POLLUTION
PREVENTION

Solid Waste Reduction: Alternatives For North Carolina

POLLUTION PREVENTION PAYS PROGRAM
NORTH CAROLINA DEPARTMENT OF NATURAL RESOURCES AND COMMUNITY DEVELOPMENT

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SOLID WASTE REDUCTION:

ALTERNATIVES FOR NORTH CAROLINA

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October 1988

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This project was funded by the Pollution Prevention Program,
N.C. Department of Natural Resources and Community Development

THE POLLUTION PREVENTION PROGRAM

The Pollution Prevention Program provides free technical assistance to North Carolina industries and municipalities on ways to reduce, recycle and prevent wastes before they become pollutants. This non-regulatory program, located in the Division of Environmental Management, addresses water and air quality, toxic materials, and solid and hazardous waste. Designated as the lead agency in waste reduction, the Program works in cooperation with the Solid and Hazardous Waste Management Branch and the Governor's Waste Management Board. The services and assistance available fall into the following categories:

Information Clearinghouse. An information data base provides access to literature sources, contacts, and case studies on waste reduction techniques for specific industries or waste streams. Information is also available through customized computer literature searches. Waste reduction reports published by the Program are also available.

Specific Information Packages. The staff can prepare facility or waste-stream-specific waste reduction reports for industries and communities. Information provided by the facility is used to identify cost-effective waste reduction options. A short report detailing these options is provided along with references, case studies, and contacts.

On-site Technical Assistance. The staff can provide comprehensive technical assistance through facility visits. During an on-site visit, detailed process and waste stream information is collected. The information is analyzed, and a series of waste reduction options are identified. A report is prepared detailing these options and includes literature, contacts, case studies, and vendor information.

Outreach. The staff can give presentations on pollution prevention to industries, trade associations, professional organizations, and citizen groups. Depending on the audience, these programs range from an overview of the State's Pollution Prevention Program to in-depth discussions of technologies for specific industries.

Challenge Grants. A matching grant program provides funds for the cost of personnel, materials, or consultants needed to undertake pollution prevention projects. Projects eligible for grant funds range from characterizing waste streams in order to identify pollution reduction techniques to conducting in-plant and pilot-scale studies of reduction technologies.

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ACKNOWLEDGEMENTS

This publication was prepared under a Research and Education grant from the North Carolina Pollution Prevention Program, directed by Roger Schecter, in the Department of Natural Resources and Community Development.

We would like to express our sincere appreciation to six individuals who gave of their valuable time to serve on the advisory committee for this project: Betsy Dorn, Mecklenburg County Engineering Department; Terry Dover, N.C. Solid Waste Management Section; Gary Hunt, Pollution Prevention Program; Sandi Maurer, Land of Sky Regional Council; Ernest Perry, Alamance County Health Department; and Cary Saul, Mecklenburg County Engineering Department. For their many hours spent reviewing materials, sitting in advisory committee meetings, and en route to and from meetings, we are truly indebted.

We would also like to express our gratitude to Terry Keating, a masters student at UNC-CH in the Department of Environmental Sciences and Engineering, for his contributions to the project as a whole, but particularly in the area of regional solid waste management.

A word of thanks is due Roger Schecter, director of PPP; David Kirkpatrick, the director of Sun Shares; Ed Regan of the North Carolina Association of County Commissioners, and Environmental Resource Project staff members, Frances Lynn and Melva Okun for agreeing to review the final draft of the manual and providing valuable input. We are grateful to those individuals and all the other individuals across the state who have willingly shared their expertise and experiences with us.

As with most research efforts, it is difficult to capture on paper the knowledge gained and the increased enlightenment this project has given us on the intricacies of waste reduction. If this subject is new to you, as it once was to us, we hope you will incorporate the ideas that are presented here not only in your work, but in your daily living. Waste reduction is not so much a procedure as it is an attitude. We challenge you to set an example for others around you and to continue to strive toward a renewed vision of a waste conscious society.

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PREFACE

In the face of the current solid waste management crunch, some public officials have chosen to address the dilemma by imposing mandatory source separation legislation in their communities, while others have instituted bans on packaging or have taken strict measures to limit disposal options. Some have chosen to do nothing. In any case, the current state of affairs has reinforced in the majority of us that solid waste management is no longer an "out of sight, out of mind" practice.

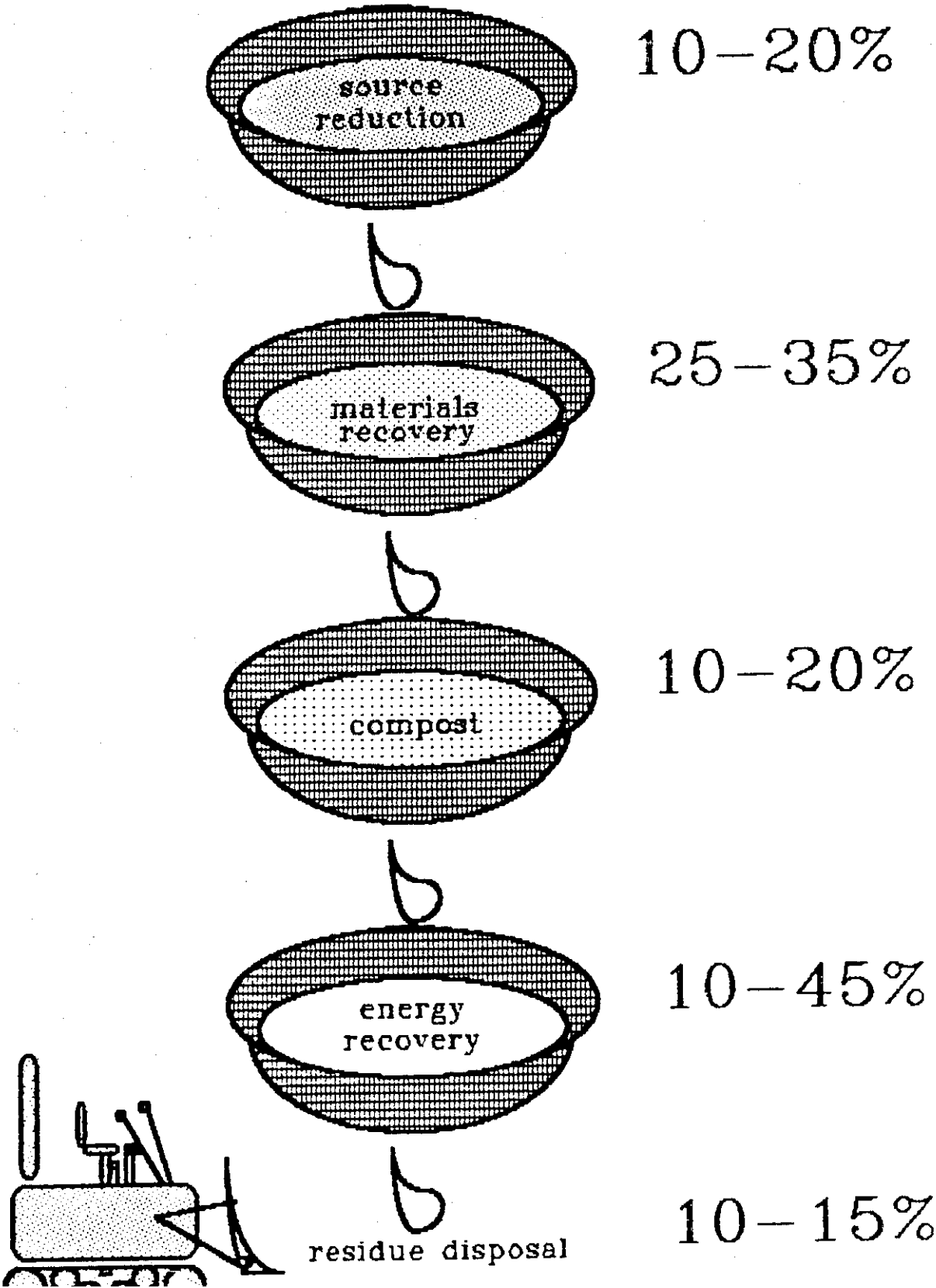
While increasing attention is being given to the solid waste issue at the state and federal levels, no simple solution exists. Selecting the right pieces of available program options and putting them together in the right proportions at the right time, is a move toward developing a waste reduction program that meets the needs of the community.

This manual is based upon the concept of integrated solid waste management. Integrated solid waste management is a conscious effort to adhere to a step-by-step approach for managing solid waste through a multi-level hierarchy. The hierarchy is characterized by five main elements:

- **REDUCTION** of the waste stream at the source of generation
- **RECYCLING** of goods and materials
- **COMPOSTING** of the organic component of the waste stream
- **ENERGY RECOVERY** of the heat value of the remaining waste
- **SAFE DISPOSAL** of the residues remaining after the other steps are taken: ash and non recoverable materials

Each level of this hierarchy represents a management strategy which aims at reducing waste volumes and toxicity to the maximum extent before moving on to the next level (see Figure 1). When incorporated on the appropriate scale, each management strategy has the ability to significantly decrease the dependence on the least desirable management option, i.e., landfilling.

Figure 1: Integrated Waste Management Hierarchy



According to Sheila Prindiville (1987) of the National Solid Waste Management Association (NSWMA), there is "no single way to rid us of our waste." Commonly held beliefs are:

- If we have a landfill we don't need to worry.
- If we have an incinerator we don't have to worry.
- If we have recycling we don't need either one.

THERE IS NO SINGLE ANSWER. All are tools in integrated solid waste management. The current situation provides a unique opportunity to step out of a cycle of short term decisions, and develop a systematic and economical approach. Development of such an approach must begin by identifying what the various waste streams are and how much each contributes to the total; defining the goals of solid waste reduction, and comparing ways of realizing those goals; and developing and implementing a program to achieve specific and measurable results.

Only a handful of counties in North Carolina have begun serious long range planning for solid waste management. Many county officials and staff people are looking for answers to the numerous questions that arise when they realize that landfilling is rapidly becoming costly and unavailable. This manual was written to address these issues, and to enable local and county officials to know their options and make wise decisions among them. Specific issues include:

- How does my county begin planning? What should be included in a waste reduction plan? Where can we get technical help?
- What role is the state playing? How could the state take more of the responsibility in initiating the process? What are other states doing?
- What are the components of a waste reduction plan? How can a program be established for my county or community?
- How can a program make the most of limited resources? Is hiring a consultant the best first step?
- Are there ways to reduce the amount of waste generated in the first place, instead of trying to figure out what to do with it after it is already generated?
- What are the options for separating out recyclables? How well do they work, how much do they cost, and which are best for this particular community?
- What are the technological options for centralized facilities to extract resources from the waste? What are the pros and cons of each?

- How should facilities be sized? Is it better to join forces with other neighboring governments, or go it alone? What are the advantages and disadvantages of regional solid waste management?

- Where do we begin?

If any or all of these questions prevent your community or county from moving on to the next step in achieving local solid waste reduction goals, perhaps it is because this is a new way of looking at an age-old problem. The practice of putting waste "out of sight" and "out of mind" is not realistic anymore.

It was our intention in producing this manual to provide enough background information and evaluative tools so that local government officials could actually begin the process of establishing a solid waste reduction program, and develop it to the point that it is producing useful results. We hope that it will be helpful to you, and we welcome responses or further inquiries from those who use it.

I

THE NEED FOR SOLID WASTE REDUCTION

I

NEED FOR SOLID WASTE REDUCTION

Americans produce some 150 million tons of municipal solid waste each year - approximately 3.4 pounds per person per day in 1986, with current projections of an increase to 4 pounds per person per day by the year 2000. Of the 150 million tons, an estimated 11 percent was recycled in 1986, 6 percent was incinerated with energy recovery, another 3 percent was incinerated without energy recovery, and the remaining 80 percent ended up in landfills (1).

In the opinion of Sheila Prindiville, director of solid waste programs for the National Solid Waste Management Association (NSWMA), any community which relies heavily on a landfill with a projected capacity of less than five years remaining is facing a crisis. It has been estimated that half of the landfills in the country will reach their capacity in the 1990s (2).

SOLID WASTE PROBLEMS IN NORTH CAROLINA

Many North Carolina localities are running out of landfill capacity for disposing of solid waste (see Table I.). It is estimated that 43 counties in the state will be out of landfill space and faced with a solid waste disposal crisis within the next five years.

Table I:

State's most crowded landfills

County	Date opened	Total acres	Acres remaining	Maximum remaining life (years)	Extend by * mounding?
Alamance	1979	165	0	1	yes
Cherokee	1972	16	4	2	yes
Franklin	1984	45	15	1	yes
Graham	1974	15	0	1	yes
Haywood	1982	20	0	1	yes
Macon	1975	10	0	1	yes
(two sites)	1975	10	0	1	yes
Mecklenburg	1972	105	45	2	no
Rowan	1978	48	4	2	no
Transylvania	1975	12	0	1	yes
Vance	1974	64	25	2	no
Wilkes	1972	32	2	2	yes

* Mounding can extend landfill capacity by piling garbage above the ground surface.

Source: N.C. Solid and Hazardous Waste Management Branch

As existing landfills run out of space, and suitable sites for future landfills become harder to find due to public opposition and changing emphasis on land use, local governments are being forced into re-thinking their approaches to solid waste management. One option which is initially attractive is to replace existing sanitary landfills with high technology landfills and incinerators. Smaller counties with small budgets will quickly be overwhelmed by these options, however, since both are orders of magnitude more expensive in terms of capital expenditures, operation and maintenance costs and the threat of long-term liability.

WASTE REDUCTION

One option to reduce dependence on landfilling in the face of increasing costs is planning and implementing a comprehensive, integrated system with a strong emphasis on waste reduction and recycling. A recycling facility which recovers 80 tons of materials per day will save landfill space ranging from roughly 64,000 to 117,000 cubic yards per year based on a conversion factor of 2.2 to 4.0 cubic yards of space per ton of landfilled waste (3). Taking the average density of 3.1 cubic yards per ton of landfilled waste, this 80 ton per day facility could save the equivalent of about 56 acres of landfill space to a depth of one foot (56 acre-feet) in the course of the first year.

This can mean different things to localities responsible for solid waste management in terms of cost savings, depending on the factors involved in assessing the cost of the landfill. In parts of the state where landfill fees are high, the avoidance of landfill expense alone often justifies recovery of recyclable materials. Even where costs are currently low, the future or replacement cost of the landfill space must be taken into consideration.

FEDERAL GOALS AND OBJECTIVES

The Resource Conservation and Recovery Act (RCRA) of 1976, as amended in 1980 and 1984, is the federal legislative basis for the regulation of solid waste management. RCRA was intended to protect public health and the environment by preventing contamination for solid and hazardous wastes. The stated objective of Subtitle D of RCRA is to encourage and assist with the development of solid waste management practices "which are environmentally sound and which maximize the utilization of valuable resources" from the waste stream including materials and energy, and to encourage the conservation of resources (4).

For roughly 11 years, EPA has given relatively little attention to the issue of non-hazardous solid waste management, except for prolonged attempts at writing new landfill and incinerator regulations. Recently, EPA has begun to recognize the magnitude of the issue, and in February 1988 announced the formation of a new Municipal Solid Waste Management Task Force to assess the current situation in solid waste management and to come up with a national strategy (see Appendix B). The task force intends to take a comprehensive perspective in developing their strategy, with special focus on such areas as:

- causes underlying solid waste management problems including health and environmental impacts, landfill capacity and public perception;
- adequacy of current approaches;
- appropriate division of responsibility between federal, state and local officials;
- potential federal regulatory direction;
- international, state and municipal programs;
- potential for:
  1) source reduction
  2) recycling
  3) waste treatment
  4) incineration/energy recovery
  5) landfilling
- ongoing and needed research; and
- marketing of recovered materials.

In a letter sent to all state and territorial environmental commissioners, EPA has publicly stated the importance of renewing efforts toward developing solid waste management strategies (5). The letter encourages states to update state solid waste management plans, and mentions the following areas in which states should concentrate their efforts:

- identification of current and projected quantities and sources of solid waste generated in the state;
- identification of projected roles of source reduction, recycling, incineration/energy recovery, landfilling and/or other management approaches;
- summaries of regulatory and permitting requirements; and
- indication of role in solid waste planning to be played by public and political subdivisions of the state;

NORTH CAROLINA LEGISLATION AND PLANNING

Solid waste management in North Carolina is governed by the North Carolina General Statutes, Article 9: 130A-290, which deals almost exclusively with hazardous waste. This Chapter does, however, require the Department of Human Resources (DHR) to maintain an administrative unit and sufficient personnel to manage the state's solid waste program effectively. The Act also assigns to DHR monitoring and supervisory responsibilities over local governments. Further, it states that local governments are to manage solid waste from a specified geographical region at a permitted facility, "in accordance with a solid waste management plan" for that region.

The same act gives to local governments the authority to regulate where waste collected in the jurisdictional or designated geographical area is taken. This **flow control authority** is granted provided that such control does not hinder source separation or recycling of materials. The act also allows units of government to displace private competition for solid waste management and disposal services. Other specific areas covered in the Act include:

- standards for qualification of recycling facilities or equipment for tax purposes;

- authorization of a permit system (the N.C. Solid Waste Management Section requires a state permit from the Department of Human Resources for any solid waste treatment and/or processing facility);

- delegation of solid waste management program authority to local governments;

- granting of rule-making authority for solid waste to the Health Services Commission, and enforcement responsibilities to DHR; and

- administration of the hazardous waste management program.

The Solid Waste Management Act gives DHR the authority to "engage in research, conduct investigations and surveys, make inspections and establish a statewide solid waste management program." The department was given authority to establish a comprehensive program, and to work with other state agencies, local government units, the federal government, industry and individuals to carry it out. In order to accomplish these tasks the Health Services Commission established the N.C. Solid and Hazardous Waste Management Branch, which became the Solid Waste Management Section in early 1988.

North Carolina DHR adopted its current Solid Waste Management Plan in 1981. Under this plan, upon request by the affected unit or units of local government, DHR can designate a geographic region in which solid waste is to be managed in accordance with a plan for that region. The elements of such plans are to include:

- existing and projected population;

- quantities of solid waste generated;

- availability of landfill sites;

- environmental impact of continued landfilling in area;

- method of solid waste disposal to be utilized;

- materials/energy to be recovered from the waste; and

- any other data DHR may require.

Annual reports of implementation of the solid waste management plan for each geographic region are to be filed with DHR.

A Memorandum of Agreement between DHR and the NC Department of Natural Resources and Community Development (NRCD) in June 1987 set a goal of 90 percent reduction in both the volume and toxicity of landfilled waste over the next 18 years (6). One of the ways in which the Solid Waste Management Section intends to encourage that goal is to revise the 1981 state solid waste plan. Such revisions are expected to take place in 1989 and will include requirements for local planning with emphasis on solid waste reduction strategies (7).

LOCAL POLICY OPTIONS TO PROMOTE SOLID WASTE REDUCTION

Setting up a waste reduction program that is right for a given locality is no easy task, but will require a level of commitment in terms of program cost and personal and political commitment that is proportional to the amount of waste to be reduced.

It may be wise to evaluate the feasibility of achieving some degree of solid waste reduction through policy strategies before implementing technological solutions. Among the local policy options which have achieved some level of successful waste reduction across the country are:

- Mandatory Provision of Services: Local governments can set requirements and guidelines for each municipality to develop services for voluntary participation by citizens, such as curbside recyclables pickup. This can include a "hammer" clause that will impose mandatory source separation if satisfactory results are not achieved by voluntary separation.

- Mandatory Source Separation: Ordinances requiring citizens to separate recyclables (specified in the ordinance or left to the discretion of municipalities) from residential and commercial waste streams can be established. Materials are selected based on those which will result in the desired level of reduction. To be most effective, such ordinances require some type of incentive or penalty (for example, a fine or refusal of service).

- Landfill Disposal Bans: Usually targeted at **easily recyclable materials** (leaves, paper, corrugated cardboard, glass, aluminum, some plastics); or **problem waste types** (lead acid batteries, waste oil, household hazardous waste, some plastics, tires). Bans can be a very effective mechanism for reducing the waste stream and increasing material recovery rates, but in order to work, they must be accompanied by **alternative programs for the banned waste.** Monitoring and enforcement are essential.

- Disposal Fee Adjustments: Increases in **landfill tipping fees**, for example, can have the double benefit of reducing the waste stream and providing additional revenues to run the waste reduction program. This type of program should include

  1) a schedule of rate increases,

  2) special (higher) rates for high volume waste for which there exist alternatives to landfilling,

  3) special (higher) rates for problem waste types, and

  4) waivers of tipping fees or special (lower) rates for customers who remove recyclable materials from the waste. Enforcement programs are also essential, especially in rural areas to prevent increases in illegal dumping in response to the higher fees.

- Flow Control Ordinances: can direct the flow of waste within a local government's jurisdiction. Flow control can be advantageous, for instance in routing waste of the proper composition to facilities for resource recovery. Flow control ordinances can also require materials recovery prior to energy recovery or landfilling.

- Litter Taxes: are a good alternative to beverage container deposit legislation ("bottle bills") for reducing roadside littering of problem waste types, and for funding clean-up and waste reduction programs. These taxes are imposed on certain types of waste that are frequently discarded as litter, and have the effect of incorporating some of the cost of disposing of these materials into the consumer price.

- Tax Exemptions: Usually in the form of property tax exemptions, these can serve as an economic development tool to provide incentives for entrepreneurial development of the recycling market. Any tax exemptions must spell out clearly what types of industries qualify.

- Procurement Policies: County or municipal guidelines can require use of recyclable materials in all government operations and by private contractors to the government. Provisions can include specifying the percent of purchased materials which must be recycled, if such an option is available. This very important aspect of waste reduction helps to expand the market for recycled materials. Some recycled materials will be more expensive at first than non-recycled counterparts, but this margin will begin to close as the market for recyclable products develops. The increased purchase cost can be justified in part by saved disposal costs and by the opportunity cost of the virgin materials that are conserved in using the secondary materials. Examples of materials which can be included in procurement specifications are:

    1) **Paper** - purchases to include a specified percentage of recycled paper, with scheduled increases;

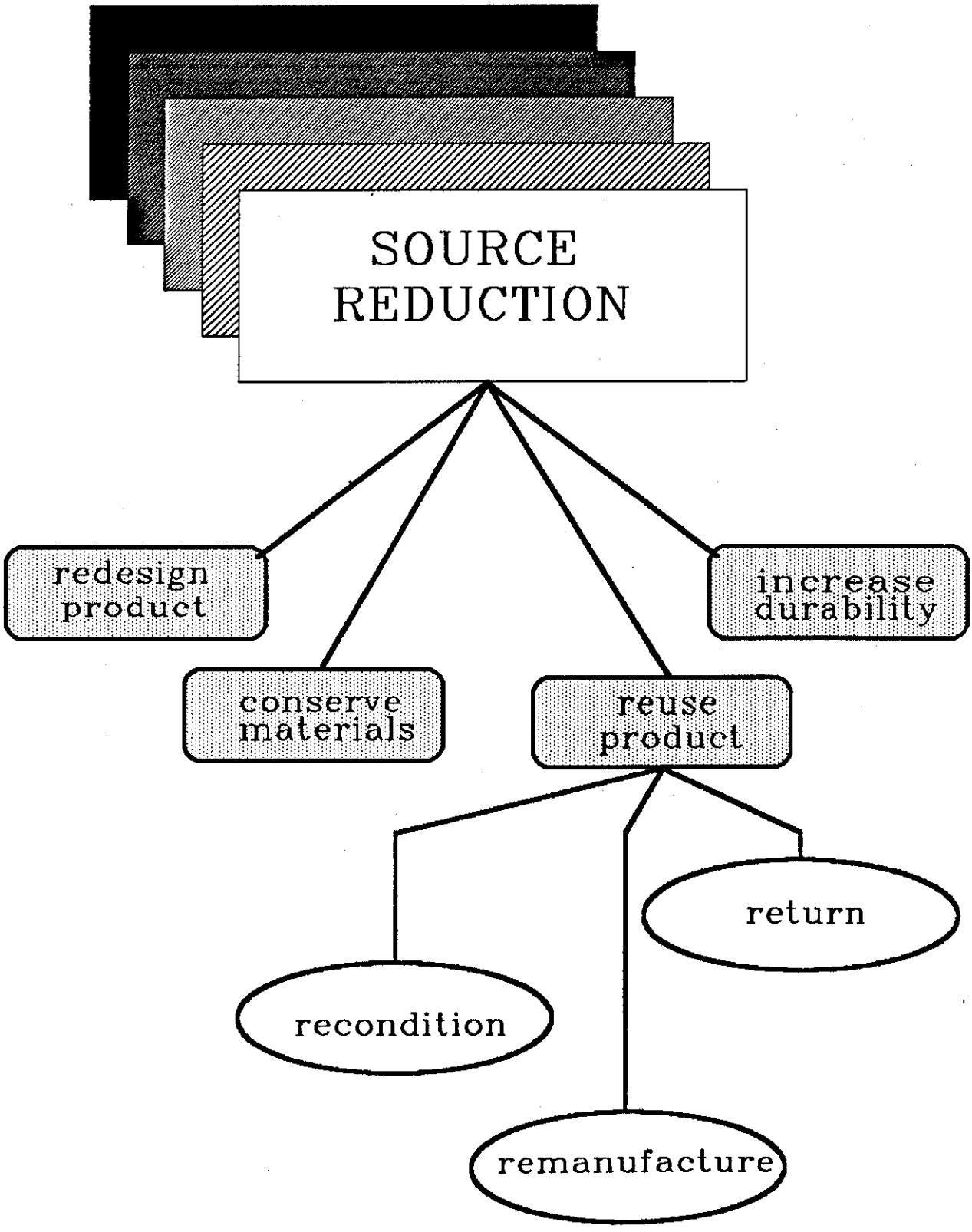
    2) **Road construction and repair** materials, to include recycled asphalt, crumb rubber and ash when available;

    3) **Roadside maintenance** materials to include wood waste mulch, compost, and co-composted sludge for soil conditioners and fertilizers.

No single policy method for waste reduction can be implemented without studying the needs of the locality and the most appropriate and effective way to achieve waste reduction. However, much can be learned from the experiences of others. Selecting appropriate components of a program based upon those which have worked under similar conditions can be a good first step.

The following chapters are intended to provide enough detailed information to allow decisionmakers to evaluate their service areas to determine which waste reduction options (policy or technology) or which mix of options best suits their needs.

II


SOURCE REDUCTION
redesign product
conserve materials
reuse product
increase durability
return
recondition
remanufacture

II

REDUCTION OF WASTE STREAM AT THE SOURCE

Source reduction is a term applied to strategies that reduce the amount of waste before it enters the waste stream. The aim of source reduction is to minimize the total amount of waste discharged, and at the same time, minimize the problems associated with the waste from both volume and toxicity standpoints. Source reduction reduces the need to rely strictly on technological waste treatment or disposal options, and shifts the focus to preventing waste generation and thus avoiding the amounts and types of waste which can cause environmental and other management problems. Approximately 10% of the waste stream can be reduced through source reduction (8).

THE NEED FOR SOURCE REDUCTION

Current estimates indicate that about 35% of the country's waste volume (almost 50% by weight) comes from packaging (9). The packaging industry produces about $28 billion worth of packaging materials each year. Consumers spend an additional $4 billion each year to dispose of these packages.

Plastic is often the "culprit" in excess packaging. Of the 1.9 million tons of plastic used in packaging each year, more than half is in the form of plastic film used for plastic bags and wrapping. Plastic packaging materials are usually very slow to degrade, and have been blamed for killing sea life either through ingestion or by animals becoming physically trapped in packaging materials such as six-pack rings (10). Legislation in some states has banned the use of plastic six pack rings for this very reason.

One major problem with management of the modern waste stream is the increasing use of disposable packaging and products. Disposable lighters, pens, razors, and other similar household items have become increasingly common items which are produced, consumed and tossed away with little thought of the problems associated with their disposal or of the waste generated during their production. Waste stream components for which there are no good means of managing once they have already entered the waste stream are prime targets for source reduction measures.

About 7% by weight of the waste stream is made up of plastics. If these are non-degrading plastics, they persist for long periods of time in landfills; if burned, they may contribute to the formation of toxic emissions. Prior to 1975, refillable glass bottles dominated the market for beverage containers: bottles require only rinsing to prepare for refilling, and are designed for 30 cycles of reuse. However, disposable plastic soft drink bottles made of polyethylene terepthalate (PET) have taken over a substantial and increasing portion of the market due to lower production costs. While PET bottles can be recycled, adequate market development has not yet been developed to fully utilize the recovered material.

The replacement of cloth diapers with disposable diapers is perhaps the epitome of the "throw-away society" in which we live: the old style cotton diapers (even with the convenience of home diaper services) are more economical. Yet, approximately 5 million tons of disposable diapers are landfilled annually, representing about 2% of the waste stream and costing consumers at least $1 billion to dispose of them in landfills where it will take an estimated 500 years for them to decompose. In comparison, it takes only 1 to 6 months for cloth diapers to decompose (11). For every dollar spent by consumers on disposable diapers, there is a hidden disposal cost of 33 cents (12). New disposable diapers made from materials which allow them to degrade much more rapidly are now beginning to come on the market.

BARRIERS TO SOURCE REDUCTION

It may seem obvious that source reduction is the first line of approach toward reducing waste, and thus avoiding the social and economic costs associated with waste generation. There are, however, a number of barriers to source reduction:

1. **Lack of information** regarding composition of products and the impact various components have on waste management are common occurrences;

2. **Political and administrative inertia** are often difficult to overcome, due to characteristic human comfort with the status quo; and

3. **Product marketing strategies** may be prioritized over waste reduction strategies, particularly in packaging, when esthetics and convenience are often the "selling features" of a given product.

Source reduction can best be accomplished through education, market pressure, and legislation (13). Some source reduction measures are probably most effectively implemented at the federal level. However, state, regional and local governments can also take some steps and save money by doing so; and federal initiatives often happen only under pressure from state and local constituencies.

Local decisionmakers must determine which of the following mechanisms for encouraging source reduction can be accomplished locally. For source reduction activities that are not immediately feasible, due to either budget or political constraints, the most appropriate action that can be taken is for the locality to support the implementation of state and federal level initiatives.

ACHIEVING SOURCE REDUCTION

EPA has begun to set an example by developing a source reduction program at the federal level. For example, EPA is emphasizing the removal of sources of toxic metals, such as lead and cadmium, which can cause management problems. Product labeling is being considered in some areas to warn consumers of the impacts that products will have when discarded.

EPA has also begun to assess the usefulness of encouraging packaging practices that would require recyclability, or increasing product prices to reflect the true cost of disposal of unrecyclable materials (14).

Voluntary initiatives by industry and/or consumers are other ways in which significant portions of the waste stream can be eliminated through source reduction (15). Examples include:

- reduce resource use in products and packaging: reduces not only the quantity of material to be managed as a waste, but also the materials and energy requirements for goods production, and hence cost to the consumer;
- increasing product lifetime: results in a decrease in replacement purchases, applicable primarily to durable goods;
- encouraging product reuse: involves switching from single use to multiple use products or packaging. Returnable beverage containers and reusable shipping containers are some examples; and

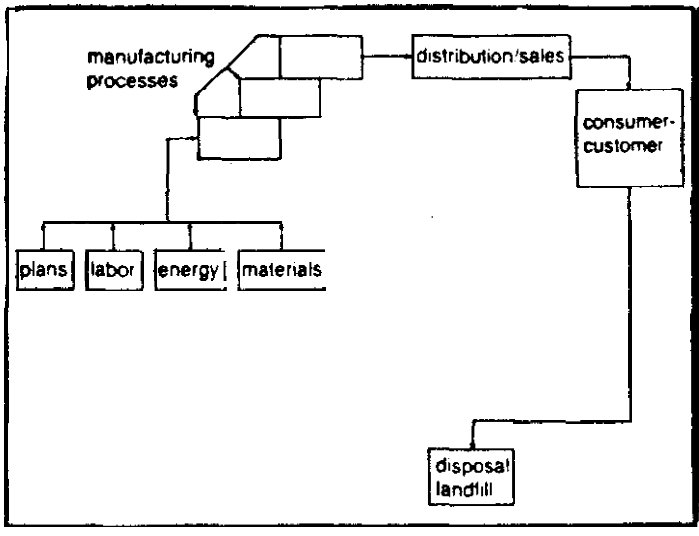
- o decreasing consumption: involves changing habits of individuals, government agencies and businesses to begin to pay closer attention to their use patterns and to product and packaging design.

PRODUCT REDESIGN

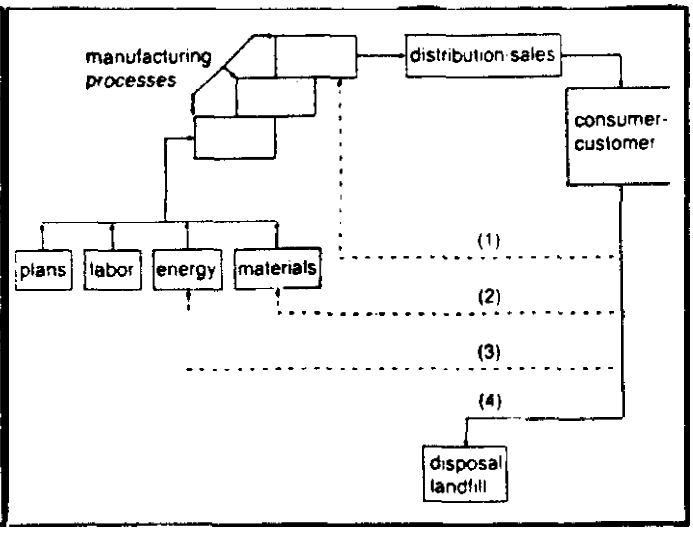
For those products that cannot be kept from entering production and consumption cycles, the waste reduction emphasis is in designing and producing them. Most products when designed must meet certain standards, including performance, safety, aesthetics, marketability and profitability criteria (16). One of the main obstacles to cost effective solid waste management is the failure to incorporate recyclability (or alternatively, degradability) into the planning and design of products. Designers must learn to assume responsibility for specifying the reuse, recycling or disposal process for products, thereby facilitating waste reduction and efficient product management throughout product life cycles (see Figure 3).

Fig.3: Product Cycles (FROM HARTMAN, 1986)

a. open cycle



b. closed cycle



Based on Figure 3 in the above diagram, products can have a low (3), medium (2) or high (1) value reuse option, all of which are of greater value than landfill disposal (4). The following key questions, if answered by the designers before products are developed, could result in a closed product cycle, which is more conserving of energy and resources:

- What would likely happen to the product after its useful life?
- What are the likely environmental impacts of the product?
- How might it be reused, and where (in the above scheme) would its reuse take it?
- What design changes could be incorporated to raise its reuse value without harm to its primary use?
- What are the optimum secondary markets?
- What is the anticipated cost of design modifications necessary to allow it to enter its optimum secondary market?

With these types of questions addressed, standards for product durability, reusability, recyclability, and degradability can be factored into product designs as automatically as those for safety or consumer appeal are now. The cost of this design modification is calculable and can be measured against the present cost of product disposal - a cost usually borne by the consumer as taxpayer or user of disposal services.

It is likely that most consumers would be willing to pay these costs up front in the form of product price increases in order to avoid the rising waste disposal costs which are not currently included. This is evidenced by a survey in which 82% of those polled indicated that recycling is extremely important to them, and that for 41% of the respondents, the recyclability of a product enters into the decision to buy one product over another (17). Note that in some communities the costs of waste disposal are a rapidly rising component of taxes and user fees.

The question remains; how best to begin bringing about these changes? Obviously product design is dependent to some degree on the cooperation of the design, production and marketing industries. To achieve source reduction through product design involves commitment to change by three basic groups: consumers, industry and legislators.

- Consumer changes- not sufficient by themselves - involve individual changes in product choice.
- Industry changes- provide consumer awareness, and can involve changes influenced by consumers or brought about by government pressure. The outcome is dependent on economics and the degree of commitment by all involved parties. It is also difficult to predict.
- Legislative changes- would provide for regulatory control authority or incentives through mechanisms implementable at the local government level, such as bans, taxes, and/or mandatory participation.

Considering the growing volume of these problem products, source reduction must be incorporated as a first line of attack in an integrated waste management program. Source reduction and packaging and product redesign are the cutting edge in the future of solid waste management, as these changes hold the greatest promise for waste reduction (18).

Though some of these methods seem far off in their observable effect, and may not provide solutions to immediately urgent problems, if they are not incorporated into an overall waste reduction program, the true costs of disposal will never be equitably distributed. Those who are ultimately responsible for waste disposal (i.e., local governments and their taxpayers' monies) will continue to subsidize profitable but costly and wasteful patterns of production.

PRODUCT REUSE

At the other end of the spectrum of source reduction techniques are programs for increasing product reuse. Many items that are sent to the landfill for disposal are still usable and product reuse is a program that can be implemented with relative ease.

This approach requires switching from single use products or packaging to multiple use items. Returnable bottles that can be washed and refilled are just one example. Reusable bottles not only save landfill space, but they represent an enormous savings in energy. With the energy required to manufacture one new 16 ounce soft drink bottle, one can make and refill three soft drink bottles ten times. (19). Reusable shipping crates or other packaging containers are another method to avoid solid waste generation.

Upgrading

Some techniques for reusing discarded or unwanted items require an investment of labor to get them there. These upgrading techniques- listed in order of the complexity of skill required- include reconditioning items to a more desirable state, repairing or rebuilding goods, and remanufacturing.

Both low-income individuals and charitable organizations or civic groups can promote product reuse by repairing items so they can be reused. These programs not only play a very valuable role in reducing solid waste, but they also provide job opportunities for the elderly, the physically impaired, and others who need work.

Not surprisingly, education plays a key role in product reuse. In convincing buyers to purchase reusable packaging, boxes or containers, reconditioned auto parts and appliances, and other reusable items, marketing is an important element in any reuse program. Local governments often team up with area civic organizations to encourage product reuse by targeting certain items at their point of entry into the waste stream and establishing special programs to divert those "wastes" from the landfill.

Exchanges

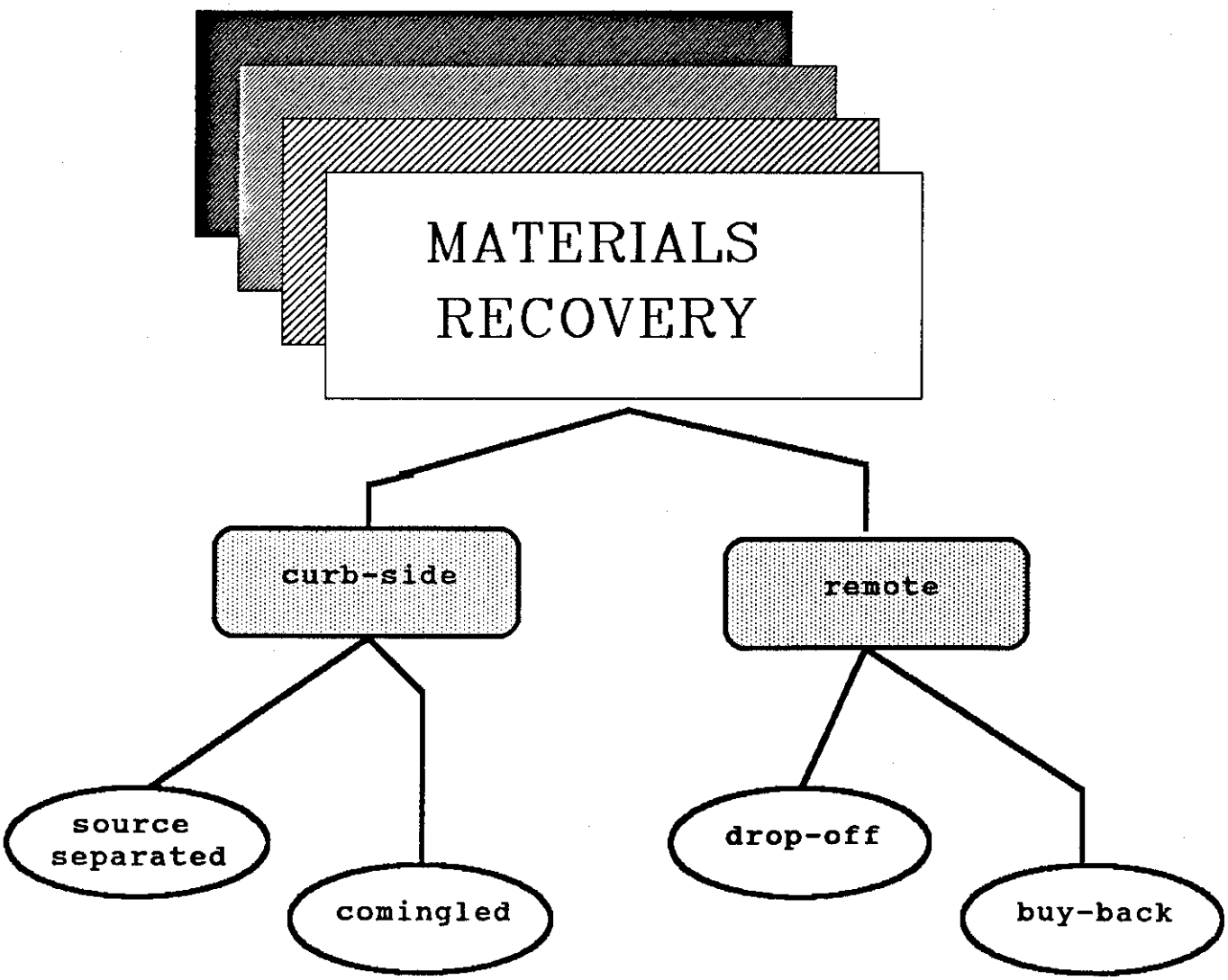
The reuse of materials is often facilitated by organizations which publish listings of industrial and commercial waste materials that are available or in demand. These materials represent potential high quality, low cost inputs for other uses. Such listings are published by approximately thirty organizations across the country, including the **Southeast Waste Exchange** administered by the Urban Institute of the University of North Carolina at Charlotte (see Appendix B for more information).

Another type of reuse program is exemplified by the city of Santa Monica, California's free paint exchange. Founded in January 1987, the paint exchange program allows city residents, businesses, schools, community groups, churches, and contractors to drop off usable paint that is no longer

wanted. Nearly all types of paint products are accepted - paint thinners, furniture stains, etc.- but other household hazardous waste is not.

With an active publicity campaign, more than 2,500 gallon containers of paint were collected during a 15 month period. Approximately 1,000 gallons of oil-based paint have been processed for use as fuel for a cement kiln; and 600 gallons of the free paint have been exchanged and used by residents themselves. As a service to the city, a local paint company reprocessed over 500 gallons of the extra latex paint that was used for a city "graffiti paint out." The program is run by the city Solid Waste Management Office (20).

III


MATERIALS
RECOVERY
curb-side
remote
source
separated
comingled
drop-off
buy-back

III

MATERIALS RECOVERY: RECYCLING

MATERIALS RECOVERY - any process of obtaining from the waste stream, either pre-segregated or otherwise, materials that still have useful physical or chemical properties after serving their intended use.

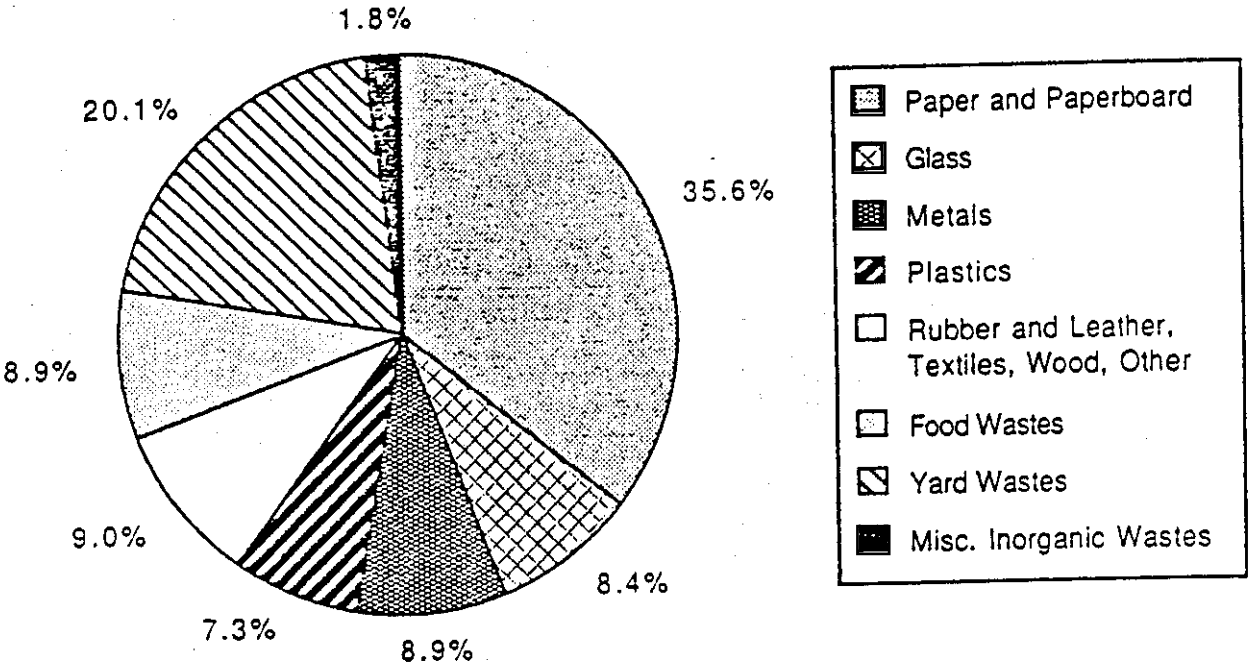
Recycling has been given a great deal of attention in some states and in many municipalities, but it has not yet been practiced in this country to the extent it is in many other countries. Japan has achieved a 50 percent rate of recycling, while the most successful state program so far in the United States (in terms of reported percent of waste stream being recycled) allows Oregon to recycle about 20 percent of its waste (21).

Though this and higher levels have been targeted in some areas, it will be no easy task to obtain such a goal nationwide. The states of Rhode Island, New Jersey, and Massachusetts have already adopted a recycling goal of 25 percent. The state of New York and the cities of Philadelphia (PA) and Berkeley (CA) have all set a goal of 50 percent recycling. North Carolina's most aggressive recycling program, in Mecklenburg County, has set as a goal a 15% reduction by the year 1990, and 30% by 1994.

TARGETING WASTE REDUCTION

Certain components of the waste stream are easier and less costly to remove than others. The ease with which those components can be removed and recycled depends largely upon the percent of the total volume that each of these major recyclable components represents. In order to determine the amounts of each of those components, a **waste stream characterization** is needed. Once a waste stream characterization has been satisfactorily conducted, priorities can be set for targeting each waste stream component which is present in a given locality's waste stream. Components which are typically found in the "average" American waste stream can be seen in Figure 4.

Figure 4: Gross Discards of Municipal Solid Waste Materials



(Franklin and Associates, 1986)

This data is from the generalized municipal waste stream, which is primarily residential with some commercial, institutional and light industrial. It is important not to rely too heavily on these generalized numbers for a particular locality, as many factors can influence the composition of the local solid waste stream. Percentages can vary so much that these estimates are useless (see discussion in the implementation chapter, and Appendix B for more complete information). This figure is helpful, however, to give a point of reference for further discussion. Though emphasis may vary from one program to the next, the following materials are those that generally make up a substantial portion of the recyclable waste stream, and should therefore receive primary attention **(22)**.

PAPER PRODUCTS

It is estimated that producing one ton of paper from discarded paper uses half the energy, half the water, results in 74 percent less air pollution, 35 percent less water pollution, and saves 17 pulp trees. This also creates five times more jobs than producing one ton of paper from virgin materials and reduces the amount of waste requiring disposal **(23)**.

The United States leads the world in paper consumption per person and trails far behind in recycling. Each year our country uses 67 million tons of paper, or 580 pounds per person. It is estimated that about 41 percent of the solid waste stream today is made up of paper products, increasing to about 45 percent by the year 2000 (see Fig. 3). Roughly 22% of the paper consumed in the United States is recycled **(24)**; six percent of office and writing paper is made from recycled fiber.

For comparison, here is the annual paper consumption per person and the national paper recycling rate for selected countries:

Table II: Paper Consumption and Recycling Rates

Country	pounds per person	percent recycled
Japan	326	45%
Spain	156	40%
South Korea	87	38%
Hungary	132	37%
West Germany	346	35%
Sweden	477	34%
Brazil	64	29%
United States	580	26%

(World Watch Institute, Papers 56 and 76, 1983 & 1987).

Collection and export of recycled paper, however, are rapidly increasing in the United States. According to the latest figures from the American Paper Institute, more than 24 million tons of recyclable paper was collected in the U.S. in 1987, an increase of 11% over 1986. Both domestic consumption of waste paper (19.6 million tons) and export shipments (4.4 million tons) were at record levels. Considerably more paper recycling could be achieved, particularly by increased segregation of paper types and more emphasis on local collection programs and marketing **(25)**.

Waste Paper Grades

Waste paper is typically broken down into categories that reflect the paper's value in terms of recyclability. The following grades of waste paper are those most commonly separated for recycling:

Newspapers: 4.4 million tons of old newspapers were collected in the United States last year, a 13% gain

from 1986 figures (26). Newspapers make up 5 to 10 percent of the waste stream. Curbside and drop-off are the most common methods of collecting newspaper.

Mixed: The American Paper Institute indicates that in 1987, the collection of this paper grade increased by 4.3% over the previous year. The export demand for mixed paper has not grown as rapidly as it has for newspaper and corrugated, reportedly because of increasing amounts of plastics, metals, and other non-fibrous materials found in the bales of mixed papers. (27).

High grades and pulp substitutes: Five and a half million tons were collected in 1987 -- a 16% increase. It is thought that most of this increase is attributable to the increased recycling of trimmings from manufacture of paper products (brochures, business forms, envelopes, etc.).

Corrugated: Corrugated paperboard ("cardboard") can comprise a significant amount of the waste stream, particularly in areas where there are a number of concentrated sources. The collection of old corrugated containers in the U.S. totaled 11.2 million tons in 1987, an increase of 11% from 1986. Of this total collected for recycling, 2 million tons were trimmings from the manufacture of corrugated containers (28).

CORRUGATED COLLECTION

Typical generators of high volumes of used corrugated cardboard include furniture and appliance stores, convenience stores, grocery stores, liquor stores, wholesalers, and manufacturers. Corrugated can comprise 50 to 60 percent of the waste stream from some of these commercial generators (29). For example, Alamance County, NC, discovered through their waste stream analysis that as much as 31 percent of the volume of the waste reaching their landfill was corrugated paperboard cartons from furniture showrooms and other sources. Recent prices for scrap corrugated have been about $40 to $50 per ton, which when added to the saved cost of landfilling makes recovery of this readily recyclable material economically attractive (30).

Practices vary, but successful programs often loan or lease compactors or balers to large generators who will agree to participate, thereby making the handling much more efficient. Medium quantity generators may be provided a specific container for corrugated material which can be collected and hauled to a central processing site for

compaction and baling. For the numerous small generators, collection is practical when the market is favorable. Local drop-off centers and processing facilities should provide space for small generators (for instance, small businesses, offices, and residential participants) to deliver clean corrugated.

Local governments can use several mechanisms to increase participation in corrugated recovery by medium to large-scale generators. Examples include:

- ordinances to require commercial establishments which generate above a specified quantity to separate and compact or bale the corrugated;
- tipping fee surcharges on corrugated at the landfill; and
- banning corrugated from landfilling.

In August 1987, Mecklenburg County, N.C. implemented a corrugated-box recovery program involving the use of one employee, one front-loader truck, and one eight cubic yard container with the lid removed. Vehicles determined by the landfill traffic director to be hauling a large amount of corrugated boxes for disposal are directed to dump at a designated site on the edge of the landfill from which the corrugated material can be recovered. This program is a pilot for a larger recovery operation to be conducted at the county's materials recovery facility (MRF) scheduled for completion in the winter of 1988. Once the MRF is in operation, the material will be cleaned and conveyed into an automatic baler and then shipped to a paper mill. The MRF will also house processing equipment for materials recovered through the county's curbside collection program and drop-off centers (see further discussion of MRF's below).

Beginning in April 1988, the Chapel Hill recycling program expanded to include the collection of corrugated boxboard. Thirty rented dumpsters were placed in businesses and other strategic locations throughout Chapel Hill and Carrboro. Loads of corrugated are picked up weekly with an average of 2.5 to 3 tons collected per week. Costs include about $480 per month in dumpster rental plus $150 per week in labor costs. Gross revenues are in the range of $95 to $105 per week, not including, of course, the savings in short and long term landfilling costs. Currently, the program is funded through tipping fees at the landfill.

OFFICE PAPER RECYCLING

One type of program growing in popularity is collection of recyclable paper by office employees. The paper is then removed to centralized locations for storage or transport to market by the office, by a service company or by the customary waste hauler. These programs can be economically beneficial to the office as well as saving resources, transportation costs, and landfill space. The value of sufficient quantities of high grade paper, along with saved disposal cost, may even cover the expenses of operations (31).

Office paper recycling programs require careful planning and attention to the following logistical requirements:

- sufficient amounts of high grade paper;
- collection;
- storage space (100-125 sq.ft. per ton);
- promotional plan;
- equipment (containers);
- secure marketing arrangements;
- support of upper management.

In June 1987 Mecklenburg County began its "Paper Chase," an in-house office paper recovery program for computer printout and white office ledger (32). Employees are asked to deposit their recyclable paper in desk-top containers or centrally located storage containers. Desk-top boxes are emptied into larger containers by housekeeping staff; the paper is then consolidated and hauled to a local dealer. The program is to be extended to all county office buildings and a pilot program is scheduled for a private, high-rise office building (33).

PAPER MARKET

One frequent barrier to paper recycling programs is the fear that the paper industry will not be able to utilize the increased load of recovered paper as more and more communities recycle. This fear may not be realistic for two reasons: U.S. paper consumption continues to rise, and the paper recycling industry has been showing encouraging trends as more paper products plants alter their processes to more effectively utilize scrap paper in their production processes. For example, newsprint consumption in the U.S.

rose 7.5 percent in January of 1988 (975,810 metric tons) over January 1987, according to the American Newspaper Publishers Association; and paperboard production in the United States through mid February 1988 was up 5 percent compared to production for the same period the preceding year, according to the American Paper Institute. During the same time period there was a 3.5 percent rise in recycled paperboard. Average weekly production of recycled paperboard for the first month and a half of 1988 was about 18.7 percent of the total weekly paperboard production.

If increased incentives are made available to producers to utilize recycled paper, and enough demand is created for the recycled end product, a paper glut need not occur (34). This is one area where local governments can help in another key way, through changing procurement policies to require the purchase of recycled paper (and other materials) and provide tax breaks or other incentives to local businesses that establish similar policies.

METALS

Metals, including steel, iron, and aluminum, comprise about 8.7 percent of the waste stream nationally, with a slight decline expected by the year 2000 (35). The recycling rate for metals is estimated at 7.3 percent of total metal discards (see Figure 4).

Mixed metal recycling began in Mecklenburg County in 1987 in response to the declining price of mixed metals. Revenues from the metal-upgrading program have exceeded the salary of the primary worker assigned to perform this function. One employee works full time and is assisted part-time by a co-worker to identify the type of metal, remove unacceptable materials, and deposit the item in the appropriate bin for its metal grade. The metal is sorted into the following grades: white goods (enameled metal appliances), ferrous scrap (steel, tin, iron, etc.), aluminum, brass, and copper. Ferrous metals can be collected at a centralized facility through electromagnetic separation (36).

Aluminum cans are being recovered at about a 50 percent rate currently, netting a relatively significant energy and economic savings (37). The level of aluminum recycling could be increased even further through enhanced segregation and collection.

GLASS

Following five straight years of declining sales, recycled glass bottles and jar sales experienced a 4% increase in 1986 and are steadily rising. Although glass has had stiff competition from the plastics industry, glass is still holding its own corner of the market. Prices were up $20 a ton in 1987 and currently stand at $65-70 a ton in 1988. For comparison, Mecklenburg County's reported high in 1987 was $45/ton (38).

Recent studies estimate that about 8 percent of the U.S. waste stream is made up of glass (39,40), declining by 2 percent by the year 2000, with the difference being picked up largely by plastic beverage containers. Only about 8.6 percent of the glass in the waste stream was recycled in 1986, even though glass is very readily recyclable with a basically wide open market. Again, as with paper, increased emphasis on separation and local collection should be the immediate focus (41).

Glass is customarily separated by color into two or three main categories for recycling. In some instances, recyclers require separation of clear, amber, and green, and in other instances recyclers allow the green and brown to be mixed together. Since there is no machinery that can automatically separate glass into three colors or different glass types (let alone remove ceramics or stones), quality control is an important consideration in glass recycling.

Cullet, or scrap glass, is valuable to manufacturers as it can help keep plant maintenance and energy costs down. A batch of "new" glass can include 40% or more cullet, especially if it is a high quality (that is, relatively free from contaminants such as metals).

In an effort to promote glass recycling nationally, the glass container industry in 1986 chose North and South Carolina as the site for a major glass recycling initiative, the **Carolinas Glass Recycling Program**. When the program began, glass recycling was in its infancy in the two state area. Only nine recycling companies were handling glass and glass manufacturing plants were recycling only about 3 million glass bottles and jars each month. By the spring of 1988 the recycling network created in the Carolinas had grown to more than 70 organizations handling volumes of more than 12 million bottles and jars per month.

Community, civic and governmental units in North Carolina can look to the Carolina Glass Recycling Program for assistance in setting up new programs and organizing recycling drives (see Appendix B for address).

PLASTICS

Recent estimates of the plastic share of the waste stream are between 6.5 and 7 percent, with projections to the year 2000 of an increase to 8.2 to 10 percent (42,43). Owing largely to the complexity of the manufacture of plastics, the large number of plastic types, and the infancy of market development for plastics, particularly mixed plastics, the recycled portion is only about 1 percent of the total.

One of the fastest moving areas of research and development in the area of recycling today is the development of new technologies, new end products, and new marketing strategies for recycling plastics (see Appendix B for contacts). Through their curbside collection program, Mecklenburg County recycles plastic soft drink bottles, commonly referred to as PET (polyethylene terephthalate).

Numerous goods can be produced from recovered plastic polymers, but to produce single polymer end products requires relatively pure batches of that type of plastic. This presents a problem for recycling some plastics that cannot be readily distinguished from one another. In a voluntary attempt to improve the ability of recyclers to obtain clean loads of plastic, the plastics industry has begun a pilot coding program which will identify to the handler the polymer type (44).

One area just beginning to surface in plastics recycling is a whole array of extruded and molded products made from mixed or comingled plastic resins. These include numerous shapes of "plastic lumber", landscaping materials, pier construction materials, parking lot tire stops, and many others. Developing the market for these materials requires new strategies to get beyond traditional preferences in products, the key to marketing in general. It is also another area where progressive government procurement policies can play a critical role in stimulating the market for recyclables.

TEXTILES

Scrap textiles make up a significant portion of the waste stream in some North Carolina counties and communities. A concentrated textile waste reduction strategy is much the same as that for corrugated or other commercial/industrial

non-hazardous waste streams. The demand for recycled textiles - both clean scrap and used clothing - is strong in the export market. There are two distinct sectors fed by the textile portion of the waste stream:

- Clean textile scraps are reprocessed into fibers for remanufacture of new fabrics, yarns, industrial felts and fabrics, carpeting, and automotive mats requiring a substantial capital investment in reprocessing equipment.

- The other sector in textiles recycling involves the reprocessing of used clothing, which is a highly labor intensive operation. These materials are purchased primarily from non-profit institutions, which already have collection networks established.

Depending on the market, these materials can be cut into industrial wiping cloths, or in some instances are soaked, shredded, and made into new wool or polyester fabrics. Synthetic knits can be reprocessed into automotive mats. Much of the waste in this sector is baled and exported for reprocessing in other countries. On the whole, scrap textiles exports increased 3.5 percent in the period beginning October 1986 and ending October 1987, with a total of 337.5 million pounds exported.

Officials in the business agree that the market for reprocessed fabrics should be stable into the foreseeable future. Recent prices for secondary textiles range from 2 to 3 cents per pound for worsteds to 18 to 29 cents per pound for mixed knits. The resale margin is very tight and requires a high-volume, efficient operation.

OTHER WASTES

Other components of the waste stream such as yard wastes, construction debris, and special waste (i.e., tires, household hazardous waste, etc.) will be addressed in later sections.

Table III: GROSS DISCARDS, RECOVERY, AND NET DISCARDS OF Municipal Solid Waste
(From Franklin and Associates, 1987)

Gross Discards of Materials in MSW
(in millions of tons)

Materials	1970	1986	2000
Paper and paperboard	43.9	64.7	86.5
Glass	12.7	12.9	13.4
Metals	13.7	13.7	15.9
Plastics	3.0	10.3	15.7
Rubber, leather, textiles wood	9.3	12.6	13.4
Food wastes	12.8	12.5	12.3
Yard wastes	23.2	28.3	32.0
Misc. inorganics	1.9	2.7	3.3
TOTALS	120.4	157.7	192.6

Trends in Managing MSW
(in millions of tons)

	1970	1985	2000
Gross discards	120	158	193
Materials recycling	8	17	24
Energy recovery	-	10	32
Net discards	112	131	137

OPTIONS FOR COLLECTION

Once it has been determined which material types will be the easiest to remove at the highest benefit, the next step is to compare methods for separating and removing them from the waste stream. To select the best recyclables collection option requires consideration of five criteria (45):

- o convenience to users,
- o applicability to area of concern,
- o cost effectiveness,
- o waste reduction potential, and
- o ease of implementation.

As budget funds become available, the program should include as many of the following elements as are required to fit local needs and goals.

Drop-off Centers

Voluntary drop-off centers are the most common method for recyclables recovery, especially for newspaper.

Advantages of drop-off centers include: practicality for rural areas, continuous daily service, low staffing needs, inclusion of multiple materials, and low start up and operating costs.

Disadvantages of drop-off centers include: the potential for vandalism, uncontrolled litter, contamination with unacceptable items, zoning restrictions and uncooperative neighbors, and the fact that drop-off centers require commitment by each household to make the trip.

Multi-material centers recover more of each type of material than single material stations. Materials most commonly collected include newspaper (clean and dry), glass (separated by color), aluminum cans, tin cans (labels removed and flattened) and sometimes corrugated cardboard and other paper types. Recovered materials can be shipped without further processing to the buyer or to an intermediate processing facility. Crushing glass, baling paper, and flattening cans increases marketability, and

reduces storage space and transportation cost. Options for transporting are either to use a private hauler, to purchase a new truck, or to retrofit an existing truck.

The drop-off site should include sufficient area for public parking, bins, storage, and processing. Satellite areas usually include only the bins for deposit and space for convenient public access. Fences are often helpful as visual and noise barriers, and signs should be clearly posted to explain procedures for dropping off materials.

Multi-material centers should be located along heavily travelled roads for visibility and convenience. Municipal properties such as public works facilities, current disposal sites, fire stations, etc, provide suitable locations. Drop-off site selection should be based on geographic location and population densities to maximize participation. The service area of each site, however, should be small enough so that potential participants need not travel long distances.

In May 1987 the Town of Chapel Hill established a drop-off recycling program. The program is sponsored by the Landfill Owners Group (LOG) of the Orange County Regional Landfill (consisting of the County, the Town of Chapel Hill and the Town of Carrboro), and is run by the Town of Chapel Hill through its Public Works Department. It is funded by tipping fees collected at the landfill, which were raised by about 100% in 1988.

Five sites have been provided as drop-off centers for glass, aluminum cans, and newspaper. Two of these sites are at Chapel Hill parks, one near the community center, one at a shopping center in adjoining Carrboro, and one at the Orange County Public Works Facility outside Hillsborough, the county seat.

All centers are unstaffed, and open 24 hours a day. There are street signs at intersections which indicate the location of the recycling sites, and signs at the entrance ways to the various facilities directing the user to the site. All containers at the sites are painted similarly to increase visual recognition.

Operation of the site combines the public and private sector and volunteers. The Town of Chapel Hill Sanitation Division contracts with the Landfill Division to provide weekly pick-up of the newspaper and aluminum cans. Newspaper is shipped in the same truck in which it is collected and sold directly to a local paper dealer. Aluminum is sold weekly to a local Boy Scout troop which has a can crusher and a scale with

which they conduct a buy-back program also open to the public. Glass is collected, processed and sold by an existing local recycler, ECOS, Inc. under contract to the Town. The Town pays this contractor a tonnage based fee for the collection service justified on the basis of avoided landfill costs, and the contractor keeps the revenue from sale of the glass.

Through the drop-off programs over 110 tons of paper, cardboard, glass, and aluminum are now recycled monthly in Orange County. This represents 1.5% of the total waste stream and is a 175% increase from the average of 40 tons per month in the previous year (for more information see Recycling Programs in NC, Appendix C).

Drop-off centers are particularly suited to low population density urban areas and rural areas, including greenbox (dumpster) sites and landfill sites, where curbside pickup is impractical. The most important factors for high participation are convenience of location and publicity (46).

Curbside Collection

Typically, a basic curbside recycling program involves pick-up of either comingled or source separated materials at the individual residence, and hauling them either directly to market, to a processing facility, or to a central storage/processing area. While curbside collection of recyclables represents a serious commitment to recycling, there are advantages as well as disadvantages to this collection option.

Advantages of curbside include: convenience to users, and the ease with which it can be integrated with regular trash service.

Disadvantages include: high operating costs, capital- and labor-intensive operations, and administrative demands.

Newspaper is the most commonly collected material, with larger programs including glass and aluminum and sometimes tin and compostables. Most programs collect on a weekly basis, which seems to generate higher participation rates and result in higher rates of recyclables diverted than less frequent collection (47). However, the expense of the operation sometimes limits localities to bi-weekly or monthly collection. Oregon has required at least weekly

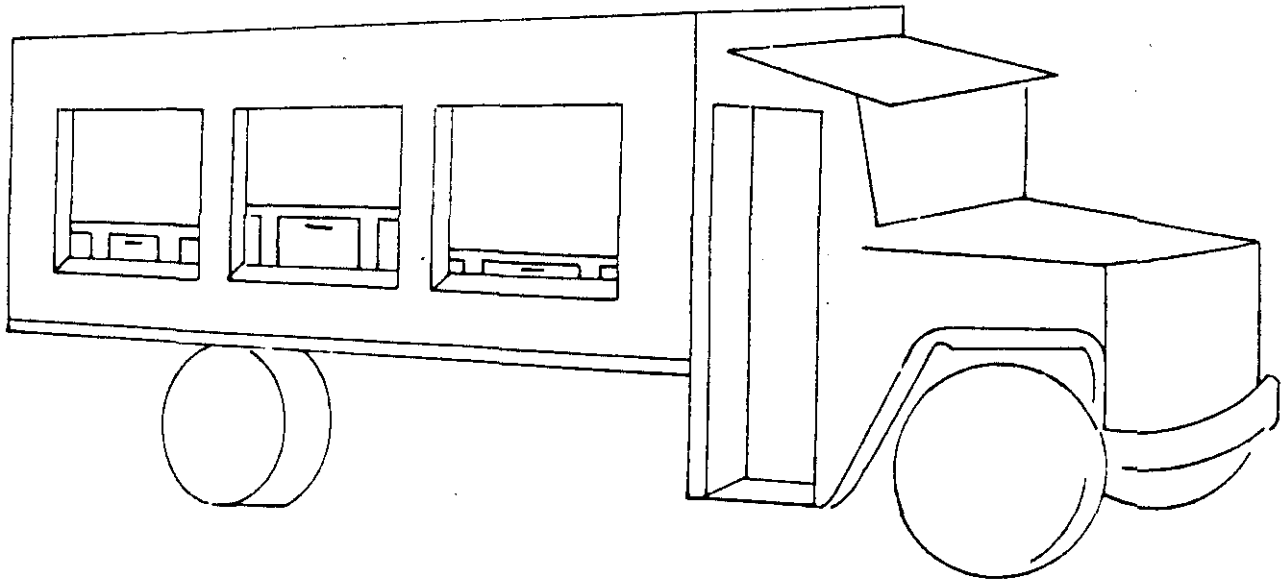
collection in towns with populations of 4,000 or more, and some communities even collect more frequently. The basic principle is to make recycling as convenient as taking out the trash.

Numerous styles and sizes of containers are available which can be supplied to the residents either free of charge or for nominal cost. Many programs require residents to sort materials before they are collected; however, some programs include separation facilities for comingled or mixed recyclables, while others use **truckside** separation of recyclables by the collection crew.

Specially designed trucks are available for curbside collection which provide separate bins on the truck (see Figure 5). It is also practical to modify trucks for recyclables collection or to add a trailer (see Figure 6).

Figure 5: Specialized Recycling Truck for Curbside Collection

LAIDLAW TRUCK (COMPARTMENTALIZED)



PEERLESS UNIT

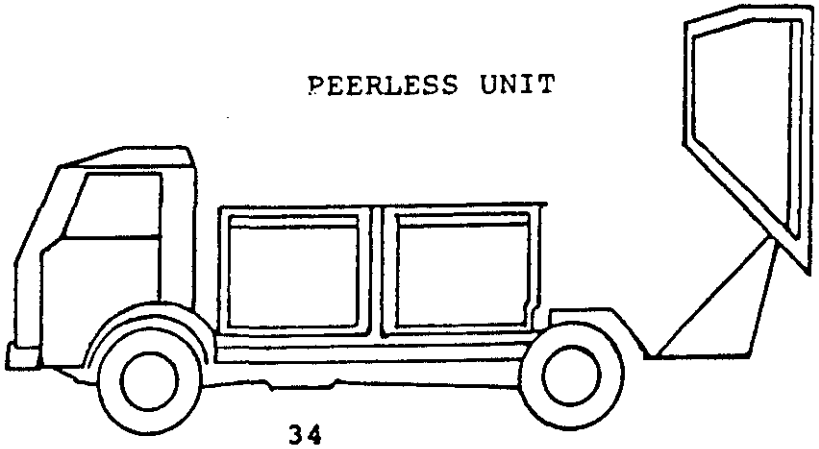
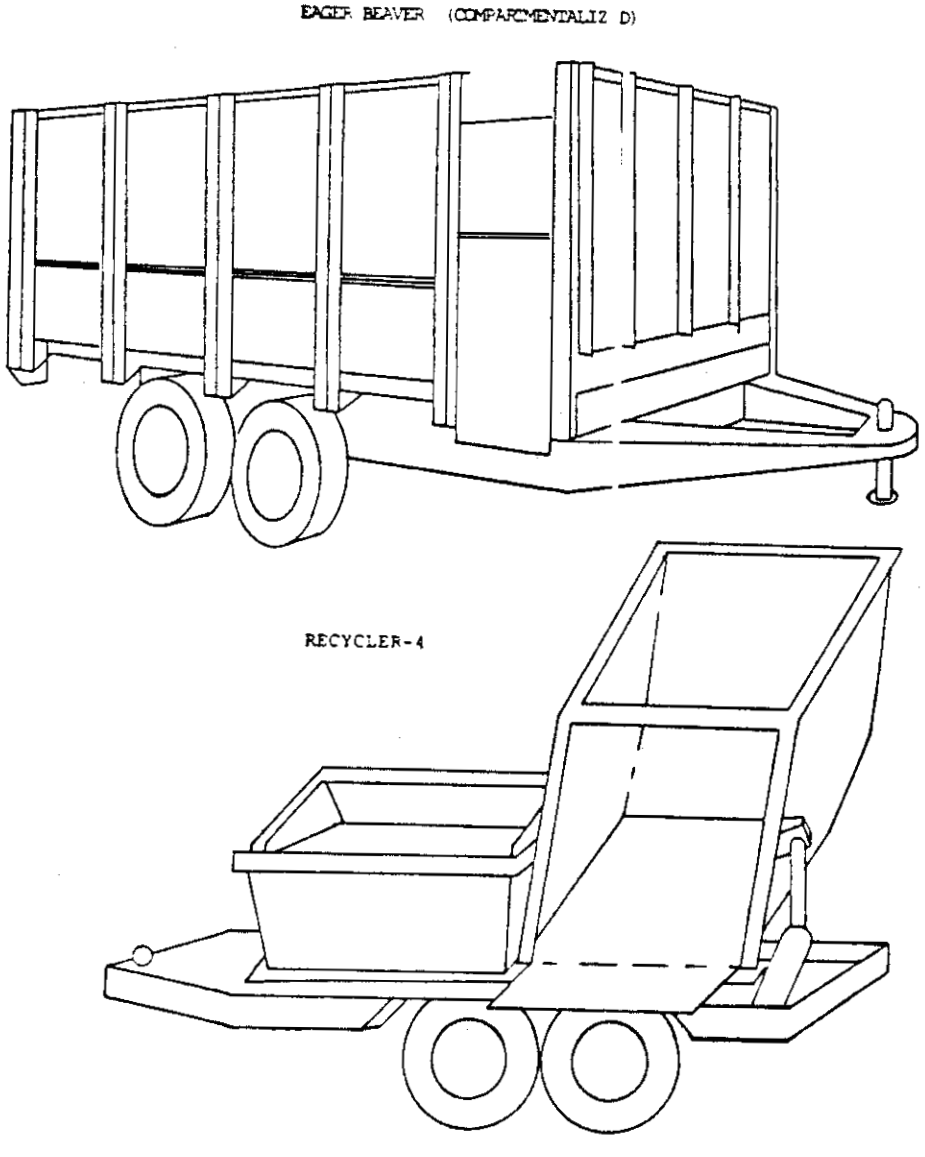


Figure 6: Modified Truck and Trailers for Dropoff Centers or Curbside Collection

Mecklenburg County has conducted a study to evaluate various types of curbside collection vehicles (48). One recycling vehicle can usually cover from two to five regular garbage routes per day; the usual crew requirements are from one to three, depending on the type of truck, the residential density of the route, and the types and amounts of materials collected (49).



The success of curbside programs is dependent upon a number of factors. Interest and publicity (or in some cases, mandatory separation) influence participation rates, while population density and program design effect the efficiency. Curbside programs collecting source-separated materials can divert from 5 to 25 percent of the waste stream, dependent on the commitment by local officials of personnel and financial resources (50).

In February 1987, Mecklenburg County launched its multi-material curbside recycling program. On a weekly basis, residents who separate bottles, cans, jars, and newspapers from their regular household trash place these recyclable materials in a red plastic container and put it on the curb for pickup. The recyclables collected at the curbside are transported to a 12,000 square foot interim facility where the recyclable materials are hand-sorted into five components: polyethylene terephthalate (PET) plastic, green glass, brown glass, clear glass, and mixed glass residue. Newspapers are handled separately. The facility also houses a can densifier that magnetically separates the bi-metal cans from the aluminum cans and crunches the aluminum cans into 18-pound "biscuits."

Mecklenburg's curbside collection program has been well received by the community. Participation levels average between 65 and 75 percent, with approximately 90 percent participation in some neighborhoods. The county expects to extend the program throughout all of its municipalities by the end of 1988 and to recover approximately 12 to 15 percent of the residential waste stream.

Plans are underway for an Orange County multimaterial curbside collection program to start operation in September 1988. Approximately 1800 homes in the Chapel Hill/Carrboro area will be targeted for collection of newspaper, glass, and aluminum cans in this pilot project.

Buy Back Centers

Cash incentive is the motivating factor for buy-back centers, which make them more successful in low income areas. Promotion is often targeted to these groups for that very reason. Buy-back centers are generally single-material collection stations, usually staffed, but sometimes consisting only of reverse vending machines which give money back for cans deposited. Mobile operations allow use by people who would not otherwise get much of an opportunity to recycle at all, particularly in rural areas.

Most buy-back centers are for aluminum. Aluminum collection stations can recover as much as 75 percent of the aluminum cans in the waste stream, depending on how well they are advertised. Paper and glass centers experience lower rates of recovery, usually due to lower market prices (51). Even for aluminum, programs must pay a stable price to avoid losing participants during times of depressed market prices and can therefore lose money in some periods; but when market prices are high they can be profitable. In some states, glass plants recognize the problem by paying one price for glass from buy-back centers and commercial suppliers, and a lower price for community and public collection programs.

Buy-back centers can experience cash flow problems. This is usually due to the practice of paying out cash for small amounts of materials coming in which must be stored until there are sufficient quantities to make it worth transporting. Other cash flow problems result from the capital investment needed to set up a center, and the high cost of advertising needed to make the program work.

Multi-Family Dwellings Collection

Multi-family dwellings, such as apartment complexes and condominiums, provide particularly difficult, though not insurmountable, obstacles to collection of source-separated recyclables. Participation rates for multi-family dwellings that have been measured range from 12 to 100 percent. Factors responsible for improving participation rates include promotion, container location, and financial incentives. Ongoing promotional programs targeting the largely transient population of many multi-family dwellings are critical to maintaining participation.

The provision of a central facility for tenants by the owner or refuse collection operator is essential to gain significant participation and avoid nuisance conditions. Containers should be provided near the regular trash depository, and should be well-marked to give clear instructions for use. Frequency of pickup will vary with the number of households, the capacity of the facilities, and the participation rate; one approach is for the operator to be contacted as needed by the supervisor or a volunteer attendant. The containers can be emptied on site or hauled away to be emptied, replacing them with empties brought by the operator. Materials are then transported to the buyer or to a storage or intermediate processing facility.

Benefits to the building owner include lower maintenance expenses and waste disposal cost savings. Crew requirements are usually low, with the largest effort involved in coordinating with the building manager and encouraging participation (52). Volunteers at the sites can help by publicizing the program and providing instructions to neighbors.

MARKETING RECYCLABLES

Simply pulling all the recyclable materials out of the waste stream is not the full picture of recycling. Successful recycling programs must also have locally available **markets** for the collected recyclables; and they must plan for **growth in the market** parallel to the expected increase in recycling rates.

Markets for recycled materials vary across the country, across the state, and through time. As more and more of the waste stream is separated for materials recovery, the demand for end use products of the reprocessed materials must also be increased so that prices remain stable. If supplies of recyclables out-pace demand for the products, markets will be depressed, and recycling will result in less recovered revenue through lowered market prices, creating a disincentive for recycling. As recycling rates decrease, the momentum and enthusiasm for recycling that is currently exhibited across the country is likely to cease.

One critical part of each program, therefore, is **market assessment**: the determination of marketing needs and the extent to which the existing market can support those needs. The Pollution Prevention Program is currently supporting the development of a recycling directory for North Carolina, one part of which will list community recyclers across the state.

A second key element is **market development**. Local, state and federal governments all need to identify incentives for governments, industry and businesses to utilize secondary materials, and both governments and businesses in fact can do much toward stimulating the markets for recycling. A key area to be targeted is the development of incentives for governments and businesses to utilize secondary materials in their own procurement policies.

PRIVATE BUSINESS INVOLVEMENT

In addition to business firms directly involved in materials recovery, trade associations are playing an increasing role in promoting solid waste reduction, primarily through recycling. Arrangements between state and local governments, regional councils, and private enterprises can range from cooperation to quasi-corporate market development options. Trade associations can perform numerous services for their member organizations and the public at large. The Oregon Sanitary Service Institute (OSSI), a statewide haulers association, provides educational materials on recycling to patrons within its service area. Such groups also provide an information network for research, development, and dissemination of new and innovative ideas and technologies.

Private and quasi-private institutions have also served as regional brokers or processors of waste materials. The Morrison County Development Association in Minnesota operates a program through which handicapped citizens recycle furniture and appliances. A private firm in Massachusetts, New England CRInc., acts as a broker for recycled beverage containers and paper. The firm collects pre-sorted wastes from local communities, haulers and commercial operations, and stores them until they can be marketed to manufacturers as high quality, high volume materials. This type of operation exemplifies the transition from basic recycling operations to more sophisticated centralized resource recovery operations.

Representatives from both the public and private sectors in North Carolina have recently established the **North Carolina Recycling Association**, a non-profit organization dedicated to promoting local, state and federal programs and policy on waste reduction, materials reuse and recycling, and resource recovery. The association will also serve as a broker for recycling services and information and plans to publish a newsletter to keep interested parties across the state abreast with recycling news (see Appendix B for more information).

CENTRALIZED MATERIALS RECOVERY

Materials recycling facilities (MRFs) are central processing plants accepting recyclable materials from surrounding areas. They may start off as small materials recycling facilities (SMRFs) to serve only a small area, and can then be expanded to extend their service to additional municipalities and surrounding areas. MRFs can be designed to handle source separated recyclable materials or the unsegregated (co-mingled) waste stream. They are usually labor intensive, low technology operations - often utilizing conveyors, crushers, and magnetic separators as the only mechanized equipment - and therefore, maintenance and operation of the equipment are quite basic. For such facilities, the size of the work force per ton of processed waste is relatively high, and workers are largely unskilled laborers. Low technology MRFs (and SMRFs) are capable of easily handling steel, aluminum cans, glass, corrugated paperboard, paper and plastic. Mixed plastic can also be recovered by MRFs, but presently faces end use marketing problems. End residues of MRFs are often suitable for composting, as they are largely organic and inert materials.

Many municipalities are now being encouraged to send their waste to MRFs at the prospect of saved disposal costs. With landfill tipping fees increasing, and expected to continue to rise, recovery of recyclables from the waste stream has become an attractive option for reducing what must be landfilled (53). The incentive here is more often **saved landfilled space** rather than revenues from the sale of the materials, though such sales do help to offset costs. Even when sales of recycled materials do not fully offset the cost of the facility, the remaining costs may still be significantly less than the cost of constructing additional landfill and incineration capacity. The creation of unskilled jobs from the presence of the facility may also be a positive benefit to many communities.

ECONOMIES OF SCALE

Additional benefits may be found in developing MRFs (or other resource recovery facilities) at a regional scale, as the cost of managing waste can be reduced while not burdening each municipality with the full costs of operating the facility or marketing the recovered materials. Human, material, financial, and natural resources often can all be

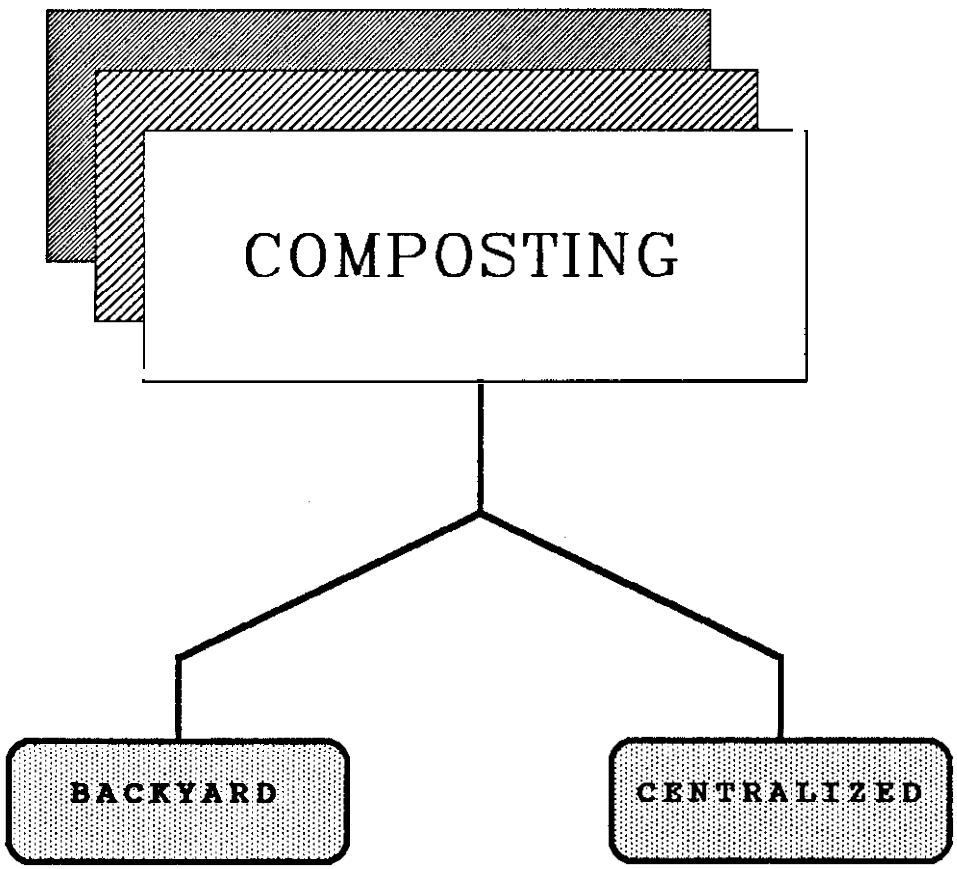
put to more specialized uses in large facilities. With larger volume operations, more classes of materials are likely to be extractable at a relatively efficient cost, and more diversity in subunits of the operation may become feasible.

Large facilities, with state-of-the art processing technology and sound management capabilities, can be more profitable than smaller ones owing to several factors related to their size and volume flow (54):

- large volumes permit more reliable flows of materials and guaranteed quality of materials to buyers, allowing for longer-term contracts and better prices;
- large volumes allow quality control practices to improve, thereby increasing market demand for the high-quality material;
- with handling of large quantities, marketing capabilities can be enhanced through computer-based brokering;
- large quantity processing, combined with adequate storage and transporting capabilities, permits stockpiling of materials while markets are unfavorable; and
- transportation cost to markets is reduced with larger quantities.

Massachusetts will soon be spending about $2.5 million per facility for 12 to 16 state-owned, privately-operated materials recovery facilities. Municipalities that wish to participate must provide source-separated refuse to the facility. Because the state will have control over a large portion of the state's waste stream, and will therefore be able to supply large amounts of materials on a reliable basis, there has been a considerable interest by secondary materials buyers in developing long range contracts for delivery (55).

IV



IV

COMPOSTING

COMPOSTING is the microbial decomposition of organic matter to produce **compost**, which is a dark partially decomposed substance similar to natural organic matter found in the soil. With the ban on outdoor burning and with laws which soon will limit dumping of leaves and grass clippings into landfills, composting and mulching have become attractive alternatives for managing yard waste and recycling natural materials.

Compostable organics are those materials in the waste stream which are suitable for composting, namely plant and animal debris or by-products.

Compost has many values, including its nutrient value as a fertilizer, its value in conserving resources in manufacture of fertilizers, and its value in saved landfill costs. Compost is usually used as a soil conditioner in such applications as:

- nursery bedding material,
- potting soil,
- roadside and median vegetative cover,
- farming, and
- strip-mine reclamation.

BACKYARD COMPOSTING

Yard wastes, such as leaves, grass clippings, straw and plant trimmings can be composted. Kitchen waste such as fruit and vegetable and animal scraps, coffee grounds, and eggshells can be added by the homeowner who wishes to establish a compost pile to handle the food waste portion of the residential waste stream. This practice is referred to as **backyard composting** and lends itself well to rural areas.

The material which is produced in these compost piles is generally a nitrogen rich material beneficial to the home garden. Hence, the backyard composting household can save on fertilizer and soil conditioners while diverting a

potentially significant fraction of household waste from the landfill. Backyard composting should be encouraged by local governments as a means of reducing the waste stream with the only cost being that of educational materials.

For those individuals who do not wish to establish backyard composting facilities or in more urban areas where backyard composting is not feasible due to space limitations, many municipalities have instituted centralized composting facilities.

CENTRALIZED COMPOSTING OPTIONS

In order to reach aggressive waste reduction goals, initiating composting as a regular solid waste management practice can divert significant volumes of waste from the waste stream. Current estimates put the yard waste component of the waste stream at 15 to 18 percent, varying seasonally (56, 57), and with a 6 percent projected increase by the year 2000 (see Table III). With the addition of food waste and miscellaneous organics to this, the waste stream is currently comprised of nearly 28 percent compostable organics with a 9 percent increase to the year 2000. Clearly a substantial portion of the waste stream can be diverted from landfilling through composting of these organics.

Yard waste utilization programs generally are easy to implement and cost relatively little. As with other materials derived from the waste stream, however, gaining public acceptance is the key to the use of compost. Procurement specifications for use of compost and waste-derived mulches in government landscaping projects, such as roadside and grounds landscaping can help to stimulate the market and to promote the virtue of this resource.

Three different levels of technology can be utilized for centralized composting. The particular technology which is most appropriate for a given application depends primarily on the site selected and the equipment and labor available. The lower the level of technology used, the greater the requirements for space, size of buffer, and composting time, but the lower the cost.

Minimal Technology: If a large area that is well isolated from sensitive neighboring land uses is available, a very low-cost approach can be used for composting. Yard waste brought to the site is formed into large windrows (a row of piled materials, for example, 12ft. high by 24 ft. wide) to be composted. Using a front-end loader, each year the

windrow is turned and reformed and an additional windrow is constructed. After three years (sometimes longer) the material in the windrow is usually stabilized and ready to be used as compost.

This method of composting is extremely inexpensive and requires relatively little space for the actual composting. A usable compost is produced. However, it does give off strong odors during turnings: usually a quarter mile or more of distance from sensitive neighboring land-uses is recommended due to the potential odor problems.

Low-Level Technology: When a large buffer zone is not feasible due to population density, a more rapid method of composting is desirable to reduce emission of unpleasant odors. In order to accomplish this, better control of moisture content, oxygenation, and temperature is necessary. Additional turnings are also required. The compost is then moved to curing piles and is turned again. Shredding is the final step to improve the physical quality and appearance of the finished compost. This approach produces compost more quickly, but requires more labor, disposal of reject materials, and higher capital costs for specialized equipment.

High-Level Technology: If even less space is available and completion of composting is desired within one year, even more technology-intensive composting is possible. Briefly, this approach consists of using forced pressure aeration of the compost pile via a perforated pipe located near the bottom of the windrow. The air blower operation is controlled by a temperature feedback system: when the temperature within the pile exceeds a preset temperature, the blower automatically turns on to remove heat and water vapor. The entire process is carefully controlled and in some cases nitrogen is added to further speed the decomposition process. This high-intensity processing lasts for approximately one month; then the blowers are removed and the mechanical turning of the piles begins.

One advantage to this approach is that large windrows can be formed at the beginning of the process, thus using less space. Extensive anaerobic conditions do not develop because of the good aeration, therefore serious odors and slower decomposition do not occur. Another advantage is that the rate of composting is rapid and can be completed within one year. However, there may still be some odor released at the beginning of the process, particularly during initial windrow formation and start up. Because of this, a moderate size buffer zone is still required.

OPERATIONS

As with other solid waste management treatment facilities, site selection and site preparation are very important to the success of centralized composting operations. Factors to be taken into consideration when a composting operation is planned include:

- o Location: A central location is preferable to reduce transportation time and costs. Access is preferably over uncongested, non-residential hard surface roads.

- o Area Requirement: A minimum of 1 acre per 3,000 to 3,500 cubic yards of leaves collected is required for the actual composting operation when using the minimal technology approach.

- o Slope and Grading: A gentle slope is preferred to prevent ponding of runoff and leachate; steep slopes are not desirable. Yearly maintenance should include regrading where necessary. Windrows should run up and down rather than across slopes, to allow leachate and runoff to move between piles rather than through them.

- o Buffer Zone: A buffer zone is required between site activities and neighboring land uses to minimize possible odor, noise, dust and visual impacts. At least 50 feet is necessary between the composting operation and an adjacent property line. At least 150 feet should be allowed between composting activities and sensitive land uses such as residential areas. In any case, the larger the buffer zone the better.

- o Stream Encroachment: Siting of a composting facility in a flood-plain should not be attempted. During high water periods, composting leaves, other yard waste and leachate might wash into the stream. Flooding can result in a multitude of problems from serious operational difficulties to increased odors, a lower decomposition rate, and of course water pollution.

- o Percolation: High soil percolation rates are desirable so that rainwater and leachate will not run off the site.

- Water Table: A high water table is undesirable because it may lead to flooding of the site. It also reduces the distance through which leachate can percolate through unsaturated soil where it undergoes natural biological and physical treatment.

- Water Supply: Water is crucial to the composting process; it is often necessary to add water to the incoming leaves during much of the collection season.

- Security: Vehicle access to the site should be controlled to prevent illegal dumping of undesirable materials.

- On-Site Roads: Because of the heavy truck traffic during the collection period, a limited road network within the site may be desirable.

ECONOMICS OF COMPOSTING

The largest direct monetary benefit of composting is the cost savings of avoided landfill or incineration costs. In addition to these avoided disposal costs, composting also has economic value as a soil conditioner or top dressing that can be used in community beautification programs. In Tenafly, New Jersey, the city marketed "Tenafly Humus" for $5 per cubic yard in 1980. It was estimated that this was sold below its market value. If a value of $6.50 per cubic yard and a yield rate of 20% of the initial volume is assumed, then this would be equivalent to $1.30 per cubic yard or $7.40 per ton.

In Mecklenburg County, NC, the county's tub grinder, located at the landfill, shreds brush and tree limbs brought in by landscapers and others to produce a shredded by-product, called "Metro Mulch." Metro Mulch is sold to the public for approximately $4 per yard and is used by city and county departments to landscape public facilities. Assuming the same yield rate of 20%, this would be equivalent to $ .80 per cubic yard or $4.50 per ton (58). With concentrated marketing strategies for the composted material, both localities could increase their revenues from selling the product. These revenues could help offset the costs of centralized composting facilities.

Expenditures for composting activities vary according to the type of operation that is selected for a given locality. Estimated costs for low-tech systems range from $8.60 to

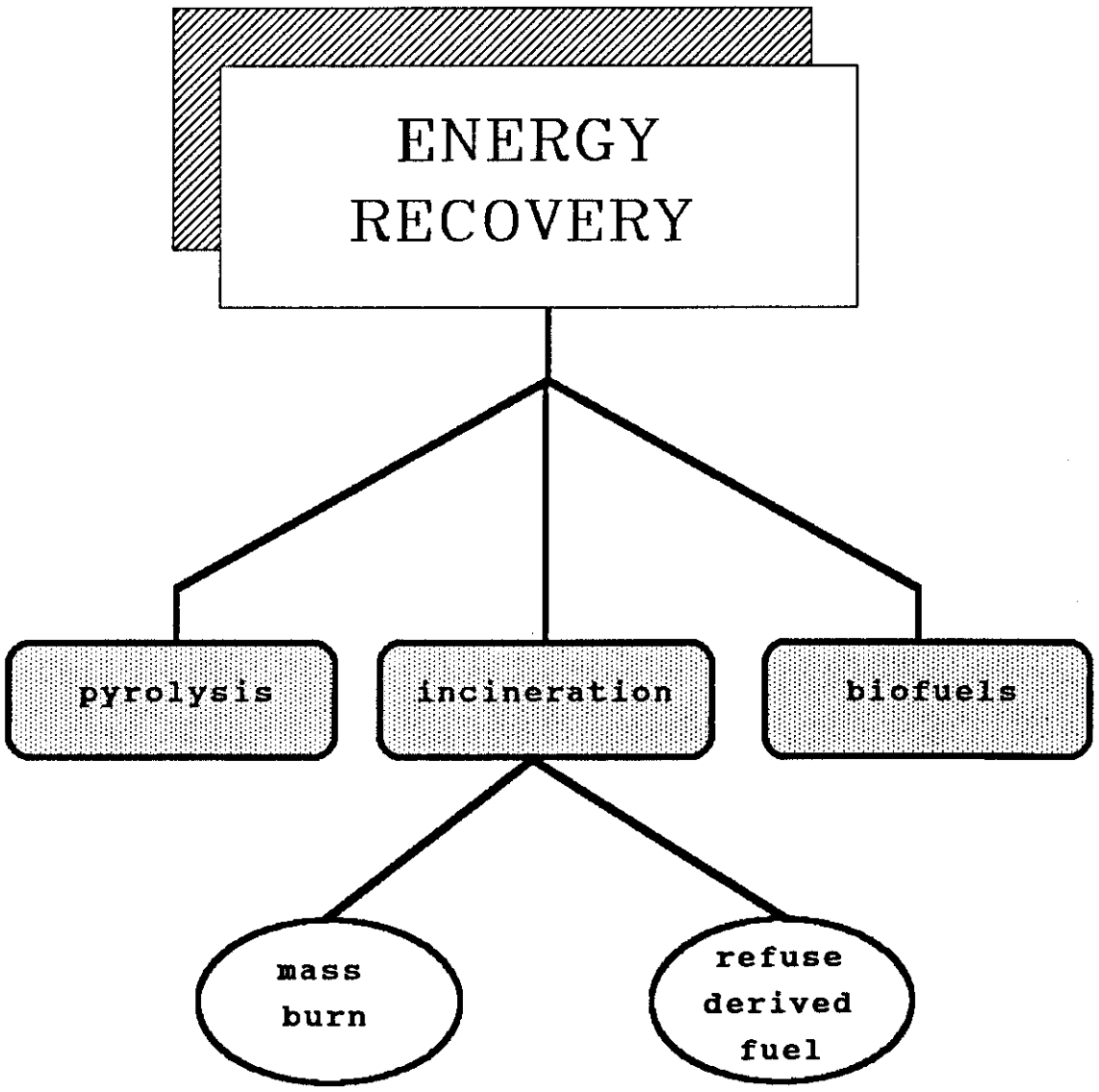
$20.00 per ton. This includes curbside pickup, transport, and operation of the composting site (59). Table IV provides another estimate of composting costs (60).

Table IV: ESTIMATED COST OF LEAF COMPOSTING PER TON OF LEAVES (1984)

Item	Dollar amount
Composting	
Land	$1.46
Land Improvements	.95
Initial Windrowing	.36
Combining Windrows	.36
Water	.49
Turning (2 times)	.72
Storage Pile Formation	.40
Separation/Shredding	3.02
Contingencies *	.60
Overhead	.83
Total	$9.19

* Refers to unspecified potential costs due to unusual weather conditions, equipment breakdown, additional temporary labor, overtime, site maintenance, etc.

V


ENERGY
RECOVERY
pyrolysis
incineration
biofuels
mass
burn
refuse
derived
fuel

V

ENERGY RECOVERY

ENERGY RECOVERY is a form of resource recovery in which a portion of the waste stream is converted to some form of usable energy.

The primary form of energy recovery from municipal sold waste involves incineration of waste in a combustion chamber in which circulating water is heated for steam production. The steam is then utilized for energy recovery in one of three common processes:

- o district heating (and sometimes cooling) with steam,
- o electric power generation from steam driven turbines, or
- o cogeneration of electricity and steam heat

Other less common energy recovery technologies include landfill gas recovery and methanol production. Though these have some promise as alternative energy recovery techniques, they are not yet widely used in the U.S. and therefore will not be addressed in this manual.

Solid waste incineration as a waste-to-energy alternative technology has the publicized characteristics of providing as much as a 90% reduction in the volume of material processed by the facility, and has the potential for producing significant amounts of energy (61).

The performance of energy recovery systems or waste-to-energy (WTE) facilities is greatly improved when initial separation of noncombustible materials is included. Separation of recyclables from the waste stream prior to processing for fuel has the following benefits in energy recovery systems:

- o conservation of natural resources (due to waste reduction and reuse of materials),
- o energy savings associated with recycling vs. use of virgin materials,
- o avoidance of toxics problems by extracting toxic materials before combustion,

- increased plant efficiency by removing noncombustibles (materials that do not burn well),
- increased operating life of plant,
- reduction in amount of ash produced, and
- avoidance of landfill costs.

If **source separation** is not employed in WTE service areas, **centralized separation** of recyclable materials from the mixed waste stream can be designed and built into the centralized facility. Rhode Island, for instance, is beginning to integrate recycling facilities into resource recovery facilities. Potential contractors for design and construction of an energy recovery plant should be evaluated not only on the basis of their thorough knowledge of energy systems, but also based on their experiences in integrated solid waste management systems that combine source separation, recycling and recovery. A contractor's experiences and policies should be evaluated with at least the following questions in mind:

- will the contractor assist in analyzing waste for recyclables, and developing a WTE proposal as an integral part of a broader waste reduction program?
- does the contractor also install and integrate processing facilities for recycling and materials recovery?
- what other support services for an integrated waste reduction program does the contractor also provide, and do they have a record of serving the community's full solid waste management needs?

ECONOMICS OF INCINERATION

As the capital and operating costs of new landfills begin to approach those of incineration, the reaction to increased costs of traditional waste management operations may result in source reduction efforts or in an increase in capital-intensive incineration facilities (62). Before deciding on technological options, however, it is important to recognize

some of the factors that affect the operating and maintenance costs of energy recovery systems. Some of the major issues include:

- price and availability of waste fuel;
- proper sizing of plant after reduction and recycling components of the program have been selected;
- transportation, storage, and disposal costs;
- life-cycle maintenance, such as the potential for equipment corrosion from chloride-containing plastics in the waste stream; and
- costs of landfilling the potentially toxic ash from the incineration process.

All these factors can add considerably to the overall operating cost of the system. Economics favor the generation of steam and/or electricity rather than incineration alone, due to rates paid for the energy which is produced. If there is a nearby steam customer, the production of both steam and electricity is even more economically attractive due to the operating cost offsets provided by the revenues from the combined sales. A more detailed discussion of technology or economics is beyond the scope of this manual, but does require careful consideration before deciding on any system. This is one area where a competent, trusted consultant may prove indispensable.

Energy recovery, or waste-to-energy, has been promoted by vendors as being the ideal alternative to landfilling and as a profitable means of reducing waste volume. Some localities are aggressively pursuing this technology, only to find that some of the same problems will be dealt with all over again as air emissions control regulations and ash disposal requirements increase the costs of operating these facilities.

As EPA tightens air emissions control regulations and residue disposal requirements, it may become cost prohibitive to build and operate small plants for single municipalities; and as facilities pass these costs on in higher user fees, it may become more difficult to maintain the flow of waste necessary to operate the facility. The uncertainty of these regulatory and economic factors should be factored into both the planning and the size scaling of WTE systems (see **Program Implementation** chapter).

Local governments can experience costs overruns if they are not fully aware of all aspects of construction, operation or service contracts. Contractual guarantees are probably the best way to assure that both parties have a clear understanding of the services requested and the nature of the final product. To help keep final costs consistent with original projected costs, the following contract guarantees are desirable:

- guarantee to construct the facility for the given price and schedule;
- guaranteed availability or the percentage of time the facility will be in service;
- guaranteed efficiency of the plant;
- guaranteed start-up and operating costs of the plant and supporting facilities; and
- guaranteed environmental conformity (including emissions control and ash management).

WASTE-TO-ENERGY (WTE) OPTIONS

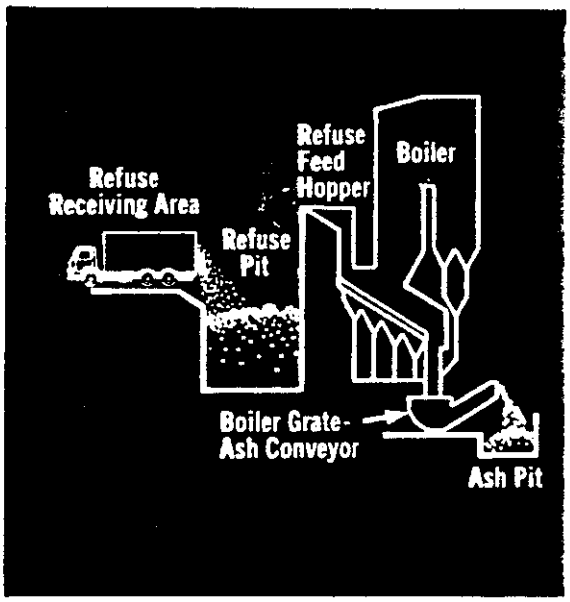
Recent figures indicate there are about 111 incinerators in operation in the country handling about 66,000 tons of waste per day, with 210 additional facilities in the planning or construction phases (63). There are two main techniques for energy recovery from municipal waste, distinguished by fuel preparation:

- **Mass burn** and
- **Refuse derived fuel (RDF)**

Mass burn facilities are those utilizing refuse "as received," without prior materials recovery to enhance fuel value. Sixty eight percent of incinerator capacity is currently served by the older mass burn incinerators (63). Common practice in the past was to remove only large or non-combustible items such as tree stumps, major appliances and engine blocks from the waste stream. Due to increased concern over air emissions from the mass burning of undesirable items such as plastics and potentially hazardous waste, and the realization that noncombustibles decrease burn efficiency, more efforts are now being devoted to removing those items prior to incineration.

Ideally, once these recyclable materials and noncombustibles are removed, the remainder is fed into the furnace where the combustibles are burned off and any remaining non-combustibles pass through to the ash pit. Mass burn usually results in 65 to 90 percent volume reduction, depending largely on how much non-combustible material is removed prior to combustion.

Figure 7: Schematic of Mass Burn Technology



There are three types of mass burn plants in common use for burning solid waste for energy recovery.

1) **Waterwall** - water in the walls of the furnace is heated by the combustion to produce steam for energy recovery.

2) **Refractory** - furnaces are lined with a refractory material, and steam is produced by heating water in conventional boilers.

3) **Modular** - plants are usually prefabricated and shipped to the site fully assembled. Heat is recovered from the hot flue gases.

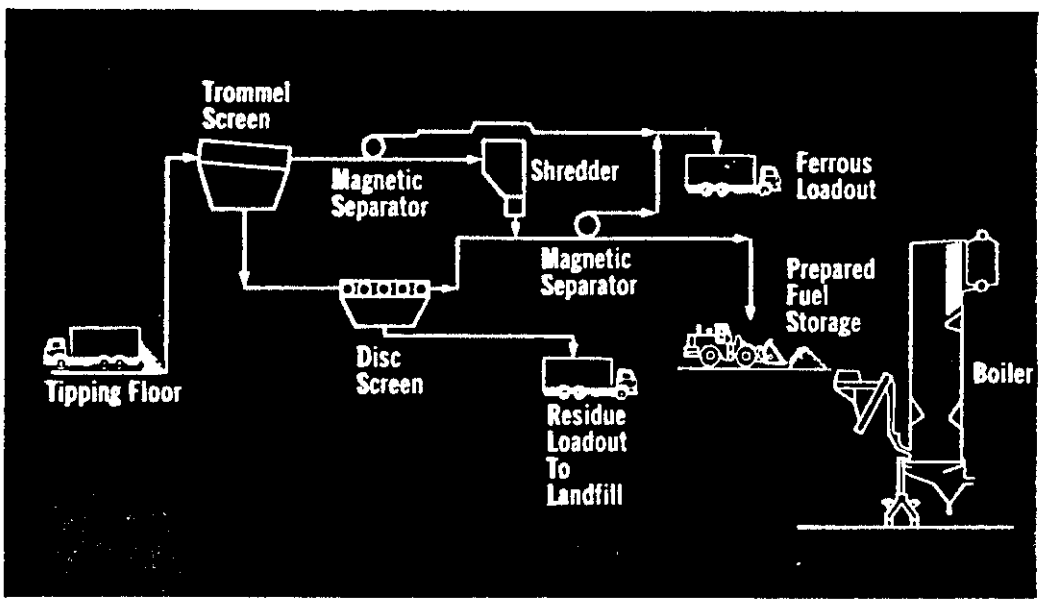
Waterwall units are generally the most efficient type of the mass burn furnaces. Waterwall and refractory plants make up the largest number of incinerator plants planned, under construction, or operating.

- **Advantages of mass burn** include lower capital costs than other types of incinerators, minimal fuel processing, and a longer record as a proven technology.

- **Disadvantages of mass burn** include unpredictable heat value and moisture content of the waste due to variability from load to load; corrosive damage to equipment, due to alternating heating and cooling which results from the differences in energy value of waste; high quantities of ash produced due to non-combustibles; increased toxics content of ash, due to toxics remaining in waste fed into furnace; and the need for rugged design, due to damaging materials and the fact that glass and ferrous metals, if not removed, can clog grates.

Refuse Derived Fuel (RDF) facilities are those which use a fuel mechanically prepared from the waste or refuse. These facilities are an increasingly popular energy recovery alternative to mass burn incineration technology. Waste as received is separated and classified, with resalable and recyclable materials removed via one of several possible systems (see **Figure 8**). The waste which is not recoverable for its material value is shredded, or ground to a suitable size for burning.

Figure 8: Schematic of Refuse Derived Fuel (RDF) Technology



The resulting fuel is uniform in size and can be fed into the furnace using feeders similar to those used to burn wood waste in the forest products industry. The fuel is suitable for combustion in semi-suspension or suspension furnaces. RDF can be sold to customers with existing furnaces for co-firing with other fuels such as oil or coal. It can also be burned in boilers dedicated solely to RDF.

- **Advantages of RDF** include more efficient, higher energy yield than mass burn; lower ash production and less toxic ash as non-combustibles are removed prior to burning; revenues can be recovered from recyclables; less forced combustion air required and more predictable operation, due to greater consistency and higher combustibility of fuel; and air emissions rates are lower for RDF than for mass burn, although achievable levels of emissions (after emission controls) are relatively similar.

- **Disadvantages of RDF** include more complex technology, and hence higher capital and maintenance costs; and lower availability, in terms of the percent of time the plant is operational, due to more shutdowns for maintenance and repairs than mass burn.

Table V: WTE Residue Analysis and Combustion Efficiency

Analyses

	Weight Percent		
	Mass	RDF	Bituminous Coal
Carbon	27.9	36.1	72.8
Hydrogen	3.7	5.1	4.8
Oxygen	20.7	31.6	6.2
Nitrogen	0.2	0.8	1.5
Sulfur	0.1	0.1	2.2
Chlorine	0.1	0.1	0
H_2O	31.3	20.2	3.5
Ash	16.0	6.0	9.0
HHV (wet) Btu/lb	5100	6200	13,000

Efficiency

	Percent		
	Mass	RDF	Bituminous Coal
Dry Gas Loss	10.1	6.3	6.2
Moisture in Fuel Loss	14.5	11.0	4.2
Moisture in Air Loss	0.2	0.2	0.2
Unburned Combustibles	3.3	2.2	2.5
Radiation	0.5	0.5	0.3
Unaccounted	1.5	1.5	1.5
Total Losses	30.1	21.7	14.9
Efficiency	69.9	78.3	85.1

AIR QUALITY IMPACTS

The incineration of municipal solid waste, though attractive from the standpoint of the potential derived energy, has associated with it the production of a variety of pollutants. The pollutants of primary concern from solid waste incineration facilities include sulfur dioxide (SO2), nitrogen oxides (NOx), volatile hydrocarbons (HC), carbon monoxide (CO), particulates (coarse and fine), heavy metals (lead, beryllium, mercury, cadmium and others), polychlorinated dibenzo-p-dioxins (PCDD or dioxin), polychlorinated dibenzofurans (PCDF or furans); hydrogen chloride (HCl) and hydrogen fluoride (HF) **(64, 65, 66, 67).**

The emissions associated with WTE must be properly controlled to minimize potential adverse impacts on air quality.

The presence of these materials, and the levels at which they are emitted, are strongly dependent on waste composition, pre-combustion waste processing, combustion conditions, and post-combustion emission controls (68, 69, 70, 71).

Mass burning of waste at WTE facilities without pre-processing of refuse to the extent of removing non-combustibles, recyclables and toxic materials and their precursors can result in poorer combustion conditions than would be optimal for minimizing emissions. Undesirable conditions include:

- lower combustion temperature, causing less complete burn;
- higher ash content, which increases residue volume; and
- inclusion of materials releasing toxic metals, dioxins and hydrocarbons.

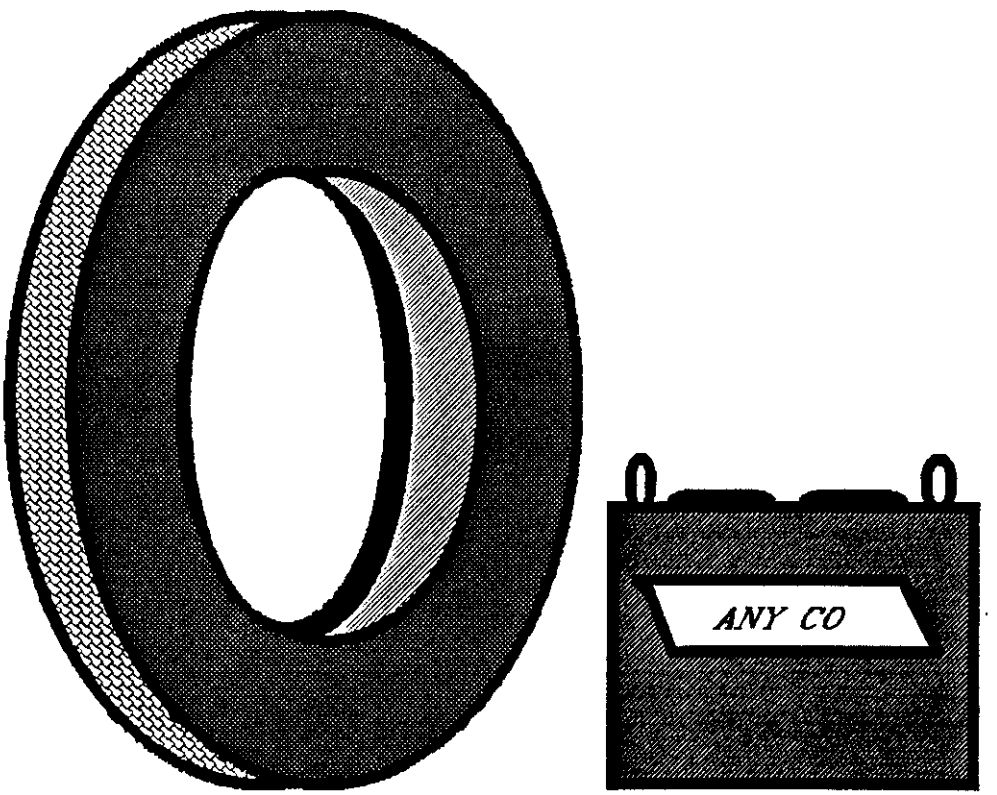
ASH DISPOSAL

Despite its impacts on solid waste volume reduction, incineration does not eliminate the need for landfills. Anywhere from 10 to 30 percent of the initial waste will remain as non-combustible residue to be removed from the furnace and air pollution control equipment. A leading controversy today over the acceptability and economic viability of WTE is how to dispose of the **residual ash** in the process. Ash from solid waste incinerators, particularly from mass burn plants which receive unseparated waste, can have significant levels of toxic materials including lead, cadmium, beryllium and mercury. Ash from such facilities will need to be disposed of in properly designed and constructed landfills or cells within a landfill. The cost of lining, groundwater monitoring, and leachate detection, collection and treatment systems for such landfills can drive the cost of the landfill to receive this ash up to $150,000 or more per acre. These costs, in terms of cost per ton of refuse, need to be included in operating cost estimates for incinerators.

Air emissions and ash disposal are the primary environmental concerns surrounding energy recovery technology. Other environmental problems which are not always considered include noise, odor, and traffic (though note that many of these problems are also common to alternatives such as recycling, composting, and disposal facilities). These may become added and unexpected financial burdens to any type of waste management facility if not addressed in the original contract. Adequate controls will need to be incorporated into the design if the facility is going to operate as a "good neighbor."

VI

SPECIAL WASTE



VI

SPECIAL WASTE

Some components of the waste stream present special problems and do not lend themselves well to traditional waste management options, although collection, transport and processing should be integrated with the overall waste management scheme. The most notable of these special waste materials are:

- **HOUSEHOLD HAZARDOUS WASTE**
- **SCRAP TIRES**
- **LEAD ACID BATTERIES**
- **WASTE MOTOR OIL**

HOUSEHOLD HAZARDOUS WASTE

Household waste that exhibits hazardous properties is a small, yet potentially harmful and administratively problematic component of the solid waste stream. Commonly referred to as "household hazardous waste," this component when disposed of in unlined municipal landfills is thought to be one of the contributors to groundwater contamination in surrounding areas (72).

Even though household hazardous waste is defined and categorized by the same characteristics that designate a substance as a hazardous waste under the Resource Conservation and Recovery Act (RCRA), household hazardous waste is exempt from Subtitle C, hazardous waste regulation. By law, therefore it is a solid waste and is regulated as a Subtitle D, non-hazardous waste.

Many counties and municipalities, despite the fact that they are not required to manage household hazardous waste separately, have targeted special efforts toward reducing this toxic component of the solid waste stream. Much of the effort has been educational. Consumers are encouraged to use non-toxic products or alternative products that are less toxic when at all possible: potentially harmful products should be purchased only in needed quantities, and any leftovers should be given away to avoid improper disposal.

Some localities have gone a step further and have instituted special collection programs for household hazardous waste. The most popular type of program has been the highly publicized "Collection Day" (better known as "Amnesty Days" in some areas), where a sponsoring organization hires a licensed hazardous waste firm to sort, classify, package, transport, and ultimately dispose of the waste. To date, more than 800 collection events have taken place across the country. In North Carolina there has only been one such event, sponsored by the GSX corporation, the local Chamber of Commerce and Boy Scout Troop in Eden and Reidsville, N.C. in 1985 **(73)**.

Although the topic of household hazardous waste has sparked the interest of many local officials, citizen groups, business and industry representatives, and the general public, collection programs require a great deal of organizational effort and are relatively costly. In addition, sponsoring organizations have been reluctant to sponsor or participate in household hazardous waste collection efforts for fear they would be considered a hazardous waste generator and therefore subject to pertinent laws and regulations. What is often not recognized, however, is that a county or municipality can be held liable under the Comprehensive Emergency Response Compensation and Liability Act (CERCLA) for the costs of remedial action for the same waste in a landfill under their control.

In addition to legal concerns, the prevention of accidents and exposure to residents in the home and to sanitation workers, and the prevention of environmental damage, are compelling reasons to initiate a collection effort designed to eliminate these materials from the waste stream.

Typical categories of waste collected at household hazardous waste programs include yard and garden products, household cleaner products, automotive products, and paint and solvent products. Items such as wood preservatives, pesticides and herbicides, antifreeze, drain cleaners, paint thinners, and old batteries are just a few examples of products that are considered as household hazardous waste.

A separate document that addresses the issue of household hazardous waste in detail is: Household Hazardous Waste: Collection and Disposal Options for North Carolina Communities. Copies are available from the N.C. Pollution Prevention Program (see **Appendix B**).

TIRES

North Carolinians discard an estimated nine million automobile tires and 2 million truck tires annually. On a national basis, 26 to 30 percent of the tires discarded are recycled as retread tires, rubber products manufacturing feedstock or miscellaneous rubber products, or are burned as a supplementary fuel. The remaining tires are disposed of primarily in landfills and scrap tire piles or left abandoned. One scrap tire dump in North Carolina is the site of an estimated 7 to 10 million tires (74).

Discarded tires are the cause of a number of environmental and public health problems. Scrap tires are often dumped over embankments, where they may be washed down creeks and rivers and into lakes. Tires that are buried whole have a tendency to "float" back to the surface. Exposed tires provide cover and nesting space for pests such as rats. The tendency of tires to trap water produces noxious odors and provides numerous breeding grounds for mosquitoes and bacteria. Scrap tire piles have often been set afire or inadvertently caught fire, and under these conditions - or if burned in solid waste incinerators without proper control equipment - emit an estimated 138 pounds of particulates per ton of tires (75).

The very properties that are desirable in road use of tires are the same properties that add to the difficulty of disposal. Chemical agents are added to modern tires to prevent decomposition by oxidants such as ozone, to retard fire, and to prevent them from rotting due to bacterial and fungal growths. It is these very agents which prolong the existence of tires once they have been discarded. Steel reinforcement in tires increases the tread life and strength of the tire on the road; yet it also increases the difficulty of recycling tires.

The objectives of a scrap tire reclamation project should be to find the most efficient means of reuse and recycling. Technology exists for the reclamation of some components of tires and subsequent use in manufacturing processes. RW Technology Inc, in Cheshire, Connecticut, is attempting to patent a new plastic which gains increased strength and durability through incorporation of finely ground auto tires. The new material, Typlax, is made from polyethylene compounds and is tougher and less costly to produce than polyethylene because of the powdered rubber additive.

Mechanically crumbed rubber has been utilized as an experimental road asphalt additive, with the following results:

- o prevents cracking,
- o reduces maintenance,
- o provides a flexible surface, and
- o lasts up to twice as long (76).

These reclamation measures are utilized on a very limited basis at present, due largely to the uncertainty in the marketability of the recycled product and to the costs associated with collection and transport. A North Carolina firm has begun offering tire removal services to counties. Arrangements include a per tire fee to the landfill operator and a box trailer on site for storage. Tires are then transported to Georgia where they are processed for use as fuel (see NC Tire Dealer's Association contact in **Appendix B**).

A primary need is to evaluate the scrap tire situation and determine the feasibility of a statewide approach toward developing markets for end products of scrap tire reclamation. This could be addressed through a program to determine if sufficient incentives exist for recovery of the state's scrap tire resources by private industry and what role, if any, state and local governments might play.

The program should also include an evaluation of existing collection and transportation infrastructure which might be accessible for scrap tire reclamation. Where transportation or collection systems are non-existent or deficient, criteria need to be developed for use in determining whether developing the needed transportation network or a localized reclamation facility would be more prudent. Costs and liabilities of collection and reclamation activities may necessitate state sponsorship.

In 1986, the North Carolina General Assembly authorized the formation of a Used Tire and Waste Oil Disposal Study Committee. The study committee recommended coordination among local and state officials, industry, researchers and the general public in efforts to solve the scrap tire problem with emphasis on recycling and recovery.

LEAD ACID BATTERIES

Lead acid batteries (typical automobile batteries) are regulated as a hazardous waste and can not be disposed of in a municipal landfill. Some states, such as Minnesota, have instituted landfill bans on batteries, accompanied by requirements placed on wholesalers and retailers to accept returned batteries. Reclaimed batteries can be recycled, eliminating potential environmental and human health problems if handled properly.

In North Carolina, spent lead acid batteries that are sent off-site to be reclaimed are not regulated as a hazardous waste. Therefore, individuals or companies who participate in reclamation activities, such as vehicle maintenance shops, service stations, retailers and wholesalers, are not required to count the batteries in determining the quantity of hazardous waste generated per month. However, spent batteries must be stored in a manner that prevents leakage of acid or hydrogen gas to the environment. The owners or operators of facilities that store spent batteries before reclaiming them on site must notify the N.C. Solid Waste Management Section and follow applicable treatment, storage and disposal facility standards and applicable permitting procedures. Batteries that are being disposed of (not recycled) must be managed at a permitted hazardous waste facility due to the lead and acid content. For more information on the handling, storage, or recycling of batteries contact Judy Lund of the Solid Waste Management Section (see **appendix B**).

WASTE MOTOR OIL

Waste motor oil is a waste that can lead to surface water, groundwater, and air pollution when improperly discarded. Crankcase oil drainings have been reported to account for more than 40% of the total oil pollution of our nation's harbors and waterways. Improperly dumped oil can be attributed to lack of options and lack of knowledge about proper disposal as well as carelessness.

Waste motor oil can be collected in household hazardous waste collection programs, and often is. If waste oil is collected in such programs, or otherwise, the preferable management option is to recycle it. Due to a drop in virgin oil prices, service stations and other collection facilities that previously accepted used oil from homeowners or other individuals are now having to pay for used oil to be collected and as a result have stopped providing this

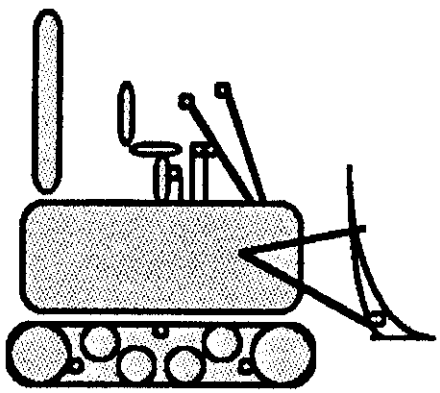
service. In order to provide available disposal options for "do-it-yourself" oil changers, some states and localities have initiated programs specifically for used oil. Minnesota state law requires retailers of motor oil to post a sign indicating the nearest location where a tank is provided for depositing oil, or to provide a tank. At the same time, Minnesota has banned motor oil by law from land disposal. Recycled oil is typically burned as a source of recoverable energy.

Project ROSE (Recycled Oil Saves Energy) is just one example of a used oil recycling program that has been quite successful in preserving the environment and saving energy while providing an option for used oil disposal. Funded by the Alabama Department of Economic and Community Affairs, Project ROSE works with government agencies, civic and volunteer groups, education and service clubs, and retailers to promote and manage used oil recycling activities throughout the state. Two statewide, toll-free energy hotlines which allow project staffers to provide information to potential users, and 318 collection centers for the "do-it-yourself" oil changers, are the center of the project's success. In recognition of Project ROSE's efforts, EPA granted the program a one-year contract to organize a region-wide used oil management/information exchange network for the southeast.

Used oil programs in other countries also demonstrate that there are many creative ways of dealing with the problem. In West Germany, 70% of all used oil is recovered. In Japan, the public is required to turn in their used oil in order to buy new oil.

Some waste oil recyclers will provide collection tanks at the landfill site and periodically service them free of charge **(77)**. For more information on waste oil recycling programs in North Carolina call Judy Lund at the Solid Waste Management Section (see **Appendix B**).

VII



RESIDUE DISPOSAL

VII

RESIDUE DISPOSAL

THE NEED FOR LANDFILLS

Even the most aggressive and most comprehensive solid waste reduction efforts will not be able to reduce the entire waste stream. While it may be possible to achieve an 85 to 90 percent reduction in volume if the integrated approach is effectively implemented, that still leaves 10 percent or more of the original waste volume requiring safe disposal. In the best case, if all recoverable and problem materials have been removed from the waste stream, it is feasible that the final residue following energy recovery will be an inert material which can be safely managed if disposed of in a properly designed landfill.

Landfills, like all other solid waste management facilities, require state permits from the Department of Human Resources. North Carolina counties have experienced a marked decrease in the number of permits granted for new facilities or for landfill extensions, due to more stringent groundwater protection regulations, and concerns with landfill gases. Standards for non-hazardous solid waste landfills are being upgraded to require leachate collection systems, landfill liners, and groundwater monitoring.

Proposed EPA sanitary landfill guidelines will have both quantifiable and unquantifiable impacts on the economics of landfilling. It is important to assess the effects of these regulatory and economic changes in comparing the options available for waste management.

LANDFILLING ECONOMICS

New Hanover County is the only county in North Carolina that found it necessary to design and construct a landfill with synthetic liners ahead of regulations requiring such action. Due to a combination of unsuitable sites, suspected groundwater contamination and permitting problems, the county found they had no alternative. Their experiences and costs provide a real-world glimpse of the direct costs of high tech landfills. These costs will not necessarily be an accurate reflection of what can be expected in the future at other sites across the state, but they do serve as one concrete illustration for comparison with other options.

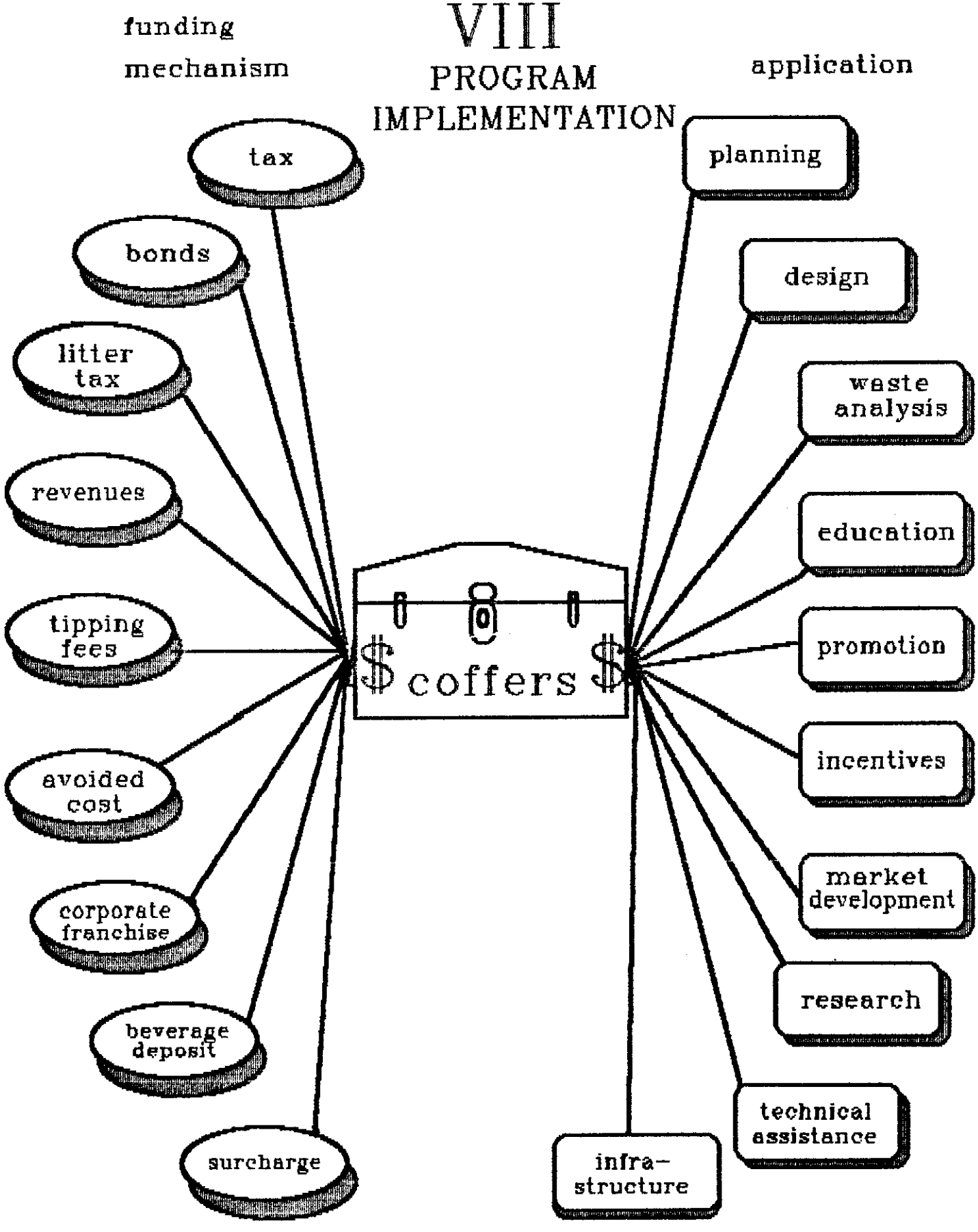
The first phase of New Hanover's landfill construction took 9 months and cost $3 million to complete. This phase included a 10 acre cell with artificial liners and a 2 acre leachate lagoon as well as a 3/4 mile access road, wells, water lines, and fencing. The second phase cost $620,000 in 1985 for construction of a 5 acre lined cell and two pump stations. The county is currently taking bids for a third cell of 7 acres, with cost estimates at about $1 million. Averaging these total costs over the full acreage available for landfilling results in a construction cost of $210,000 per acre (78).

In addition to construction costs, New Hanover County has had sufficient operating experience to identify some of the costs and problems associated with the operation of high-technology landfills. Operation and maintenance costs for this landfill are currently budgeted at $750,000 per year, and with debt servicing are over $1 million per year. Additional costs incurred will be for final closure and monitoring.

Solid waste management officials and operators need to assess their situation to determine the feasibility of passing costs on to the user; and if so, whether tipping fees or taxes or some other funding mechanism can be instituted. The extent to which waste generators will turn to illegal dumping as an option to avoid the increased cost of legal landfills will also need to be assessed. In some localities the answer may be to contract with one of the growing private comprehensive waste management firms, while others may find some relief in various arrangements with local industries through which some of these costs can be absorbed.

In any event, the rising costs of landfilling are just beginning to be realized in North Carolina; an occurrence that is likely to become the norm. In the face of rising costs, the benefits to be gained from diverting as much waste as possible from landfills increases accordingly. Part of that benefit includes the **savings in avoided costs of disposal**. These cost savings may prove to be far more significant benefits than the value of recovered material or energy alone.

VIII
PROGRAM IMPLEMENTATION



VIII

IMPLEMENTING SOLID WASTE REDUCTION PROGRAMS

This section is intended to help local governments develop their own approach to waste reduction. We have identified stages of program development that are critical to the success of a waste reduction program, suggested guidelines for setting clear goals and objectives, and discussed how to judge progress by establishing evaluation milestones along the way.

Regardless of existing circumstances, designing and implementing a solid waste reduction plan requires a commitment to do the job and do it right. The mere fact that one is willing to commit to preventive planning rather than continue operating in a "bandaid" mode is a step in the right direction. This section is designed to provide guidance for getting started and to address critical steps in the process of implementing a waste reduction program.

The five primary phases in designing and executing a waste reduction program are:

- **ESTABLISH TASK FORCE**
- **COLLECT DATA**
- **DESIGN PROGRAM**
- **INITIATE PROGRAM**
- **EVALUATE PROGRAM**

PHASE I: ESTABLISH TASK FORCE

It is essential to assess needs, priorities, resources, and local situations before committing to particular programs and technologies. Inadequate planning can lead either to premature commitments to costly and inappropriate choices, or to premature failure of what might have been <u>good</u> ideas.

No one person can do this alone. The decisions that must be made to initiate a solid waste reduction program involve deciding on the type of methodology to use, the scale for the program, supporting ordinances needed, financing arrangements, and other issues which either directly or indirectly affect many people with diverse and sometimes conflicting concerns. Although a regional, county, or

conflicting concerns. Although a regional, county, or municipal staff person may have ultimate responsibility for program implementation, outside input into the decisionmaking process is essential.

One way to reach agreement on program attributes and community needs is through a **solid waste task force.** Establishment of such groups helps local government hear all views before decisions are made, demonstrate that decisions are not set in concrete, and ultimately, build broad community understanding and support for solutions. Task forces serve as a forum for discussion, brainstorming, critical analysis, and if all goes well, eventual endorsement of a proposed project or action. It is necessary for the task force to develop a sense that decisions made by the group will in fact be heeded when elected officials or other decision-makers ultimately decide upon waste reduction strategies.

Typical task force roles can include:

- providing opportunities for citizens to assist in planning efforts (voting seats on a solid waste task force),
- providing avenues for more widespread review of planning documents and public educational materials;
- providing opportunities for the public to ask questions and give input into technology selection (i.e., composting vs. RDF plants), and
- development of site selection, and local control provisions for proposed facilities.

Waste reduction programs can include a variety of technologies and policies that are perceived in conflicting ways by different parties. Success of the waste reduction program requires general agreement on the philosophy of the program and a solid base of support for the subsequent actions by the group. Actively recruiting individuals who are truly representative of different sectors, and committed to working together to lay the groundwork for a waste reduction program is worth the time it may take.

As with any new initiative, lines of communication should be recognized and established where necessary. If a newly formed task force is located within an existing department or agency, the creation of it, the members serving on it, and its roles should be publicized. An announcement of the task force, or an initiative to begin work on a waste

newsletters, interagency publications, and in the local press. This allows for a better understanding of the initiative toward waste reduction and primes affected groups and individuals when more substantive proposals or actions are released.

To gain support and to establish credibility for a new idea, a foundation must be built upon which to operate. An attempt should be made on the part of the task force or by the agency involved to identify other agencies, groups, and individuals who would be potentially interested in a waste reduction initiative. For example, the public health department, public works department, planning and budget offices, as well as public information, public service, and other organizations with an interest in solid waste or other environmental or land use issues should be notified.

Technical Support: Even in very preliminary stages, some technical support is needed in the way of finances and human resources to support the activities of the task force. One of the most effective ways of accomplishing this is to specify it outright in the planning budget and staff assignments of the coordinating agency most directly involved in the waste reduction program. In many cases, this will be the public works department.

Getting Started

Some of the first questions that need to be addressed before committing significant amounts of time and resources toward a waste reduction program, include:

- What are the motivating circumstances directing our locality toward solid waste reduction?
- What objectives are to be accomplished by establishing a solid waste reduction program?
- What is the desired outcome of the program?
- Is there a serious commitment on the part of individuals involved?
- Is the timing "right" to bring up the idea?
- What has been done already in the way of waste reduction, and how much more needs to be done?

These and other similar questions provide a starting point for discussion and future action. Again, this is an

These and other similar questions provide a starting point for discussion and future action. Again, this is an excellent job for a task force and for paid staff persons who will be integrally involved in the implementation of a waste reduction program.

Set Goals and Objectives

A goal statement should specify the direction and desired outcome of the waste reduction program as defined by the philosophies, values, ideals and constraints of the community. Goal setting gives an overall, explicit purpose to the program in terms of how much waste is to be reduced. For example, Mecklenburg County's Board of County Commissioners set a recycling goal of at least 30 percent of the waste stream by the year 1994 (79). Sunshares set a recycling goal for Durham County of 250 tons per month by the end of their first year. According to the director of Sunshares, they are ahead of schedule. It is important to keep the goal realistic and achievable, but also challenging.

Objectives, on the other hand, are more specific targets against which solid waste reduction achievements are measured. Objectives provide incremental information, or milestones for gaging how well one is attaining the stated waste reduction goals. For example, one objective of a county which found that 30 percent of its waste stream being landfilled was cardboard might very well be a program in which 80 percent of the cardboard is to be removed. Current data on the waste stream are required in order to set worthwhile objectives.

It may be necessary to reassess program goals and objectives at various points along the way to adapt to changing needs. It is especially useful to conduct an evaluation of the program's progress, and make program modifications based upon the successes (or failures) of stated objectives in time for budget submission for the coming funding cycle. This might involve cutting back on certain aspects of a program that are not working or stepping up those aspects that are.

PHASE II: COLLECT DATA

In order to design a waste reduction program suitable for a specific locality, there must be some idea of what wastes are currently being managed. To achieve this requires answers to the following questions:

- How much waste is generated?
- What types of waste are generated?
- What are the sources and locations of each waste type?

Waste Stream Characterization

Gathering data on the types and quantities of waste is important, as is determining the source of concentrated, single component waste streams. Few localities have actually assessed their waste streams as yet to allow for long-range integrated waste management planning. While national waste stream data is helpful, the reliance upon such generalized information provides insufficient data on the types and sources of waste generated in a specific community. Studies indicate that the types and amounts of waste vary significantly from one locality to the next, depending on a number of socio-economic, geographic, and other area-specific factors which are not well represented by national estimates **(80, 81)**.

Waste characterization should be carried out over a full year, if at all possible, to detect seasonal variations. Yard waste volumes, for example, fluctuate significantly at different times of the year **(82, 83)**. Scales at the landfill site are helpful in gaining waste characterization data. If they are not part of the permanent equipment, shared purchase or rental of portable scales by multiple counties within a region is a potentially affordable option.

Model waste stream analysis methodologies have been developed and used by the Land-of-Sky Regional Council in Asheville, NC, for several of the council's member counties. In Land of Sky's Solid Waste Planning Manual for Local Governments, Development Districts, and Councils of

Government, the basics of a workable waste stream characterization study are outlined and discussed (see **Appendix B** for full reference). Some of the elements of a waste characterization study include:

- o weighing techniques,
- o composition sampling techniques of waste deposited at the landfill (including residential vs. commercial/industrial sampling),
- o sorting techniques,
- o data entry and analysis,
- o duration and costs of study,
- o possible problems,
- o tailoring the study to the locality, and
- o using information to evaluate alternatives.

In order for exchange of data and technical assistance to be useful, it is important to use a standardized method of collection. Practicality of the collection method and simplicity in technique will influence participation levels among localities, and hence, help develop more complete data. Standardization of the collection technique from one locality to another is essential, particularly if the data are to be used for regional projects.

An instructional videotape on waste stream characterization at the Buncombe County landfill is available from the **Environmental Quality Institute** at the University of North Carolina - Asheville. The videotape explains the logic and methodology of a waste stream characterization study in sufficient detail to begin planning the study (see **Appendix B**).

Projection of waste quantity and composition

It is impossible to project commercial and residential quantities and composition with complete certainty. Realistic projections based on available data are integral to program design and often dictate its long term viability. Projections should be based on such factors as population density and growth estimates, and should focus on long-term trends (10 to 20 years) rather than short term trends **(84)**.

Projections on the low side are likely to be less damaging to the program in the long run than erring on the high side, especially when it results in over-sizing capital intensive facilities (85).

How much waste can be reduced?

Based upon the data obtained from the waste stream analysis, one can begin to identify and explore possible options for targeting waste reduction within the service area. For example, in Alamance County, county officials and members of the solid waste task force learned that corrugated alone accounted for 31% of the county's total waste stream (86). Based upon those findings, a significant reduction in the volume of waste going to the near-capacity landfill could be accomplished by an aggressive recycling program which would include corrugated box recycling as a high priority component.

Even if the results of a waste stream analysis don't always point to such clear steps of action, the benefits of knowing which wastes and how much are produced within the service area will help those involved in subsequent planning efforts. In addition to providing information needed to prioritize components of the waste stream to target, if done properly, the data gathered will enable decisionmakers to develop strategies for various components based on their source. For example, this information can help determine whether to separate at the landfill, or require the generator to reduce or separate certain concentrated waste types.

Market Assessment

Once data are obtained on the quantities of recyclables (and other types of materials) in the waste stream, and the percentage of each which is recoverable is estimated, it is necessary to assess the secondary materials market available to the locality. A good initial source of information is a local scrap dealer or trade association. The yellow pages of the local phone book, or a phone book from the nearest metropolitan area, can be consulted to help identify markets and obtain free technical assistance and advice. Categories to search under include:

- recycling Centers
- scrap Metals

- specific material types (glass, paper, etc.)

The more information that can be provided to the companies being contacted, the better the information obtained on the potential of the various markets. For example, if estimates can be made as to the quantity of the specific materials that can be expected to be recovered from the waste stream, the more likely dealers will be to give higher estimates and to give a written indication of interest along with the price they will pay and the terms of delivery (87). For more information on materials dealers and trade associations, see **Appendix B.**

Inventory Resources

Prior to implementation of a waste reduction program, it is helpful to assess the resources which are available for program use. Available resources to be inventoried to assist in planning include financial resources, personnel, equipment, and in-kind services. Use of the following guidelines will help direct efforts to identify resource inadequacies and to realize and utilize potentially "hidden resources":

- **current motor fleet-** How many trucks are currently in use? What kind of shape are they in? What is the feasibility of retrofitting vehicles for recycling efforts?

- **personnel-** How many people are involved in current solid waste operations, support services, and management? What types of skills do they have?

- **organizational structure-** How is the agency responsible for solid waste set up and administered? Who has decisionmaking authority?

- **funding-** Where does program funding come from? What is the annual budget? Have there been any significant budget changes within the last few years? What mechanisms are there for securing additional funding for a waste reduction program (for example, an increase in tipping fees)?

- **collection routes-** What geographical areas does the current collection route cover? How are collection routes determined? How often are they changed? Is

routing done via computer? Are there any special types of collections (i.e, non-routine collections, such as bulky items, hazardous waste, etc.). If so, with what frequency?

- **treatment/disposal practices-** What happens to the waste once it is collected? Is there any attempt to separate waste after collection? Are there any recycling efforts (and if so, for what materials)? Any other treatment methods (i.e., composting, incineration, etc.)? Where is the waste ultimately disposed? How are landfills managed? What is the current remaining capacity?

- **local policies affecting operations-** What are the state and local policies that govern solid waste management within the service area? What is the history behind these policies?

- **other special circumstances-** Are there other aspects (resources or constraints) of the solid waste program that must be taken into consideration or require special efforts?

The information gathered during the course of the program assessment can be compared to what would be needed for setting up the program elements. The difference indicates the need for additional resources, and allows for acquisition of these resources to be factored into the development of a budget.

Identify Information Gaps

By this point it should be apparent to the task force if there are significant pieces of information that are needed in order to move forward with waste reduction planning. If unanswered questions prevent the group from continuing with its mission, a decision of whether to seek the help of an outside consultant must be made. Whichever route the group chooses to take, the primary information that will provide criteria upon which to make informed decisions, is that of program feasibility and cost, given different scenarios of program design.

Conduct Feasibility Study

If a formal program feasibility study is conducted, it must include **technical, environmental, political,** and **economic** factors. An economic analysis is often the first step, and in many instances, a comparison of economics between alternatives is the single most important evaluation made to determine feasibility. A good feasibility study is a step-wise assessment of costs and benefits of all alternatives using comparable data. Feasibility study methodology is generally conducted in the following sequence of tasks: 1) gathering basic data, 2) identifying markets, 3) selecting alternatives, 4) modeling net system costs, and 5) comparing alternatives.

Hiring a Consultant or Staff Person

Many communities have opted at some point to hire outside consultants to study their waste management needs. Others, due to time or budgetary constraints, or the good fortune of having competent analysts on staff, have chosen to continue with in-house program development.

Prospective consultants can be identified through the following channels:

- trade journals,
- recommendations,
- solicitations/advertisements, and
- phone book

The task force, elected officials, involved staff, and the public must be in agreement that the firm selected is in fact a reliable and trusted contractor who will be working to meet the community's needs. It is extremely wise, therefore, to establish guidelines for selecting a consultant before any requests for proposals (RFP's) are drawn up. The following points should be kept in mind when evaluating consultants for selection:

- avoid hard-sell tactics,
- avoid conflict of interest (consultants which design, sell, and/or operate facilities), and
- avoid conflicting philosophies and personalities.

There are two basic strategies for preparing requests for proposals (RFP); 1) request a proposal for scope of services that will be provided for a fee named in the RFP, or 2) request a proposed cost of performing a given scope of services outlined in the RFP (88). Selection should be done by an evaluation committee using the following criteria (89):

- o experience
- o technical soundness
- o accuracy of response to RFP
- o cost

If a consulting firm is approached by a task force with this much "homework" completed, it should be possible to develop a good relationship that will result in development of the program best suited for the specific locality. Once the consultant has been selected, a committee should be assigned to work closely with them to assure that the final report will be addressing the questions the consultant has been hired to study. It is important to maintain review authority and to keep good records of all agreements and changes in scope or deadlines. Consultants should be given a free rein to be creative and voice opinions and disagreements. Other experts should be consulted regarding unresolved conflicts.

PHASE III: DESIGN PROGRAM

With a waste reduction task force in place and a preliminary assessment of the resources and constraints of the service area complete, an appropriate waste reduction program can be designed. The design process is an important one, and should be carried out with adequate input from key players. The program design should allow for adjustment or expansion as the program matures.

Choose Appropriate Mix of Program Elements

At this point, a close examination of the various program elements and possible combinations of those elements will need to take place in order to arrive at a decision on a suitable waste reduction program. While economics play a major part in the design process, program designers must be aware of the trade-offs between economics, environmental soundness, and public acceptability, in order to develop a

program design that provides the appropriate mix of elements for a county or community. For a decision that is acceptable to all parties, it is imperative that the task force, technical consultants and other decisionmakers work together to determine the exact nature of the waste reduction program that is to be implemented. **Table VI** illustrates some of the program elements of a waste reduction program and the pros and cons of each.

Table VI: Waste Reduction Options

	Which components of the waste stream can be managed?	What percentage of the total waste stream are these components?	What percentage of the waste stream is each option capable of managing?	Total system cost: Potential collection, transport, processing, sales, disposal (cost per ton)
WASTE REDUCTION				
Reduce resource use	nearly all	100	<3	?
Increase product lifetime	nearly all	100	<3	?
Product reuse	nearly all	100	<3	?
Decrease consumption	nearly all	100	<3	?
COMPOSTING				
Low tech	Yardwaste, leaves	6-16	1-16	$9-20
High tech	All organic material	50-70	50-70	$80-100
MATERIAL RECOVERY				
Collection station	newsprint, glass metals, plastic, corrugated,	35-45	<1-5	$10-30
Curbside	newsprint, glass metals, plastic, corrugated	35-45	3-15	$30-70
Office paper	paper	8-12	3-8	$<5>-0
Corrugated	corrugated	10-15	5-10	$<10>-0
Site separated	newspaper, metals office paper, plastic corrugated	35-45	10-20	$50-60
ENERGY RECOVERY				
Mass burn	All but largest objects and ash remaining from incineration	98	60-75	$85-95
Refuse Derived Fuel	Combustibles: paper, food, textiles, rubber, wood	98	60-75	$90-100
LANDFILL	All	100	100	$60-70

(From West Michigan Environmental Action Council Education Foundation, 1986. Integrated Waste Management.)

Determine Financial Needs

Any new initiative requires start up costs, program planning costs, personnel and equipment costs, and operation and maintenance costs. Some of these expenditures may be partially absorbed by existing personnel and programs, while others may represent a new direction that will require additional financing from non-traditional sources. In many cases, this entails a resetting of priorities and may require a new way of thinking and spending by the agency or organization in charge.

The costs associated with waste reduction will be determined by the individual locality and its strategies for targeting waste reduction. Some localities choose to build a waste reduction effort incrementally, while others dive right in and invest a significant portion of financial resources to avoid redesigning programs and procedures thus avoiding additional costs.

In evaluating costs, a key point that is often overlooked is that **costs savings**, gained through reduced landfilling of waste may be far greater than revenues from recycling activities. The concept of cost savings is sometimes difficult one to comprehend and advocate, because there is not always a tangible return on one's investment. "Selling" saved costs is somewhat like trying to sell prevention. The effort required to do something often is not present until a problem emerges -- i.e., the proverbial "squeaky wheel" syndrome.

Develop Program Financing Strategies

Regardless of the program, innovative financing options are always in great demand. The following are the most common means of securing the funding needed to finance waste reduction programs:

- General Obligation Bonds are backed based on the public entity's credit rating, regardless of risks associated with the project. They generally have the lowest interest rates and involve the public through the requirement of voter approval.

- Revenue Bonds are long-term, and tax exempt obligations paid entirely from revenues generated by the project. These are issued by local governments.

- o Leveraged Leasing allows a public entity to pass the benefits of tax breaks or lower financing costs, through lease arrangement, to an otherwise non-qualifying private investor.

- o Industrial Revenue Bonds are long-term, tax exempt bonds issuable by a public benefit corporation to promote industrial or economic development. This type of arrangement usually involves the leasing of the project or loaning bond proceeds to a private corporation.

- o Pollution Control Revenue Bonds are long-term, tax exempt bonds similar to industrial revenue bonds, with the difference that they can only be applied to pollution control equipment. This option is very limited.

- o Grants are not available for waste reduction activities in any substantial amount from the state at present. The Governor's Waste Management Board provides Community Assistance Grants for public education programs.

- o Other Financing Strategies include: tipping fees, direct (product) taxes, and litter taxes (see **Chapter I** under Local Policy Options).

Developing the optimal financing package for a comprehensive waste reduction program involves evaluating and selecting the preferred method of financing for each of the program's components. The participants in the project - local governments and contractors - should each be satisfied with the distribution of the economic risks and benefits associated with the program **(90)**.

PHASE IV: INITIATE PROGRAM

Develop Public Awareness Program

One of the most important aspects of a waste reduction initiative is the development and implementation of a public awareness program. Once awareness of an issue has been established, misconceptions or misinformation can be addressed. The problem of inadequate disposal capacity, the costs of waste management, and the need for waste reduction must be effectively communicated to everyone who generates waste.

Approximately six months prior to the actual start-up of a waste reduction program, an increased effort to publicize the program should be initiated. This is particularly true if the program requires a great deal of public participation to make it work (as is the case in recycling). Increased visibility can be accomplished via promotional materials or by committing a portion of staff time to speak to other agencies, organizations, and clubs about the program and how it will work. While these educational mechanisms are helpful in the short term, some serious thought should be given to long term educational strategies as well.

Targeted groups of individuals can be educated by specific methods such as educational curricula, and through experiential education - learning by experiencing the problem first hand, for example, by touring a landfill or incinerator facility.

Some waste professionals believe that educating young people is the most effective form of solid waste education. The benefits are obvious: not only do children tend to be more receptive to learning, leading the way for them to become informed adults, but they in turn, teach their parents about waste issues **(91)**.

A program of the Columbus, Ohio Health Department called Columbus Clean Community (CCC) has sponsored numerous educational programs for people of all ages. Some of its most effective programs, however, are in local elementary and high schools. "Science Day Research Ideas" is a three year old program that encourages high school students to use solid waste topics to meet their mandatory science project requirement. Students receive a booklet of more than 30 research ideas, suggested experiments, and background information. As an added incentive, the educational specialist at CCC offers to set up tours of facilities and arrange interviews for those choosing a waste-related project. The results of the program have been quite encouraging. One of the students was even successful in selling the results of his project (a survey on the efficiency of different tire shredding equipment) to a manufacturer.

A similar program for high school students was recently developed in Missouri. The Missouri Waste Control Coalition (MWCC) and the state Department of Natural Resources co-sponsor an awards program which recognizes with cash awards, student research and study in the areas of solid waste, hazardous waste, air pollution, and water pollution.

These and other educational programs on solid waste are taking place all over the country. Since an important part of the solid waste disposal problem is public attitudes, these efforts to educate citizens of all ages are an important part of a community's program (see **Appendix B**).

Media Campaign

Awareness will also be increased as the program starts up through participation, visibility, and peer education (word-of-mouth). However, successful development of a public awareness program requires a continued commitment and willingness to try new ideas, and to keep education and information at the forefront of the program. There are many creative mechanisms that can be developed for conveying messages to the public about solid waste issues, the need for waste reduction, and increasing the public's overall knowledge of the problem. The basic elements which can be used to develop a public awareness program include:

- Bumper stickers, pins, posters, flyers, and decals;
- Slide shows or videotapes on waste reduction;
- A speaker's bureau
- Special events and promotions encouraging participation;
- News releases and taped public service announcements;
- A creative logo and letterhead (on recycled paper);
- Media briefings and press conferences;
- Written materials such as a recycling guide.

A well-run public awareness program will require a substantial commitment in financial resources, yet the benefits of the program can be significant in terms of saved disposal costs, avoidance of project delays (such as siting efforts) and increased compliance with aspects of the

program that require active participation (such as residential source separation). Even with the best public awareness programs, however, there will still be individuals who:

- have not been exposed to publicity regarding the program;
- have been exposed and are willing to participate, but have not done so because the incentive is not great enough;
- have been exposed, but have chosen not to participate unless required to, as in areas where mandatory recycling programs have been implemented, or;
- have chosen not to participate under any circumstances.

There have been many ways in which incentives have been used to encourage waste reduction. **Direct monetary incentives** (financial reward for compliance), **indirect monetary incentives** (avoided cost for compliance), and the **provision of services** are just a few examples.

Recognizing the link between incentives and participation rates in recycling programs, some programs have incorporated incentive opportunities into their waste reduction programs. One widely publicized incentive program was initiated in Rockford, Illinois as the "Cash for Trash" recycling program. The program mascot, known to the citizens of Rockford as "Trashman," would sort through randomly selected curbside garbage cans in pre-dawn inspections to see who was participating in the community's recycling efforts. To households separating paper, aluminum and glass, "Trashman" would award cash prizes as high as $4,000 **(92)**.

Even though the city of Rockford has discontinued this approach, other recycling programs, including the one in Davidson, NC, have utilized similar incentives to encourage participation and to get the attention of individuals who on their own initiative would not likely be participants in a voluntary waste reduction program. It remains to be seen whether or not the participation rates observed in the presence of the cash incentive will begin to decline with the removal of the incentive.

An excellent example of the indirect type of incentive is the case of the Boyerstown Disposal Service, Inc., of southeastern Pennsylvania. This waste hauler offers customers a discount on their waste service bill if they voluntarily limit themselves to two trash bags or one 30 gallon can per month. Reducing to this level requires that residents take recyclables to a recycling center. Recyclers in the area claim their business has increased as much as twofold, requiring capital improvements to meet the demand for services. The hauler is contributing money to a non-profit organization to help meet the increased demand.

According to the waste hauling company, the benefits go beyond reducing the landfilled volume of waste, and associated savings in tipping fees. The company has gained a competitive edge on other services in the area by being able to provide lower service rates through the bonus. The company also feels it improves its image in the community by being a responsible player (93).

Initiation of High Payoff Component

In implementing a waste reduction program with limited funds, it is often necessary to start up in steps, or incrementally. Carrying out this incremental process involves assessing the various components of the overall design and initiating that piece which will likely give the highest initial payoff as the "kickoff component." **Payoff**, as used here, is more than monetary gain, although that is one component. Other results that pay off in terms of increasing the program's worth and survivability include:

- maximizing waste reduction relative to program cost;
- increasing public awareness;
- increasing acceptance by public officials;
- gaining media attention;
- expanding the program scope ;
- increasing community, business and budgetary support; and
- increasing participation levels.

Examples of high payoff components might be theme recycling centers, pilot curbside separation programs, landfill bans of problem waste types, or high volume "clean waste" source separation (for example, commercial cardboard recycling). As the component most likely to enhance the program is put in place, and support and participation increase, the next highest payoff component can be implemented, and so on.

Monitor Program

During implementation, it is essential to keep accurate records so that the program can be evaluated as it develops. The areas in which data can be collected should be identified in advance, and documentation forms should be obtained or developed in order to standardize the collection of data.

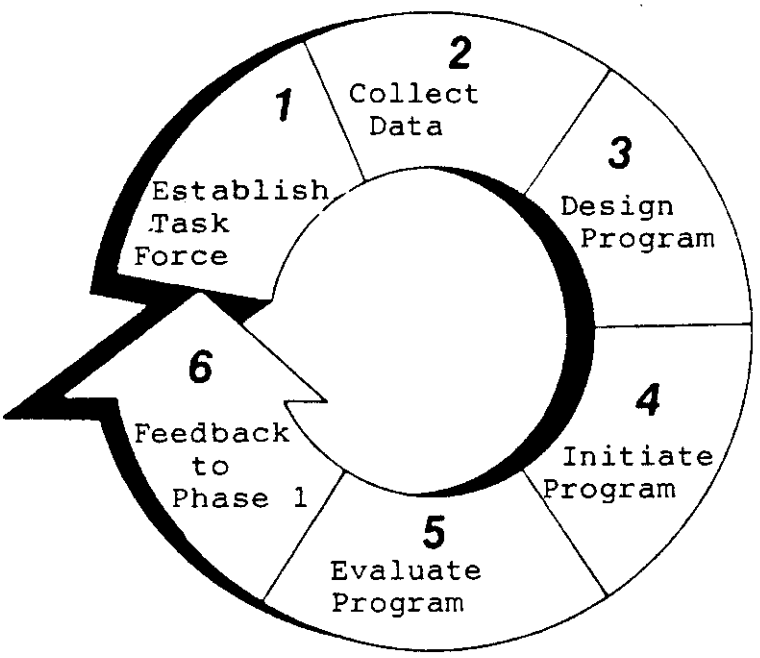
Figures on types and tonnages of waste diverted from the waste stream and from treatment and disposal facilities should be documented. Numbers of participants (individuals, companies, etc.) should also be noted. Expenditures, in-kind contributions, and unexpected costs or savings should also be recorded.

Obvious program flaws or inconsistencies will surface almost immediately, and in most cases can be corrected with minor modifications. More subtle trends or long term effects will only be detected after the program has been in operation for some time, and non-routine occurrences (such as seasonal effects and market changes) are taken into account.

PHASE V. EVALUATE PROGRAM

The full picture of program progress (or lack of progress) cannot be adequately assessed and modified without concentrated evaluative effort. Program evaluation should take place continuously through the implementation process. Actual program implementation, therefore, is a cyclical process that incorporates feedback into the process in the form of a continuous "feedback loop" (see **Figure 10**).

Figure 10: EVALUATIVE PROCESS



Whether one chooses to conduct a self-evaluation using in-house staff and resources, or to look for outside assistance in conducting the evaluation, is a matter of preference. There are advantages and disadvantages of both. Utilizing in-house expertise is less expensive and in most cases less time consuming. Staff members are familiar with data tracking, systems monitoring, know where missing data can be obtained, and are knowledgeable of program goals and objectives.

At the same time, staff members can exhibit "evaluator bias" and may not present an accurate picture due to their intimate involvement in the day-to-day operations of the program. Independent evaluators, on the other hand, may require assistance in interpreting data due to peculiarities in the way in which it is collected, and may not fully understand the program's intent. The objectivity which can be provided by outside consultants, can be extremely

valuable. They may be able to see program flaws or inefficiencies that only someone outside the operation can detect. Regardless of who performs the evaluation, it must be taken seriously as a critical step in the process that will guide future action.

Review Goals and Objectives

The time period over which the original goals and objectives apply will dictate the success with which those goals and objectives can be measured. As a rule of thumb, objectives should cover a manageable length of time. The period of one year, for example, may prove sufficient. With annual review, enough time is allocated for the program to have had a chance to operate and make minor adjustments, yet too much time has not elapsed without the program undergoing more intense scrutiny.

If the program goals and objectives were written clearly and in measurable terms, it should be possible to determine whether the program has accomplished what was intended. If there is much ambiguity in the way in which the goals and objectives were worded, it becomes difficult to determine whether the program is headed in the right direction. In either case, looking back at documents a year after they were written, with the added insight gained during that time should help in assessing program performance.

Identify Problem Areas

What may seem problematic one month may actually not be problematic at all, but rather the result of some other outside influence on the program. It is important to identify problem areas and to study possible solutions or alternative methods for addressing those issues.

Modify Program

Once problems have been identified, the program may need to be modified accordingly. In some cases, however, the cost of modifying a program may exceed the benefit of eliminating the problems of concern. In other cases, large, unforeseen problems may arise in attempting to alleviate small problems. The decision to modify a small segment of a program or to revamp a significant portion of a program must be based on the relative value of the desired results.

Modify Goals and Objectives

Based upon the successes and failures during the first evaluative period and how those affect goal attainment, new goals and objectives may need to be established. The same format should be utilized as recommended when initial goals and objectives were set, yet experiences and "lessons learned" should have a real impact on the development of new guidelines from which to operate.

IX

APPENDICES

LIST OF APPENDICES

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C: RECYCLING PROGRAMS IN NORTH CAROLINA

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APPENDIX A: GLOSSARY

BUY BACK CENTER: an intermediate facility which purchases secondary materials, usually from the public, and sells them to brokers, processors, or manufacturers.

COMPOSTING: the microbial decomposition of organic matter to produce **compost** which is a dark partially decomposed substance similar to natural organic matter found in the soil.

CONSTRUCTION AND DEMOLITION DEBRIS: material considered to be not soluble or hazardous, including but not limited to glass, brick, concrete, or asphalt roofing material.

DISPOSAL: discharge, deposit, injection, dumping, spilling, leaking or placing of any solid waste or hazardous waste into or upon any land or water so that the waste or any constituents may enter other lands or be emitted to air or discharged into any waters, including groundwaters, or otherwise enter the environment.

ENERGY RECOVERY: the processing of the waste stream to utilize the heat content of the waste.

FLOW CONTROL ORDINANCE: local ordinance controlling the flow and/or final disposition of waste within a wasteshed or service area.

GARBAGE: rejected food waste including but not limited to waste from animal, fruit or vegetable matter used or intended for food, or that waste resulting from the preparation, use, cooking, distributing, or storing of meat, fish, fowl, fruit or vegetable.

HDPE: (High Density Polyethylene) a dense plastic used for such items as milk containers, detergent bottles, etc.

INTEGRATED WASTE MANAGEMENT: an approach toward solving solid waste management problems using a hierarchy of waste management techniques consisting of planning for source reduction as the first priority, materials recovery through recycling as next highest priority, followed by composting of remaining compostables, and volume reduction with energy recovery to be preferable prior to safe disposal of residues.

MANDATORY RECYCLING: law requiring citizens to source separate, or otherwise make available for recycling, those materials determined to be most amenable to recycling.

MATERIALS RECOVERY: any process of obtaining from the waste stream, either pre-segregated or otherwise, materials which still have useful physical or chemical properties after serving their intended use.

ORGANIC WASTE: the compostable fraction of the waste stream composed mostly of yard waste, food scraps, garden residues, and carcasses.

PET: (Polyethylene terephtalate) a flexible plastic used primarily in beverage bottling.

RECYCLING: a four part process involving: 1) separation of usable materials from a waste stream, 2) collection (before or after separation), 3) processing, and 4) utilization of the processed material as a raw material for products which may or may not be similar to the original.

RECYCLABLES: that which is of a group of materials that can be collected and reprocessed after original use into a new and useful product.

REFURBISH: to repair, clean, or otherwise upgrade discarded materials to a reusable condition.

REFUSE: anything thrown away or rejected as worthless or useless; waste.

REFUSE DERIVED FUEL: material which is derived from non-hazardous solid waste following one of a number of available mechanical processes whereby the non-combustible and recoverable (recyclable) materials portion of the waste stream have been removed and the remaining refuse is reduced in size for use as a fuel substitute.

REMANUFACTURE: to disassemble and reassemble products, the parts of which are cleaned, repaired, or replaced in the process (REBUILD).

RESIDUES: Materials remaining after material recovery, processing, composting, and incineration which have no immediately apparent value or use, and must be managed as the final concentrated waste (eg. ash).

RESOURCE RECOVERY: the process of obtaining useful materials or energy resources from the solid waste stream through one or a combination of one of the following three primary technology categories: 1) **materials recovery**, 2) **composting**, 3) **energy recovery** (see definitions above).

RESOURCE RECOVERY FACILITY: any facility for the purpose of which is materials or energy recovery, recycling or reprocessing of materials.

REUSE: to use goods of production more than once in their same form and for their original purpose.

RUBBISH: non putrescable solid waste, excluding ashes, consisting of both combustible and noncombustible waste, including paper, cardboard, metal containers, yard clippings, wood, glass, bedding, crockery, construction and demolition materials, or litter.

SALVAGE: recovery of items with remaining useful life from a disposal or transfer site.

SECONDARY MATERIALS: materials which have been put to use at least once before and which can be used again in place of virgin materials.

SOLID WASTE: garbage, rubbish, refuse,or other discarded material including solid, liquid, semisolid, or contained gaseous material resulting from domestic, industrial commercial, mining, agricultural, or governmental operations, including sludge from a waste treatment works, water supply treatment plant or air pollution control facility.

SOURCE REDUCTION: any effort which decreases the production of waste, including, but not limited to increased product durability, decreased consumption, products and package reuse, product redesign to reduce waste it produces; the first priority in waste management hierarchy.

SOURCE SEPARATION: the setting aside of separated recyclable materials at their post consumer point of generation, either household or commercial, by the generator.

TIPPING FEE: a fee charged at waste management facility for "tipping", or depositing, waste based on the amount (either volume or weight) deposited.

VIRGIN MATERIAL: material which has not previously been used in manufacturing of goods.

VOLUME REDUCTION: the process of reducing the volume of the waste stream through processes including but not limited to incineration, pulverization, compaction, shredding baling and composting.

WASTE MANAGEMENT HIERARCHY: a set of approaches to managing the solid waste stream, prioritized based on the economic and ecological benefits derived (1-REDUCTION, 2-REUSE/RECYCLING, 3-COMPOSTING, 4-ENERGY RECOVERY, 5-RESIDUE DISPOSAL).

WASTE REDUCTION: any treatment or diversionary action which keeps waste out of the solid waste stream destined for disposal.

WASTESHED: an area which shares solid waste disposal systems.

WASTE TO ENERGY FACILITY: facilities, including RFD facilities, ethanol facilities, methane producing facilities, high-rate composting facilities, and incinerator facilities which use solid waste as a feedstock or fuel source to recover heat or steam for its energy value.

WHITE GOODS: large enameled metal household and commercial appliances such as refrigerators, stoves, washers, dryers, dishwashers, and freezers.

APPENDIX B: RESOURCES

- **CONTACTS**

Federal Government

Environmental Protection Agency - Municipal Solid Waste Task Force
401 M. St., S.W.
Washington, DC 20460
Contact: Edward Klein 202/ 382-3345

Office of Technology Assessment - Municipal Solid Waste Program
Congress of the United States
Washington, DC 20510-8025;
Contact: Howard Levenson 202-228-6854

State Government

Solid Waste Management Section
NC Department of Human Resources
P.O. Box 2091
Raleigh, NC 27602-2091
Contact: Terry Dover 919/ 733-0692 (permits)
Judy Lund 919/733-2178 (motor oil, batteries, HHW)

Pollution Prevention Program
Division of Environmental Management
NC Department of Natural Resources and Community Development
P.O. Box 27687
Raleigh, NC 27611-7687
Contact: Roger Schecter 919/ 733-7015

Governor's Waste Management Board
325 N. Salisbury Street
Raleigh, N.C. 27611
Contact: Hope Lucas 919/ 733-9020

Keep North Carolina Clean and Beautiful, Inc.
NC Department of Transportation
P.O. Box 25201
Raleigh, NC 27611
Contact: Jean Dodd 919/ 733-7621

University Contacts

Environmental Quality Institute (EQI)
University of North Carolina at Asheville
One University Heights
Asheville, NC 28804-3299
Contact: Cam Metcalf 704/ 254-4414

Institute for Environmental Studies (IES)
311 Pittsboro St. CB# 7410
University of North Carolina
Chapel Hill, NC 27599-7410
Contact: Mary Beth Edelman 919/ 966-1301

Institute for Transportation Research and Education (ITRE)
P.O. Box 12551
Research Triangle Park, NC 27709-2551
Contact: Larry Minor 919/ 787-8233

Southeast Waste Exchange
Urban Institute
University of North Carolina at Charlotte
Charlotte, NC 28223
Contact: Mary McDaniel 704/ 547-2307

o **ASSOCIATIONS**

State Associations

North Carolina Recycling Association
P.O. Box 31667
Charlotte, NC 28231
Contact: Sandi Maurer 704/ 254-8131

North Carolina Association of County Commissioners
215 N. Dawson St.
P.O. Box 1488
Raleigh, NC 27602
Contact: Ed Regan 919/ 832-2893

NC League of Municipalities
215 N. Dawson St.
Raleigh, NC 27602
Contact: Laura Kranifield 919/ 834-1311

North Carolina Tire Dealers Association
P.O. Box 516
Deep Run, NC 28525
Contact: Johnny Braxton 919/ 568-3124

North Carolina Glass Recycling Program
Suite 808, 1515 Mockingbird Lane
Charlotte, NC 28209
Contact: Jim Heimberger 704/ 525-8259

National Associations

Aluminum Association
818 Connecticut Avenue, N.W.
Washington, DC 20006
202/ 862-5100

Aluminum Recycling Association
900 17th Street, N.W.
Washington, DC 20036
212/ 785-0550

American Iron & Steel Institute
1000 16th St. N.W.
Washington, DC 20036
202/ 452-7100

American Paper Institute
260 Madison Avenue
New York, NY 10016
212/ 340-0600

American Retreaders Association
P.O. Box 17203
Louisville, Kentucky 40217
502/ 367-9133

Association of Petroleum Re-refiners
Suite 1111
2024 Pennsylvania Avenue
Washington, DC 20006
202/ 833-2694

Association of State and Territorial Solid Waste Management Officials (ASTWMO)
Suite 345 Hall of the States
444 North Capitol Street, N.W.
Washington, DC 20001
202/ 624-5828

Automotive Dismantlers & Recyclers of America
1000 Vermont Ave. N.W.
Washington, DC 20006
202/ 628-4634

Can Manufacturers Institute
821 15th Street, N.W.
Washington, DC 20005
202/ 232-4677

Copper & Brass Fabricators Council
Suite 440
1050 17th St. N.W.
Washington, DC 20036
202/ 833-8575

Council on Plastics Packaging in the Environment (COPPE)
1275 K St.
Washington, DC 20005
202/ 371-5228

Fibre Box Association
5725 East River Road
Chicago, IL 60631
312/ 693-9600

Glass Packaging Institute
1800 K Street, N.W.
Washington, DC 20006
202/ 872-1280

Government Refuse Collection & Disposal Association (GRCDA)
P.O. Box 7219
Silver Spring, MD 20910
301/ 585-2898

Institute of Scrap Recycling Industries
1627 K Street, N.W.
Washington, DC 20006
212/ 466-4050

National Association for Plastic Container Recovery (NAPCOR)
P.O. Box 7784
Charlotte, N.C. 28241
704/ 523-8543

National Association of Solvent Recyclers
1406 Third National Bldg.
Dayton, OH 45402
513/ 223-0419

National Solid Waste Management Association (NSWMA)
Suite 1000 1730 Rhode Island Ave. Nw
Washington, DC 20036
202/ 861-0708

National Recycling Coalition (NRC)
45 Rockefeller Plaza, Rm. 2350
New York, NY 10111
212/ 765-1800

National Textile Processors Guild
51 Chambers Street
New York, NY 10007
212/ 875-2300

National Tire Dealers and Retreaders
1343 L Street, N.W.
Washington, DC 20005
202/ 789-2300

Paperboard Packaging Council
1800 K Street, N.W.
Suite 600
Washington, DC 20006
202/ 872-0180

Rubber Manufacturers Association
1901 Pennsylvania Avenue, N.W.
Washington, DC 20006
202/ 682-1338

Society of the Plastics Industry (SPI)
1275 K St. N.W.
Washington, DC 20005
202/ 371-5200

Solid Waste Council of the Paper Industry
1619 Massachusetts Ave., N.W.
Washington, DC 20036
212/ 797-5786

Technical Association of Pulp & Paper Industries
One Dunwoody Park
Chamblee, GA 30341
404/ 394-6130

Tire Retread Information Bureau
Box 811
Pebble Beach, CA 93953
408/ 649-0944

- **PUBLICATIONS**

Periodicals

BIOCYCLE (monthly)
Box 351
Emmaus, PA 18049
202/ 291-4222

PLASTICS RECYCLING UPDATE (quarterly newsletter)
Resource Recycling Inc.,
P.O. Box 10540
Portland, OR 97210
503/ 227-1319

RECYCLING TODAY! (monthly)
4012 Bridge Avenue
Cleveland, OH 44113
216/ 961-4130

RESOURCE RECYCLING (seven times/yr.)
P.O. Box 10540
Portland, OR 97210
503/ 227-1319

RETURNABLE TIMES (quarterly newsletter)
Environmental Action Foundation
1525 New Hampshire Ave., N.W.
Washington, DC 20036
202/ 745-4870

WASTE AGE (monthly)
Suite 1000, 1730 Rhode Island Ave., N.W.
Washington, D.C. 20006
202/ 861-0708

WASTE ALTERNATIVES (published quarterly)
Suite 1000, 1730 Rhode Island Ave., N.W.
Washington, D.C. 20006
202/ 861-0708

WORLD WASTES (monthly)
6255 Barfield Road
Atlanta, GA 30328
404/ 256-4800

Additional Reference Materials

Coming Full Circle (Successful Recycling Today), Environmental Defense Fund, Inc., New York, 1981. Available from: Environmental Defense Fund, 257 Park Avenue South, New York, NY 10010, (212) 686-4191.

Comprehensive Municipal Recycling Implementation Plan, (Kirkpatrick, David and Kehrer, Larry) Durham, 1987. Available from: N.C. Pollution Prevention Program, P.O. Box 27686, Raleigh, N.C. 27611-7687, (919) 733-7015.

Pennsylvania Recycling Manual. Available from: Pennsylvania Governor's Energy Council (contracted to Synergic Resources Corporation), Harrisburg, PA.

Guide to Residential Source Separation, Ministry of the Environment, Ontario, Canada. Available from: Waste Management Branch, Ontario Ministry of the Environment, 135 St. Clair Ave., W, Toronto M4V 1P5, (416) 965-7117.

A Guide to Recycling in Your Community, Lansing, MI, 1985. Available from: Michigan Department of Natural Resources, Community Assistance Division, Resource Recovery Section, P.O. Box 30028, Lansing, Michigan, 48909, (517) 373-0540).

Sorting it Out: Recycling Options in California, Sacramento, CA, 1982. Available from: California Office of Appropriate Technology, 1600 Ninth Street, Suite 330, Sacramento, California, 95814, (916) 445-1803.

Integrated Waste Management, Grand Rapids, MI, 1986. Available from: West Michigan Environmental Action Council Education Foundation, 1432 Wealthy S.E. Grand Rapids, MI, 49506, (616) 451-3051.

Use it Again: A Recycling Guide for North Carolina Communities, Durham, NC, 1982. Available from: ECOS, Inc., Rt. 6, Box 261, Chapel Hill, NC 27514, (919 967-3676.

The Solid Waste Handbook, (Robinson, W. D. 1986). John Wiley and Sons, Inc. New York, NY.

Solid Waste Planning Manual for Local Governments, (Maurer, S., ed.), Asheville, NC, June 1988. Available from: Land of Sky Regional Council, 25 Heritage Drive, Asheville, N.C. 28806, (704) 254-8131.

Educational Materials

"The Great Glass Caper"- Free from the Carolina Glass Recycling Program, Suite 808, 1515 Mockingbird Land, Charlotte, NC 28209.

A teaching kit designed for fourth, fifth, and sixth graders. Includes teacher's guide, activity masters, a wall chart and filmstrip.

Lingenfelter, J. et.al. A-Way With Wastes: A Waste Management Curriculum for Schools, 1985, 352 pp. Washington State Department of Ecology, Redmond, WA.

A K-12 Curriculum designed around four concepts of waste management: Revise, Reuse, Recycle, and Recover. Waste management subjects include: composting, consumer awareness, resource conservation and recovery, source separation, and waste reduction. Interdisciplinary activities can be used by any elementary or secondary teacher.

Solid Waste Environmental Education Program (SWEEP). SWRL Educational Research and Development. California State Department of Education, Sacramento, CA.

A teaching kit designed for third graders (Wizard of Waste) and sixth graders (Trash Monster). Each unit comes with a poster, pre-and post-tests, self survey, pupil booklet, home information leaflet, badge/sticker, and picture cards. Concepts taught include: understanding solid waste concepts; identifying recyclable solid waste; and analyzing and changing solid waste practices.

APPENDIX C: RECYCLING PROGRAMS IN NORTH CAROLINA

ALAMANCE COUNTY

TYPE OF PROGRAM: DROP-OFF

MATERIALS COLLECTED: Glass, newspaper, and waste motor oil.

Contact: Jim Connor
Alamance County Health Department
209 N. Graham-Hopedale Rd.
Burlington, N.C. 27215
(919) 227-0101

BUNCOMBE COUNTY

TYPE OF PROGRAM: DROP-OFF

MATERIALS COLLECTED: Glass, aluminum, newspaper

Contact: Marvin Waddey
Buncombe County Engineering Services
Buncombe County Courthouse
Asheville, NC 28801
(704) 255-5066

BURKE COUNTY RECYCLING

TYPE OF PROGRAM: MOBILE UNIT

MATERIALS COLLECTED: Glass, aluminum cans, and newspaper.

Contact: Tom Rhodes
Burke County Waste Management/Recycling
P.O. Box 219
Morganton, NC 28655
(704) 433-4000

CHATHAM COUNTY

TYPE OF PROGRAM: DROP-OFF

MATERIALS COLLECTED: Glass, aluminum, and newspapers.

Contact: Judy Ingram
Chatham County
Pittsboro, NC 27344
(919) 542-2841

CUMBERLAND COUNTY

TYPE OF PROGRAM: MOBILE UNIT

MATERIALS COLLECTED: Newspapers, glass, aluminum.

Contact: Larry Carter
Cumberland County Sanitation Department
698 Ann Street
Fayetteville, NC 28301

TYPE OF PROGRAM: DROP-OFF

MATERIALS COLLECTED: Glass, aluminum and paper.

Contact: Wanda Jones
Cumberland Clean Community Committee
308 Green Street
Fayetteville, NC 28301
(919) 483-4357

DURHAM COUNTY (Contracted to SUN SHARES, a non-profit recycling organization)

TYPE OF PROGRAM: CURBSIDE/DROP-OFF/LANDFILL SALVAGE/YARD WASTE

MATERIALS COLLECTED: Glass, aluminum, newspaper, office paper, corrugated cardboard, and scrap metal.

Contact: David Kirkpatrick, Director or
Larry Kehrer, Recycling Program Manager
Sun Shares
813 Ellis Rd.
Durham, NC 27703
(919) 596-8170

HAYWOOD COUNTY

TYPE OF PROGRAM: MOBILE UNIT

MATERIALS COLLECTED: Corrugated, glass, aluminum, and newspaper.

Contact: Trudy A. Messer
Haywood County Project Pride, Inc.
Haywood County Annex II
1600 North Main Street
Suite 1-50
Waynesville, North Carolina 28786
(704) 452-6661

MECKLENBURG COUNTY

TYPE OF PROGRAM: CURBSIDE/DROP-OFF/LANDFILL SALVAGE

MATERIALS COLLECTED: Newspapers, glass, aluminum cans, and plastic soft drink containers (PET only); wood waste, corrugated, and scrap metals.

Contact: Betsy Dorn, Recycling Coordinator or
Brenda Barger, Waste Recovery Specialist
Recycling Program
700 North Tryon Street
Charlotte, NC 28202
(704) 336-2713

ORANGE COUNTY

TYPE OF PROGRAM: CURBSIDE/DROP-OFF/LANDFILL SALVAGE

MATERIALS COLLECTED: Glass, aluminum, newspaper, and corrugated.

Contact: Blair Pollock
Recycling Coordinator
Town of Chapel Hill
306 N. Columbia St
Chapel Hill, NC 27514
(919) 968-2796

PITT COUNTY

MATERIALS COLLECTED: Corrugated cardboard, newspaper, mixed paper, glass and aluminum.

Contact: Pitt County Engineering Department
1717 W. 5th Street
Greenville, NC 27834
(919) 830-6354

WAKE COUNTY

TYPE OF PROGRAM: DROP-OFF

MATERIALS COLLECTED: Glass, metal, and newspaper.

Contact: Liz Cave
Wake County Recycling, Inc.
P.O. Box 1812
Raleigh, NC 27602
(919) 834-7719

APPENDIX D:

LITERATURE CITED

(1) Franklin and Associates. 1987. Clean Michigan Fund: recycling feasibility study for Washtenaw County, Michigan. Final report prepared for Michigan Department of Natural Resources.

(2) Marshall, E. 1987. America's Big Mess: After You Take Out the Trash, Where Will They Put It? Governing. December, 1987:32.

(3) JRB Associates. 1981. Solid Waste Data: A Compilation of Statistics on Solid Waste Management Within the United States. EPA Contract No. 68-01-6000.

(4) Campbell, W. A. 1986. Resource Recovery in North Carolina. Popular Government. Summer, 1986:1-10.

(5) Porter, J. W. 1988. Letter to all state and territorial environmental commissioners. EPA Office of Solid Waste and Emergency Response. Washington, D.C.

(6) DHR- NRCD. 1987. Memorandum of Agreement signed on 4 June 1987, by the respective secretaries of the North Carolina Department of Human Resources, Department of Natural Resources and Community Development, and Department of Administration. Raleigh, NC.

(7) Dover, T. 1988. Personal communication on 14 April 1988. Solid Waste Management Section, NC Department of Human Resources. Raleigh, NC.

(8) Lampi, R. 1987. Personal Communication. Environmental Task Force, Washington, DC.

(9) Duncan, R. 1987. Goals, alternatives & changes. Waste Age, November 1987:238.

(10) Rhode Island Solid Waste Management Corporation. 1986. Annual Report. Providence, RI.

(11) Ibid.

(12) Ibid.

(13) Hurst, K. 1987. Solid Waste Source Reduction: Attacking the Solid Waste Disposal Problem at the Source. B.A. Thesis. Center for Environmental Studies, Brown University. NJ.

(14) Op. Cit. Porter, J. W.

(15) West Michigan Environmental Action Council Education Foundation. 1986. Integrated Waste Management. Grand Rapids, Michigan. October 1986.

(16) Hartman, R. A. 1986. Product design for recycling. Resource Recycling, Jan/Feb 1986:25.

(17) Consumer Survey. 1987. Packaging June 1987:48-54.

(18) Op. Cit. Lampi, R. 1987.

(19) Washington State Department of Ecology. Guide to Household Recycling. Olympia, WA. April 1983.

(20) Leonard, L. 1988. "To Keep Paint Out of Landfills, City Founds Paint Exchange", Waste Age, Vol 19, No. 5:167

(21) Goldoftas, B. 1987. Recycling: Coming of Age. Technology Review, November/December, 1987:28.

(22) Porter, J. W. 1988. A National Perspective on Municipal Solid Waste Management. Presented at the Fourth Annual Conference on Solid Waste Management and Materials Policy. New York, NY. 29 January 1988.

(23) Mining Urban Wastes: The Potential for Recycling. Worldwatch Paper 76, Worldwatch Institute, 1986.

(24) Franklin and Associates. 1986. Municipal Solid Waste Generation, 1960 to 2000. Prepared for EPA Office of Solid Waste under subcontract to PRC Environmental Management.

(25) Op. Cit. Porter, J. W. 1988.

(26) Waste Age, Vol.19 No.5 May, 1988, p. 8.

(27) Ibid.

(28) Ibid.

(29) Op. Cit. Franklin and Associates. 1987.

(30) Sharring, F. A., ed. 1988. Official Board Markets. Magazines for Industry, Inc., Chicago.

(31) Op. Cit. Franklin and Associates. 1987.

(32) Dorn, B. Personal communication. Mecklenburg Co. Engineering Dept. 1988.

(33) Mecklenburg County Engineering Department. 1986. Mecklenburg County Solid Waste Management Plan (Preliminary).

(34) Prillaman, B. 1988. Presentation at Municipal Solid Waste Source Reduction and Recycling Conference. 24 March 1988. Hot Springs, VA.

(35) Op. Cit. Franklin and Associates. 1986.

(36) Porter, J. W. 1988.

(37) Porter, J. W. 1988.

(38) Snow, D. and C. Johnson. 1988. Trends in Collecting Recyclables. Waste Alternatives 1(1):40 - 48.

(39) Op. Cit. Franklin and Associates. 1986.

(40) Op. Cit. Porter, J.W. 1988.

(41) Porter, J. W. 1988.

(42) Op. Cit. Franklin and Associates. 1986.

(43) Op. Cit. Porter, J. W. 1988.

(44) Council on Plastics and Packaging in the Environment. 1988. Plastic Containers Coded For Recycling. COPPE Quarterly, 2(2):1.

(45) Op. Cit. Franklin and Associates. 1987

(46) Ibid.

(47) Ibid.

(48) Op. Cit. Dorn, B. 1988.

(49) Op. Cit. Franklin and Associates. 1986.

(50) West Michigan Environmental Action Council Education Foundation. 1986. Integrated Waste Management. Grand Rapids, MI.

(51) Op. Cit. Franklin and Associates. 1987.

(52) Ibid.

(53) Leff, D.K. 1986. Memorandum re. New developments in state recycling programs. 10 July 1986. Office of Legislative Research, Connecticut General Assembly. Hartford, CT.

(54) Prete, P.J., M.B. Edelman, and T. Keating. 1988. Regional Approaches to Solid Waste Management. Final report to the National Association of Regional Councils. Washington, D.C.

(55) Op. Cit. Leff, D.K. 1986.

(56) Op. Cit. Porter, J. W. 1988.

(57) Op. Cit. Franklin and Associates. 1986.

(58) Op. Cit. JRB Associates. 1981.

(59) Op. Cit. West Michigan Environmental Action Council Education Foundation. 1986.

(60) Strom, P.F. and Finstein, M.S. Leaf Composting Manual for New Jersey Municipalities. New Brunswick, NJ: 1986.

(61) US EPA. 1975. Compilation of Air Pollution Emission Factors: Second edition (AP-42). Office of Air Quality Planning and Standards. Research Triangle Park, NC. March 1975.

(62) US EPA. 1980. Technology, Prevalence and Economics of Landfill Disposal of Solid Waste. SW-754. Washington, DC.

(63) Op. Cit. Marshall, 1987.

(64) Public Law 98-616. 1987. The Solid Waste Disposal Act as Amended by The Hazardous and Solid Waste Amendments of 1984 (PL 98-616). USGPO. Washington, DC.

(65) Daly, J. B. 1985. Resource Recovery in New York State: The Dioxin Controversy. A Report by the Joint Legislative Commission on Solid Waste Management, Office of the Vice Chairman. November 1985.

(66) Bellin, J. S. and D. G. Barnes, 1986. Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-Dioxins and Dibenzofurans (CDs and CFs). Draft. US EPA, Washington, DC. April, 1986

(67) Peterson, N. M. 1986. How a Waste-to-Energy Facility will Affect Your Community, in Waste-to-Energy Facilities: a Decisionmaker's Guide. National League of Cities. National Publishing Co. Alexandria, VA. June 1986.

(68) Wurmbrand and Atkins, 1985. Interactions of Emission Factors, BACT Alternatives and Predicted Impacts in Air Permit Applications for Resource Recovery Facilities. Presented to the Acid Gas & Dixon Control for Waste-to-Energy Facilities Conference. Washington, DC. November 25, 1986.

(69) Reason, J. 1986. Next Step for Waste-to-Energy: Better Availability, Efficiency. Power, July, 1986: 17-24.

(70) Sommer, et al., 1985. Effects of MSW Preprocessing on Thermal Conversion of MSW in Mass Burn Incineration. National Recovery Technologies, Inc. under contract to United States Department of Energy contract No. DE-AC05-84ER80177.

(71) Op. Cit. US EPA. 1975.

(72) Thompson, J. M. 1987. Household Hazardous Waste and Groundwater Contamination. Paper presented at the fifth Student Pugwash USA International Conference. Stanford University, June 28-July 4, 1987.

(73) Ruff, J.C. 1985. GSX Helps With Cleanup. Reidsville Review. Reidsville, NC.

(74) Braxton, J. 1988 personal communication. North Carolina Tire Dealers Association.

(75) Op. Cit. US EPA. 1975.

(76) Schnormeier, R. H. 1986. Municipal Use of Asphalt Rubber. Presented at the Scrap Tire Recycling and Vendors Workshop. Fayetteville, NC. November 13, 1986.

(77) Connor, J. 1988. Personal communication. Recycling coordinator, Alamance County.

(78) Church, R. 1988. Presentation at "Wastes to Resources: Local/Regional Solid Waste Alternatives" Conference, Land of Sky Regional Council. 9 June 1988. Asheville, NC.

(79) Op. Cit. Mecklenburg County Engineering Department. 1986.

(80) Maurer, S. ed., 1988. Solid Waste Planning Manual for Local Governments, Development Districts, and Councils of Governments. Land of Sky Regional Council, Asheville, NC.

(81) SCS Engineers. 1987. Waste Characterization Study. File No. 48611. Prepared for Solid Waste Department, Portland Metropolitan Service District, Portland Oregon.

(82) Op. Cit. Maurer, S. ed., 1988.

(83) Op. Cit. SCS Engineers 1987.

(84) Robinson, W. D., P.E. 1986. The Solid Waste Handbook. John Wiley and Sons, Inc. New York, NY.

(85) Ibid.

(86) Hazen and Sawyer. 1987. Report to Alamance Co., NC. October, 1987.

(87) Op. Cit. Robinson, W. D., P.E. 1986.

(88) Dorn, B. 1988. Presentation at the Waste to Resources Conference. Land of Sky Regional Council, Asheville, NC. June 10, 1988.

(89) Ibid.

(90) Op. Cit. Mecklenburg County Engineering Department. 1986.

(91) Brown, E.R. "Teaching Kids to Teach Others", Waste Age, Vol. 19, No.4. April 1988.

(92) "Trashman" Retires Costume, World Wastes, Vol. 31, No. 4, April 1988, pp 7-8.).

(93) Spleen, T. 1987. Hauling Company offers Discounts to Recyclers. Waste Age, August, 1987:12).