Model-Based Analysis and Tracking of Airborne Mercury Emissions to Assist in Watershed Planning* (Washington, D.C.: August 2008).

²⁸The United Nations Environment Programme, *The Global Atmospheric Mercury Assessment: Sources, Emissions and Transport* (Geneva, Switzerland: December 2008).

Figure 7: Estimated Contributions of Global Mercury Emissions from Human-Caused Sources in 2005



Source: United Nations Environmental Program Report.

Note: Percentages do not add to 100 percent due to rounding.

^aThe Oceania region includes the islands of the southern, western, and central Pacific Ocean, such as Australia, New Zealand, Melanesia, Micronesia, and Polynesia.

EPA Faces Challenges Using Clean Water Act Regulations to Address Atmospheric Deposition

Listing impaired waters and TMDLs are the primary regulatory tools EPA uses under the CWA to identify water pollution resulting from atmospheric deposition, but EPA faces challenges in using these tools, as well as other nonregulatory tools, to address the effects of atmospheric deposition. Three TMDLs we reviewed illustrate the challenges associated with using these tools.

Key Regulatory Tools Do Not Directly Regulate Atmospheric Deposition

EPA has regulatory and nonregulatory tools available under the CWA for addressing atmospheric deposition.

Regulatory Tools

EPA's key regulatory tools for considering the effects of atmospheric deposition on water quality are listing of impaired waters and TMDLs, but the CWA does not directly regulate nonpoint sources of pollution, including pollution resulting from atmospheric deposition. When states identify waterbodies that are impaired—that is, that do not meet CWA water quality standards with existing controls—the CWA requires states to formally identify them as impaired, and generally to set a TMDL for each pollutant that does not meet the standards. TMDLs are not self-implementing and CWA does not expressly require they be implemented; states generally have the lead role for implementation. TMDL allocations for permitted point sources are typically implemented via NPDES permits. Relevant NPDES permits issued to facilities for point sources of that pollutant must be consistent with the allocations established by the TMDL, but there is no comparable permitting mechanism under the CWA directly limiting pollutants from nonpoint sources. Nevertheless, states must account for nonpoint sources of pollution in their TMDLs and may include estimated reductions from those nonpoint sources. Where a state provides EPA with “reasonable assurance” that the reductions from nonpoint sources of pollution identified in the TMDL will be achieved, EPA often can allow NPDES permits for point sources of pollution identified in the TMDL to be less stringent than they would have otherwise been.²⁹ EPA makes “reasonable assurance” determinations based on factors such as whether practices to reduce the nonpoint source pollutant are technically feasible and likely to be implemented. While this creates an incentive for a state to reduce pollution from nonpoint sources, the CWA provides no direct requirement—such as permitting—that states implement such reductions.

A further challenge in using TMDLs to address atmospheric deposition is that the pollution impairing a waterbody can originate outside of the state responsible for implementing the TMDL. For example, pollutants travel in the atmosphere and harm air quality and the environment in downwind communities. To help address this challenge, EPA allows states some flexibility in addressing these situations. Specifically, EPA allows states

²⁹EPA requires reasonable assurance to allow EPA to determine that the TMDL has been established at a level necessary to implement water quality standards. Under EPA guidance, reasonable assurance is only needed for TMDLs that include allocations for both point and nonpoint sources. A TMDL developed for waters impaired solely by point sources does not have to demonstrate reasonable assurance. Also, the NPDES permit, and the requirements associated with it, constitutes the reasonable assurance that a TMDL's allocation for point sources will result in the attainment of water quality standards.

with a waterbody impaired primarily from atmospheric sources of mercury to defer developing a TMDL for that waterbody if the state is carrying out a comprehensive mercury reduction program and demonstrates progress in reducing in-state mercury sources. This approach provides a public accounting of the status of mercury impaired waters and a way for states to demonstrate progress in reducing in-state mercury sources. According to an EPA document describing this approach, it may also be useful in situations where other pollutants are primarily from atmospheric deposition. However, according to EPA officials, this approach is intended to encourage states to address in-state sources of mercury, and EPA has not encouraged the use of this approach for other pollutants such as NO_x or SO₂.

According to EPA officials, despite these limitations of the CWA, TMDLs may play an important role in understanding the role of atmospheric deposition to impairment of a particular waterbody, such as identifying the contributions from air sources to water and the reductions needed in air sources in order to meet water quality standards. In addition, according to EPA officials, TMDLs may parse the contributions from various air sources to waterbodies, including separating the contributions from local and global sources, which may help states identify whether there are air sources that can be controlled at the state level.

Nonregulatory Tools

EPA also has nonregulatory tools available under the CWA to provide incentives and assistance to the states to address nonpoint source pollution and improve water quality. However their use in addressing atmospheric deposition presents challenges. The most notable of these tools is the nonpoint source management program known as the Section 319 Program. Under this program, EPA offers technical and financial assistance to states and local agencies to develop projects to control nonpoint sources of water pollution.³⁰ According to an EPA official, only a small portion of projects that have been funded in this program have addressed atmospheric deposition. According to the official, projects typically involve source control—slowing down stormwater flow to prevent erosion or building fences to keep livestock out of streams—but the source of atmospheric deposition can be diffuse, as is the case with cars, or originate in other countries, as is the case with mercury. According to

³⁰For more information, see GAO, *Nonpoint Source Water Pollution: Greater Oversight and Additional Data Needed for Key EPA Water Program*, [GAO-12-335](#) (Washington, D.C.: May 31, 2012).

the official, a local or state agency that deals with water quality issues does not have authority or tools to control these types of sources and would find it difficult to develop a project to control atmospheric deposition.

Another CWA tool relevant to atmospheric deposition is the interstate management conference process,³¹ whereby states or regions can petition the EPA Administrator to convene a management conference of all states that contribute nonpoint source pollution to the state's or region's waterbodies. The purpose of the conference is to forge an agreement to reduce the sources of nonpoint source pollution from the states or regions contributing to the pollution. However, even if a conference is held, there is neither a requirement that an agreement to address the problem be reached nor is there a requirement that any agreement that is reached be binding. EPA granted the petition for one such conference on the atmospheric deposition of mercury, which took place in 2010. However, as discussed below, participants in this conference did not reach an agreement on steps to reduce atmospheric deposition of mercury.

Three TMDLs Highlight Challenges in Addressing Atmospheric Deposition under the Clean Water Act

Northeast Regional TMDL for Mercury

The three TMDLs that we reviewed illustrate the challenges that states face in mitigating sources of atmospheric deposition when these sources originate from outside of the state or region. These three TMDLs are the Northeast Regional TMDL for mercury, a New York State TMDL for acid rain in the Adirondacks, and the Chesapeake Bay TMDL for nitrogen.³²

In the Northeast Region, more than 10,000 lakes, ponds, and reservoirs, and more than 46,000 river miles are listed as impaired for fish consumption primarily due to the presence of mercury—mostly from atmospheric deposition.³³ A committee of representatives of each of the

³¹See 33 U.S.C. § 1329(g) (2012). When a state petitions EPA for a conference, the provision does not give EPA specific responsibilities or authority beyond holding the conference.

³²In addition to nitrogen, the TMDL addresses other pollutants, but the atmospheric deposition of these other pollutants is not a significant source to the bay.

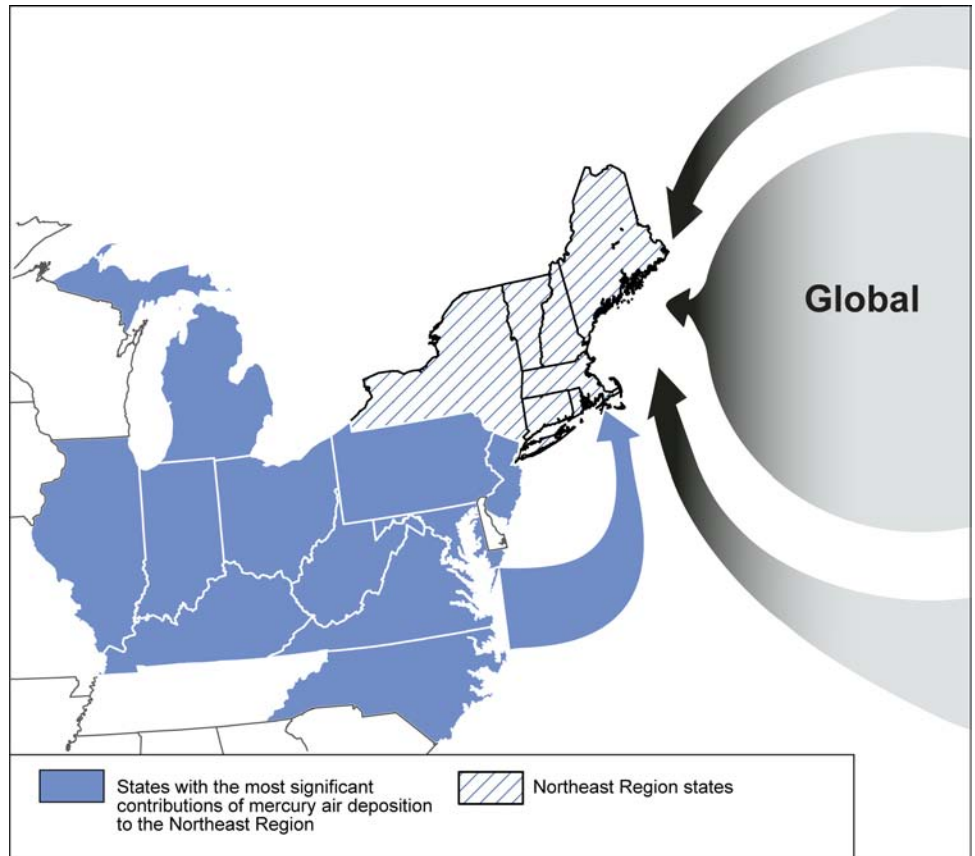
³³The Northeast Region, as referred to here, includes the New England states (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont) and New York State. According to TMDL documents, about 98 percent of the mercury comes from atmospheric deposition.

Northeast states and the New England Interstate Water Pollution Control Commission (NEIWPCC) developed a TMDL for mercury and an implementing strategy to reduce the mercury concentration in fish in Northeast Region waterbodies.³⁴ EPA approved the TMDL in 2007. However, the TMDL acknowledged that given the magnitude of the reductions required to implement the TMDL, the Northeast Region cannot reduce in-region sources further to compensate for insufficient reductions from out-of-region sources. According to the TMDL, prior mercury emission limits implemented by the Northeast Region had contributed to reducing in-region mercury deposition by approximately 74 percent from 1998 to 2002. By 2002, most of the remaining mercury deposited in the region was from out-of-region sources, with roughly two-thirds from the global pool of mercury and the remaining from domestic sources, split roughly evenly between sources in the Northeast Region states and sources in 11 other states, according to our analysis of a 2008 study by the Northeast States for Coordinated Air Use Management (NESCAUM).³⁵ Figure 8 depicts the out-of-region sources of atmospheric deposition in the Northeast Region as of 2002.

³⁴The NEIWPCC is a not-for-profit interstate agency, established by an act of Congress, which serves its member states individually and collectively by providing coordination, public education, research, training, and leadership in water management and protection in the New England region and New York State.

³⁵The Northeast States for Coordinated Air Use Management, *Sources of Mercury Deposition in the Northeast United States* (March 2008). This study presents numeric estimates of the amount of mercury deposited in the Northeast Region states and the sources of that mercury. These estimates were obtained from a report prepared for EPA in 2006, based on 2002 data (ICF International, *Model-Based Analysis and Tracking of Airborne Mercury Emissions to Assist in Watershed Planning* (San Rafael, CA: Nov. 30, 2006). According to the authors of the ICF report, the numeric estimates result from a model that includes some uncertainty, and the estimates should be used to show the relative amounts of mercury originating from, and depositing in, different states or originating from global sources. The most recent year for which this data is available is 2002.

Figure 8: Sources of Atmospheric Deposition of Mercury in the Northeast Region, 2002



Sources: GAO analysis of data from The Northeast States for Coordinated Air Use Management, *Sources of Mercury Deposition in the Northeast United States* (March 2008); Map Resources (map).

To address domestic but out-of-region mercury sources, in 2008, Northeast Region officials used the CWA interstate management conference process discussed above and petitioned EPA to hold a conference with 11 states that, according to a 2008 NESCAUM study, were the states outside the region that contributed the most to the Northeast’s mercury problem. The conference participants discussed developing a “principles document” that would outline next steps. However, according to a NEIWPC representative, there was not enough agreement among the states to move forward with the principles document, and no formal agreement was reached to reduce the atmospheric deposition of mercury. In the end, according to the representative, all of the participating states have made some efforts to

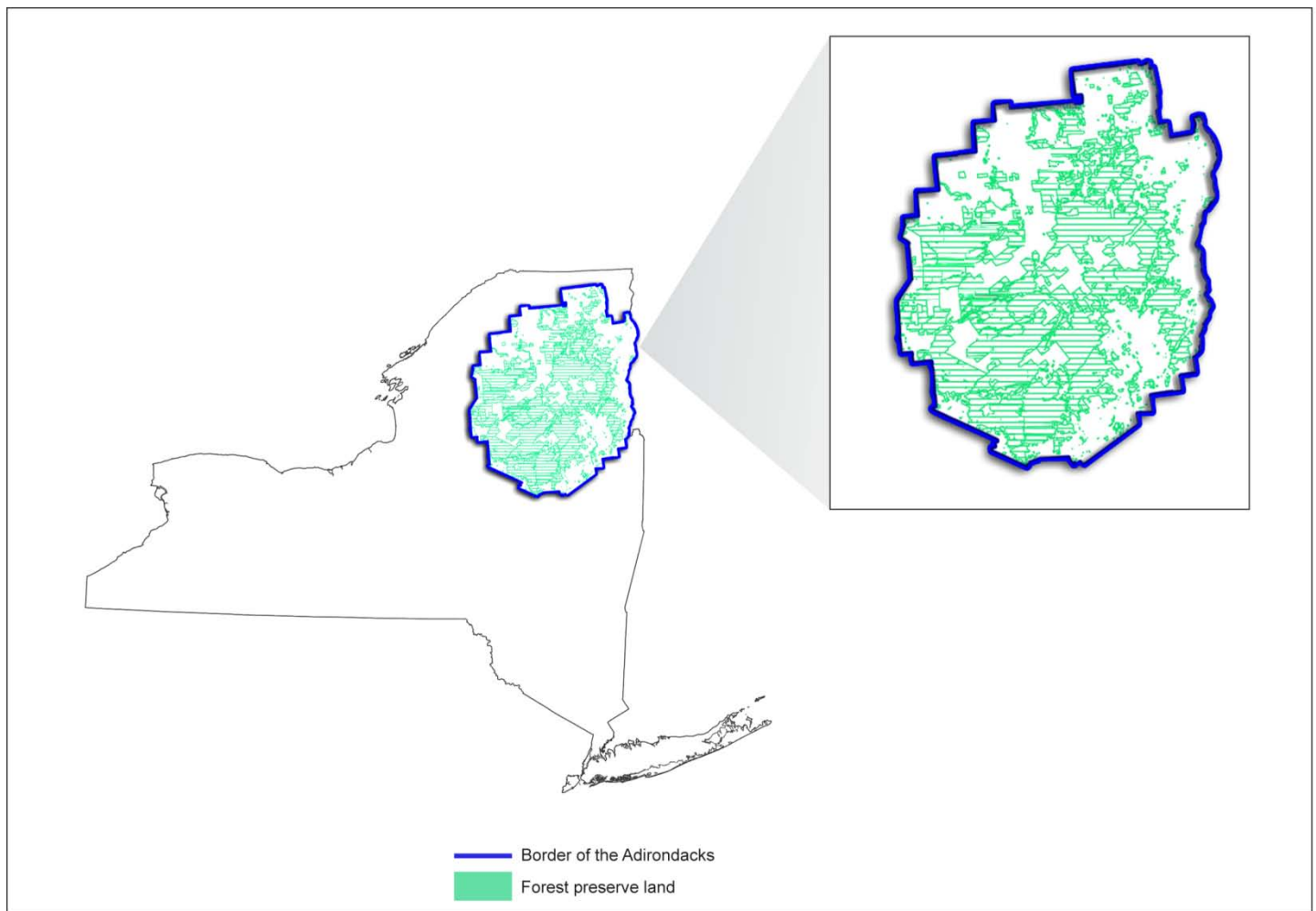
Adirondacks Region Lakes
TMDL for Acid Rain

reduce mercury, but the level of commitment varies by state. According to EPA officials, the conference brought together senior air and water program officials from upwind and downwind states and allowed participants to learn about successful mercury programs in other states.

Over the last several decades, acid rain has resulted in the significant loss of fish populations in the Adirondacks Region located in northeast New York State. In 2006, the New York State Department of Environmental Conservation (NYSDEC) developed a TMDL for an acid rain restoration plan to address 143 impaired lakes on state-owned forest preserve lands in the Adirondacks.³⁶ Figure 9 shows the forest preserve lands within the Adirondacks.

³⁶These lands are regulated by the New York State Constitution as being “forever wild.”

Figure 9: Location of New York State Forest Preserve Lands in the Adirondacks



Source: GAO analysis of NYSDEC data.

According to state officials, over the last two decades the state has reduced in-state emissions of SO₂ by about 90 percent and reduced in-state emissions of NO_x to a lesser extent.³⁷ This in turn has reduced acid rain and improved water quality in the Adirondack lakes. However, state

³⁷NO_x emissions decreased from 30 percent to 90 percent depending on the emission source but there is not reliable data on the overall reduction.

Chesapeake Bay TMDL for Nitrogen

officials said that reducing acid rain to the levels called for in the TMDL remains a challenge because almost all of the NO_x, SO₂, and other sulfur oxides contributing to acid rain in the region can be attributed to out-of-state sources—mostly from the Southeast, and Midwest United States and Canada. Specifically, data compiled by the NYSDEC in the mid-1980s estimated that 83 to 87 percent of acid rain came from emissions of NO_x, SO₂, and other sulfur oxides originating out-of-state, and NYSDEC officials stated that this percentage is now likely higher as a result of the in-state reductions. According to NYSDEC officials, meeting the TMDL goals for acid rain is dependent on emissions reductions in other states, but they said the department will continue to address its responsibilities for improving air and water quality within the state through implementation of federal programs under the CAA, as well as state air programs, such as its Acid Deposition Reduction Program. According to NYSDEC officials, the state has not used other nonregulatory tools available under the CWA to help address acid rain, such as petitioning for conferences with other states, but they said that this is an option that needs to be considered.

Most of the Chesapeake Bay and its tidal waters are impaired, in part because of the effects of excess nitrogen. According to TMDL documents, atmospheric deposition of NO_x accounts for about 22 percent of the total nitrogen entering the bay. Other sources of nitrogen include agricultural (i.e., ammonia from chemical fertilizer and manure), municipal and industrial wastewater, and storm water runoff.³⁸ The Chesapeake Bay watershed covers 64,000 square miles and includes parts of six states—Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia—and the District of Columbia.

In December 2010, EPA established the Chesapeake Bay TMDL for nitrogen. Among other things, for each of the seven jurisdictions in the watershed, the TMDL sets an allocation for total nitrogen entering the bay watershed, including from atmospheric deposition, needed to reduce nitrogen to meet water quality standards.³⁹ However, as with the Northeast and Adirondack TMDLs discussed, the jurisdictions that are a

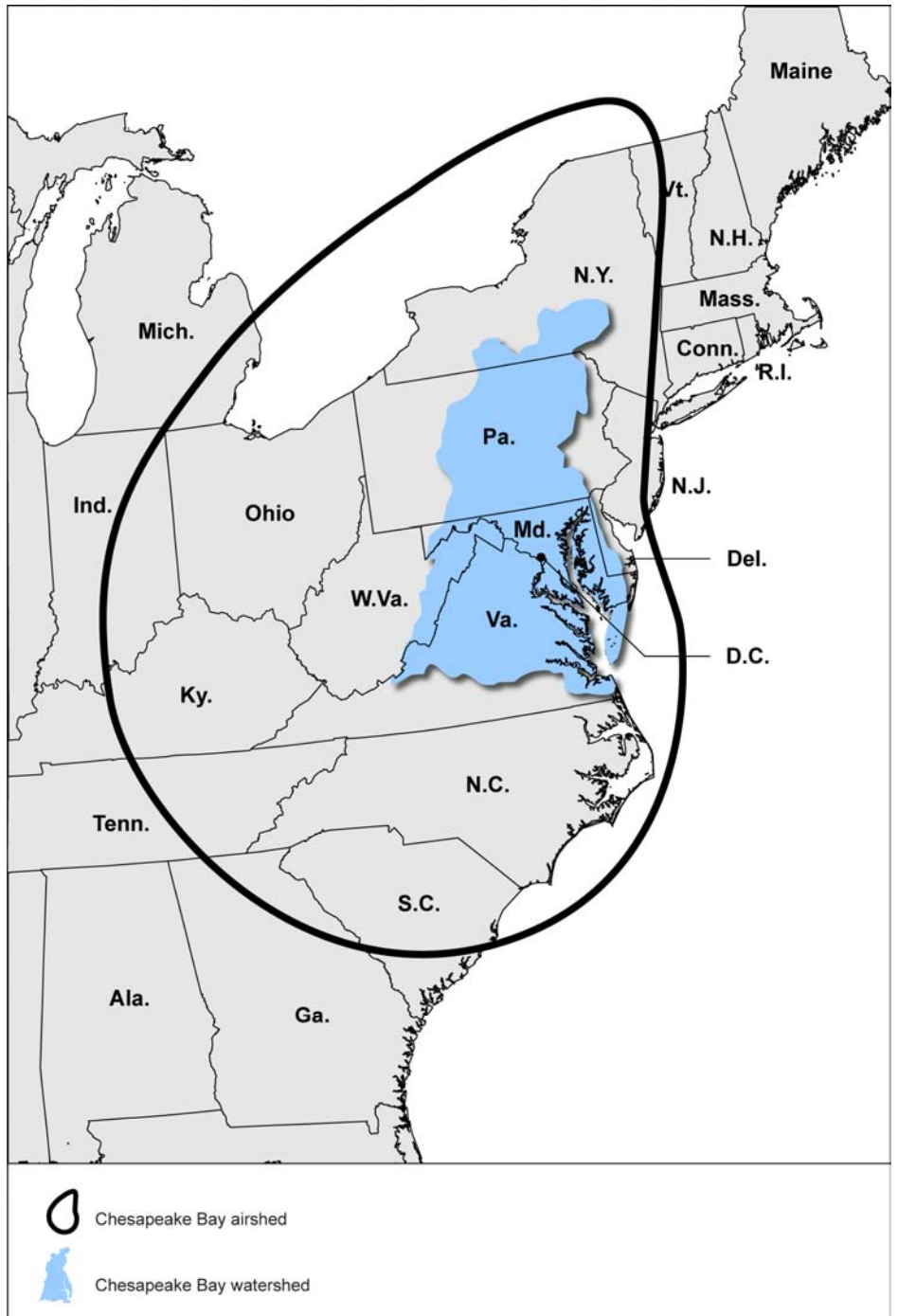
³⁸Atmospheric deposition of ammonia accounts for about 11 percent of total nitrogen impacting the bay.

³⁹The total limit for the jurisdictions was set at about 186 million pounds, or about a 25 percent reduction from previous limits.

party to this TMDL can only control those pollution sources inside their own jurisdictions. The bay's watershed is contained within the boundaries of the seven jurisdictions party to the TMDL, but the bay's NO_x airshed extends beyond the seven jurisdictions' boundaries. According to EPA, about 50 percent of the NO_x impacting the bay comes from sources outside of the seven jurisdictions. Figure 10 depicts the Bay's watershed and NO_x airshed—defined by the area from which 75 percent of the NO_x emissions that contribute to the bay originate.⁴⁰

⁴⁰According to EPA, 25 percent of NO_x emissions that contribute to the bay come from outside the seven jurisdictions but within the NO_x airshed, and 25 percent come from outside of the airshed.

Figure 10: Location of NO_x Airshed and Chesapeake Bay Watershed



Sources: GAO analysis of Chesapeake Bay Foundation data; Map Resources (map).

Clean Air Act Regulations Address Atmospheric Deposition, but EPA Faces Challenges Addressing Effects on Waterbodies

Implementation of CAA regulations has reduced emissions of NO_x, SO₂, and mercury and lessened the impact of atmospheric deposition on water quality and aquatic ecosystems. However, atmospheric deposition continues to affect water quality and harm aquatic ecosystems, and EPA faces challenges in using the CAA to further lessen the impact.

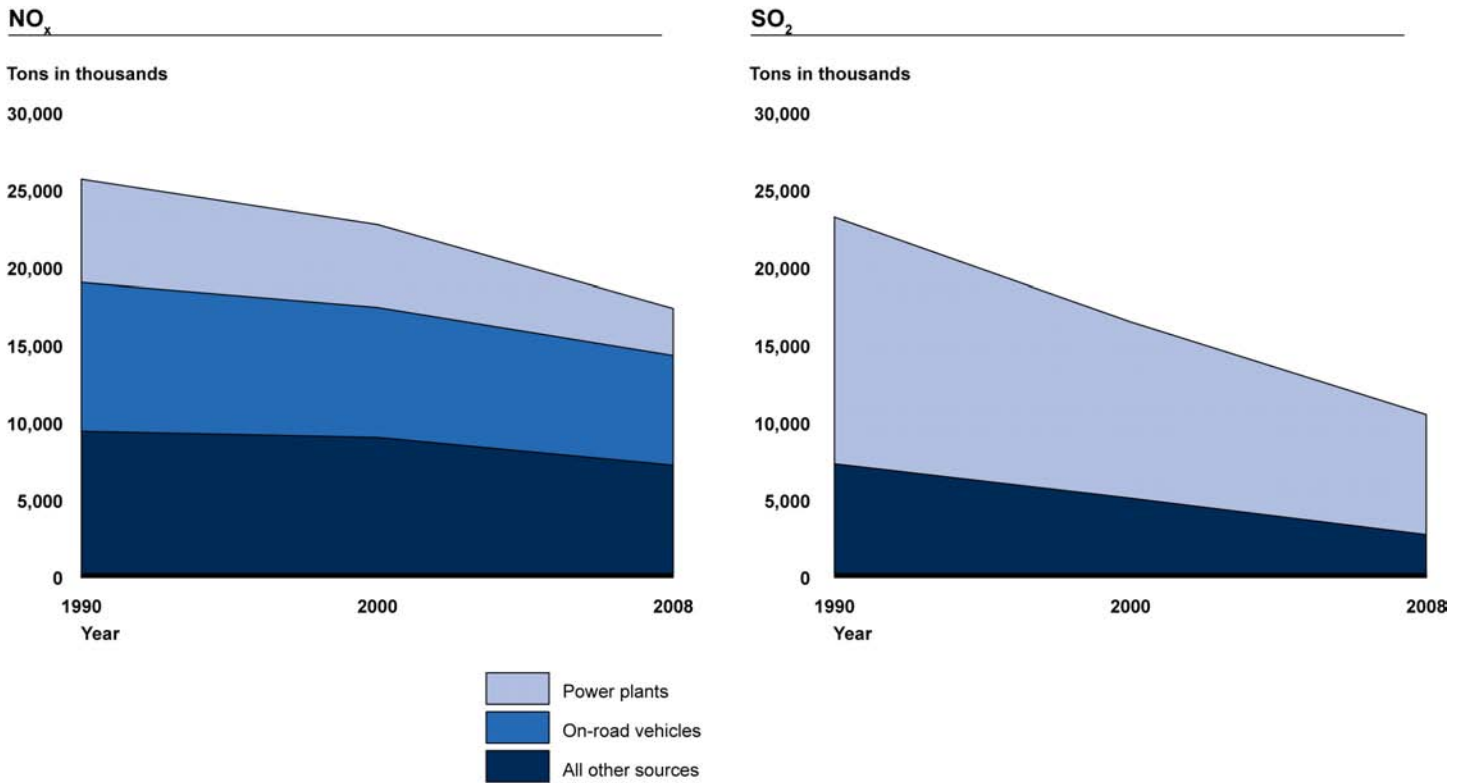
CAA Regulations Have Lessened the Effect of Atmospheric Deposition on Waterbodies, but Such Deposition Is Still Occurring

Implementation of EPA's CAA regulations has reduced emissions of NO_x, SO₂, and mercury, but most were designed to address the effect of these pollutants on air quality and related human health effects, not water quality and aquatic ecosystems. While not designed specifically to address water quality, reductions in emissions that have occurred as a result of the implementation of CAA regulations have had a beneficial effect on water quality. Even with these reductions in pollutants, atmospheric deposition continues to affect water quality and harm aquatic ecosystems.

NO_x and SO₂ Emissions

According to EPA's 2008 National Emissions Inventory, domestic emissions of NO_x declined from about 26 million tons in 1990 to about 17 million tons in 2008—about 74 percent of this reduction came from reduced emissions from power plants and on-road vehicles. Also according to the inventory, emissions of SO₂ declined from 23 million tons in 1990 to 10 million tons in 2008—about 64 percent of this reduction came from reduced emissions from power plants. Figure 11 shows the decline in NO_x and SO₂ emissions.

Figure 11: NO_x and SO₂ Emissions in 1990, 2000, and 2008 by Source



Source: 2008 National Emissions Inventory.

Note: Regarding the figure depicting SO₂ emissions, the category "All other sources" includes on-road vehicles. According to the National Emissions Inventory, on-road vehicles emitted 503 tons of SO₂ in 1990 and 117 tons in 2008.

EPA has identified the following three key regulations or programs as contributing to these reductions (1) CAA Title II emission standards for moving sources (i.e., vehicle emission standards), (2) actions designed to meet primary NAAQS,⁴¹ and (3) the Acid Rain Program. Neither the vehicle emissions standards nor the actions to meet primary NAAQS are

⁴¹Actions designed to meet primary NAAQS include, for example, emissions reductions under the Clean Air Interstate Rule, as well as other state-led programs such as the NO_x Budget Program.

designed to address the effect of NO_x and SO₂ on waterbodies.⁴² Vehicle emission standards limit certain vehicles' emissions of pollutants, including NO_x, to the greatest extent achievable through the application of available technology, giving appropriate consideration to cost, energy, and safety factors. Even with these reductions in pollutants, atmospheric deposition continues to affect water quality and harm aquatic ecosystems. EPA established primary NAAQS to provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly, for six principal pollutants, which are called "criteria" pollutants to protect public health based on scientific information on their effects.⁴³ In contrast, the Acid Rain Program was designed, in part, to address the effect of NO_x and SO₂ on waterbodies. The program implements CAA requirements for significant decreases in the emissions of NO_x and SO₂ from power plants to improve air quality and protect ecosystems that have suffered damage from acid rain, including aquatic ecosystems. According to the 2011 NAPAP report, the mandated emission reductions have been achieved, and thus no additional reductions in emissions can be expected from this program.⁴⁴

However, two broad trends—recent environmental regulations and changing market conditions—could affect emissions from power plants. Regarding environmental regulations, as we have previously reported, beginning in June 2010, EPA proposed or finalized two key regulations that would, among other things, reduce emissions of NO_x and SO₂ from coal-burning power plants, but the requirements and deadlines these

⁴²While EPA has not promulgated such regulations explicitly designed to address atmospheric deposition, EPA officials pointed out that EPA's mobile source standards do in fact address impacts on public welfare, which would include impacts of air pollutants on waterbodies. These officials noted that mobile source standards are "applicable to the emission of any air pollutant...which may reasonably be anticipated to endanger public health or welfare." The officials stated that they had addressed the mobile source standards' impact on public welfare in their rulemakings.

⁴³EPA has also established secondary NAAQS. Secondary NAAQS can be specifically designed to address a pollutant's impact on water quality and aquatic ecosystems, but the current secondary NAAQS for NO_x and SO₂ are designed to protect land-based ecosystems.

⁴⁴National Science and Technology Council, *National Acid Precipitation Assessment Program Report to Congress 2011: An Integrated Assessment* (Washington, D.C.: 2011).

regulations may establish for power plants are uncertain.⁴⁵ In particular, both regulations have been challenged in federal court. For example, EPA finalized the Cross-State Air Pollution Rule in August 2011. The regulation would have required reductions of certain emissions of air pollutants, including NO_x and SO₂, in 28 states. The U.S. Court of Appeals for the D.C. Circuit recently issued an opinion that would strike down the regulation, and EPA has asked the full court to rehear the case, creating uncertainty as to what may be required from power plants in the future to address such emissions.⁴⁶ Regarding broader market conditions, important market drivers have been weighing on the viability of coal-burning power plants. Key among these has been the recent decrease in the price of natural gas, which has made it more attractive for power companies to use natural gas instead of coal to generate electricity. Power plants that use natural gas instead of coal to produce electricity generally emit less NO_x and SO₂ per unit of electricity generated. Nevertheless, coal is likely to continue to be a key fuel source for electricity generation in the United States, although its share as a source of electricity is expected to decline.⁴⁷

Additionally, there have recently been key mobile source standards, like the 2010 Emissions Control Area and the 2011 Heavy Duty Vehicle GHG standards, which provide large reductions in both NO_x and SO_x from ocean-going ships and heavy-duty trucks, respectively. In addition, according to EPA officials, the upcoming planned Tier 3 vehicle standards, which are scheduled to be proposed in 2013, will provide significant NO_x reductions in the future.

⁴⁵See GAO, *EPA Regulations and Electricity: Better Monitoring by Agencies Could Strengthen Efforts to Address Potential Challenges*, [GAO-12-635](#) (Washington, D.C.: July 17, 2012).

⁴⁶As of December 2012, the court has not yet ruled on the petitions for rehearing. The Cross-State Air Pollution Rule is not in effect pending resolution of the case; rather, a predecessor rule, the Clean Air Interstate Rule, remains in effect. Specifically, in 2008 the U.S. Court of Appeals for the D.C. Circuit remanded the Clean Air Interstate Rule, but did not vacate it, finding that allowing the rule to remain in effect until it is replaced by a rule consistent with the opinion would at least temporarily preserve environmental values. The Cross-State Air Pollution Rule was EPA's response to the court's remand of the Clean Air Interstate Rule.

⁴⁷See *Electricity: Significant Changes Are Expected in Coal-Fueled Generation, but Coal is Likely to Remain a Key Fuel Source*, [GAO-13-72](#) (Washington, D. C.: Oct. 29, 2012).

The reduced domestic emissions of NO_x and SO₂ into the atmosphere are having a beneficial impact on water quality and aquatic ecosystems, according to EPA's 2011 report on the benefits and costs of the CAA.⁴⁸ The report analyzed how reductions in NO_x and SO₂ emissions attributable to the CAA are affecting the levels of acid rain and the amount of nitrogen contributing to nutrient over-enrichment in bays and estuaries, among other things. The analysis compared two scenarios for the time frame 1990 through 2020. The first scenario assumes that federal, state, and local air regulations promulgated from 1990 through September 2005 are implemented through 2020. The second scenario freezes federal, state, and local air pollution controls at the levels of stringency and effectiveness that prevailed in 1990. The analysis assumes that the geographic distributions of population and economic activity remain the same between the two scenarios. According to the report, air regulations limit levels of acid rain, and the greatest benefits for areas sensitive to acid rain occur in the Blue Ridge Mountains, the mid-Appalachian Region, western Virginia, and central Pennsylvania. The report also notes that air regulations limit nitrogen deposition, and the greatest benefits for estuaries occur along the southeastern coast, Gulf Coast, and Southern California coast.

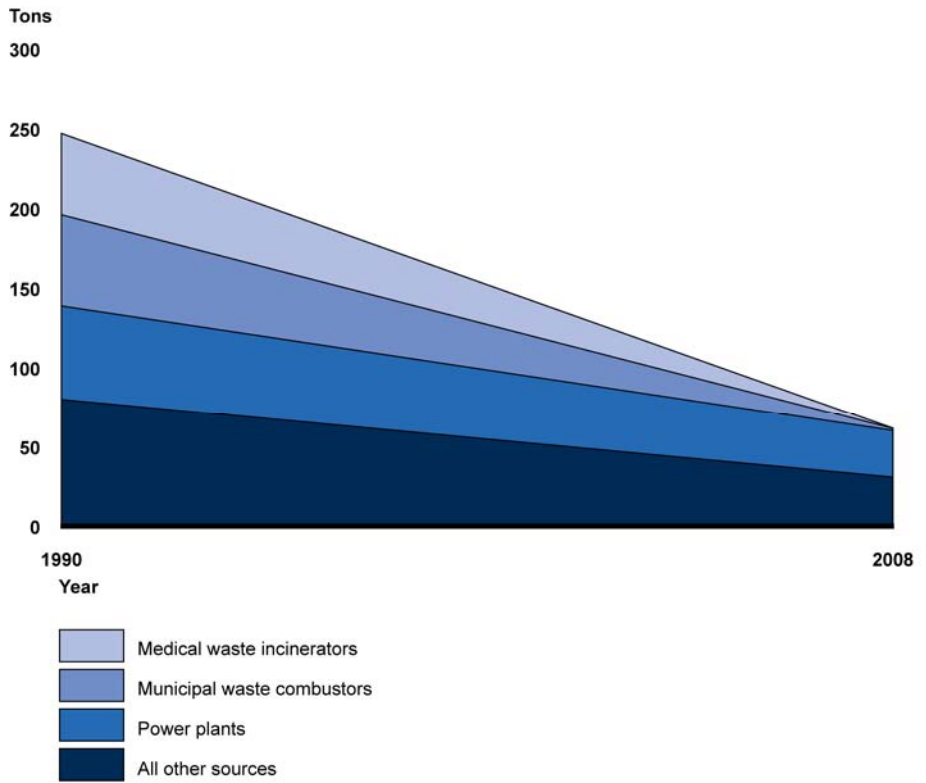
Mercury Emissions

Mercury emissions from human-caused domestic sources declined from about 246 tons in 1990 to about 61 tons in 2008, according to the 2008 National Emissions Inventory. More than half of this decline can be attributed to reduced emissions from municipal waste combustors and medical waste incineration.⁴⁹ According to the inventory, in 1990, these two sources emitted about 108 tons of mercury; in 2008, they emitted less than 2 tons of mercury. Mercury emissions from power plants also declined from about 59 tons of mercury in 1990 to about 30 tons of mercury in 2008. Figure 12 shows the decline in human-caused domestic mercury emissions.

⁴⁸U.S. Environmental Protection Agency, Office of Air and Radiation, *The Benefits and Cost of the Clean Air Act from 1990 to 2020*, Final Report (Washington, D.C.: March 2011). Section 812 of the 1990 Clean Air Act Amendments requires EPA to develop biannual reports that estimate the benefits and costs of the Clean Air Act. This report is the third in the Section 812 series. The previous two reports covered different time frames.

⁴⁹Municipal waste combustors are incinerators or facilities that generate energy from garbage.

Figure 12: Mercury Emissions in 1990 and 2008 by Source



Source: 2008 National Emissions Inventory.

Note: all other sources include electric arc furnaces; Portland cement nonhazardous waste; and industrial, commercial, and institutional boilers, and process heaters.

EPA issued regulations in 1995 and 1997 under the CAA limiting mercury emissions from municipal waste combustors and medical infectious waste incinerators.⁵⁰ They were not designed to address the effect of mercury on waterbodies but were instead technology-based standards, as directed

⁵⁰See EPA, Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Municipal Waste Combustors, 60 Fed. Reg. 65,387 (Dec. 19, 1995) and EPA, Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Hospital/Medical/Infectious Waste Incinerators, 62 Fed. Reg. 48,348 (Sept. 15, 1997).

by CAA.⁵¹ According to EPA, power plant emissions of mercury also declined. Specifically, according to EPA, power plant emissions declined primarily because of state rules targeting mercury emissions and CAA regulations targeting emissions of other pollutants that incidentally also reduced mercury emissions. Additionally, in February 2012, EPA promulgated the Mercury and Air Toxics Standards (MATS),⁵² establishing for the first time emission limitations on mercury and other toxic pollutants from existing and new power plants.⁵³ The rule was challenged in federal court. Regarding the provisions for existing units at power plants, the legal challenges are pending before the U.S. Court of Appeals for the D.C. Circuit. Regarding the provisions applicable to certain new units at power plants, EPA granted a petition for reconsideration; the court proceedings are on hold, and the provisions will not take effect before EPA completes that process, expected in March 2013. Similar to the regulations limiting mercury emissions from municipal waste combustors and medical waste incinerators, MATS are technology-based standards, as directed by CAA, and thus are not designed or established with the specific purpose of addressing the effect of mercury emissions on waterbodies. EPA projects that MATS will reduce future mercury emissions from power plants to about 9 tons by 2016, a 70

⁵¹Each regulation sets maximum achievable control technology (MACT) standards. A MACT standard is a technical standard applying to a particular industry that releases hazardous air pollutants, such as mercury. MACT standards are designed to reduce emissions of hazardous air pollutants to a maximum achievable degree, taking into consideration the cost of reductions and other factors.

⁵²CAA required EPA to study the public health hazards from electricity generating units' emissions of mercury and other hazardous air pollutants and to regulate those emissions under section 112 if it finds that such regulation is "appropriate and necessary." EPA made such a finding regarding certain electricity generating units in 2000 but did not issue a regulation under section 112. In 2005, EPA reversed this finding and finalized a regulation under section 111 of the CAA regulating mercury emissions from certain electricity generating units, which a federal court later struck down. Pursuant to a settlement agreement to resolve a lawsuit for failing to meet the statutory deadline for issuing a section 112 regulation, EPA published the final MATS regulations in February 2012.

⁵³See EPA, National Emission Standards for Hazardous Air Pollutants From Coal- and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units; Final Rule, 77 Fed. Reg. 9304 (Feb. 16, 2012). In addition to the new standards for emission of mercury and other air toxics, the rulemaking also included amendments to new source performance standards for several criteria pollutants.

percent reduction from 2008.⁵⁴ According to an EPA official, the reduced emissions of mercury have lessened the amount of mercury deposition into water because most mercury in water comes from atmospheric deposition, but estimates of the amount of mercury that has been prevented from depositing in water are difficult to determine. Even with these reductions in mercury, atmospheric deposition continues to affect water quality and harm aquatic ecosystems.

EPA Faces Challenges in Addressing Atmospheric Deposition with Clean Air Act

EPA faces challenges in using air regulations to further address the effects of atmospheric deposition from NO_x, SO₂, and mercury. According to the agency, its recent efforts to establish secondary NAAQS to address acid rain and nutrient over-enrichment were not successful because of insufficient scientific data. Air regulations have limited and, are expected by EPA to further limit, domestic mercury emissions, but mercury emissions originating outside of the United States are also contaminating U.S. waters.

NO_x and SO₂ Emissions

As part of its most recent 5-year review of secondary NAAQS, EPA concluded in the 2011 notice for its proposed rule on secondary NAAQS that current levels of NO_x and SO₂ are sufficient to cause acidification of aquatic ecosystems through acid rain and contribute to nutrient over-enrichment in estuaries, among other effects, and that existing secondary NAAQS for NO_x and SO₂ do not provide adequate protection from these effects.⁵⁵ Ultimately, however, the agency did not establish any additional secondary NAAQS to protect against these effects for ecosystems, citing challenges in available sufficient scientific data to set standards.⁵⁶

⁵⁴EPA also projects that MATS will reduce SO₂ emissions from power plants.

⁵⁵See EPA, Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Sulfur; Proposed Rule, 76 Fed. Reg. 46,084 (Aug. 1, 2011). According to EPA, it based its proposed conclusions on the following assessments: U.S. EPA, Integrated Science Assessment for Oxides of Nitrogen and Sulfur Ecological Criteria, U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/082F, 2008 and U.S. EPA, Risk and Exposure Assessment for Review of the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur, U.S. Environmental Protection Agency, Washington, D.C., EPA/452/R-09-008a, 2009.

⁵⁶EPA, Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Sulfur; Final Rule, 77 Fed. Reg. 20,218 (April 3, 2012).

To address the effects of acid rain, EPA developed an innovative approach to establish a secondary NAAQS but faced challenges including insufficient scientific data to determine the degree of protectiveness that would likely be provided by such standards. Specifically, the CAA requires that NAAQS be both national in scope and provide the requisite degree of protection—that is, that the standards are neither more nor less stringent than necessary. Because many areas in the United States are naturally resistant to the effects of acid rain due to underlying geological conditions, EPA’s approach was to establish a secondary NAAQS that would apply nationwide but would account for differences in the sensitivity to acid rain of ecosystems across the country.⁵⁷ As part of this approach, EPA identified 84 regions, referred to as ecoregions, based on ecological factors relevant to acid rain in aquatic ecosystems. The 84 ecoregions cover the contiguous United States. However, in the notice for its April 2012 final rule on secondary NAAQS, EPA concluded that it could not determine with an acceptable degree of scientific certainty that the secondary NAAQS under this approach would provide the requisite degree of protection for each ecoregion because of uncertainties related to ecological and atmospheric modeling and limitations in available field data. An important piece of field data needed to determine the requisite degree of protection is “critical load”—the amount of acid rain that an area can experience before ecological damage occurs. The number of critical load estimates for the 84 ecoregions ranged from about 700 estimates for one ecoregion to less than five estimates for several ecoregions.

To address the uncertainty related to modeling and field data, EPA has begun a 5-year field pilot program to enhance its understanding of the degree of protectiveness that would likely be afforded by a secondary NAAQS using its new approach. EPA described the pilot program in its April 2012 final rule notice, stating that the program would serve to inform future reviews of NAAQS to address acid rain. However, according to an EPA official, the pilot program is a “proof of concept” project and not designed specifically to obtain sufficient scientific data to meet applicable legal standards for establishing secondary NAAQS. The official said that three sites have been chosen from which to gather additional data, but that resource constraints prevent EPA from moving forward with two of those areas. It is unclear if the agency will be able to address the

⁵⁷ EPA describes its new approach for developing NAAQS for acid rain at length in its 2011 proposed rule. See 76 Fed. Reg. 46,084 (Aug. 1, 2011).

scientific uncertainties related to ecological and atmospheric modeling and limitations in available field data in time for the next 5-year interval for reviewing NAAQS and establishing a secondary NAAQS under its innovative approach. According to agency officials, EPA has not identified alternative strategies to address the acidification of aquatic ecosystems if it cannot resolve the scientific uncertainties.

EPA also faces challenges in addressing the contribution of NO_x to nutrient over-enrichment under the CAA. EPA announced in its 2011 notice for its proposed rule on secondary NAAQS that it would not consider establishing an additional secondary NAAQS to address other effects from atmospheric deposition associated with NO_x and SO₂, including the contributions of NO_x to nutrient over-enrichment in aquatic ecosystems, because of the limited quantity and quality of available scientific data relative to that available for acid rain. According to an EPA official, establishing a secondary NAAQS for NO_x to protect against nutrient over-enrichment in a waterbody would be difficult because there can be many sources of nitrogen unrelated to atmospheric deposition, and these sources can be the dominant contributor of nitrogen to the waterbody.

Furthermore, in a 2011 report, the EPA Science Advisory Board made recommendations regarding the adverse effects of nitrogen from all sources on water quality and aquatic ecosystems, as well as the effects of nitrogen on biodiversity, forests, and human health, among other effects.⁵⁸ In response, EPA announced in 2012 that it will develop a “Nitrogen Roadmap” that identifies how it will foster research, program implementation, and policy integration for nitrogen and other pollutants across the agency. According to EPA officials, the roadmap is a scoping document that will precede more concrete steps to develop an integrated nitrogen research strategy to address acidification and nutrient over-enrichment. The goals of the strategy are to ensure coordination among research areas within EPA, and among EPA scientists and policy analysts. An EPA official also noted that developing partnerships with other federal agencies, state and local governments, and

⁵⁸The EPA Science Advisory Board is a federal advisory committee established by Congress in 1978 with a broad mandate to advise the agency on technical matters. The board’s recommendations are found in its report: *Reactive Nitrogen in the United States: An Analysis of Inputs, Flows, Consequences, and Management Options – A Report of the EPA Science Advisory Board*, EPA-SAB-11-013, August 2011.

nongovernmental organizations, will be an important step that will help foster nonregulatory solutions to address nutrient over-enrichment. According to the official, the roadmap is scheduled to be released in 2013, but the effort to address nutrient over-enrichment will likely be long-term. This effort may lead to more suitable approaches to address nutrient over-enrichment than establishing secondary NAAQS by themselves.

Mercury Emissions

EPA also faces challenges in addressing mercury contamination because most mercury atmospheric deposition within the continental United States comes from sources that are outside of the scope of EPA's authority. According to a 2010 National Research Council report, studies suggest that 10 percent to 80 percent of the mercury deposited in the contiguous United States is from human-caused domestic emissions—depending on location—with an average of about 30 percent for the country as a whole.⁵⁹ According to the report, the remainder comes from natural sources, human-caused emissions from other countries, and the global pool of mercury. The United States is responsible for a relative small percentage of the global mercury emissions that contribute to the global pool of mercury. According to the 2008 UNEP report, total global emissions of mercury from human activity in 2005 ranged from 1,300 tons to 3,200 tons.⁶⁰ According to data EPA used for the MATS rule, domestic mercury emissions from human activity totaled about 105 tons in 2005. Thus, even without reductions in mercury emissions beyond the 2005 level, over 90 percent of human-caused mercury emissions originate outside of the United States.

EPA is involved in international negotiations to limit global mercury releases into the environment. In February 2009, the Governing Council of the UNEP agreed on the need to develop a global, legally binding agreement on mercury to reduce risks to human health and the environment, including reducing atmospheric emissions of mercury. The council outlined a negotiating process to reach an agreement. The first negotiation meeting was held in June 2010, and the fifth and final meeting

⁵⁹National Research Council, *Global Sources of Local Pollution: An Assessment of Long-Range Transport of Key Air Pollutants to and from the United States*. (National Academies Press, Washington, D.C.: 2010).

⁶⁰The United Nations Environment Programme, *The Global Atmospheric Mercury Assessment: Sources, Emissions and Transport Mercury Assessment* (Geneva, Switzerland: December 2008).

is scheduled to be held in 2013. The third negotiating session (held in October and November 2011) produced a draft text of the agreement. The draft text includes language for consideration that would call on parties to the agreement that have significant aggregate mercury emissions from listed source categories to adopt national or numeric emission reduction goals that are, at a minimum, consistent with best available practices for reducing and, where feasible, eliminating atmospheric mercury emissions from sources such as coal-burning power plants. Language for consideration in the draft text would also call on parties to (1) develop and maintain an inventory of these sources and reliable emissions estimates and (2) develop and implement an action plan that includes strategies and timetables for achieving emission reduction goals.

Conclusions

EPA has long recognized atmospheric deposition as a problem and has sought to mitigate its effects; however, EPA's efforts are being hindered by limitations in the regulatory tools available to it. The CAA provides EPA with regulatory tools to reduce airborne emissions—and this has reduced atmospheric deposition. Even with these reductions, atmospheric deposition continues to affect water quality and harm aquatic ecosystems. One CAA tool for airborne emissions is also currently available to EPA to directly address the effects of atmospheric deposition—secondary NAAQS—but EPA has not been successful in using secondary NAAQS to protect water quality and aquatic ecosystems from acid rain or nutrient over-enrichment.

We acknowledge the innovative approach EPA developed for establishing secondary NAAQS to address acid rain. However, as of April 2012, EPA stated it did not have sufficient scientific data to determine with an acceptable degree of scientific certainty if its new approach would meet applicable legal standards to establish the secondary NAAQS. Further, the 5-year pilot program it has initiated to inform future reviews of NAAQS to address acid rain is not designed specifically to obtain these data. However, EPA has not identified alternative strategies to address the acidification of aquatic ecosystem if it cannot resolve the scientific uncertainties that prevented it from issuing the secondary NAAQS in April 2012. Furthermore, secondary NAAQS may not be well suited to address acid rain because EPA must satisfy the legal requirement that secondary NAAQS provide the requisite degree of protection—that is, that the standards are neither more nor less stringent than necessary—for all parts of the nation, and some areas of the nation are sensitive to the effects of acid rain, while others are naturally resistant to them.

Additionally, EPA does not have the scientific data it needs to establish a secondary NAAQS to address the contribution of NO_x to nutrient over-enrichment in aquatic ecosystems. Because there can be many sources of nitrogen that contribute to nutrient over-enrichment in a waterbody, including sources of nitrogen unrelated to atmospheric deposition, secondary NAAQS by themselves may not be well suited to address nutrient over-enrichment. EPA announced in 2012 that it will develop a “Nitrogen Roadmap” that identifies how it will foster research, program implementation, and policy integration for nitrogen and other pollutants across the agency. This roadmap is intended to be a scoping document that is to precede more concrete steps to develop an integrated nitrogen research strategy to address nutrient over-enrichment. We encourage EPA to continue its effort to develop an integrated nitrogen research strategy, which may lead to more suitable approaches to address nutrient over-enrichment.

Regarding mercury, because most emissions originate outside of the United States, EPA’s regulatory tools are of limited applicability to the majority of emissions, but the agency is involved in the UNEP negotiations to, among other things, reduce atmospheric emissions of mercury on a global scale. This will be an important step toward reducing mercury levels in our nation’s waters.

Recommendation for Executive Action

To help ensure that EPA can address atmospheric deposition of NO_x and SO₂ impairing the nation’s waters, we recommend that the EPA Administrator determine whether EPA can obtain in a timely manner the data it needs to establish secondary NAAQS adequate to protect against the effects of acid rain and, if not, identify alternative strategies to do so.

Agency Comments and Our Evaluation

We provided a draft of this report to EPA for comment. In written comments, which are reproduced in appendix II, EPA agreed with the recommendation in our report. EPA stated that under the CAA, it is required every 5 years to complete a thorough review of the latest scientific knowledge, and as necessary, make revisions to the NAAQS or promulgate new NAAQS. For NO_x and SO_x, it stated that it will continue to review the science, as it develops and gather new data as resources permit. Additionally, EPA provided technical comments to provide additional clarity and completeness to the report. An overview of these technical comments is included in the written comments reproduced in appendix II. We incorporated the technical comments as appropriate.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the Administrator of the Environmental Protection Agency, the appropriate congressional committees, and other interested parties. In addition, the report will be available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or trimbled@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.



David C. Trimble
Director
Natural Resources and Environment

Appendix I: Scope and Methodology

Our objectives were to (1) examine the extent to which the atmospheric deposition of nitrogen oxides (NO_x), sulfur dioxide (SO₂), and mercury contributes to the impairment of the nation's waters and identify the key sources of these pollutants;(2) identify the regulatory tools that the Environmental Protection Administration (EPA) uses under the Clean Water Act (CWA) to address the effects of atmospheric deposition, and the challenges, if any, that it faces in doing so; and (3) identify the regulatory tools that EPA uses under the Clean Air Act (CAA) to address the effects of atmospheric deposition, and the challenges, if any, that it faces in doing so.

To examine the extent to which atmospheric deposition of NO_x, SO₂ and mercury contributes to the impairment of the nation's waters, we analyzed EPA's Assessment, TMDL (Total Maximum Daily Load) Tracking, and Implementation System (ATTAINS) database. To assess the reliability of its data, we interviewed knowledgeable agency officials and conducted electronic testing of the data. We determined that, although the data have limitations, as specified below, they were sufficiently reliable to present reported atmospheric deposition impairment on assessed waters for selected categories of water bodies. The ATTAINS data we analyzed were the most recent available data from states and not the most current reporting-cycle year, 2012, because these 2012 data are undergoing review. Because some states are more current than others in reporting, the state data we analyzed for a given state could be from any reporting cycle year from 2002 to 2010, depending on the state.¹ Our analysis also included data from the 50 states, the District of Columbia, Puerto Rico, Guam, the U.S. Virgin Islands, American Samoa, and the Commonwealth of Northern Mariana Islands. ATTAINS also included data from the Delaware River Basin Commission, but we excluded these data in our analysis because EPA does not include it in its reports or queries related to the quality of the nation's waters. In analyzing the data, we first identified how many miles, acres, or square miles of waters in each waterbody category in ATTAINS were assessed and classified as impaired. The ATTAINS database contained 10 different categories of waters. However, we did not report on coastal waters, ocean and near coastal waters, wetlands, Great Lakes shoreline, inland lake shoreline, and Great Lakes connecting channels because states have only

¹One state had data from reporting cycle 2002; one state had data from 2004; six states had data from 2006; six other states had data from 2008, and the rest of the states had data from reporting cycle 2010.

assessed a small percentage of these waters, and there was insufficient data or, in the case of Great Lakes shoreline, because we were reporting on Great Lakes open water. We reported on impaired waters in the following four categories:

- Streams, creeks and rivers;
- Lake, reservoirs, and ponds;
- Bays and estuaries; and
- Great Lakes open water.

We then identified what pollution sources the states associated with these impaired miles, acres, or square miles of waters and considered only those waters whose impairment was attributed by states to atmospheric deposition. Our analysis of ATTAINS data represents only those waters that states have assessed and associated with atmospheric deposition as an impairment source. It is possible that additional impairment due to atmospheric deposition has occurred, but that states either did not report atmospheric deposition as an impairment source in ATTAINS or reported it as unknown or unspecified. In addition, our findings represent waters impaired by the atmospheric deposition of all reported air pollutants and are not specific to the atmospheric deposition of NO_x, SO₂, and mercury. We examined data on the reported causes and pollutants for waters with impairment that the states associated with atmospheric deposition and found that we could not reliably report on the causes or pollutants, such as NO_x and SO₂, because of data inconsistencies.

For additional information on the extent to which atmospheric deposition of these three pollutants contribute to the impairment of the nation's waters, we reviewed studies from EPA and other federal agencies, the United Nations, and others. We assessed the reliability and methodology of these studies, including limitations and assumptions, and determined that they were sufficiently reliable for the purposes of examining the extent to which atmospheric deposition is contributing to the impairment of the nation's waters. In addition, we examined state reported-data in EPA's 2010 National Listing of Fish Advisories (NLFA) and assessed the reliability of the data. We determined that despite some NLFA limitations—such as states' different monitoring methods for sampling contaminants in fish tissues and limited waters monitoring – the data were sufficiently reliable for the purposes of reporting the number of states with mercury-related fish advisories and the extent of mercury-related fish

advisories for certain types of waters. We also interviewed officials and scientists from EPA's offices, including the Office of Air and Radiation and the Office of Water; the Department of Commerce's National Oceans and Atmospheric Administration; and academic, state, and private sector scientists.

To identify the key sources of NO_x, SO₂, and mercury, we examined emission estimates from EPA's National Emissions Inventory (version 2)—a national database of air emissions information with input from numerous state and local air agencies, tribes, and industry. For source estimates on NO_x, SO₂, and mercury emissions, we used 2008 National Emissions Inventory estimates because EPA is currently collaborating with state, local, and tribal agencies in preparing the 2011 inventory. We also talked with EPA officials and reviewed National Emissions Inventory-related documentation on quality assurance to assess the reliability of National Emissions Inventory estimates. We determined that despite some limitations—such as methodological and modeling differences used in estimating emission across various years and versions of the inventory—the 2008 National Emissions Inventory data were sufficiently reliable for the purposes of identifying in the national aggregate the top emission sources of NO_x, SO₂, and mercury, and for reporting emission estimates from the top emitting sources. In addition, we reviewed EPA documents related to mercury emissions and sources, as well as a 2008 United Nations Environment Programme (UNEP) assessment on global mercury sources, emissions, and transport.

To examine the regulatory tools that EPA uses under the CWA to address the effects of atmospheric deposition, and the challenges, if any, it faces in doing so, we reviewed the law, relevant EPA regulations and guidance, and other pertinent documents, and interviewed relevant EPA and state officials. As a result, we identified listing impaired waters and the TMDL as the primary regulatory tools EPA uses to address the effects of atmospheric deposition. We also chose to examine a nonprobability sample of three TMDLs in greater detail to illustrate the challenges EPA faces in using CWA to address atmospheric deposition. We selected each TMDL because it addressed a different effect caused by the atmospheric deposition of the three pollutants on which we are focusing. Specifically, we chose the Northeast Regional TMDL because it is addressing mercury, including atmospheric deposition of mercury. We chose a New York State TMDL because it addresses acid rain caused by NO_x and SO₂. Finally, we chose the Chesapeake Bay TMDL because it address nutrient over-enrichment, including from NO_x. To describe these TMDLs and the challenges they present, we examined key documents

and interviewed EPA, state, and regional officials responsible for implementing the TMDLs.

To examine the regulatory tools that EPA uses under CAA to address the effects of atmospheric deposition and the challenges that it faces in doing so, we reviewed the law, relevant EPA regulations and guidance, and other pertinent documents and studies, and interviewed relevant EPA officials. We used data from the 2008 National Emissions Inventory and 2011 EPA study on the benefits and costs of the CAA amendments of 1990 to identify the reductions in NO_x, SO₂, and mercury, key regulations that contributed to the reductions, and the associated beneficial effects on water quality and aquatic ecosystems. We assessed the reliability and methodology of these sources of information, including limitations and assumptions, and determined that they were sufficiently reliable for the purposes of attributing estimates of some reductions in NO_x, SO₂, and mercury to CAA. We reviewed the CAA and pertinent regulations to determine the design of the regulations. To understand the challenges that EPA faced in trying to develop a secondary National Ambient Air Quality Standard (NAAQS) to reduce emissions of NO_x and SO₂ in order to protect ecosystems sensitive to the effects of acid rain, we reviewed documentation developed as part of the rulemaking process and interviewed knowledgeable officials responsible for the rulemaking. To understand EPA's integrated nitrogen research strategy, we reviewed pertinent documents and interviewed relevant EPA officials. For challenges related to mercury, we reviewed a UNEP study on global mercury emissions, sources, and transport, and other UNEP mercury-related documents on global efforts to reduce mercury emissions and interviewed knowledgeable EPA officials.

We conducted this performance audit from September 2011 to January 2013 in accordance with generally accepted auditing standards. Those standards require that we plan and perform the audit to obtain sufficient and appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Comments from the Environmental Protection Agency



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JAN 7 2013

OFFICE OF
AIR AND RADIATION

Mr. David C. Trimble
Director
Natural Resources and Environment
U.S. General Accountability Office
Washington, D.C. 20548

Dear Mr. Trimble:

Thank you for the opportunity to review and comment on the General Accountability Office's (GAO) draft report "Water Quality: EPA Faces Challenges in Addressing Damage Caused by Airborne Pollutants." As stated in the draft report, the objectives in this review were to: (1) examine the extent to which atmospheric deposition of NO_x, SO_x and mercury contribute to the impairment of the nation's waters and identify the key sources of these pollutants; (2) assess the regulatory tools that the EPA uses under the Clean Water Act (CWA) to address the effects of atmospheric deposition, and the challenges, if any, that it faces in doing so; and (3) assess the regulatory tools that the EPA uses under the Clean Air Act (CAA) to address the effects of atmospheric deposition, and the challenges, if any, that it faces in doing so.

I am responding on behalf of the EPA offices that participated in this review – the Office of Air and Radiation and the Office of Water. Below, I am providing our comments on the report's recommendation, as well as an overview of a few important clarifications on the technical findings. Under separate cover, EPA will be submitting suggested modifications to the technical findings that could provide more clarity and completeness to the report.

Recommendation: *To help ensure that the EPA can address atmospheric deposition of NO_x and SO₂ impairing the nation's waters, we recommend that the EPA Administrator determine whether the EPA can obtain in a timely manner the data it needs to establish secondary NAAQS adequate to protect against the effects of acid rain and, if not, identify alternative strategies to protect these areas.*

Response: The EPA accepts the GAO's recommendation. We are committed to protecting human health and the environment from the detrimental effects of atmospheric deposition, including the protection of our nation's waterways. As the report notes, efforts were made by the EPA to develop secondary national ambient air quality standards (NAAQS) for NO_x and SO_x to protect waters from acidic deposition. These efforts made major progress in the scientific understanding of the effects of atmospheric deposition on waterways, but the EPA concluded that the uncertainties in translating the available information into an appropriate NAAQS were

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too great to allow the Administrator to set a standard for NO_x and SO_x deposition. Under the CAA, the EPA is required every five years to complete a thorough review of the latest scientific knowledge, and as necessary, make revisions in the NAAQS or promulgate new NAAQS. For NO_x and SO_x, the EPA will continue to review the science, as it develops, and gather new data, as resources permit.

The EPA appreciates the discussion regarding the limitations of the CWA in addressing pollutants from air deposition. However, despite these limitations, Total Maximum Daily Loads (TMDLs) can play an important role in identifying the contributions from air sources to water. In particular, TMDLs can parse the contributions from various air sources to waterbodies, including separating the contributions from local and global sources. This, in turn, can help states identify whether there are air sources amenable to controls at the state level. The EPA has provided some suggestions in the technical comments on where the report may be able to include this important point. In addition, the EPA would like to note some of the positive aspects of the CWA Section 319(g) management conference on mercury held in 2010 between the Northeast states and eleven upwind states. While no formal agreement or consensus was reached among the participating states, the conference was the first to bring together air and water managers from both upwind and downwind states to share lessons learned from their respective mercury programs.

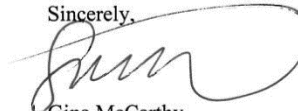
The EPA appreciates the GAO effort to summarize some of the CAA rules relevant to water quality. However, a few more rules are important to mention. Since 2005, there have been key mobile source standards, such as the 2010 Emissions Control Area and the 2011 Heavy Duty Vehicle standards, which provide large reductions in both NO_x and SO_x from ocean-going ships and heavy-duty trucks, respectively. In addition, the planned Tier 3 vehicle standards will provide significant NO_x reductions in the future. The 2012 adjustments to the air toxics standards for industrial boilers and certain incinerators will reduce SO₂ emissions by 572,000 tons per year. The Mercury Air Toxics Standards (MATS) are noted in the report for their impact on mercury emissions, but the report fails to mention the large expected reductions in SO₂ emissions (1.5 million tons). The report also notes that the EPA's MATS rule substantially reduces mercury emissions from power plants (the largest source in the U.S.), but does not adequately recognize that those emissions are a significant contributor to mercury deposition in many freshwater lakes and streams in the U.S.

In addition to the Acid Rain Program, NO_x emissions reductions under the NO_x Budget Program and NO_x and SO₂ emissions reductions under the Clean Air Interstate Rule (CAIR) have led to improved air quality, decreased atmospheric deposition and some improvements to aquatic and terrestrial ecosystems. While the EPA is appealing the decision by the U.S. Court of Appeals for the D.C. Circuit in August 2012 that struck down the Cross-State Air Pollution Rule (CSAPR), CAIR remains in effect and will remain in effect until replaced by another rule requiring SO₂ and NO_x emission reductions. Annual 2012 SO₂ emissions levels from power plants within the CSAPR region are on track to be 23% below what CSAPR would have required in 2012. Similarly, annual NO_x and ozone season NO_x emissions in the CSAPR region are projected to be 12% and 5% below what CSAPR required for 2012.

**Appendix II: Comments from the
Environmental Protection Agency**

In closing, the EPA remains committed to protecting public health and the environment, including our nation's waterways. As the GAO found, utilizing the tools of the CWA and the CAA can be complicated, but the current rules achieve much of the reductions that are needed. Thank you again for the opportunity to review and respond to the draft GAO report. If you have any questions, please contact Randy Waite at (919) 541-5447.

Sincerely,

A handwritten signature in black ink, appearing to read "Gina", with a large, sweeping flourish that loops back to the right.

Gina McCarthy
Assistant Administrator

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

David C. Trimble, (202) 512-3841 or trimbled@gao.gov

Staff Acknowledgments

In addition to the individual named above, Barbara Patterson, Assistant Director; Elizabeth Beardsley; Greg Carroll; Bernice Hill Dawson; Charles Egan; Michelle Fejfar; Michael Hix; Catherine Hurley; Alison O'Neill; Madhav Panwar; Carla Rojas Paz; and Carol Herrnstadt Shulman made key contributions to this report.

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