

US EPA ARCHIVE DOCUMENT





# PREFACE



The *Decision Maker's Guide to Solid Waste Management, Vol. II* has been developed particularly for solid waste management practitioners, such as local government officials, facility owners and operators, consultants, and regulatory agency specialists. The Guide contains technical and economic information to help these practitioners meet the daily challenges of planning, managing, and operating municipal solid waste (MSW) programs and facilities. The Guide's primary goals are to encourage reduction of waste at the source and to foster implementation of integrated solid waste management systems that are cost-effective and protect human health and the environment.

Because the infrastructure and technology for handling MSW are rapidly changing, the information presented should help decision makers consider the numerous factors associated with successful implementation of new solid waste management solutions. Readers are encouraged to carefully evaluate all of the elements in their waste-handling systems and implement source reduction, recycling, and environmentally sound disposal.

Communities are encouraged to coordinate their goals for waste reduction and management, environmental protection, community development, and employment. Communities, businesses, institutions, and individuals should apply their creativity and ingenuity in drafting policies and designing programs that prevent the generation of waste in the first place. When waste generation is unavoidable, the materials can be viewed as a resource from which reusable materials, raw feedstock, minerals, organic matter, nutrients, and energy can be recovered for beneficial uses. Residual materials requiring disposal must be carefully managed to protect human health and the environment.

We encourage all individuals involved with MSW management to expand their professional skills and to help other practitioners and community members better understand the challenges we face and the opportunities available to us. It is primarily through such cooperative enterprises that governments, communities, and businesses can make the best possible decisions for the reduction and management of municipal solid waste.



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# PREFACE (continued)

## A Note on Using This Guidebook

For a quick overview of the issues covered in each chapter, readers are encouraged to review the highlights presented at the beginning of each chapter and the margin notes appearing throughout the Guide.

## Disclaimer

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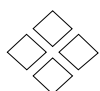
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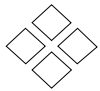
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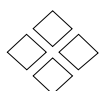
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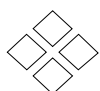
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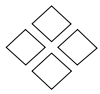
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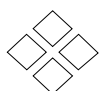
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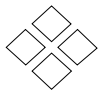
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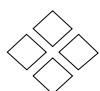
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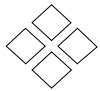
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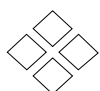
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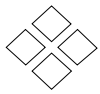
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# INTRODUCTION



Volume I of the *Decision Maker's Guide to Solid Waste Management* cites estimates by the U.S. Environmental Protection Agency (USEPA) that 160 million tons of municipal solid waste were generated in the United States in 1989. Since Volume I was published, the estimated annual generation rate has risen to nearly 195.7 million tons (see Table I-1), and it appears that America's propensity for producing waste is not diminishing.

Volume I described a better way of dealing with the growing municipal solid waste problem. That solution, called integrated solid waste management (see Figure I-1), involves a combination of techniques and programs to manage the municipal waste stream. Using the integrated approach, a community can tailor its own unique system to prevent and handle various components of the waste stream in the most economical and environmentally sound manner. In Volume I, readers were introduced to the concept of developing a community integrated waste management system.

Volume II expands the information provided in Volume I. It offers decision makers more detailed information so they can help communities successfully implement integrated solid waste management programs. This volume will assist decision makers and technical professionals who must understand the key technical, legal, economic, political, and social issues that must be addressed to develop effective waste management programs.

Volume II focuses on municipal solid waste management issues. It does not address management of other important waste types, including hazardous waste, municipal sewage sludge, or agricultural residues.



**EMERGING ISSUES**

*Technical requirements for facility siting and operating are becoming more stringent.*

*Government procurement policies are stimulating recycling markets.*

*The cost of integrated waste management programs is stimulating interest in source reduction and recycling.*

Waste management practices in the United States are continually changing. Public and private activities at the local, state, federal, and even international levels are having major impacts on community waste management programs. Following are just a few examples of emerging issues that will greatly affect waste management decision making.

Technical requirements for siting and operating waste management facilities are becoming more stringent. Federal and state laws require that landfills have engineered safeguards such as liners, leachate collection systems, gas management, and environmental monitoring. New laws require that waste-to-energy facilities have special technology for capturing emissions and that ash residues be specially managed. Standards for work place safety and working conditions are likely for waste management facilities such as recycling centers and composting operations. These new technical requirements will probably increase the cost and the public scrutiny of proposed methods for managing waste.

New state and federal guidelines requiring that governments procure products made from recycled materials are stimulating development of recycling markets. Procurement laws should spur the development of new capacity for recycling a variety of products, especially paper. Market development is expected to increase worldwide, since the sale of recyclable material constitutes a major international market, especially for communities on America's east and west coasts.

In contrast, the true cost of alternative waste collection, processing and disposal options is not yet well understood by most communities and citizens. As these costs become clearer, source reduction and recycling efforts are likely to be more attractive options. Establishing and operating successful solid waste management programs requires the existence of steady markets for recycled products, compost, and the energy produced from WTE plants. This in turn may require increasing the demand for such products. Communities may also need to consider looking for alternative funding sources to support source reduction, recycling, and other programs. How much voters and waste generators are willing to pay for integrated waste management programs has not yet been widely determined.

**Table I-1**

Municipal Solid Waste Generated in 1990 (in millions of tons)

6.7%*	Glass	13.2
6.7%	Food scraps	13.2
8.3%	Plastics	16.2
8.3%	Metals	16.2
14.6%	Rubber, leather, textiles, wood	28.6
17.9%	Yard trimmings	35.0
37.5%	Paper and paperboard	73.3
TOTAL WEIGHT:		195.7

\*Percent of total waste generated.

Source: USEPA, *Characterization of Municipal Solid Waste in the United States: 1992 Update*

Despite major uncertainties facing decision makers in the United States, there will be a continuing need to address solid waste management issues in a timely manner. Decision makers and technical professionals considering how best to manage community waste must be aware of changing conditions and emerging issues, but they should not be deterred from developing waste management projects. This volume of the *Decision Makers' Guide* will help these persons understand the issues and develop successful integrated waste management programs.

**Figure I-1**

Hierarchy of Integrated Solid Waste Management

**Source Reduction**

Source reduction tops the hierarchy because of its potential to reduce system costs, prevent pollution, consume resources, and increase efficiency. Source reduction is discussed in more detail in Chapter 5. Source reduction programs are designed to reduce both the toxic constituents in products and quantities of waste generated. Source reduction is a front-end waste avoidance approach that includes strategies such as designing and manufacturing products and packaging with minimum volume and toxic content and with longer useful life. Businesses, institutions, and citizens may also practice source reduction through selective buying and the reuse of products and materials.

**Recycling**

Recycling (including composting) is the second step in the hierarchy. It involves collecting materials, reprocessing/remanufacturing, and using the resulting products. Recycling and composting can reduce the depletion of landfill space, save energy and natural resources, provide useful products, and provide economic benefits. These options are discussed in more detail in Chapters 6 and 7.

**Waste Combustion and Landfilling**

Waste combustion and landfilling are at the bottom of the hierarchy—USEPA does not rank one of these options higher than the other, as both are viable components of an integrated system. Waste combustion, discussed in Chapter 8, reduces the bulk of municipal waste and can provide the added benefit of energy production. State-of-the-art technologies developed in recent years have greatly reduced the adverse environmental impacts associated with incineration, and although waste combustion is not risk-free, many communities are relying on this waste management alternative.

Landfilling, discussed in Chapter 9, is necessary to manage nonrecyclable and noncombustible wastes, and is the only actual waste "disposal" method. Modern landfills are more secure and have more elaborate pollution control and monitoring devices than earlier landfills. Environmental concerns at properly managed landfills are greatly reduced. Also, many new landfills are using methane recovery technologies to develop a marketable product.

Source: USEPA

EPA's hierarchy of integrated solid waste management includes:

- Source reduction
- Recycling
- Waste combustion and landfilling.

**REFERENCES**

- USEPA. 1992. *Characterization of Municipal Solid Waste in the United States: 1992 Update*. Washington, D.C. EPA/530-R-92-019 (July).
- USEPA. 1989. *Decision Makers Guide to Solid Waste Management*. Washington D.C. EPA/530 SW-89-072 (November).

