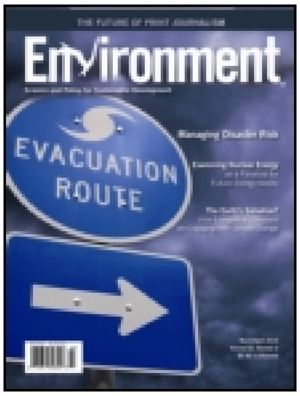

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DISCLOSURE OF TOXIC RELEASES IN THE UNITED STATES

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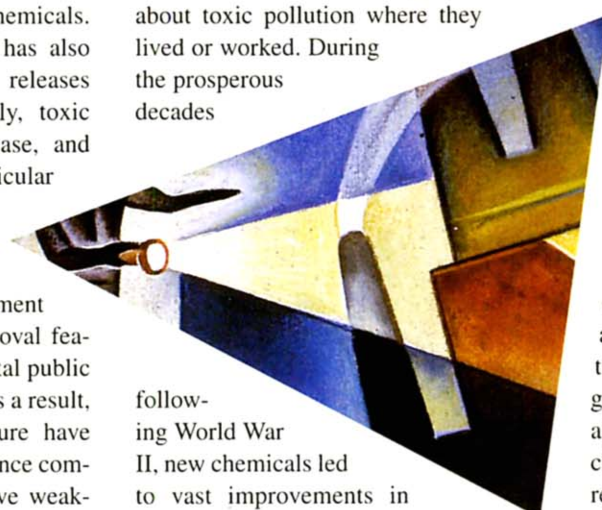
IN THE EARLY MORNING OF 3 December 1984, a deadly cloud of methyl isocyanate gas escaped from a pesticide plant in Bhopal, India, and drifted over nearby residential areas. Twenty-five tons of toxic gas leaked from a ruptured storage tank, killing at least 2,000 people and injuring 100,000 more. The media called it history's worst industrial disaster. During the months that followed, a number of less serious chemical leaks in the United States—including one at a Union Carbide plant in Institute, West Virginia, that sent more than 100 people to the hospital—created a new level of public concern about the potential dangers of accidental pollution. In response,

BY MARY GRAHAM AND CATHERINE MILLER

Congress approved the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA). The new law fostered the creation of emergency response systems in communities around the country to minimize the health effects of such incidents.[1]

As part of that effort, Congress tacked on a last-minute, little-noticed requirement that U.S. manufacturers tell the public each year about the amounts of toxic chemicals released into the environment. This disclosure system, administered by the U.S. Environmental Protection Agency (EPA), is credited with helping to reduce toxic releases by 46 percent in 11 years. Two assumptions have often dominated discussions about this remarkable decline: that public disclosure has exerted a steady downward pressure on releases; and that the who, what, when, and how of disclosure is a relatively simple matter. Closer analysis suggests a more complicated and interesting story. Reported releases have indeed declined substantially, and the decline has been somewhat greater for some particularly harmful chemicals. Recycling of toxic chemicals has also increased. But reductions in releases have now slowed substantially, toxic waste has continued to increase, and economic factors affecting particular industries have sometimes played a disproportionate role in national trends. Further, this disclosure requirement is extremely complex. Its approval featured clashes among fundamental public values and political interests. As a result, some aspects of its architecture have given it unusual power to influence companies, while other aspects have weakened its potential to improve human and environmental health.



A Novel Use of Structured Disclosure

The Toxics Release Inventory (TRI) requires that manufacturers disclose to the public their routine toxic releases—releases that are generally intentional and lawful.[2] Its scope and structure were negotiated mainly by Senator Robert Stafford, a moderate Republican from Vermont who was then chair of the Environment and Public Works Committee, Frank Lautenberg (D-N.J.), and Lloyd Bentsen (D-Tex.). Behind the scenes, David Sarokin and Warren Muir, working with the New York–based environmental research group INFORM, Inc., explained to congressional staff the need for more publicly available information about toxic pollution. Senate committee staffer Ronald Outen championed the idea of requiring disclosure of routine releases and helped translate it into legislative language.

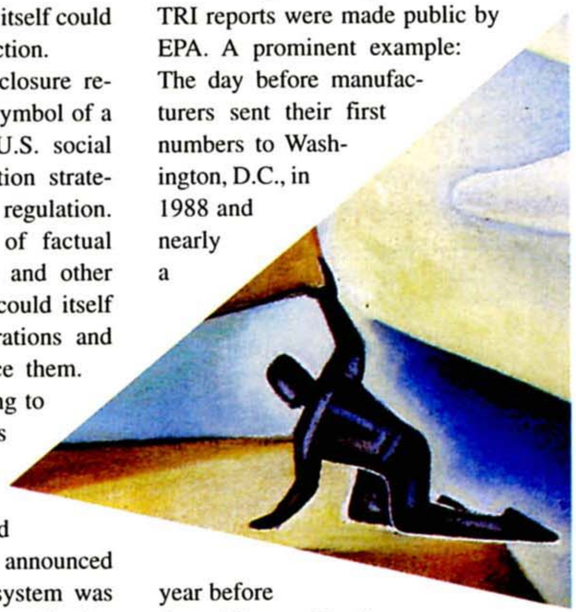
Interestingly, neither EPA nor most environmental groups took much interest in the proposed requirement. Simply providing information seemed weak compared to standards that set maximum pollution levels backed by strict penalties, and the requirement would add more paperwork to an already overburdened agency. But congressional sponsors emphasized that the people of the United States had a "right to know" about toxic pollution where they lived or worked. During the prosperous decades following World War II, new chemicals led to vast improvements in industrial and agricultural efficiency, making life easier for most people in the United States. However, their use often preceded understanding of their environmental effects. By the 1970s, advances in analytical chemistry and extensive epidemiological studies had produced growing evidence that toxic pollution could create serious risks to human health and the environment. In response, Congress passed a number of laws to regulate toxic pollution, but implementation was slow. By 1986, federal regulators had written or negotiated final test rules for only 26 existing chemicals and regulated only one class of chemicals as representing an unreasonable risk—chlorofluorocarbons as aerosol propellants. Some of the most toxic chemicals remained in wide circulation. In the mid-1980s, the U.S. National Research Council concluded that the United States still lacked any coherent national picture of the movement of key toxic chemicals in the water and air and on land.[3]

The 1986 law required manufacturers in certain Standard Industrial Classification (SIC) codes to report releases of a government-provided list of chemicals each calendar year, facility by facility, and chemical by chemical. Companies reported these data to the administrator of EPA. EPA created a national database and issued an annual report that summarized the data. EPCRA mandated that manufacturers use a standardized form for reporting and required that data be made available to the public electronically as well as on paper. Facilities that employed fewer than 10 full-time employees, manufactured or processed 25,000 pounds or less of listed chemicals, or otherwise used 10,000 pounds or less of listed chemicals were not required to report their releases. The law provided, however, that the EPA administrator could add or remove chemicals from the initial list and broaden or narrow the categories of entities required to report. It also gave the administrator authority to change the prescribed thresholds for reporting for any chemical.

TRI provided an evolutionary bridge between familiar national policies that treated information as a public right and emerging strategies that employ information as regulation. By the mid-1980s, the idea of community right-to-know was a familiar, if amorphous, national goal. For two decades, a variety of federal and state laws had required broad public access to information that was collected by the government from corporations and other organizations. When industry leaders responded to the initial TRI report with major commitments to reduce toxic pollution and when releases of listed chemicals plummeted in the next five years, policy makers concluded that the power of information itself could improve environmental protection.

Within a decade, this disclosure requirement would become a symbol of a newly prominent trend in U.S. social policy—the use of information strategies as an instrument of risk regulation. The systematic disclosure of factual information about pollution and other health and safety problems could itself create incentives for corporations and other organizations to reduce them. From 1988 to 1999, according to the TRI reports, facilities reduced releases of listed chemicals by 46 percent (for chemicals reported in all years).[4] In 1997, EPA announced that this simple disclosure system was considered "one of the most effective environmental programs ever legislated by Congress and administered by EPA."[5] The sentiment was bipartisan. In April 2001, when Christine Todd Whitman, appointed by Republican President George W. Bush as the administrator of the agency, released the 1999 data, she declared that "[t]his inventory is a powerful tool for helping to protect public health and the environment. We're seeing constant decreases of emissions to air, land, and water."[6]

As it came to be viewed as a regulatory instrument, TRI complemented but did not replace established controls of toxic chemicals. It differed from existing approaches in three ways. First, it targeted mainly lawful, rather than illegal, toxic pollution. Second, it influenced corporate decisions by means of public pressure, not sanctions. Third, it adopted a multimedia approach. TRI was the first law to address the toxic releases to air, water, and land combined. In that respect, it reflected a growing recognition among scientists and policy makers that reducing pollution in one medium might simply increase pollution in another.



The new requirement for disclosure of toxic releases inspired executives of some large companies to promise huge voluntary cuts in toxic pollution. Some took anticipatory action, announcing reduction goals many months before TRI reports were made public by EPA. A prominent example: The day before manufacturers sent their first numbers to Washington, D.C., in 1988 and nearly a year before the public would gain access to them, Richard J. Mahoney, then chief executive officer of the Monsanto Corporation, announced in a memorandum to his managers that Monsanto would eliminate 90 percent of its toxic air pollution in less than five years. "The public has spoken," Mahoney told *Newsweek*, "and it's unmistakable they will no longer tolerate toxic emissions. Might as well get on with it."[7] In 1992, Mahoney announced that the company had met its goal.

The perceived success of TRI in reducing toxic releases created political pressures to expand its reach. During the 1990s, President Bill Clinton's administration issued new rules that doubled the number of chemicals for which disclosure was required, called on several new industry sectors to report, and lowered the thresholds for reporting some particularly harmful chemicals. These new rules also required federal facilities to report their releases.[8] By the end of the decade, TRI had become a platform for a wide variety of government and private programs that aimed to monitor and reduce toxic pollution. EPA used the data to identify industry leaders in pollution control and to help assess ecosystem health. Industry trade associations developed programs to encourage reduction of toxic wastes, and environmental and right-to-know groups initiated efforts to inform the public about toxic risks in their neighborhoods. Particularly as the Internet gained wider use, EPA, industry, and public interest groups created web sites that combined TRI data with other sources of information in an effort to provide the public with a more complete picture of corporate performance and toxic risks (see the box on page 12).

The Complex Story Behind the Numbers

Behind the assertion that TRI helped to reduce total toxic releases by 46 percent from 1988 to 1999 lies an interesting and complex story. A close examination of the TRI data confirms a core of positive trends. Reported releases have declined by almost half, releases of some chemicals that may be particularly harmful to human health have declined at a faster rate than total releases, and recycling has increased, all in the context of a rapidly growing economy. On the other hand, the rate of decline slowed markedly after the first five years of reporting, and generation of toxic waste has continued to increase. In addition, relatively few facilities have employed source reduction to cut releases. (Source reduction includes the substitution of raw materials as well as changes in maintenance procedures, product reformulation, and process efficiency to reduce the amount of toxic chemicals used in the manufacturing process.) Furthermore, the decline in releases is not so much a national phenomenon as it is a media-, industry-, and often facility-specific phenomenon. One prevailing theme of this story behind the numbers is that if public access to information about toxic releases exercises a generalized pressure on at least some companies to reduce releases, economic forces and regulatory changes can trump that

Navigators Gain Political Power

In the new world of electronic access to information about pollution, navigators—entrepreneurs who design software to provide the public with information—have emerged as newly powerful intermediaries in the mid-1990s. They give whatever organization they work for (citizen groups, industry, or the government) important new means of promoting its perspectives.

In the spring of 1998, Environmental Defense, a leading advocacy group, launched a web site that demonstrated the new power of the navigator. Scorecard (http://www.scorecard.org/) merged routinely disclosed data about toxic pollution with information from other public databases to create a new picture of environmental risks. Users who typed in their zip codes could quickly access whatever information was available about industrial sources of toxic chemicals in their county, compare the importance of toxic pollution from industrial sources with that from vehicles and small businesses, learn what was known about the toxicity of specific chemicals and exposure risks, and send prewritten faxes or e-mails to a company president, the administrator of the U.S. Environmental Protection Agency (EPA), or a member of Congress.

The site was created by Bill Pease, a former community organizer trained in toxicology, at an initial cost of about $450,000. Working at the School of Public Health at the University of California at Berkeley in the early 1990s, Pease was deluged with requests from people to explain government data on toxic releases. Later, as a senior environmental health scientist at Environmental Defense, he appealed to the Clarence E. Heller Charitable Foundation in San Francisco to back his idea of explaining toxic releases on the Internet. Teaming up with two computer

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experts—Philip Greenspun, a graduate student in computer science at the Massachusetts Institute of Technology, and David Abercromby, an expert in complex data systems—Pease began working on Scorecard in January 1996 and launched it in April 1998. Almost immediately after its debut, Frederick L. Webber, president of the Chemical Manufacturers' Association (now called the American Chemistry Council), issued a statement warning the organization's members that they would have to start making further cuts in toxic releases. A new source of political power had emerged.

The site made it easy for users to slice and dice information in new ways that created multiple lists of polluters. With a few clicks, they could rank sources of toxic pollution nationally or by state or county to show chemicals with high volume and low toxicity or low volume and high toxicity—tasks that had previously taken enterprising reporters or advocates months to do. Toxics Release Inventory data could be characterized in 40 different ways, and chemicals were ranked by an inevitably controversial risk scoring system, with the score reflecting a combination of toxicity and exposure information.

Today, Scorecard features interactive maps that allow users to quickly access neighborhood-specific data. The site also provides information about the top environmental priorities for particular states and regions that have been identified by expert panels. Since 1999, the site has provided information about local health risks based on EPA's estimates of local levels of toxic chemicals. This year, Scorecard announced the launching of its sister web site, PollutionWatch (http://www.scorecard.org/pollutionwatch/), which profiles toxic chemical releases in Canada. Scorecard also now provides environmental justice data reports for every community in the United States, which indicate the different degrees of environmental burden felt by various ethnic and income groups.

pressure in some situations and reinforce it in others. Scrutiny of the data provides a more nuanced understanding of the combined effects of disclosure, economic forces, regulatory actions, and management choices on trends in toxic releases as well as some clues about the ways in which those factors interact.

Most of the often-cited decrease in toxic releases occurred in the first five years of TRI reporting, and such releases remain substantial. From 1988 to 1993, total releases decreased by 37 percent, with reductions averaging 7 percent a year. From 1993 to 1998, total releases decreased 10 percent, with reductions averaging 2 percent a year. The decrease from 1998 to 1999 was 4 percent. EPA officials suggest two reasons why the decline of releases has slowed. First, some manufacturers were able to make relatively inexpensive and rapid changes in the early years of TRI reporting. Later changes, such as developing new processes or products, may be more costly and time-consuming. Second, the booming economy of the 1990s increased production in many sectors, and that trend made absolute reductions more difficult.[9] Despite a decade of reductions, manufacturers reported that 1.7 billion pounds of toxic substances were released into the air and water or disposed of on land or by underground injection in 1999 (see Figure 1 on page 13).

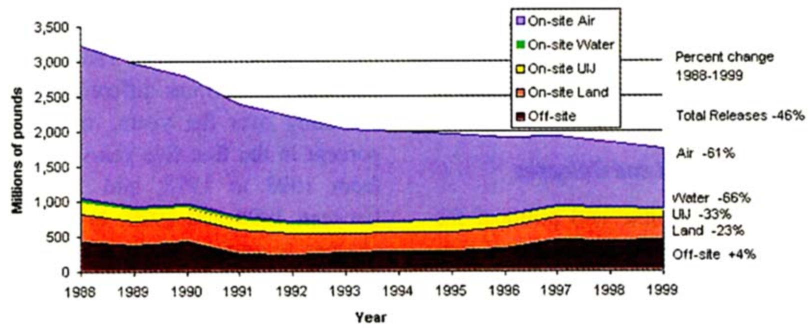
While toxic releases decreased during the 1990s, toxic waste reported by manufacturers under TRI increased to 23.1 billion pounds in the context of a rapidly growing economy. The term "release" was created by Congress to describe that portion of toxic waste that is discharged directly into the environment. The largest portion of toxic waste is recycled (about 43 percent) or treated (about 32 percent).[10] Only about 10 percent is released. From 1991 to 1999, total production-related waste reported by the manufacturing sector increased by 5 percent, while overall U.S. manufacturing production rose by a remarkable 48 percent (see Figure 2 on this page).[11]

However, less than 25 percent of manufacturing facilities reported reducing waste through source reduction methods—the preferred environmental approach under current national policy—according to their 1999 reports. Approximately 23 percent of all manufacturing facilities reported that they undertook source reduction activities during 1999, most frequently as changes in operating procedures or process modifications. In a hierarchy of means to control toxic chemicals, the national Pollution Prevention Act of 1990 gives highest priority to source reduction because it not only prevents pollution but also reduces potential exposure of workers and community residents and minimizes disposal and liability costs. After source reduction, the preferred means of waste management is recycling, followed by energy recovery and treatment and, as a last resort, on-site release or off-site disposal.[12]

Recycling and treatment increased markedly in the 1990s. Since 1991 (the first year TRI collected data on recycling), recycling of TRI chemicals both on- and off-site increased by 12 percent, and treatment of the waste increased by 24 percent, while energy recovery decreased 11 percent, and releases decreased by 28 percent. Trends in recycling of toxic wastes are influenced by economic as well as technological factors, including costs of raw materials, selling prices for byproducts, and costs of off-site disposal versus costs of recycling. As these prices rise or fall for particular industry sectors, waste and releases (releases include off-site transfers for disposal) may decrease or increase in those sectors.

Another encouraging trend is that releases of some of the most toxic chemicals have declined more rapidly than releases of less toxic TRI chemicals. Among the more than 600 chemicals currently on the TRI list, EPA has identified about 165 known or suspected carcinogens that must be reported.[13] From 1995 to 1999, total releases of all TRI chemicals decreased by 7 percent.[14] As a group, the designated carcinogens decreased at more than twice that rate, by 16 percent. However, individual carcinogens showed significant variation. The TRI-designated carcinogens with the largest releases in 1999 were

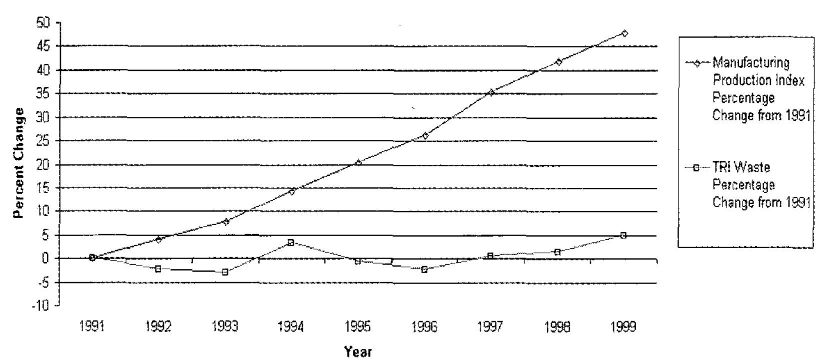
Figure 1. TRI on-site and off-site releases, 1988–1999



NOTE: UIJ stands for "underground injection." Not included are chemicals deleted or added to the TRI list since 1988: aluminum oxide, ammonia, hydrochloric acid, and sulfuric acid. Data from industries first reporting under TRI for 1998 are not included. Off-site releases include metals and metal compounds transferred off-site for disposal, solidification/stabilization, and wastewater treatment.

SOURCE: Data from U.S. EPA, *TRI Public Data Release* (April 2001). On-site release data from Section 5 of TRI Form R. Off-site release data from Section 6 of TRI Form R.

Figure 2. TRI production-related waste, 1991–1999, compared to manufacturing production index, cumulative change



NOTE: Not included are chemicals deleted or added to the TRI list since 1991: ammonia, hydrochloric acid, and sulfuric acid. Data from industries first reporting under TRI for 1998 are not included. Base 1991=100.

SOURCE: TRI production-related waste data from U.S. EPA, Section 8 of TRI Form R, *TRI Public Data Release* (April 2001). Manufacturing production index data from U.S. Census Bureau, *2000 Statistical Abstract of the United States*, Table 1238.

styrene, dichloromethane, and formaldehyde, and they accounted for more than 50 percent of all reported carcinogen releases. While releases of dichloromethane[15] decreased by 40 percent since 1995, styrene[16] and formaldehyde[17] releases increased by 26 percent and 22 percent, respectively.[18]

Air, Water, and Land Releases

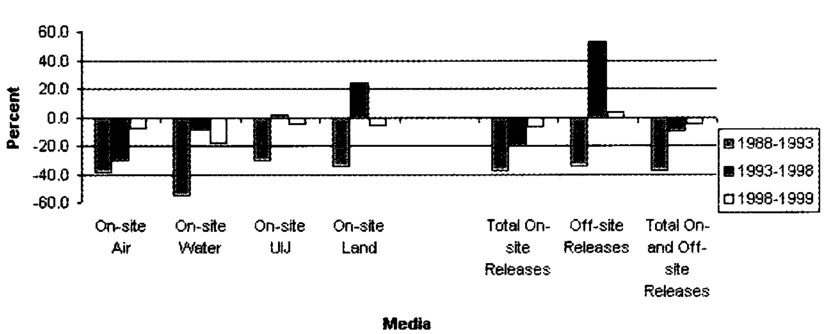
Specific economic and political factors—such as the increased cost of recycling, reduced demand for products, new legislation, and enforcement actions—have helped create very different trends in toxic releases into air or water and on land. Air releases have declined at a fairly steady pace while releases to surface water have increased or decreased more than 10 percent in some single years and releases via land disposal have increased recently (see Figure 3 below).

Air releases, which account for more than half of all reported releases, have decreased dramatically, influenced in part by new legislation. They declined a remarkable 61 percent for the group of core chemicals reported in all years.[19] Decreases have been reported each year and at a fairly steady pace, averaging 8 percent per year. Incentives for companies to decrease air releases were strengthened in the 1990s because the Clean Air Act of 1990 required new regulatory controls on toxic air emissions.

Although discharges to surface water fell by 66 percent from 1988 to 1999, they have sometimes differed quite significantly over the years, dropping 55 percent in the first five years, 9 percent from 1993 to 1998, and 18 percent between 1998 and 1999. In 1999, discharges to surface water accounted for less than one percent of total releases and were reported by only about 12 percent of facilities. Several facilities that dominate surface water discharges can have a large effect on these changes. For example, since 1988, three pulp and paper facilities have reduced water discharges of methanol by more than 10 million pounds, accounting for 40 percent of the total reduction in surface water discharges. These reductions occurred because one of the three facilities closed down, one operates at reduced capacity due to market demand, and one installed pollution control equipment as a result of a consent decree with EPA.[20]

Land disposal of toxic chemicals has risen in recent years, due in part to temporary jumps in the price of recycling.

Figure 3. Percent change in types of TRI releases, 1988–1999



NOTE: UIJ stands for "underground injection." Not included are chemicals deleted or added to the TRI list since 1988: aluminum oxide, ammonia, hydrochloric acid, and sulfuric acid. Data from industries first reporting under TRI for 1998 are not included. Off-site releases include metals and metal compounds transferred off-site for disposal, solidification/stabilization, and wastewater treatment.

SOURCE: Data from U.S. EPA, *TRI Public Data Release* (April 2001). On-site release data from Section 5 of TRI Form R. Off-site release data from Section 6 of TRI Form R.

From 1993 to 1998, on-site land disposal increased by 24 percent and off-site disposal increased by 53 percent, which is primarily a reflection of increased disposal of toxic wastes in landfills, a marked shift from the decreases of previous years. Land releases on- and off-site decreased about 35 percent from 1988 to 1993. From 1998 to 1999, on-site land disposal decreased by 6 percent (the first year since 1994 that a decrease was reported), but off-site disposal increased by another 4 percent.

Land disposal is particularly important because reported chemicals that are disposed of on land consist almost entirely of metals, which can have long-term and serious consequences for human health. In 1999, metals and their compounds constituted more than 90 percent of all TRI releases via land disposal on- and off-site. The 18 metals for which TRI reporting is required do not degrade and are not destroyed by treatment.[21] Some metals—such as arsenic and inorganic arsenic compounds, beryllium, cadmium, hexavalent chromium compounds, cobalt, lead and inorganic lead compounds, and nickel—are known or suspected carcinogens. These and other metals have been shown to cause developmental defects in humans and adverse effects in aquatic and terrestrial organisms. They also are known to bioaccumulate in fish and reach humans through the food chain.

From 1995 to 1998, a number of facilities that sent increased amounts of metals to landfills did so because of temporary increases in the price of recycling. EPA officials observed that land disposal of metals increased during these years by 185 million pounds, which was matched by a decrease of similar magnitude (169 million pounds) in off-site transfers of metals to recycling, a shift from increases in recycling in previous years. In an effort to understand these shifts, they contacted some of the facilities with the largest off-site transfers of metals for disposal and learned that a major recycler of metals had raised prices between 1995 and 1997, causing facilities to switch to landfill disposal.[22] The recycler subsequently lowered prices, and reduced levels of off-site disposal of metals were expected as the contracts for landfill disposal expired and the facilities returned to recycling.

Another form of disposal, the injection of fluid wastes underground into wells, has varied erratically from year to year. Because of limitations of state law and geology, it is used by relatively few facilities with very large releases, averaging almost 1.3 million pounds of releases per facility.[23] Underground injection decreased 30 percent from 1988 to 1993, increased 1 percent over the next five years, and decreased 4 percent from 1998 to 1999, showing an overall 33 percent decrease from 1988 to 1999. In 1999, underground injection accounted for only 6 percent of total releases, and less than 0.5 percent of TRI facilities reported any on-site underground injection.

Trends in the most recent years for which data are available provide a particularly troubling example of varied patterns of releases. From 1995, when EPA added almost 300 new chemicals to the TRI list, to 1999, the most recent year of reporting, overall releases of the expanded list of chemicals decreased by 8 percent. Air emissions and underground injection each decreased by more than 20 percent, but on-site land disposal increased 14 percent, off-site land releases increased 46 percent, and surface water discharges increased by 32 percent. These increases are particularly important because many of the chemicals added to the TRI list in 1995 and now being tracked are carcinogens, reproductive toxins, or developmental toxins. The chemicals added include more than 150 pesticides, some Clean Air Act chemicals, Clean Water Act Priority Pollutants, and Safe Drinking Water Act chemicals.

Toxic Releases by State, Industry, and Facility

Despite the usual emphasis on national trends, the types and levels of releases vary significantly among states and localities. Three states have accounted for nearly 20 percent of national releases, and three counties (with a total of eleven facilities) have accounted for about 2.5 percent of national releases in 1999. Texas, Ohio, and Indiana reported 20 percent of releases from manufacturing facilities in 1988 and also in 1999. In Texas and Indiana, relatively few facilities discharging large amounts of releases accounted for the high numbers. (In Texas, 1,200 facilities averaged 136,000 pounds of releases per facility, compared to a nationwide average of 83,700 pounds; and in Indiana, 972 facilities averaged 118,000 pounds per facility.) However, Ohio, with almost 30 percent more facilities reporting than Texas and 60 percent more than Indiana, owed its position among the top three states not to a few large facilities but to an unusually large manufacturing base (1,550 facilities averaged 77,000 pounds per facility). Furthermore, remarkably few facilities account for a large portion of national releases. In 1999, just 50 out of almost 21,000 manufacturing facilities reporting under TRI accounted for 31 percent of all TRI releases.[24] Gila, Arizona (with 3 facilities); Tooele, Utah (with 5 facilities); and Lewis and Clark, Montana (with 3 facilities), each reported about 2.5 percent of national releases.

Evidence also indicates that facilities with relatively large amounts of releases have been more successful at reducing them than facilities with smaller amounts of releases. Annual reports by the North American Commission for Environmental Cooperation (CEC) compare TRI data with the equivalent in Canada.[25] The 1997 CEC report looked at TRI facilities reporting less than 100,000 pounds of releases and transfers in 1995 and compared them to those reporting more than 100,000 pounds. The change from 1995 to 1997 for these two groups of facilities showed opposite trends. The group of facilities with relatively smaller amounts reported a 4 percent increase, while the group of facilities with larger amounts reported a 7 percent decrease.[26] An analysis of the reports from New Jersey facilities conducted by the environmental research organization INFORM, Inc., showed similar results and suggested that for smaller facilities a larger portion of the chemicals used ends up in waste rather than in the product. New Jersey facilities using less than 100,000 pounds per year reported greater increases in releases, transfers, and waste than the fewer facilities using the largest amounts, according to the INFORM, Inc., study. Facilities with smaller amounts of releases reported that, on average, 35 percent of the amount of chemicals used was generated as waste, compared to about 10 to 25 percent for larger facilities.[27]

Overall decreases in toxic releases also mask widely varying trends in major manufacturing industries. From 1988 to 1999, toxic releases declined 46 percent overall. However, the food and beverage industry reported increases of 62 percent. Chemical manufacturing, which reported the largest amounts of total releases in 1988, reduced them by 56 percent from 1988 to 1999. After 1996, the primary metals sector, which includes steel mills and smelters, reported the largest amounts of releases, reporting only an 8 percent decrease from 1988 to 1999. This sector was also responsible for most of the increase in releases of metals. Releases of metals and their compounds increased 32 percent from 1988 to 1999—the largest increase in rece snt years. The primary metals sector accounted for 68 percent of those releases in 1999.

New Industry Sectors

Industries closely related to manufacturing that reported for the first time in 1998 ("new" TRI facilities) increased their releases from 1998 to 1999 by 5 percent, while the "original" manufacturing industries reported a 3 percent decrease. These newly reported releases were dominated by metal mining, which reported an increase of 12 percent from 1998 to 1999, and electric utilities, which reported an increase of 2 percent, including a 5 percent increase in air emissions.[28] The new industries also included coal mines, chemical wholesalers, petroleum terminals and bulk storage facilities, hazardous waste treatment facilities, and solvent recovery facilities (see Figure 4 below).

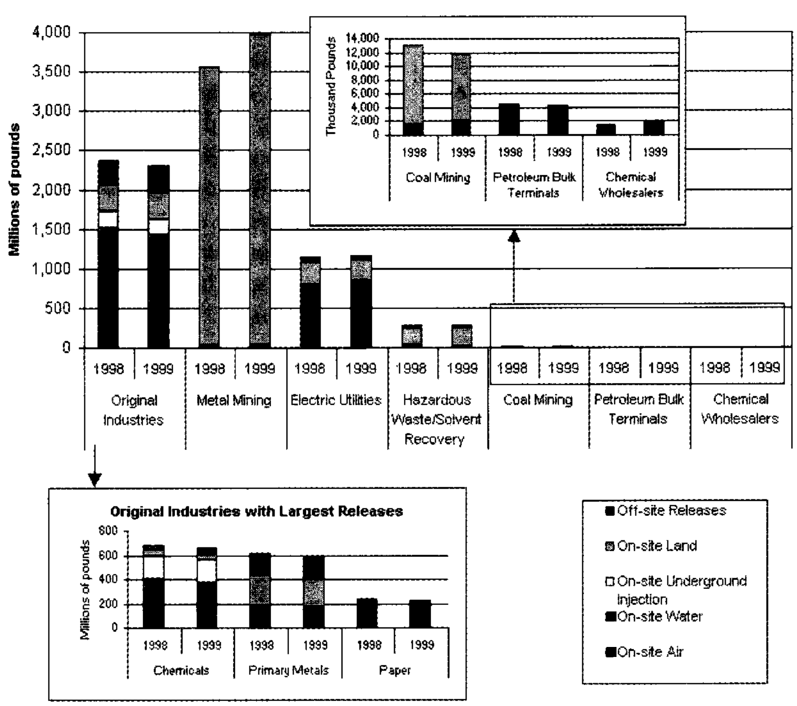
In the new industries, relatively few facilities account for huge toxic releases. Only 108 metal mines produced 4.0 billion pounds of releases in 1999, and 625 electric utilities reported 1.2 billion pounds of releases. By contrast, the approximately 20,700 original manufacturing facilities reported 2.3 billion pounds of releases. These original facilities accounted for about 30 percent of the reported releases. TRI releases from metal mines accounted for about 50 percent, and releases from electric utilities accounted for 15 percent.

The types of releases reported by these new industries also differ from those of the original industries. While the original manufacturing industries reported 50 percent of all releases as on-site air emissions in 1999, metal mines reported 99 percent of their releases as on-site land disposal, consisting primarily of copper, zinc, and arsenic.[29] Electric utilities reported more than 73 percent of their releases as on-site air emissions, primarily as hydrochloric acid (see Figure 4).[30] The new industries recycled about 4 percent and treated 16 percent of their reported waste in 1999. (The original manufacturing sector recycled almost half and treated almost one-third of their reported waste.) The new industries reported more than 75 percent of all their waste as releases where, as was noted above, only 10 percent of all production-related waste from the original manufacturing sector is released.

Close examination of the data suggests three tentative conclusions. First, political emphasis on the striking overall decrease in toxic releases over 11 years masks other important trends. On the positive side, recycling has increased substantially, and releases of carcinogens have declined at a somewhat faster rate than overall releases. Government action has also expanded reporting substantially, with the number of reported chemicals doubled, industrial sectors added, and thresholds lowered for some particularly harmful substances. On the other hand, releases of toxic chemicals into the environment remain substantial after a generation of national efforts to control them; toxic waste has increased markedly as the economy has grown; releases are decreasing at a considerably slower rate in recent years than when TRI was first implemented; and the most recent data suggest that only about a quarter of facilities cut releases by reducing waste at the source.

Second, emphasis on the power of public disclosure to significantly reduce toxic releases obscures other important forces. Closer analysis of the data suggests that economic factors in particular industries, federal and state regulatory actions, and choices by managers of relatively few facilities with very large releases have a disproportionate impact on national trends. Changes in recycling costs have influenced trends in land disposal of toxic chemicals, particularly of metals that can pose long-term threats to human health. In some instances, changes in markets, new regulations, or enforcement actions have created substantial increases or decreases in releases as a few facilities with large releases alter levels of production or shut down. Finally, the usual emphasis on national trends of toxic releases deflects attention from what is fundamentally specif-

Figure 4. TRI releases, 1998–1999, original and new industries



SOURCE: Data from U.S. EPA, *TRI Public Data Release* (April 2001).

ic to states and localities. Manufacturing releases are concentrated in a few states, and a relatively small number of facilities produce a large portion of releases—especially to surface water and land.

The Strengths and Limits of TRI's Architecture

A second broad assumption concerning releases of toxic chemicals in the United States also deserves closer scrutiny. In an open society, the proposition that more public information is always better is often taken to be self-evident. Information provides the foundation for public debate and voter choices, and improving public access to information is considered a relatively simple matter. As the sponsors of TRI stated during congressional debates, because companies already have the data, it cannot be very complicated to give it to the public.

But disclosure requirements are not as simple as they may appear. The proposal to disclose toxic releases conflicted with other enduring values, especially the need to protect trade secrets and minimize regulatory burdens, as well as with political interests, especially companies' concerns about exposing their environmental performance to public scrutiny. In creating this new system of public access to private-sector information in 1986, Congress struggled to resolve contentious issues and in so doing constructed TRI with a specific architecture that in turn has influenced incentives for target companies. The law and regulations specify a particular purpose, target, scope, structure, audience, and enforcement mechanism—architectural elements that are common to most systems of mandatory disclosure (see the box on this page). The character of each of these elements was framed by political compromise. The result is a disclosure system with particular design strengths and weaknesses with regard to its potential for improving environmental protection.

Design Strengths

TRI has served as an important example of ways in which disclosure of standardized factual information about environmental performance can complement other regulatory measures. Because of specific design features, it provided public, industry, and government officials with information about toxic pollution that was authentically new and had potential to provide novel incentives to reduce releases, even after more than a decade of national regulation.

The requirement's particular strengths lay in its unusual structure. Reporting to the general public in standard formats, at regular intervals, and by facility and by chemical for all types of toxic releases made it possible for the first time to compare companies and to track changes over time. Disclosure was structured to draw attention to both national and local levels of pollution and to limit claims of confidentiality. Because the law required executives to add up the numbers and to sign off on annual reports to EPA, managers were forced to focus on national levels of pollution from all of their facilities, often for the first time. Because it also provided the first multimedia approach to releases at each factory, some managers responded by taking local action as well. In its first formative decade, TRI also benefited from a continuing interest on the part of permanent constituencies—government officials, environmental groups, and industry representatives—in improving the quality of the data as well as expanding coverage to more chemicals and more industries.

The initial totals of toxic releases were much larger than previous estimates. Representative Henry A. Waxman (D-Calif.) recalled that when he estimated in 1985 that 80 million pounds of toxic chemicals were released into the air each year, "industry went haywire. They denounced the figure as environmental paranoia." When toxic releases reported under TRI were tallied, they initially showed releases of air toxins that totaled 2.7 billion pounds.[31] These large numbers quickly added momentum to the debate about the need to revise national and state environmental laws to improve control of toxic pollution. EPA's past programs had focused mainly on a limited number of air and water pollutants and on improving landfills. The Clean Air Act Amendments of 1990, which emphasized the importance of reducing toxic emissions, were one example of a political action that derived strength from those early TRI revelations.[32]

Design Limitations

At the same time, some features of TRI's particular architecture limited its usefulness as a tool for improving environmental protection. First, because its targets included only manufacturers and a limited category of those, it could not create incentives for the reduction of many of the nation's largest sources of toxic pollution. Government reports

Characteristics of Mandatory Disclosure Systems

Mandatory disclosure systems generally contain the following six elements:

- a public purpose (*why* disclosure is required);
- a specific target (*who* is required to disclose);
- a defined scope (*what* is required to be disclosed);
- an articulated structure (*how and when* information is communicated);
- an intended audience (*to whom* information is communicated); and
- an enforcement system (*how* accountability is ensured).

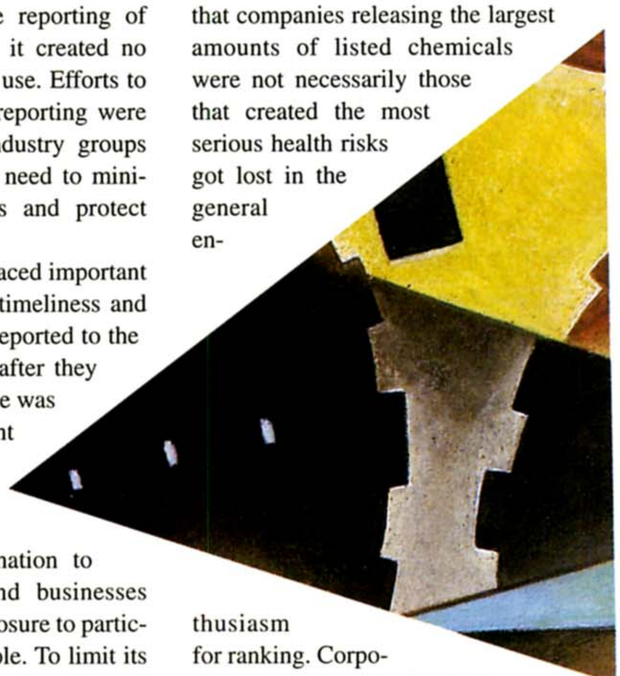
indicated that the sources of most toxic air pollution, for example, were mobile sources (cars, trucks, and buses) and small businesses.[33]

Second, its scope was limited to a partial list of toxic chemicals. Initially, its framers chose a politically expedient shortcut. They combined lists of toxic chemicals assembled by state officials in New Jersey and Maryland, which had been developed for state-specific purposes. While this list was later expanded significantly, one incentive created for manufacturers was simply to substitute unlisted toxic chemicals for listed ones, regardless of their relative toxicity.

Third, as noted previously, TRI's structure did not require reporting of chemical use. Therefore, it created no incentives to reduce such use. Efforts to include chemical use in reporting were repeatedly rejected as industry groups argued forcefully for the need to minimize paperwork burdens and protect trade secrets.

Fourth, TRI's design placed important limitations on the data's timeliness and accuracy. Releases were reported to the public more than a year after they took place. While that pace was not unusual for government reports compiled from complex private-sector data, it limited the usefulness of the information to community residents and businesses interested in avoiding exposure to particular chemicals, for example. To limit its cost to industry, the law also allowed reporting to be based on estimates rather than on actual monitoring and permitted companies to choose from a variety of estimating techniques, thereby limiting the accuracy of the data and also complicating year-to-year and company-to-company comparisons.

Reporting may also have been influenced by the phenomenon of "paper changes." For example, a facility may report an activity as on-site recycling one year but then consider it in-process recovery (not reportable to TRI) another.[34] One study of changes in amounts of waste reported under TRI between 1991 and 1994 found that fully half of the reductions were due to paper changes.[35] (In some instances, paper changes increased reported releases. For example, the pulp and paper industry trade association used new estimating methods for 1994 that significantly increased reported air emissions of methanol from these plants, in some cases by a factor of ten.[36])



The requirement's structure also created special pressures for companies to come up with quick fixes to reduce releases. The annual reports on toxic releases inevitably produced national and local lists of top polluters. Efforts by government officials, environmental groups, and some journalists to explain that companies releasing the largest amounts of listed chemicals were not necessarily those that created the most serious health risks got lost in the general enthusiasm for ranking. Corporate executives who decided to take action in response to TRI had one overriding goal: to get off the list by the next time it was published. Therefore, changes in cleaning procedures and maintenance and relatively simple substitutions of chemicals were appealing because they provided quick reductions, especially in the early years. More costly and more time-consuming modifications in products or processes were less likely to provide the quick relief that executives sought from media attention and other forms of public pressure. Then, staying off the "top polluter" list in later years could require more difficult modifications once the quick fixes were completed.

A complicating factor was that the requirement's structure lacked a metric that was calibrated to risk. Toxic releases were reported only in total pounds, without adjustments for human exposure to chemicals or for their relative toxicity. Even if reporting had been calibrated to risks, estimates would have had limitations. TRI was instituted at a time when little was actually known of the relative risk of most of the listed chemicals. The absence of any effort to take account of risks, however, meant that companies had no incentive to concentrate on reducing emissions that created the most serious threats to human health or the environment. It also meant that members of the public had no basis for taking action that was predicated on degree of risk. In the late 1990s, EPA, industry, and environmental groups initiated an ambitious program to expedite toxicity testing for a large number of chemicals in wide use—a costly and time-consuming effort.[37]

To recapitulate, Congress created TRI with a complex set of architectural elements that influenced its potential effectiveness as an information strategy to improve environmental protection. The requirement's novel combination of structured disclosure of factual information to a broad audience at regular intervals about the environmental performance of identified companies and facilities created unusual incentives for some companies to reduce toxic releases. At the same time, the requirement's narrow targets and scope limited its effectiveness as a means of improving environmental protection, and structural characteristics added further limitations.

Future Challenges

Given these strengths and limitations, what role will this disclosure system play in future improvements in environmental protection? More than a decade of experience suggests three challenges. First, TRI can serve as a source of lessons for designers of future information strategies that rely on public disclosure to reduce environmental risks. Its innovative combination of standardized information concerning environmental performance, reporting by facility and by chemical, reporting at regular intervals, and mandatory disclosure to a broad audience created an unprecedented opportunity to compare companies' track records and assess changes over time. In 1996, Congress adopted a disclosure requirement in the Safe Drinking Water Act Amendments that built on TRI's demonstration of the strengths of this combination. This provision required the nation's public and private water authorities to prepare consumer confidence reports that disclose to customers levels of a list of detectable contaminants in drinking water. A concerted effort to learn from the implementation of these emerging disclosure regimes could lead to improvements in design of future requirements.

Second, TRI will continue to provide a valuable source of raw data that serve many useful purposes—as long as the significance of the data is not oversold. The TRI data have informed government officials about possible needs for new legislation or regulation. They have provided local, state, and national community groups with a foundation for discussions with industry officials about reducing risks. They have sometimes provided companies with new information about the character of their waste products, revealed opportunities to increase efficiency, and fostered community outreach. However, what the data cannot do is indicate risk. Using disclosure as a platform for educating the public about scientific uncertainties and the complexities of determining risks associated with toxic chemicals is a formidable challenge.

Third, the growing power of computers and information technology may offer particular hope for the future role of TRI in creating incentives to improve environmental protection. Such technology creates the potential to bring the nuances of trends in toxic pollution to the attention of the interested public. It also creates the potential for government agencies and private groups to combine data from TRI with data from other sources and with indicators of risk as those become more sophisticated. Optimistically, such combinations might minimize the importance of the architectural limitations of TRI or any other single database. They might eventually grow into a web of reliable information about environmental risks that would increase incentives for reducing them and minimize public scares. Progress in improving the accuracy, timeliness, and completeness of data should not be taken for granted, however. Disclosure systems, like other forms of regulation, are difficult to reform and can be outdistanced by changing technology or markets. Long-term improvements may depend on such factors as the transparency of methodologies and the continuing presence of influential constituencies with a strong interest in improving the data. However TRI evolves, it has already provided considerable public benefits by contributing to a national and international learning process about the emerging role of informational strategies in improving environmental protection.

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NOTES

1. Some of the material in this article is drawn from M. Graham and C. Miller, "Disclosure of Toxic Chemicals in the United States" (paper presented at a John F. Kennedy School of Government workshop on information-based environmental policies, Cambridge, Mass., 10–11 May 2001); M. Graham, *Information as Risk Regulation*, Occasional Paper for the Innovations in American Government Program, John F. Kennedy School of Government (July 2001); M. Graham, "Regulation by Shaming," *The Atlantic Monthly* (April 2000); and M. Graham, *Democracy by Disclosure* (forthcoming 2002). For recent and provocative analyses of the Toxics Release Inventory (TRI), see also B. C. Karkkainen, "Information as Environmental Regulation: TRI and Performance Benchmarking, Precursor to a New Paradigm?" *Georgetown Law Journal* 257, no. 89 (2001); A. Fung and D. O'Rourke, "Reinventing Environmental Regulation from the Grassroots Up," *Environmental Management* 115, no. 25 (2000); and W. F. Pedersen, "Regulation and Information Disclosure: Parallel Universe and Beyond," *Harvard Environmental Law Review* 25, no. 1 (April 2001). For a review of TRI's implementation, see M. A. Greenwood and A. K. Sachdev, *A Regulatory History of the Emergency Planning and Community Right to Know Act of 1986: Toxics Release Inventory* (Washington, D.C.: prepared for the Chemical Manufacturers' Association, April 1999).

2. 42 *United States Code* 11023 (1994 & Supp. III 1997).

3. M. Shapiro, "Toxic Substances Policy," in P. Portney, ed., *Public Policies for Environmental Protection* (Washington, D.C.: Resources for the Future, 1993), 206–37, citing National Research Council, *Toxicity Testing: Strategies to Determine Needs and Priorities* (Washington, D.C.: National Academy Press, 1984); and J. C. Davies and J. Mazurek, *Pollution Control in the United States: Evaluating the System* (Washington, D.C.: Resources for the Future, 1998), 84.

4. U.S. Environmental Protection Agency (EPA), *1999 Toxics Release Inventory Public Data Release* (Washington, D.C.: EPA, 2001). Unless otherwise stated, all of the data in this article that refer to the "original" industry sectors or to chemicals that have been on the TRI list since 1988 are from the *1999 Toxics Release Inventory Public Data Release*. (TRI data for the reporting year 1999 are the most recent available. Facilities were required to have reported their 2000 data by July 2001, which EPA expects to release by March 2002 after performing quality control checks.) In 1995, the number of chemicals on the TRI list was almost doubled, but these new chemicals are not included in analyses comparing 1988 or 1991 data because no data are available for the new chemicals prior to 1995. In 1998, several "new" industry sectors were required to comply with the TRI reporting requirements, the reports of which are also not included in comparisons with 1988 or 1991 as well as 1995 data.

5. EPA, *1997 Toxics Release Inventory* (Washington, D.C.: EPA, April 1999), 1–7.

6. EPA, "EPA Issues New Toxics Report," press release (Washington, D.C., 11 April 2001).

7. "Air Pollution: It's All Legal," *Newsweek*, 24 July 1989, 28.

8. If a private contractor operated a federal facility and met the TRI reporting requirements, then the private contractor had to report the facility's releases beginning in 1986 when TRI was first implemented. The Clinton administration's new requirement covered federal facilities operated by the government and any other facilities that did not fall within the manufacturing sector.

9. In addition, in the first few years of reporting, some companies may have switched from initial conservative estimation techniques to actual measurements, creating an appearance of sudden decreases in releases.

10. In addition to reporting the chemicals in releases, TRI-regulated facilities report the chemicals in waste that are treated, recycled, or otherwise managed. Therefore, TRI tracks the total amount of the chemical generated as waste, how the waste stream is managed, and how much of the chemical is released, treated, or recycled.

11. Facilities can achieve lower rates of waste generation even in the face of rising production in several ways: Some manufacturing processes may be more efficient in using the chemicals at higher rates of production, new uses for chemicals in the wastes may be developed, and facilities may add pollution control or recycling equipment to reduce releases or implement source reduction projects. Increases in toxic waste were not steady, however. Waste decreased in 1991 and again from 1994 to 1996 and then increased again from 1996 to 1999. Comparisons are made from the baseline year 1991 because that is the first year TRI required reporting on the elements of waste (in Section 8 of the TRI Form R). Comparisons only include data reported by the manufacturing industry sectors that have reported to TRI since its inception in 1986. Starting with the 1998 reporting year, several new industry sectors were also required to report. Their waste is not included here but is discussed later in the article. In 1995, the TRI list of chemicals was almost doubled, but these new chemicals are not included in comparisons with data from years before 1995.

12. Energy recovery involves burning waste as fuel, for example, in cement kilns or industrial boilers. The toxic chemicals in waste may also be treated by a variety of means, including chemical or biological treatment, such as that provided by sewage treatment plants or incinerators.

13. These designated carcinogens are chemicals that are listed in at least one of three sources: the U.S. Department of Health and Human Services National Toxicology Program's *Annual Report on Carcinogens*, the World Health Organization's International Agency for Research on Cancer's Monographs on the Evaluation of Carcinogenic Risks to Humans, or the U.S. Department of Labor Occupational Safety and Health Administration's list of Toxic and Hazardous Substances (29 CFR 1910, Subpart Z).

14. The analyses in this paragraph include data on all chemicals currently on the TRI list rather than the smaller number reportable since 1988. The analyses do not include data from the new industry sectors that started reporting in 1998.

15. Dichloromethane is widely used as a solvent in paint strippers, including furniture strippers, home paint removers, and aircraft maintenance products. It can be used as a solvent and degreasing agent in metal cleaning and as a process solvent in pharmaceutical production. It is also used in the production of plastics (polycarbonate and triacetate fiber) and polyurethane foam. Other uses include electronics manufacture; film processing; food processing; and production of pesticides, synthetic fibers, paints, and coatings. Besides cancer found in laboratory studies, dichloromethane can cause hearing and vision impairment. About 500 facilities reported releases of dichloromethane for 1999.

16. Styrene is mainly used (two-thirds) in producing polystyrene, acrylonitrile-butadiene-styrene (ABS) resins and acrylonitrile-styrene resins, which are used in automobile parts, appliances (including refrigerators and freezers), pipes, business machines, luggage, and recreational goods. It is also used to produce styrene-butadiene latex and rubber. In addition to suspected cancer-causing properties, inhalation of styrene can cause depression, concentration problems, muscle weakness, fatigue, and nausea. Other possible effects include irritation of the eyes, nose, and throat. Laboratory studies show damage to nose and liver as well as reproductive and fetal toxicity. About 1,500 facilities reported releases of styrene for 1999.

17. The largest use of formaldehyde is in the production of resins including urea-formaldehyde (UF) and phenolic resins (used in particleboard and plywood, respectively). It is also used in the production of acetylenic chemicals (butanediol), methylene diisocyanate (MDI), and other industrial chemical products; as a preservative in medical laboratories; and as an embalming fluid and sterilizer. Besides causing cancer of the nasal passages in laboratory studies, repeated exposure to formaldehyde can cause bronchitis and asthma-like allergies. About 800 facilities reported releases of formaldehyde for 1999.

18. Because these chemicals are widely used in U.S. manufacturing processes and products, it is important to note that TRI provides information on releases and waste generation from their manufacture or use in the manufacturing processes (not from their use as or in commercial products) and only if their manufacture exceeds 10,000 pounds per year or if their use in manufacture of other chemicals or products exceeds 25,000 pounds per year.

19. All TRI data in this article are taken from EPA's *TRI Public Data Release* (April 2001). Only those chemicals reportable since 1988 are included in the analyses that make comparisons to 1988 data. Therefore, chemicals added or deleted from the list since 1988 are excluded, as are ammonia, aluminum oxide, hydrochloric acid, and sulfuric acid because the definitions of these chemicals for TRI reporting purposes has changed. For analyses that include data from 1988 to 1999, only data from facilities in the manufacturing sectors—the original industries—are included because other new industries were required to report beginning in the 1998 reporting year. Data from reports of these new industries are discussed later in the article.

20. EPA, "Pulp and Paper Industry," in *1996 Toxics Release Inventory Public Data Release* (Washington, D.C.: EPA, 1998).

21. Some metals may be converted to less toxic forms. For example, hexavalent chromium (a known carcinogen) may be converted to the less toxic trivalent form. In addition, some forms of metal may be treated so that they are less likely to be transported through soils. However, such treatment does not destroy the metal.

22. EPA conducts data quality checks on the TRI data before publicly releasing it by contacting facilities with the largest reported changes each year.

23. Regulations require that most waste disposed of via underground injection be injected into deep geological formations that are isolated below potable water supplies.

24. If new industries as well as the original industries were included, the 50 facilities with the largest releases reported 57 percent of total releases for 1999. Thus, the new industry facilities are even more concentrated, with fewer facilities reporting larger releases. Among the new facilities, large metal mining and electric generating facilities account for the largest releases, as discussed later.

25. North American Commission for Environmental Cooperation (CEC), *Taking Stock: North American Pollutant Releases and Transfers, 1994–1998* (Montreal: CEC, 1997, 1998, 1999, 2000, 2001). The CEC annual reports include data from the subset of TRI chemicals and industries that are also reported by Canadian facilities under Canada's National Pollutant Release Inventory.

26. CEC, *Taking Stock: North American Pollutant Releases and Transfers, 1997* (Montreal: CEC, 2000), 390.

27. INFORM, Inc., *Toxics Watch 1995* (New York: INFORM, Inc., 1995), 457–9.

28. The overall increase in releases by new facilities and the large increase reported by metal mines can be accounted for by one facility that reported a one-time on-site land release of 505 million pounds when retiring a leach pad in 1999. An increase of 3 percent reported by hazardous waste and solvent recovery facilities consisted of increases in on-site land disposal and off-site transfers to disposal.

29. Releases from metal mines include chemicals in waste rock—the material removed from the mine to gain access to the ore. Waste rock as well as waste from ore processing is often disposed of in on-site landfills. If the waste in landfills is exposed to rain or snow, the chemicals may leach into surface and ground waters. Mines may control such leakage with water control technologies used to contain contaminated water or with subsurface barriers. In January 2001, a U.S. district court in Colorado ruled that toxic chemicals released from rock as a part of coal and metal mining operations were not "manufactured" within the meaning of the law and were therefore not required to be reported. (*National Mining Association v. Browner*, Civil Action No. 97 N 2665, Order filed 16 January 2001; Order of Clarification, 30 March 2001.)

30. Hydrochloric acid is generated during the combustion of coal to produce electricity. Acid aerosols can contribute to respiratory problems, including bronchitis, asthma, and emphysema. Hydrochloric acid emissions may enhance the acidity in clouds downwind from the facilities, contributing to the formation of acid precipitation. Only electric utilities that combust coal and/or oil are required to report releases under TRI, and they report air emissions generated after any pollution control that may be in place.

31. *Newsweek*, note 7 above. Initial totals included a number of chemicals that were later de-listed.

32. Graham (2001), note 1 above.

33. In 1998, EPA reported that 41 percent of air toxics derived from mobile sources, 35 percent derived from small businesses and other diffuse sources, and 24 percent derived from manufacturers and other large sources. EPA, *Taking Toxics Out of the Air* (Washington, D.C.: EPA, 1998), 3.

34. In-process recovery is considered under the Pollution Prevention Act as recycling that is integral to and necessary for the production of a product. However, because TRI reporting instructions do not define in-process recovery, facilities are free to define their activities as they choose.

35. T. E. Natan, Jr. and C. G. Miller, "Are Toxics Release Inventory Reductions Real?" *Environmental Science & Technology*, 1 August 1998, 368–74.

36. EPA, *1994 Toxics Release Inventory Public Data Release* (Washington, D.C.: EPA, 1996), 194, 206–7.

37. In April 1998, EPA announced the High Production Volume (HPV) Challenge Program, a cooperative program with industry and environmental groups to collect more complete toxicity information on HPV chemicals. The program uses six internationally recognized testing protocols that together provide a basic picture of the toxicity of the chemical. Only 55 percent of TRI chemicals had been tested before the program was initiated. The primary objective of the program is to make the information available to the public, especially through the Internet. Some companies have used toxicity weighting to prioritize pollution reductions and demonstrate environmental performance. For example, ICI Group, a corporation of international companies, calculates the "environmental burden" of its air and water emissions based on factors such as the ozone depletion potential or potential to form acid rain of each of the chemicals released. (For more information about the program, visit http://www.epa.gov/opptintr/chemrtk/hpvchmlt.htm.)