

GAO

United States General Accounting Office

Report to Congressional Requesters

March 1992

**WASTE
MINIMIZATION**

**Major Problems of Data
Reliability and Validity
Identified**





United States
General Accounting Office
Washington, D.C. 20548

**Program Evaluation and
Methodology Division**

B-235931

March 23, 1992

The Honorable Quentin N. Burdick
Chairman, Committee on Environment and Public Works
United States Senate

The Honorable Max Baucus
Chairman, Subcommittee on Environmental Protection
Committee on Environment and Public Works
United States Senate

In your letter of January 31, 1990, you asked us to evaluate the quality of the Environmental Protection Agency (EPA) data that will be used to determine the need for mandatory waste minimization requirements. We presented initial findings in response to this request in August 1991. This report presents our detailed findings on this issue; that is, our assessment of (1) the degree and causes of measurement error in EPA's National Survey of Hazardous Waste Generators, (2) how to reduce or eliminate these errors, and (3) how to minimize any future problems.

If you have any questions or would like additional information, please call me at (202) 275-1854 or Kwai-Cheung Chan, Director of Program Evaluation in Physical Systems Areas, at (202) 275-3092. Other major contributors to this report are listed in appendix II.

Sincerely yours,

Eleanor Chelimsky
Assistant Comptroller General

Executive Summary

Purpose

National policy concerning the management of hazardous waste has undergone a profound shift since the passage of the Resource Conservation and Recovery Act of 1976, the first national legislation specifically addressing this issue. Hazardous waste minimization, which seeks to avoid the production of waste, has now become the preferred alternative to the handling of waste once it has been produced. To gauge the amount of hazardous waste minimization occurring and to assess the need for related regulatory statutes, the Environmental Protection Agency (EPA) must have hazardous waste minimization data that are valid enough to measure the extent to which the U.S. industrial sector is preventing the generation of hazardous waste, as well as the factors that are associated with successful waste production avoidance. However, the EPA hazardous waste information system has suffered from serious deficiencies, making the quality of the data questionable. Accordingly, Senators Baucus and Burdick of the Senate Environment and Public Works Committee asked GAO to examine the reliability and validity of these data.

Background

The Resource Conservation and Recovery Act of 1976 (RCRA) established federal requirements for managing hazardous waste; the emphasis of this first attempt was to assure that management was monitoring hazardous waste streams from “cradle to grave” and to ensure that wastes were managed in an environmentally safe manner. The Congress declared hazardous waste minimization to be the national policy of the United States in the Hazardous and Solid Waste Amendments of 1984 (HSWA).¹ However, hazardous waste minimization programs have not been mandated. EPA has relied on voluntary efforts by industry to achieve hazardous waste minimization, and according to EPA, hazardous waste minimization is driven by a number of potential incentives. These incentives include the increasing costs of treating hazardous waste, difficulties in siting new hazardous waste management facilities and obtaining permits to operate these facilities, financial liability of hazardous waste generators, shortages of liability insurance, and public pressure. If these incentives are effective, federal regulatory levers may not be needed to achieve waste minimization. Reliable and valid data are necessary, however, to determine whether these efforts have, in fact, resulted in less hazardous waste produced and whether additional actions are needed to implement the national policy.

GAO reported in February 1990 that, based on design problems, EPA’s efforts to obtain reliable and valid data on hazardous waste would be frustrated in the areas of information-requirements system development,

¹HSWA further amended and modified the statutes of RCRA.

measurement, and data collection.² In view of these findings, GAO evaluated the quality of actual hazardous waste minimization data collected under this information system to determine if the design problems we predicted did in fact occur.

Results in Brief

GAO found that EPA's baseline hazardous waste minimization data are fraught with measurement problems, most of which are severe enough to greatly limit the data's usefulness in profiling the extent of waste minimization progress. As predicted, these problems include ambiguities in (1) definitions of key concepts, terms, and questions; (2) governmental reporting requirements; and (3) the relationship of production amounts and types to the volume of hazardous waste produced. These ambiguities cause reliability and validity problems for waste minimization program elements, waste stream information, and production mix data. The problems are of such severity that the data cannot be adjusted to account for imperfect measurement; hence, waste minimization progress cannot be ascertained.

Principal Findings

Definitions

EPA has not sufficiently defined several concepts, terms, and questions that are used in its survey instruments. For example, we found that "waste minimization program" was not defined for respondents. This ambiguity caused officials of generating firms to attempt to define nearly every action on their part as a program to reduce the output of hazardous waste. Consequently, the reported number of existing waste minimization programs appears to be greatly inflated. Furthermore, EPA has not refined the RCRA categories that use codes to profile hazardous waste types. Since these codes are not mutually exclusive, hierarchical, or categorical, officials reported waste types that do not accurately represent types of waste produced or minimized.³ Without an improved RCRA waste code system, EPA cannot accurately profile the extent and determinants of minimization for specific hazardous wastes.

²Hazardous Waste: EPA's Generation and Management Data Need Further Improvement (GAO/PEMD-90-3, Feb. 9, 1990).

³Hierarchical codes are those that are rank-ordered for waste types, from simple to complex. If a code is mutually exclusive, its presence excludes the presence of other codes for the same waste. An exhaustive list of codes includes all possibilities for characterizing waste.

Reporting Requirements

We found that waste minimization data problems often result from company record-keeping systems that are not adequately designed or maintained to meet the complicated reporting requirements. The lack of standardized record-keeping systems has led to the current wide range of record accessibility and quality among waste generators. Furthermore, the lack of sufficient record-keeping capabilities leads individual respondents to make judgments and estimations of the data that may not be representative of the information collected.

Production Mix

EPA's attempt to accurately represent waste minimization by relating it to production mix is flawed. For this measure to be appropriate, a company with more than one product must specifically account for the variation in product mix from year to year, and companies must not have any nonproduction activities that generate hazardous waste. Most firms we evaluated have multiple product lines and do not keep hazardous waste information on the basis of these individual products. We also found that certain nonproduction activities, such as research, generate waste that is not accounted for by production measures. Similarly, one-time events, such as spill clean-ups, may not be related to production activities but will affect the amount of hazardous waste reported. Such irregular occurrences can have spurious effects on measurements of the causal relationship between waste minimization programs and waste minimization progress.

Recommendations

In light of these findings, GAO recommends that EPA (1) investigate alternatives to the production mix measure in order to accurately depict the extent of waste minimization progress; (2) clarify waste stream definitions by making RCRA waste code categories more definitive; (3) clarify regulatory status so that respondents do not confuse RCRA-defined hazardous wastes, hazardous wastes exempt from RCRA, and wastewater; (4) request that hazardous-waste-generating industries define waste minimization programs to ensure that goals, budgeting, incentive programs, use of technical assistance, and assessments are well delineated; (5) request that hazardous-waste-generating industries maintain record-keeping systems that provide sufficient detail on goals, activities, and progress of waste minimization activities; and (6) conduct site visits of a sample of hazardous waste generators in order to maintain quality assurance and control in waste minimization program activities.

Agency Comments

We discussed the results of our work—including tentative findings, conclusions, and recommendations—with responsible agency officials and have incorporated their comments where appropriate. These officials generally agreed with our findings, conclusions, and recommendations. We therefore believe that written agency comments were not necessary in this instance.

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Abbreviations

EPA	Environmental Protection Agency
GAO	General Accounting Office
HSWA	Hazardous and Solid Waste Amendments of 1984
NPDES	National Pollution Discharge Elimination System
RCRA	Resource Conservation and Recovery Act of 1976
SIC	Standard Industrial Classification
SWDA	Solid Waste Disposal Act

Introduction

In 1984, the Congress declared it “the national policy of the United States that, wherever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible.”¹ With this declaration, the Environmental Protection Agency (EPA) was given the authority to investigate actions that would result in the reduction or elimination of the volume or toxicity of hazardous wastes produced, including source reduction and recycling techniques. The Congress specifically asked EPA to investigate whether the voluntary waste minimization program for industry was effective and, on the basis of these findings, to recommend any legislative initiatives that could encompass mandatory management practices, standards of performance, and other requirements. In the meantime, our evaluation of the EPA hazardous waste generation and management information design systems cast doubt on the quality of hazardous waste data, including those data that would be used to make policy decisions about waste minimization.²

On January 31, 1990, Senators Baucus and Burdick of the Senate Environment and Public Works Committee asked us to evaluate the quality of the EPA data that will be used to determine the need for mandatory waste minimization requirements.³ We recently completed an initial report on our assessment of the quality of waste minimization data.⁴ In this report, we present more detailed information about the reliability and validity of the EPA waste minimization data. We also present recommendations for data improvements.

History of Waste Minimization

Historically, the primary approaches to managing hazardous waste have emphasized its treatment, storage, and disposal. For the most part, although hazardous waste was required to be managed, it was placed into the nation’s landfills, water, and air. A major policy shift occurred in 1976 when EPA issued a policy statement outlining its preferred hazardous waste management strategy. That strategy favored source reduction and recycling (collectively known as waste minimization) over treatment and land disposal. While this strategy was preferred by EPA, the agency did not

¹The term “hazardous waste” refers to waste types covered by the hazardous waste provisions of the Resource Conservation and Recovery Act of 1976.

²U.S. General Accounting Office, *Hazardous Waste: EPA’s Generation and Management Data Need Further Improvement*, GAO/PEMD-90-3 (Washington, D.C.: February 9, 1990).

³We define waste minimization to include the separate components of source reduction and recycling. Source reduction is defined as the elimination of initial production of hazardous waste, while recycling refers to the reuse of hazardous waste so that discharge to the environment is eliminated.

⁴*Waste Minimization: EPA Data are Severely Flawed*, GAO/PEMD-91-21 (Washington, D.C.: August 5, 1991).

develop any mandatory program requirements or enforcement provisions. In 1986, EPA submitted a report to the Congress in response to the requirements of Section 8002(r) of the Solid Waste Disposal Act (SWDA) as amended by the Resource Conservation and Recovery Act of 1976 (RCRA) and the Hazardous and Solid Waste Amendments of 1984 (HSWA).⁵ This report to the Congress was mandated by HWSA to identify any legislative changes, including mandatory requirements, that were feasible and desirable in order to implement the policy of minimization of hazardous waste:

"The Congress hereby declares it to be the national policy of the United States that, wherever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible. Waste that is nevertheless generated should be treated, stored, or disposed of so as to minimize the present and future threat to human health and the environment."⁶

Section 8002(r) of the Solid Waste Disposal Act required the EPA Administrator to specifically evaluate the feasibility and desirability of

"Establishing standards of performance or of taking other additional actions under RCRA to require generators of hazardous waste to reduce the volume or quantity and toxicity of the hazardous waste they generate; and of establishing, with respect to hazardous waste, required management practices or other requirements to ensure such wastes are managed in ways that minimize present and future risks to human health and the environment."

In 1986, EPA's legislatively mandated report to the Congress concluded that existing data were insufficient to make any determination of the need for mandatory waste minimization requirements and promised to report to the Congress by the end of 1990 concerning recommendations on this issue.⁷ In the intervening years, EPA continued to gather data on hazardous waste production and minimization.⁸ Subsequently, we found that EPA had improved their data methods and procedures for gathering these data.⁹ However, we also anticipated problems in data reliability and validity that

⁵Throughout this report, the amended Solid Waste Disposal Act will generally be referred to as RCRA, reflecting common usage.

⁶HSWA

⁷EPA did not issue their recommendations on mandatory controls by the stated deadline. In lieu of this, they informed us on progress and problems encountered in honoring commitments made in their 1986 report to the Congress. See Hazardous Waste: Data Management Problems Delay EPA's Assessments of Minimization Efforts, GAO/RCED-91-131 (Washington, D.C.: June 13, 1991).

⁸These data were gathered from the RCRA biennial reporting cycles in 1987 and 1989, the National Survey of Hazardous Waste Generators, the Toxic Chemical Release Inventory, and the National Survey of Management Facilities (1986).

⁹See Hazardous Waste: EPA's Generation and Management Data Need Further Improvement, GAO/PEMD-90-3 (Washington, D.C.: February 9, 1990).

would result from three remaining design flaws in the data base produced by the various data-gathering instruments. These flaws include unclear definitions of concepts, terms, and questions in the survey instruments; problems with reporting requirements, and failure to identify industrial processes and production mix.

This previous study addressed data design problems from which problems in reliability and validity could arise. In this current evaluation, we analyze actual hazardous waste generation and minimization data to assess their reliability and validity.

Objectives

In this evaluation, we focus on the data collected by EPA's redesigned hazardous waste information system. The objective of this study was to determine whether the system design flaws we had identified in our earlier study did in fact produce the data reliability and validity problems we had predicted and, if so, to determine their magnitude. We translated the request into the following evaluation questions:

1. What is the magnitude of measurement error in existing EPA hazardous waste minimization data, and how does it affect the usefulness of EPA's original data?
2. How should EPA's estimates be adjusted to account for imperfect measurement?

Scope

The information on which this report is based was obtained from two major sources. First, we analyzed data from the EPA National Survey of Hazardous Waste Generators (1986).¹⁰ In addition, we administered a retest of certain questions addressing hazardous waste minimization from the generator survey to a sample of 25 large-quantity generators, all of which participated in the original survey. These questions addressed waste minimization program and waste stream information. To strengthen the generalizability of our results, we restricted our sampling frame to hazardous waste generators that are large-quantity producers (more than

¹⁰We selected the National Survey of Hazardous Waste Generators because EPA had selected it to be the baseline of any trend study in waste minimization progress.

1,000 kilograms in any month during 1986), privately owned, and recurrent waste producers.¹¹ Of all facility types, we believe that these are most likely to be targeted for waste minimization legislation, due to their size and consistent production of waste. To further refine our sampling frame, we determined the range of generators that, when totaled, produced 90 percent of all the waste reported in the generator survey.¹² This ensured that we specifically targeted the major producers of waste in the large-quantity-generator category.

While the scope of our evaluation included only those facilities covered in the National Survey of Hazardous Waste Generators, our findings also apply to other EPA data collection efforts, such as that used in the biennial reporting process, where certain data collection aspects are identical. However, our findings do not apply to any EPA reporting instruments containing questions with wording that is significantly different.

Methodology

We used a variation of cluster sampling techniques to choose facilities for participation in the retest of the 1986 Generator Survey. We divided the United States into three segments (East, Middle, and West) and selected "hub" cities as anchor points. We selected 10 cities in the East, 10 in the Middle, and 11 in the West. This selection allowed us to include a mix of geographic regions, which helped ensure that we would not become overburdened with certain Standard Industrial Classification (SIC) categories that dominate particular regions.¹³ We ordered facilities on the basis of proximity to these cities, and we chose the cities and facilities surrounding them on a random basis. This procedure resulted in a final sample size of 25 facilities. We visited generator facilities in the following states: California, Connecticut, Florida, Georgia, Idaho, Iowa, Kansas, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, New Hampshire, North Carolina, Ohio, Oregon, Tennessee, Texas, Utah, and Washington. The generators are listed by 18 SIC categories:¹⁴

¹¹The generator survey included some government-owned facilities (federal, state, or local), but these only totaled about 8 percent of the cases. Small-quantity generators comprised less than 1 percent of the cases. In all, our sampling frame included nearly 79 percent of the survey cases, or a total of 4,372 facilities.

¹²Only 381 generators produced 90 percent of the cumulative waste in the survey. Therefore, a very small proportion of the generators produced a large proportion of the waste.

¹³For example, the Gulf Coast area has an overabundance of petroleum firms, and northern Michigan has many automobile manufacturers.

¹⁴Our sample included one facility per SIC code, unless otherwise indicated in parentheses.

- alkalis and chlorine;
- industrial gases;
- industrial inorganic chemicals, not elsewhere classified (2);
- medicinals and botanicals;
- cyclic crudes and intermediates;
- industrial organic chemicals, not elsewhere classified;
- petroleum refining;
- electrometallurgical products;
- plating and polishing (3);
- electronic computing equipment;
- motors and generators;
- household laundry equipment;
- semiconductors and related devices (3);
- electronic components, not elsewhere classified;
- motor vehicles and car bodies (3);
- aircraft;
- environmental controls; and
- switch gear and switchboard apparatus.

We created a retest instrument of the 1986 EPA National Survey of Hazardous Waste Generators. This instrument, and accompanying instructions, were taken directly from the original EPA survey. We made telephone contact with each facility, explained the purpose and procedures of our study, and set up appointment dates to meet with facility officials.¹⁵ We instructed facilities to use any data for completion of the survey except the original EPA Survey of Hazardous Waste Generators itself.¹⁶ Normally, we allowed each facility between 1 and 3 weeks to complete the questionnaire.

We visited each site and reviewed the generator's responses to the retest instrument with appropriate firm official(s), as well as presented the original responses from the 1986 generator survey. This on-site debriefing ascertained reliability and validity in several ways. We compared each answer in the retest to the original survey to determine if and to what extent differences existed. We discussed with officials any possible reasons for answer divergence. Even if the answers were identical, we attempted to determine the reasons for consistency for each answer so that we could determine whether other responses might have been more appropriate. We

¹⁵We assured each generator official of the confidentiality of the study and the importance of his or her participation.

¹⁶In order to ensure a true test of reliability, generator officials were instructed not to use a copy of the original EPA survey. All other data sources were permitted, including hazardous waste manifest forms, state reporting forms, and worksheets.

also discussed question wording so that we could determine how respondents perceived the design of the survey instrument. Finally, we discussed respondents' suggestions for improvements in the EPA hazardous waste information system.

Waste Minimization Data Measurement Error

In this chapter, we answer our evaluation questions:

1. What is the magnitude of measurement error in existing EPA hazardous waste minimization data, and how does it affect the usefulness of EPA's original data?
2. How should EPA's estimates be adjusted to account for imperfect measurement?

Our discussion focuses upon the reliability and validity of waste minimization program data elements and waste stream information. From this assessment, we determine whether these data can be adjusted to allow for the determination of waste minimization progress.

Waste Minimization Data and Measurement Errors

The principal data set that EPA has used to reach conclusions concerning waste reduction program progress was developed through the 1986 National Survey of Hazardous Waste Generators. This survey includes the data that provide the base year statistics for EPA trend analyses.¹ As we indicated earlier, our first evaluation concluded that there were three types of design flaws with the 1986 generator survey: definitional, reporting, and production-mix tracking. The following discussion presents our findings on the three kinds of data problems we found over several data types. These data types are grouped into two categories. The first data type is composed of the following waste minimization program data elements:

- existence of program,
- duration of program,
- existence of policy statements,
- knowledge of opportunity assessments and audits,
- comprehensiveness of assessments and audits,
- frequency of assessments and audits,
- specific facility staffing,
- specific parent-company staffing,
- incentives/rewards program,
- employee training program,
- presence of technical assistance,
- source(s) of technical assistance,
- application for state financial assistance,
- receipt of state financial assistance,
- application/receipt of private-market financial assistance, and finally,

¹A more specific list of these measures is given in appendix I.

- management encouragement.

The second data type is comprised of the following waste stream information:

- total waste stream production amounts,
- RCRA waste codes and waste stream classifications,
- RCRA waste stream regulatory status,
- Standard Industrial Classification (SIC) codes,
- wastes generated on-site in 1985 but not in 1986,
- removal of wastes due to process or equipment modification,
- removal of wastes due to elimination of production process,
- removal of wastes because of source reduction,
- removal of wastes because of recycling, and
- removal of wastes because of purchase or input of raw material from off-site.

Data Reliability and Validity

Waste Minimization Program Data Elements

In the generator survey, EPA asked a series of questions about waste minimization programs and activities. We included these questions on the retest. Table 2.1 summarizes the reliability of the answers by comparing the generator responses of the EPA and GAO surveys. First, for each item, the table shows the percentage of respondents giving the same answer in both surveys. The second table column shows the statistical correlation between first and second responses among the group of 25 respondents. By convention, items that are correlated at less than the 0.80 level are considered unreliable.²

²In theory, the correlation coefficient can take any value between +1 and -1.

Table 2.1: Reliability of Waste Minimization Program Data Elements^a

	Percentage same	Correlation	Standard error ^b
Existence of program	96	^c	3.9
Duration of program	32	0.94	9.3
Existence of policy statements	72	0.57	9.0
Knowledge of opportunity assessments and audits	76	0.52	8.5
Comprehensiveness of assessments and audits	68	0.71	9.3
Frequency of assessments and audits	56	0.22	9.9
Specific facility staffing	64	0.32	9.6
Specific parent company staffing	56	0.59	9.9
Incentives/rewards program	84	0.63	7.3
Employee training program	72	0.45	9.0
Presence of technical assistance	88	0.51	6.5
Source(s) of technical assistance ^d	32	0.32	8.1
Application for state financial assistance	96	^c	3.9
Receipt of state financial assistance	96	^c	3.9
Application/receipt of private-market financial assistance	100	^c	0.0
Management encouragement	92	^c	5.4

^aBased on a comparison of the EPA and GAO waste generator surveys.

^bThese figures allow the use of the sample statistics to make statements about the population of waste generators. The standard error shows the lower and upper bounds of the range of possible "percentage same" population results, when subtracted or added to the "percentage same" score. For example, with high probability, the percentage of respondents with consistent answers to "existence of program" could range from 96% - 3.9% (92.1%) to 96% + 3.9% (99.9%) in the population.

^cCorrelation coefficient undefined, since there was no answer variability in at least one of the surveys.

^dThe resulting figures are a composite of the 11 scores for the various sources of technical assistance. Appendix I gives these individual items.

The generator survey queried the existence of waste minimization programs, and although response reliability was high, we found the resulting data to have serious validity problems. For example, respondents systematically overreported the existence of programs because the wording of the survey question forced a "yes" answer. Several officials

suggested that they would most likely respond "yes" to this question in order to project an image favorable to EPA regulators.³ This survey question is so vague that it provides officials extreme latitude in justifying such responses. As a result, respondents offered widely varying interpretations of what either a waste minimization program or management encouragement of waste minimization is. For example, the officials of some of the companies claiming to have a waste minimization program told us that what existed in 1986 was nothing more than an employee suggestion program. Other generator officials told us that they considered cost reduction, recycling, and reclamation done at the end of the production process as constituting an overt waste minimization program. Further discussion with these officials revealed, however, that cost, not waste minimization, had been driving these efforts for many years. This issue is important because we believe that, without cost advantages, such a waste minimization program would cease to exist. Cost reduction is a positive result for many companies that minimize hazardous waste. However, EPA's policy interest in waste minimization has its foundations in the protection of human health and the environment.

With regard to the responses to the question concerning the duration of waste minimization programs, there was little agreement between the two surveys. For most firms, adequate documentation of when the waste minimization programs and activities began did not exist. Officials reported having to guess at the correct response to this question, causing poor reliability. In fact, we found that respondents had great difficulty specifying the date at which any waste minimization program activities officially began.

Respondents were asked if any waste minimization policy statements existed for their firms.⁴ Some generator officials were unable to answer this question consistently across the two surveys. In other cases, officials answered this question on the basis of what they believed to be true,

³Section 3002(b) of HSWA requires generators to certify on their waste manifests that they have in place a program "to reduce the volume or quantity and toxicity of such waste to the degree determined by the generator to be economically practicable." However, EPA does not define specific elements of such a program.

⁴We believe that such a statement should be able to distinguish a waste minimization program from other corporate endeavors by describing how stated activities can achieve EPA's stated goals of protecting human health and the environment.

although they were unable to locate the actual policy documents upon which to base precise answers.

The EPA generator survey and our retest asked companies if they conducted waste minimization opportunity assessments or audits between 1984 and 1987.⁵ Response agreement between the two surveys was low. For example, officials with whom we spoke suggested that EPA did not describe sufficiently what was meant by "assessment or audit." The questions allowed them broad and random interpretation of the meaning of these terms. These interpretations included (1) an assessment by independent evaluators who measure amounts of waste, compare them to past years' figures, and determine how to decrease those amounts in the future; (2) daily programs designed to reduce waste; and (3) looking at different generation processes to determine how they can be altered so that less waste is produced in the future. Some officials told us that they had not conducted formal assessments; instead, they relied upon employee awareness or suggestions. We also found low agreement on the question concerning the comprehensiveness (facility-wide versus restricted) of assessments and audits. Frequency of audits was also difficult for respondents to determine, and data reliability for the sample was poor. For example, one generator official stated that his firm had continual assessments that were not mutually exclusive, and were therefore difficult to distinguish from each other. Furthermore, if officials found it difficult to determine what an assessment or audit is, they would be unlikely to accurately report how often such activities occurred or how comprehensive they were. Hence, these activities cannot be counted for reporting purposes. (We believe that the lack of uniform definitions of terms may explain these measurement problems.)

Officials were asked one question each about whether their firms assigned specific facility staff or parent company staff to investigate waste minimization practices. We found that response reliability for the sample was low. For example, some officials interpreted these questions to mean a staff person exclusively assigned to identifying and investigating waste minimization opportunities. Other officials interpreted the question as meaning the presence of any employees who investigate and identify waste minimization opportunities as part of other duties.⁶

⁵A waste minimization opportunity assessment or audit is a procedure that identifies specific sources of waste. It then evaluates each source to determine opportunities for source reduction or recycling.

⁶These duties typically involved environmental reporting to the appropriate federal, state, and, in some cases, city and/or county governments. Some officials are also required to report information to the corporate headquarters of their facilities.

Respondents were asked whether their facility had an incentive or reward program to encourage waste minimization practices. We found that data reliability and validity for the sample were questionable due to differing understandings of what incentive or reward programs designate. Some officials told us that their companies had employee suggestion programs but that these did not focus exclusively on waste minimization. Similarly, one official suggested that his company's employee performance appraisal system considered any waste minimization efforts that staff members made as part of the program.

The questionnaire asked if companies had any "employee training programs to educate and encourage employees to practice good operating procedures and to identify . . . possible source reduction and recycling practices." Again, we found that agreement was low, partially because of the double-barreled nature of the questions. Thus, the two parts to the question—"educate and encourage employees to practice good operating procedures" and "identify possible source reduction and recycling practices"—must both be either true or false if the response is to be considered valid; therefore, responses may not be representative of actual company practices.

Officials of generating firms were asked if their facility received technical assistance on waste minimization and the sources that provided this assistance. We found that many responses were unreliable concerning whether technical assistance was received. Furthermore, the sources of this assistance were themselves a significant source of data reliability problems for the sample.⁷ Responses to the two surveys do not always correspond, suggesting that officials are not certain of these sources. In addition, the validity of these data are questionable since, as one respondent suggested, the question as worded does not enable EPA to determine whether the company officials asked for the technical assistance or ever utilized it.

Respondents were asked about financial assistance applied for or received from state governments and the private market. We found high data reliability for these responses. We believe that the straightforward nature of these questions, combined with the generators' infrequent use of such financial assistance, led to response consistency.

⁷These include local, state, and federal agencies, trade associations, suppliers/vendors, other parts of the surveyed firm or facility, literature/magazines, consulting engineers, universities, conferences/seminars, and other firms.

Both surveys asked officials if management actively encouraged the implementation of source reduction and recycling practices in 1986. According to our site visits, the wording of the question leads the respondent to answer affirmatively, no matter how management views waste minimization. Due to company loyalty, we believe, respondents were likely to cast the firms' management in the best light possible.

Waste Stream Information

EPA's generator survey asked a series of questions about waste stream information. We included these questions on the retest. Table 2.2 describes, for each retested facility, the total waste stream production amounts reported to EPA in the Survey of Hazardous Waste Generators, the amount reported to us in the retest, and the absolute differences between these amounts. We also discuss other waste stream information, including essential data for tracking minimization progress.

Chapter 2
Waste Minimization Data Measurement Error

**Table 2.2: Total Waste Stream
 Production Amounts in Tons Reported
 to EPA and GAO**

Facility	Reported to EPA	Reported to GAO	Difference
A	347,636	222,635	125,001
B	195,500	7,791	187,709
C	435,400	476,833	-41,432
D	273,576	430,917	-157,341
E	283,333	283,333	0
F	652,104	2,272	649,832
G	183,382	23,760	159,622
H	279,791	233,197	46,594
I	1,218,333	1,513	1,216,820
J	175,900	48,864	127,036
K	634,205	634,205	0
L	546,797	980	545,817
M	219,305	219,071	234
N	1,952,000	5,287,187	-3,335,187
O	255,908	113,349	142,559
P	417,041	127,873	289,168
Q	322,049	32,624	289,425
R	242,609	18,731	223,877
S	209,846	468,181	-258,334
T	963,714	119	963,594
U	186,381	186,381	0
V	217,281	246	217,034
W	2,566,665	2,566,665	0
X	278,756	280,902	-2,146
Y	805,437	805,437	0
Total	13,862,949	12,473,066	1,389,884

Total absolute difference 8,978,764

Mean absolute difference 359,151

As table 2.2 indicates, the absolute differences of total waste produced for each facility ranged from 0 to 3,335,187 tons, with a mean of 359,151 tons.⁸ The summation of the absolute differences equaled 8,978,764 tons,

⁸For ease of analysis and presentation, waste amounts reported in gallons were converted to tons.

showing that waste streams were not sufficiently defined to ensure reliable measures.⁹ We found that hazardous waste production was systematically overstated because of data-definition and reporting problems. Some companies reported hazardous waste volume in both gallons and tons, even though the survey form instructed respondents to check only one unit of measure. Furthermore, although certain wastes are exempt from RCRA reporting requirements, some officials of generating firms included these in their reports. Finally, some officials reported hazardous wastes that were never released outside of their facilities. For example, one respondent reported wastes that were maintained in closed-loop recycling processes.

Under RCRA, EPA has devised an elaborate coding scheme for classifying hazardous waste streams: RCRA codes exist for waste source, waste description, and waste treatment. However, these codes are neither hierarchical, mutually exclusive, nor exhaustive.¹⁰ This ambiguity resulted in two significant definitional problems. First, EPA and the officials of generators assigned different treatment, description, or source codes to the same waste type, or used a single such code to describe more than one waste type. For example, one generator official used the waste source codes S01 through S06 to describe chemicals for cleaning, while an official from a different generator reported using these same chemicals for etching. Officials confused codes that describe the process that generates the waste with those that describe how the facility treats the waste after it is generated. For example, even within the same facility, some respondents used their personal judgment to assign codes describing the process that generated the waste, while others used codes that describe how the waste was treated.

Respondents also defined and divided waste streams differently for different reports. For example, an official at one company we visited reported having 12 waste streams. He told us he could easily have grouped all solvents into one waste stream and all acids into another. This would have resulted in only 6 waste streams being reported. An official at another company we visited reported over 300 waste streams to EPA and 16 broad categories of waste streams to us. First of all, then, officials made individual judgments concerning whether to include both RCRA-regulated and other wastes in the reports. For example, one respondent reported 47

⁹As table 2.2 indicates, the differences between the EPA survey and our retest, when the direction of error is considered, total 1,389,884 tons.

¹⁰Hierarchical codes are those that are rank-ordered for waste types, from simple to complex. If a code is mutually exclusive, its presence excludes the presence of other codes for the same waste. An exhaustive list of codes includes all possibilities for characterizing waste.

waste streams to EPA and 5 to us. He stated that the 5 waste streams he reported to us were considered hazardous by the state.¹¹ This variation occurred despite the instructions in the EPA generator survey and our retest, which direct respondents to include all wastes considered hazardous by the state.

Second, officials failed to keep records that were adequate for the review and understanding of individual reporting judgments. For example, when we reviewed the waste streams reported with several company officials, we could not match the data on waste with the waste streams reported because the facility official who filled out the EPA generator survey divided the waste streams differently, and no documentation existed to show how he derived these divisions.

Further, officials of generating firms were confused about the RCRA regulatory status definitions of their waste streams. First, they often made random judgments on what wastes are hazardous under subtitle C of RCRA. These decisions caused differences between what they reported in the EPA generator survey and in our retest. Second, generator officials were unclear about how they should consider wastewater in estimating the volume of hazardous waste. While instructions for both the EPA generator survey and our retest advised respondents to include wastewater pretreated before discharge under the National Pollution Discharge Elimination System (NPDES), RCRA specifically exempts wastewater if it is treated before discharge.¹² As a result of this discrepancy, a substantial number of respondents who reported wastewater to EPA in the generator survey did not report it to us. Central to the measurement of waste minimization progress is the availability of production-mix information. The type of production mix must be accounted for as facilities track waste minimization progress. Some products result in the generation of more hazardous wastes than other products. If a facility generates more hazardous waste per unit of production for product A than for product B, it can give the appearance of reducing overall hazardous waste generation simply by producing less of A and more of B and maintaining the same overall level of goods produced. This shift, of course, is not true waste minimization because the facility operators made no lasting technological or organizational changes to reduce waste. The level of hazardous waste production could rise again simply by restoring products A and B to their original production levels. Thus, comparing overall production of goods to

¹¹When asked to identify which 5 of the 47 waste streams he had reported to us, he could not do so. He further stated that he had counted a total of 82 waste streams at that company.

¹²Federal regulations require that waste be treated before being discharged.

overall hazardous waste levels is meaningless unless the production mix is sufficiently defined and documented.

We found that many of the generators in our study had multiple product lines. These product lines are subject to change from year to year, but the waste minimization data provided to EPA and us did not include information on the extent and dynamics of these product lines. As table 2.3 shows, Standard Industrial Classification (SIC) codes have a relatively high level of reliability. However, officials of generating firms reported two validity problems with the codes. First, SIC codes, which classify types of production, are not sufficiently defined to represent many product line changes. There are not enough classification code designations for some newer, rapidly changing industries. For example, the new semiconductor industry contains only one attribute, while the more established leather goods industry contains 11. Furthermore, officials reported confusion over whether to use the SIC codes for products resulting from an entire facility's production process or, alternatively, for components of products resulting from each segment of a waste-generating production process. For example, one official reported SIC code 3471 (plating) to EPA and code 3317 (pipes and tubes) to us. When questioned about this difference, the official explained that the firm's operation involved plating of pipes and tubes and suggested that different codes could be used to represent various parts of the production processes.

Table 2.3: Reliability of Waste Stream Information^a

Data element	Percentage same	Correlation	Standard error ^b
Standard Industrial Classification (SIC) codes	80	0.99	8.0
Wastes generated on-site in 1985 but not in 1986	72	0.46	9.0
Removal of wastes due to process or equipment modification	88	0.47	6.5
Removal of wastes due to elimination of production process	72	0.35	9.0
Removal of wastes because of source reduction	84	0.24	7.3
Removal of wastes because of recycling	88	0.51	6.5
Removal of wastes because of purchase or raw material from off-site	92	^c	5.4

^aTwo of the waste stream information elements (RCRA waste codes/ waste stream classifications and RCRA waste stream regulatory status) are not included in this table because we were unable to develop reliability scores for them. Respondents offered such varied interpretations of these elements that we could not quantitatively match waste stream data in the two surveys in a meaningful way. However, we were able to address the reliability issue for these items qualitatively.

^bThese figures allow the use of the sample statistics to make statements about the population of waste generators. The standard error shows the lower and upper bounds of the range of possible "percentage same" population results, when subtracted or added to the "percentage same" score. For example, with high probability, the percentage of respondents with consistent answers to "Standard Industrial Classification (SIC) codes" could range from 80% - 8.0% (72.0%) to 80% + 8.0% (88.0%) in the population.

^cCorrelation coefficient undefined, since there was no answer variability in at least one of the surveys.

The application of SIC codes fails to account for hazardous waste generated from atypical events, such as one-time spills of hazardous waste that resulted in the disposal of contaminated soil and disposal of waste from cleaning factory floors or waste filters. In addition, certain activities, such as pharmaceutical research, are part of a hazardous waste production mix. Waste generated from research activities may not be directly related to production activities, so SIC codes may not capture the relevance of such waste.¹³

¹³However, we acknowledge that measuring waste output on the basis of research activity would be very difficult, even exceeding the complexity in the measurement of product production. While number and types of products can be quantified, research activity is a much more complex and abstract phenomenon. Since research is experimental in nature, a company cannot assume that a given number of final products will result from some quantified amount of research effort.

To assess waste minimization progress, EPA must profile waste production amounts and reasons for changes over time. The survey asked officials of generating firms if any of the wastes generated on site in 1985 were not generated in 1986 and, if not, the reason for the waste removal. As table 2.3 indicates, our analysis shows poor reliability for the responses that addressed the change in waste production from 1985 to 1986. We believe that the problems of definition and reporting discussed earlier caused respondents to be unsure of what types of waste were being produced over time. The inability to account for production mix as it relates to waste production caused difficulties in tracking waste output trends. As a result, the response categories given for the waste removal questions have relatively poor reliability, and we also question the validity of these measures, since the categories are not mutually exclusive. A particular waste may no longer be generated on-site for a variety of reasons given in the questionnaire, but the respondent is forced to make one choice only.¹⁴

Summary and Conclusions

Waste minimization program data elements and waste stream information are fraught with reliability and validity problems. EPA's lack of concrete definitions for these data elements caused respondents to make an array of individual judgments while completing waste minimization questionnaires. Additionally, the lack of stringent EPA reporting requirements caused company record keeping systems to vary greatly in quality and focus. In fact, some of the record keeping systems were not sufficient to track the extent and determinants of waste minimization progress. Most importantly, waste stream production amounts indicated low reliability between the two surveys, and the data were unable to characterize production mix as it relates to waste output. Because of these problems, we do not believe that the EPA waste minimization data can be adjusted to account for imperfect measurement.

Recommendations

We recommend that the Administrator of EPA direct the Assistant Administrator for Solid Waste and Emergency Response to

- investigate alternatives to the production mix measure in order to accurately depict the extent of waste minimization progress;
- clarify waste stream definitions by making RCRA waste code categories more definitive;

¹⁴For example, one reason for waste removal is "source reduction practices implemented" and another is "change or elimination of a production process." However, one explicit way to implement source reduction would, in fact, be to change or eliminate a production process.

- clarify regulatory status so that respondents do not confuse RCRA-defined hazardous wastes, hazardous wastes exempt from RCRA, and wastewater;
- request that hazardous-waste-generating industries define waste minimization programs to ensure that goals, budgeting, incentive programs, use of technical assistance, and assessments are well delineated;
- request that hazardous-waste-generating industries maintain record-keeping systems that provide sufficient detail on goals, activities, and progress of waste minimization activities; and finally,
- conduct site visits of a sample of hazardous waste generators in order to maintain quality assurance and control in waste minimization program activities.

Responses to EPA and GAO Waste Minimization Activities Surveys

Responses are not consecutively numbered because not all survey questions were included in this appendix.

1. What is the primary four-digit SIC code for this facility?

EPA	GAO
2812	2812
2813	2813
2819 (2)	2819 (2)
2833	2833
2865	2865
2869	2869
2911	2911
3313	3312
3471 (3)	3317
3573	3471
3610	3573
3621	3613
3633	3621
3674 (3)	3633
3679	3674 (3)
3711 (3)	3679 (2)
3721	3711 (2)
3822	3713
3721	
3822	

Note: Correspondence = 80%. Number of cases = 1, unless otherwise indicated in parentheses.

3. Does this facility have a waste minimization (i.e., source reduction or recycling) program in place?

	EPA	GAO
Yes	100%	96%
No	0	4

Note: Correspondence = 96%.

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4. How long has this waste minimization program been in effect (years)?

EPA	GAO
1	1
2 (4)	2 (5)
3 (6)	3
4 (4)	5
5	6 (5)
6	7 (2)
7 (2)	9
10 (2)	10 (2)
15 (2)	15 (2)
25	21
36	28
	40

Note: Correspondence = 32%. Number of cases = 1, unless otherwise indicated in parentheses.

5. During 1986, did this facility have a written policy or statement that outlines goals, objectives, and methods for waste minimization (i.e., source reduction or recycling)?

	EPA	GAO
Yes	76%	50%
No	24	50

Note: Correspondence = 72%.

6. During 1986, did management at this facility actively encourage the implementation of source reduction and recycling practices?

	EPA	GAO
Yes	100%	92%
No	0	8

Note: Correspondence = 92%.

7. From November of 1984 to January of 1987, did this facility conduct a waste minimization opportunity assessment or a waste minimization audit?

	EPA	GAO
Yes	68%	71%
No	32	29

Note: Correspondence = 76%.

8. What was the scope of this waste minimization opportunity assessment/audit?

	EPA	GAO
Facility-wide	59%	65%
Restricted to one or several processes	41	35

Note: Correspondence = 68%.

9. How often did this facility conduct waste minimization opportunity assessments/audits from November 1984 until January 1987?

	EPA	GAO
Less than once per year	29%	41%
Once per year	47	47
More than once per year	24	12

Note: Correspondence = 56%.

10. Are any employees at this facility SPECIFICALLY ASSIGNED to investigate and identify possible waste minimization practices such as modification or substitution of a raw material, reformulation or redesign of a product, modification of a process or equipment, segregation of waste streams, recycling of waste streams, or development of better operating practices, in order to reduce the volume or toxicity of the hazardous waste generated or subsequently treated, stored, or disposed of on-site?

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	EPA	GAO
Yes	52%	80%
No	48	20

Note: Correspondence = 64%.

11. From November 1984 to January 1987, were any employees at the PARENT COMPANY of your facility specifically assigned to investigate and identify possible waste minimization practices such as modification or substitution of a raw material, reformulation or redesign of a product, modification of a process or equipment, segregation of waste streams, recycling of waste streams, or development of better operating practices, in order to reduce the volume or toxicity of the hazardous waste generated or subsequently treated, stored, or disposed of on-site?

	EPA	GAO
Yes	60%	42%
No	28	46
No parent company	12	12

Note: Correspondence = 56%.

12. During 1986, did this facility have an employee training program to educate and encourage employees to practice good operating procedures and to identify to management possible source reduction and recycling practices?

	EPA	GAO
Yes	76%	56%
No	24	44

Note: Correspondence = 72%.

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13. During 1986, did this facility have an incentive (rewards) program to encourage employees to identify and develop possible source reduction and recycling practices?

	EPA	GAO
Yes	32%	32%
No	68	68

Note: Correspondence = 80%.

14. From November of 1984 to January of 1987, did this facility receive information or technical assistance on waste minimization?

	EPA	GAO
Yes	88%	84%
No	12	16

Note: Correspondence = 88%.

15. From what source(s) did this facility receive information or technical assistance on waste minimization?

Local government agencies:

	EPA	GAO
Yes	8%	12%
No	92	88

Note: Correspondence = 84%.

State government agencies:

	EPA	GAO
Yes	16%	24%
No	84	76

Note: Correspondence = 84%.

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Federal agencies:

	EPA	GAO
Yes	20%	16%
No	80	84

Note: Correspondence = 80%.

Trade associations:

	EPA	GAO
Yes	44%	48%
No	56	52

Note: Correspondence = 80%.

Suppliers/vendors:

	EPA	GAO
Yes	64%	56%
No	36	34

Note: Correspondence = 84%.

Other parts of your firm or facility:

	EPA	GAO
Yes	52%	44%
No	48	56

Note: Correspondence = 72%.

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Literature/magazines:

	EPA	GAO
Yes	76%	64%
No	24	36

Note: Correspondence = 80%.

Consulting engineers:

	EPA	GAO
Yes	24%	32%
No	76	68

Note: Correspondence = 72%.

Universities:

	EPA	GAO
Yes	16%	16%
No	84	84

Note: Correspondence = 92%.

Conferences/seminars:

	EPA	GAO
Yes	64%	64%
No	36	36

Note: Correspondence = 68%.

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Other firms:

	EPA	GAO
Yes	8%	24%
No	92	76

Note: Correspondence = 84%.

16. From November 1984 until January 1987, did this facility apply for financial assistance, loans, grants, or preferential tax treatment from the state government for the implementation of waste minimization practices?

	EPA	GAO
Yes	0%	4%
No	100	96

Note: Correspondence = 100%.

17. From November 1984 until January 1987, did this facility receive financial assistance, loans, grants, or preferential tax treatment from the state government for the implementation of waste minimization practices?

	EPA	GAO
Yes	0%	4%
No	100	96

Note: Correspondence = 96%.

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18. From November 1984 until January 1987, did this facility apply for or receive financing from the private market for the implementation of waste minimization practices?

	EPA	GAO
Yes	0%	0%
No	100	100

Note: Correspondence = 100%.

19. Were any of the hazardous wastes that were generated on-site at this facility during 1985 not generated on-site in 1986?

	EPA	GAO
Yes	52%	40%
No	48	60

Note: Correspondence = 72%.

20. Why was this hazardous waste(s) no longer generated on-site?

Similar wastes are now generated on-site, but the hazardous constituents have been removed as a result of process or equipment modification:

	EPA	GAO
Yes	16%	4%
No	84	96

Note: Correspondence = 88%.

Change or elimination of a production process:

	EPA	GAO
Yes	36%	16%
No	64	84

Note: Correspondence = 72%.

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Source reduction practices implemented:

	EPA	GAO
Yes	12%	12%
No	88	88

Note: Correspondence = 84%.

On-site or off-site recycling of waste:

	EPA	GAO
Yes	12%	16%
No	88	84

Note: Correspondence = 88%.

Purchase of exact same input or raw material from off-site:

	EPA	GAO
Yes	0%	4%
No	100	96

Note: Correspondence = 96%.

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