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Generic Technology Assessment Solid Waste Management

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New York State/Department of Environmental Conservation

GENERIC TECHNOLOGY ASSESSMENT

SOLID WASTE MANAGEMENT

June 1990

New York State Department of Environmental Conservation
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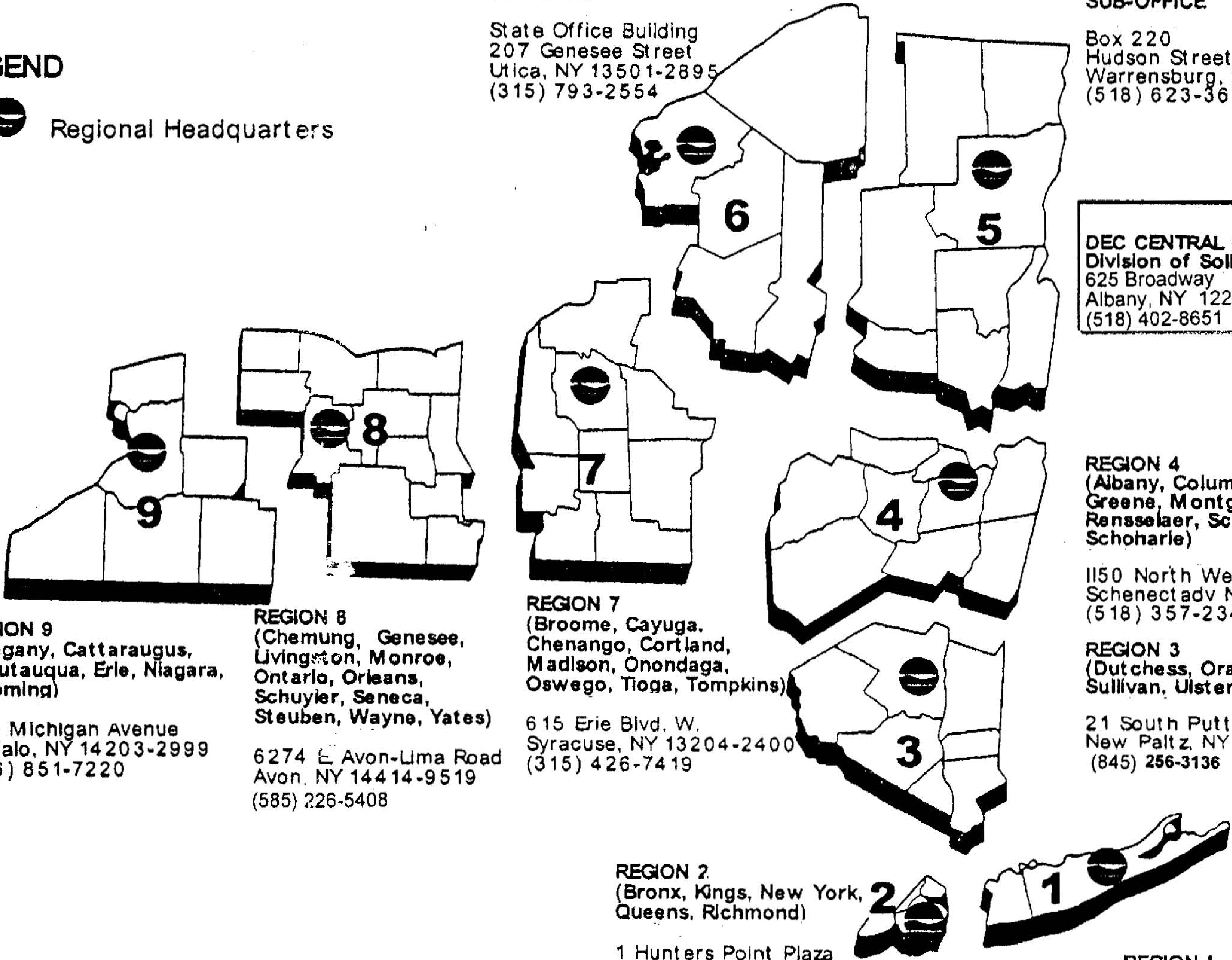

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FORWARD

Local solid waste management plans must contain, among other things, an assessment of available solid waste management technologies. This guidance document on Generic Technology Assessment is provided as a resource for those responsible for preparing a local solid waste management plan for planning units. The information is presented in the same order of solid waste management priorities established as New York State solid waste management policy in the Solid Waste Management Act of 1988 (Chapter 70).

The solid waste management priorities in New York State are:

a) First, to reduce the amount of solid waste generated;

b) Second, to reuse material for the purpose for which it was originally intended or to recycle material that cannot be reused;

c) Third, to recover, in an environmentally acceptable manner, energy from solid waste that cannot be economically and technically reused or recycled; and

d) Fourth, to dispose of solid waste that is not being reused or recycled or from which energy cannot be recovered, by land burial or other methods approved by the Department.

Each of the first four chapters address one aspect of the State solid waste management policy, as follows:

* Chapter One: Waste Reduction
* Chapter Two: Reuse and Recycling
* Chapter Three: Waste-to-Energy
* Chapter Four: Land Burial and Other Disposal Options

Each of these chapters presents information on available technologies and factors to consider in evaluating them. In addition, generic environmental impacts associated with the various solid waste management alternatives are presented in Chapter Five. The mention of trade names, commercial products, or consulting firms in this guidance document does not constitute endorsement or recommendation for use by the New York State Department of Environmental Conservation.

This guidance document is not intended to provide an all-inclusive review of every option available for solid waste management and associated environmental impacts as they relate to any specific planning unit. However, this document will provide generic information on the major options currently available for managing municipal solid waste, to which planning unit specifics can be added. The Department will revise this document from time to time to incorporate additional information as it becomes available.

Comments and suggestions on improving this generic technology assessment document are welcome and may be sent to:

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TABLE OF CONTENTS

GENERIC TECHNOLOGY ASSESSMENT: SOLID WASTE MANAGEMENT

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The current New York State solid waste capacity crisis highlights the need to plan for all aspects of solid waste management at the regional level. Failure to plan for proper solid waste management will result in continued reliance on existing solid waste management facilities, the majority of which are currently degrading the environment through discharges to the State's groundwater, surface waters, and air. Local governments need to develop alternative solid waste management strategies, consistent with the State solid waste management policy and 6 NYCRR Part 360, to solve this capacity crisis. Proper planning will lead to the implementation of integrated solid waste management systems, which will result in increased waste reduction, increased reuse, recycling and resource recovery, and a decreased reliance on land burial of raw wastes.

This guidance manual is provided as a resource to aid planning units and others involved in the development of local solid waste management plans. Planning units are defined as:

- a county;
- two or more counties acting jointly;
- a local government agency or authority established pursuant to State law for the purposes of managing solid waste; or
- two or more municipalities which the Department determines to be capable of implementing a regional solid waste management program.

Solid waste management plans must contain, among other things, an assessment of solid waste management alternatives. The required contents for a local solid waste management plan can be found in 6 NYCRR Subpart 360-15, Grants for Comprehensive Solid Waste Management Planning.

The chapters which follow present generic information on solid waste management technologies and factors to consider in evaluating and comparing these technologies. Unless otherwise noted, costs are presented in 1989 dollars, and represent average costs that have been reported for the various solid waste management alternatives. Actual costs will always vary based on the particular site and technology chosen. Planning units will need to develop detailed costs evaluations which are specific enough to make a sound economic decision on the technologies that best fit the planning unit's needs and conditions.

Planning unit representatives and others involved with solid waste management planning are encouraged to meet with the Department to discuss the various aspects and requirements for their solid waste management plans.

CHAPTER 1
WASTE REDUCTION

I. Introduction

A. General

Waste reduction has first priority in New York State's solid waste management policy. Waste reduction activities are directed at preventing waste at its source. At the manufacturing level, waste reduction means redesigning products and packaging with waste reduction as a goal. At the consumer level, it means changing purchasing and disposal habits and attitudes, so that the overall quantity of solid waste is measurably reduced from previous levels.

Although consumer education and industry cooperation can achieve measurable results, waste reduction may be most successful when it is mandated by specific laws. In general, the most effective waste reduction legislation would be enacted at the state and federal levels, while action at the local level may be limited to consumer education programs and waste disposal regulations.

B. Identification of Alternatives

Waste reduction is a pre-management tool because it prevents waste by decreasing the volume and/or weight of materials prior to their entry into the waste stream. Decreasing the waste stream can have an impact on the size and life of waste disposal facilities in an integrated solid waste management system.

Waste reduction alternatives described in this chapter include:

- controlling product packaging;
- mandatory industrial/commercial waste reduction programs; and
- changing consumer habits.

II. Assessment of Alternatives

A. Description of Alternatives

1. Controlling Product Packaging

Packaging waste accounts for approximately one third of the State's municipal solid waste stream. Packaging is used to sell, transport and preserve products in the marketplace. Purely voluntary actions by industry to reduce packaging waste have been limited because of concerns for protecting products and maintaining competitive position in the marketplace. Also, historically, inexpensive solid waste disposal fees did not foster concern about packaging waste. Significant reduction of packaging wastes seems possible only through legislation and government/industry cooperation at the state and federal level, with public support. However, public and industry awareness and the threat of statutory measures has caused some companies to become more aware of how their packaging contributes to the solid waste stream and to take voluntary action to reduce that waste.

Control of product packaging can take several forms, including:

- packaging standards;
- packaging bans; and
- fees applied to certain types of packaging.

Regulatory standards for materials packaging could be established to control bulk, weight and overall packaging. In addition, regulations could be established that ban a particular package or packaging, although this is not normally recommended.

Although packaging bans have direct and immediate impacts, they may not produce the desired results. Banning materials from the marketplace may do little to reduce waste, because other products or materials may replace the banned product with no net effect on waste reduction. Bans are politically popular in some areas, but as an effective solid waste management tool they are highly questionable.

A system of packaging fees or taxes based on recyclability or recycled content of the materials incorporates the costs of solid waste management into the product packaging. Under such a system, packaging materials would be rated for recyclability and recycled content and fees would be levied according to the ease or difficulty in recycling the packaging or percentage of recycled material in the package. Packaging for materials with identified markets would incur a minimum fee. Fees would increase in relation to availability of markets for particular materials with the highest fees levied against packaging materials for which no market exists. Fees would be adjusted as markets develop and reusable packaging or packaging subject to deposit programs would be exempt. Although politically popular, a fee program is practically impossible to administer in an equitable manner, considering the thousands of packaging and product categories.

A non-regulatory, non-fee approach to controlling product packaging would be directed at consumers and industry with the use of "environmentally friendly labelling" to educate them about packaging. The New York State recycling emblems are an example of this type of labelling. New York State has proposed establishing voluntary recycling emblems and regulations (proposed 6 NYCRR Part 368) governing the proper use of recycling emblems which will identify products containing materials which have been recycled or materials which may be recyclable or reusable. The State intends to subsequently implement and conduct a program of public education and information to inform both public and private sectors as to the merits of the use of secondary materials and for consumers to actively seek consumer products which contain secondary materials or which are easily recycled or reused.

In general, legislative action is needed to implement the waste reduction measures for controlling product packaging. Several legislative options have been considered by New York and other states to control product packaging.

2. Mandatory Industrial/Commercial Waste Reduction Programs

As a result of more stringent environmental regulations and increased disposal costs, many industrial and commercial waste generators are in various stages of developing and implementing waste reduction programs of their own. These programs focus not only on reducing the amount of wastes they generate, but also on reducing the toxicity of wastes. Elements of these programs usually include:

- good housekeeping practices -- including waste segregation, improved operation and maintenance, inventory controls and spill/leak prevention;

- input substitution or input material modification -- replacing a material used in a process or product with a non-toxic, less toxic, recycled, or recyclable material;

- technology modification -- improved controls, process redesign, process modification and equipment changes;

- product reformulation -- substituting an end product with one that is more durable or requires a less toxic production process or a process that produces less waste; and

- lightweighting -- substituting lighter and fewer materials for traditional packaging or product materials (this may reduce weight but not necessarily volume of solid waste).

Efforts would go further if these programs were made mandatory, but this should be most effective at the federal level to avoid placing New York industries at a competitive disadvantage. Requirements for mandatory waste reduction programs could range from requiring a written program to establishing industry-specific waste reduction targets.

3. Changing Consumer Habits

In the past, purchasing decisions by most consumers rarely reflected recycling or other solid waste management concerns. But as decreasing landfill space and other solid waste issues appear more frequently in the press, many consumers are becoming more aware of these concerns. It is entirely appropriate for State and local government officials to encourage the public with economic incentives and effective public education programs to be mindful of the impact of their purchasing habits on the solid waste stream, and to alter those habits. The New York State recycling emblems were designed to further this objective.

Economic incentives include deposits and local user fees. The purpose of deposit programs, such as New York's Returnable Container Act, is to give consumers an incentive to return packaging materials and thereby remove these materials from the waste stream. Local user fees for solid waste collection, such as "fee-per-bag" programs, also encourage consumers to reduce the amount of waste they discard. (Although local user fees may foster littering and illegal dumping, as well.)

A concerted long-term education program, starting in grade school, is necessary to change the throwaway ethic that Americans have developed since World War II. Public education programs designed by planning units should encourage waste reduction by focusing on the relationship between consumer habits and waste management and disposal.

Consumers can reduce waste by purchasing more durable products, products which use less packaging, and products in larger packages or reusable/recyclable/recycled containers. Industry will most likely yield to the pressure to reduce packaging and offer other packaging options as consumers begin to change their buying patterns, borrow or rent items, and otherwise change life-styles. Table 1-1 lists ways consumers can practice waste reduction.

B. Evaluation of Alternatives

1. Applicability/Capacity

Waste reduction can be applied to most elements of the waste stream. However, aside from consumer education and local user fees, most actions necessary to mandate waste reduction would be most effective if initiated at the state and federal level. A cooperative effort between government and the private sector would enhance implementation of new waste reduction laws.

Waste reduction programs should, where applicable:

- maintain uniform market conditions to the maximum extent possible;
- expand markets for recycled/recyclable/reusable materials;
- consider the potential for effectiveness given the various local, state, regional and other markets;
- influence consumer action through purchase practices geared to reduce the solid waste stream; and
- utilize or implement waste exchange programs.

Table 1-1

Waste Reduction Suggestions for Consumers

1. Purchase only what is needed, and in bulk quantities whenever possible.
2. Purchase recycled products.
3. Purchase durable products.
4. Purchase unpackaged products.
5. Purchase sensibly packaged products.
6. Avoid excess packaging.
7. Get Involved:
    - Write to companies about wasteful packaging
    - Write to legislators about waste reduction
    - Practice waste reduction
    - Talk to retailers about your waste reduction preferences and practices
8. Borrow or repair products instead of purchasing or throwing away.
9. Eat at restaurants that do not use disposable food containers.
10. Use both sides of writing paper.

Source: New York State Department of Environmental Conservation
Division of Solid Waste

2. Reliability/Experience

Since waste reduction is a matter of legislative and social change and still in the early stages of development, few quantitative estimates can be made. However, one successful waste reduction program now in effect in New York does provide some data: New York State's 1983 Returnable Container Act (RCA) has been successful in reducing the weight of the waste stream by five percent and the volume by eight percent.

3. System Cost

In general, administrative costs of developing and implementing packaging standards and fees, and mandatory industrial/commercial waste-reduction programs are prohibitively high, especially if they are developed on a product-by-product or single-industry basis. Furthermore, the cost to the packaging industry and the consumer must be fully explored.

The cost of education programs is highly variable and depends upon the content, media, audience, scope and life of individual projects. In the long run, a grade school curriculum that encourages sound solid waste practices may be the most cost-effective public education tool.

III. Summary

Reduction of the solid waste stream is the first element in New York State's solid waste management policy. Although some action is possible at the local level, most initiatives must occur at the state and federal level and are dependant on public and industry support.

The New York State Solid Waste Management Plan calls for an eight to ten percent reduction of the waste stream by 1997. Cooperation and mutual support between industry, local government and consumers is needed to achieve this goal. Planning unit efforts to enhance and promote state and federal waste reduction initiatives should include:

- lobbying for sound state and federal legislation to mandate reduction in packaging volume, changes in packaging materials, expansion of the RCA, and deposit or fee laws for batteries, tires and other problem wastes;
- developing local education programs to foster good waste reduction practices. These programs should be incorporated in planning unit's overall recycling plans. Local education programs should include the support of waste reduction and recycling programs starting as early as possible in grade schools;
- in extreme cases, instituting local packaging bans unequivocally determined to be detrimental to local solid waste management programs and the environment;

- adopting local user fees on waste disposal; and
- implementing waste reduction program within local government offices and work places.

IV. References

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CHAPTER 2
REUSE AND RECYCLING

I. Introduction

A. General

Reuse and recycling are the second element in the State's solid waste management policy. Reuse refers to minimizing the amount of waste requiring disposal by reusing items otherwise destined for the waste stream. Recycling means separating or extracting materials from the waste stream and using them to manufacture new products.

The March 1987 New York State Solid Waste Management Plan established a Statewide 50 percent waste reduction/reuse/recycling goal by 1997 (8-10 percent waste reduction and 40-42 percent reuse/recycling). A local solid waste management plan must contain a recyclables recovery program which seeks to maximize to the extent economically and technically practicable the recovery/reuse of solid waste. The program must include specified, progressively increasing percentages of the waste stream that are intended to be recovered as recyclables. The percentages must reflect ambitious, yet realistically attainable goals.

A local solid waste management plan also must address the source separation mandate which was added to Section 120-aa of the General Municipal Law by the Solid Waste Management Act of 1988. The source separation mandate requires that municipalities adopt laws or ordinances to "require that solid waste which has been left for collection or which is delivered by the generator of such waste to a solid waste management facility, shall be separated into recyclable, reusable, or other components for which economic markets for alternate uses exist."

B. Identification of Alternatives

This chapter will discuss the various technologies available for reuse and recycling. Section II discusses source separation, which means setting specified waste materials aside for recycling where they are generated -- at the household, business, industry or institution -- rather than discarding them with other wastes. Source separation programs can be voluntary until September 1, 1992, then must become mandatory.

Collection systems can be designed for pickup, drop-off or some other arrangement, depending upon the planning unit's evaluation of costs and of system design. Section III discusses collection systems.

Once collected, recyclables may undergo some period of storage before, and/or after they are processed. Section IV discusses storage and transfer of recyclables.

Section V discusses the processing facilities which are termed "intermediate processing facilities" or "material recovery facilities", depending upon the nature of the processing performed.

Composting is a form of recycling and is also discussed in this chapter. Section VI discusses various current composting techniques and their applicability.

II. Source Separation

The Solid Waste Management Act of 1988 requires all municipalities in New York State to adopt a local law or ordinance requiring source separation of wastes for which "economic markets for alternate uses exist" no later than September 1, 1992.

A. Description/System Design

Recyclables can be separated at the source, meaning at the household, business, industry or institution where they are generated. If sufficient container and storage space is available, recyclables can be gathered and kept for collection without being mixed with other wastes. Separated recyclables can be mixed together, or "commingled," in one container. Alternatively, separated recyclables can be stored in separate containers. Recyclable materials can be picked up at the source by municipal or private carters or transported directly by the generator to a collection center.

The extent of source separation depends on the number of recyclables to be separated and the requirements of the intended market. As a general rule, markets prefer recyclables which are clean, high quality, dry, and uncontaminated by food, other wastes, or recyclables.

1. Source Separation: Voluntary

The success of voluntary source separation programs depends upon community participation and public education. The decision to participate is left up to the individual resident, business or institution. However, voluntary programs are only an option until September 1, 1992, when source separation becomes mandatory in New York State.

A voluntary program can appeal to and build community spirit, while minimizing costs to local government and staff. Since compliance is generally lower at the start of a recycling program, most communities will not at first need additional collection capability to handle the volume of recyclables. However, a drawback of voluntary programs is that participation levels tend to be low and the quantity of recyclables may not be sufficient to make the recycling program cost effective. Markets are generally volume-oriented and may require a minimum guaranteed volume. This is one incentive for local governments to act together in a regional program.

2. Source Separation: Mandatory

A mandatory or-'nance requires that recyclables covered by the ordinance be separated fr m other trash and put out for collection or disposed of at specified locations, with specific penalties for non-compliance. The degree to which a mandatory program will produce high levels of participation is a function of public information and enforcement of the ordinance. Table 2-1 shows the relationship between mandatory ordinances and voluntary programs in terms of the degree of participation. Table 2-1 demonstrates that weekly collection of recyclables helps to achieve greater participation than programs where collection occurs less frequently.

Mandatory recycling can be encouraged through incentive systems or by a consistent system of increasing penalties for the first, second, or third offenses. For example, if a household does not comply after several warnings, the municipality might refuse to provide collection until the residents separate recyclables. Peer pressure, at least in some neighborhoods, can also serve as a strong incentive to recycle, especially where a separate, highly visible container is set out at curbside for collection.

3. System Design

Source separation is not a facility-oriented operation. However, there are several "design" considerations that influence a source separation program. Such design considerations focus on the degree of separation that occurs at the source. At one end of the spectrum is "commingled" recycling, in which recyclables, regardless of type, are separated out as one mixed group from the non-recyclable material. At the other end of that spectrum is detailed or multiple separation of recyclables, in which each recyclable to be collected by the municipality is separated from the others at the source. System design should also reflect the way in which recyclables are prepared, i.e., rinsed containers, cap removal, bundled vs loose newspapers. These considerations may affect container design and participation rates.

Commingled recyclables must be further separated or sorted either when collected at truckside or during subsequent processing. In some cases, the buyers of recyclables will sort the materials themselves. Generally speaking, prior separation makes the recyclables more attractive to the markets that will use or process them.

Detailed separation requires participants to sort their recyclables into separate containers, one for each of the materials being recycled, or into one compartmentalized container. The degree of public participation tends to drop off as the number of recyclables to be separated increases. This can be overcome to some extent by starting with two or three recyclables and gradually increasing the number of categories to be sorted as public awareness and participation increase.

Convenience will increase participation, as well. For example, different-colored containers -- a distinct color for each

Table 2-1

Effect of Collection Frequency on Public Participation*

	Collection Frequency	
	Weekly	Less than Weekly
Voluntary Programs		
Number Surveyed	17	14
Participation Range	10-80%	4-65%
Average Participation Rate	46%	29%
Mandatory Programs		
Number Surveyed	9	6
Participation Range	40-98%	25-85%
Average Participation Rate	73%	48%

*Public participation is defined as the percentage of potential participants that participates. Public participation percentage does not equal percentage recovery of targeted recyclables.

Source: Camp, Dresser & McKee, 1988

recyclable -- make source separation easier for both participants and pick-up crews.

B. Technology Evaluation

1. Applicability/Capacity

Source separation can help materials stay clean and remain uncontaminated by other wastes, making them more attractive to a wider market. In addition, source separation in itself does not require funding from government unless the recycling program decides to provide bags or containers to participants to encourage their cooperation.

All three major groups of waste generators -- residential, commercial and industrial -- can source separate. The degree to which source separation will be successful in each of three groups depends on the types of wastes generated, the proportion of recyclables in the waste and the degree of participation by each sector. Sound public education programs along with local ordinances will encourage source separation. Other social, cultural, and physical factors also may apply.

Residential wastes tend to be the most diversified of the three main categories of waste. Because the most frequently recycled materials -- newspapers, bottles and cans -- are found in residential waste, source separation is highly applicable to residential wastes. Residential wastes can also be the most contaminated with garbage or other debris.

Commercial and institutional wastes come from sources such as retail stores, supermarkets, restaurants, home and garden centers, auto repair shops and professional offices, among others. Some commercial wastes contain a high percentage of paper products, while others, such as bars and restaurants, have a high percentage of glass and food wastes. The types of wastes generated from a particular establishment will generally remain consistent. Some seasonal variations occur such as during the Christmas holidays or in the warmer months in areas with many visitors.

Industrial wastes refers to solid wastes generated by manufacturing or industrial processes. The material from a particular source is generally homogeneous and predictable. However, industrial wastes vary significantly from location to location. Some industrial sources may have a very high proportion of recyclable wastes, others may not. Also, some types of wastes may not be applicable to a source separation program, though the waste itself may be highly recyclable through an industrial waste exchange or by other means. The Northeast Industrial Waste Exchange, headquartered in Syracuse, attempts to match waste generators with waste users by providing a listing of specific industrial wastes that are potentially recyclable or reusable and by providing a listing of potential waste recyclers.

Table 2-2 summarizes advantages and disadvantages of source separation alternatives. Before making decisions, planning units should consider existing solid waste disposal practices and conditions as well as the markets available for recyclables. Will a source separation program require additional equipment, personnel or fiscal resources? How homogeneous must the recyclables be? The urgency of implementing a source separation program is usually dependent on the remaining available disposal capacity.

Source separation can be accomplished in any community, regardless of area, total population or current collection system. Planning units should structure programs to maximize source separation for a given area. All areas within a planning unit's jurisdiction may not be suited to one type of collection system. In sparsely populated areas, a drop-off center may be more effective than curbside collection. Commercial, institutional and industrial sources of recyclables should not be overlooked; they may generate large quantities of homogeneous materials at one location, simplifying collection and marketing.

2. Reliability/Experience

The reliability of source separation strategies can be directly correlated with the degree of participation. The major advantage of mandatory source separation is that participation rates are higher than in voluntary programs. Increased rates of compliance are attributed to fear of penalty as well as to peer pressure. Since more people cooperate with a mandatory plan, a greater volume of waste is usually diverted from the disposal facility.

3. System Cost

System costs for source separation depend on many variables, such as the size of the community, the equipment used, and the degree of sorting. Most of the costs of source separation are associated with collection and with public education. A community should also expect some administrative and enforcement costs associated with the source separation program. System costs are covered in more detail in the applicable sections of this chapter.

Most communities implementing a source separation program hire a "recycling coordinator." This person will usually oversee the administration, enforcement and education of the source separation program, as well as the marketing of the collected recyclables. When hiring a recycling coordinator, the most important qualification that person should have is previous recycling experience. The costs of a recycling coordinator are similar to those of adding an administrative staff person to the community work force, including salary and additional office and administrative costs.

Table 2-2

Source Separation

Advantages	Disadvantages
Extends landfill life - removes potential wastes from the waste stream. Lowers net disposal costs for solid waste disposal.	People may object to source separation because it is time and space consuming.
Separation is done by the household with no cost to the community as far as separating recyclables from the waste stream.	Additional facility space may be needed to handle source-separated materials.
Source separation is highly applicable to to residential wastes.	Voluntary programs may not achieve the desired level of recycling.
Source separated industrial wastes may be recyclable through industrial waste exchanges.	Secondary materials markets can be unstable.
Mandatory source separation is an effective and reliable means of achieving recycling.	People may not prepare recyclables properly, resulting in diminished recyclability of materials.
Source separation can be implemented on a small-scale, then expanded.	
Source-separated recyclables are usually uncontaminated by garbage and other debris.	

Source: New York State Department of Environmental Conservation
Division of Solid Waste

C. Summary

According to the Solid Waste Management Act of 1988, all municipalities in the State must, by no later than September 1, 1992, adopt a local law or ordinance requiring that solid waste be separated into recyclable, reusable or other components for which economic markets for alternate uses exist.

A community may choose to begin on a voluntary basis, then go to mandatory recycling once the groundwork has been laid and the program is ready to expand. Starting with voluntary recycling enables planners to identify and correct problems or flaws in program design. If a mandatory program is chosen, the community may, for the same reasons, set up a mandatory pilot program.

Ideally, a recycling program should evolve over a period of time, from one or two recyclables at first and eventually to every recyclable material. However, many municipalities need to begin recycling as soon as possible because of severe disposal capacity problems, and cannot afford to wait through a test of voluntary or pilot mandatory programs.

Cooperation with other localities in a regional source separation and recycling program is usually more efficient and produces recyclables in greater quantities, making them more attractive to markets. Economies of scale will reduce costs.

The key concept in source separation is public participation. Without it, source separation doesn't work. Public education is, therefore, one of the most important elements in a successful source separation program.

III. Collection Systems

Curbside collection, drop-off centers and buy-back facilities are the major ways in which recyclables can be collected. These methods and the necessary equipment and operational strategies associated with collecting recyclables are described below.

A. Description/System Design

1. Curbside Collection

Curbside collection means that recyclables are picked up at the point of generation. Curbside service usually is offered in cities and suburbs, because it is the most cost-effective and convenient method of collecting recyclables in medium to high density population areas. In general, communities with more than 300 people per square mile or greater than 5,000 inhabitants should consider curbside collection.

Curbside collection is convenient for waste generators, requiring little or no change in their routines. This system also has the highest potential for keeping recyclables out of the disposal facility because participation is relatively easy. Curbside collection is the best means for encouraging participation, especially if collection of recyclables takes place on the same day as regular collection, and specific highly visible set-out containers are used. Wastes may be commingled or sorted into the components being recycled. If curbside garbage collection is provided, then curbside collection of recyclables must also be provided.

In residential recycling, set-out containers are frequently used. A set-out container is usually made of plastic and is often box-shaped and stackable. Some larger set-out containers can hold a large quantity of recyclables and can be rolled to the curb. Communities distribute the containers to residents generally two or three weeks before the recycling program is scheduled to begin. Residents can use their containers to store recyclables until pickup day.

2. Drop-off Facilities

A second collection option is the use of one or more drop-off facilities, which consist of a centrally-located facility with covered bins, large containers, or stalls or trailers to receive and store recyclables. Drop-off stations are most often used in rural areas where it is inconvenient or prohibitively expensive to provide curbside service. Typically, one or two staff persons are on-site to discourage vandalism, maintain the site, assist those who are dropping off recyclables, and insure the safety of persons who use the facility. Staff may also sort recyclables and provide quality control. Dropoff stations are sometimes provided for items that are recyclable but not usually collected at curbside.

Residents and other generators transport their recyclables to the drop-off center. They may be required to separate the various materials into distinct bins or be allowed to deposit them in a commingled bin.

Start-up costs for drop-off stations are relatively low because equipment, personnel and maintenance requirements are minimal. These stations are a cost-effective method of collecting bulky items (such as major appliances) or special materials (such as waste oil and batteries).

The mobile drop-off center is a specialized collection vehicle or a vehicle carrying separate containers which stops at a specified location on a regular schedule.

3. Buy-Back Facilities

Buy-back facilities are similar to drop-off stations because participants must transport their recyclables to the facility. The difference is that participants are paid in cash for the items they bring to the facility. Some buy-backs are privately owned and operated, such as R2B2 in New York City, but municipally-owned centers do exist. Buy-back centers are typically located in urban, low-income areas in order to foster participation through direct incentives. These centers also have a litter-reducing effect.

The advantage of buy-back facilities is the financial incentive which attracts a core clientele and influences them to gather and deliver high-value materials such as aluminum. Buy-backs are not always advantageous for local government-run recycling programs. If citizens can get cash for recyclables, they are less likely to give them to the local government which is collecting them. Moreover, participation rates are low for buy-back systems, making them the most costly per-ton method of materials recovery.

4. Special Collection Day

In a curbside recycling program, "special collection" indicates that recyclables are collected on a different schedule from regular garbage. For instance, a different day of the week or time of day can be designated during which only recyclables or certain recyclables will be collected.

A variation on this idea for both curbside and drop-off programs is to designate a day or week during which recyclables are collected or dropped off. Special curbside collection allows pickup of recyclables without overburdening staff and equipment used for regular collection. Drop-offs are well-suited to special collections of specific materials, since people seem willing to participate in a well-publicized occasional program for the collection of seasonal, i.e. yard waste, or hard to recycle materials such as "white goods" or household hazardous waste.

A special collection may incur added costs for staff, equipment and publicity. Household hazardous waste collection events, for instance, require specialized equipment and staff for collecting, storing, and transporting the wastes, and may also require permits. Also, special collection days must be adequately publicized so that the public knows that it is taking place.

5. Collection Equipment

For most municipalities starting a source separation program, additional equipment should be selected on the basis of efficiency, cost, safety, labor requirements, capacity, collection schedule and market arrangements. In many cases, existing equipment can be modified and used until new equipment is purchased. Equipment also can be "borrowed" from or shared with other municipal departments.

a. Compactor Trucks

Compactor trucks can be used to collect recyclables. They have the advantage of being able to reduce the volume of the waste because they are equipped to compress the waste as it is received. Most collection fleets already have compactor trucks.

Compactor trucks are easy to load and unload and can be used to collect recyclables as long as the vehicle is cleaned thoroughly before use. In some instances, recyclables have been contaminated by inadequately-cleaned compactor trucks. Therefore, compactor trucks should be dedicated exclusively to recycling, if used. The compactor pressure can be adjusted to avoid breaking recyclable glass. With a trailer attached, both recyclables and regular garbage can be picked up by compactor trucks. However, compared to other vehicles for collecting recyclables, compactor trucks are very expensive to operate. Also, unlike other types of recycling collection vehicles, they cannot handle two or more source separated recyclables.

b. Smaller Collection Vehicles

Included in this category are refuse scooters and box-bed, pick-up, dump-body and stake-body trucks.

Small collection vehicles cost less to operate and maintain than compactor trucks. They are more versatile and can be used by the municipality in other programs. The major disadvantage is that some of these vehicles have no dumping mechanisms; materials must be unloaded manually at considerable cost, risk and loss of time. These vehicles also have an elevated loading height, making collection difficult and less efficient.

c. Compartmentalized Vehicles

Many vehicles specifically designed for recycling are now available on the market. These vehicles have distinct loading and storage compartments to collect two or more recyclables. They include covered vehicles with two to three compartments, uncovered vehicles with four to five compartments, and open vehicles with side-dumping bins. A smaller truck also can be compartmentalized by equipping it with bins or drums. This allows for the collection of more types of recyclables, but smaller quantities of each.

Compartmentalized vehicles provide for efficient collection of two or more types of recyclables, have a large capacity, and are less expensive to operate than compactor trucks. One disadvantage is that one bin may fill faster than another. However, some vehicles are equipped with adjustable bins, so that the operator can adjust the number and capacities of the bins to a particular situation.

d. Racks

Racks are mounted on the side or underneath vehicles to hold newspaper while the rest of the garbage is being collected. They are not usually recommended because they are open and newspaper can get soggy in bad weather or from splashing through water on the roads. Also, their capacity is usually inadequate.

e. Trailers

Trailers can be purchased with self-dumping compartments to collect different recyclables and can be attached to collection trucks. Recyclables are collected more economically in this manner than with a separate truck or a specially-designed truck. Trailers are available in a variety of sizes and designs, and can be modified inexpensively.

Trailers can be used in two ways. The first is to attach a trailer to a truck tractor to collect different recyclables simultaneously. The second is to collect one or more recyclables along with refuse by attaching the trailer to a collection vehicle.

The disadvantages of trailers is that they have maneuvering problems and may be less feasible in areas with many alleys, steep hills, dead-ends or severe winters. The trailers may also fill up more quickly than the refuse truck. Also, some insurance companies won't provide liability or workman's compensation for drivers working with truck and trailer combinations.

f. Special Containers

Some recycling programs provide residents with special containers in which to sort and store their recyclables. This measure of providing residents with a highly visible, daily reminder to recycle appears to improve participation (see Table 2-3) by 10 to 20 percent. Placement at curbside increases public awareness of recycling, and creates a degree of peer pressure to recycle, as well as a sense of community spirit. However, the size of the container should be appropriate for use by residents. A recycling program may consider providing different-sized containers for the various types of households.

B. Technology Evaluation

1. Applicability/Capacity

Curbside collection is particularly applicable in areas where there is already curbside collection of wastes. When source separation of recyclables becomes mandatory on September 1, 1992, curbside collection of recyclables will be required in New York State where there is curbside collection of wastes. Curbside collection is typical in more densely populated areas of the state and is found less frequently in more rural areas.

Curbside collection of recyclables where there is already curbside collection of garbage makes it possible to pick up recyclables at the same time as the waste. In some cases, to minimize expenses, the same vehicles, with modification, can be used for both purposes.

Table 2-3

Effect of a Special Curbside Collection Container On Public Participation

Community	Public Participation (%)	
	With Special Container	Without Special Container
Champaign, Illinois	83	11
Kitchener, Ontario	75	65
San Jose, California	75	48
Santa Rosa, California	70	35
Toronto, Ontario	66	42

Source: Camp, Dresser & McKee, 1988,

A curbside collection program for recyclables where there is not already a curbside collection of garbage will undoubtedly cost more, and may not be practical because of the added cost. Recyclables collection schedules and routes would have to be developed and collection vehicles and personnel would have to be provided.

Drop-offs can be a useful way to start a recycling program and especially useful in communities where the residents already bring their waste to a disposal facility. Drop-offs are also suitable for the collection of infrequently generated wastes such as used oil, white goods, batteries, tires and household hazardous waste.

Special collections are ideal for seasonal recyclables such as yard waste, Christmas trees, leaves or debris from spring cleaning, as well as for infrequently generated materials such as household hazardous wastes or materials which accumulate in small amounts over a period of time (tires, white goods, batteries, bedsprings). Publicizing a special collection is essential for its success.

Buy-backs are typically run by private entities for profit or by volunteer groups to gather recyclables that they can sell for fund-raising purposes. Buy-backs tend to bring in the recyclables which command the highest prices. However, privately run buybacks will compete with local government programs.

2. Reliability/Experience

Curbside collection has proven to be an effective means of collecting source-separated recyclables, especially where curbside collection of waste already occurs. There is generally a much higher participation rate than drop-off programs, because participants need only to separate the recyclables and place them at the curb. This minimizes the effort required by the participant and results in a higher participation rate. Efforts can be further minimized by having recyclables collected on the same day as when regular wastes are collected.

A separate vehicle is often employed for the collection of recyclables in a curbside program. Combined collection of trash and separated recyclables by a trailer towed behind the trash collection vehicle has been found not to work well, particularly during the winter when roads are slippery.

Compared to curbside collection programs, drop-off centers are less expensive in capital costs as well as operation and maintenance costs, but they may not significantly reduce the waste stream.

Buy-back centers have proven useful in industrialized and urbanized areas.

3. System Cost

Collection and transportation costs are site-specific cost components of a recycling program, varying with the type of program (e.g., source separation) and such factors as population density, participation levels and area served. As such, general cost ranges are virtually impossible to establish for a recycling program.

Table 2-4 lists the costs of various collection equipment. Curbside collection is more costly than drop-off or buy-back alternatives, because of equipment costs.

C. <u>Summary</u>

The major options for collecting recyclables include curbside collection by municipal or private recycling crews (required where curbside pickup of garbage is provided), drop-off centers where residents bring their recyclables to a special location, and buy-back facilities where residents are paid for their recyclables. Many factors must be taken into account in deciding which of these options or combination of options to select. Some of these factors include population density, waste generation rates, existing collection practices and facilities, available markets and public attitudes. Table 2-5 summarizes the various advantages and disadvantages of collection options and equipment.

In designing and implementing collection systems, a planning unit should consider how to maximize the collection of recyclables while minimizing costs, and consider ways in which recyclables collection can be integrated with existing collection systems.

In general terms, curbside collection of recyclables would be practiced in municipalities that already have curbside collection, either by private haulers or the municipality. In less populated and rural areas, or areas with a depressed local economy, drop-off or buy-back centers might be more appropriate, although participation will be lower. A planning unit ought to compare various strategies and the cost of implementing them when designing its recyclables collection program.

Since the greatest degree of household participation in source separation will occur if recyclables are put out at the same time as "trash," it makes sense to pursue options that will allow the collection of recyclables at the same time that "trash" is collected. However, this may not be feasible for many reasons, including the quantity of recyclables collected and where they are taken for processing.

The geographic location and environmental setting where processing takes place will influence the design of the collection system. Wherever possible, the collection process should try to fit in with the collection of regular garbage. This will not only ensure the greatest degree of participation by households, but also will minimize collection costs.

Table 2-4

Recycling Collection Vehicles Costs

Compactor Trucks

Description	Capacity	Estimated Price
- rear packer	20 C.Y.	$ 90,000
- rear packer	31 C.Y.	$ 110,000
- front-loading packer	30-40 C.Y.	$ 120,000

Smaller Collection Vehicles

Description	Capacity	Estimated Price
- flatbed truck with bins	10-15 C.Y.	$16,000-25,000
- dump truck	7-12 C.Y.	$25,000-35,000

Compartmentalized Trucks

Description	Capacity	Estimated Price
- Automatic loading - 3-6 compartments - telescopic hoist for rear dumping - side and top loading	31-32 C.Y.	$56,000-84,000
- Manual loading - up to 8 compartments - hoist for rear dumping	Up to 34 C.Y.	$35,000-50,000

Source: New York State Department of Environmental Conservation
Division of Solid Waste

Table 2-5

Collection Systems

Collection Equipment - Compactor Trucks

Advantages	Disadvantages
Compactor trucks are easy to load and empty.	Compactor trucks must be completely clean before being used to collect recyclables.
Compactor trucks can also be used to collect recyclables as long as the vehicle is cleaned thoroughly and compactor pressure is adjusted to avoid breaking recyclable glass.	Compactor trucks cannot hold separate recyclables except by attaching a trailer for recyclables.
With a trailer attached, both recyclables and regular garbage can be picked up by compactor trucks.	

Collection Equipment - Small Vehicles

Advantages	Disadvantages
Small collection vehicles cost less to operate and maintain than compactor trucks.	Small trucks have no dumping mechanisms; materials must be unloaded manually at considerable cost, risk and loss of time unless a dump mechanism is purchased and fitted.
Small collection vehicles are more versatile (can be used in many ways by the municipality).	Small collection vehicles have an elevated loaded height making collection dangerous and inefficient.
By equipping a smaller truck with bins or drums, more types of recyclables can be collected.	Small vehicles may have to make more unloading runs as recycling participation rates increase.

Table 2-5 (continued)

Collection Equipment - Compartmentalized Vehicles

Advantages	Disadvantages
Compartmentalized vehicles provide for efficient collection of two or more streams of recyclables.	Specialized equipment such as compartmentalized vehicles are less versatile than multi-purpose equipment, which can be put to other uses by the municipality.
Compartmentalized vehicles have large capacity.	
Existing vehicles can be modified with bins for recycling.	

Collection Equipment - Trailers

Advantages	Disadvantages
Trailers attached to collection trucks can collect recyclables more economically than a separate truck or a specially designed truck.	Trailers have maneuvering problems and use of them in areas with many alleys, steep hills, dead-ends or severe winters is questionable.
Trailers are available in a variety of sizes and designs.	Some waste hauling unions prohibit their members from working with trailers.
Trailers cost little for a municipality to modify.	Some insurance companies won't provide liability or workmen's compensation for drivers working with truck and trailer combinations.

Source: New York State Department of Environmental Conservation
Division of Solid Waste

IV. Storage/Transfer of Unprocessed Recyclables

Following collection, recyclables may be delivered to temporary storage/transfer facilities, directly to a buyer or to an intermediate processing facility. This section discusses the storage/transfer of unprocessed recyclables. In most cases, some form of storage/transfer is required in order to achieve economical transport and market-acceptable quantities.

A. Description/System Design

The need for and type of storage/transfer facilities will depend on market arrangements and specifications, the recyclables collection system and the location of processing facilities. In rural areas, the same facility may serve both as drop-off center and storage facility.

Low-population communities often require storage of recyclables until enough materials are accumulated for economical transport and marketing. Many small towns and villages use a trailer located at a town garage, or some other convenient location, to store recyclables brought in by residents, accumulated from drop-off centers and special collection events, or collected at curbside. When the trailer is full, it can be attached to a truck tractor to transport the recyclables to market.

In larger communities where specialized recycling vehicles are utilized, transfer to transport vehicles is common when markets are distant. In most cases, storage is provided to allow for equipment down-time, weekends and holidays, overnight storage and transfer of materials and market lulls. Long-term storage of unprocessed recyclables is not commonly practiced because of the potential for odors, vectors, fires, etc.

1. System Design

Storage/transfer facilities can use different designs and equipment, depending on the volume of recyclables, the nature of materials collected and the location of the market.

Trailer bodies and bins or stalls are the predominant equipment used at storage facilities. Trailer bodies or roll-off containers provide enclosed space for storing recyclable materials; they are mobile, and can be attached to a truck tractor to transport the recyclables. A storage trailer can be parked at any facility, such as a landfill or a town garage. Individuals can bring recyclable materials and transfer them to the trailer body. In some cases, the equipment is lent by or rented from the buyer of the recyclable materials as part of the market agreement.

Bins are containers which are enclosed on four or five sides and open on one side for access. They can be made from wood, steel, cement block or cement; however, since they are stationary, recyclables must be transferred from them for transport. The bins should be covered and kept as clean as possible. The site chosen for storage should be fenced to prevent vandalism and to insure the safety of visitors. The storage site should not be allowed to become littered and unsightly. It may be necessary to staff the site for security and maintenance. Weatherproof storage, if required, can be provided in a warehouse, quonset hut or shed.

The design elements of a transfer station for recyclables are similar to those for a transfer station for refuse. System design should integrate the site with the building floor plan, taking into account the need for utilities, road access, minimization of travel between the collection points and the transfer station, and location of the site away from residential areas to mitigate environmental impact such as noise and truck traffic.

The design of the building itself should incorporate areas for loading, unloading and storage of recyclables as well as for transfer station equipment. Consideration also should be given to ease of access for removing the recyclable or shipping them to intermediate processors or end users. For instance, if it is expected that most of the recyclables can be shipped by rail to their markets, strong consideration should be given to locating the transfer station at a rail siding. Otherwise, the facility should be located near a major highway. Transfer operations should be kept as simple as possible, and the building and appurtenances sized accordingly.

B. Technology Evaluation

1. Applicability/Capacity

Almost every community with a recycling program needs some kind of short-term storage facility. It may be used only for contingencies, such as when markets are depressed for a particular recyclable, or it may be an integral part of the program, particularly if recyclables must be shipped to an end-user or an intermediate processing facility or transported only in large quantities. These concerns might be particularly applicable to smaller communities.

2. Reliability

From a facility design point of view, the storage and transfer of recyclables shares some of the design considerations of a transfer station for unsorted solid waste. Complex mechanical systems have a greater chance of suffering downtime, as do unproven technologies. The simpler the system, the more effective it is likely to be.

3. System Cost

Table 2-6 lists the costs for various storage and transfer containers. In many cases existing public work sites can be used for small storage/transfer operations. Capital costs for new storage/transfer facilities and sites are associated with building and site improvements. Average capital costs can range from $15,000 per ton of capacity for a small self-haul facility to approximately $5,000 per ton of capacity for a large truck transfer facility. Operational costs are associated with on-site labor, maintenance, utilities and hauling. Operating costs can range from $15 per ton to $8 per ton respectively for the facilities discussed. Based on round trip transfer times of 60 minutes, these costs will increase as haul distances increase.

C. Summary

Table 2-7 lists the advantages and disadvantages of the storage and transfer options for recyclables. The planning unit should consider the size and number of storage and transfer facilities, as well as the location of the facilities so as to minimize transportation costs and maximize the efficiency of the collection process. Siting is also very important in terms of minimizing noise from transfer operations. The overall plan dictates the size, location, and number of storage and transfer facilities that the planning unit will operate. Future capacity needs should also be considered in sizing storage structures.

V. Materials Recovery Facilities/Intermediate Processing Facilities

As discussed in this chapter, the materials recovery facility (MRF) or intermediate processing facility (IPF) does not separate recyclables from the waste stream, but further separates or processes source-separated recyclables in order to meet the quality control requirements of a particular buyer or end-user. The term MRF is used within this text, but may be referred to as an "IPF" as well.

A. Description/System Design

MRFs are designed and operated to sort, clean and densify source separated recyclables by manual and mechanical means for subsequent transport and sale. They may utilize sophisticated separation and processing equipment to separate the waste stream into several fractions, including ferrous metals, glass, aluminum, plastics, paper, an organic or light fraction, and residue. A MRF will usually contain a building with a paved receiving area, lights, heat, plumbing and adequate space for processing and storage. The facility is staffed to operate equipment and help sort and process materials. The processing facility also may contain a drive-on scale for billing purposes, a tipping floor, front-end loaders in order to feed the recyclables or raw waste onto conveyor belts and assorted processing machinery (described below). Additionally, machinery may be used to receive and convey recyclables.

A distinction is made from other types of facilities, especially refuse-derived fuel plants and composting plants that process raw municipal waste and separate out significant quantities of recyclables such as glass, metal, and other unprocessible materials prior to processing. This fraction of the waste can be recycled, but, because it is not source-separated, is not as clean or as easily marketed as source-separated material, unless the system employs a washing stage. Such facilities will use processing equipment similar to that used in a MRF to separate out glass, metal and other materials that cannot be incinerated or composted.

Table 2-6

Costs of Storage/Transfer Containers

Description	Capacity	Estimated Price
Roll-off Container	20 C.Y.	$ 2,800
Roll-off Container	30 C.Y.	$ 3,100
Roll-off Container	40 C.Y.	$ 3,400
Bins w/forklift tubes	2 C.Y.	$ 450
Bins w/forklift tubes	3 C.Y.	$ 500
Bins w/forklift tubes	4 C.Y.	$ 550
Trailers - Flatbed	Variable	$5,000-10,000
Trailers - Flatbed w/bins	Variable	$15,000-30,000

Source: New York State Department of Environmental Conservation
Division of Solid Waste

Table 2-7

Storage/Transfer of Unprocessed Recyclables

General

Advantages

Storage facilities give low-population communities a means to accumulate sufficient recyclables for economical transport.

A storage facility gives the community a place where residents can drop off recyclables, regardless of the type of recyclable program in effect.

To some extent, storage space gives the community a place to store recyclables when the market is low or non-existent for a particular recyclable.

Storage trailers are mobile, and can be located wherever most needed - e.g., shopping mall, town garage, etc.

Environmental impacts are low.

Storage systems are generally simple and not subject to breakdown or mechanical failure.

Disadvantages

Storage of recyclables for extended periods of time may result in market risk if prices should decrease while the recyclables are stored.

If not carefully maintained, extended storage periods may create odors and vermin problems.

Some noise and increased traffic will be associated with the storage facility.

Bins/Stalls

Advantages

Stationary bins are easy to use and clean. They are simple enough to construct that recycling programs can make their own.

Disadvantages

Additional handling of materials is needed because the contents of bins must be transferred for transport.

Stationary bins are not water tight, but can be made so with modification.

Table 2-7 (continued)

Advantages	Disadvantages
Indoor Storage	
Recyclables are kept clean, separated and dry for later retrieval.	Security may be needed to prevent vandalism.
Existing unused structures can be used.	
Roll-Off Containers	
Roll-off containers come in a variety of sizes and require little maintenance.	Roll-off containers do not protect recyclables from the weather, but can be protected with tarps.
Roll-off containers eliminate additional handling of recyclables because they can be moved onto a roll-off truck to transport the materials.	
Roll-off containers are available commercially and can be leased.	

Source: New York State Department of Environmental Conservation Division of Solid Waste

Three basic operations may occur at a MRF: cleaning, sorting, and densifying. These are discussed in detail below:

1. Cleaning Systems

Cleaning is a process that prepares recyclable material for market. Clean material is of considerably higher value than contaminated or dirty material; in fact, many markets will not accept recycled material that is not clean. Cleaning operations typically include:

- manually removing rings, lids caps, labels; and
- using trommel screens to remove dust and dirt.

2. Sorting Systems

Sorting divides recyclables into specific categories. These functions may be carried out by: hand sorting for small appliances, glass, metals, heavy plastics, and various grades of paper; using trommel screens to pass lighter recyclables such as paper and plastics, and to drop out metals, glass and ceramics; using a magnetic separator to remove ferrous metal recyclables from commingled recyclables; using air classifiers and ballistic separators to sort light recyclables from heavier materials; using eddy currents for aluminum; and using optical sorters to sort glass by color.

A MRF may perform any or all of the following operations:

- sorting metals into ferrous and non-ferrous;
- sorting paper by grades or from heavier recyclables;
- sorting containers by material (plastic, glass and metal); and
- sorting glass according to color.

a. Air Classifier.

Waste can be separated based on the relative weights of materials; the air classifier uses gravity to sort materials according to this principle. Four basic types of air classifiers exist: air knife, rotary drum, vertical system and horizontal system. In all cases, a stream of air is used to separate materials such as paper and light plastic from the heavier fractions of waste.

b. Ballistic Separator

Another type of classifier which can separate two or three waste streams simultaneously is the ballistic separator. In this system, the waste is carried up a conveyor belt at a certain angle, allowing the lighter materials to travel up the belt, and the heavier materials to fall back.

c. Screens

Screens are designed to separate wastes by size. The most commonly used screen is called a rotary trommel screen, a cylindrical rotating chamber with holes. Smaller-sized particles such as glass, dirt and other small contaminants pass through the holes and are removed. Larger particles such as paper and plastics generally will be carried along on the screen for further processing. Other types of screens which are used less frequently in solid waste management are vibratory deck screens and disc screens.

d. Magnetic Metal Separator

This device uses magnets to separate ferrous from non-ferrous metals. Markets pay well for aluminum cans, but they must be uncontaminated by other metals.

e. Aluminum Separators

Aluminum separation usually takes place along with glass and plastic separation, as these two components are usually what is left after other separation operations have taken place in an MRF.

Aluminum separation is accomplished in one of two ways. The most commonly-used method is known as heavy media separation or froth flotation which involves the use of an aqueous suspension of finely-divided particles of magnetite or ferrosilicate which give the solution a high specific density, causing the aluminum to float on top where it can be skimmed off. In order for this process to work well, the plant should have a feed rate of 2,000 to 3,000 tons per day of raw material.

The other method, called an "aluminum magnet," currently is in use in only a few facilities, including one at Gallatin, Tennessee, and at the Rhode Island MRF in Johnston, Rhode Island. The process involves the generation of a magnetic field known as an eddy current around a rotating drum. When a non-ferrous conducting material enters this field, it is deflected by the eddy currents. The method has limitations because the deflection is dependent upon the geometry and size of the object being deflected. In Rhode Island, the process is used to separate aluminum cans from other source-separated materials.

f. Optical Sorting

This process separates glass based on the light-reflective properties of the glass. The glass must be in the range of 1/4 to 3/4 inches in diameter, and is passed along a vibrating feeder where a sensor measures the optical reflectivity of the glass. A blast of compressed air then separates the glass from the rest of the waste stream.

Optical sorting separates glass from non-glass particles at an efficiency of 99%; it also separates colored from clear glass. The processing rate varies from one half ton to fifty tons per hour.

3. Densifying Systems

Densifying is a process which reduces the volume of recyclables for storage and transport. Paper and plastic can be shredded and baled, glass can be crushed, cans flattened and white goods crushed and shredded. A variety of equipment can be used to perform these processes. The most commonly used machinery is described below:

a. Baler

A baler is a compaction device that crushes material into large rectangular blocks, reducing it in volume and making it uniform in shape for easy storage and shipping. Balers are versatile because they can process several kinds of materials and can be designed for specific components of the waste stream, including aluminum, paper, and plastic. Three factors are important in a baler: degree of compaction, throughput and bale size. "Throughput," or operating capacity, is the most important of the three.

b. Shredder

Some shredders work on many types of materials, such as paper, plastic and aluminum. Others are designed to handle a single type of material. A hogger, for example, works on demolition wood. A plastic shredder may be very beneficial because of the volume reduction achieved; however, the market may dictate the volume reduction technique it prefers, (i.e. shredding, baling, etc.). Shredders are prone to explosions if items such as gas tanks and propane tanks are not removed prior to shredding. This is more of a concern where shredders are used to process raw municipal solid waste, and is less of a concern where recyclables alone are processed.

c. Can Crusher and Flattener

By crushing or flattening cans, the number of cans transported per shipment is greatly increased. The largest can crushers process thousands of cans an hour. Some can crushers have special features, such as a blower that automatically feeds the cans into a truck.

d. Glass Bottle Crusher

These crushers simply crush the glass to reduce volume. Mechanical bottle crushers are preferred to manual crushing because they are less dangerous for personnel. Some models have attached screens or trommels to remove paper and aluminum contaminants.

e. Granulator

Granulators are generally used to reduce the volume of plastics. Some also remove impurities, usually by means of an air classifier that operates on the principle of sedimentation to sort materials.

f. Chipper

A chipper is a slower-speed shredder generally used for demolition lumber, tree scrap, pallets, boxes and old furniture. The product of chipping is useful as fuel or mulch. Chippers may also be used to shred tires to produce a useful fuel or recyclable material.

B. Technology Evaluation

A MRF processes source-separated recyclables to meet the specifications of markets. The objective of these facilities is to process high volumes of recyclables and prepare them for efficient bulk shipment.

1. Applicability/Capacity

In most cases, collected recyclables must be prepared or processed to meet market specifications. Processing yields clean, homogeneous secondary materials which have been reduced in volume to facilitate transport. As a general rule, secondary materials can be used in the same way as virgin materials as long as they are not contaminated.

Typically, recyclables recovered from the waste stream will include:

- residential recyclables, such as glass (clear,amber and green), cans (ferrous and non-ferrous), newspaper, corrugated cardboard, and rigid plastic;
- commercial recyclables, such as corrugated cardboard, computer paper, and white ledger paper; and
- residential and commercial compostables, such as leaves, yard waste, tree trimmings and wood pallets.

A MRF can be customized to the needs of the municipality and the type of materials being recovered. Because such facilities are expensive to build and operate, they are most suitable where the population served is great enough to justify the cost of construction and operation.

Source-separated recyclables have not been mixed with raw waste and are generally clean and more marketable than recyclables from a pre-processing operation for composting or waste-to-energy production. Keeping recyclables clean should be a goal when designing a recycling program, since some end-users are more particular than others about contaminants in recyclables. Contamination may result in a lower price or rejection of the recyclables.

2. Reliability

MRFs are complex mechanical systems. The components of the system must be carefully matched in processing capacity so that one component does not overwhelm the others in the system. Redundancy also is important in these systems. MRFs usually have a high degree of reliability since unprocessed waste does not enter the system.

3. System Cost

Costs can vary according to the processing capacity size, number of processes and technologies employed and prices received for the recyclables. An example of the capital costs (estimated) for a facility in New York State is given in Table 2-8; this facility is designed to handle commingled glass, cans and plastic containers, as well as newspaper and cardboard.

C. Summary/Conclusions

A MRF is an effective way to process source-separated recyclables, particularly in urbanized areas. But because of the costs involved, a planning unit should consider carefully its proposed recycling program and targeted markets before electing to construct and operate a MRF.

VI. Composting

Composting takes advantage of, and accelerates the natural process of decay of organic matter to produce a stable, humus-like mixture suitable as a mulch or soil conditioner. A large volume of organic wastes such as leaves and yard wastes, food waste and sewage sludge can be processed by composting.

A. Description/System Design

Composting is a biological method of solid waste management that recycles organic waste through decomposition. Organic materials can be composted in a variety of ways:

1. Windrow System

Windrows are long piles of compostable materials, usually approximately 12 feet wide and 6 feet high. The rows are kept moist and turned over to aerate the system, which promotes uniform decomposition, and ensures that all the material decomposes at a satisfactory rate. Because of the amount of land area required and labor needed, windrow systems are most commonly used for yard wastes. Windrow composting of yard wastes produces a usable product in six months to two years, depending on the rate of decomposition. To accelerate decomposition, compostable materials can be shredded, nitrogen added (if needed), and the windrow turned over more

Table 2-8

WESTERN FINGER LAKES
MATERIAL RECYCLING CENTER CAPITAL COST ESTIMATE
(75 TONS PER DAY)

Cost Category		Expected Cost
Equipment		$ 500,000
Land		30,000
Site Improvements		50,000
Building		800,000
	TOTAL:	$1,370,000
	AMORTIZED COST:	155,383*

*Includes the cost of debt service reserve fund, capitalized interest fund and cost of bond issuance for 20 years at 7% annual interest rate.

WESTERN FINGER LAKES
ESTIMATED OPERATING COSTS FOR MATERIALS RECYCLING CENTER
(75 TONS PER DAY)

Cost Category		Expected Cost
Annual Operating Cost		$ 551,654
Amortization Cost Per Year		155,383
	TOTAL GROSS OPERATING COST:	$ 707,037
Gross Cost/Ton		$ 51
Average Revenue/Ton		43
Net Cost/Ton (tipping fee)		8
	NET COST PER YEAR:	$ 108,987

Source: Pytlar, Theodore S. "Evaluating and Selecting Among Waste Management Alternatives in the Western Finger Lakes Solid Waste Management Program", Materials and Energy Recovery From Municipal Solid Waste (Third Annual Symposium sponsored by The Nelson A. Rockefeller Institute of Government and the State University of New York, October, 1987).

frequently. These additional operations can shorten the time needed for decomposition to less than one year.

2. Aerated Static Pile

In this composting system, the material to be composted, usually sewage sludge, is typically mixed with a bulking agent such as wood chips, and formed into piles. A system of pipes underneath the piles are connected to blowers which force air through the piles which are usually covered with woodchips which provide a source of carbon, structural stability, and increased porosity for air flow. The microbes that metabolize and decompose organic wastes need aeration (oxygen) to prevent excessive heat buildup and remove moisture from the piles. With an aeration system, piles can be built wider and consume less land than windrow systems. When composting is complete, the piles are broken up and can be screened to remove the bulking agents.

3. In-vessel Composting

Mechanical equipment is available that accelerates decomposition by controlling the flow of air and water. Some of these are enclosed and computer-controlled to further accelerate the decomposition process. Most of these systems are modular and fall into four major types:

a) agitated bed systems;

b) silo systems;

c) tunnel systems; and

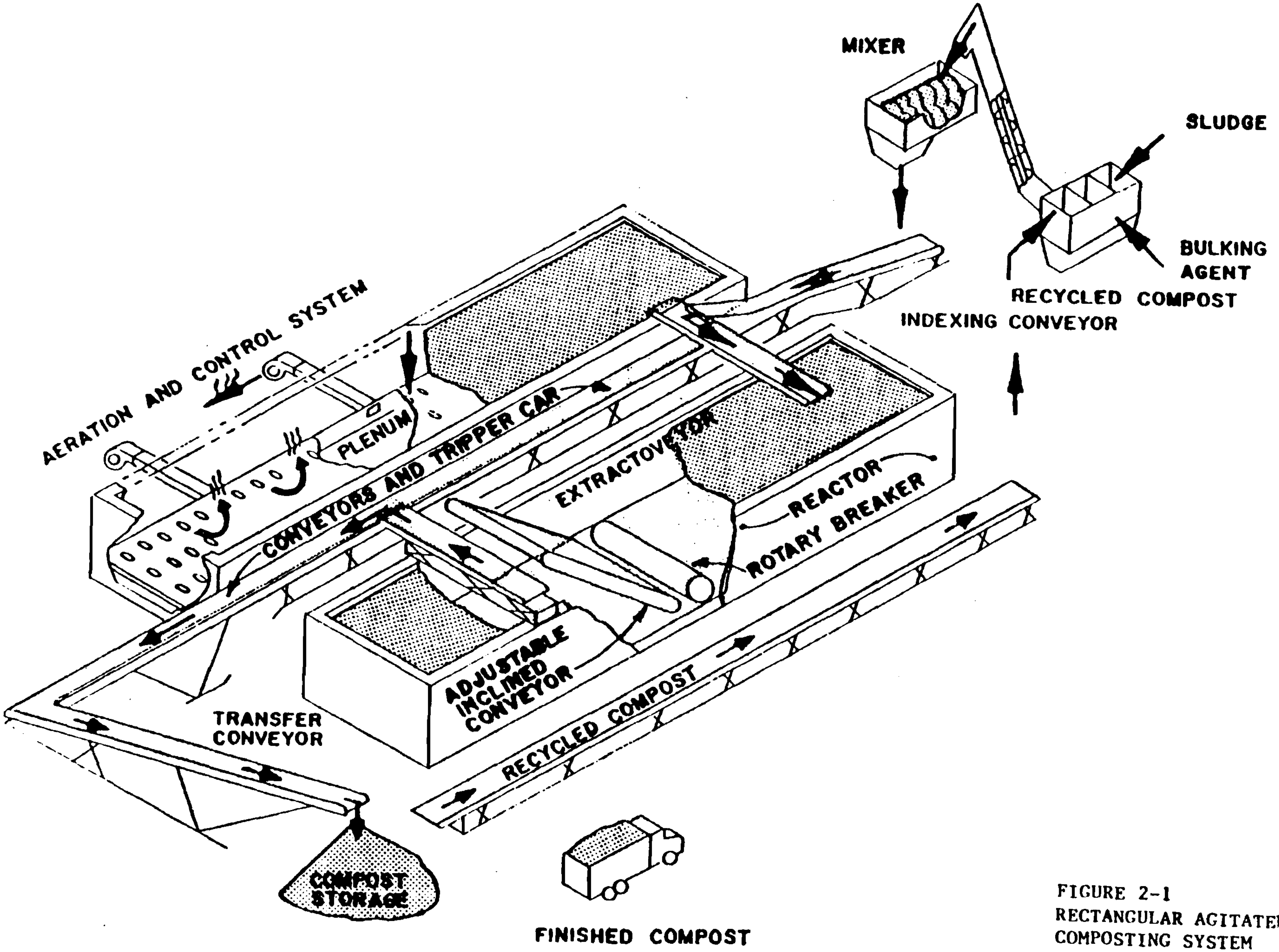
d) enclosed static piles.

a. Agitated Bed Systems

Agitated bed systems use a shallow compost pile to minimize compaction, which in turn lessens the pressure requirements for aeration. The reactor flow is horizontal, and the design can be either rectangular or circular. In either case, the systems are sized for a 14-day retention time and provide intermittent mixing of the composted material. Figures 2-1 and 2-2 illustrate a rectangular agitated bed system and a circular agitated bed system, respectively.

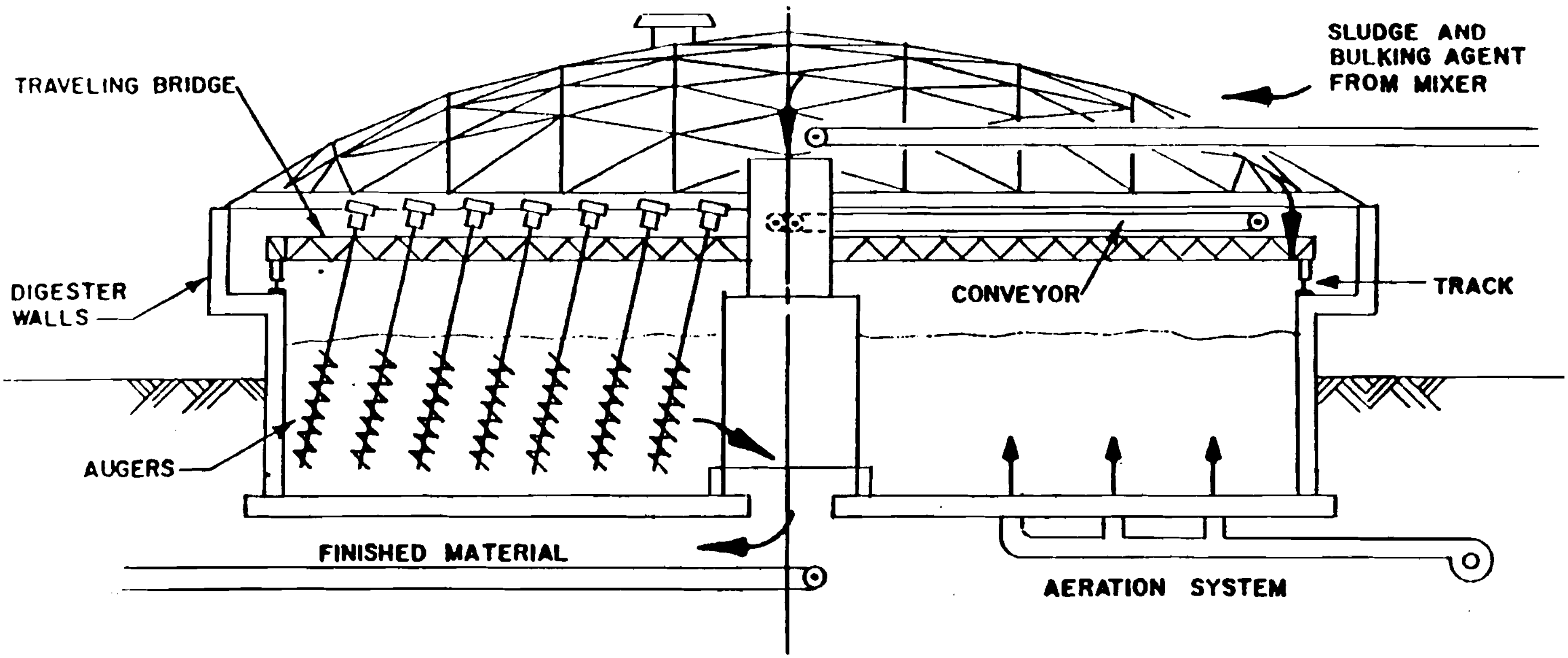
b. Silo Systems

Silo systems are vertical plug flow reactors. The feed mixture is added to the top of the reactor, and air is typically forced upward through the compost and exhausted at the top. Like agitated bed systems, the design can be either rectangular or circular. Reduction of pathogens and volatile solids occurs in the upper portion of the reactor. Figure 2-3 illustrates a silo-type system.



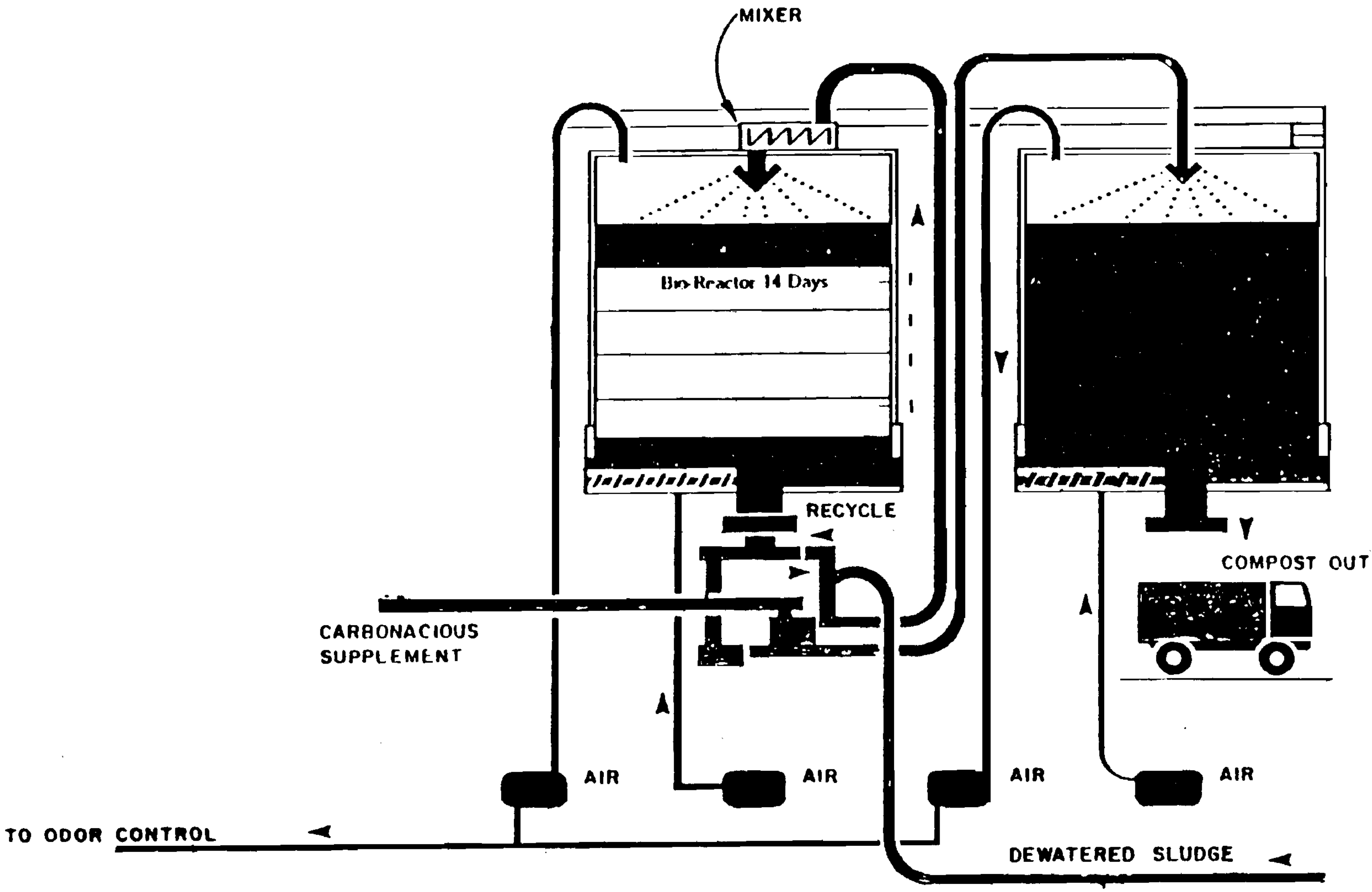
SOURCE: GREELY AND HANSEN, 1988

FIGURE 2-1
RECTANGULAR AGITATED BED
COMPOSTING SYSTEM



SOURCE: GREELY AND HANSEN, 1988

FIGURE 2-2
CIRCULAR AGITATED SOLIDS
BED COMPOSTING SYSTEM



SOURCE: GREELEY AND HANSEN, 1988

FIGURE 2-3
PLUG-FLOW SILO TYPE
COMPOSTING SYSTEM

c. Tunnel Systems

Tunnel systems are horizontal plug flow reactors that receive waste materials from a conveyor. The reactor consists of a rectangular concrete container which can be stacked one on top of the other to reduce space requirements. The reactor is divided into four compartments and air is injected perpendicular to the waste flow. A hydraulic ram is used to create a cavity in which to add more waste. Tunnel systems are used primarily to compost sludge, but other wastes may be co-composted with the sludge.

d. Enclosed Static Pile Systems

Unlike the other processes described above, enclosed static pile systems are stationary. Feed materials are added to each pile in a width-wise direction, until the pile reaches a predetermined width. The piles compost for three weeks in an enclosed, insulated building. Finished compost is removed, screened, and sent to a curing and storage area.

4. Co-Composting

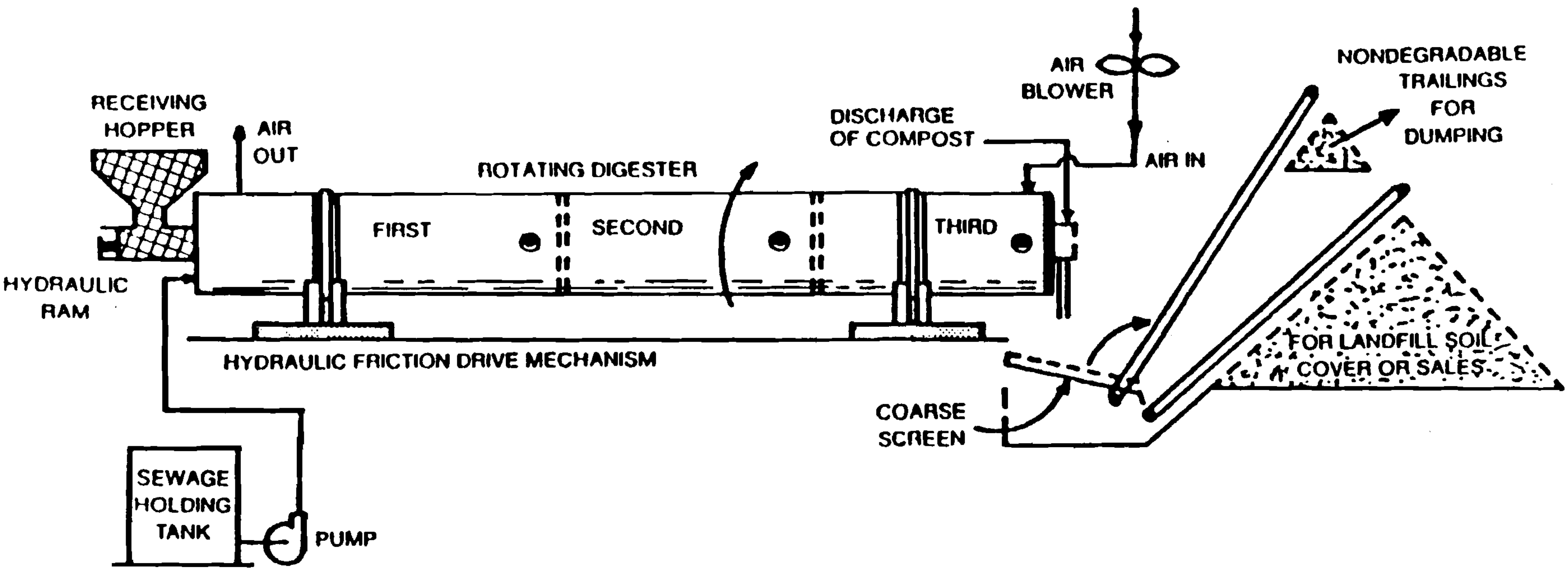
Co-composting means the simultaneous composting of two or more diverse waste streams, typically mixed municipal solid waste and sewage sludge. Co-composting of municipal solid waste with sludge is best handled in an enclosed system because of the potential for odors and the need for leachate collection. Sludge can also be mixed with chipped yard wastes, which will accelerate the process because sludge is rich in nitrogen and woody wastes and leaves are rich in carbon, both required for composting to occur; a carbon nitrogen ratio of 20:1 or 30:1 is best. Any co-composting requires careful design and management. Co-composting of municipal solid waste, in particular, requires a stringent program to remove household hazardous waste, which can interfere with the composting process and contaminate finished compost.

There are widely varying types of co-composting systems on the market. They differ in important aspects such as preprocessing requirements, the volume of residuals, the quality of the resulting compost, and the amount of nutrients. Figure 2-4 illustrates a co-composting system.

5. Backyard Composting

As part of an overall municipal solid waste management program, householders should be encouraged to compost in their own yards. The householder attempting to compost must have adequate outdoor space for the bin or pile.

Backyard composting is an excellent method of diverting grass clippings, leaves, tree trimmings and some kitchen wastes (without meat, bones or fatty foods) from the municipal waste collection system and disposal facility. A mixture of materials makes the best compost for plants. Backyard composting produces valuable material for mulching and



SOURCE: GREELEY AND HANSEN, 1988

FIGURE 2-4
CO-COMPOSTING SYSTEM

mixing with soil to nourish flowers, vegetables, trees and shrubs or for seeding new lawns or bare spots when carefully applied.

Community benefits include savings on collection and disposal of waste. However, composting requires some effort on the part of the householder, and information on the proper methods for backyard composting should be obtained from a local Cooperative Extension office or library. In addition, a brochure is available from DEC entitled "Easy Backyard Composting."

B. Technology Evaluation

1. Applicability/Capacity

a. Mixed Municipal Solid Waste

Composting can divert a significant portion of the waste stream from disposal, since approximately 40-50% of municipal solid waste is organic in nature and potentially compostable. The organic fraction of municipal solid waste includes paper, cardboard, food and yard wastes. The municipal waste stream typically will require processing prior to composting. Furthermore, household hazardous wastes must be removed prior to processing. Keep in mind that a municipal solid waste composting facility will generate residues that must be properly disposed of, typically at a landfill.

b. Yard Wastes

Yard wastes can constitute up to 20 percent or more of the waste stream, and can be effectively composted. Leaves and yard waste are generated seasonally; therefore, collection would take place only during certain periods of the year.

Land requirements depend on the volume and types of yard waste to be composted and the type of equipment used for composting. Yard wastes usually are composted by the windrow method. For preliminary planning purposes, roughly one acre is needed for each 3,000 cubic yards of yard waste.

A solid waste management facility (Part 360) permit is not required for facilities that compost 3000 cubic yards per year or less, which allows communities to try composting on a small scale without the additional expense of the permitting process.

c. Sewage Sludge

With the recent enactment of the Federal Ocean Dumping Ban Act of 1988 and the current landfill capacity crisis, many communities are seeking alternative methods for managing sludge from wastewater treatment plants. Of those alternatives, composting is probably the fastest-growing. The number of communities that have begun sludge composting in the last six years has risen dramatically in New York State, and continues to grow. Also, with less and less land available for landspreading sewage sludge, particularly in heavily-populated areas, composting is becoming an attractive alternative.

Sludge typically is composted by either the aerated static pile or in-vessel composting methods. For the aerated static pile method, approximately one acre of land is needed for each five dry tons of sludge composted. Good quality sludge and proper operational control are essential to the success of a sludge composting program.

2. Reliability/Experience

a. Mixed Municipal Solid Waste

Several communities in New York State are planning to compost their mixed municipal solid waste. Their experiences and the experiences of other communities in other states and other nations can be a valuable resource to those who are considering municipal waste composting. At present, composting of mixed municipal solid waste has had limited success. There are eight operating composting facilities for municipal solid waste in the United States at this time.

There are several factors to consider prior to municipal waste composting:

- Composting waste is sensitive to the incoming waste. A number of physical, chemical and biological conditions must be carefully controlled in order for the waste to compost properly. Because municipal solid waste is heterogeneous, waste must usually be processed before or, in some cases, after it is composted. The purpose of the processing is to remove as much of the inorganic fraction of the waste as is practical and to make the organics a uniform size;

- As with any recyclable, the compost product must be effectively marketed. Multiple outlets for the material should be identified prior to operation of the facility. Municipalities should use it in public works and highway projects;

- Compost must be monitored carefully to ensure that it meets regulatory requirements; compost must not exceed regulatory limits for heavy metals and organic compounds. Compost that does not meet the applicable standards cannot be used for its intended purpose. The Department of Environmental Conservation also requires that a sufficiently high temperature be maintained in the material in order to destroy viral, bacterial and parasitic pathogens. Additional requirements apply, depending upon the composting method used.

- Entering refuse must be well-characterized prior to facility design. Excessive amounts of commercial, non-putrescible or other waste components will affect the sizing of the facility components and the composting process;

- Municipal solid waste composting facilities tend to be very mechanically oriented; therefore, the separation and processing equipment used prior to composting must be reliable. Facilities have experienced operational problems with front-end separation and shredding equipment in particular;

- A municipal solid waste composting facility does not eliminate the need for a sanitary landfill. A landfill must be available to accept by-pass waste from facility shutdown, unmarketable compost and uncompostable wastes.

b. Yard Waste

Yard waste is relatively easy to compost and can be effective because leaves, a major portion of yard wastes, usually are collected separately and readily degrade. Leaf composting methods are well-documented in terms of facility design and control. Composting leaves is a good way for a community to begin composting and make a significant decrease in the waste stream destined to be landfilled.

c. Sewage Sludge

Before 1983, sludge composting was practiced by only a handful of communities. Since then, many communities have implemented sludge composting projects, and many more are in the planning stages. Sludge composting is a proven technology, with worries about marketing the sludge taking a back seat to odor control as the major concern. However, much research is currently underway to develop effective operational methods and odor control systems. Several methods have been found effective.

Marketing the sludge appears to be less of a problem than it used to be, with most composted sludge now going to landscaping and general contractors, public works projects, nurseries and homeowners.

3. System Cost

The costs of composting can vary considerably, depending upon the size and type of facility and the wastes being composted.

a. Municipal Solid Waste

Limited cost information is available on the capital and operating costs of mixed municipal solid waste composting. For municipal waste composting, capital costs vary widely for an in-vessel facility, but can be estimated at $50,000-75,000 per ton-per-day of design capacity. The operation and maintenance costs, exclusive of the revenue received from the sale of compost and other recyclables, can be estimated at $35-45 per ton. Costs include pre-processing of the waste prior to composting, which may involve shredding, screening and magnetic separation. The estimated operation and maintenance costs include labor, electricity, fuel, maintenance, monitoring, material supplies, water, administrative costs, building maintenance and renewal, and replacement costs. Annual debt service and landfilling costs must be added to these estimated capital and O&M costs. Capital and other costs can vary significantly with the amount of preprocessing required, the equipment used, and amount of waste or compost that must be landfilled.

b. Yard Waste

Costs for yard waste composted by the windrow method range from $4.00 to $6.00 per cubic yard, depending upon the size of the facility. Paradoxically, the cost does not get cheaper as the facility gets larger. The larger facility (over 30,000 tons per year) will cost about $6.00 per cubic yard to process wastes. Yard waste composting costs include: land, land improvements, equipment usage, initial windrowing, combining windrows, water application, second windrow turning, curing pile formation, shredding and screening, insurance, supplies, contingencies and overhead.

c. Sewage Sludge

Costs of composting sludge vary considerably, depending upon the method used. Biocycle magazine conducts an annual survey of sewage sludge composting facilities. According to the 1988 survey, the cost per dry ton for aerated static pile facilities ranged from $59 to $300, with most costs falling between $125 and $175. The average windrow composting project had operating costs of $130 per dry ton, with costs ranging from $80 to $158. In-vessel sludge composting costs ranged from $71 to $325 per dry ton, with the average being $175 per dry ton.

C. Summary

Table 2-9 lists the advantages and disadvantages of the various types of composting. Planning units should not expect a municipal solid waste composting facility to meet all of their solid waste disposal needs.

A composting facility will not eliminate the need for a landfill, since one is needed to handle by-pass wastes, materials unsuitable for composting, and unsuitable compost. Also, composting is not cost-free; it can require a major investment in equipment and process control in order to ensure that it works properly. The planning unit also must ensure the availability of reliable markets or uses for the composted material as a first condition in the consideration of composting on a large scale.

Composting of mixed municipal waste also requires careful pre-processing of the waste stream and vigilant monitoring of conditions during composting. But with proper pre-processing and process control, composting can recycle a significant portion of the solid waste stream.

Composting does not reduce the volume of waste as much as a waste-to-energy plant. It transforms waste into a usable organic material. As such, one of the most important considerations for a community considering composting is: What do we do with the compost?

Table 2-9

Composting

Advantages	Disadvantages
I. All Types	**I. All Types**
All composting can produce a useful soil enricher to use for public parks, lawns, and residents or plant nurseries.	Odors are a potential problem. More compost may be produced than there is a use for; marketing may help overcome this disadvantage.
II. Municipal Solid Wastes	**II. Municipal Solid Waste**
Same as I: Reduces the amount of waste which need landfilling or other types of disposal.	Typically, this is very equipment-oriented and, therefore, reliable and proper sizing are critical. High costs. Monitoring is crucial to prevent heavy metal content from rendering compost unmarketable. Facility siting may be difficult in urbanized areas.
III. Yard Wastes	
Composting eliminates the need to dispose of a large seasonal waste stream. The compost can often be sold to residents or plant nurseries, thereby reducing the processing costs.	
IV. Backyard	**IV. Backyard**
If residents compost in their yards, the municipality doesn't have to collect and dispose of the waste, thus saving costs for these services. Backyard composting produces a valuable material for mulching and mixing with soil to nourish flowers, vegetables, trees and shrubs, or for seeding new lawns or bare spots. Backyard composting instills good recycling habits in children.	Adequate space is needed for a compost bin or pile. Care must be exercised in composting kitchen wastes so as not to attract flies or animals.

Source: New York State Department of Environmental Conservation Division of Solid Waste

VII. Additional Considerations

The selection of recycling technologies has to be based on a number of interrelated considerations. These include:

- Planning Unit Characteristics
- Recycling Program Goals
- Organizational Structure
- Markets and Marketing
- Facility and Personnel Needs
- Availability of Funds
- Public Education and Promotion

Detailed information on these additional considerations can be found in the New York State Recycling Resource Handbook, and A Planning Guide for Communities...Recycling.

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CHAPTER 3
WASTE-TO-ENERGY

I. Introduction

A. General

The third priority in the state solid waste management policy is energy recovery from waste that cannot feasibly be reduced, reused or recycled. The waste-to-energy (WTE) technologies discussed in this chapter are based on some form of thermal processing, with the exception of biogasification which is based on biological processing.

The electricity and steam generated in a waste-to-energy facility are marketed under the Public Utilities Regulatory Policy Acts (PURPA) program. Under this program, a local utility company must purchase the electricity and steam produced by the WTE facility.

Use of a WTE facility, combined with aggressive waste reduction/reuse/recycling programs and sanitary landfills for ash residues and materials that cannot be incinerated, can be a successful solid waste management scheme for many planning units. Facility sizing must take many factors into consideration so that the WTE facility can be assured of a long-term supply of waste without interfering with recycling activities. These factors include available equipment, bypassing of waste, downtime, seasonal peaks in waste supply, future waste generation projections and the planning unit's recycling program.

All new WTE systems will require sophisticated air emission and ash residue management systems to protect public health and the environment. Such systems, which are discussed in Chapter 5, include advanced furnace design, state-of-the-art pollution control equipment, ash residue cradle-to-grave management, and safe operating and disposal practices.

The new Part 219 State regulations for incinerators require that new facilities have more pollution controls, operate at more efficient rates at higher temperatures and be monitored more closely by better trained operators. For the first time, limits are set for dioxin emissions.

Emissions from a properly designed and operated waste-to-energy facility, using state-of-the-art pollution controls, should not significantly or unacceptably increase risks to human health or the environment.

The NYSDEC takes the view that ash residue from municipal energy recovery facilities that burn household and non-hazardous industrial and commercial solid waste is exempt from regulation under the federal hazardous waste program (under Section 3001(i) of the Resource Conservation and Recovery Act). Nonetheless, the New York State Part 360 regulations essentially require a "cradle-to-grave" approach for ash residue management from waste-to-energy facilities. Ash residue from incinerators will be placed in lined landfills with leachate collection. This step-by-step management approach allows the Department to monitor and control ash residues from its point of generation to the point of final disposition, thereby protecting human health and the environment from the potential dangers of mismanagement. This approach is formalized in a required ash residue management plan, which is prepared by the applicant and which will be an enforceable provision of the permit issued to operate the facility.

The NYSDEC Part 360 regulations require solid waste incinerator operators to prepare a Waste Control Plan that provides a program to identify, control, separate out, record, and prevent untreatable waste from being burned at the facility. Untreatable waste for a solid waste incinerator is defined in our Part 360 regulations to include, but is not limited to: "batteries, such as dry cell batteries, mercury batteries and vehicle batteries; refrigerators; stoves; freezers; washers; dryers; bedsprings; vehicle frame parts, crankcases, transmissions, and engines, lawn mowers; snow blowers; bicycles; file cabinets; air conditioners; hot water heaters; water storage tanks; water softeners; furnaces; oil storage tanks; metal furniture; propane tanks; and clean fill." By removal of these untreatable wastes, the primary sources of heavy metals in the solid waste incinerator ash residue, lead and cadmium in particular, will be significantly reduced.

B. Identification of Alternatives

There are numerous WTE technologies in varying stages of development. The six technologies discussed here -- mass burn, modular, refuse derived fuel (RDF), fluidized bed combustion, biogasification and pyrolysis -- have had varying degrees of success at full scale operation. In the following sections, WTE technologies are discussed in order of better commercial availability, number of systems on line and experience with design, construction and operation. However, based on the lack of operating history, the fluidized bed combustion, biogasification and pyrolysis technologies cannot be considered proven technologies for mixed municipal solid waste management in New York State.

1. Combustion Technologies

In mass burn, modular, RDF and fluidized bed waste-to-energy facilities, waste is combusted at high temperatures and heat is recovered by a boiler. Table 3-1 is a list of proposed and operating waste-to-energy facilities in New York State. The key features of a combustion facility include:

- waste storage and handling;
- waste feeding;
- combustion;

- steam and electricity generation;
- air pollution control; and
- ash residue handling.

The combustion of waste occurs in four stages: (1) drying -- moisture is evaporated from the waste; (2) devolatilization -- combustible volatiles are released from the waste; (3) ignition -- volatiles are ignited in the presence of oxygen; and (4) combustion of fixed carbon -- volatile matter is completely combusted and the fixed carbon is oxidized to carbon dioxide.

2. Non-Combustion Technologies

In contrast to combustion, pyrolysis uses heat in an oxygen-deficient or oxygen-free atmosphere to decompose organic wastes physically and chemically into a gas or liquid energy product.

Biogasification is a process by which organic matter is decomposed, anaerobically (in the absence of oxygen) and without the addition of heat, to generate methane gas.

II. Mass Burn

A. Technology Description

1. Description

In mass burn, the most common waste-to-energy technology, combustion of solid waste occurs with minimal preprocessing of the waste at the facility. In a typical mass burn facility, the refuse collection vehicle is weighed as it enters the site and then proceeds to the tipping area where it dumps the refuse into a bunker or storage pit. The refuse bunkers are enclosed and include travelling overhead cranes that feed refuse to the mass burn furnace via a waste hopper and waste delivery chute. The overhead cranes also are used to thoroughly fluff and mix the refuse to loosen it and improve its firing quality. The refuse is combusted as it travels through the furnace on grates. Energy is recovered as steam and bottom ash is removed from the combustion chamber.

2. System Design

Mass burn facilities use grate systems to mix and agitate waste as it travels through the furnace. Agitation also aerates the waste, promoting thorough combustion of the refuse. Commonly used grate systems include reciprocating grates, reverse reciprocating grates, rocking grates, cascade grates and drum grates. Figure 3-1 illustrate these different types of grates.

The air required for combustion is supplied by fans or blowers through openings in the furnace from below the grates (under-fire air) and

TABLE 3-1

STATUS OF WASTE-TO-ENERGY IN NEW YORK STATE
(AS OF MARCH 1990)

MUNICIPALITY	DESIGN CAPACITY (tons per day)	STATUS AS OF 10/89
A. LONG ISLAND		
Glen Cove (C)	250	Operational
Hempstead (T)	2319	Operational
Long Beach (C)	200	Operational
North Hempstead (T)	990	In Permitting
Oyster Bay (T)	1080	In Permitting
Babylon (T)	750	Operational
Islip (T)	400	Operational
Islip (T)	400	Under Planning
Huntington (T)	750	Under Construction
Brookhaven (T)	600	Under Planning
SUBTOTAL CAPACITY:	7739	
B. NEW YORK CITY		
Brooklyn Navy Yard (Brooklyn)	3000	In Permitting
Arthur Kill (Staten Island)	3000	Under Planning
Barretto Point (Bronx)	2000	Under Planning
Sherman Creek (Manhatten)	1200	Under Planning
Maspeth (Queens)	1200	Under Planning
SUBTOTAL CAPACITY:	10,400	
C. UPSTATE NEW YORK		
Westchester County	2250	Operational
Dutchess County	400	Operational
Albany (C)	600	Operational
Albany (Am. Ref-Fuel)	1500	Under Planning
Montgomery/Fulton/Otsego/ Schoharie Counties	400	Under Planning
Washington/Warren Counties	400	Under Construction
Oneida County	200	Operational
Herkimer/Oneida Counties	400	Under Planning
St. Lawrence County	250	In Permitting
Oswego County	200	Operational
Broome County	570	In Permitting
Onondaga County	990	In Permitting
Cattaraugus/Allegany Counties	108	Operational
Niagara Falls (C) (Occidental Energy Corp.)	2200	Operational
SUBTOTAL CAPACITY:	10,468	
TOTAL STATE CAPACITY:	28,607	

SOURCE: NYS Department of Environmental Conservation
Division of Solid Waste
State Solid Waste Management Plan, 1989/90 Update

above the grates (over-fire air). Under-fire air initiates combustion and supplies oxygen to the refuse burning on the grates. Over-fire air mixes with volatile gases given off as the refuse burns and causes ignition and combustion of the gases. Residual or bottom ash is removed from the furnace bottom by a conveyor and cooled by spraying or quenching with water. In most cases, fly ash, composed of the particles suspended in the gas stream and removed by air pollution control equipment, is combined with the bottom ash.

There are three major types of mass burn furnaces-the waterwall, refractory and rotary kiln. Figures 3-2, 3-3 and 3-4 illustrate these typical furnace designs.

In a waterwall furnace, energy is recovered by a closely-spaced steel tube furnace lining which forms a continuous wall around the combustion chamber. In a refractory furnace, energy is recovered by a convection-type waste heat boiler installed at a point after the combustion chamber. Of the two, the waterwall furnace is more efficient and economical and heat recovery rates range from 65 to 70 percent, compared with a 60 percent heat recovery efficiency for refractory-lined furnaces.

The rotary kiln furnace is a modification of the refractory lined furnace. Refuse is fed to a primary combustion chamber where it is pre-dried and ignited. Burning is completed in a refractory-lined rotating furnace. The rotating action of the furnace mixes the refuse, allowing better combustion and causes the materials to move through the furnace. The expected heat recovery rate from a rotary kiln furnace is comparable to a waterwall furnace-about 65 to 70 percent.

The quantity of energy recovered in a waste-to-energy facility is related to the type of furnace employed. On average, approximately 500 to 600 kilowatt hours (kwh) of electricity is generated per ton of refuse; steam is produced at an average rate of approximately three to four pounds per pound of solid waste. In both cases, these averages represent net energy output after internal uses to run the facility.

B. <u>Technology Evaluation</u>

1. <u>Applicability/Capacity</u>

A mass burn facility can handle most solid wastes. In general, no preprocessing (sizing, shredding or separation) of waste is needed, other than the removal of bulky or potentially hazardous materials. A mass burn facility can reduce the waste stream by 90 percent in volume and 70 to 75 percent in weight.

Commercially available mass burn units range in size from 100 to 1000 tons per day (tpd). Typical designs consist of multiple furnaces to achieve total burn capacity and provide both reliability and flexibility. The Part 360 regulations requires three units per facility to ensure availability. The largest facility allowed by law is 3000 TPD. The mass burn technology is utilized for larger facilities, usually in excess of 400 TPD. Most mass burn facilities are field erected, but prefabrication of major components is possible.

A mass burn facility can be designed for co-generation of steam and electricity. Mass burn furnaces, especially the refractory-lined type, have been used for co-disposal of municipal solid waste and sewage treatment sludges.

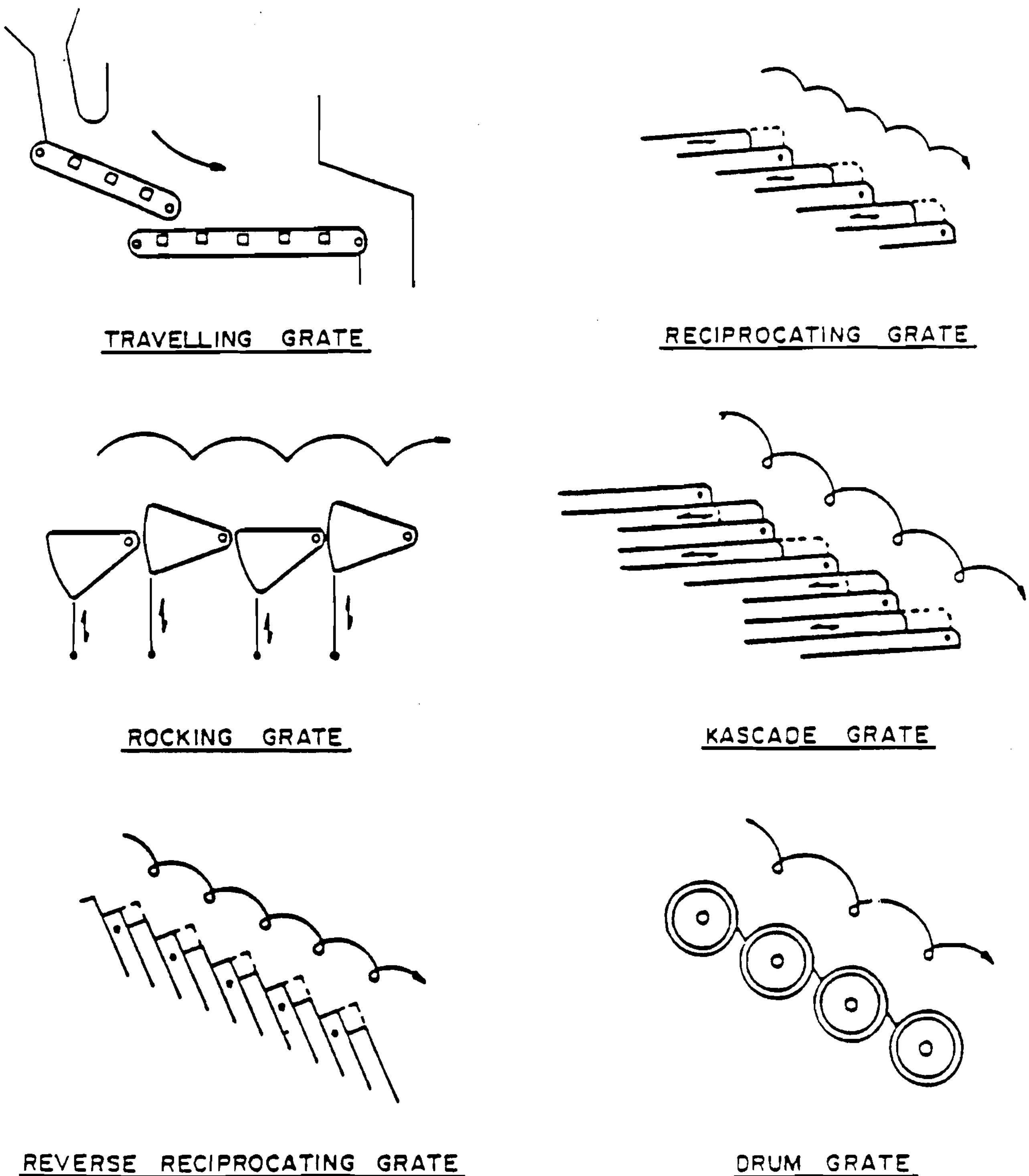
2. Reliability/Experience

Mass burn technology has been in use in some form or other since the 1930s. It is proven and reliable with extensive design, construction and operating experience. More than 300 facilities currently are in operation in the U.S., Europe, Japan and South America.

The most advanced of the mass burn furnaces is the waterwall furnace which employs advanced stoker design, combustion control, uniform air flow and state-of-the art air pollution control equipment and operating methods. An on-line reliability rate of up to 90% has been reported for waterwall furnaces. A number of qualified vendors are licensed to market mass burn technology in the United States.

3. System Cost

The capital cost for mass burn facilities ranges from $100,000 to $135,000 per ton per day of design capacity. Estimated operating costs range from $25 to $35 per ton and tend to increase as plant size decreases. Estimated revenues from the sale of electricity are $30 per ton, assuming six cents per kilowatt hour (Kwh) and 500 Kwh per ton of waste. Additional cost considerations are discussed in Section VIII.B of this chapter.



SOURCE: DVIRKA, 1986

FIGURE 3-1
GRATE SYSTEMS

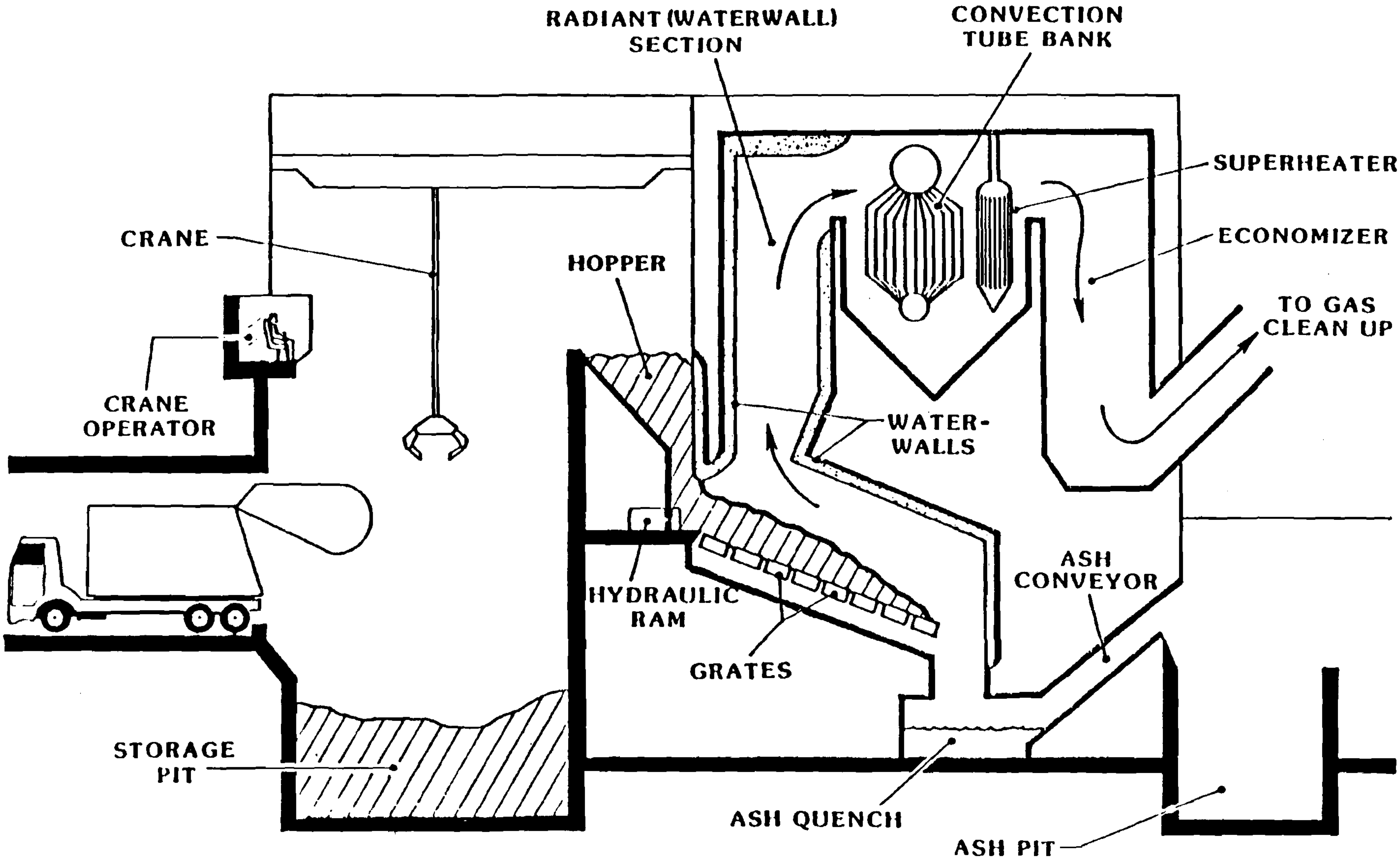


FIGURE 3-2
MASS BURN WATERWALL FACILITY

SOURCE: USDOE, 1988

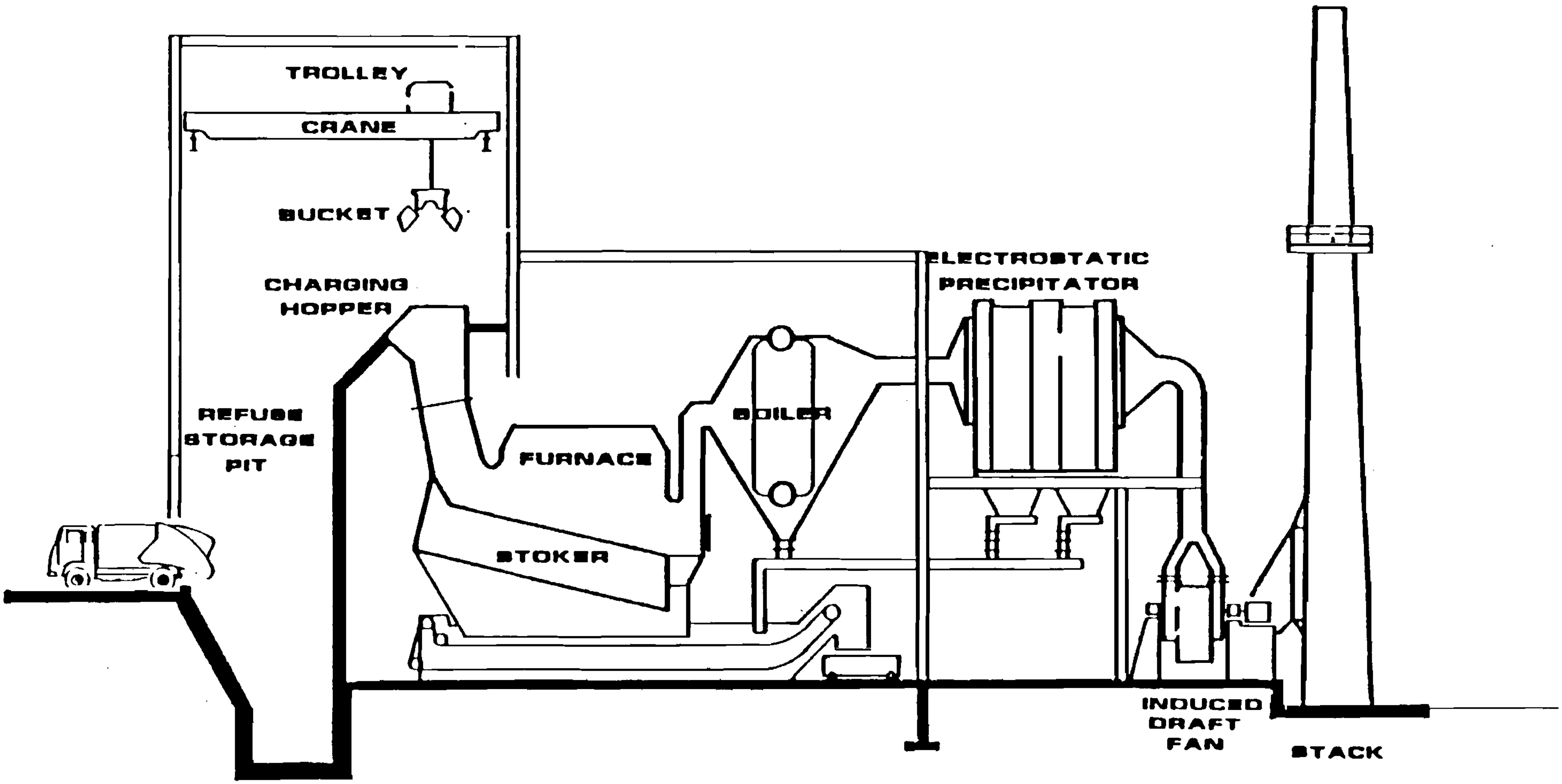


FIGURE 3-3
MASS BURN REFRACTORY FURNACE/
CONVECTION BOILER FACILITY

SOURCE: MALCOLM PIRNIE, INC., 1989

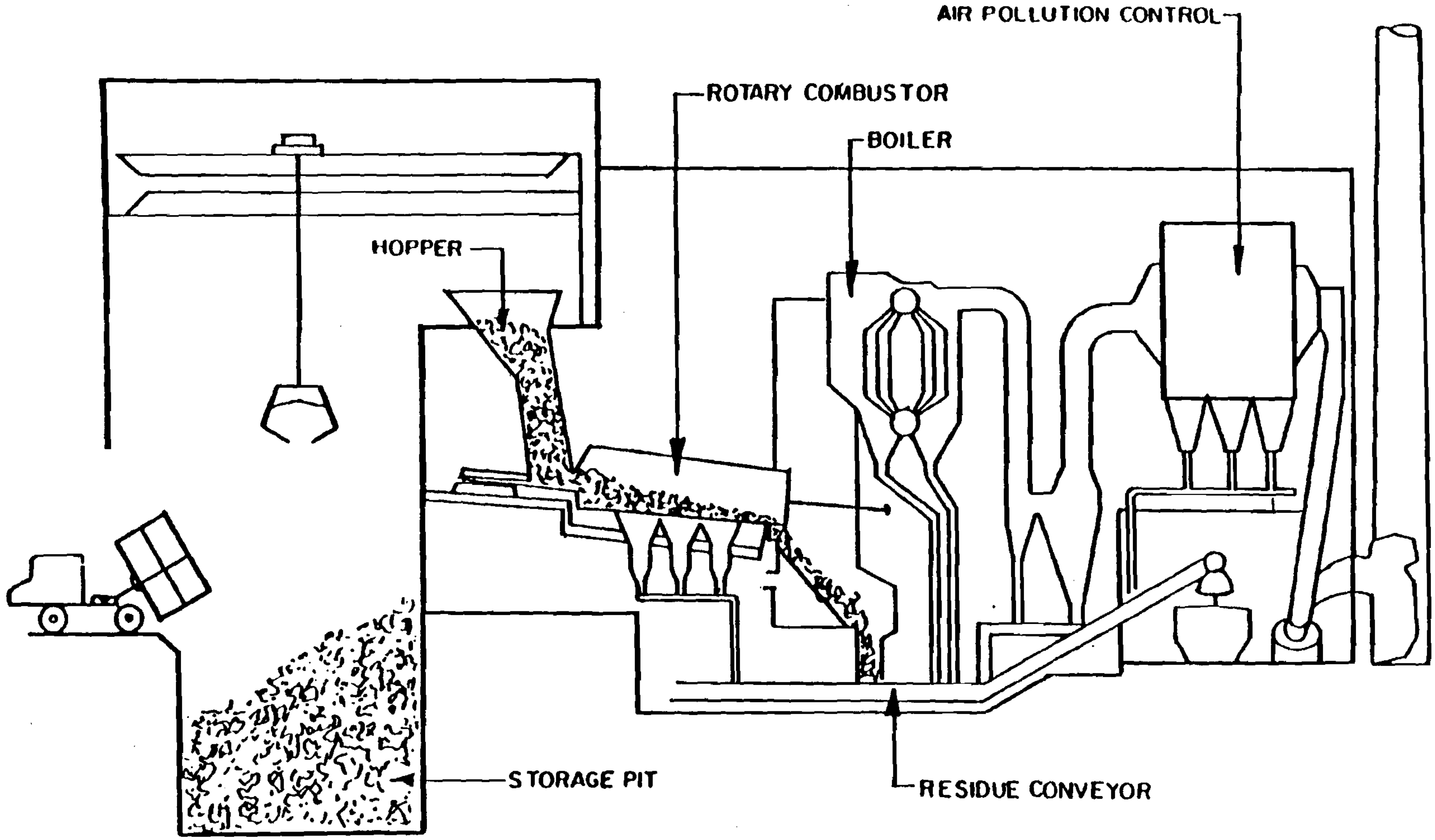


FIGURE 3-4
MASS BURN ROTARY
COMBUSTOR FACILITY

SOURCE: BARTON & LOGUIDUICE, 1989

III. Modular Combustion

A. Technology Description

1. Description

Modular combustion systems are small-scale, waste-to-energy facilities comprised of multiple pre-designed and factory manufactured modular combustion units that are assembled on site. Modular systems are available in two designs-modular waterwall or modular starved (or controlled) air refractory units.

2. System Design

In modular facilities, refuse is dumped on the tipping floor and loaded into the feed hopper with a front-end loader or bulldozer. Typically, waste is fed to the furnace intermittently with a horizontal hydraulic ram. Some modular systems have grates similar to those employed in field-erected installations. Figure 3-5 illustrates a typical modular waste-to-energy system.

Modular waterwall furnaces are controlled-air, fully oxidizing furnaces. These furnaces have good combustion efficiency with respect to ash residue quality, since there is greater reduction in the organic or volatile matter of the ash with a modular furnace. However, because of the low-cost design of the feeding and mixing mechanisms, combustion efficiency is lower than mass burn waterwall furnaces. The thermal efficiency of this system is approximately 50 to 60 percent. Electrical generation rate for modular facilities is approximately 400 to 450 kwh per ton of waste burned, after internal use. Steam production ranges from two to three pounds per pound of solid waste, after internal use.

In a modular starved-air system, there are two combustion chambers. In the primary chamber, partial pyrolysis of the refuse occurs under starved-air conditions, reducing the peak combustion rate and producing incompletely burned residues. In the secondary chamber, the partially pyrolized products are burned with excess air and an auxiliary fuel burner. The thermal efficiency of this system is approximately 50 to 60 percent.

B. Technology Evaluation

1. Applicability/Capacity

Modular waste-to-energy facilities currently in operation range in size from 50 to 400 tons per day (tpd). Individual modular units range in size from 25 to 120 tpd. Modular systems can handle most waste streams without preprocessing except for removal of large bulky items. However, modular facilities usually are not cost competitive with mass burn facilities for facilities greater than 400 tpd.

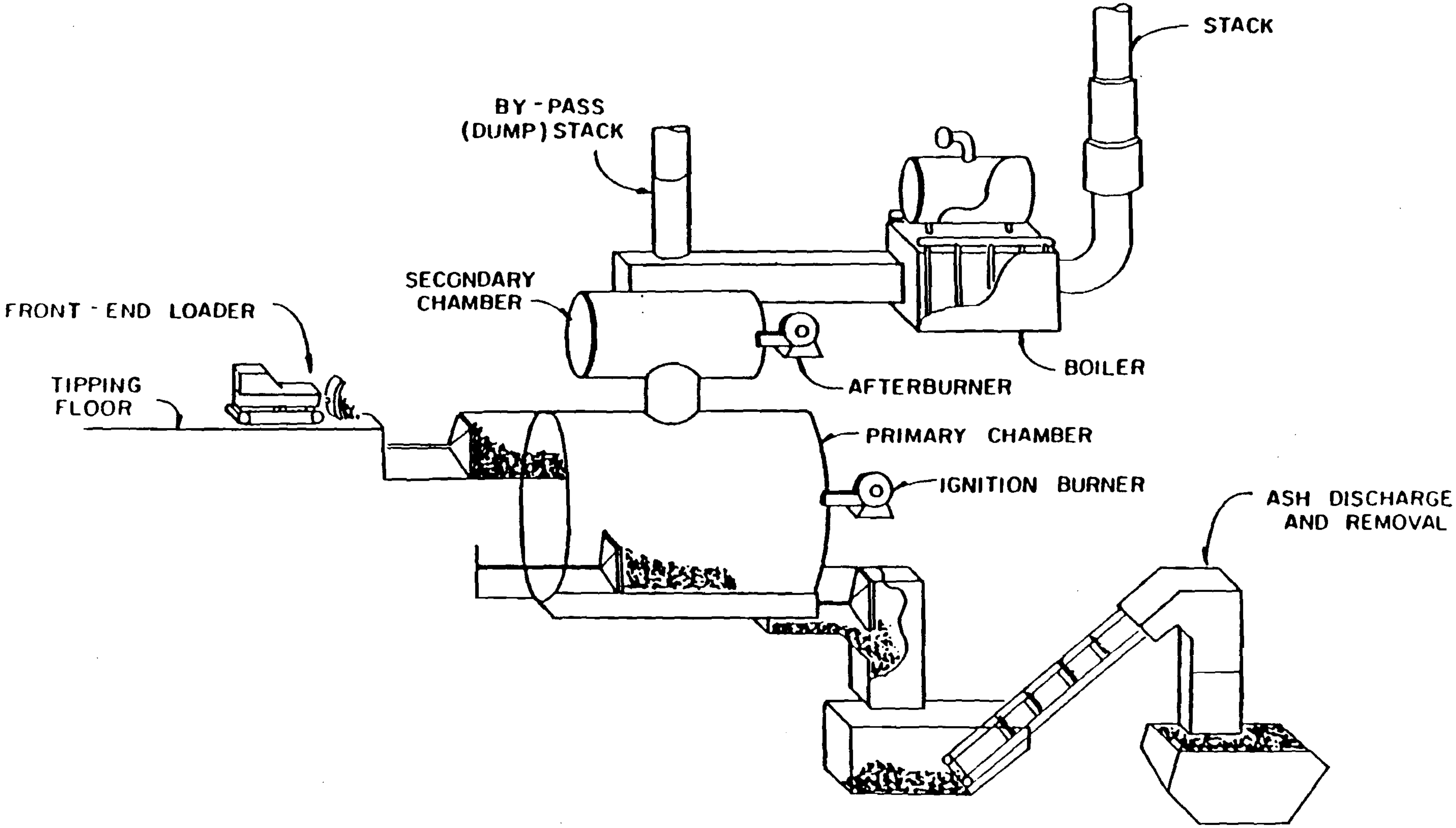


FIGURE 3-5
MODULAR WASTE-TO-ENERGY
FACILITY

SOURCE: USEPA, 1987

The construction time for modular systems is 12 to 18 months compared with 18 to 36 months for field-erected mass burn systems. The waste reduction capability of modular systems is approximately 85-90 percent by volume and 50-60 percent by weight.

The option to use multiple units with variable sizes allows flexibility in the design and operation of modular systems.

2. Reliability/Experience

A number of modular systems have been in operation since the 1970s. However, not all of these systems accept mixed municipal waste and many were designed for homogeneous industrial wastes. The simple design of modular systems is more suitable for smaller energy and steam generating systems. On-line reliability of modular furnaces is slightly less than for mass burn furnaces. Available data indicate that the operating life of a modular incinerator is shorter than a mass burn incinerator.

3. System Cost

Capital costs of a modular waste-to-energy facility are significantly lower than for a mass burn facility. However, operation and maintenance costs are higher. Estimates for capital costs range from $75,000 to $90,000 per ton per day of design capacity and for operating costs, $30 to $40 per ton. Estimated revenues from the sale of electricity are $24 per ton, assuming six cents per kilowatt hour (Kwh), and 400 Kwh per ton of waste. Additional cost considerations are discussed in section VIII.B of this chapter.

IV. Refuse-Derived Fuel (RDF) Facilities

A. Technology Description

1. Description

Refuse-derived fuel (RDF) is a fuel product or fuel supplement derived from processing municipal solid waste. RDF preparation involves size segregation and reduction and may include materials recovery. This preprocessing (sorting and refining) of waste enhances its fuel value and also creates the opportunity for recycling materials such as glass and ferrous metals. Materials recovery also results in fewer boiler operating problems and a reduction in the volume of incinerator residue that must be landfilled.

The technology used for burning solid fuels such as coal and wood is well developed and generally applicable to RDF-based facilities. However, coal and wood are very homogeneous and easily combustible. RDF is heterogeneous and therefore difficult to burn, necessitating careful design of an RDF furnace.

a. Types of RDF

RDF is characterized by: (1) wide range of material density; (2) wide range of particle size; (3) wide range of time required for combustion; (4) variable moisture content; and (5) presence of heavy inert materials, such as glass, sand, dirt, metals, etc.

Currently, three general types of RDF are being produced on a commercial basis: coarse, fluff and densified. These RDFs differ in the degree of material processing they undergo. Mechanical processing of coarse RDF typically consists of single stage shredding, separation and removal of organics and metals, and screening to remove inorganic particles. Fluff RDF involves additional stages of shredding, separation and screening to produce a higher fuel value. Densified RDF is produced by compacting RDF into pellets, briquettes, or cubettes.

2. System Design

There are two major components of RDF-based systems: the RDF processing system and the RDF-based furnace. Design criteria for both components must be considered when evaluating waste-to-energy alternatives. In general, approximately 0.5 to 0.7 pounds of RDF can be produced from each pound of solid waste.

a. RDF Processing Systems

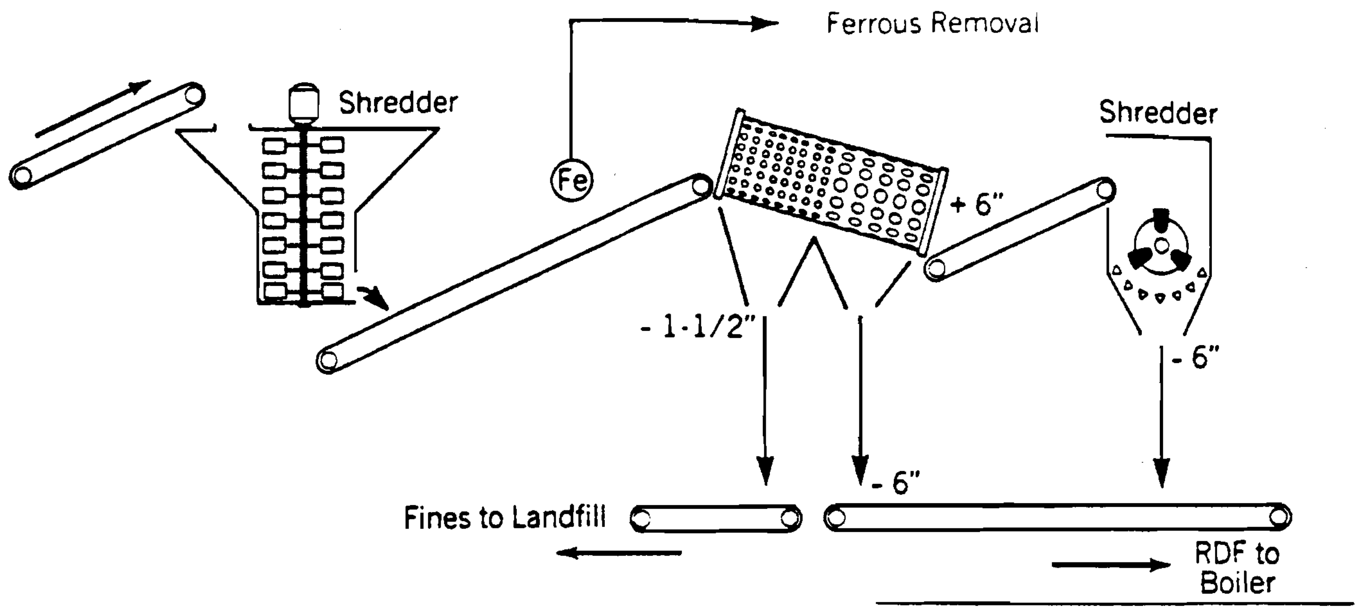
Four basic processes are involved in the production of RDF: size reduction, separation, materials recovery and densification. Figure 3-6 illustrate two processing facilities utilized for the production of RDF. A number of proprietary processes are available for preparing RDF.

In many RDF systems, size reduction is the first step in the production process. The waste is reduced in size and broken up for subsequent separation. Flail mills and hammermill shredders are commonly used for size reduction.

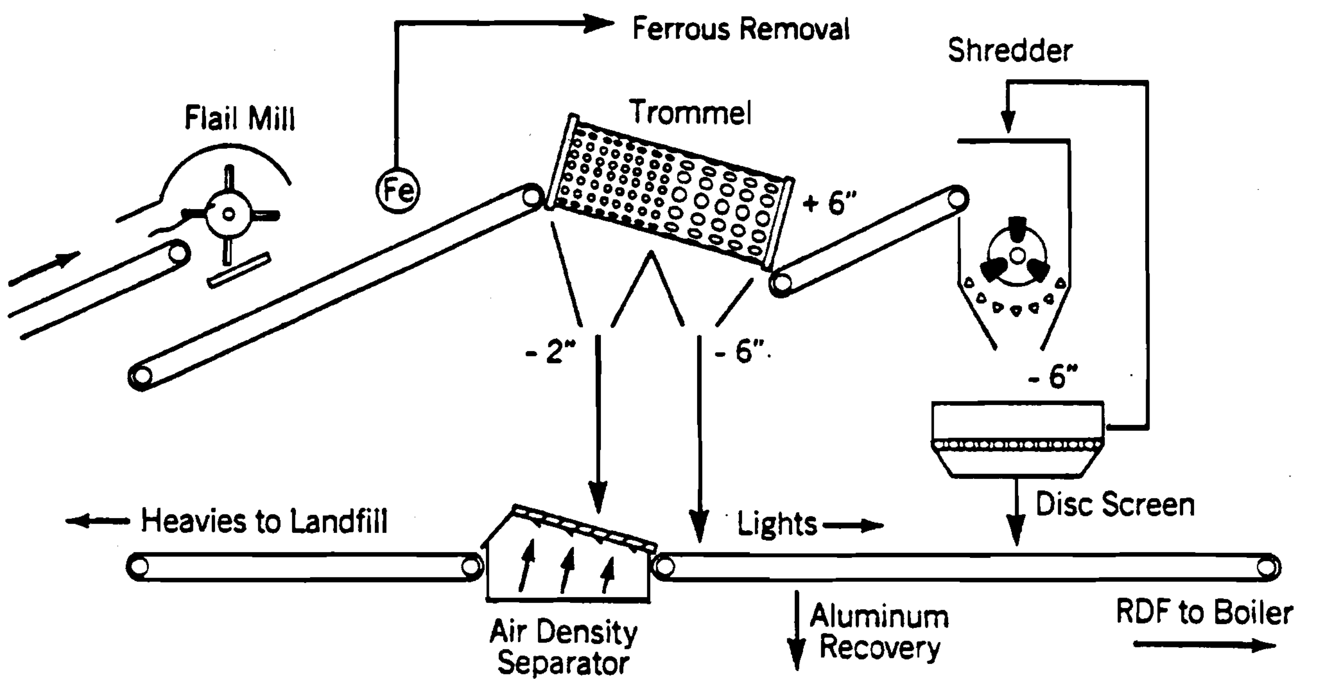
In the separation step, trommels, disc screens, vibrating screens and air classifiers can be used to separate non-combustibles. The remaining fraction is a product called the light fraction that is rich in combustible materials. This light fraction, or RDF, can be used directly or undergo further processing.

In the materials recovery step, the heavy fraction, ferrous metals, nonferrous metals and glass, can be further separated by magnetic separation, screening, and air classification.

Densification is the fourth step in some RDF processing. RDF is usually densified if it is to be stored for extended periods or transported to an industrial user. Densified RDF is produced by condensing the light fraction into pellets, cubettes or briquettes.



PROCESS FLOW SCHEMATIC (HAVERHILL, MA)



PROCESS FLOW SCHEMATIC (PALM BEACH, FL)

SOURCE: WASTE AGE, APRIL 1989

FIGURE 3-6
RDF PROCESSING
FACILITIES

b. RDF Combustion Systems

RDF can be used for energy production by co-firing with fossil fuels in industrial or utility boilers, or as the sole or primary fuel in a dedicated RDF boiler. The latter approach has become more common since it allows for the design of a furnace that can handle the difficulties associated with the burning of RDF.

RDF can be burned in grate burning systems, suspension-fired systems, fluidized bed systems or a combination thereof. Grate burning systems (and the combustion process) are similar to mass burn and modular systems where the waste is combusted as it travels through the furnace. In suspension-fired furnaces, the fuel is burned in suspension; there is no burn-out grate for completion of combustion or for removal. To ensure complete combustion, only high quality "fluff" RDF fuel can be used in this type of furnace. In fluidized bed systems, RDF is mixed in the furnace with an inert material (sand) and circulated until complete burnout is achieved. The fluidized bed technology is discussed in more detail in Section V of this chapter.

B. Technology Evaluation

1. Applicability/Capacity

RDF production processes incoming refuse and separates the organic fraction from the inorganic fraction and metals. The organic fraction is used as a fuel; the inorganic fraction and metals can be processed for materials recovery. Hence, an RDF system can enhance the recyclables recovery program of a municipality. However, the materials recovered are not as clean or as easily marketed as source-separated material.

The capacity of an RDF facility will depend on its two components: the furnace and the RDF production facility. Typically, the design capacity of RDF facilities is between 600 and 2000 tons per day (tpd). An RDF plant below 600 tpd capacity is not economical compared with a mass burn facility because of the high costs associated with the front-end processing requirements of an RDF facility.

An overall volume reduction of 90 to 92 percent can be expected from an RDF facility with a corresponding weight reduction of 80-85 percent. These reductions will depend on two major factors: the composition of the raw municipal waste and the materials recovery that takes place during fuel processing.

An RDF boiler is approximately 10% more efficient than a mass burn waterwall furnace because RDF is more homogeneous than raw municipal waste and inert materials have been removed prior to burning.

The energy requirements for the entire RDF system are greater than any other combustion process. Even so, after internal usage, approximately 500-525 kwh of electricity can be generated per ton of combusted RDF. Steam availability is two to three pounds per pound of combusted RDF.

2. Reliability/Experience

Commercial RDF facilities were started in the 1970s when the energy crisis emphasized the need for energy conservation and materials recovery. Many of the first-generation RDF incinerators were unsuccessful for both technological and economic reasons.

In many cases, the RDF fuel did not meet specifications and this deficiency led to boiler corrosion, slagging, incomplete combustion and excessive emission of particulates and other air pollutants. Experience has indicated that RDF incinerators are more reliable when only RDF is burned instead of mixing RDF with other fuels. Recent generations of RDF facilities have overcome these difficulties and are operating successfully.

3. System Cost

The capital and operating costs on a ton-per-day basis of an RDF waste-to-energy system are closely comparable to other types of waste-to-energy systems. RDF furnaces can be smaller because a significant portion of the waste stream that is burned in the RDF furnace has been removed in the RDF fuel production process. But any savings from smaller furnace size are offset by the costs associated with the RDF production process.

Capital costs for the RDF waste-to-energy system range from $110,000 to $140,000 per ton per day of design capacity. Estimated operating costs of an RDF system range from $30 to $40 per ton. These operating costs can be offset by the sale of electricity or steam and by the sale of materials recovered in the RDF production process. Additional cost considerations are discussed in Section VIII.B of this chapter.

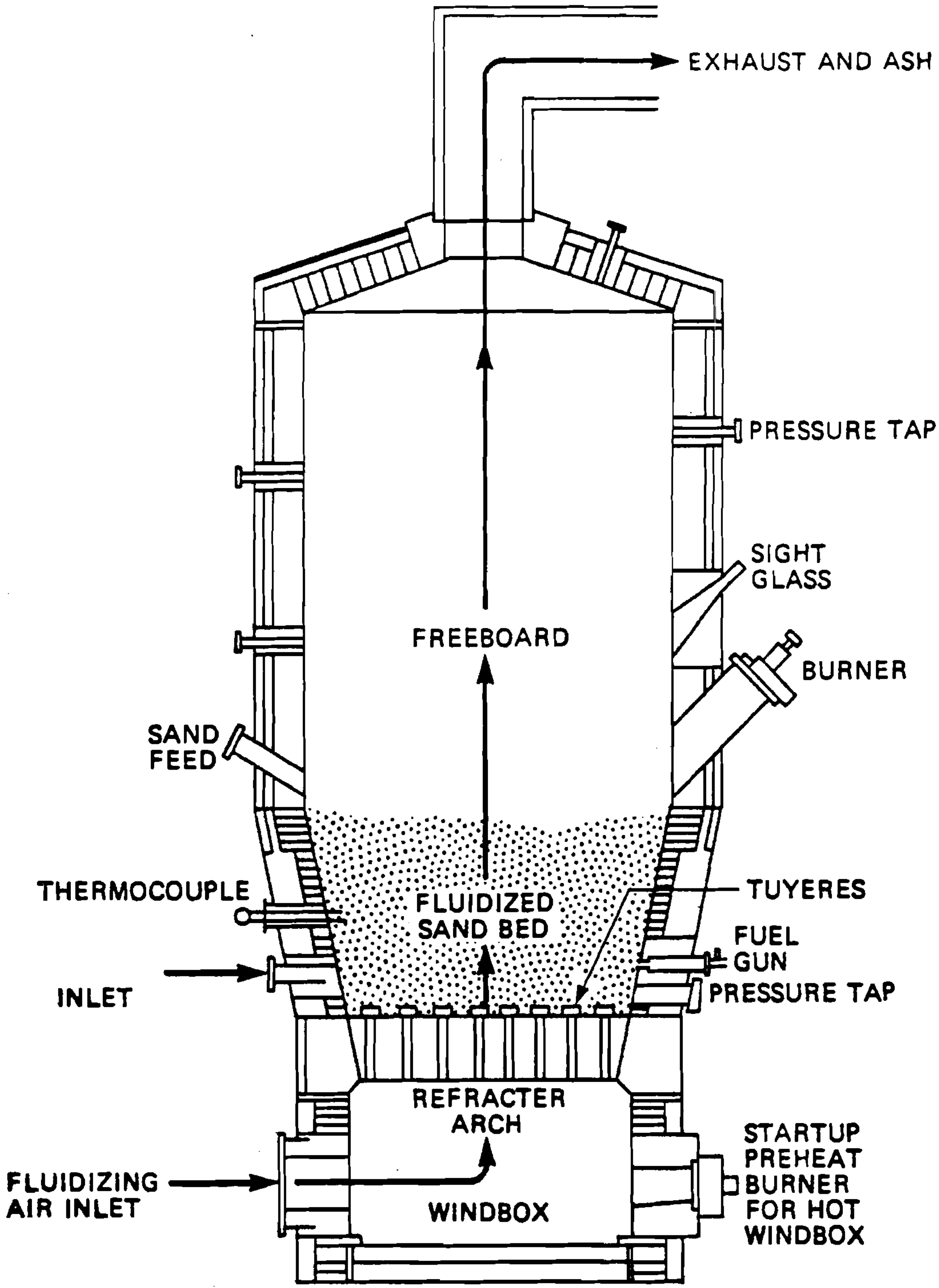
V. Fluidized Bed Combustion

Use of the fluidized bed technology for the disposal of mixed municipal waste is still considered to be in the emerging stages, and data on long-term reliability and operating experience are limited.

A. Technology Description

1. Description

The fluidized bed furnace is a cylindrical refractory-lined shell with a bed of sand. The bed of sand is expanded by air pressure during operation to mix the waste with the sand and air. Solid waste must be processed into RDF prior to combustion in a fluidized bed furnace.



SOURCE: USEPA, 1979

FIGURE 3-7
FLUIDIZED BED
FURNACE

2. System Design

The fluidized bed furnace, as shown in Figure 3-7, is a very simple design with no interior moving parts. The air-blowing fan is its major moving component.

Preheated air is introduced under pressure and flows through a bed of sand supported by grids and plates. This air flow under pressure fluidizes the sand bed and expands it 30 to 40 percent in volume. Coarse, fluff or densified RDF is introduced into the sand bed where it mixes with the sand and air and is combusted. Because of the complete mixing that occurs in the furnace, excess air requirements are minimal. Complete combustion is possible by controlling retention time of the waste in the furnace. Careful control of air pressure prevents waste from floating above the combustion zone. The energy recovery unit may be integral with or separate from the combustion chamber.

B. Technology Evaluation

1. Applicability/Capacity

Fluidized bed combustion systems have been used extensively for sewage sludge disposal. Municipal waste must be processed into an RDF-type fuel in order to be used in a fluidized bed furnace.

2. Reliability/Experience

Fluidized bed combustion facilities for burning municipal waste to recover energy exist in Japan. A facility in Duluth, Minnesota, burns a combination of shredded waste and sewage sludge. No facilities utilizing this technology exist in New York State.

While the use of fluidized bed furnaces for sludge incineration is common, the technology is still being refined for municipal solid waste applications and limited operational data is available to predict long term reliability and costs.

3. System Cost

Preliminary capital costs can be estimated by multiplying the design tonnage per day times $200,000 per ton. Operating costs are estimated at $45 per ton. Estimates include the RDF processing system. Additional cost considerations are discussed in section VIII.B of this chapter.

VI. Biogasification

The biogasification technology is still in its developmental stages and cannot be considered a proven technology for disposal of mixed municipal solid waste.

A. Technology Description

1. Description

Biogasification is a biological process in which organic matter is decomposed by anaerobic organisms (organisms that grow in the absence of air), producing methane gas as a major by-product. The three basic steps involved in the process are:

a. Pre-processing -- organic material is separated from the waste stream, shredded and mixed into a slurry;

b. Decomposition -- the slurry is placed in anaerobic digesters for a 5 to 30 day period (14 days is typical) for generation of methane gas; and

c. Treatment -- methane gas is refined to market specifications.

2. System Design

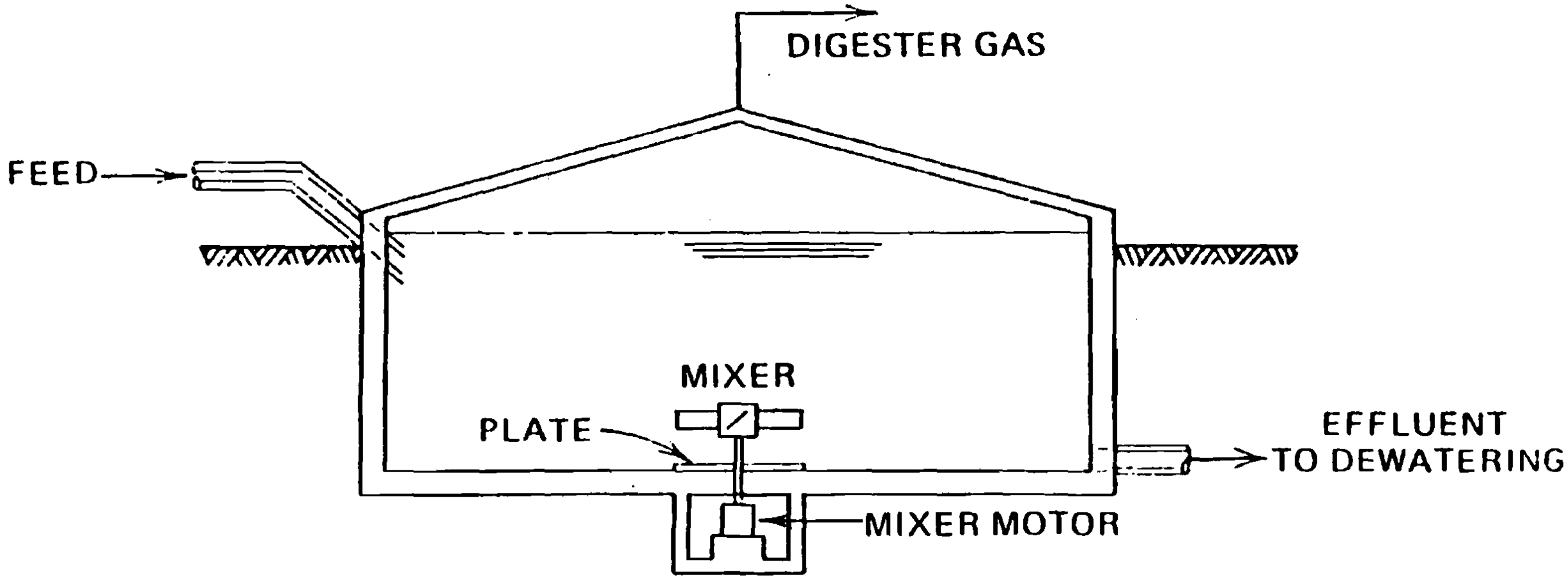
Many varieties of design exist for biogasification systems. The key component of any commercial biogasification system is one or several continuously stirred digesters with pre- and post-digester processing. The stirring improves contact of the biological organisms with the waste, provides through mixing of the tank contents, and breaks up scum. Figure 3-8 shows schematics of a typical continuously-stirred commercial biogasification reactor.

In a typical facility, the solid waste is delivered to a receiving area and processed to remove the non-organic material and reduce particle size of the remaining organic material. After processing, the organic material goes into a pre-mix tank, where the waste is mixed with primary sludge, nutrients and steam. The slurry from the pre-mix tank is fed into digesters for anaerobic decomposition. Methane gas produced during the digestion process is refined into a useable product. The solid residue from the process is an organic material that can be dewatered and may have potential for use as fuel in a dedicated boiler.

B. Technology Evaluation

1. Applicability/Capacity

A facility based on biogasification can be sized to meet the capacity needs of a planning unit. However, only the organic fraction of the waste stream can be processed by biogasification. In general, about 50 percent of the waste stream is organic matter. However, this depends on the characteristics of the planning unit, and, especially, the amount of yard waste entering the waste stream. Only about 50 percent of organic solid waste fed into the digester is converted to gas. The remainder requires further processing or disposal.



SOURCE: WALTER, 1986

FIGURE 3-8
BIOGASIFICATION REACTOR

Furthermore, the system requires large quantities of water for processing and generates large quantities of liquid and solid waste which must be further treated or disposed. This system also generates a filter cake with high heavy metal concentration.

Plant material, though organic in nature, is not readily biodegradable and thus not suitable for biogasification without preprocessing. On the other hand, sewage sludges are readily biodegradable.

Markets exist for gas produced by the biogasification process.

2. Reliability/Experience

A 100 tpd demonstration project in Pompano Beach, Florida, has operated successfully since 1978 and is the only large-scale system operating in this country. More research and development is needed before the biogasification process can be considered a reliable solid waste management alternative. Furthermore, gas production is reduced at temperatures below 50°F, therefore making it a less desirable technology in colder climates.

3. System Cost

Substantial capital investment is required for a biogasification facility. Cost information is not available to estimate planning and development costs for this type of facility.

VII. Pyrolysis

The technological and economic feasibility and operational reliability of the pyrolysis technology has not been proven on a commercial basis for disposal of mixed municipal waste.

A. Technology Description

1. Description

Pyrolysis uses heat in an oxygen-deficient or oxygen-free environment to decompose municipal solid waste. The products of pyrolysis include combustible gas or liquid hydrocarbons, such as hydrogen, methane, and carbon-monoxide, which can be burned immediately to produce steam, or stored for later use or sale. Pyrolysis also produces solids, including carbon-rich residue and non-combustible materials such as glass and metals.

The products of pyrolysis depend on many factors. The most important of these are the type of carbonaceous solids in the waste, the operating temperatures, the heating rate and the type of equipment used. Temperatures below 1000°F and slow heating favor production of char and oxygenated gases. Temperatures above 1500°F and rapid heating favor production of flammable gases.

2. System Design

The application of pyrolysis for municipal solid waste is relatively new and can be traced back to about 1968. The major components of a typical system are storage facilities for municipal solid waste, a feed system, a front-end-RDF system, a pyrolytic reactor, a product cleaning or treating system, a product collection and storage system and a solid, liquid and gaseous by-product and residue removal system.

Various types of pyrolysis systems have been marketed. Figure 3-9 shows a schematic for pyrolysis reactors.

B. Technology Evaluation

1. Applicability/Capacity

There are no commercial, full scale, successfully operating pyrolysis systems. Conceptually, a facility can be designed to meet the capacity needs of the planning unit.

2. Reliability/Experience

Pyrolysis has been used for many years for coal gasification and to produce methanol, acetic acids and turpentine from wood. However, more research and development are required to make this technology a viable alternative for municipal solid waste management. Currently, no full scale municipal solid waste pyrolysis facility exists in the U.S.

3. System Cost

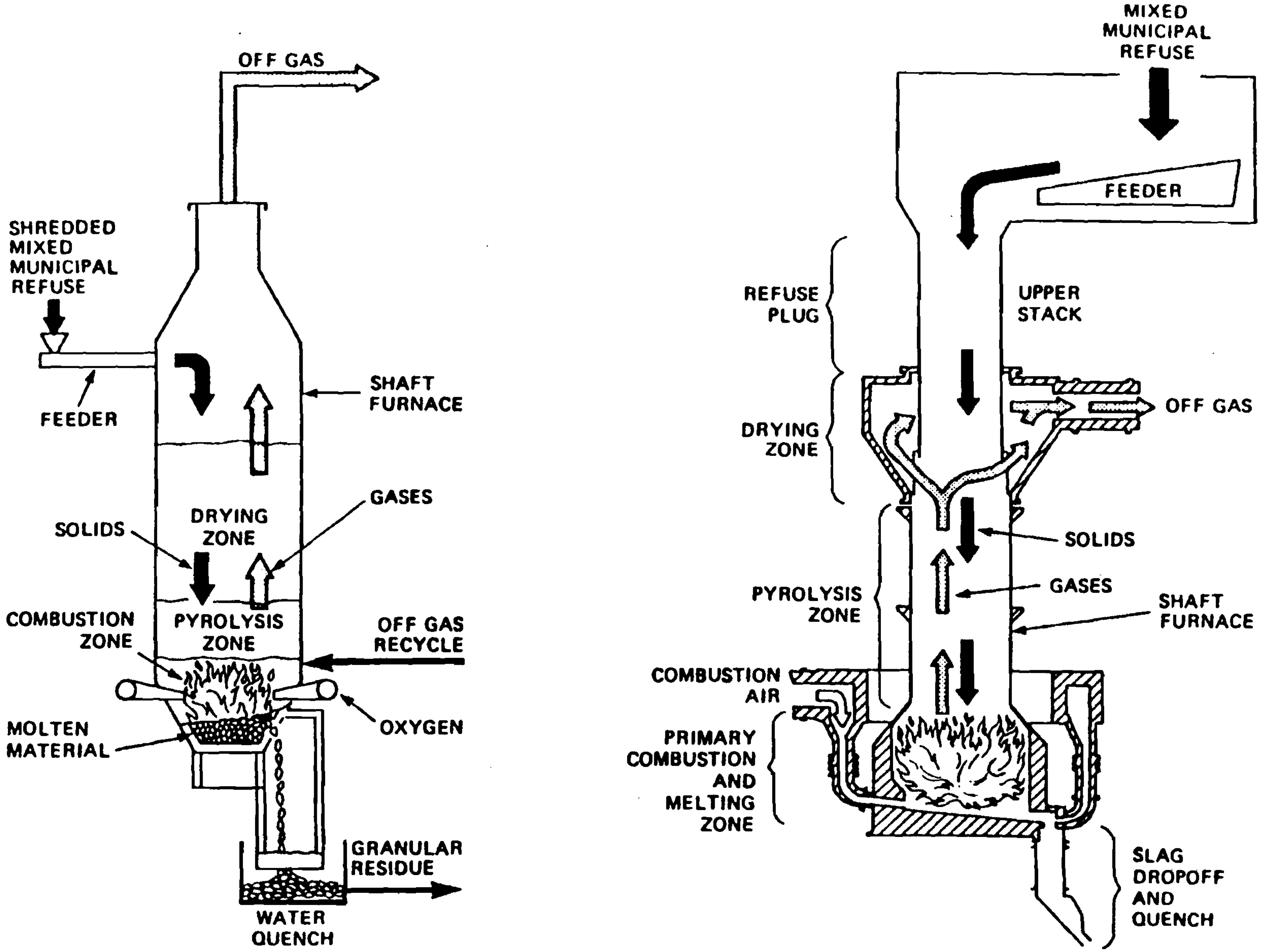
Preliminary estimates of capital costs for pyrolysis facilities are approximately $150,000 per ton per day of capacity. Operating costs range from $35 to $45 per ton.

VIII. Technology Selection

A. Size and Capacity Considerations

Local governments can integrate recycling and waste-to-energy through careful solid waste management planning to ensure that integrated solid waste management projects can manage the current waste stream and accommodate changes to it. Planners must consider the relationship of facility processing capability, waste flow projections and guarantees for delivery of solid waste over the life of the facility. Forecasting these and any other changes to the waste quantity and quality is essential for planning successful programs.

If a waste-to-energy facility is financed with revenue bonds, the long-term economic viability of the project depends on a guarantee for



PUROX™ REACTOR

ANDCO-TORRAX REACTOR

FIGURE 3-9
PYROLYSIS REACTORS

SOURCE: USEPA, 1979

the life of the facility of a definite amount of solid waste for which the facility will be paid by the municipality at a certain tipping fee per ton delivered. The municipality's guarantee of solid waste ensures that the facility will be able to produce for sale a certain amount of energy. In effect, guaranteeing the input solid waste and the output energy of a waste-to-energy facility guarantees the facility's long-term financial viability.

The key to success is proper sizing of a waste-to-energy facility to assure a long-term supply of waste without interfering with recycling activities. Facility sizing must take many factors into consideration, including sufficient capacity to maintain facility availability at all times. Bypassing solid waste would result in a decrease of available landfill space, if space is even available, and would incur a significant cost for the community.

The fact that the waste-to-energy facility has capacity beyond that required to process the solid waste remaining after reuse/recycling does not, in and of itself, represent a conflict with recycling/reuse programs. Excess capacity in a larger facility does not equate to a commitment to burn additional wastes, including recyclables, especially in light of permit conditions that require maximum recycling/reuse programs regardless of the size of the facility. A larger facility may, indeed, be advisable from an engineering and solid waste management perspective.

Overall, facility size must be sufficient for normal facility operation and maintenance as well as for outages resulting from equipment malfunction. In addition, the facility must be sized to accommodate seasonal peaks in the amount of solid wastes that generally occur during spring cleaning, tourist seasons and after holiday weekends. In some cases, the fluctuation in the amount of solid waste from peak to low periods can approach 40 percent. The facility can be designed with an incineration unit as a standby or back-up to increase overall facility availability. This redundant capacity may be needed at facilities where bypassing of solid waste is difficult because of limited landfill space or because the landfill is distant from the facility.

Municipalities can also factor future needs of the community into the plans for the configuration and size of the facility. For example, the facility can be sized to include surrounding areas that do not participate initially or to account for changes in area population growth and waste generation rates. Socio-economic considerations such as changes in employment patterns, economic growth or individual "throw-away" attitudes also can be considered in determining facility size.

6 NYCRR Part 360-3.2(a)(6)(i) requires the applicant for a waste-to-energy facility to "...submit a table or graph showing the projected quantities delivered per month during the first year of operation and the background data and assumptions used to produce this table or graph...." In addition, the Part 360 application for a permit to construct a solid waste management facility must describe seasonal solid waste variations and projections for future quantities of solid waste to be

processed. Departmental review of all data and assumptions is undertaken to assure validity.

As part of a permit application, 6 NYCRR Part 360-1.9(f) requires the development of a comprehensive recycling analysis and implementation of a recyclables recovery program. Section 360-1.11(h) specifies that a recyclables recovery program must be included as part of the permit conditions for a solid waste management facility. By inclusion in the permit application process, the quantity of solid waste reduced and recycled is made a consideration in sizing.

The facility design capacity represents the maximum capacity of the facility to process solid waste. The facility design capacity does not represent a contractually-obligated amount of solid waste to be delivered to the facility. Therefore, as long as the "put or pay" contractual obligation of a municipality to provide solid waste to a WTE facility accommodates the waste reduction and recycling program developed by the municipality and approved by the Department, a balance is struck between the size of a waste-to-energy facility and waste reduction/recycling programs.

B. Cost Considerations

Previous sections in this chapter provided relative cost ranges for the various technologies. The unit capital costs include the cost for system engineering, design, permitting, site work, buildings, combustion, energy production, air pollution and ancillary equipment, startup and testing, insurance and contingencies. Additional legal, financial and administrative costs must be added to the unit capital costs to estimate the total project cost. In general, these additional costs can be estimated at 33 percent of the unit capital costs.

The unit operating and management (O&M) costs include labor, maintenance, materials, supplies and utilities. The capital and O&M costs do not include the costs for bypass and residue disposal, which are discussed in Chapter 4, and the annual debt service for the total project cost. As an example, the average annual debt service for a facility with a unit capital cost of $100,000 per ton per day of design capacity would be approximately $37 per ton assuming an interest rate of 8 percent over 20 years.

Actual capital and O&M costs will depend on procurement procedures, project financing, and other factors specific to the planning unit. Therefore, both capital and O&M costs must be determined by the planning unit using cost information specifically applicable to the planning unit. In addition, the economics associated with waste-to-energy facilities depend heavily on the sale of recovered energy to help offset projected costs. Table 3-2 provides a detailed list of factors to consider.

TABLE 3-2

GENERAL WASTE-TO-ENERGY COST FACTORS

Pre-development:
- Site Selection
- Environmental Assessments
- Permit Application (includes Engineering/Legal Fees)
- Land Acquisition/Lease

Site Preparation and Construction:
- Site Preparation
- Construction Labor
- Construction Management
- Structures (Materials and Equipment)
- Start-up
- Acceptance Testing
- Insurance During Construction
- Financing costs (Capitalized Interest, Bonding, etc.)
- Miscellaneous (Sales and Use Taxes, etc.)

Facility Operation and Maintenance:
- Administrative Personnel
- Equipment (Labor, Contracts, Supplies, Spare Parts)
- Facility and Building (Labor, Contracts, Supplies, Spare Parts)
- Fuel and Chemicals
- Testing and Monitoring
- Contract Services
  - Reporting Requirements
  - Legal
  - Management
  - Equipment Rental
- Host Fees
- Residue/Bypass Hauling, Treatment, and Disposal*
- Major Equipment Replacement (Replacement Year and Replacement Cost)
- Equipment Rentals or Leases
- Insurance

Closure/Post Closure: (if any)

Revenues:
- Recovered Energy (Steam and/or Electricity)
- Tipping Fees

* Refer to Table 4-1 for costs factors associated with residue and bypass landfills.

SOURCE: NYSDEC DIVISION OF SOLID WASTE TAGM: SW-89-5001, April 5, 1989
NYS SOLID WASTE MANAGEMENT POLICY GUIDANCE

IX. Summary

Planning units can use the information presented in this chapter and the information specific to the planning unit for assigning values and factors for the evaluation of WTE technologies. The following procedure, which involves assigning comparative values to important factors, has been used in many solid waste management studies.

Factors	Comparative Values
Design	Proven; Partially Proven; Unproven
Reliability/Safety	High; Medium-high; Low-medium; Low
Environmental Impacts	Low; Medium; High
Capital Costs	Low; Medium; High
O&M Costs	Low; Medium; High
Capacity/Applicability	No or Yes
Recommendations	High; Medium; Low

Scores may be calculated by assigning a rating or ranking to the comparative values. Factors considered more important to a planning unit may be weighted with a higher rating. The planning unit should also refer to the NYSDEC Technical and Administrative Guidance Memorandum: New York State's Solid Waste Management Policy Guidance: SW-89-5001, April 5, 1989.

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CHAPTER 4
LAND BURIAL AND OTHER DISPOSAL OPTIONS

I. Introduction

In New York, the goal is to use landfills and other disposal options for the disposal of wastes that cannot be reduced, reused, recycled or combusted in waste-to-energy facilities. These wastes include some sewage sludges; wastes needing disposal while waste-to-energy facilities are temporarily out of service; construction and demolition debris; wastes from areas where other waste management methods are not practical; and ash residues from waste-to-energy facilities.

A. Landfills

Although landfilling has the lowest priority in the State's solid waste management hierarchy, it is essential to all solid waste management planning regardless of the other solid waste management options that are selected. Waste reduction and recycling will not account for all of the solid waste stream, and untreatable waste and residue as well as bypass waste from waste-to-energy facilities will require disposal. Current regulatory requirements in New York State make landfilling an environmentally safe and appropriate part of any effective solid waste management plan.

Therefore, solid waste planners don't need to decide whether or not to utilize a landfill. Rather, they must consider the type of wastes to be disposed of and the size of the landfill. To make these decisions, the following questions should be addressed:

1. What solid waste must be disposed of in a landfill during the planning period and what is the expected volume?

2. Are there any wastes particular to the planning unit which may require special treatment or can be handled by an alternative method?

3. What can the planning unit do to encourage further reduction in wastes that must go to a landfill?

4. What treatment or waste handling methods will reduce the volume and increase the chemical and physical stability of wastes to be landfilled? (For example: Is combustion of the waste prior to landfilling an appropriate way to decrease the volume and toxicity of the leachate being produced? Or is shredding the waste accompanied with leachate re-circulation and methane recovery a more economically viable method of producing a stable waste mass?)

5. Can the overall cost of landfilling be reduced by using more than one type of landfill? (For example: Will separate landfills or landfill cells for raw bypass waste, ash and construction and demolition debris result in a cost savings?)

6. What factors should be considered in siting the landfill to select the best site and streamline the permitting process?

7. How large will the facility need to be to provide capacity for the duration of the planning period?

B. Incineration Without Energy Recovery

Incineration without energy recovery and land burial have equal priority according to the hierarchy in the State solid waste management policy. Waste incineration results in roughly a 90 percent reduction in waste volume. Even greater volume reductions can be achieved when accompanied by source separation and recycling. In addition, there is no need for boilers and electric generation equipment at such a facility. This alternative might be appropriate in areas where only household waste is incinerated and steam or electric markets are not available. The reasons for selecting this alternative must include a comparison of the relative merits of incineration without energy recovery versus incineration with energy recovery. It is unlikely that such a comparison will support incineration without energy recovery.

II. Landburial

A. Technology Description

1. Description

Land burial, or landfilling, is the process of disposing of solid waste by spreading it in thin layers, compacting it to the maximum extent practicable, and covering it, as required by the waste type, to minimize environmental problems. A new landfill built according to 6 NYCRR Part 360 will require proper siting, detailed planning and design, careful construction, and a controlled, efficient operation. New Part 360 state-of-the-art solid waste landfills will have basic engineering and construction standards similar to those required for hazardous waste landfills in New York State. Under the Part 360 regulations, landfills will be required to conform to rigid siting restrictions which will keep them from being built where they may have a negative impact upon sensitive environments, such as principal and primary aquifers or regulated wetlands. In addition, the requirements for siting studies will compel selection of the most environmentally appropriate sites for new landfills.

a. Past Practices

In the past, open dumps and open burning were the primary methods of solid waste disposal. In 1976, the Federal Resource Conservation and Recovery Act (RCRA) outlawed the open burning of refuse and required its disposal in "sanitary landfills" in which the waste was covered to prevent fires, vectors (disease carrying animals and insects), odors and blowing papers.

These open dumps were usually unlined and uncontrolled, and led to two major routes of environmental contamination. The first route was through the migration of contaminated water. Water percolating through the landfill (leachate) became contaminated through contact with the waste. This leachate was allowed to enter the soil under the assumption that natural attenuation processes would remove contaminants before degradation of the underlying groundwater occurred. Natural attenuation, however, proved insufficient to handle the volume of leachate being produced at these often poorly sited facilities. Where site soils were less permeable and restricted the flow of leachate, surface outbreaks of leachate were the norm, sometimes causing contamination of nearby rivers, streams, and other surface water bodies.

The second contaminant migration pathway was the release of gases. Subsurface migration of gases from the site had the potential to cause explosions from the build-up of methane in nearby buildings, pipes and other structures. Aerial release of these contaminants had a variety of air quality impacts, most of which were difficult to quantify. Odors also posed a highly noticeable problem to those living near these facilities.

In some cases, the levels of contamination contained in these releases were increased by the dumping of a variety of toxic chemical and industrial wastes which, at the time, was considered a legal and acceptable practice.

b. Today's Landfills

The NYSDEC regulations for solid waste management facilities (6 NYCRR Part 360) require extensive environmental controls, possibly the strictest in the nation for solid waste management facilities. These regulations contain specific criteria for the various types of landfills, including construction and demolition debris landfills, waste-to-energy ash landfills, industrial landfills and mixed municipal waste landfills. These regulations were developed to keep the problems of the past from recurring. Among other things these regulations require that:

- landfills be constructed with state-of-the-art, conservatively designed, liners and leachate collection and removal systems to prevent the uncontrolled migration of leachate or landfill gas below the ground;

- landfills must also be sited in geologically appropriate areas, with the greatest possible thickness of clay-rich soils, where natural attenuation will be maximized to ensure long term integrity of the site;

- landfills must be surrounded with an effective groundwater monitoring system which is capable of rapidly detecting any changes to groundwater quality caused by the facility as a backup measure to protect the environment;

- all waste be covered daily using appropriate materials to prevent above-ground problems, such as vectors, odors and litter and; once the facility is closed, final cover be installed to minimize rainwater infiltration into the facility;

- operational measures be taken to reduce the potential mobility of contaminants within the waste mass and to lessen the strength of the leachate. (These provisions include the maximization of waste separation, recycling, incineration and any other available treatment methods); and

- stringent gate control and waste inspection measures be taken to prevent the unauthorized disposal of hazardous waste materials.

Landfills are also regulated by the State Environmental Quality Review Act (SEQRA), 6 NYCRR Part 617, and 6 NYCRR Part 420 which regulates mining in New York State. If any wastewater discharges exist from the facility, they are regulated by the State Pollution Discharge Elimination System regulations (SPDES), 6 NYCRR Parts 750-757.

2. Landfill Siting

Proper siting of a landfill is a powerful tool to reduce potential environmental impacts. The siting process can eliminate sites which will have visual, air quality, traffic and other adverse impacts and, most importantly, can reduce the possibility of water quality degradation from accidental or long-term containment failure. Ideal sites should be distant from valuable groundwater or surface water resources and at a location with abundant clay rich soils. When such a site is used for a landfill, the trace amounts of leakage which can be anticipated from modern landfills would be attenuated readily by natural processes to preclude significant levels of groundwater contamination.

New York State's Part 360 regulations include provisions for proper landfill siting. These include prohibitions from siting landfills on lands which contain: certain agricultural lands; floodplains; habitats of endangered species; regulated wetlands; primary water supply and principal aquifers; unstable areas; and unmonitorable or unremediable areas. Landfills accepting putrescible waste must also meet certain setback requirements from airports. The regulations also include requirements for conducting the siting process, site evaluation criteria, and other factors which must be considered in siting.

3. <u>System Design</u>

New York State requires strict design standards that provide nearly 100% accountability for leachate from landfills. The level of design and environmental control required for each of the various types of landfills has been defined in regulations based upon the type of waste to be deposited and its potential to leach contaminants into surface and groundwater.

These environmental controls are accomplished by a variety of means:

a. <u>Liners</u>

Landfill liners, coupled with leachate collection and removal systems, prevent or reduce leachate migration and contamination of groundwater resources. Liner construction materials include clay rich soils, synthetic materials, or a composite of the two. For most mixed municipal waste landfills in New York State, double composite liners are required by regulation.

The advantages and disadvantages of the various liner materials are discussed below:

1) <u>Soil Liners</u>

Soil liners are constructed by the compaction of naturally occurring clay-rich soils, or soils with clay admixtures, until a proper density is reached to make the soil liner low in permeability. Compaction must be performed by properly controlling the moisture content, lift thickness, and other necessary details to obtain satisfactory results. Permeability is the ability for fluids to pass through a specific material. Thus, low permeability materials restrict the escape of fluids to the environment. These soil liners have the ability to restrict the flow of liquids at the bottom of the landfill and to direct them into a leachate collection system for removal and proper treatment. Generally, soil liners are several feet thick, and are constructed in several thin layers, called lifts, to insure uniform compaction throughout the liner.

Soil liners have many advantages including some ability to attenuate contamination as leachate passes through them, some ability for clays to expand to fill cracks to stop leakage, and a thickness which makes liner penetration through puncture far less likely than it is for a thin synthetic liner.

The efficiency and durability of soil liners can vary greatly with changes in the mineralogy and homogeneity of the soil, the efficiency of compaction, the design of the leachate collection system and the nature of the liquid that is to be contained. Field studies have shown that macro-scale construction defects and cracking caused by drying or freeze/thaw can cause soil liners to have actual permeabilities several orders of magnitude greater (liquids pass more quickly) than predicted laboratory values. Potential problems can be minimized by careful construction, covering during construction to avoid drying, and covering after installation with a sufficient thickness of waste to prevent freeze/thaw damage.

The most important factor, however, seems to be the depth of leachate (head) allowed to collect on top of the liner. As this liquid layer thickens, the accompanying hydraulic head can force the liquid through the liner at an increased rate. The buildup of leachate head due to poorly designed or even non-existent leachate collection systems may have been the most common cause of liner failure in the past. Conversely, drainage of the leachate before a head builds up will increase significantly the containment efficiency of liners.

2) <u>Geosynthetic Liners</u>

Geosynthetic liners are large man-made impermeable sheets, transported to the site and seamed together to form a continuous liner. These liners have an advantage over soil liners in that they are essentially impermeable, exhibiting permeabilities which are in the realm of 10^{-12} cm/sec. The best clay liners in New York State have a permeability of roughly 10^{-7} cm/sec. This makes geosynthetic liners excellent for primary containment because any fluids reaching this layer will be rapidly transmitted to the leachate collection system, thus reducing leachate head to a minimum.

The low permeability of geosynthetic liners also makes them very useful for liners under a leak detection system because even a minor amount of leakage will be rapidly transmitted to the detection points. A wide variety of geosynthetic liner materials are available that are resistant to attack by those chemicals anticipated to be in the wastestream, and are able to withstand anticipated stress. Currently, the most commonly used synthetic liner material in New York State municipal solid waste landfills is high density polyethylene (HDPE).

The disadvantage of geosynthetic liners is their limited thickness and lack of self-healing capabilities. Improper seaming or a puncture or tear will allow relatively unimpeded leakage. Such problems can be avoided to a great extent by selecting liner types which are chemically compatible with the wastes being disposed of and employing rigid quality assurance and quality control standards during construction. In addition, the liner should be designed and handled in ways that protect it from puncture, tear, or cracking. Post-installation care should include covering the liner with drainage materials as rapidly as possible to avoid damage from sunlight and changes in the ambient temperature from day to night. Traffic on the liners should be limited and, at the start of landfilling, items which could puncture the liner should be removed from the waste.

3) Composite Liners

The possibility of groundwater contamination from landfills lined by either a soil or geosynthetic liner alone is dramatically reduced by combining them into what is termed a composite liner. The geosynthetic liner component gives the composite liner the ability to rapidly transmit leachate to the collection or leak detection system, thus precluding a head build up on the soil component of the liner. The soil liner, which underlies the geosynthetic liner, provides a barrier to leachate flow through any small holes or seam breaks which may occur in the geosynthetic liner. Based upon theoretical hydraulic analyses of a composite liner in New York State, the anticipated leakage through a single composite liner, assuming several flaws, will be only one gallon of leachate per acre per day.

4) Double Composite Liners

While the anticipated leakage from a single composite liner is extremely low, New York State regulations require double composite liners for many classes of solid waste landfills, such as those taking unprocessed mixed municipal waste. The double liner system places a secondary leachate collection/leak detection system beneath the primary liner and adds a redundant, second composite liner. It is anticipated that there will be no significant leakage from a properly sited and installed double composite liner system and that such a system will allow no impact on groundwater quality. Figure 4-1 illustrates a double composite liner.

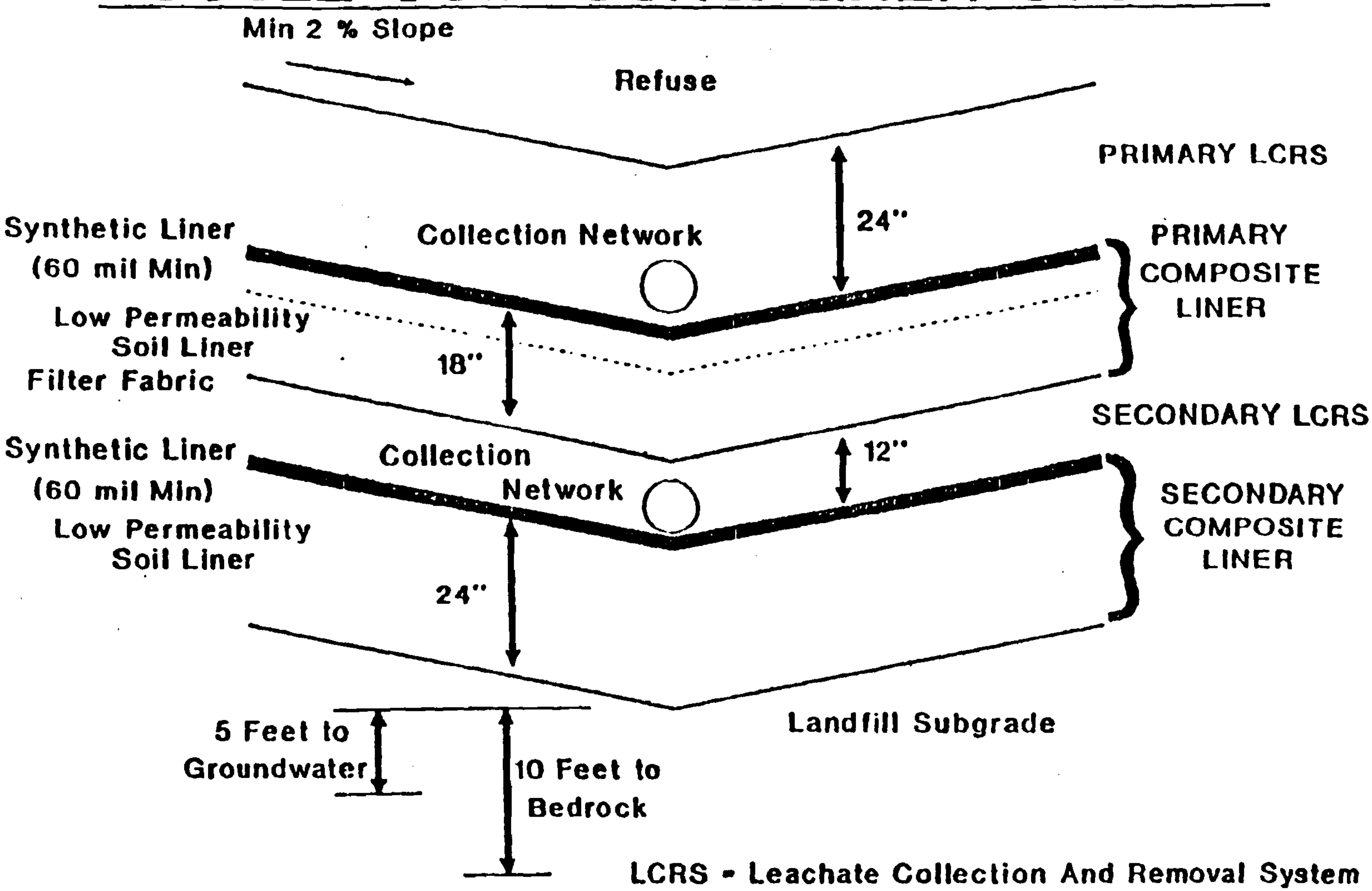
b. Leachate Collection/Leak Detection Systems

Collection and removal of leachate from above the landfill's primary liner is essential to prevent the buildup of the leachate head. Once removed, by the primary or secondary leachate collection system, leachate is stored and properly treated prior to discharge. The secondary leachate collection system not only keeps leachate from building up on the secondary liner, it also provides an indicator of the performance of the primary liner.

Generally, the efficiency of these leachate collection systems is improved by increasing the permeability differential between the liner and the drainage materials, using collection pipes within the drainage materials, increasing the slope of the liner between collection pipes, decreasing the distance leachate must flow before entering a collection pipe and proper design and maintenance of these pipes to prevent biological or physical clogging. Thus, the design and operation of the total landfill will determine the efficiency of leachate collection.

FIGURE 4-1

DOUBLE COMPOSITE LINER SYSTEM



SOURCE: NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF SOLID WASTE

c. Landfill Gas Controls

In any landfill which accepts organic matter, decomposition of solid waste will produce landfill gas. Initially, waste decomposition is an aerobic process and the primary gas product is carbon dioxide. As available oxygen is consumed, anaerobic microorganisms begin to predominate and generate roughly equal amounts of methane and carbon dioxide. Trace amounts of other organic gases are also produced. Some of these gases are decomposition by-products of organic materials in the waste. Other organic gases are volatilization products from various chemicals disposed of in the landfill. As decomposition proceeds with time, the rate of gas production usually decreases.

The current standards for landfill lining and gas venting, coupled with proper facility siting, can virtually eliminate the threat of lateral gas migration. However, a potential for atmospheric gas release, especially odors, can still remain. Accordingly, measures to reduce the amount of gas produced and/or limit the impact of its release to the atmosphere should be undertaken. Possible measures include:

- increased reliance upon source separation, composting, incineration or other treatment methods to reduce the amount of putrescible organic matter being landfilled, thereby, reducing the quantity of gas produced. (Various treatment options for the waste are discussed in section j.);

- cover materials and methane recovery systems at raw (unprocessed) refuse landfills to collect and utilize gas, rather than allowing its uncontrolled discharge. (Methane recovery is discussed more fully in section d.);

- controlled ignition of gaseous emissions, or flaring of gas vents where methane recovery is not being employed;

- proper gate control and source separation to prevent unauthorized hazardous waste disposal, to reduce the amount of household hazardous waste disposed, and to reduce the accompanying volatilization products in the landfill gas; and

- proper storage and treatment of leachate to minimize odors. This can include proper placement of the leachate holding facilities to avoid the migration of odors off-site.

d. Methane Recovery

Methane recovery is the process by which methane produced at a solid waste landfill is collected and then used as an energy source or sold as a by-product. Methane recovery is conducted most effectively at large landfills. It can be used at smaller landfills, however, if the rate of degradation of organic materials is high. Techniques to encourage methane production, such as leachate recirculation or waste shredding, can be utilized to improve gas production rates. A discussion of such treatments can be found in section j.

Ideally, a landfill which recovers methane should be located close to its market. This can include use at on-site facilities, a plant using methane as a fuel, an electricity generating plant set up specifically to utilize methane from the landfill or a natural gas pipeline. When a landfill is located in a rural site the gas can be bottled and shipped to a suitable market.

The recovered methane is usually corrosive and contains gases which lower its Btu content. It needs either to be cleaned or blended in minute quantities with "normal" methane. If cleaned, a condensate is produced which can contain a variety of organic contaminants and will require appropriate treatment and disposal.

e. Groundwater Monitoring

Groundwater monitoring is required for nearly all types of landfills in New York State. Groundwater monitoring is the process of periodically collecting and analyzing groundwater samples from specially constructed monitoring wells (designed to intercept any potential contaminant released) and, where appropriate, from nearby residential or other wells. The purpose of monitoring is to detect a leachate release in a timely manner, before contamination spreads to the surrounding geologic formations. This monitoring serves as a redundant check on leachate control at the landfill and as an early warning system, in the unlikely event that containment failure occurs.

f. Daily and Intermediate Cover

Daily cover is material placed on top of the waste each day to prevent odors, fires, scavenging, vectors and fugitive dust or litter. Cover materials may vary in composition as long as they meet these goals. Intermediate cover is used when a portion of the landfill is to remain inactive for more than thirty days, but less than one year.

The most commonly used daily or intermediate cover is natural earth materials such as sand and gravel or glacial till. These excellent materials are frequently available from on-site excavation or from off-site sources called "borrow pits."

When using natural soil materials it is preferable, wherever possible, to avoid clay rich soils which can form a barrier to leachate and gas migration and, as a result of channeling, cause breakouts from the side of the landfill. In addition, restricting the flow of moisture can result in uneven degradation of wastes, causing some areas of the landfill to settle more than others. Such differential settlement will complicate the placement and maintenance of final cover. If clay rich soils are unavoidable, these problems can be ameliorated by removing a portion of the daily cover each day prior to the deposition of the next lift of waste.

One disadvantage of the use of soil daily cover is that it takes up valuable landfill space. This problem can be eliminated by the use of alternative daily cover materials. For example, paper mill sludge, if properly applied, may meet the requirements for daily cover without loss of landfill capacity, since it is also a waste requiring disposal. The use of foam cover materials which compress under the weight of the next days garbage may prove acceptable for daily cover, provided that their environmental suitability can be demonstrated.

g. Final Cover

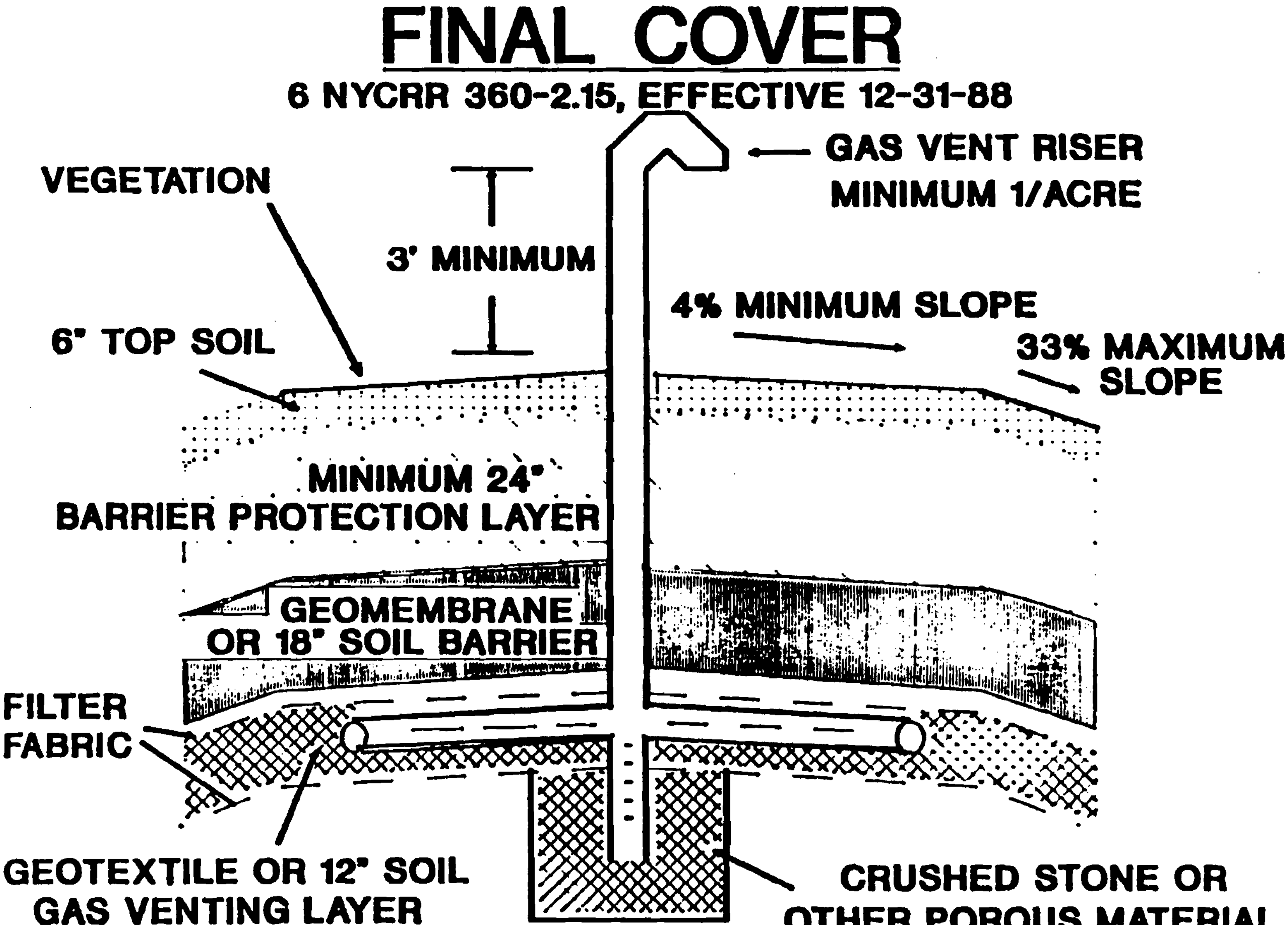
The final cover, or the landfill cap, is one of the most important elements in leachate control. By stopping the inflow of precipitation into the waste mass, the cap reduces or stops the production of leachate. Proper capping provides monetary savings by reducing the volume of leachate requiring treatment and disposal. The final cover also contains layers of soil to protect the cap, promote drainage and allow a zone for vegetative growth.

New York State regulations contain strict provisions for final cover of landfills. Figure 4-2 shows the required configuration for final cover on mixed municipal waste landfills and other landfills which are capable of producing landfill gas in significant quantities. The requirements for final cover at other types of landfills are similar except that the gas collection features may be omitted.

Landfill caps can be constructed using synthetic or soil materials similar to those used for liners. In both cases, however, differential settlement of the waste mass can create problems in construction or in long-term maintenance. For example, when compacting soil liners, the lack of a firm foundation can result in a higher permeability of the cap than desired. With synthetic or natural caps, differential settlement can cause distress of the liner and a loss of its water shedding capabilities. Thus, proper planning for the final cover should include the consideration of processes such as source separation, composting, incineration, waste compaction, shredding and baling, to make the waste mass physically stable and to reduce its leaching potential.

Potential mechanisms for cap degradation include: differential settlement of the waste mass; erosion from natural processes such as wind and rain, and human activities like intrusion by off-road vehicles; cracking caused by drying; animal burrowing; plant root penetration; and the loss of vegetation due to the escape of uncontrolled landfill gas. Thus, while the regulatory minimum maintenance period is 30 years, some level of continued maintenance beyond this minimum may be needed. Post closure maintenance will also have to extend to the leachate collection system. If a cap begins to leak and the landfill begins, once again, to produce contaminated leachate, the leachate collection system

FIGURE 4-2



SOURCE: NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF SOLID WASTE

must continue to function properly to prevent a leachate buildup which could exceed the leachate holding capacity of the liner.

The benefits of capping can be enhanced by practicing sequential development of the landfill, and keeping the active areas as small as practically possible. This can be done by constructing the liner in small sections, called cells, to keep ahead of the waste mass. At the same time, active disposal areas should be filled to their final height as soon as practicable and capped to reduce infiltration. Sequential development can include the use of berms to divert the flow of uncontaminated rainwater falling on lined areas which have not yet received waste. The diverted water that is uncontaminated will be suitable for direct discharge, rather than requiring storage and treatment as leachate.

h. Gate Control - Allowable/Excludable Wastes

An important factor in reducing the potential hazards posed by solid waste landfills is the restriction of inappropriate waste. Gate control also can be used to exclude recyclables from that portion of the waste stream destined to be landfilled. Additionally, segregation and proper alternative disposal of wastes which do not require disposal in a double composite liner, will extend the landfill life while still providing the required level of environmental protection.

Some waste types which should be considered for exclusion from a mixed municipal waste landfill are:

- recyclables - Wherever possible, these should be excluded from the landfilled waste stream and sent to an appropriate recycling facility. Local ordinances may be adopted which restrict landfilling of recyclables;

- combustibles - These should be excluded from the landfill and sent to a waste-to-energy facility, if available;

- hazardous materials - All hazardous waste from a hazardous waste generator as defined by 6 NYCRR Part 372, must be excluded from municipal waste landfills. Household hazardous waste (cleaners, oils, pesticides, etc.), while not excluded from landfilling by regulation, also should be segregated wherever appropriate and recycled or sent to a hazardous waste facility;

- tires - Tires create problems in landfills because, unless shredded or cut into small pieces, they tend to float up through the waste, making landfill capping difficult. More important, however, tires can be reused or recycled, or they can be burned in a permitted facility to produce energy;

- oils - Wherever possible oils should be recycled or burned in a permitted facility to produce energy;

- construction and demolition (C&D) debris - Because these materials do not require disposal in a double lined landfill, to save space they can be excluded and deposited into a permitted C&D landfill; and

- yard wastes - Leaves, trees, brush, grass clippings and other yard wastes are not required to be disposed of in a double-lined landfill. Whenever possible, they should be excluded from the waste stream and, composted or chipped and shredded for mulch.

i. Leachate Handling, Storage and Treatment

Leachate is the liquid which results when water from precipitation percolates through the waste mass. As the water passes through the waste, it picks up the readily leachable contaminants. In a lined landfill, steps must be taken to insure the proper handling, storage, and treatment of the collected leachate.

Generally, leachate composition will vary with the composition and leaching potential of the waste. Leachate generated from raw mixed municipal solid waste contains a variety of organic and inorganic dissolved and colloidal solids (the products of decomposition of organic materials) and a variety of soluble ions. Leachate from municipal waste ash, on the other hand, is dominated by metals and common anions, such as chloride, sulfate and bicarbonate, and contains only very small amounts of a few organic compounds. Other leachates, such as those from specific industrial wastes, also will have their own signature. Regardless of composition, all leachate must be properly managed.

For most types of landfills, New York State regulations contain strict provisions for leachate accountability during on-site leachate storage and handling. These regulations generally are as rigorous as the liner requirements for the landfill itself. The required storage capacity must be evaluated on a case by case basis taking into account: the original moisture content of the waste; the amount of precipitation at the site, both annually and during peak leachate production; the area of landfill which will be uncovered at any one time, and thus open to collect precipitation; any leachate recirculation performed; and the method and frequency of leachate transport from the facility. In order to provide adequate storage capacity using the smallest possible land area, many of today's landfills are being designed with above-ground storage tanks.

The transport and treatment of leachate can be costly because of the volume of leachate produced. Most commonly, leachate is sent to an existing municipal sewage treatment plant. When compared to most municipal wastewaters, however, leachate is very high-strength for inorganic components and contains specific organic materials which can be difficult to treat. Thus, care must be taken not to overload the sewage treatment plant. Generally, this can be accomplished if the leachate loading does not exceed 5% of the plant's daily flow.

In some cases pre-treatment of the leachate on-site, to reduce its strength before it is shipped, is necessary to meet industrial pre-treatment limits set by the wastewater treatment facility. Aeration of the leachate in holding tanks is one option which is often appropriate and easily implemented.

Another possible method of on-site pre-treatment is leachate recirculation, where a portion of the collected leachate is recirculated through the landfill. Leachate recirculation is believed to smooth the seasonal fluctuations of the leachate flow. It also may be useful to hasten landfill stabilization for raw waste landfills. Unfortunately, recirculation can greatly increase the rate of biological growth in the leachate collection system. This, combined with increased amount of liquid in the overall system, can result in increased head levels on the leachate collection system. Thus, if leachate recirculation is to be considered, the design of the facility should include a highly efficient leachate collection system which can be easily cleaned. Additionally, the facility must have a highly efficient leak detection layer which can demonstrate that increased head levels have not resulted in leakage through the primary liner.

Complete on-site treatment of the leachate may be possible in some cases. However, because of the need to meet SPDES effluent limitations this method is generally restricted to sites with adequate receiving streams for the leachate treatment plant effluent.

Whenever possible, waste treatment methods, as discussed in section j, should be used to stabilize the waste mass and reduce its leaching potential to the maximum extent practicable. This will make the leachate easier to treat and may shorten the time, during which contaminated leachate is produced after closure of the facility.

j. <u>Waste Treatment Methods</u>

Many of the previous sections have discussed how waste stability will affect the design and operation of a state-of-the-art landfill. Some waste treatment methods, such as shredding, will lead to an increased rate of percolation and waste decomposition. Other methods, such as baling, will decrease this rate. A landfilling analysis should select appropriate treatment options to achieve a stable waste mass that will immobilize potential contaminants to the greatest extent practicable. Thus, one should select either methods that will maximize waste degradation prior to capping or those that will minimize any potential for water percolation through the waste mass. The chosen goal should be appropriate for the anticipated waste stream.

Many of the following waste treatment methods have been discussed elsewhere in this report. Some of the methods are useful prior to landfilling; others represent management techniques to be used after landfilling.

1) Waste Separation

Waste separation will reduce the amount of waste going to a costly double-lined landfill. Reuse and recycling will reduce some materials before they become wastes. Other materials, such as construction and demolition debris and yard wastes, can be disposed of in ways other than landfilling; still others can be treated to increase their stability in a landfill. Waste separation also can be used to remove household hazardous wastes from the waste stream, therefore reducing the contaminant levels in the leachate and gas.

2) Combustion

Combustion, either with or without energy recovery, can reduce waste volume up to 90% over raw waste deposition. Combustion also will remove much of the organic matter and produce an ash which binds up most of the inorganic contaminants. Thus combustion produces a landfillable ash which is:

- physically more stable than raw waste, not subject to differential settlement and thus leading to increased final cover integrity;
- biologically more stable than raw waste so that methane production will be minimized or even eliminated; and
- chemically more stable than rate waste so that leachate will be free of organic contaminants and will contain relatively low concentrations of inorganic contaminants.

In some cases in New York State, these changes in the waste characteristics also can allow for a reduction in the regulatory requirements for lining and gas venting.

3) Ash Stabilization

There are a variety of techniques for stabilization of ash prior to landfilling. In-place compaction of the ash can result in a more stable, low permeability waste mass which will be easier to manage. Lime-treated fly ash may be eligible for a regulatory reduction in the liner requirements. In the future, vitrification of ash may even produce a useful product which will not require landfilling. Stabilization of other types of waste, such as sludges, also may be useful to reduce their leachate strength.

4) Composting

Source separation and composting of putrescible organic wastes, rather than landfilling will make the overall waste mass more stable and less prone to differential settlement, leaching of contaminants and production of gas. In some cases, composted wastes may be suitable for use as an agricultural product. In other cases, the composted waste may be used as daily cover material in the landfill.

5) Shredding

Shredding of raw waste increases the surface area and improves biological and chemical degradation. Shredded waste will degrade more rapidly than will un-shredded waste especially when combined with leachate recirculation. Care must be taken, however, to avoid over compaction of the shredded waste if rapid degradation is being sought. Rapid degradation will result in:

- a volume reduction over a period of time, saving landfill capacity;
- a less highly concentrated leachate with time. (Initially, a more concentrated leachate will be produced but the contaminant concentration should decline rapidly as the waste mass stabilizes.);
- a temporary increased rate of methane production, desirable for methane recovery facilities; and
- a more physically stable waste mass which should facilitate capping and reduce the level of differential settlement, especially if capping is postponed until the waste has degraded.

Shredding may be most useful where waste is to be composted instead of, or prior to, landfilling. Shredding also will be helpful where reclamation of the waste and reuse of the liner are being proposed and rapid degradation is important.

6) Baling of the Waste

Baling of raw waste can have the opposite effect of shredding. In tightly bound bales, the amount of water percolating through the waste can be reduced, slowing degradation and resulting in a reduction in the concentration of contaminants in the leachate and in the rate of leachate and methane production. Baling also can reduce landfill settlement and baled waste will take up less landfill space.

Baling is useful where the overall intent is to rely upon capping to create a secure burial vault for long-term disposal. It should be accompanied with rigorous cap and leachate collection system maintenance after landfill closure. If degradation is sufficiently retarded, bales might even be suitable for exhumation and material recovery or incineration for energy recovery at some future date. Baling is also useful where wastes must be transported over long distance.

7) Leachate Recirculation

Leachate recirculation can be useful to speed decomposition of the waste-mass prior to capping. There are, however, many potential difficulties in this process. The earlier discussion of leachate handling, storage, and treatment (see section i) discusses some of these.

8) Delayed Capping of the Facility

Delaying capping of the facility allows greater degradation of raw waste prior to capping. Delayed capping can be coupled with leachate recirculation and shredding to increase the effectiveness of these processes. Delayed capping, however, can result in increases in methane escaping from the facility, potential odor problems, and total quantity of leachate generation due to increased precipitation infiltration. Delayed capping, therefore will require a variance to the Part 360 final capping requirements.

9) Reclamation of Recyclables from Landfills

Landfill reclamation is a new, emerging technology. Waste reclamation is accomplished by removing cover material and screening the decomposed wastes to remove recyclables, combustibles and any decomposed matter which can be used for daily cover in another operating area of the landfill. In general, reclamation appears to be most appropriate at facilities where decomposition of raw waste already has occurred. Reclamation has the advantage of putting a finite end to the landfill's period of potential impact by actually removing the waste. Thus it may prove most useful as an alternative to capping of an old site, and may possibly allow the re-use of existing landfill sites.

The NYSDEC, in conjunction with the New York State Energy Research and Development Authority (NYSERDA), is currently conducting a pilot project to evaluate the feasibility of landfill reclamation in New York State.

In the State of Delaware, a pilot program is currently being undertaken to evaluate ways to speed decomposition in specially constructed landfill cells. The ultimate goal is to develop a system whereby individual cells may be: filled; encouraged to decompose; reclaimed; and, after the liner has been re-built, reused. It will be interesting to see the results of this study, however it may be more appropriate to separate the putrescible materials at the start, and conduct composting in a more controlled environment. If future reclamation is considered in a solid waste management plan, it may be possible to use a portion of the landfill to stockpile certain sorted waste materials that may be recyclable in the future but for which no market currently exists. Such stockpiling may require daily cover and other environmental controls to preclude creation of unnecessary hazards or nuisance conditions at the landfill.

k. Contingency Plans

Contingency plans are a requirement for all landfills in New York State. These plans must specify what actions will be taken in a variety of circumstances such as detection of leachate in the leak detection system, or detection of contamination during groundwater monitoring. These plans must outline the specific actions necessary to insure that circumstances which could potentially become a problem will be handled properly in a timely manner. In this way, future environmental or public health problems will be avoided.

B. Technology Evaluation

1. Applicability/Capacity

A landfill is necessary in every solid waste management program, even where other waste disposal options are heavily employed. In most cases, daily landfill capacity can easily be increased or decreased to meet the changing needs of the planning unit. The ultimate capacity of the facility, however, will be limited based upon the availability of land, especially in heavily populated areas. With limited landfill space, the need to reduce the amount of waste to be landfilled and to diminish the potential toxicity of leachate becomes paramount.

These needs can be met by using the preferred management options specified in the State's solid waste management policy. Reduction in waste going to landfills also will reduce the maintenance cost and environmental risk of closed landfills. While landfills might, in theory, be constructed to handle all of the solid waste generated for any given planning unit, their use is restricted, both by law and by landfill availability, to only those wastes for which recycling, reuse, and alternative treatment and disposal methods are not feasible.

The required level of design at any landfill is related to the pollution potential of leachate and gas from the waste stream. A landfill for mixed municipal waste may be very different from one for industrial waste or for construction and demolition debris. In New York State, liner requirements vary according to the type of waste as required in the Part 360 Regulations for Solid Waste Management Facilities.

The discussion which follows provides some general information on liner requirements and any peculiarities of a particular waste stream which will require special handling. Sections a-d are not appropriate for landfills in Nassau and Suffolk Counties, where the requirements of the Long Island Landfill Law will apply. The requirements for Long Island Landfills are found in Section e.

a. Mixed Municipal Waste Landfills

Mixed municipal waste landfills are those that take any non-hazardous solid wastes generated within the planning unit. These wastes include household wastes, ash residues, sewage sludges and industrial and commercial wastes. While it is assumed that the amount and type of waste from each of these sources will be controlled by the landfill operating permit, the design of the facility should be such that whatever comes in will be safely handled with the appropriate environmental controls.

According to the Part 360 regulations for solid waste management facilities, a mixed municipal waste landfill must be properly sited according to rigorous standards and must be constructed with two separate liner systems, each a composite of low-permeability soil and a geosynthetic layer, with collection and removal systems above each liner. Operational requirements include: gate control; specific requirements for particular wastes which may cause operational difficulties; compaction of the waste; application of daily, intermediate and final cover and vigilant monitoring for leakage into the secondary collection system, for groundwater contamination and for the release of methane.

Requirements for facility closure include a low permeability soil cover or a synthetic membrane to minimize infiltration of rainwater into the landfill and continued monitoring for a minimum period of thirty years after closure.

b. Solid Waste Incinerator Ash Monofills

Ash monofills are those used solely for ash generated in solid waste incinerators. Because of the reduced concentrations of contaminants in leachate from the ash, New York State regulations allow the use of a single composite liner for ash monofills used for mixed fly-ash and bottom ash, or for bottom-ash alone. Where the ash is to be mixed with raw municipal waste or where fly ash alone is to be disposed of, a double composite liner is required. Landfill gas collection is not required for solid waste incinerator ash. All other regulatory requirements are the same as for mixed municipal waste landfills.

Because the liner requirements are reduced for facilities which do not accept raw wastes, plans that include an ash monofill should also provide a landfill or other means of handling bypass waste during periods when the incineration plant is not operating and other bypass waste which cannot be combusted.

c. Industrial Waste Landfills/Sludge Landfills

Regulatory requirements in New York State for landfills used solely for the disposal of wastes from industrial or commercial operations (monofills) will vary according to waste type and its potential for environmental impact. They may be either more or less stringent than requirements for mixed municipal waste landfills. Where non-hazardous sludges are landfilled, they must be stabilized and dewatered to a minimum of 20 percent solids with no free moisture evident.

d. Construction and Demolition (C&D) Debris Landfills

The regulatory requirements for construction and demolition (C&D) debris landfills in New York vary with the size of the facility. For facilities under two acres, the siting requirements are slightly relaxed and water quality monitoring may not be required. Landfills larger than two acres will require siting and groundwater monitoring. For those facilities over five acres, an engineered base, meeting certain permeability requirements, and a leachate collection and removal system will be required. Specific operational requirements, similar to those for mixed municipal waste, are placed upon all C&D landfills.

e. Long Island Landfills

The regulatory requirements for landfills in Nassau and Suffolk Counties are defined in 6 NYCRR Subpart 360-8 based upon the Long Island Landfill Law (ECL 27-0704) and are different from those for landfills elsewhere in the state. For landfills other than clean fill landfills, the requirements state:

- liability protection must be provided against pollution of groundwater, surface water and air, based upon the estimated costs of providing an alternate potable water supply, corrective action and operation of leachate collection systems;

- no new landfills may be allowed within the deep flow recharge areas. Extensions of operation for existing landfills may be allowed by the Department in certain cases. A limited landfill expansion, for providing disposal capacity to no later than 12/18/90, may be approved within the deep flow recharge areas provided certain requirements are met; and

- after December 18, 1990, only wastes which are the result of resource recovery, composting or incineration and a limited amount of downtime waste may be deposited in landfills outside the deep flow recharge areas. The design of these landfills must be equivalent to that required for mixed municipal waste landfills elsewhere in the state, i.e. constructed with a double composite liner; except that the synthetic portions of the two liners must use two different materials. No new landfills may be located in the deep flow recharge area.

Clean fill landfills are those that take materials consisting of concrete, steel, wood, sand, dirt, soil, glass, C&D debris and other inert material as approved by DEC. On Long Island, these may be located either within or outside of the deep flow recharge areas. Specific regulatory design requirements, far exceeding those for construction and demolition (C&D) debris landfills elsewhere in the state, are contained in 6 NYCRR Part 360-8.6.

2. Reliability/Experience

The reliability of landfilling as an option should be considered from two standpoints: continuously available waste disposal capacity and reliability of environmental controls.

a. Continuously Available Waste Disposal Capacity

Except for reaching the end of its physical capacity, there are not many circumstances that will completely stop a modern landfill from accepting waste. Most of the equipment involved (loaders, compactors, etc.) is portable and easily replaceable in the event of mechanical failure. Failure of the liner could stop deposition in a particular waste cell. However, with a double composite liner, if leakage of the primary liner occurs, a new landfill cell can be constructed to replace the leaking cell before a release to the environment occurs. In some facilities, such as construction and demolition (C&D) debris landfills, a determination of groundwater contamination could result in premature facility closure. However, even in this case, there probably will be some lead time while groundwater testing and evaluation of the nature and origin of the contaminants is completed, in order to locate an alternative disposal site. When constructed and operated according to current regulations, landfills are highly reliable and are limited only by the size of a facility and its capacity.

b. Reliability of Environmental Controls

A significant amount of research went into the development of the composite liner required for most landfills in New York State. There is a high degree of confidence placed in the double composite liner system, and even in single composite liners. Beyond this, there are strict regulatory requirements in New York State for proper siting of landfills, and for groundwater monitoring and contingency plans for remediation in the event of a liner failure. Therefore, it is anticipated that landfills will have an extremely high degree of environmental reliability.

3. System Cost

A common problem across the nation has been an underestimation of the costs of landfilling. The costs of landfilling can be estimated in a variety of ways. It is extremely important to understand the full range of costs for landfilling when comparing it to other solid waste management options. A full accounting of costs, from the start of the landfill development process all the way through to post-closure maintenance, is essential to perform a true economic comparison of other treatment and disposal methods and to show the true value of avoided costs through recycling, reuse and other waste reduction methods.

For the purposes of this estimate, costs have been broken down into initial development costs and operational costs for mixed municipal waste; municipal waste ash and industrial waste landfills. A third section discusses the costs of construction and demolition (C&D)

debris landfills. There will be a large variability in the initial development costs for different facilities. This discussion, therefore, gives a typical range of costs based upon a telephone survey of recently constructed facilities and proposed facilities, which meet, or come close to meeting, the current requirements for a Part 360 mixed municipal waste landfill. The discussion also describes some of the variables which will impact the development costs within this range. Operational costs cover all other expenses, exclusive of haul costs to the site, and include the cost of development of subsequent areas, debt service on the initial development and the cost for closure and post-closure monitoring.

a. Initial Construction Costs

The minimum anticipated initial development costs, for all reports, testing, constructing and legal or engineering services from the start of the site selection process to the actual initiation of landfilling, range from $4,500,000 to $9,000,000.

Such a cost estimate is appropriate for a well-sited, mixed municipal waste or industrial landfill, or ash monofill in upstate New York, with an initial development area of roughly 10 to 12 acres. It also may be applicable for a clean-fill landfill on Long Island. However, costs can exceed the limits of this range when site-specific conditions are complex and require additional studies or extensive development. For example, costs will be more than double the upper range above for a facility at an extremely large site that requires complex hydrogeologic investigation and extensive site development, including excavation and bentonite amendment of the liner soil. Similarly, site development costs may escalate for municipal waste ashfills on Long Island or in other complex situations.

Some factors which will influence the actual initial site development cost include:

1) Permitting Costs

Permitting costs will vary with the amount of public opposition to the site, the site's hydrogeologic complexity and its environmental sensitivity. These costs include such items as site selection studies, hydrogeologic and geotechnical investigations, environmental impact analyses, impact mitigation measures and host community benefits packages.

2) Ancillary Structures

The need for and size of ancillary structures, including leachate transmission and holding facilities, access control structures and waste processing equipment can escalate costs for the initial phase of construction. These items are usually necessary at a new facility but may not be needed when an existing facility is expanded. At one recently constructed landfill, the cost of ancillary structures, combined with permitting costs, far exceeded the actual construction costs for the 11-acre liner.

3) Complexity of Design and Construction Details

The complexity of the design and construction details including the need for: major excavation of the site; construction of a dewatering system prior to liner placement; special care installing complex pipe penetrations through the liner; and any other features which might complicate the construction, quality control or quality assurance procedures.

4) Materials Handling

The cost to import or improve clays and other natural materials to be used on site through crushing, screening or bentonite admixture.

5) Delays

Construction delays due to adverse weather conditions.

6) Hydrogeologic Complexity

Complex hydrogeologic features such as variable groundwater flow conditions, or pre-existing contamination which can complicate the development of a groundwater monitoring system and the determination of existing water quality.

b. Operating/Closure Costs

The operating costs for a landfill can include such items as: personnel, equipment maintenance and replacement, insurance, environmental monitoring, vector control, daily cover materials, fuel, leachate hauling and treatment, facility closure and post-closure maintenance of the facility, debt service, and the establishment of a sinking fund to finance any remedial activities required in the event of a contaminant release.

The range of costs for operation will be from:

- $25 to $35 per ton without debt service or closure costs;
- $40 to $50 per ton including debt service; and
- $50 to $60 per ton when all costs are included.

Operating costs should take into account factors which might enter into the total cost of landfilling. These should include:

- additional costs for waste or leachate hauling if the landfill is to be located in a remote area or outside the planning unit;

- any special waste treatment costs to be incurred for sorting, shredding, bailing, dewatering or other processes;

- income generated by tipping fees or landfill gas generation; and

- cost for closure and post-closure maintenance of existing facilities which will be replaced by the new landfill.

Solid waste management plans should include a full evaluation of landfilling costs. Table 4-1 provides a list of factors useful for this evaluation.

c. Construction and Demolition (C&D) Debris Landfills

Currently there is little information on actual construction and operation costs for C&D landfills. These costs probably will vary widely based on the size of the facility and on site-specific factors. Where the C&D facility can be operated in conjunction with a municipal waste landfill or ashfill at the same site, the cost for the C&D facility itself will be minimal. Operation and maintenance costs for a new C&D facility will be somewhat less than those for other landfills.

Estimated costs, derived from the the Regulatory Impact Statement in the Part 360 Regulations, are given below.

Site Size	Site Development	Site Closure
2 acres or less	Up to $10,000/acre	$15,000-20,000/acre
2-5 acres 2 acres	Up to $15,000/acre	$30,000-70,000/acre
Over 5 acres	$45,000-60,000/acre	$30,000-70,000/acre

TABLE 4-1

GENERAL LANDFILL COST FACTORS

Pre-development:

- Site Selection
- Environmental Assessments (Includes Hydrogeologic Investigation)
- Permit Application (includes Engineering/Legal Fees)
- Land Acquisition/Lease

Site Preparation and Construction:

- Site Preparation;
  - Clearing & Grubbing
  - Base Area Preparation
- Construction Labor
- Construction Management (includes Quality Assurance/Quality Control)
- Structures (Materials);
  - Liner & Leachate Collection System
  - Leachate Storage Facility
  - Buildings & Scales
  - Access Road & Control Roads
- Insurance during Construction
- Financing Costs (Capitalized Interest, Bonding, etc.)
- Miscellaneous (Sales and Use Taxes, etc.)

Facility Operation and Maintenance:

- Personnel
- Equipment (Purchase, Maintenance and Replacement)
- Facility and Building Maintenance, (Labor, Contracts, and Supplies)
- Leachate Hauling & Treatment
- Environmental Monitoring/Testing
- Contract Services
  - Reporting requirements
  - Legal
  - Management
- Host Fees
- Maintenance (Grounds and Leachate Collection System)
- Insurance

Closure:

- Engineering
- Construction Labor
- Construction Management (Quality Assurance/ Quality Control)
- Structures (Materials)
  - Final Cover System
  - Gas Control
- Insurance During Construction

Post-Closure:

- Leachate Hauling & Treatment
- Environmental Monitoring
- Annual Inspections
- Maintenance (Cap & Leachate Collection System)
- Insurance

Revenues:

- Recovered Energy (Methane Recovery)
- Tipping Fees

SOURCE: NYSDEC DIVISION OF SOLID WASTE TAGM: SW-89-5001, April 5, 1989
NYS SOLID WASTE MANAGEMENT POLICY GUIDANCE

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CHAPTER 5
ENVIRONMENTAL ASPECTS

Similar potential environmental impacts are inherent to all major solid waste management facilities. Because of strict new regulatory requirements for design and operation of these facilities, the impacts that have historically been associated with solid waste management facilities (litter, odors, groundwater contamination, gas migration, air pollution) are not expected to occur when these facilities are properly designed, constructed and operated. However, because new solid waste management facilities usually will serve large regional areas and be larger than those of the past, the impacts associated with their construction and operation and with transportation of solid waste could be greater and more centralized than those of the past.

The impacts associated with the construction and operation of a solid waste management facility can occur at the facility site or in the surrounding area. As such, the solid waste management planning process is often combined with the preparation of a Generic Environmental Impact Statement (GEIS). The requirements for preparation of a GEIS are set forward in 6 NYCRR Part 617 and further explained in the State Environmental Quality Review Act (SEQRA) Handbook. Both documents are available from DEC's Division of Regulatory Affairs. Be sure to consult these sources during preparation of a GEIS.

The discussion below presents the generalized potential impacts for the full range of solid waste management facilities, followed by impacts for each specific major type of facility.

[NOTE: The evaluation of these impacts should be modified to address the specific plans being considered by the planning unit, and to address specific conditions within the planning unit. This discussion also should include the impacts of existing landfills or other solid waste management facilities which the new facility will be replacing. The discussion of mitigation should include the influence of such local factors as soil types, topography and availability of transportation routes. These factors can enhance the level of mitigation through proper facility siting.]

I. <u>General Potential Impacts From All Facilities</u>

A. <u>Groundwater/Surface Water</u>

1. <u>Impacts</u>

Possible impacts upon groundwater or surface water from any SWM facility include:

° a reduction of available water supplies caused by an increased use of water during construction and/or operation of the facility; and

- contamination caused by improperly disposed wastewater or surface water runoff, leachate (water which has come in contact with the waste), or water from sanitary uses at the facility.

2. Mitigation

Methods to mitigate a reduction in water supply include the use of alternate water sources and the conservation, treatment and reuse of contaminated water wherever possible during construction and operation of the facility. Mitigation plans for wastewater, leachate and runoff contamination should include proper collection, handling and treatment of all such waters.

B. Air

1. Impacts

Air impacts from construction and operation of any solid waste management facility can include:

- the release of gas containing methane or other organic chemicals produced by decomposition or volatilization of waste materials;

- fugitive dust from dry wastes or from excavated areas and haul roads used during construction and/or operation;

- exhaust from vehicles transporting waste to the site and from equipment used on-site; and

- emissions from fires.

2. Mitigation

Reduction of gaseous emissions and odors from the waste can be accomplished by:

- limiting the amount of time waste is stored before being processed;

- covering waste upon deposition at landfills and properly managing the gas produced; and

- enclosing all waste handling and storage areas and waste hauling vehicles.

Effective dust controls for roads and stockpiles and during construction include:

- the use of water trucks and other watering devices during construction;

- paving or otherwise treating roads which are to be heavily utilized;
- enclosing trucks and material stockpiles which may produce dust; and
- controlling material handling methods (such as reducing the drop height from loaders or processing conveyors).

Available measures for controlling fugitive dust from dry wastes include wetting the wastes and rapidly covering it with other wastes or daily cover.

Exhaust fumes can be controlled through the use and maintenance of appropriate air pollution control devices on all equipment, along with proper planning to reduce the number of vehicle trips. Shutting off equipment when not in use also will help.

Mitigation of emissions from fires is best accomplished by preventing fires. Contingency plans should be developed to deal with fire rapidly and effectively should they occur. In some cases, these contingency plans will need to include training and equipping local fire departments so they will be prepared in the event of an emergency.

C. Methane Gas Migration and Explosion

1. Impacts

Whenever putrescible solid waste is accumulated and allowed to decay, gases will form. Large accumulations of waste allowed to decay for long time periods can generate methane and create explosive conditions.

2. Mitigation

For most solid waste management facilities, the amount of gas produced probably will be small, if waste is processed quickly and not allowed to accumulate. Further mitigation can be accomplished by venting any waste storage or processing areas and quickly removing putrescible waste that is to be disposed of elsewhere. Wherever putrescible waste is stored as a feedstock for processing, older stockpiles should be used first to insure that degrading material is rapidly removed.

Greater amounts of methane will, of course be generated at raw waste landfills. The mitigation of methane impacts at landfills is discussed in Section V.C.

D. Visual

1. Impacts

Construction and operation of solid waste management facilities may have negative visual impacts. These include:

- de-vegetation during construction;

- machinery at the construction site or during operations;

- a change in topography or the character of an area resulting from excavation, buildings and other structures; and

- lights from a facility operated at night.

2. Mitigation

These negative visual impacts can be minimized or eliminated by:

- proper site selection to find sites with natural screening wherever possible;

- facility design to make the view harmonious with existing conditions and to maximize the use of natural screening; and

- use of buffer areas, berms and other man-made features to obscure visual impacts. These can be constructed and planted with appropriate vegetation early in the construction phase to block out the visual impacts of construction as well as impacts from facility operation. Temporary barriers also can be used to block off unsightly views or lights.

E. Vectors

1. Impacts

At any solid waste management facility handling raw putrescible waste, animal vectors can be troublesome. Vectors can include flies, rats, birds and other animals and insects attracted by the waste. Vectors can spread diseases, create a hazard to aircraft and pose a risk to facility operators.

2. Mitigation

Mitigation of vector problems starts with good housekeeping practices. These can include:

- litter control;

- baiting of the facility with rodenticide;

- avoiding the collection of stagnant water where mosquitoes, flies and other insects can breed;

- rapid processing or covering of waste to discourage growth in vector populations; and

- treatment or processing of waste to remove materials that will attract vectors.

F. Litter

1. Impacts

Litter can be a common problem for any solid waste management facility, not only on site, but also in the area surrounding the facility and along major transportation routes to the facility.

2. Mitigation

The most effective measures for controlling litter are the use of good housekeeping practices. These should include:

- active litter collection;

- litter fences near the working area and around the perimeter of the facility; and

- gate restrictions against trucks with uncovered or improperly secured waste to encourage proper waste transport and to reduce the amount of litter at the facility and on public roads.

G. Traffic

1. Impacts

An increase in heavy vehicle traffic is common at any major solid waste management facility and in its vicinity. This can occur both during operations and during facility construction. Traffic brings with it noise, exhaust fumes, dust and a greater risk of accidents. Disruption of local traffic patterns also can occur during facility construction, especially when the facility location requires the construction of new access roads or interchanges.

2. Mitigation

Mitigation measures for traffic impacts include:

- use of flag-persons, traffic lights and other traffic control measures;

- proper planning of access routes to and from the site to avoid residential areas, congested traffic areas and peak traffic hours;

- weight and traffic restrictions on local roads;
- reconstruction of roads or interchanges that are likely to become congested due to facility construction and operation; and
- gate restrictions against admitting vehicles with improperly functioning mufflers or exhaust systems or vehicles that cannot otherwise safely operate on roads leading to the facility.

H. Noise

1. Impacts

Much of the noise at a solid waste management facility will be from trucks carrying waste to and from the site. Another potential source of noise is on-site waste processing equipment and other equipment used during facility operations.

2. Mitigation

Mitigation of noise impacts includes:

- selecting a site with natural topography that blocks direct sound transmission routes;
- maintaining adequate buffers;
- designing the facility so that areas where noise generating equipment is used are far from the site perimeter and take maximum advantage of topographical barriers;
- using moveable and fixed barriers, such as berms, to reflect the sound up and away from populated areas; and
- incorporating noise control into equipment design, operating noisy equipment only during appropriate hours and shutting off noisy equipment when it is not in use.

I. Fuel Spills

1. Impacts

An increase in construction, solid waste hauling and other traffic brings with it the potential for fuel spills.

2. Mitigation

Impacts from spills can be avoided by:

- using prescribed methods for all fueling operations to insure safety;

- using temporary or permanent containment systems in areas designated for refueling and fuel storage; and

- fueling equipment only during hours of the day when a full compliment of workers, trained in proper spill response procedures, can be assembled quickly.

J. Erosion/Siltation

1. Impacts

Soil erosion most commonly occurs during facility construction. It can also occur once the facility is constructed, if proper site grading, seeding and other erosion control measures are not completed. Uncontrolled siltation of eroded soils into receiving streams and lakes can harm water resources and aquatic life in the area of the facility.

2. Mitigation

Erosion can be controlled by:

- stripping the vegetation only from small areas just ahead of construction so that the time between vegetative stripping and construction will be minimized;

- using berms, grading, mulching, terracing of slopes, silt dams and temporary or permanent settlement ponds to slow the rate of erosion and contain runoff; and

- maintaining roads, culverts and drainage ditches.

K. Loss of Open Lands

1. Impacts

The loss of open lands is inherent in the construction of many types of solid waste management facilities. The loss can be significant when it impacts agricultural lands, wildlife habitat, wetlands, scenic views and archaeological resources.

2. Mitigation

By New York State regulation, proper siting procedures must seek to avoid siting a solid waste management facility in valuable open areas. Once a site is selected and valuable areas are identified, the design of the facility can be modified to afford the greatest possible measure of protection. In some cases, a buffer zone or direct replacement of the lost area may be appropriate.

In areas where valuable resources already have been affected by previous solid waste disposal facilities or other activities, it may be possible to include remediation of these areas in development plans for the new facility. In this way, the overall impact of the facility on open lands can be positive.

Thus, while some loss of land will occur, proper siting and site development can minimize and possibly reverse this impact.

L. Increased Mining

1. Impacts

Where large amounts of natural soil materials are needed for construction or operation of a solid waste management facility, the increased rate of mining either on-site or in the vicinity could have a potentially adverse impact.

2. Mitigation

Proper management of the mine sites, in accordance with a mining permit issued pursuant to the New York State Mined Land Reclamation Law, will minimize the adverse effects. If appropriate, reduction in mining can be accomplished by the use of cover materials other than those natural materials that require mining.

M. Host Community

1. Impacts

The overall impact of a solid waste management facility on its host community can be more than just the sum of the individual impacts described above. Host community impacts are the cumulative effects of all of these, combined with the perception of those living in that community that they are victims of the facility siting process. The ultimate result of this synergistic effect can be an unquantified loss in quality of life which may result in lowered property values and fear of health risks. Additionally, there may be an increased need for services, including fire protection and road maintenance, in the host community. Specific impacts in this category will vary for each site, type of facility, and level of opposition to the facility by the community.

2. Mitigation

Mitigation of these impacts can be best accomplished by incorporating host community benefits into the facility planning and site selection processes. This package should be designed to determine what, specifically, the quality-of-life impacts are likely to be and to work with those involved to achieve equitable solutions. These solutions will vary greatly, as they are designed to meet the needs of specific individuals and communities.

Some of the host community benefits which can be considered include:

- ° encouraging public participation at the start of the site selection process;
- ° guaranteeing property values to the host community and to individuals who may be affected, and providing additional public services in the community;
- ° establishing and funding locally-run boards to monitor the facility with the power to effect changes in facility design and operation;
- ° establishing financially-backed contingency plans; and
- ° doing whatever else is needed to insure that no one in the community perceives themselves becoming a victim of the need for waste disposal capacity.

N. Economic

1. Impacts

Many of the economic impacts from the establishment of a solid waste management facility will be positive. Some, however, may be negative.

The positive impacts can include:

- ° increased employment in the area for construction workers, testing laboratories, engineering firms and ancillary service industries;
- ° decreased haul costs if the facility replaces a more distant facility;
- ° industrial growth. (In one upstate county the existence of a recently completed state-of-the-art, environmentally sound landfill is viewed by industries as an important incentive for locating their operations within that county); and
- ° guaranteed solid waste disposal capacity at a reasonable cost.

Some negative economic effects may occur due to:

- diminished property values in the vicinity of the facility; and

- increased costs to the planning unit for solid waste management.

It is anticipated that, for a well-planned facility, the overall economic impacts will be positive for the entire community.

2. Mitigation

As discussed in Section I.M., host community benefits can be designed to mitigate the potential impact on property values. Proper planning to use the most cost effective state-of-the-art solid waste management techniques can help mitigate higher costs.

II. Impacts of Local Waste Reduction Programs

In general, any reduction in the solid waste stream will have an overall positive impact on the environment. As discussed in Chapter 1, most waste reduction programs, except local waste reduction education programs and local user fees, will be initiated at the State or federal level.

Beneficial impacts include:

- conservation of resources that are used in manufacturing processes;

- reduction in the amount of waste requiring further recycling or disposal;

- savings from reduced collection, transfer and disposal costs; and

- increased public consciousness towards practicing waste reduction.

Adverse impacts may be associated with:

- costs of developing, implementing and administering the local waste reduction program; and

- in the case of local packaging bans, the substituted packaging may inhibit recycling or reuse, or adversely impact other solid waste management operations.

III. Impacts of Recycling Facilities

Most of the impacts associated with recycling are beneficial because recycling removes a significant amount of waste from the environment, extends landfill life and conserves valuable natural resources such as raw materials and open space. Overall the benefits should greatly outweigh any negative impacts. However, any negative impacts must be considered and properly mitigated.

The magnitude of the potential environmental impacts associated with recycling facilities will vary depending upon the collection system employed and the mix of facilities that comprise the overall recycling program. However, the potential impacts from the construction and operation of drop-off stations, recycling centers, transfer and storage facilities and yard waste composting centers are expected to be substantially less than the potential impacts associated with a materials recovery facility or mixed municipal waste composting facility.

The potential impacts discussed in Section I of this chapter would apply to all types of recycling facilities. In general, the magnitude of these potential impacts would increase as the size of the facility or operation increases. The following sections describe major environmental concerns for the significant components of a recycling program.

A. Collection of Recyclables

If separate collection routes are utilized for the collection of recyclables there will be an increase in traffic and fuel consumption. An increase in noise may occur and the visual impact of additional traffic may become apparent to local residents along the collection routes. These impacts can be mitigated through proper route design and utilizing appropriate collection vehicles and equipment, as discussed in Chapter 2.

B. Drop-off Stations and Facilities for Storage and Transfer of Unprocessed Recyclables

In general, such facilities are small and the predominant potential impacts associated with them are traffic, noise and visual impacts, which can be mitigated as discussed in Section I. When properly operated, these facilities receive only non-putrescible, source-separated recyclables. As such, odors and vectors should not be a concern. Construction impacts should be minimal if proper procedures are practiced. In addition, when these facilities are located near existing solid waste or other municipal public works operations, the mitigation of the potential impacts can be incorporated into operations of the existing facilities.

C. Materials Recovery Facilities

A materials recovery facility (MRF) is an industrial operation similar to warehousing and direct contact with the environment is limited. However the construction related impacts described in Section I are applicable, as well as the potential traffic, noise, litter and visual impacts. Furthermore if the facility processes non-source separated waste, then odors and explosions can be a significant concern.

D. Composting Facilities

The major environmental concerns associated with composting facilities are vectors, odors, noise and surface/groundwater impacts. The generation of odors can be minimized and vectors can be controlled by operations that minimize waste storage and promote rapid aerobic decomposition. Selection of a suitable site at an ample distance from nearby residences, commercial areas and other areas likely to be affected also would mitigate impacts associated with odors and noise. In addition, the topography and soil characteristics should be selected to avoid creating stagnant pools of water to minimize surface water run-off onto adjacent properties and to avoid leachate problems.

The refuse delivery and preprocessing aspects of a refuse composting facility would generate similar impacts to those associated with a materials recovery facility.

The use of compost produced from refuse and sewage sludge is subject to the same NYSDEC regulations which apply to the land application of sewage sludge. In addition, the method for disposal of any unmarketable compost must be approved by the NYSDEC. The use of yard waste compost is not restricted.

IV. Impacts of Waste-to-Energy Facilities

The construction and operation of a waste-to-energy facility can be expected to trigger the full range of potential impacts and require the full range of mitigation measures discussed in section I of this Chapter. However, the potential impacts on air quality and the disposal of ash are major environmental concerns associated with waste to energy facilities. These impacts and relevant mitigation measures are discussed in the remainder of this section. Specific impacts from non-combustion waste-to-energy facilities (pyrolysis and biogasification) are not included because, as discussed in Chapter 4, they are not considered proven technologies.

Recently revised 6 NYCRR Part 219 regulations call for strict air emission controls at waste-to-energy facilities. In addition, the recently revised 6 NYCRR Part 360 regulations include stringent provisions for regulating incinerator ash to prevent the ash from being released during transfer, handling, transport, and disposal. The requirements contained in the 6 NYCRR Part 219 and Part 360 regulations assure that incinerator emissions and ash residue will not pose a threat to public health and the environment.

A. Ash Residue

1. Ash Residue Composition

a. Bottom Ash

Bottom ash is a solid material that remains after the combustion of solid waste. Bottom ash comprises about 90 percent of the total ash produced in a typical waste-to-energy facility.

b. Fly Ash

Fly ash consists of very fine, powder-like particles suspended in flue gas and removed by air pollution control equipment. In newly designed WTE furnaces with flue gas scrubbers, lime is added to control acid gas emissions, which adds a significant amount of lime to the fly ash. Usually, fly ash and bottom ash are combined for ease of management.

2. Contaminants of Concern

The metal contaminants observed in combined ash from a WTE facility are arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver. Of these, lead and cadmium are contaminants of concern. Major sources for lead and cadmium in solid waste are lead-acid and household batteries, consumer electronics and plastics.

Chlorine atoms present in solid waste combine with carbon atoms and form chlorinated materials and polyaromatic hydrocarbons. The two major chlorinated organic contaminants of concern in the ash residue are chlorinated dibenzo-p-dioxins (CDD), and chlorinated dibenzo-furans (CDF). Plastics and paper are sources of chlorine.

3. Release Pathways and Environmental Impacts

Two conditions must exist for ash residue to significantly impact human health or the environment: Concentrations of contaminants must be high enough to be considered harmful, and one or more pathways must exist for the release of contaminants at harmful concentrations.

Releases can occur during handling, storage, transportation and disposal of ash residue from a waste-to-energy facility. During handling, storage and transportation, caution must be exercised against inhalation of airborne ash and direct contact with ash through the skin or by ingestion. Public concern about ash focuses mainly on disposal and the potential release of toxic concentrations of contaminants from ash residue to the surface water or groundwater.

4. Management of Ash Residue

All permit applications for construction and operation of solid waste incinerators must include an ash residue management plan. The plan must describe the methods, equipment and structures that will be used to prevent the uncontrolled dispersion of ash residue. The plan must take into account potential pathways of human or environmental exposure including, but not limited to, inhalation, direct contact and groundwater and surface water contamination. The management plan also must address the generation, handling, storage, transportation, treatment, disposal and/or beneficial use of ash residue. Requirements for the ash residue management plan are contained in 6 NYCRR Subpart 360-3.

a. Handling

Ash handling systems must ensure that ash residue, whether bottom ash, fly ash, or combined ash, is properly wetted or contained to ensure that dust emissions are controlled during on-site storage, loading, transport, and unloading.

b. Storage

Sufficient on-site storage capacity must be provided to assure that ash residue, whether bottom ash, fly ash or combined ash, is either:

- stored in watertight, leak-resistant containers located inside a building or enclosed structure, designed to allow free liquid to drain from the ash residue during the loading process; or

- stored on-site on an impermeable base, which is located in an enclosed structure and include a run-off management system to collect and control the free liquid which is allowed to drain from the ash residue.

The quantity of ash residue stored on-site must not exceed seven times the daily design output of ash.

c. Transportation

Ash residue transportation requirements call for watertight and leak-resistant containers and trucks that are also enclosed or covered.

d. Disposal

Ash disposal requirements provide for disposal in the form of fly ash only, bottom ash only, treated fly ash, or combined fly and bottom ash as follows:

- For fly ash only: Disposal in a monofill with a double composite liner and leachate collection and leak detection systems.

  Treatment of fly ash may be substituted for the monofill requirement if the applicant can demonstrate that the treatment will physically or chemically alter the fly ash to immobilize the release of heavy metals in the leachate generated after treatment under acidic and non-acid conditions. Treated fly ash then can be disposed of with municipal waste in a double composite lined landfill with a leachate collection system, or placed in a monofill equipped with a single composite liner with a leachate collection system.

- For combined ash, bottom ash or treated fly ash: Disposal either in a monofill equipped with a single composite liner with a leachate collection system or disposed of with municipal waste in a double composite lined landfill with leachate collection and leak detection systems.

- Ash residue disposal in Long Island must comply with the Long Island Landfill Law.

e. Beneficial Use

Ash residue beneficial use requirements provide for the use of ash residue as an ingredient or as a substitute for a raw materials feedstock in an industrial process to make a product. If the ash residue is to be used, the applicant must demonstrate that:

- the resulting material or product is not a waste;

- the resulting material or product has a known market or disposition;

- the ash residue is not accumulated speculatively; and

- in contractual agreements made with a second party to use the ash residue in a production process, and the second party has the necessary equipment to do so.

B. Air Emissions

1. Air Emission Composition

Air emissions of concern include particulate matter, acid gases (primarily hyrochloric acid), organic compounds - including polychlorinated-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), inorganics (trace metals) and nitrogen oxides (NOx). Particulate matter, sulfur dioxide, nitrogen oxides and carbon monoxide are federal criteria pollutants and, as such, short and/or long term ambient air quality standards exist and compliance with these standards is necessary.

a. Particulate Matter

Particulates are small solid particles suspended in the flue gas from WTE facilities. Particulate matter has two components, inorganic particulates and combustible particulates.

Most of the inorganic particulates in flue gas result from the carryover of mineral matter introduced with the waste. Inorganic particulates also can occur from mechanical degradation of the refractory (furnace) lining or oxidation or flaking of metal surfaces in the furnace.

Combustible particulates are produced by incomplete combustion of solid waste. Burning waste rich with carbon at high temperature with low oxygen can lead to soot formation.

b. Acid Gas

i) Hydrochloric Acid

Chlorine is present in the waste stream in organic compounds and inorganic salts. The major sources of chlorine in solid waste are plastics and paper. During combustion, organic chlorine reacts with excess hydrogen and forms hydrochloric acid which can contribute to acid rain.

ii) Sulfur Oxides

During combustion, the sulfur in solid waste is oxidized into many forms. In air emissions, sulfur compounds of concern are present as inorganic or organic sulfides, free sulfur and sulfur in organic or inorganic acid. Sulfur will appear in flue gas as sulfur dioxide or sulfur trioxide.

Sulfur oxides may affect human health, especially the respiratory system, and have corrosive effects on natural and synthetic materials. In the atmosphere, sulfur oxides react with rainwater and contribute to acid rain. Sulfur trioxide can cause serious corrosion within the combustion system, especially in the stack where it reacts with water to form sulfuric acid.

c. Inorganics

Metals and metal compounds are found throughout municipal solid waste. Silver, chromium, lead, tin and zinc are used in metallic surface coatings, galvanizing and soldering. Plastic objects contain metallic compounds, especially cadmium, as stabilizers and additives. Cadmium, chromium, and lead also are present in paints and inks associated with paper, fabric and plastic materials. Metals in solid waste may volatilize during combustion and can be released in air emissions.

d. Organics

Hydrocarbons can be present in WTE emissions as a result of incomplete combustion. Most of these compounds are low molecular weight hydrocarbons and partially oxygenated species like aldehydes and organic acids. The hydrocarbons of concern in air emissions are the polychlorinated-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs).

e. Nitrogen Oxides (NOx)

During combustion, nitrogen combines with oxygen to form nitrogen oxide and nitrogen dioxide, collectively referred to as nitrogen oxides. These emissions can react with sunlight to produce a variety of oxygenated compounds which can result in reduction in visibility and creation of smog in urban areas.

2. Release Pathways and Environmental Impacts

Release pathways for air emissions to humans or to the environment can be direct or indirect. Inhalation of particulates and gases from air emissions is a direct release pathway. Settlement of particulates on the surface of soil or water is an indirect release pathway. Particles can absorb gaseous contaminants before they settle on the soil or water. From surface soil, the contaminants can migrate with runoff into groundwater or surface water and thus find their way into drinking water. The soil itself can be ingested and through soil and water, contaminants can get into the food chain.

3. Management of Air Emissions

Air emissions from waste-to-energy facilities are controlled by proper design and operation based on state-of-the-art technology capable of eliminating most emissions of pollutants produced during solid waste incineration.

To protect public health and the environment, New York State regulations impose stringent air emission limitations on new municipal solid waste incineration facilities. The Department of Environmental Conservation (DEC) designed the regulations with the intent that there should be no adverse environmental or health impacts associated with a waste-to-energy facility that is designed, built and operated in accordance with the 6 NYCRR Part 360 and Part 219 regulations.

Highlights of Part 219 regulations regarding emissions from a waste-to-energy incinerator are described below. In addition to the requirements of the Part 219 regulations, an applicant for an air permit to operate a municipal solid waste incinerator will be required under SEQR to include a health risk assessment as part of the environmental impact statement, if appropriate, or their permit application. This quantitative health risk assessment will provide the public with an up-front assessment of the health impacts from both regulated and unregulated air emissions from the proposed facility.

a. Emission Limitations (Section 219-2.2)

Sets limits for particulate, acid gas and dioxin emissions. Nitrogen dioxide emissions must be controlled through best available control technology (BACT) in ozone attainment areas (areas that meet EPA ozone standards) or through lowest achievable emission rate (LAER) control in ozone non-attainment areas (areas that do not meet EPA ozone standards).

b. Design Requirements(Section 219-2.3)

Requires thermal destruction of toxic organics and collection and removal of volatile contaminants. Furnaces must be designed to operate so that combustion gases reach 1800 F for at least one second. Facility design also must include auxiliary burners and must provide for a reduction in flue gas temperature to promote condensation of volatile contaminants.

c. Operation Requirements (Section 219-2.4)

Requires monitoring of carbon dioxide and carbon monoxide in exhaust gases and establishes a combustion index to check on efficiency of combustion. A facility must demonstrate continuously that the 1800°F, one-second design requirement and flue gas temperature limit are met.

d. Emission Testing (Section 219-2.6) and Continuous Emission Monitoring (Section 219-2.7)

Require emissions testing from the stack and reporting of results to DEC, county health department and county environmental quality agency. Also require continuous measurement of specific combustion gases and monitoring of operation parameters.

V. Impacts from Landfills

The potential for uncontrolled environmental impacts from today's state-of-the-art landfills is far less than from the open dumps of the past. The likelihood of major impacts from groundwater contamination or from uncontrolled gas migration will be reduced to insignificant levels (or even eliminated) by compliance with New York State's strict regulatory requirements. In cases where a new landfill will be replacing one or more old, unlined landfills that may be contaminating surface and groundwater, the net impact on groundwater resources for the planning unit will be positive.

Because of the large area landfills occupy compared with other solid waste management facilities, subsidiary impacts such as dust, odors, noise, loss of valuable land areas or visual degradation are concerns. Additionally, because the waste taken to a landfill will remain, rather than be treated and removed, the impacts from vectors can be greater than at other solid waste management facilities. Careful planning and regulatory compliance will, in most cases, provide effective mitigation to all of these potential impacts.

Potential impacts and mitigation measures most related to landfilling are discussed below:

A. Groundwater/Surface Water

1. Impacts and Mitigation

New York State's strict requirements for environmental controls at landfills will greatly reduce the probability of ground and surface water contamination from leachate. The regulations call for:

- strict inspections and quality control procedures during construction;
- proper siting;
- highly effective liners with leachate collection and leak detection systems;
- proper gate controls to exclude hazardous and other inappropriate wastes; and
- tight controls on leachate handling from the time it is generated to its treatment or removal from the site.

No significant impacts to groundwater or surface water are expected from landfills which are properly designed, constructed and operated according to New York State's regulations. If, in the unlikely case that leakage occurs, impacts to groundwater are further mitigated by:

- groundwater monitoring designed to rapidly detect leakage, and
- contingency plans which will initiate remedial efforts at the first sign of a problem, before significant environmental damage can occur.

The potential for groundwater contamination can be decreased further by reducing, separating and treating waste prior to disposal in a manner which will reduce its overall leaching potential.

As new facilities are constructed, and the use of existing, unlined landfills can be phased out, it is likely that the overall water quality impacts from landfills within the planning area will be greatly reduced.

B. Air

1. Impacts

The large size of landfills coupled with the fact that the waste brought to a landfill remains, rather than being treated and removed, means that potential impacts on air resources can be greater than those at other solid waste management facilities. For example:

- large exposed areas of sandy or silty soils or drainage materials during construction and at the start of filling, can result in a significant potential impact of dust and blowing sand (i.e., fugitive dust emissions);

- large quantities of putrescible waste can create significant amounts of methane and other odorous gases. In addition, the methane can act as a carrier gas for other organic gases emitted from the waste;

- methane, and the presence of combustible waste, can increase the chances of uncontrolled fires with accompanying air pollution potential; and

- large masses of dry wastes which can be easily dispersed by wind can result in blowing debris and dust.

2. Mitigation

For the most part, strict compliance with the operational requirements for landfills (most notably the strict daily, intermediate, and final cover requirements) will reduce the potential for these impacts. Active recovery and use of methane and other landfill gases will also greatly mitigate air impacts. Additionally, the required buffer zones, combined with the large areas of the landfills themselves, will mean that potential receptors will be sufficiently distant from the sources of these air pollutants, greatly reducing or even eliminating the actual impact off-site. Therefore, the actual impact on air resources should be low.

C. Gas Migration and Explosion

1. Impacts

Although subsurface gas migration and its potential for explosion was a problem of landfilling in the past, the current liner requirements for landfills in New York State will prevent such problems. For example, mixed waste landfills are required to have two impermeable composite liners that will provide redundant barriers to gas migration. Also required are two leachate collection systems that can serve as passageways for the proper removal and collection of landfill gas. A mixed waste landfill also must have a gas venting system when the facility is closed to reduce overall gas pressure and its accompanying potential for subsurface migration.

Generally, aerially transported explosive gases at landfills will not collect in sufficient concentration to create an explosion hazard.

At ashfills, and other monofills where the organic materials have already been removed prior to landfilling, gas production will be at a minimum or non-existent. Production of explosive gas at construction and demolition (C&D) debris landfills has not been a problem because of the nature of the waste. Odorous gases (most notable hydrogen sulfide), however, have been found, especially where processed (ground up) C&D materials are disposed of.

2. Mitigation

At mixed-waste landfills and industrial or ash monofills, compliance with the regulatory requirements will provide adequate mitigation for subsurface gas migration.

At C&D landfills, the gases generated do not carry the potential for explosion associated with mixed waste decomposition gases. However, their odor can create a significant impact on neighbors. Control methods for gas migration at C&D facilities may need to exceed the regulatory requirements in certain cases and should be addressed on a site-specific basis.

Some methods for reducing the impacts of gas production and migration at C&D landfills can include:

- proper siting to avoid areas where the migration of gases will cause a problem;
- providing passive or active gas collection systems to allow controlled venting of the waste mass so that the gases can be properly treated and disposed;
- strict gate control to preclude the deposition of unauthorized materials which can exacerbate the gas production problem;
- surrounding the site with more extensive buffers than those required in the regulations to mitigate the potential for off-site impacts from gas migration;
- separation and special handling or treatment of the materials most responsible for the production of decomposition gases to reduce their potential impact; and
- rapid placement of final cover, which will slow the degradation of the waste materials and the production of gases.

D. Visual Impacts

The major difference in the potential visual impacts between landfills and other solid waste management facilities is their greater size. Visual impacts from landfills can include de-vegetation of large areas, raw garbage and machinery at the working face, and a change in topography as the landfill increases in height. If the landfill will operate at night, lights can present an additional visual impact.

All of the negative visual effects of landfills can be minimized or eliminated by careful site selection and design using the methods described for the general visual impacts (Section I.D) of all solid waste management facilities.

E. Vectors

1. Impacts

Because the waste coming to a landfill remains on site rather than being treated and moved off-site, landfills disposing of raw putrescible waste can have a greater potential for problems with vectors. The one vector impact most commonly associated with landfills is the hazard to aircraft presented by birds.

Another problem associated with birds and landfills that has been the subject of much discussion is that of birds contaminating a nearby surface water supply after leaving a landfill. To date, no data is available to show that such an impact has ever occurred.

2. Mitigation

Proper mitigation of vector problems associated with landfills includes strict compliance with the regulatory requirements, especially covering the waste, using good housekeeping practices and following the recommended vector mitigation measures outlined in the general vector impacts for all solid waste management facilities (Section I.E.). The use of incineration or other waste treatment methods can create a waste material which will not be attractive to vectors in the first place.

The potential threat to aircraft can be minimized by compliance with the regulatory setback requirements from airports. Consultation with the Federal Aviation Authority prior to selection of a site for putrescible waste landfills is also recommended. Additionally, mechanical devices to discourage bird congregation and vigilant covering of the waste have proven to be effective in reducing bird populations.

F. Increased Mining

For the most part, the impact of increased mining identified under the general increased mining impacts for all solid waste management facilities (Section I.L) will occur primarily at landfills. The potential measures for mitigation of this impact also are discussed in that section.

G. Loss of Open Lands

The loss of open lands is inherent in the construction of any solid waste management facility. For a landfill, which takes up multiple acres, this impact can be greater than that of other facilities. However, on average, the loss is only two to five acres per year at any particular landfill which is a relatively small loss when compared with other kinds of development.

Compliance with the regulatory requirements for landfills, and the use of the mitigation measures described in the general loss of open lands impacts for all solid waste management facilities (Section I.K) will mitigate this impact.

VI. Health and Safety

Many of the health and safety risks historically associated with solid waste management facilities have been minimized or even eliminated by the strict environmental controls required in New York State.

Those health and safety risks that remain include:

- accidents as a result of heavy equipment and other traffic on the site;
- physical and chemical hazards to on-site personnel when identifying, processing, separating out and removing bulky and hazardous materials from the facility;
- physical and chemical hazards to personnel involved in sorting and processing recyclables; and
- hazards of being bitten by animal disease vectors such as rats, insects and other small animals which will live on the site.

Use of mitigation measures as described in the general impacts section (Section I) will reduce the level of most of these risks dramatically. The danger of accidents with heavy equipment and materials recovery equipment can be decreased by the use of specific safety measures in the design and operation of the facility and by proper training of personnel.

Generally, actual health and safety risk will depend on the level of involvement an individual has with a facility. The greatest level of risk will be for those who work at the facility. This risk is about the same as that incurred by any worker involved with the movement of materials or heavy industrial equipment. The risk for a resident who comes to the landfill only occasionally, or a neighbor to the facility, will be extremely small.

VII. Other Environmental Considerations

A. Impacts

The possible impacts for solid waste management facilities have been discussed previously.

B. Unavoidable Adverse Impacts

Adverse effects of solid waste management facilities on the environment are, for the most part, avoidable by compliance with the regulatory requirements in New York State. In addition to strict environmental controls, proper siting can further reduce or eliminate many remaining potential impacts. (eg. groundwater problems, visual disruption and noise).

Many adverse impacts can be avoided by proper planning and use of the techniques outlined in the State's solid waste management policy. For example, source separation, composting and/or combustion of waste prior to landfilling can eliminate most or all of the organic materials and greatly reduce the problems associated with gaseous emissions, odors and vectors. Additionally, because it has been shown to be more dilute, leachate from a waste-to-energy ashfill will have a far smaller potential to impact groundwater resources than will leachate from a raw mixed waste landfill.

There can, however, be a few unavoidable impacts from solid waste management facilities. These include:

- construction related impacts;
- potential loss of land area;
- increased traffic; and
- host community impacts.

Mitigation of these impacts was discussed in Subchapter I.

C. Irreversible, Irretrievable Commitment of Resources

The major irreversible, irretrievable commitment of resources associated with the development of a solid waste management facility are:

- loss of land for construction of the facility; and
- depletion of natural materials for construction and operation of the facility. Some of this depletion may possibly be avoided by the use of synthetic alternative materials.

D. Growth-Inducing Aspects

The development of a state-of-the-art solid waste management facility may impact the growth of the community it serves. By providing guaranteed, environmentally sound long-term solid waste disposal capacity, a facility can serve as a positive incentive for industries to locate or continue their operations in the area.

Major improvements in the transportation system serving the solid waste management facility also can be beneficial to both commercial and residential growth in the vicinity of the facility. Residential development immediately surrounding the site may, however, decline.

A new solid waste management facility will provide employment opportunities for a number of people in the community.

E. Use and Conservation of Energy

The impact of a new solid waste management facility on energy use and consumption depends upon a variety of factors. For example:

- energy consumption during construction probably will be large;
- energy used to operate the facility probably will be roughly the same as for operation of one or more existing solid waste management facilities that the new facility is replacing;
- if the new facility is closer to, or farther from, the center of waste generation overall fuel consumption could be reduced or increased accordingly; and
- a reduction in overall energy use could be realized if a new solid waste management facility is equipped to collect and utilize landfill gas or to recover energy from incineration.

F. Coastal Impacts

The impact on coastal areas will depend on the proximity of the solid waste management facility to coastal areas. The range of potential impacts of solid waste management facilities sited near coastal areas is basically the same as for other areas.