UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 1
BOSTON, MASSACHUSETTS 02203

INFORMATION PACKET ON LEAF COMPOSTING

by the Research Library for RCRA
(617) 573-9687

Autumn, 1993

The following compilation of documents on the subject of leaf composting has been assembled to assist residents and municipalities in Massachusetts, Connecticut, and New Hampshire comply with new laws banning the disposal by landfilling of leaves and other yard wastes. For further information about documents contained in this compilation, contact the Research Library for RCRA. For further information about programs described in these documents, contact the document publisher or author or contact agency listed.

CONTENTS

The Department of Environmental Protection, Division of Solid Waste Management "Network of Home Composters" Program, 1992. (MA)

Agricultural Composting In Massachusetts: Past, Present, and Future, by Maarten van de Kamp, Massachusetts Department of Food and Agriculture, n.d. (MA)

Commercial Leaf Composting Facilities And Management Services, August 20, 1991. (MA, CT, NH)

Connecticut Composting: Towns And Quantity, October 16, 1991. (CT)

NH Municipalities That Compost, October 14, 1991. (NH)

Massachusetts Registered Leaf Composting Operations As Of November 1, 1990. (MA)

Beyond Beleaf, by MASSPIRG, October, 1990. (MA)

Leaf Composting Technical Assistance Materials, by Massachusetts Department of Environmental Protection, August, 1991. (MA)

Planning For a Municipal Leaf Composting Program, by Massachusetts Department of Environmental Protection, n.d. (MA)

Leaf and Yard Waste Composting Guidance Document, by Massachusetts Department of Environmental Protection, September, 1991. (MA)

Leaf Composting: A Guide For Municipalities, by Connecticut Department of Environmental Protection, January, 1989. (CT)

Compost Marketing in New England, by Mark E. Lang and Ronald A. Jager, n.d. (MA, CT, NH)

Expert Advice Sought On Eliminating Odor From Rotting Leaves, by Neal Learner, St. Louis Post-Dispatch, May 20, 1993. (MA, CT, NH)

Leaf Composting Manual For New Jersey Municipalities, by Peter F. Strom and Melvin S. Finstein, Department of Environmental Science, NJ Agricultural Experiment Station, Rutgers University and New Jersey Department of Environmental Protection, n.d. (MA, CT, NH)

Backyard Composting, by City of Boulder Environmental Affairs Department, [1991]. (MA, CT, NH)

Leaf Compost Program: Falls Township, Pennsylvania, by International City Manager's Association, January, 1990. (MA, CT, NH)

COMMERCIAL LEAF COMPOSTING FACILITIES

AND MANAGEMENT SERVICES
(listed alphabetically)
8/20/91

Agresource
101 River Rd.
Merrimac, Ma. 01860
Contact: Nathan Tufts
(508) 346-9286

An organic waste management company will accept bagged (paper) or bulk clean leaves and yard waste for incorporation in on-going composting programs at Ipswich and Hamilton.

Browning Ferris Industries (BFI)
1080 Airport Rd.
Fall River, Ma. 02720
Contact: Robert DeRosa
(508) 676-1091

Will collect or accept leaf and yard waste at their Fall River facility.

Earthgrow Compost Services
Earthgro, Inc.
Route #207, P.O. Box 143
Lebanon, Conn. 06249
Contact: Chris Fields
(203) 642-7591

A composting facility in Lebanon Ct. will accept, or collect (pick-up) leaves, grass, other yard waste and brush. Also offers site management services. Utilizes Scat windrow turner, has capability to debag plastic and paper leaf bags.
* (does not recommend use of plastic bags)

Fine Tree Farm
4 Smith St.
Rehoboth, Ma. 02769
Contact: Jerry Fine
(508) 226-3734

A composting facility in Rehoboth, Ma. Accepts leaf and yard waste material. Also offers on site management services, can provide a mobile dedicated windrow turner (Wildcat).

High Acres Associates
38 School St.
Hopkinton, Ma. 01748
Contact: E. Joseph DiCarlo. Pres.
(508) 435-5927

Operates a composting facility in Upton, Ma. Accepts leaves and other yard wastes. Will make arrangements to collect (pick up) materials.

Laidlaw Waste Systems, Inc.
404 Wyman St.
Suite # 320
Waltham, Ma. 02154
Contact Allen Dusault
(617) 890-1937

Operates a composting facility in Plainville, Ma. Will collect or accept leaf and yard waste materials.

Organic Recycling, Inc.
P.O. Box 176
150 Wampanoag Rd.
E. Greenwich, RI 02818
Contact: Stanley Wick, Dir. of Operations
(401) 884-1455

A composting management company that offers full site development and management services. They also accept leaves at a regional facility in Melrose, Ma. They offer the use of a Scat windrow turner, which can be used in the debagging of leaves collected in plastic or paper leaf bags.

Recycled Earth Technologies (RET)
22 Parmenter Rd.
Framingham, Ma. 01710
Contact: Mark Smith
(508) 788-0623

Operates a leaf and yard waste composting facility in Sudbury. Ma. In addition to yard waste, this facility also accepts brush.

Recycled Wood Products
25 Atlantic Ave.
P.O. Box 3043
Woburn, Ma. 01888
Contact: Greg Kaknes
(617) 933-3818

A wood and yard waste processing facility. Their product is a fine, double-ground landscape mulch. They accept; leaves, grass, shrubs, brush, and tree limbs.

Arthur Schofield, Inc.
265 Old Connecticut Path
P.O. Box D
Wayland, Ma. 01778
Contact: Arthur Schofield
(617) 235-6922 or (508) 358-2503

Vendor for bark mulch, screened loam, and compost. Accepts leaves for composting on a case by case basis. Operates a mobile tub grinder and processes trees, limbs, brush, and pallets. (no size limits on wood waste)

Westwood Nurseries
34 High Rock St.
Westwood, Ma. 02090
Contact: Jay Beausang
(617) 329-4822

A shredding service for leaves and brush.
* At present has no site and shredding equipment not yet purchased.

Sam White & Sons
16 Westmill St.
Medfield, Ma. 02052
Contact: Daniel White
(508) 359-7291

A leaf, yard waste, and brush processing facility in Medfield Ma. Will accept or collect (pick-up) the above materials. Materials are ground and mixed with loam and sold to customers.

Yarr Organic Composting Facility
Danforth St.
Framingham, Ma. 01701
Contact: Timothy Schad
(617) 643-9217

A leaf and yard waste facility located at NE Sand and Gravel Co. in Framingham. They accept leaves and brush.

Composting

Towns & Quantity 10/16/91

	Town	Quantity
1	Ansonia	2,304 cy
2	Ashford	100 cy
3	Avon	8,000 cy
4	Barkhampstead RRDD#1	5,760 cy
5	Beacon Falls*	500 cy
6	Branford	4,000 cy
7	Bridgeport	8,000 cy
8	Bridgewater	200 cy
9	Bristol	25,000 cy
10	Brookfield	500 cy
11	Canaan	100 cy
12	Cheshire*	5,340 cy
13	Coventry*	1,000 cy
14	Cromwell	3,000 cy
15	Danbury	10,000 cy
16	Darien**	6,000 cy
17	Derby	5,000 cy
18	East Haddam	800 cy
19	East Hartford	3,500 cy
20	Enfield	5,000 cy
21	Farmington	3,500 cy
22	Granby***	4,000 cy
23	Groton	1,000 cy
24	Guilford*	250 cy
25	Hamden*	5,000 cy
26	Hartford	7,820 cy
27	Harwinton	100 cy
28	Hebron*	500 cy
29	Lebanon****	20,000 cy
30	Lyme***	1,200 cy
31	Madison	2,000 cy
32	Manchester	18,000 cy
33	Mansfield	700 cy
34	Middletown	10,000 cy
35	Milford*	10,000 cy
36	Morris*	?
37	New Britain*	15,000 cy
38	New Fairfield	3,000 cy
39	New Milford****	10,000 cy
40	Newington	10,000 cy
41	North Canaan	3,200
42	North Haven	20,000 cy
43	North Stonington	800 cy
44	Orange*	?
45	Plainville***	3,600 cy
46	Prospect*	1,500 cy
47	Rocky Hill	5,000 cy
48	Shelton	3,000 cy
49	Simsbury	300 cy
50	South Windsor	12,000 cy
51	Southbury**	2,500 cy
52	Southington#	12,140 cy
53	Southington#	18,840 cy
54	Stamford	9,000 cy
55	Stamford	20,000 cy
56	Stonington*	1,000 cy
57	Stratford	9,000 cy

Leaf Composting
A Guide for Municipalities

The State of Connecticut Department of Environmental Protection
Local Assistance and Program Coordination Unit
Recycling Program

Leslie Carothers, Commissioner

CONNECTICUT RECYCLES!

January 1989

Prepared by
The University of Connecticut Cooperative Extension Service

This document is printed on recycled paper

I. Planning A Leaf Composting Operation

Planning is the first task in establishing a leaf composting facility. Several key decisions must be made regarding leaf collection, processing and end use. This section outlines the items that local officials should consider.

A. Volume

Estimate the amount of leaves to be composted. Estimates generally run between 5-10% of the total solid waste stream. More specific estimates should be made during the fall collection period by measuring truck loads collected. If leaves are collected with other solid wastes, compare weekly volume during the rest of the year to the volume of the fall collection.

B. Site Selection

Given the estimated amount of leaves to be composted, select an adequate site, the size of which should be determined by the volume of leaves collected. Approximately 3,500 to 12,000 cubic yards of leaves per year can be composted on one acre of land depending on the method used. The compost site requires relatively flat or gently sloping land and moderately drained soil which is not affected by seasonal high water. Site alterations may include grading, drainage control, security fencing, road improvements and provisions for fire protection.

C. Collection

Determine the leaf collection system. Leaf collection involves both municipal collection and independent hauling by residents, groundskeepers, and privately hired haulers. Independent hauling is common in suburban communities with leaves brought to the composting site or a supervised collection station. A major decision is whether to collect leaves in loose form or in bags.

D. End Use

Determine the end use of the compost since this decision will determine the composting method and equipment to be employed. Leaf compost is valuable as a mulch, soil amendment and topsoil substitute. Potential users can include the town parks, public works departments, residents, landscapers and nurserymen. Where high quality compost is required, additional steps will be necessary for processing and screening.

E. Processing Method

Choose a composting method appropriate to the end use. Four methods are available for composting leaves by themselves, of which the *windrow and turn* method appears thus far to be the most common and cost effective.

- *Passive Leaf Piles* involve placing the leaves in large piles and letting them remain there until a usable product is developed, a minimum of 2-3 years. Although it is a minimal management method, piling should not be considered a permanent disposal technique.
- *Windrow and Turn* requires the leaves to be placed in individual rows and turned frequently. A final product can be achieved in one year or less.
- *Aerated Static Pile* requires the leaves to be placed in a large windrow through which air is pumped or pulled. Information regarding use of this technology with leaves is limited, but it appears that in order to achieve a final product leaves composted by themselves require an estimated time of 4 to 6 months. There is extensive information regarding this method with composting sewage sludge.
- *In-vessel* composting is a fully enclosed "factory type" operation involving mechanical devices, controls and/or forced aeration. The processing period may be as short as 10 days, depending upon the mix of raw materials.

F. Program Management

Choose a management structure. A compost site can be managed in one of three ways:

- *Municipally operated and managed.* Involves the assignment of municipal employees and equipment to the site, with a designated site manager.
- *Municipally operated, privately managed:* Involves the assignment of municipal employees and equipment to the site but overall management of pile or windrow building, turning, watering, etc. is conducted by a private consultant or manager who is paid a flat fee or percentage of the tipping fee, usually calculated on a cubic yardage basis. Normally, the private firm is also responsible for marketing the final product.
- *Privately operated and privately managed:* Involves total system operation by the private sector under

contract with the community. Normally, such contracts are of a long-term (5 years or more) nature and may or may not involve the availability of municipally-owned or controlled sites for composting. As with the municipally operated/privately managed approach, the firm receives a fee for leaf delivery and markets the final product.

A further option would be for a local agricultural producer to take the leaves from the town or region and compost them on the farm, using the compost as a soil amendment for crop production.

The above management options can also be applied on a regional basis with one town supplying a site, and others providing equipment and manpower, either continuously or on a rotating schedule. In New Jersey, one such arrangement results in tipping fees covering most of the costs of the host community's composting program.

G. Budget

Define equipment and personnel requirements and project costs for collection, processing and end use.

- *Equipment:* A front-end loader is required to build, turn and break down piles. Additional equipment (turning machine, shredder, screen, vacuum trucks, etc.) will vary depending upon collection, processing and marketing needs.
- *Personnel:* Properly trained and dedicated staff must be assigned to the operation. At a minimum, a site manager and equipment operator are required. During the fall, assignment to the site will be on a daily basis, with less frequent assignments during winter, spring and summer. As with equipment, additional personnel needs will be dictated by the system selected.
- *Budget analysis:* should be an on-going process in order to evaluate alternative collection, composting and disposition methods. Worksheets are provided in Section IV for this purpose.

H. Process Management

Specify training techniques and time involved. Proper employee training and site monitoring is critical to ensure a trouble-free composting operation. Employee training should be done before operations begin and periodically thereafter. Local and/or regional training programs will be necessary.

I. Permits

Prepare a plan for permit request. A leaf composting operation is a solid waste volume reduction processing facility which will require state permits through the Solid Waste Management Unit of the Department of Environmental Protection (DEP). Specific guidelines for preparation of an application for a permit can be obtained through DEP. The plan which is submitted to DEP should include, but not be limited to a schematic layout of the site, a listing of equipment and personnel with their qualifications (and/or what training they will receive); an explanation of the composting process, the monitoring and record keeping techniques for both the process and the end-product; provisions for control of odors and leachate from the compost piles, and a contingency plan if the compost operation temporarily ceases. Local permits may also be needed.

J. Education

Choose a program to help educate the public. An on-going public education program will help maintain long-term interest and participation. During the planning stages, public meetings should be held and/or materials distributed to explain the economic and environmental benefits of composting as well as to alleviate concerns about its effects on the neighboring community.

Additionally, in an area where residents live in close proximity, a citizens advisory committee can be created to contribute ideas during planning and to monitor on-going operations. A staff person can be designated to respond to inquiries about the program.

Before the composting program begins, flyers or a mailing to residents should be made to generate interest in the program and to explain how to participate. Regular follow-up publicity campaigns, before and after a year's or a season's operation, are important for on-going cooperation.

K. Schedule

Prepare an estimated schedule. A leaf compost facility may take up to a year or more to select, design and build.

L. Additional Assistance Contact the following State departments for assistance on leaf composting.

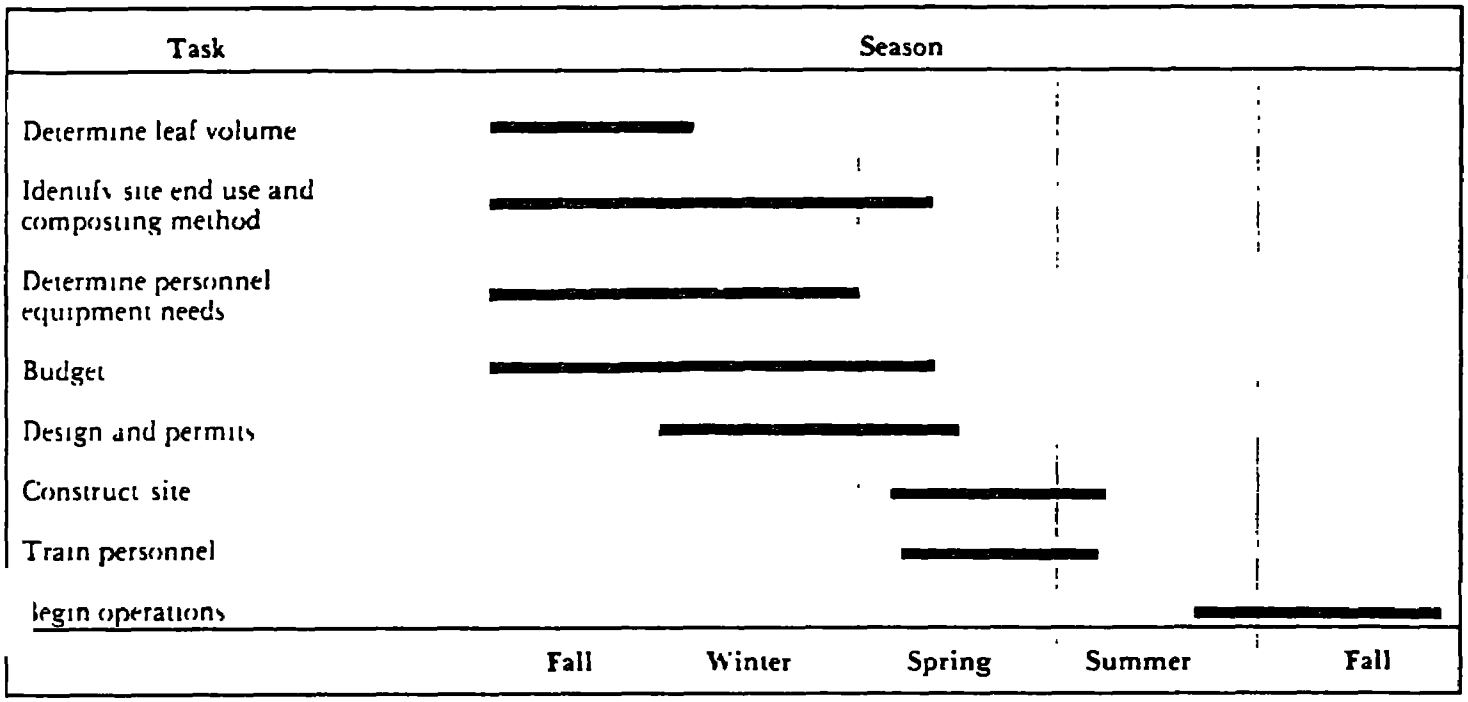
Overall Coordination and Information

DEP Local Assistance and Program
Coordination Unit
Connecticut Recycling Program
Rm 115, State Office Building
165 Capitol Avenue
Hartford, CT 06106 (203) 566-8722

Permitting and Regulatory Issues

DEP Solid Waste Management Unit
122 Washington Street
Hartford, CT 06106 (203) 566-5847

Time Schedule



Technical Assistance

DEP Local Assistance and Program
Coordination Unit
Connecticut Recycling Program
Rm 115, State Office Building
165 Capitol Avenue
Hartford, CT 06106 (203) 566-8722

DEP Solid Waste Management Unit
122 Washington Street
Hartford, CT 06106 (203) 566-5847

The University of Connecticut Cooperative
Extension Service
Box U-36, 1376 Storrs Road
Storrs, CT 06269-4036 (203) 486-1126

The University of Connecticut
Department of Natural Resources Management
and Engineering
Box U-87, 1376 Storrs Road
Storrs, CT 06269-4087 (203) 486-2840

Connecticut Agricultural Experiment Station
123 Huntington Avenue
New Haven, CT 06504 (203) 789-7272

II. Leaf Collection

The following section describes various techniques which can be employed for leaf collection The primary requirement of any leaf collection system is that the leaves be collected free of extraneous material, such as glass, metal, paper and household solid waste so that a high-quality compost can be produced This means that anyone responsible for bagging or collecting leaves needs to be trained and any drop-off location, whether temporary or at the composting site itself, must be supervised. Beyond this, the choice of a specific collection technique should reflect the volume and quality needs of the end user and the cost of processing the leaves to supply that end user If the compost is to be used as landfill cover, for instance, some extraneous material may be tolerated and screening of the end product may be unnecessary Landscapers and nurseries, however, will not accept a product which has extraneous material and the compost may require screening to achieve uniformity.

A. Volume

As with other recyclables, the more convenient the collection service for leaves, the higher the participation rate. Consequently, the volume of leaves arriving at a municipal composting site will vary with the size of the area serviced by municipal collection and the convenience of the collection site to residents and independent haulers.

Population density, established practice, accepted levels of public service and municipal costs need to be considered when determining the size of the area to be provided with municipal leaf collection In some cases, the appropriate approach will simply be to supervise and publicize an area near the composting site where residents, as well as landscapers, businesses and independent haulers can deliver leaves for composting. To maximize the amount of leaves composted, however, a municipality may decide to provide a collection service for the whole town in addition to providing the supervised drop-off area near the composting site.

If a municipality determines that it cannot economically provide service throughout the town but wants to ensure considerable convenience to its residents and businesses, a compromise can be achieved by providing curbside leaf collection to the more densely populated areas while providing community collection stations in the rest of the town The latter approach involves stationing a supervised compactor truck, roll-off or other container at designated locations in accordance with a well-publicized schedule. The town takes the responsibility for transporting the full containers to the composting site

B. Municipal Collection Methods

Municipalities which provide leaf collection must make a series of choices about collection techniques and equipment. Since these choices impact collection and processing costs and the quality of the end product, a variety of scenarios should be considered before a decision is made The best combination of techniques and equipment for a given municipality is that which most efficiently provides the compost required by the end user For instance, leaves can be collected bagged or unbagged Bagged leaves typically have little extraneous material and can be collected quickly with a standard compactor truck. However, labor is required at the composting site to remove the leaves from the bags Conversely, unbagged leaves can be collected with a vacuum truck or a front loader. This process is more time-consuming and the choice of equipment is less obvious The vacuum works well on dry leaves, the front loader is more efficient for wet or frozen leaves. In addition, the amount of extraneous material is likely to be higher than when leaves are bagged.

A summary of the advantages and disadvantages of various collection techniques appears in Table 1. Information regarding leaf collection equipment is found in Appendix C. In utilizing this information to design an appropriate collection approach, the following issues should be considered:

(1) Effectiveness in excluding extraneous material;
(2) Availability and cost of labor;
(3) Existing equipment;
(4) Capital, operating and maintenance costs of equipment;
(5) Cost of bags (plastic, degradable plastic, paper);
(6) Convenience for residents and businesses;
(7) Susceptibility to adverse weather;
(8) Hazards associated with placing leaves at curb or in street; and
(9) Potential noise and dust from collection equipment

C. Scheduling Municipal Leaf Collection

Leaf collection is a seasonal operation beginning in mid-October and continuing through early December. If an initial collection is made early in this period, a second collection may be necessary. In addition, some towns also make a spring collection of leaves and other yard debris. A site for receiving leaves from independent haulers should be made available even if there is not a municipal collection in the spring. The leaves from the spring collection should be composted separately from the fall collection.

D. Public Education and Notification

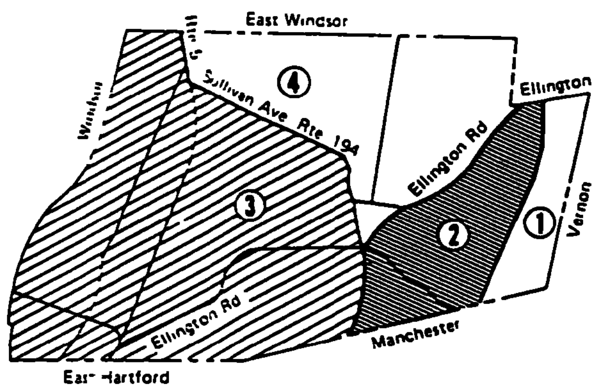
Regardless of the method of collection chosen, residents and businesses must be educated on a regular basis about the requirements for participation in the composting program and the importance of keeping extraneous material out of their leaf bags or piles. This type of education can be incorporated into the ongoing publicity for the overall recycling program. In addition, there should be a special public notification for each leaf collection. The notification should include:

(1) A statement of the intent and community benefits of the composting program;
(2) A description of the intended uses of the compost;
(3) A statement that leaves must not contain extraneous material such as branches, glass, metal, paper or household solid waste.
(4) Instructions regarding the piling, or if bags are used, the type of bag and bag closure to be used;
(5) Instructions regarding the placement of leaves at the curb or in the street;
(6) The dates when leaves will be collected in designated districts and the locations and hours of community collection stations and other drop-off locations.

Residents can be notified of the leaf collection dates by letter or announcements in the newspaper or on a local radio station. If on-street parking is banned during leaf collection, a notice should be posted on the street at least 24 hours in advance, and parking bans should be rotated within each community.

A map such as that in Figure 1, can be provided to residents showing the designated leaf collection areas and the tentative dates for collection in each district. Since the rate of collection is dependent on weather conditions, however, any revisions to the dates need to be publicized.

Figure 1. Leaf Collection Areas Designated by Districts (Source: South Windsor)



District	Leaf Collection Start Date
1	Oct. 29
2	Nov. 4
3	Nov. 12
4	Nov. 19

Table 1. Collection Options

Procedure and/or Equipment	Advantages	Disadvantages
A. Bagged leaves	Keeps leaves out of street and prevents blowing leaves. Pickup not sensitive to weather. Pickup at low cost without specialized equipment. Instructions can be printed on bags provided by the town.	Cost of bags Time required for debagging Plastic in compost must be avoided.
1. Bag type:		
(a) Nonbiodegradable plastic.	Lower cost of bag Debris can be removed when bag is emptied	Costs and possible shortage of labor for emptying bags.
(b) Biodegradable and photodegradable plastic.	Little information is now available on the use of these bags for leaf collection or how they break down during composting.	
(c) Biodegradable paper	Convenience in bagging and greater compaction than with plastic bags	Higher cost of bag Extra effort in the distribution of special bags. Shredding may be required. Possible increase in time needed for composting.
2. Equipment and procedure.		
(a) Compactor truck.	Large quantity per load due to compaction.	High equipment costs unless the compactor is used for other purposes
(i) Empty bag into compactor.	Maximum opportunity for removal of debris. Efficient dumping into windrows. Eliminates debagging operation at site.	Inefficient use of compactor.
(ii) Empty bag at composting site.	Pickup may be quicker.	Inconvenience in emptying bags and forming piles or windrows.
(b) Dump truck.*	No specialized equipment.	Small quantity per load in absence of compaction.
B. Loose leaves		
1. Location of piles:		
(a) Curbside.	Avoid problems associated with leaves in the street.	Raking of leaves by collection crew is labor intensive, especially when collection is by front end loader. More extraneous material in leaves.
(b) In street.	Most convenient for collection in absence of parked cars.	Danger to children playing in leaves. Danger of fire from catalytic converters. Either raking or repeated collec-

*Bags can be either hand loaded directly or piled into a front end loader and then lifted into the truck

Table 1. Collection Options — continued

Procedure and/or Equipment	Advantages	Disadvantages
		tion if cars are parked on the street. More extraneous material in leaves.
2. Vacuum leaf collector with discharge into wire or mesh-covered box on dump truck or trailer.	Leaves are shredded to some degree and are compacted, especially if somewhat damp.	Ineffective if excessively wet or frozen. Dust if dry. Noise Moderate expense for specialized equipment.
(a) Mounting options: (i) On trailer with discharge into truck.	Load one truck while another is in transit.	Potential danger to operator and inconvenience from operation at rear of truck.
(ii) On front of truck (on hoist used for snow plow).	Driver can see operator.	Not generally available with belt drive
(iii) On trailer with leaf box.	Can be pulled with any type of truck including one equipped for snow plowing and sanding.	Inconvenience in backing trailer to unload. Potential danger to operator and inconvenience from operation at the rear of the truck.
(b) Drive options: (i) Belt.	Belt drive reduces vibration from impeller to engine which reduces maintenance costs and increases service life.	Higher initial cost.
(ii) On engine crankshaft.	Lower initial costs.	Vibration from impeller increases maintenance costs and decreases service life.
(iii) Power take-off.	Intermediate cost relative to other options.	Intermediate cost relative to other options.
3. Catch basin cleaner.	Large units (12 inch suction hose) are fast and effective with sufficient suction for collection of wet leaves.	Small units (6-8 inch suction hose) are slow and clog in excessively wet or freezing conditions. Very high initial costs. Rather high maintenance costs. Noise.
4. Front end loader and dump truck.	Specialized equipment is optional. Effective with wet and/or slightly frozen leaves. Efficiency can be increased if front end loader works with a small snow plow and final cleanup is with a street sweeper.	Leaves must be raked into the street. (A tractor-pulled rake can be used only in suburban areas.) Inefficient with dry leaves.
5. Front end loader and compactor truck with chute for receiving leaves.	Same as in number 4 except that effective capacity is much greater with a compactor.	Same as in number 4.

III. Technical Information

This section contains detailed information about the composting process and is intended for those individuals who will design, manage and operate leaf composting facilities

A. Basics of Composting

Composting is a biological process in which microorganisms break down organic materials, like leaves, into a soil-like product called compost The microorganisms are naturally present among the leaves If nutrients, oxygen and moisture are present in the proper amounts, the microorganisms will heat the leaves up to 100-140 degrees (F) and produce a near neutral (pH) product.

This section briefly describes some of the principles with which one should be familiar before developing a composting facility The application of the principles is explained in subsequent sections.

- *Microorganisms* Decomposition is conducted primarily by microscopic organisms naturally present in leaf waste, including bacteria, actinomycetes, and fungi. These microorganisms grow rapidly on the organic material, using it as a source of food. Heat, carbon dioxide, water vapor, and compost are produced in the process
- *Nutrients.* The availability of carbon and nitrogen is a limiting factor in the composting process. The microorganisms need nitrogen for protein, body building and population growth, and carbon is their energy source In addition, efficient composting requires carbon and nitrogen to be present in the proper balance.

  The optimum range of the carbon to nitrogen (C:N) ratio is from 20:1 to 30:1. The more the C:N ratio deviates from this range, the slower the decomposition process becomes. With a ratio of greater than 40 to 1, nitrogen represents a limiting factor and the reaction rate slows. With a C:N ratio lower than 15 to 1, excess nitrogen is driven off as ammonia. While this loss of nitrogen is not detrimental to the process of decomposition, it lowers the nutrient value of the compost product.

  The C:N ratio in leaves tends to range between 60:1 to 80:1, thus, leaf composting is generally slower than most composting applications. By adding nitrogen-rich materials, such as seaweed or grass clippings, the C:N ratio will be reduced and improved.
- *Oxygen:* An adequate supply of air is essential to the maintenance of efficient composting Aerobes, the organisms primarily responsible for the rapid decomposition of organic material, require oxygen to convert organic waste to compost Normal air is about 21% oxygen If the oxygen content falls below the optimum level of 5%, these organisms begin to die off and the composting process is taken over by anaerobes, organisms which do not require oxygen. They operate much less efficiently and can cause severe odor problems.
- *Temperature* Temperature is a key environmental factor affecting biological activity and should be monitored frequently The metabolism of the microorganisms present in the leaves results in a natural temperature increase Due to the insulating effect of the leaf compost pile, the temperature achieved in the pile affects the makeup of the microbial population The optimum temperature range is between 100 and 140 degrees F.

  Two categories of microorganisms are active in aerobic composting At temperatures above freezing, mesophilic organisms become active. As a result of their activity, the temperature within the compost pile increases At temperatures in excess of 110 degrees F, thermophilic organisms become active, increasing the rate of decomposition. As the temperature approaches 140 degrees F, the rate of decomposition begins to decline rapidly as organisms begin to die off or become dormant.
- *Moisture:* In leaf composting, the optimal moisture content is 40% to 60%, by weight, or about the consistency of a wrung-out sponge. Moisture is required to dissolve the nutrients utilized by microorganisms as well as to provide a suitable environment for bacterial population growth. A moisture content below 40% limits the availability of nutrients and limits bacterial population expansion. When the moisture content exceeds 60%, the flow of oxygen is inhibited and anaerobic conditions begin to develop Leaves usually require additional water at the start of the process.
- *pH:* During the composting process, the material will become slightly acidic and then return to near neutral conditions as stability is approached. Decomposition is most efficient with a pH of between 6.0 and 8.0 If the pH is too high, nitrogen is driven off as ammonia As the pH drops below 6.0, the microorganisms begin to die off and the decomposition slows

The pH level of the compost pile partially determines the type of organisms available to the decomposition process

Bacteria are most successful as decomposers when the pH is between 6.0 and 7.5. Fungi have an optimum range between 5.5 and 8.0. Normally, operating leaf compost systems should not present a pH (acidic) problem. Should such an occurrence develop, the addition of lime may be necessary. To minimize this possibility, keep the pile in an aerobic state. The normal pH range for finished leaf compost is neutral to slightly alkaline (7-7.5).

- *Particle Size:* The microorganisms act on the surface of the composting materials. Smaller particles (the size of a quarter or smaller) have greater surface area and break down more quickly. However, extremely small particles limit air flow through the materials so some compromise is required.
- *Time:* The time required to transform leaves into finished compost varies considerably, depending on the process utilized, from 10 days to 3 years. Frequent aeration, fine particle size and the proper ratio of carbon to nitrogen speed the process. The process is slowed by low temperatures and materials with a high portion of cellulose and lignin.

B. Composting Methods — An Overview

Selection of the methodology best suited for the community will depend upon a variety of factors, including marketing options, availability, site constraints, and equipment opportunities. Additionally, the availability and usefulness of other organic wastes may influence the decision-making process within each municipality. The windrow and turn method has been used most often for leaf composting. A leaf compost guidance summary can be found in Table 2

- *Passive Leaf Piles:* Leaves are deposited in piles ranging in height from 9 to 20 feet and are left undisturbed for a minimum of two to three years. Leaf piles that are too small (less than 6 feet high) should be combined. An optional measure is to turn and aerate the leaf pile in the early spring or late fall. Although process management is minimal, the leaf piles should be maintained to avoid an unsightly appearance and should be combined after there is a noticeable volume reduction from the initial leaf pile size. Odor may be a problem when these piles are disturbed as anaerobic conditions may exist in the oxygen starved center of the pile, so wind directions should be considered before work on the piles is undertaken. Compost consistency for end use is fair, as it may retain clumps of uncomposted leaves.
- *Windrow and Turn:* Leaves are deposited on a compacted pad to form a triangular shaped windrow (Figure 2a) measuring 10 to 20 feet at the base with a height of 6 to 12 feet or higher. The windrow length can be up to several hundred feet long or as long as the site allows. In this process, the windrows are turned periodically with a front end bucket loader or a special turning machine and water is added as needed. The frequency of windrow turning is determined by the temperature and moisture content of the windrow. Windrows are combined as they shrink in size. The leaves compost through the winter and spring, cure over the summer and are available for end use by the next collection season. The finished compost can be removed from the composting site to make room for incoming leaves. The consistency of compost for end use is good as periodic turning will result in fewer clumps of undecomposed leaves.

Figure 2. Windrow and Turn Profiles

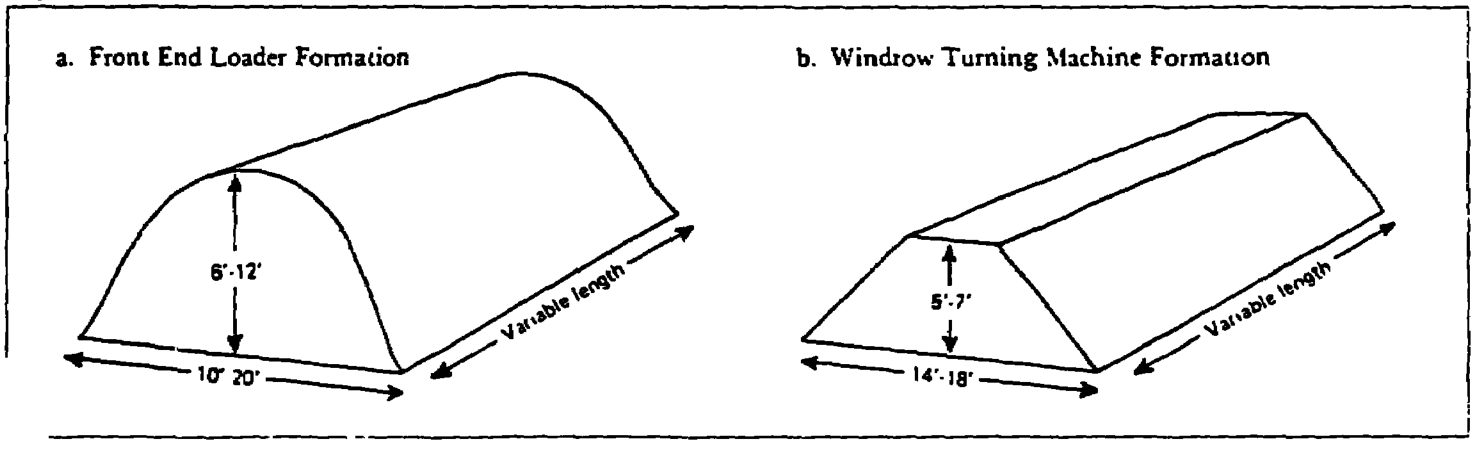


Table 2. Leaf Compost Guidance Summary.

Parameter	Method		
	Leaf Pile	Windrow and Turn	Forced Aeration
1. Site information. Size cubic yards leaves/acre	8,000-12,000	3,500-8,000	5,000-10,000
Surface	Earth pad	Earth pad (paved surface acceptable)	Earth or paved
Grade	2% slope (min)	2% slope (min)	2% slope (min)
Drainage			
Subsurface	Moderate	Moderate	Moderate
Surface	Satisfy acceptable water quality criteria for discharge (or contain on site if needed). Divert surface water from piles.	Satisfy acceptable water quality criteria for discharge (or contain on site if needed). Divert surface water from windrows.	Satisfy acceptable water quality criteria for discharge (or contain on site if needed). Divert surface water from aerated windrows.
2. Suggested separation distances (in feet) from compost site.			
To residential and business complexes	200-250′	200-250′	200-250′
From adjacent property line	100′	100′	100′
From a surface water body	100′	100′	100′
From ground surface to bedrock	5′*	5′*	5′*
From ground surface to seasonal high water table (highest seasonal level)	5′*	5′*	5′*
3. Compost process time	2-3 years	Varies with frequency of turning windrows 6-12 months	4-6 months
4. Curing time (following compost process)	Not applicable	1 month (min)	1 month (min)
5. Odor generation	Can be high at time of initial pile disturbance.	Some odor potential when pile is first disturbed; proper management will reduce or eliminate this potential; decreases with pile turning frequency.	Minimal problem if the system is properly designed, installed and operated.

*Current State of Connecticut practice followed for siting solid waste land disposal facilities.

Table 2. Leaf Compost Guidance Summary continued.

Parameter	Method		
	Leaf Pile	Windrow and Turn	Forced Aeration
6 Equipment needs	Front end loader daily during leaf collection period.	Front end loader daily during leaf collection period and when windrows are turned. Three or 4 foot stem type thermometer. For large leaf composting facilities, evaluate the use of specialized mechanical equipment for turning windrows.	Front end loader, tub mill grinder, blower type fan, temperature and timer switch controls, plastic piping (both solid and perforated lengths needed), 3 or 4 foot stem type thermometer Adequate electrical capacity. Optional leaf shredder.
7 Water supply	Required for fire control and wetting of leaves. Up to 45 gals/cu yd.	Required for fire control, wetting of leaves; can use water hose or a portable water tank source having water spray capability. Up to 45 gals/cu yd. Large operations may require on-site water.	Required for initial wetting of leaves (see windrow) and for fire control Up to 45 gals/cu yd.
8. Operational	Nothing done to leaf piles, may combine leaf piles after initial pile shrinkage. Maintain height of at least 6 feet.	Combine windrows after pile shrinkage occurs (1 or 2 months after their formation). Turn windrows as indicated by temperature and moisture data.	Blow air through the pile An organic material such as wood chips, sawdust or compost is used as a pile cover for insulation. The frequency and time of aeration is by timer switch or temperature controlled.
9. Comments	End product quality may limit marketablity; shredding will improve appearance.	Acceptable compost quality; screening of compost will give a more uniform product.	The field experiment data available for this application is rather limited. Method has been used successfully where leaves have been composted with sewage sludge (Greenwich, CT).

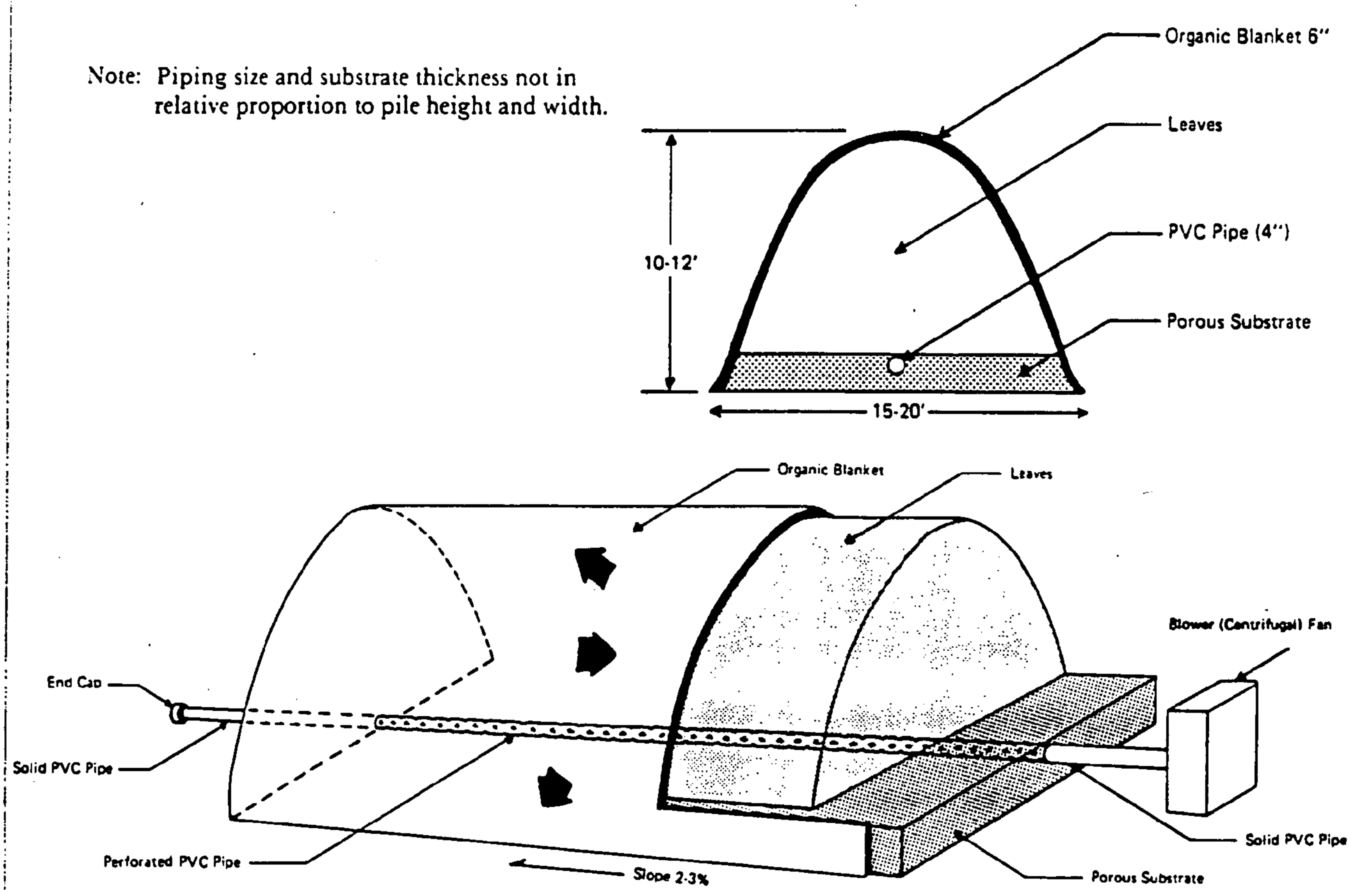
Use of specialized windrow-turning machines improves aeration, resulting in shorter time requirements for composting. The turning machine is either self-propelled or machine driven. If machine driven, it is important that the drive method selected be properly matched to the machine.

With windrow-machine turning, the machine selected limits the windrow height to 5 to 7 feet. Windrow width varies from 14 to 18 feet to give a trapezoidal shaped pile, (Figure 2b).

- *Aerated Static Pile:* The windrow configuration is similar to that described for windrow and turn except that the windrow is stationary (static pile) and has a base of wood chips or some other porous material. Since the leaves are not turned in this process, it is particularly important that non-compostable materials are removed before windrow formation. The leaves are also put through a tub grinder or shredder before forming the windrow. A perforated plastic pipe is placed over or in the base material and air is forced through the pipe into leaves using an air blower (Figure 3). After the windrow is formed, a 4"-6" layer of compost, wood chips, sawdust or an equivalent porous material is placed over the pile to help retain process heat, moisture and odor. In order to manage windrow temperature the air movement is controlled either by a timer switch or manually. Experience with this method for composting leaves is limited. It is generally used in sewage sludge composting.
- *In-vessel Composting:* In-vessel composting encompasses a variety of systems involving mechanical agitation, forced aeration and enclosure within a building. These systems are designed and supplied by consultants or commercial suppliers. They are

Figure 3. Aerated Static Pile Profile

Note: Piping size and substrate thickness not in relative proportion to pile height and width.



generally not economically feasible for composting leaves alone but may be appropriate if sludge disposal is an issue The advantages include fast processing, avoidance of weather problems and better process and odor control

Composting Leaves with Sewage Sludge: Leaves can be added to sewage sludge to provide a bulking agent for the sludge The leaves provide a carbon nutrient source and increase the number of voids (air spaces) to improve air passage for process temperature control addition of oxygen, and removal of excess moisture Sewage sludge composting involves environmental and health concerns far beyond those associated with leaf composting and requires additional approvals and or permits from DEP It should be noted, however, that using leaves in this way could serve as an alternative to the separate composting of leaves Composting leaves with sewage sludge would normally be an option with the forced aeration and in-vessel methods There may be other materials currently being composted for which leaves can serve as a bulking agent.

Composting Leaves With Other Plant Materials: Leaves can be composted with other forms of plant material, such as seaweed or grass clippings. One advantage of a composting practice is an improvement in the n to nitrogen ratio (C N) The fresh plant material des the nitrogen source and results in a faster composting rate Experimentation is advised before undertaking this method of composting on a large scale because high nitrogen levels will require much more frequent turning to prevent odor problems

Backyard Composting: Backyard composting involves the composting of leaves and other yard wastes on a small scale within the confines of one's own property. This method is particularly appropriate for areas where the residences are located on one-half acre plots or larger. Backyard composting should be encouraged because residents benefit from readily available leaf compost and the municipality benefits by avoiding the cost of handling and processing the leaves. For further information regarding backyard composting, contact the local office of The University of Connecticut Cooperative Extension Service

C. Facility Siting and Design Considerations

Area Requirements

Processing Sites The facility is sized according to the yearly seasonal volume of leaves to be handled, taking into consideration the method of leaf collection and the composting method employed. A good leaf volume ate can be made from records of the number of truck s of leaves hauled For this purpose, one ton of leaves ...en to be the equivalent of approximately four cubic yards of leaves Additional information is provided in Appendix B In the absence of such information a leaf volume of six percent of the total annual solid waste volume can be used Space requirements vary according to the composting method, ranging from 3,500 to 12,000 cubic yards of leaves per acre For example, a suggested guideline for a windrow and turn facility is one acre for each 6,000 cubic yard of leaves Additional space is required for the compost storage and site buffer areas

Compost Storage Area For the windrow and turn method, the storage area for finished compost should be an additional 15 percent the size of the windrow composting area Compost will need to be kept in the storage area for a minimum of one month while it cures

Buffer Area Consider the impact of potential odor, on-site operational noise and visual appearance on the surrounding neighborhood when siting a compost facility Minimum suggested separation distances of the compost processing and storage site are 200-250 feet from occupied buildings and at least 100 feet from adjacent property lines. Existing trees and landscaping may be used to improve aesthetics by screening the site from public view and to reduce equipment noise. The potential impacts of composting odor and traffic flow on adjacent areas should also be considered.

Ground and Surface Water Protection: A minimum of 5 feet should be maintained between the base of the deposited leaves and the maximum high water table or bedrock This recommendation is based upon the current State of Connecticut practice for siting solid waste land disposal facilities but may be modified in accordance with specific site conditions such as soil permeability and hydrologic setting High groundwater can cause severe problems for equipment movement, especially in the late winter and spring months when piles must be turned.

The compost processing and storage site should be at least 100 feet from a surface water body such as a brook, pond or stream Facilities must be sited in accordance with the Connecticut Inland-Wetlands and Water Courses Act and the Connecticut Sedimentation and Erosion Control Act.

Site Layout and Preparation: Once an appropriate site has been chosen, a site plan needs to be prepared Sample diagrams are found in Figures 4 and 5

Compost Pad: This is the surface where composting occurs It should be constructed of well-drained materials and be designed for heavy equipment use in all seasons. Windrow length should parallel the slope. To prevent ruts from forming a paved surface can be used as a pad

Roads: Roads should be laid out to provide easy access for the public, leaf hauling vehicles and fire protection equipment. The road surface should be able to sustain the load of the vehicles indicated, and be functional in all types of weather conditions.

Drainage: Locate the site on moderately to well-drained soil. Excessively well-drained soils should be avoided, unless site modifications are made. Surface water should be diverted away from the compost process site and storage area using a diversion ditch, an interceptor berm (baled hay or other means) or an interceptor drain. Any surface or subsurface discharge away from the site must be made in an environmentally safe and acceptable manner. Design water diversions and discharge systems for a 25-year rainstorm. Slopes should be graded at 2-3 percent (2-3 foot drop in 100 feet), to assist in surface water removal from the pad. Be sure not to exceed a 5 percent grade.

Water: A source of water is needed for wetting the leaves, and provision must be made for fire protection. Where a water source such as a pond or a hydrant is not available, a water tank vehicle can be used. For very dry leaves, approximately 45 gallons of water are required for each cubic yard of leaves. For large operations, an on-site water source may be necessary.

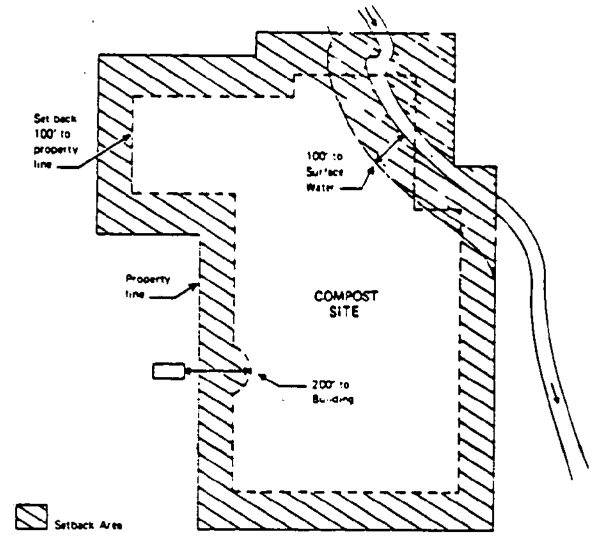
Site Clearing: Clear the site to provide enough space for roads, compost processing, storage of compost, and for fire protection. Before clearing, consider the need for a buffer zone and visual screening.

Signs: Post a sign at the entrance to the facility identifying the facility and indicating the hours of operation. Directional signs will be needed for traffic control. The leaf receiving area should be identified. Signs may also be needed to clarify the fact that the facility is for leaves only, thereby minimizing the addition of contaminants.

Security: Control access roads so that illegal dumping or vandalism does not occur.

Please see Table 2 for a summary of facility siting and design considerations.

Figure 4. Site Setback Distances



Note: Depending on site constraints such as property lines, buildings and surface water, available acreage for composting will vary. Area loss could be significant.

D. Composting Operation

The following section focuses on the windrow-and-turn method of composting leaves. In most settings, this method will strike a good balance between process efficiency and operational simplicity. Details about the operation of the other methods mentioned here can be found in the references or from consultants engaged to design a composting system. In addition, a trouble-shooting guide for operating a windrow and turn facility is included as Appendix A.

Annual Site Preparation: Prior to the start of the leaf collection season, regrade the site as needed to maintain a 2-3 percent slope and to maximize run-off and minimize ponding of surface water. Bring in fill as needed. Maintain the drainage system components such as subsurface drains or diversion ditches.

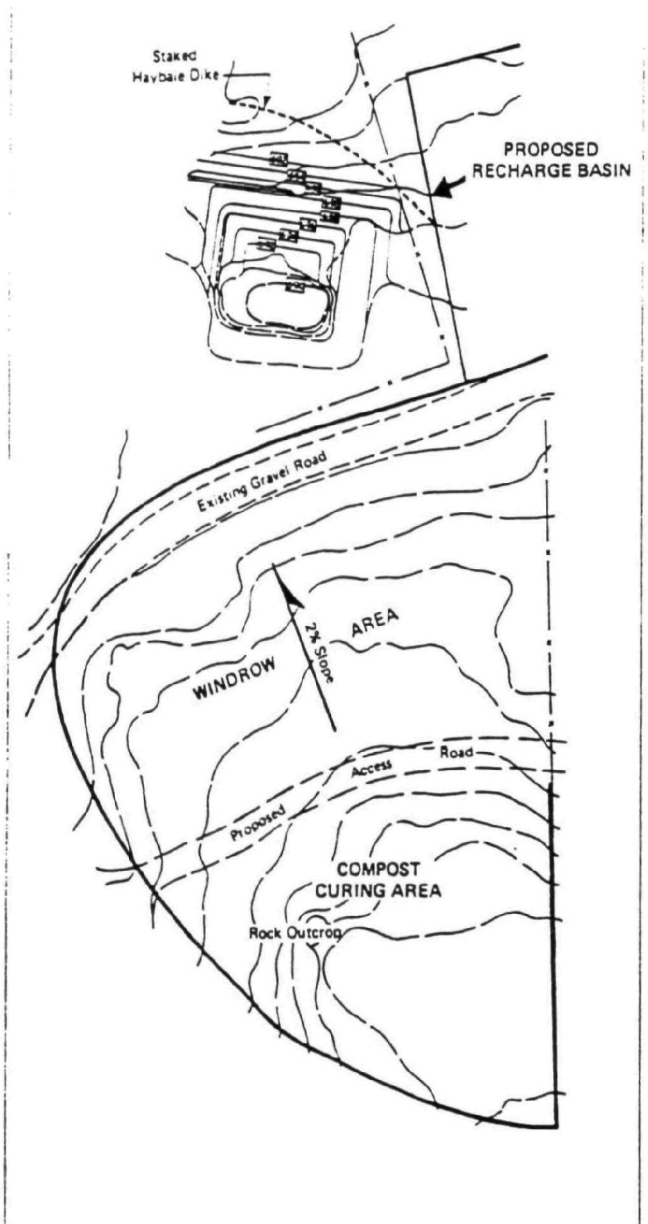
Review and prepare the site to ensure good vehicle operation conditions.

Check the availability and method for handling water to wet leaves. If there is no water at the site, a water hauling tank vehicle and a mechanism for spraying the water on the leaves will be needed.

Processing Equipment: Equipment needs and preferences will vary with each community. Use of existing equipment is encouraged but this may not always result in the most efficient operation. In some instances, it may be possible to share specialized equipment (i.e., a sieve or shredder) with nearby towns.

The basic piece of equipment needed for any type of leaf composting operation is the front end bucket loader. It is used daily at the site during the leaf collection season. With windrow-and-turn operations the loader or other turning equipment must be available for the remainder

Figure 5a. Preliminary Site Layout Showing Windrow and Curing Areas, Proposed Stormwater Management System and Access Road.
Source: Massachusetts Department of Environmental Quality Engineering, Division of Solid Waste.



of the year for windrow turning and reconstruction when needed. For large operations, specialized turning and mixing equipment may be feasible. Information regarding compost processing equipment is found in Appendix D.

For compost process temperature monitoring, a 3-4 foot pointed stem-type thermometer capable of reading between 0 to 200 degrees F is needed. A spare thermometer is recommended to confirm temperature calibrations.

Screens, shredders or tub grinders are optional but can be used to reduce volume, obtain compost uniformity and remove unwanted materials. Shredding of leaves to reduce leaf size normally is not needed at the initial stage as the leaves are adequately reduced in size through the physical process of moving and turning during collection and composting. Such shredding, however, may assist the compost process if moisture levels are low by reducing the free air space. At the end of the composting curing process, it may be appropriate to screen the compost to remove large clumps and woody material. This creates a more marketable product with a consistent level of appearance.

Handling Incoming Leaves: Incoming leaves can be brought directly to the leaf processing area or to a receiving (staging) area for later transfer to the leaf compost pad. Compacted leaves brought directly to the compost pad must be loosened and fluffed for proper aeration. If citizens are allowed to bring leaves to the site, a separate drop-off point should be provided for debagging, traffic control and safety considerations. Site supervision is required during this period for quality control and the recording of leaf volume delivered to the site.

Although a leaf receiving area adds another step to the site operation it allows flexibility in scheduling the start of the leaf composting process and in scheduling the debagging of leaves. The leaves should be transferred to the windrows within a couple of days to prevent the compost process from starting in the receiving area.

Unless biodegradable bags are used, leaves should be debagged before they are placed in the windrow. Debaggers should work on the face of the pile — not from the ends — so that more people can work on one pile at the same time. Simple hand tearing of bags seems to be as efficient as other methods. Empty bags should be removed immediately and placed in receptacles so they do not end up in the windrows. If a staging area is used, leaves should be removed from the debagging area immediately after opening to make space for the debaggers to work.

Leaf Wetting: Incoming leaves should be checked for moisture. A "hand squeeze" test is adequate. If no water oozes from a handful of squeezed leaves, the leaves should

Figure 5b. Compost Site Cut and Fill Recommendation for Site Grading.

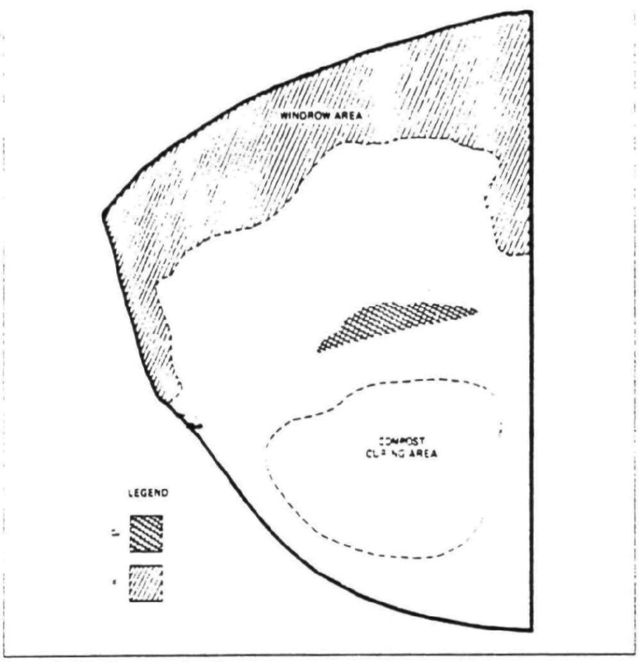
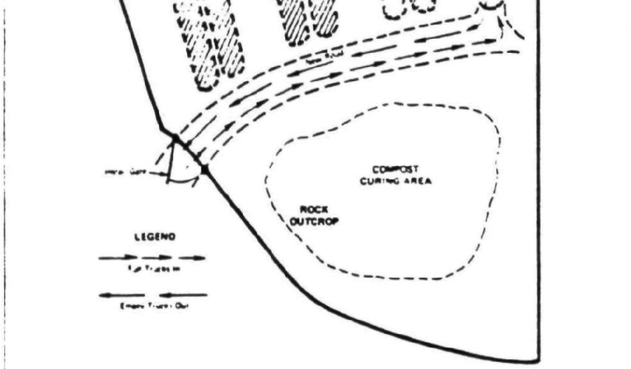


Figure 5c. Compost Windrow and Curing Areas Showing Vehicle Traffic Pattern.

Source: Massachusetts Department of Environmental Quality of Engineering, Division of Solid Waste.



be wetted before or while they are being placed in the windrow. Leaves can be wetted using a hose connected to the water source or by using a pump-spray mechanism attached to a portable water tank.

During the early stages of composting, leaves must be mixed during wetting, otherwise the water will run off the pile surface instead of penetrating the windrow. Over-watering is normally not a problem as excess water will drain off. Once the leaves start to break down, watering can be done after turning without problems.

With specialized windrow-machine turning, the leaves are wetted after the first or second turning using a fire or stick hose. The initial leaf turning breaks up the leaves to improve their water retention capability. Leaves should not be over-watered in this process. If pile moisture measurements can be made, aim for a pile moisture content of about 45-50 percent.

Windrow Formation: The windrow should be at least six feet high with a bottom width of about 10 to 14 feet. (See Figure 2). If a greater height is used, the windrows will require more frequent turning.

Start the first windrow 20 feet from the edge of the composting pad. Leave two feet between the first two windrows and a 20-foot space between pairs of windrows. Windrows should run in the direction of the slope to reduce any tendency for ponding. (Figure 6).

After the windrows have been reduced to almost one-half of the initial size (about 1 to 2 months after windrow formation), each pair of windrows is combined into a single windrow.

During specialized machine turning of the windrow, leaves will fall into the vacant aisle. It will be necessary periodically to gather these leaves and place them in the windrow. Depending on how the windrows are spaced, windrows are combined 15 to 25 days after the start of the composting process.

Windrow layout should address fire protection concerns as needed. Although a leaf windrow fire is an unlikely occurrence, the layout of the windrows and the site conditions should provide access for fire fighting equipment (fire lanes or fire hose and water hydrant).

Compost Process Monitoring: Windrow temperature measurements should be made and recorded at least twice a week to monitor the compost process and to determine when it is complete (see Table 3). Other data to record at that time are the ambient air temperature, weather conditions, odor (if detected), pile moisture conditions and site observations. There should be at least three temperature measurements per 100 feet of windrow taken at the lower third of the leaf compost pile using a 3 foot stem-type thermometer (figure 7).

Time odor and temperature are indicators of when the compost process is complete After a period of about 6 months begin checking for compost stabilization as follows Place a sample of the compost in a plastic bag, seal it, store at room temperature 24 to 48 hours, and then open it If there is no significant odor, the process is complete and the compost is ready for movement to the storage area for curing. Temperature recovery after windrow turning is another sign of stabilization. If there is no odor nor increase in temperature in the windrow occurring within seven days, the compost is stable and ready for the curing stage

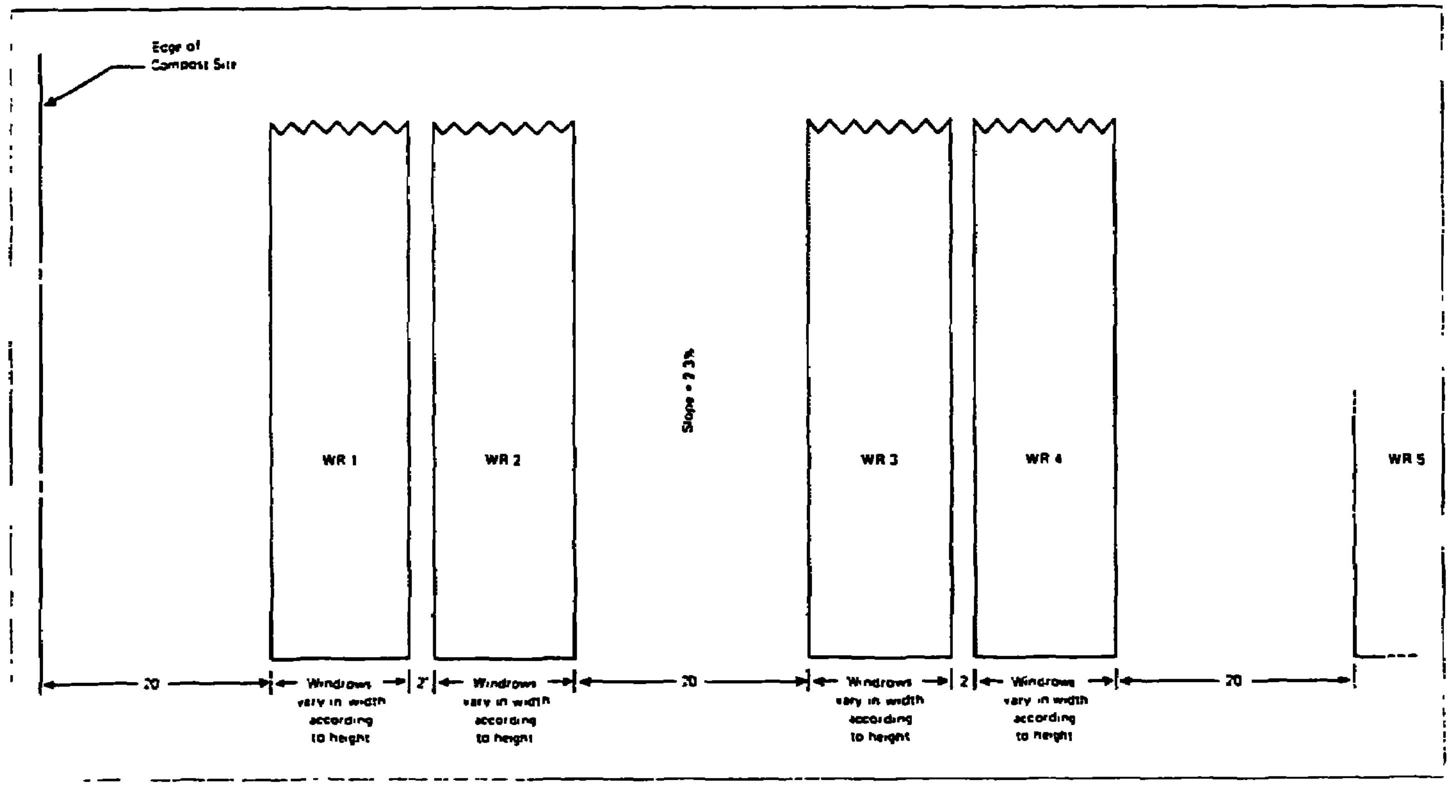
Windrow Turning: Windrows should be turned when the compost pile temperature drops to 100 degrees F or if the temperature exceeds 140 degrees F. The windrows may require turning if other process problems develop, such as odor or excess moisture at the base of the windrow When turning, the leaves should be lifted high with a bucket and allowed to cascade to a new location (figure 8) The next turning should be done in the opposite direction In all cases, operators should attempt to get those leaves on the bottom of the windrows to the top of the new windrows. At the time of turning, check and remove contaminants Common ones include plastic, bottles or containers, rocks or stones, automotive hubcaps, tennis balls, and miscellaneous bulky materials

If moisture has to be added to the windrow, try to schedule the turning operation to coincide with rain or snow to avoid having to pump or deliver water.

At compost sites near residential areas, schedule windrow turning to avoid noise and/or odor complaints. Try to select a time when the wind is blowing away from neighboring buildings. A wind sock erected at the site can be used as a wind direction indicator. Choose a time of day when most people are likely to be away or inside their buildings

Leaf Curing: After the leaves have been composted, a brief curing period is needed to complete biological stabilization. This can be done at the compost pad or a separate bulk storage area The compost is left as is for at least one month for curing before use. At this point, compost can be made into large piles as opposed to windrows thereby taking up less space

e 6. Windrow (WR) Spacing



Finished Product: The finished compost can be screened to break up clumps to provide product uniformity and improved appearance. An analysis of compost for selected chemical constituents such as nitrogen, phosphorus and potassium, lead, cadmium and pH, should be made. Municipalities may obtain appropriate analysis of the compost through the Connecticut Agricultural Experiment Station in New Haven.

Record Keeping: The importance of good record keeping cannot be over-emphasized. Records should be maintained on the quantity of leaves received, process temperature and moisture, operating costs, the chemical composition of the compost produced and the quantity of compost shipped. Such information is useful in assessing the efficiency of the operation and developing a cost/benefit analysis. Regular observations concerning odor, noise, and dust are important in evaluating comments received by local and or state officials. The site observation recorded for the day that the complaint was reported might serve to substantiate whether or not the problem could be associated with the leaf composting process. Appendices E and F may be copied out of this manual for use by the site manager.

Contingency Plan: There should be an alternative arrangement available in the event that leaves cannot be composted due to unforeseen circumstances; e.g., equipment failure or natural disaster.

E. Other Management Considerations

Grass Clippings: Grass clippings have a relatively higher content of nitrogen than leaves. In some instances, however, grass may have concentrations of herbicides (weed killers) used in normal lawn maintenance programs. Once applied to turf the herbicide may take a few weeks or months to degrade to a relatively harmless state. Ongoing research at Rutgers University is expected to provide additional information on this topic.

Road Salt: Road salt used in ice and snow removal has not been found to be a problem with regard to high concentrations in leaves used for composting. Generally, any concentration of salt that may be deposited on leaves (during an early fall snowstorm or over the winter for those leaves picked up in spring) becomes diluted with a larger amount of leaves that have not been in contact with road salt.

Pesticides: Pesticides used on trees are normally confined to a few insecticides and possibly some fungicides. In a normal year, only a few trees will be selectively sprayed and in most instances will be treated early in the growing season (June-July). During those years of high insect infestation (e.g., gypsy moth caterpillars), a more intensive spraying program may be necessary. However, even in this case treatment will be completed early in the season (May-June), and by the time leaf fall occurs, the pesticides will be significantly degraded.

Aspergillus fumigatus: A fungus spore *Aspergillus fumigatus,* may be produced by the composting process especially when wood chips are used as a bulking agent in sewage sludge composting. This fungus may be a cause of lung infections in susceptible humans. Little evidence exists to demonstrate that this is a concern with leaf com-

Figure 7. Temperature Measurement Technique

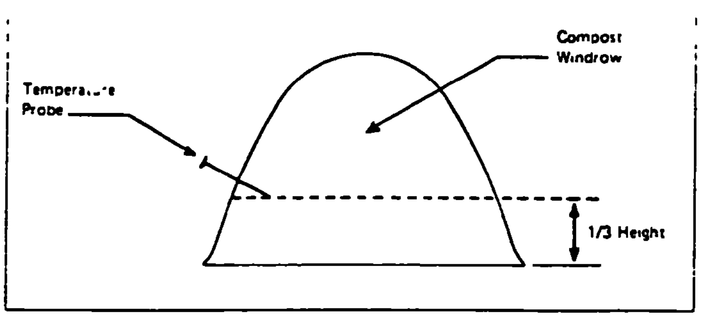
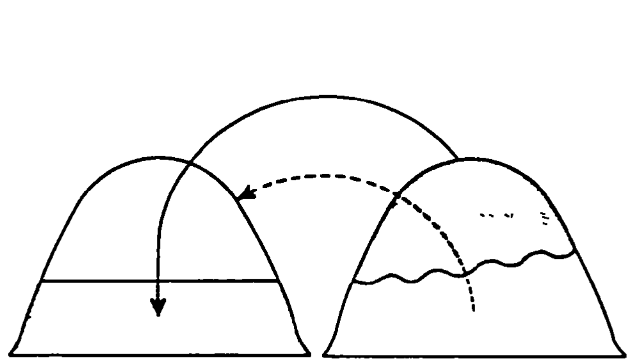


Figure 8. Windrow Turning for Aeration and Mixing of Leaves

Lift leaves high with bucket loader and let leaves fall to new location to create a cascading (mixing) effect



Note The principle of the mixing technique is to move the top of the windrow to the bottom of the windrow being formed, mixing the leaves well during this process.

osting operations However municipal compost sitesould not be established in close proximity to hospitals or nursing homes People with diseases causing immune suppression (including arthritis) should not work near compost In addition, people taking drugs that suppress the immune system, like cyclosporin, should not work with compost

Lead: Lead is sometimes found in finished compost products, particularly in sludge composting Very limited data exist concerning concentrations that may be expected to be found in compost produced only from leaves, and there appears to be no published data comparing lead levels in leaves by source (e g street trees in an urban setting vs yard trees in low density suburban settings). Research in New Jersey indicates that relatively low levels should be expected

F. End Use and Disposition of Leaf Compost

General Characteristics: Leaf compost is a soil-like material valued primarily as a soil amendment. The nutrient content of leaf compost is usually too low to consider it as a fertilizer Generally, leaf compost piles include clumps of uncomposted leaves, branches and other foreign materials which, if not screened out, significantly decrease the value of the compost Screening or shredding increases the value of the compost.

Market Opportunities: In determining market opportunities the following procedure should be followed.

Inventory possible markets
Identify their specifications.

- Identify their capacity to absorb the compost. This should include the amount used each year, the seasonality of use, and projections for long-term usage.
- Identify their shipping and delivery requirements.
- Identify revenue potentials of target markets

There are a number of market opportunities for leaf compost. They include.

Municipalities: Continual and extensive need for compost type products as soil amendments and mulch. Screening the compost will make the product usable on a larger variety of jobs.

Landscaping Industry Continual and extensive need for compost-type products as soil amendments and mulch The compost should be screened to remove unwanted material and be of consistent appearance

Greenhouse Nursery Large demand for compost if it is of consistently good quality based upon physical and chemical characteristics The compost must be screened to remove unwanted materials and present a consistent appearance Leaf compost can comprise up to 20% of the potting soil mix for either bedding plants or nursery plants Chemical analysis of N P, K and pH is needed to accommodate the nutrient needs of the plant

Home Grounds Gardening Useful as an amendment to garden soil and as mulch around landscape plantings. Does not require screening

Agriculture: Agricultural producers annually add organic matter to improve soil conditions and crop production. Compost is useful if conveniently and readily available in large enough quantities Does not require screening

Distribution Channels Product movement off-site will be determined by the availability of users and distribution options Distribution channels include·

Municipal: Equipment can be used to move compost off-site to road jobs, school landscaping, etc.

Giveaway: Commonly used, residents pick-up at site.

Wholesale to Distributors Several large compost marketing companies operate in the northeast and can handle bulk or retail distribution of high quality compost While this option will not provide much income to the compost producer, it will save time and management required for distribution

Bulk Sales: Sold to large-scale users (landscapers, greenhouse, etc). Charge assessed on yardage or tonnage basis Product can be delivered or picked up at the site.

Retail. Sold directly to public, usually on a volume or vehicle basis. Usually unbagged. Requires management of funds at site for each sale If considering sale of bagged compost, a marketing study is recommended.

Appendix A: Trouble Shooting Guide For Operating Windrows

Problem	Cause	Solution
Odor	Excess moisture	Turn windrow
	Temperature greater than 140° F	Turn or reduce windrow size
	Leaf compaction	Turn or reduce windrow size
	Surface ponding	Eliminate ponding/regrade
Low windrow temperature	Windrow too small	Combine windrows
	Insufficient moisture	Add water while turning windrow
	Poor aeration	Turn windrow
High windrow temperature	Leaf compaction	Turn or reduce windrow size
	Insufficient oxygen	Turn windrow
Surface ponding	Depressions or ruts	Fill depression and/or regrade
	Inadequate slope	Grade site to recommended slope design
Rats	Presence of garbage	Remove garbage
Mosquitoes	Presence of stagnant water	Eliminate ponding

Appendix B: Weight, Volume and Bag Count Data

Description	Data*
A. Bagged or loose leaves in a compactor truck:	
(1) Actual count based on one full load of 31 cu yd, weighing 14,525 lb and containing 1,550 bags (Springfield, MA, 1987, reported by Macy)	9.37 lb/bag 50.0 bags/cu yd; 468.5 lb/cu yd;
(2) Average by truckload based on truck capacity without adjustment for partially filled loads:	
a. Averaged over 1,745,380 lb (Springfield, MA, 1987, reported by Macy)	414 lb/cu yd
b Averaged over 1,413,010 lb (Waterbury, Ct, 1987, from town records)	555 lb/cu yd
(3) A general estimate (reported by Derr)	450 lb/cu yd
B. Loose leaves collected with vacuum equipment and blown into a leaf box:	
(1) Average by truckload based on truck capacity without adjustment for partially filled loads	
a. Averaged over approximately 150 loads, Scarsdale, NY (reported by Rice)	190 lb/cu yd
(2) A general estimate (reported by Derr)	350 lb/cu yd
C. Loose leaves loaded into an open truck with a front end loader:	
(1) Average by truckload based on truck capacity without adjustment for partially filled loads.	
a. Averaged over 13 loads (Springfield, MA, 1987, reported by Macy)	371 lb/cu yd
(2) A general estimate (reported by Derr)	250 lb/cu yd
D. Bagged leaves in an open truck:	
(1) Based on 9.37 lb/bag and an assumed average bag volume of 25 gallons (3.34 cu ft/bag)	75.7 lb/cu yd

*These estimates reflect a variety of measurement techniques, moisture conditions, and degrees of compaction and are presented here as a general guide.

Appendix C: Leaf Collection Equipment and Approximate Prices in 1988

Description	Cost
A. Compactor trucks:	
(1) 20 cu yd; 240 hp diesel, automatic transmission, single axle	$ 80,000
(2) 25 cu yd, 270 hp diesel, automatic transmission double axle	$ 95,000
B. Vacuum leaf collectors:	
(1) Trailer mounted; belt driven; 12-inch intake; 12,000 cfm;	
a) With gasoline engine	$ 20,000
b) With diesel engine	$ 21,500
(2) Trailer mounted; power-take-off and clutch connection; 18-inch intake; 24,000 cfm; diesel engine	$ 14,000
(3) Trailer mounted; impeller on engine crankshaft; 18-inch intake, 22,000 cfm; gasoline engine;	$ 7,500
a) With 14 cu yd dump box	$ 14,500
b) With 20 cu yd dump box	$ 16,000
C. Catch basin cleaners:	
(1) Complete unit including truck; 12-inch intake; 12,000 dfm; diesel engine on vacuum unit;	
a) 10 cu yd capacity	$100,000
b) 16 cu yd capacity	$120,000

Appendix D: Compost Processing Equipment and Approximate Prices in 1988

Description	Cost
A. Front end loaders:	
(1) 90 hp with 1.75 cu yd bucket	$ 55,000
(2) 115 hp with 3 cu yd bucket	$ 70,000
(3) 155 hp tractor (without bucket)	$ 80,000
a) 3 cu yd bucket	$ 4,800
b) 7 cu yd woodchip and snow bucket	$ 7,400
c) Quick attachment system	$ 3,900
(4) 82 hp tractor (without bucket)	$ 60,000
a) Lease with 1.6 cu yd bucket	$ 2,600/month
(5) 123 hp tractor (without bucket)	$ 87,000
a) Lease with 2.4 cu yd bucket	$ 3,600/month
(6) 158 hp tractor (without bucket)	$111,000
a) Lease with 3.0 cu yd bucket	$ 4,600/month
(Note: Based on experience in Springfield, MA, a 3 cu yd loader can turn approximately 180 cu yd per hour with each load lifted high and allowed to cascade into a new windrow.)	
B. Specialized aerating and turning equipment:	
(1) Flail type, self propelled; turns windrows up to 7 ft. high and 18 ft. wide at a rate of up to 3,000 tons per hour; 360 hp; not easily transported between sites (10' 6" wide and 14' 6" high on low bed trailer)	$160,000
(2) Auger type, mounted on a tractor that can be used with numerous optional attachments, turns windrows up 6 ft. high and 10 ft wide at a rate of up to 3,000 tons per hour; engine options of 177 to 225 hp; not convenient for long distance transport; can be driven on road at a maximum speed of 20 mi/hr	$180,000
(3) Flail type; powered by 177 hp engine while attached to a front loader (loader not included); turns windrows up to 5 or 6 ft. high and 14 ft. wide at a rate of up to 800 tons per hour; can be loaded on a flat bed truck with a front end loader equipped with a quick catch system	$ 65,000
(4) Flail type; attaches to a large farm type tractor with a three point hitch and power-take-off (The tractor should have 100 to 225 hp and a hydrostatic transmission or a creeper transmission with 2 or 3 speeds under 1/3 mi/hr with power-take-off at 1,000 rpm); turns windrows 5 to 6 ft. high and 14 ft. wide at a rate of up to 600 tons per hour; special wheels for over the road transport	$ 30,000
C. Separating and shredding equipment:	
(1) 25 cu yd/hr; 18 hp gasoline engine	$ 17,000
(2) 75 cu yd/hr; 55 hp diesel engine	$ 40,000
(3) 200 cu yd/hr; 110 hp diesel engine	$ 91,000

COMPOST MARKETING IN NEW ENGLAND

Mark E. Lang
Ronald A. Jager

Composting has become a widely accepted sludge management technology throughout New England. Thirty-five facilities currently operate in the six state region, processing approximately 150 dry tons of sludge per day. Interest in composting continues, as demonstrated by sixteen facilities in the design or construction phases. Another seventeen municipalities and six regional authorities are considering implementing composting programs.

A survey of the thirty-five composting facilities currently operating in New England was conducted to determine the success of their compost marketing programs. The survey was designed to provide market demand information to municipalities and regional authorities considering the implementation of composting facilities, as well as those responsible for developing and maintaining existing compost marketing programs. The information was obtained by telephone interviews and a literature review.

BACKGROUND INFORMATION ON PLANTS SURVEYED

Table 1 presents general information about each of the facilities. The table describes the type of wastewater treatment process, and gives information about the composting processes employed by the facility. Types of amendment used and product screening are factors noted as having an impact on compost marketability. These impacts are discussed in a later section. For comparison purposes the table provides the current amendment cost(s) incurred by each facility and compost screening methods.

TABLE 1. COMPOST PROCESS INFORMATION

FACILITY	TREATMENT PROCESS	AVERAGE SLUDGE PRODUCTION (DT/DAY)	COMPOST PROCESS	AMENDMENT	COST OF AMENDMENT ($/CY)	PRODUCT SCREENING
CONNECTICUT						
BRISTOL	AS	13.0	ASP	BA	20/TON	NONE
FAIRFIELD	AS	3.0	HAB	YW	0	NONE
GREENWICH	AS	1.7	ASP	SD	NA	TROMMEL
RIDGEFIELD	EA	3.5	SP	YW	0	NONE
MAINE						
BANGOR	P	2.0	ASP	WC	3.00	NONE
BAR HARBOR	AS	0.8	ASP	WC	NA	NONE
KENNEBUNKPORT	AS	0.1	ASP	BA	8.00	NONE
KITTERY	AS	0.1	ASP	WC	6.00	NONE
LINCOLN	RBC	0.5	CW	WS	1.25	NONE
OLD ORCHARD BEACH/ SACO	AS AS	3.0	ASP	WC	6.00	TROMMEL
OLD TOWN/ORONO	RBC/AS	1.3	ASP	WS	2.75	NONE
RUMFORD/MEXICO	AS	0.4	ASP	WC/WS	3.40	NONE
SCARBOROUGH	AS	0.9	ASP	BA	8.00	NONE
SOUTH PORTLAND	AS	3.3	AW	SD	11.00	NONE
YARMOUTH	AS	0.5	CW	WC	5.40	NONE
MASSACHUSETTS						
BARRE	EA	0.01	ASP	WC	4.00	NONE
BRIDGEWATER	RBC	0.7	ASP	WC	5.50	TROMMEL
LEISTER	EA	0.1	ASP	WC	7.80	NONE
MANSFIELD	AS	1.2	ASP	WC	5.00	HARPWIRE
MARLBOROUGH	AS	9.8	ASP	WC	5.00	TROMMEL
ROCKPORT/ GLOUSTER	AS P	1.2	ASP	HB	0	NONE
SOUTH BRIDGE	AS	1.9	ASP	WC	7.00	TROMMEL
SWAMPSCOTT	P	0.5	AW	WC	0	NONE
WESTBOROUGH/ SHREWSBURY	AS AS	2.7	ASP	WC	5.25	TROMMEL
WILLIAMSTOWN/ HOOSAC	AS AS	8.0	ASP	WC	7.23	HARPWIRE
NEW HAMPSHIRE						
BRISTOL	EA	0.3	ASP	WC	0	NONE
CLAREMONT	AS	3.0	ASP	WC/BA	5.50/8.00	TROMMEL
DURHAM	AS	1.4	ASP	WC	6.50	TROMMEL
LEBANON	AS	1.2	ASP	WC	5.00	TROMMEL
MERRIMACK	AS	12.0	ASP	WC	4.00	HARPWIRE
MILFORD	AS	0.8	ASP	WC	5.00	TROMMEL
PLYMOUTH	P	0.3	ASP	WC/SD	6.60	NONE
SUNAPEE	EA	0.2	ASP	WC	NA	NONE
RHODE ISLAND						
JAMESTOWN	EA	0.2	CW	WC	0	NONE
WEST WARRICK	AS	14.0	ASP	BA	2/TON	NONE

LEGEND:
NA = NOT AVAILABLE
AS = ACTIVATED SLUDGE
EA = EXTENDED AERATION
P = PRIMARY
RBC = ROTATING BIOLOGICAL CONTACTOR
ASP = AERATED STATIC PILE
AW = AERATED WINDROW
CW = CONVENTIONAL WINDROW
HAB = HORIZONTAL AGITATED BIN
SP = STATIC PILE
BA = BIOASH
HB = HORSE BEDDING
SD = SAWDUST
WC = WOOD CHIPS
WS = WOOD SHAVINGS

COMPOST MARKETING INFORMATION

Compost is used in various ways. Table 2 presents typical uses and selling prices of finished compost in New England. Where available the approximate distribution of compost among end users is indicated as a percentage of the total volume.

Compost distribution methods also vary. The most popular is compost pick up at the treatment facilities. Most facilities load bulk user vehicles, while small quantity users must load their own vehicles. Several facilities delivered compost locally for a modest fee. The price charged for compost varies considerably throughout New England, from give away programs to $10 per cubic yard. The average price charged for facilities which sell compost is $4.37 per cubic yard for large volume commercial users and $2.55 per cubic yard for small volume residential users.

Twelve of the facilities surveyed give compost away. These include five facilities which supply all of their compost to public agencies and publicly owned landfills. To date, twelve facilities have either not identified markets or developed pricing structures.

The survey identified seven primary compost uses. They are loam production, agriculture, land reclamation, use by public agencies, contractors, home owners and private brokers. Of the thirty-five facilities, eighteen have developed more than one end use for the product.

TABLE 2. COMPOST MARKETING INFORMATION

FACILITY	COMPOST SELLING SELLING PRICE COMM/RESID ($/CY)	TYPICAL USES
CONNECTICUT		
BRISTOL	0	LANDFILL. daily cover
FAIRFIELD	0	PUBLIC AGENCIES highway dept., tree nursury LANDFILL: vegitative support
GREENWICH	10/3	PUBLIC AGENCIES. highway dept., parks dept. HOMEOWNERS CONTRACTORS. (70%)
RIDGEFIELD	0	LANDFILL. intermediate cover
MAINE		
BANGOR	5	PUBLIC AGENCIES: parks dept., building grounds HOMEOWNERS CONTRACTORS
BAR HARBOR	3	HOMEOWNERS CONTRACTORS
KENNEBUNKPORT	3/0	PUBLIC AGENCIES: parks dept. HOMEOWNERS LOAM PRODUCTION
KITTERY	NA	PUBLIC AGENCIES: highway dept.
LINCOLN	5/1	HOMEOWNERS: (34%) LOAM PRODUCTION: (66%)
OLD ORCHARD BEACH/ SACO	0	PUBLIC AGENCIES: parks dept., new construction LANDFILL: vegitative support HOMEOWNERS: (90%) CONTRACTORS
OLD TOWN/ORONO	2/4	PUBLIC AGENCIES: cemetary LANDFILL: vegitative support CONTRACTORS NURSURIES LOAM PRODUCTION
RUMFORD/MEXICO	0	HOMEOWNERS LAND RECLAMATION: gravel pit
SCARBOROUGH	0	NURSERIES: (AVERAGE = 25%) LOAM PRODUCTION: (AVERAGE = 75%) AGRICULTURE
SOUTH PORTLAND	NA/0	PUBLIC AGENCIES: parks dept. LOAM PRODUCTION PRIVATE BROKER
YARMOUTH	5	CONTRACORS. (20%) NO MARKET IDENTIFIED: (80%)
MASSACHUSETTS		
BARRE	NA	STOCK PILE: awaiting classification
BRIDGEWATER	NA	STOCK PILE awaiting classification

TABLE 2. COMPOST MARKETING INFORMATION
(continued)

FACILITY	COMPOST SELLING SELLING PRICE COMM/RESID ($/CY)	TYPICAL USES
MASSACHUSETTS (continued)		
LEICESTER	NA	STOCK PILE. awaiting classification
MANSFIELD	NA	STOCK PILE. recently classified
MARLBOROUGH	NA	PRIVATE BROKER: contract pending compost classification
ROCKPORT/ GLOUCESTER	NA	LANDFILL: vegitative support AGRICULTURAL
SOUTHBRIDGE	0	STOCK PILE: type III compost
SWAMPSCOTT	NA	STOCK PILE: no market identified
WESTBOROUGH/ SHREWSBURY	NA	STOCK PILE: type III compost
WILLIAMSTOWN/ HOOSAC	NA	PUBLIC AGENCIES parks dept., highway dept. LANDFILL. vegitative support
NEW HAMPSHIRE		
BRISTOL	0	LAND RECLAMATION. sand pit
CLAREMONT	0	PUBLIC AGENCIES. parks dept., building grounds, cemetaries
DURHAM	0	PUBLIC AGENCIES parks dept., highway dept. HOMEOWNERS: (40%) CONTRACTORS UNIVERSITY OF NEW HAMPSHIRE
LEBANON	0	HOMEOWNERS CONTRACTORS
MERRIMACK	2	PUBLIC AGENCIES. parks dept., highway dept. HOMEOWNERS PRIVATE BROKER
MILFORD	NA/0	PUBLIC AGENCIES: highway dept., cemetaries HOMEOWNERS CONTRACTORS LAND RECLAMATION: gravel pit
PLYMOUTH	NA	PUBLIC AGENCIES. building grounds STATE COLLEGE: (50%) HOMEOWNERS
SUNAPEE	0	NO MARKET IDENTIFIED
RHODE ISLAND		
JAMESTOWN	NA	LANDFILL. vegitative support
WEST WARRICK	0	LANDFILL. vegitative support

NA = NOT AVAILABLE

PUBLIC AGENCIES

Nineteen facilities provide compost for public agencies to use. Typical recurring uses include the maintenance of parks, recreational areas, cemeteries, road embankments and building grounds. Workers apply compost as mulch around trees and shrubs or as a top dressing on lawn areas. Bristol, Connecticut uses all of its compost as daily cover on their landfill.

Large one-time uses of compost have included the construction of baseball fields, cemeteries, and the installation of roadside curbing. By far the largest bulk use of compost by the public sector has been in the operation and closure of landfills. One town uses compost as grading material prior to capping and seven use compost to development vegetative support layers on their capped landfills.

CONTRACTORS

General and landscape contractors also represent a major market for compost in New England. Nine facilities reported the sale or give away of compost to contractors. In Kennebunkport, Maine, compost facility operators call contractors each spring to take the compost stockpiled throughout the winter. In the spring of 1989 the facility distributed 800 to 900 cubic yards of compost in less than three hours. Operators reported lines of waiting trucks.

LOAM PRODUCTION

Five facilities reported the use of their compost in the production of loam. Where markets have been developed, loam production represents a significant segment. Contractors buy nearly 75 percent of the compost produced by the Scarborough, Maine facility for $3 per cubic yard. The contractors mix the material with sandy soil at volumetric compost to soil ratios ranging from 1:2 to 1:5. Loam is currently selling for $10 to $14 per cubic yard along the Maine sea coast.

HOMEOWNERS

Homeowners also represent a significant market at several facilities. Maine's Bangor, Bar Harbor and Old Orchard/Saco facilities dispense the bulk of the compost to homeowners. Recipients typically pick up compost at the plant in containers ranging from five-gallon buckets to pickup trucks. A disadvantage of this method of distribution is the amount of time the operating staff spends helping homeowners load containers. Educating individual users on the proper use of the product also takes time.

AGRICULTURE

To date, the agricultural market in New England is underdeveloped. Only two facilities, Rockport/Gloucester, Massachusetts and Scarborough, Maine, report using compost as a top dressing on hayfields.

PRIVATE BROKERS

Private brokers understand the benefits of using compost and are often associated with large volume soil users. As a result, they can develop broad markets for compost, ranging from nurseries to the establishment of golf courses. Municipalities benefit by having their product professionally marketed, provided they maintain the quality of their compost. Two of the facilities contacted had entered contracts with private brokers and a third has an agreement pending successful classification of their compost by the Massachusetts Department of Environmental Protection (DEP).

LAND RECLAMATION

Two facilities report the use of their compost to reclaim exhausted gravel pits and a third reports using compost in reclaiming a sandpit.

NO MARKET IDENTIFIED

Of the nine facilities which had not successfully marketed their compost, three were awaiting classification of the compost by the Massachusetts DEP, one only recently received classification, and two received Type III classifications. Type III compost is the lowest classification assigned in Massachusetts. Producers cannot distribute this material unless the Massachusetts DEP approves its suitability for a specified use and grants a certificate authorizing the person receiving the compost to use it.

The remaining three facilities which have not identified markets for their compost were small generators. Two produced an average of ten to fifteen cubic yards of compost per day. The third composts sludge after reed bed dewatering. That facility cleans its reed beds every seven to ten years, which produces about ninety cubic yards of compost.

FACTORS AFFECTING MARKETABILITY

Three primary factors emerged as having an impact on compost marketability. These are the type of amendment used, final compost screening, and the level of effort associated with the marketing program.

Most composting facilities in New England use woodchips as an amendment. Several facilities, however, have produced what they feel to be a more desirable product by switching to other amendments. Greenwich, Connecticut facility personnel note that a significant amount of their compost is used as surface dressing on new lawns. When woodchips were used as an amendment the chips became visible during rainstorms, a characteristic that owners found unattractive. Operators noticed an increase in interest in their compost when they switched from woodchips to yardwaste as the amendment.

Similarly, South Portland Maine operators saw an improvement in their market when they switched from aerated static pile composting with woodchips as the amendment to aerated windrow composting with sawdust.

Five facilities now use bioash as an amendment. Though the primary reason for switching to bioash was odor control, several facilities noted that it also produces a more desirable product. Scarborough Maine had trouble distributing their compost when it included woodchips. Now, with a product that is jet black and looks much like high quality loam, contractors take compost as fast as the facility generates it. Kennebunkport, Maine operators say that although they were always able to market their compost, interest has increased since they switched to bioash.

Although woodchips in the final product may be desirable for some uses, such as in mulch, several facilities found a screened product easier to market. Greenwich, Connecticut and Merrimack, New Hampshire both noted a higher degree of interest in their product when they screened. The Sunapee, New Hampshire operators, who cleaned the facility's reed beds two years ago, believe high woodchip content is a key factor in their inability to distribute their product.

Today, marketing at most facilities remains low profile and is dependent primarily on word of mouth. Operators emphasize process control. While they must produce a consistently high quality product to develop and maintain markets, they must also begin developing and maintaining marketing programs.

The survey identified four key factors in existing successful marketing programs. Successful marketers understand the proper use of compost and convey this information to end product users. They maintain communication with users to help overcome any difficulties, and share in their successes. They also encourage public agencies and contractors performing public work to use compost, allowing development of visible examples of its benefits.

Mark E. Lang and Ronald A. Jager are Project Manager and Project Engineer respectively, for Dufresne-Henry, Inc. in North Springfield, Vermont.

REFERENCES:

1. Goldstein, Norma; Riggle, David; "Healthy Future for Sludge Composting." Biocycle, December 1989.

2. Donovan, John. "Markets for Sludge Composts." Biocycle, February 1990.

St. Louis Post-Dispatch

May 20, 1993, THURSDAY, FIVE STAR Edition

SECTION: ZONE WEST; Pg. 1

LENGTH: 657 words

HEADLINE: EXPERT ADVICE SOUGHT ON ELIMINATING ODOR FROM ROTTING LEAVES

BYLINE: Neal Learner Post-Dispatch Special Correspondent

BODY:

The foul smell coming from Ladue's leaf mulching facility continues to create foul tempers among nearby residents.

Ladue's Superintendent of Public Works, Dennis Bible, presented the Ladue City Council with several proposals to stop the vile smell caused by decaying vegetation at the leaf composting site, 9810 South Outer 40 Road. But Bible recommended seeking advice from several experts before going ahead with plans that would cost the city nearly $ 200,000.

A number of residents from the adjacent neighborhoods of Twin Springs and Tall Timbers expressed anger at a situation they felt had already gone on too long. They demanded the board take immediate action or close down the facility.

Resident Alicia Tierney said, "It's unbearable. We're regularly prevented from using our yards and opening our windows. We don't want to sacrifice another summer." Others complained of headaches caused by the smell.

Council Member Joyce Merrill, 3rd Ward, said of her visit to the neighborhood last Thursday, "I had trouble breathing. I thought I was going to be sick to my stomach."

Bible said the smell comes from the huge stockpile of leaves at the site. "When you dig into it, it really hits you. It's doubly bad because we've had so much rain." He noted that the leaves were being sprayed with chemicals to knock out the smell, but that the rain would "drive out the stuff we treated."

The runoff from the persistent rain has created a standing swill of decomposing, rotten vegetation.

Mayor Edith Spink said, "The only way to get rid of the problem is to get rid of the swill."

This is one of Bible's proposals. He explained that the stockpile lies on a grade of only 2 percent, which does not allow water to drain quickly. The proposal calls for placing the stockpile on a steeper 7 percent grade, creating a more efficient drainage system for the swill.

Another possibility is to create more rows of leaves where the decomposition takes place. According to Bible, these rows create no smell. With the facility using less than 5 acres on a 14-acre plot, Bible said the area could accommodate enough rows of leaves to eliminate any need for a stockpile.

Councilman Robert Mudd, 3rd Ward, said, "I don't mind spending $ 200,000 for the existing site if there is a 95 percent chance of success." Mudd agreed with Bible that further opinions should be sought before funds could be allocated.

"I want to have two other opinions about the source of the smell by the next meeting," he said.

Resident Burdick Burtch said he appreciated the board's intentions to fix the problem, but that if the city's efforts were unsuccessful, the city should remove the facility from a residential neighborhood.

Bible has already looked into the possibility of hauling the leaves to a landfill. The cost to do this would be more than $ 656,000. Other immediate, less expensive options call for covering the stockpile with a plastic tarp or shelter to keep off rain water.

The smell is not the only problem at the site. Noise from the facility's hammer-mill, used for making wood chips, can be heard throughout the area. The council is considering installing an innovative "living-wall" built of recycled plastic segments that are filled with dirt. Harry Sanders, president of the company that builds these earth-based walls, presented his product to the board.

He said this type of wall, which has been used in several European countries, has never been built in America. The dirt in the wall absorbs the sound rather than bouncing it back like traditional metal or plastic barriers. The barriers can also be planted with vegetation to greatly improve its appearance.

The walls can be adjusted to a height of 21 feet, depending on the recommendation of sound engineers.

Spink noted that this type of wall was less expensive than the traditional barriers.

LANGUAGE: English

LEAF COMPOSTING MANUAL FOR NEW JERSEY MUNICIPALITIES

Peter F. Strom

Melvin S. Finstein

Department of Environmental Science
Cook College and NJ Agricultural Experiment Station
Rutgers, the State University of New Jersey

New Jersey Department of Environmental
Protection, Office of Recycling

The Economics of Leaf Composting

Leaf composting, in relation to other wastes, has several advantages: (1) Leaves are already separated, (2) they are relatively easy to collect, (3) they do not give off serious odors during collection, (4) they can usually be transported to nearby sites, (5) a low-level composting technology can be used, (6) collection and processing equipment is easily available, (7) composting produces a useful product, and (8) the composting process is very economical.

The following sections discuss how municipalities can properly assess the costs and benefits that are associated with leaf composting.

COSTS

The costs associated with the composting of leaves are summarized in Table 1, including land, land improvements, windrow formation, combining windrows, turning, curing pile formation, separation/shredding and overhead. Collection costs are not included since it is assumed that the fallen leaves will be collected regardless of which solid waste management option is exercised by the municipality.

The total annual cost of leaf composting can be determined for a specific site by adding all cost categories shown in the attached budget worksheet which are appropriate for that facility. The computation of the annual cost for any depreciable asset lasting for more than a year can be made using the capital recovery factor (CRF). The asset's total cost is multiplied by the appropriate CRF. The costs for equipment should be calculated by multiplying their purchase price by the CRF and then multiplying this amount by the actual fraction of the time the equipment is used for composting. A listing of CRF's can be found in Table 3.

The computation of the annual land cost deserves separate mention. Land is normally not depreciated since the site is not destroyed through use. Also, the site could be used for other purposes if composting were to cease or be relocated to another site. The appropriate charge for land, therefore, would be its market value multiplied by the interest rate that could have been earned if this value was invested.

BENEFITS

The largest direct monetary benefit of leaf composting is the cost savings of avoiding landfill tipping fees. The tipping fees at landfills range from $13 to $40 per ton. Landfill fees will continue to escalate in order to pay for landfill closures, expansions and environmental improvements as well as additional surcharges from new legislation. In particular, A-1778 (Resource Recovery Financing and Procurement, Ch. 38, P.L. 1985) imposes an increase of $2.50 per ton in 1985, and additional increases in the following years.

The landfilling of leaves incurs important "hidden" costs such as increased transportation and maintenance costs on collection vehicles. These costs can be reduced as well through composting, although exact estimates are difficult.

Another direct benefit of leaf composting is a municipality's eligibility for receiving tonnage grants based on documentation showing the quantity of leaves recycled. These tonnage grants are provided under the authority of the New Jersey Recycling Act of 1981 (N.J.S.A. 13:1-92 et seq). Additional information on recycling tonnage grants may be obtained from the county recycling coordinator or the New Jersey Department of Environmental Protection, Office of Recycling.

Leaf mold, the end product of leaf composting, has a market value as well. Tenafly, New Jersey marketed "Tenafly Humus" for $5 per cubic yard (wet basis) in 1980. The quick sale of the total stock at this price indicates that most likely it was sold below its market value. If a value of $6.50 per cubic yard and a yield rate of 20 percent of the initial volume is assumed, then this would be equivalent to $1.30 per cubic yard or $7.40 per ton in revenue for the original volume. It would be appropriate for a municipality to use $7.40 per ton in their benefit calculations whether the leaf mold is sold or given away. The benefits associated with leaf composting are summarized in Table 2.

Additional Economic Considerations

Municipalities may want to consider some type of cooperative agreement whereby equipment and facilities are shared. For example, one community may supply the leaf composting site while another supplies the front-end loaders. Also, they may want to consider jointly leasing equipment for peak demand periods.

Data from other leaf composting operations suggest that costs are very high for small volume facilities but decrease rapidly as size increases. Costs decrease in large part due to the spreading of fixed costs of equipment, supervision, land and land improvements over more tons of leaves.

Contracting with a private vendor for leaf collection and composting may be an economical alternative. Equipment could be used more days during the year, thus lowering unit costs. A vendor could handle a sufficient number of smaller communities so that the volume would be large enough to keep costs to an acceptable level. Also, a vendor would have a greater incentive to meet the current market needs (both quantity and quality) for leaf mold or for self-use such as residential landscaping.

The following estimates are based upon a system handling 30,000 cubic yards of leaves each year on a 10-acre site. This example represents a rather large composting facility so costs per ton would be minimized.

<u>Composting Costs</u>: The compost site includes 10 acres of land valued at $8,500 per acre and land improvements at $3,200 per acre. (It is assumed that the leaves are turned two times, moved to a storage area, and that water is added to enhance composting.) A 9-percent interest rate is charged on any assets and a 10-year life expectancy is used to compute the depreciation. Composting costs are estimated to be $9.19 per ton of leaves composted (Table 1).

<u>Benefits</u>: Total benefits are estimated to be $24.65 per ton, exceeding the cost of composting (Table 2). If a municipality is already collecting its leaves, then it needs to look only at the composting costs and compare them to the benefits in order to make the decision whether to compost or not.

The tipping fee avoided is the largest benefit followed by the value of composted leaves. The tonnage grant is based upon an $8 per ton rate apportioned over a 10-year period using the capital recovery factor. In essence, the rebate is assumed to be placed in an interest-bearing account. The original rebate and interest are apportioned over the 10 years to offset costs. If the tonnage grant program is modified to provide yearly grants, then this benefit would increase.[1] The value of composted leaves is estimated at $7.40 per ton of original volume. The reduced depreciation and maintenance on trucks is a nominal rate, because actual data are not available.

In sum, estimates of benefits and costs of leaf composting indicate a very favorable outcome—more favorable than the direct monetary benefits and costs of other recycling programs.

---

[1]Such a change appears imminent as of the date of this publication.

Table 1. Estimated Cost of Leaf Composting Per Ton of Leaves (1984) 1/

ITEM	$
Composting	
Land	1.45
Land Improvements	.95
Initial Windrowing	.36
Combining Windrows	.36
Water	.49
Turning (2 times)	.72
Storage Pile Formation	.40
Separation/Shredding	3.02
Contingencies 2/	.60
Overhead	.83
Total	9.19

1/The cost of windrowing, adding water, and separation/shredding was derived from Leaf Composting. An Implementation Guide for Municipalities (July 1980).

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

Table 2. Estimated Benefits of Leaf Composting per Ton of Leaves, 1984

Tipping Fees Avoided 1/	$15.00
Recycling Rebate 2/	1.25
3. Value of Composted Leaves	7.40
4. Savings due to less trips to landfill (Nominal) 3/	1.00
Total	$24.65

1/ Reflects the minimum tipping fee rates in New Jersey. Tipping fees are much higher in some communities.

2/ The recycling rebate is annualized using the capital recovery factor. It is assumed that a first year only rebate is placed in an interest account (9 percent), so principal and interest can be used as revenue.

3/ Refers to the savings in transport costs, waiting time at landfills, and reduced depreciation and maintenance costs on garbage trucks resulting from fewer trips to the landfill.

Table 3. Capital Recovery Factor Values 1/

Years	Interest Rate 7	8	9	10
1	1.0700	1.0800	1.0900	1.1000
2	.5531	.5608	.5685	.5762
3	.3811	.3880	.3951	.4021
4	.2952	.3019	.3087	.3155
5	.2439	.2505	.2571	.2638
6	.2098	.2163	.2229	.2296
7	.1855	.1921	.1987	.2054
8	.1675	.1740	.1807	.1874
9	.1535	.1601	.1668	.1736
10	.1424	.1490	.1558	.1627

1/ The formula for computing capital recovery factors not presented here is as follows:

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

where: i = interest or discount rate
n = number of years

BUDGET WORKSHEET FOR LEAF COMPOSTING COSTS AND BENEFITS

Costs:

Labor

1. Gate monitoring, directing trucks, measurement and sale/give away of leaves:
(hrs/wk) x (wks/yr) x ($ /hr) = $ /yr.

2. Front-end loader equipment operators (windrow formation and turning):
(hrs/wk) x (wks/yr) x ($ /hr) = $ /yr.

3. Adding water to leaves:
(hrs/wk) x (wks/yr) x ($ /hr) = $ /yr.

4. Equipment operators to remove leaves from compost site area to storage:
(hrs/wk) x (wks/yr) x ($ /hr) = $ /yr.

5. Leaf separation and shredding:
(hrs/wk) x (wks/yr) x ($ /hr) = $ /yr.

6. Equipment repair:
(hrs/wk) x (wks/yr) x ($ /hr) = $ /yr.

7. Other - site maintenance:
(hrs/wk) x (wks/yr) x ($ /hr) = $ /yr.

Total hourly labor costs: Add lines 1, 2, 3, 4, 5, 6 and 7 = $ /yr.

9. (Total cost of hourly wages) x
(. Percent fringe benefits) = $ /yr.

10. Total labor costs: add lines 8 and 9 = $ /yr.

B. Land
Total Value

11. (Acres) x (Current value per acre) = $ /yr.

12. Total land cost:
(Total value) x (. Interest Rate) = $ /yr.

C. Land Improvements

13. ($ Site Grading) x (. CRF) = $ /yr.

14. ($ Drainage System) x (. CRF) = $ /yr.

15. ($ Water System) x (. CRF) = $ /yr.

16. ($ Roads) x (. CRF) = $ /yr.

17. ($ Gate/Fence) x (. CRF) = $ /yr.

18. Total land improvements cost: Add lines 13, 14, 15, 16, and 17 = $ /yr.

D. Equipment

19. ($ Front End Loaders) x (.percent usage for composting) x(. CRF) = $ /yr.

20. ($ Separator/shredder)1/ x(. CRF) = $ /yr.

21. ($ Hand tools) x(. CRF) = $ /yr.

22. Total equipment costs: Add lines 19, 20 & 21 = $ /yr.

E. Buildings

23. ($ Gate house)1/ x(. CRF) = $ /yr.

24. ($ Storage)1/ x(. CRF) = $ /yr.

25. Total building costs: Add lines 23 and 24 = $ /yr.

F. Other Costs

26. ($ Insurance) = $ /yr.

27. ($ Legal fees) = $ /yr.

28. ($ Gas and oil) = $ /yr.

29. ($ Water) = $ /yr.

30. ($ Supplies) = $ /yr.

31. ($ Electric) = $ /yr.

32. ($ Site, building and equipment maintenance = $ /yr.

33. <u>Total other costs</u>: Add lines 26, 27, 28, 29, 30, 31, 32 = $ ______ /yr.

34. <u>Total direct costs</u>: Add lines 10, 12, 18, 22, 25 and 33 = $ ______ /yr.

35. <u>Overhead costs</u>
(Total Direct Costs) x
(. Percent overhead) = $ ______ /yr.

36. <u>Total composting costs</u>: Add lines 34 and 35 = $ ______ /yr.

37. Total costs per ton
($ Total composting costs) ÷
(Total tons of leaves composted) 2/ = $ ______ /ton

1/Optional expenditures.

2/Density of leaves varies by the collection method. For estimating purposes, leaves picked up and placed in an open truck weigh 250 pounds per cubic yard; leaves that are vacuumed weigh 350 pounds er cubic yard; and leaves that are compacted weigh 450 pounds er cubic yard. Actual values will vary depending on moisture content.

Benefits

1. Tipping fees avoided
   Tipping fee per ton of leaves to be composted = $ /ton

2. Recycling tonnage grant
   ($ per ton) x (. CRF) = $ /ton

3. Value of leaf mold produced per ton
   of leaves to be composted = $ /ton

4. Time, distance, maintenance and
   depreciation saved on garbage trucks
   not traveling as often to landfills
   per ton of leaves to be composted = $ /ton

5. Total benefits of leaf composting per ton:
   Add lines 1, 2, 3 and 4 = $ /ton

References

Derr, Donn A. The Economics of Leaf Composting, New Jersey Agricultural Experiment Station, Cook College, Rutgers, the State University of New Jersey, New Brunswick, N.J., 1983, P-02513-1-83. Reviews the costs and benefits of leaf composting and suggests ways to lower the costs.

Estes, Jack C. Compound Interest and Annuity Table, McGraw-Hill, Inc., 1975. Lists the capital recovery factors for interest rates from 5 to 30 percent and for 1 through 60 years.

Kasper, Victor, Jr. and Donn A. Derr, Sludge Composting and Utilization: An Economic Analysis of the Camden Sludge Composting Facility, New Jersey Agricultural Experiment Station, Cook College, Rutgers, the State University of New Jersey, New Brunswick, N.J., 1981. This report goes into great detail on estimating procedures applicable to leaf composting.

Royer Foundry and Machine Co., Municipal Leaf Composting, A Solid Waste Recycling Program, Kingston, Pa., 1973. A reference on the technical aspects, equipment and leaf collection costs of leaf composting.

.id Waste Division, Minnesota Pollution Control Agency, Leaf Composting, An Implementation Guide for Municipalities, Roseville, Minn., July 1980. Covers the technical aspects, land requirements, equipment and collection and composting costs.

Various issues of Biocycle (formerly Compost Science) on leaf composting. Articles cover technical and marketing aspects of leaf composting. Municipal government experiences are also discussed.

NJAES Department
Research Report Series
No. P-02550-2-85

The Economics of Leaf Composting

by

Donn A. Derr

Department of Agricultural Economics and Marketing
Cook College
New Jersey Agricultural Experiment Station
Rutgers, the State University of New Jersey
New Brunswick, New Jersey 08903

New Jersey Agricultural Experiment Station, Publication No. P-02550-2-85 supported by State funds. The author would like to acknowledge the helpful review comments by Dan Rossi, Frank Flower, Peter Strom and Roger Guttentag.

Leaf Composting Summary for Field Personnel

When biodegradable materials are placed in a pile, a natural process known as self-heating often occurs. The microorganisms normally present (mainly bacteria and fungi) grow rapidly on the materials, using them as a food source and breaking them down. Heat is released as part of this process. If the pile is large enough, it acts as an insulator, keeping in the heat. The temperature then increases, sometimes to a very high level.

Composting is a process which uses this self-heating to treat waste materials such as leaves. During composting the amount of waste material is greatly reduced. The finished product, known as compost, is much different than the starting material, and is very useful when added to soil. Composting of leaves is usually much cheaper than taking them to a landfill.

For successful composting to occur, adequate moisture, oxygen, and temperature levels must be provided. Otherwise the process may be too slow, or serious odor problems may occur. To prevent these problems the piles must be constructed and handled in a particular way. Leaves brought to the site are dumped in a staging area. A front-end loader breaks apart the compacted leaves, and water is added with a fire hose. Water cannot be economically added after piles are already formed. Instead the leaves act like shingles and the water runs off the outside of the pile. It should be possible to squeeze a few drops of water from a fistful of properly wetted leaves.

Long piles known as windrows are then formed by the loader. These windrows should be 6 feet high, 12 to 14 feet wide at the base, and any convenient length. After about one month of composting the windrows have shrunk considerably, and two windrows are then combined. These combined windrows are again about 6 feet by 14 feet, which is large enough to prevent the material from becoming too cold during the winter. Each pile is turned again at least once more in the spring. During combining or turning, as much mixing and "fluffing" of the material as possible is desired. Compaction, such as from running equipment onto or over the windrows, should be avoided. Compaction prevents air, which contains the needed oxygen, from penetrating into the windrow. If the windrows are too large, this will also prevent adequate oxygen penetration.

After about 10 months, the composting leaves are moved to the edge of the site to form larger "curing" piles. Curing helps to finish the composting. This also allows the site to be cleared to get ready for the leaves from the next year. The following spring the compost in the curing piles is ready, and can be shredded. This breaks up clumps and removes waste materials such as rocks, branches, and plastic. A high quality finished product results.

I. INTRODUCTION

A. Leaves as a Municipal Waste

Municipal waste collected routinely from households includes a heterogeneous mixture of glass, plastic, metal, ceramic, leather, paper, cardboard, food waste, and yardwaste. Leaves are exceptional in that they occur seasonally and are often segregated from the overall waste stream. In season, leaves may account for over half the municipal waste collected and on a yearly basis may comprise 5% to 20% of the total.

Because segregated leaf waste is homogeneous, seasonal, and potentially non-obnoxious, it lends itself to treatment by relatively uncomplicated composting procedures. The end product of the process is compost, which can usefully serve as an organic amendmentforsoil.

The objectives of leaf composting as a waste treatment process are a reduction in the mass and volume of the starting material and the destruction of putrescible (odor-causing) substances. For compost production, reduction of the carbon to nitrogen ratio (see Section III.F) and elimination of weed seeds and any plant pathogens are also desirable. Of course, cost effectiveness is always a primary concern. The economic and other advantages of composting leaf waste are striking when compared to the other available alternatives.

B. Alternatives for Managing Leaves

There are three major alternatives for managing municipal leaf collections: landfilling, inc ineration, and composting. Among these, only composting requires segregated leaf collection, potentially imposing some additional collection costs. Segregated collection is already widely practiced, however, and well accepted. An economic analysis of leaf composting is provided in a separate addendum written by Dr. Donn A. Derr.

1. Landfilling

Landfilling is the primary disposal method for municipal solid wastes in New Jersey. With the recognition of the need for environmental controls at landfills, however, the cost of this method has increased dramatically. Thus one disadvantage of landfilling leaves is the tipping fees ($13 to $40 + per ton).

Siting of new landfills has become extremely difficult, and landfill capacity has been decreasing sharply. Placing leaves in landfills uses up this limited capacity for a relatively innocuous material, rather than saving it for the more obnoxious fraction of the municipal solid waste stream.

As the number of remaining landfills declines, the hauling time and distance increases for many communities. Likewise the waiting time for trucks to dump at some landfills has become even longer - in some cases two hours or more. Landfills also exact a high price in terms of increased maintenance costs for the trucks which ride on them - tires, transmissions, fuel tanks, hydraulic lines, and other components receive hard wear.

Ironically, once leaves are placed in landfills their biodegradability, which makes them suitable for composting, adds to the gas, leachate, and settling problems which landfills experience. Thus landfilling of leaves is not only expensive but also environmentally unsound.

2. Incineration

An effort is underway in New Jersey to establish mass burning with energy recovery as a major means of solid waste management. However, tipping fees usually will be higher than at landfills. Also, the more material which is burned, including leaves, the more air pollutants will be released - although with proper controls it should be possible to keep emissions within acceptable limits.

Leaves will be difficult to handle at incineration facilities. Often they will be too wet to burn well, reducing the potential for energy recovery. On the other hand, when they are dry, they tend to be too light and fluffy, adding to the fly ash.

Beyond these problems, incinerating leaves may simply be impractical because of their large volume and highly seasonal nature. Designing a mass burning facility to handle this peak loading may be economically infeasible, since the excess capacity would usually have to be idle for the remainder of the year. For more economically sized facilities, peak (as well as down-time) refuse loads will have to be diverted to landfills. Of course for most communities, even if the incineration option were to be chosen, it would be several years before a facility was operating.

3. Composting

For many communities, composting has proven to be the best and least expensive method for managing leaves. In fact, over 150 leaf composting facilities have received permits from the New Jersey Department of Environmental Protection's (NJDEP's) Division of Waste Management. Generally the biggest economic advantage is the avoidance of the high tipping fees charged for landfilling (or incineration, if available). Tonnage grants from the New Jersey Department of Environmental Protection, Office of Recycling can reduce composting costs even further.

Additionally, there are usually savings in hauling distance and waiting time, and in vehicle maintenance. The post produced has some small monetary value, which may be ognized in reduced purchases of organic matter (such as mulch and top soil) by the municipality, and occasionally even as product sales.

From an environmental perspective, composting saves valuable landfill space, and compost improves soil. Composting also provides a good image as a visible, community-sponsored recycling activity, and it may encourage participation in other recycling programs.

Thus, composting can be both an economic and an environmentally sound alternative for handling leaves. However, to fully realize these benefits and to avoid some of the potential problems, care must be exercised in selecting a site and designing and operating the facility.

II. DESCRIPTIONS OF PROCESS AND PRODUCT

A. Composting (the Process)

When biodegradable organic materials containing sufficient moisture and inorganic nutrients are placed in a pile or windrow (elongated pile), a natural process known as self-heating often occurs. Microorganisms, mainly bacteria nd fungi, begin to grow rapidly on the organics, using them a food source and decomposing them. Because the microbes are not 100% efficient, some of the chemical energy stored in the organics is wasted and released as heat. A large enough pile will act as an insulator, retaining heat and leading to an increase in temperature. Thus, the organic material "self-heats" through the intense metabolic activity of the microorganisms. Eventually the readily biodegradable food supply becomes exhausted, growth and heat generation slow down, and the pile cools.

The process which employs self-heating for waste treatment objectives is called composting. It has been used for many years for treatment of agricultural wastes and in more recent times for treating sewage sludge, municipal solid waste fractions, certain industrial wastes, and leaves.

B. Compost (the Product)

As composting progresses, the original material becomes less recognizable, although certain structures, such as the veins of oak leaves, persist longer than others. The material darkens, acquires a granular texture, increases in water- holding capacity and eventually develops the pleasant odor characteristic of freshly turned soil. Compost bears little resemblance to the original starting material.

A. Microorganisms

Microorganisms found on leaves and other wastes are fully capable of starting the composting process and carrying it forward. Nonetheless, commercial inoculums, starters, and "bioaugmentation" products are offered for sale. Based on testimonials, these are often claimed to be beneficial, but no support for these claims can be found in scientific journals. Properly controlled experimentation indicates that inoculation has no useful effect on the process. Therefore, such products should not be purchased for leaf composting operations.

B. Leaf Type

Maple leaves decompose more rapidly than oak leaves, and other leaf types doubtless differ in this respect. Mixtures would ordinarily be received at a leaf composting facility, and no specific recommendation is made based solely on leaf type.

C. Water

Water is essential for biological functions in general, and leaf composting is no exception. Indeed, adding water at the start of composting is very important to insure adequate moisture throughout the pile at the time of its formation and thereafter. Rainfall, even if heavy, penetrates the pile only slowly and cannot be relied upon to remedy initial dryness. Similarly, once the pile is formed, the interior material is not easily wetted by applying water to the surface. Initial dryness is a common and serious cause of slowness in leaf composting and as such should be prevented. An initial moisture content of at least 50% (wet weight basis) is recommended.

Leaves can also be excessively wet, slowing oxygen penetration (see Section III.D). This condition is self-correcting, however, as excess water drains from the pile. Depending on weather conditions prior to collection, the leaves might be sufficiently moist upon receipt, but this cannot be relied upon in routine operation. In general, it is better to start with a pile that is too wet than to risk dryness.

Specific recommendations for providing a water supply and for adding water at the time of leaf receipt are given in sections IV.I, VI.C and Appendix A.

D. Oxygen

Composting is basically an aerobic process (requires oxygen), although anaerobic (without oxygen) metabolism (fermentation) may also occur to a significant extent. Most the heat produced in composting results from the degradation of organic materials with consumption of oxygen and production of carbon dioxide and water. Thus, the pile must be sufficiently porous to allow oxygen in and carbon dioxide out. For this reason leaves should be placed loosely in the piles and compaction avoided.

E. pH

Fresh leaves are close to being chemically neutral (pH near 7). With the onset of composting the production of organic acids causes the pH to decline, possibly to as low as 4.2 if extensive anaerobic conditions develop. The pH subsequently recovers to a neutral or slightly alkaline level (perhaps pH 7.5) as the acids decompose in the presence of oxygen. A persistently acidic pH is indicative of prolonged anaerobic conditions. Adjustment of the pH with lime or other additives is not ordinarily necessary.

F. Inorganic Nutrients

Leaves have a high carbon-to-nitrogen ratio (C/N), and this condition can slow microbial action early in the composting. This nutritional imbalance rights itself as carbon is lost in the form of carbon dioxide, while nitrogen is conserved within the system. Supplementation with nitrogen at the outset would accelerate decomposition, but this measure is not generally necessary. It might be justified, in conjunction with other measures, if the resultant saving in process time were essential for the success of the overall operation (see section V.C.2). Note that the increased rate of decomposition from nitrogen addition could lead to other problems, such as an increased need for oxygen supply, which would also then have to be addressed. Appreciable deficiency of other nutrients such as phosphorus and potassium is not likely.

Supplementation of the end-product compost with nitrogen, phosphorus and potassium would increase its quality in terms of plant nutrition. This benefit has to be weighed against the costs involved.

G. Temperature

At any time the temperature of the pile reflects the balance between microbial heat generation and the loss of heat to the surroundings. The rate of heat generation is a function of factors such as temperature, water, oxygen, nutrients, and the remaining concentration of easily biodegradable organic materials. The rate of heat loss is a function of factors such as ambient temperature, wind velocity, and pile size and shape.

Temperature is a powerful determinant of the rate of decomposition. Temperatures of less than 68°F (20°C) slow decomposition. Temperatures above 140°F (60°C), which is about the temperature setting of most home hot water heaters, are similarly unfavorable because they kill most of the desirable microorganisms. Thus, the range of favorable temperature is approximately 68° to 140°F. Precise control over temperature is usually not essential for leaf composting, but gross departure from the desired range should be avoided. Maintenance of the proper temperature, along with oxygenation, is the basic consideration underlying the recommendations for windrow size and turning operations (see Section VI). If precise measurements of pile temperature are required, the County Extension Service should be consulted.

E. *Windrow Size and Turning*

Control over process temperature and oxygen content can be exercised to a useful extent through windrow size and turning operations. A basic problem is to reconcile the needs for oxygenation and heat conservation, which are somewhat in conflict. The need for oxygenation favors small windrows to minimize the distance that air must penetrate to the pile interior. In contrast, the need for heat conservation, especially in the winter, argues for large windrows for greater insulation. Excessively large windrows, however, might result in excessively high temperatures and anaerobic conditions. These requirements can be reconciled in part by management of windrow size and turning. Specific recommendations are given in Sections V and VI.

IV. FACILITY SITING AND INITIAL PREPARATION

Site selection is an extremely important decision that should be made only after careful consideration, as each situation is unique. The deliberation over site selection should take into account nearness to residences and streams, prevailing winds, traffic patterns, travel distance and its effect on equipment and labor costs, and other factors. Many of these are discussed below, yet familiarity with local circumstances is essential and cannot be reduced to written instruction. It is suggested that the County Extension Service and County Department of Solid Waste Management, among other agencies, be involved in the early stages of planning.

A. Permits

In New Jersey a State permit is required for all solid waste management facilities, including leaf composting. For information on obtaining this permit, for which there presently is no fee, contact the Bureau of Resource covery, Division of Waste Management, New Jersey partment of Environmental Protection, CN 028, Trenton, NJ 08625, phone 609-292-1250. A pre-application meeting is strongly recommended. Composting facilities also must be incorporated into the District (usually the County) Solid Waste Management Plan.

B. Area Requirement

A minimum of one acre per 3000-3500 cubic yards of leaves collected is required for the actual composting operation. This assumes the use of the low-level technology described later, and is in addition to the requirement for a buffer zone.

C. Buffer Zone

A buffer zone is required between the site activities and neighboring land use to minimize possible odor, noise, dust and visual impacts. There are no hard and fast rules, however, on the size of the buffer zone needed for composting. It would seem prudent to provide at least 50 feet between the composting operation and the property line. At least 150 feet should be allowed between composting activities and any sensitive neighboring land uses, such as residences.

The buffer zone may include a berm, consisting at least in part of finished compost to serve as a visual barrier, help control vehicular access, and reduce noise levels off-site. A landscaping plan, including plantings, is strongly recommended to enhance the appearance of the facility.

D. Location

A centralized area is preferable to reduce transporation time and costs, although such sites are not often available or otherwise practical. Access is preferably over non-crowded, non-residential, hard surface roads.

E. Stream Encroachment

Siting of a leaf composting facility in a flood plain is normally not allowed by state regulations. During times of high water the windrows might impede water flow, and/or leaves and leachate might wash into the stream. In any case flooding of the site could pose serious operational difficulties, including problems with equipment access and operation. Flooding of the windrows also may lead to extensive anaerobic conditions and the attendant problems of odor and lower decomposition rate. Flood plain maps are available through the Federal Emergency Management Agency or the NJDEP, Division of Water Resources, Bureau of Flood Plain Management (609-292-2402).

F. Slope and Grading

Steep slopes are unsatisfactory because of problems with erosion, vehicular access, and equipment operation. A gentle slope, however, is desirable to prevent ponding of runoff and leachate. Initial site preparation usually requires grading, and yearly maintenance should include regrading where necessary.

Drainage characteristics of a site can be determined from U.S. Geological Survey topographic maps and a plot plan survey. The New Jersey Department of Agriculture's "Standards for Soil Erosion and Sediment Control" (N.J.A.C. 2:90) provides information on grading to promote drainage and prevent erosion and sedimentation.

Windrows should run up and down rather than across slopes to allow leachate and runoff to move between piles, rather than through them.

G. Percolation

High soil percolation rates are desirable so that excessive rainwater and leachate will not run off the site. Where percolation is poor, or where an impervious surface is used, particular care must be taken to prevent ponding. Also, while an impervious surface, such as a paved site, may offer advantages in terms of vehicle access and equipment operation, these may be outweighed by the greater difficulties in leachate management. The Soil Conservation Service may be consulted to determine soil characteristics of sites under consideration.

H. Water Table

A high water table is undesirable because it may lead to flooding of the site. Flooding will make operation more difficult and can lead to extensive anaerobic conditions. A high water table also reduces the distance for percolation of leachate. Wetlands and wetland buffer areas especially should be avoided. The New Jersey Department of Agriculture's Division of Soil Conservation publishes a local soil conservation district "Soil Survey" booklet for each county containing information on depth to ground water.

I. Water Supply

The ability to supply water is critical since it usually is necessary to add water to the incoming leaves during much of the collection season. Water can best be supplied by using a hose from a fire hydrant or by pumping from a nearby lake, stream, or well. Use of a water truck is not usually practical because too much water is needed. ...roximate average water requirements are 20 gallons per ...ic yard of leaves (see Appendix A).

J. Security

Vehicular access to the site must be controlled to prevent illegal dumping of various materials. A gate across the entrance road is a minimum precaution. In some cases the entire site may have to be fenced, but usually preexisting features such as streams, trees, and embankments will provide partial security. A berm consisting of earth and finished compost often can serve in place of a fence at other points. In some areas vandalism may be of concern.

K. On-Site Roads

Because of the heavy truck traffic during the collection period, a limited road network (possibly paved) within the site may be desirable to improve all-weather access. A circular traffic flow pattern may be advantageous at heavily used sites. The purpose of the on-site roads is to make drop-off of the leaves as quick and easy as possible, and particularly to help prevent trucks from getting stuck during muddy conditions. An extensive on-site road network is not required.

L. Safety Considerations

Safety precautions usual to any operation involving heavy machinery should be exercised. Road layout should be designed with safety in mind. Public access should be restricted.

Normally the windrowed leaves will burn only poorly since the interior is wet. Thus, while vandals may be able to ignite the dry surface leaves, a major fire is unlikely. Fire safety is further accommodated by having a ready supply of water and delivery capacity, initial wetting of the leaves, and providing aisles between windrows.

One relatively new concern with leaf composting is the release of spores of the fungus Aspergillus fumigatus. These spores are capable of producing an allergic response in some individuals, and in a few cases they are also capable of causing infection in individuals with a weakened immune system. These spores have been found to be of some limited concern in sludge composting, but no work has been published to date on their importance for leaf composting. In any case, it might be expected that adequate wetting and ...nimum disturbance of the windrows, such as has been ...commended here, would reduce any potential problem.

Regardless, potential workers at the composting site should be screened for conditions that might predispose them to infection or allergic response. Such conditions include asthma, a history of allergic responses, a weakened immune system, the taking of antibiotics or adrenal cortical hormones, or a punctured eardrum. Workers having such conditions should not be assigned to the composting operation (as well as any other tasks putting them at similar elevated risk) unless a health specialist is consulted.

V. APPROPRIATE LEVEL OF TECHNOLOGY

Three different levels of technology for leaf composting can be considered. The particular one which is most appropriate for a given application will depend mainly on the site selected, although the equipment and manpower available are also factors. Table 1 indicates that the lower the level of technology, the greater the requirements for available space, size of the buffer, and composting time, but the lower the cost.

A. Minimal Technology

If a large area that is well isolated from sensitive neighboring land uses is available, a very low-cost approach to leaf composting is possible. Leaves brought to the site are formed immediately into large windrows (for example, 12 feet high by 24 feet wide) using a front-end loader. Once each year the windrow is turned and reformed. An additional windrow is constructed with the new leaves each fall. After three years the material in a windrow is usually sufficiently well stabilized to be used as compost.

With this "minimal" technology the necessary conditions for rapid composting are not achieved. Much of the pile remains anaerobic for a full year at a time between turnings. The center of the pile will probably also reach inhibitively high temperatures, especially the first year. However, the greatly reduced rate of activity is compensated for by providing a prolonged composting time.

Using this approach, some odor can be expected prior to the first turning, and serious odors may be released during the first turn. Usually by the second turning, odors have diminished. Because of these odors, an extensive buffer zone is required. In fact, up to a quarter mile distance or more to sensitive neighboring land uses is recommended.

The obvious advantage of this approach is that it is extremely inexpensive. Only a few days per year of front-end loader operation is required. Even wetting of the incoming leaves may not be necessary except in very dry years, since the large piles will conserve moisture, and the long time period ensures the cumulative exposure to considerable precipitation.

A second advantage is that relatively little space is required for the composting itself because the piles are so large and little aisle space is needed. For example, using foot high by 24 foot wide piles, a single windrow 60 ... is long would contain 3000 cubic yards of leaves. Even though the leaves must stay on site for at least three years, a half acre site should be adequate for a yearly collection of 3000 cubic yards.

Note, however, that because of the odors produced, a large buffer zone is needed. Thus, a very large total area is required, although only a small portion of it is actually utilized for the composting. Examples where this might be useful would be in a wooded area, so that only a small clearing would be required, or at an isolated industrial site or public works yard.

B. Low-Level Technology

In densely populated New Jersey, siting of a minimal technology facility is rarely possible. Therefore, the necessary conditions for rapid composting have to be more nearly met. In particular this means that a better job will have to be done of ensuring adequate moisture content, oxygenation and temperature control.

The simplest way to achieve the desired temperature range would seem to be to build piles large enough to serve sufficient heat, but not so large as to overheat. the other hand, adequate oxygenation by passive diffusion of air from the outside of the pile could be achieved if the piles were small enough. Unfortunately no single pile size completely reconciles these conflicting goals. However, the desired conditions can be approached by starting with moderate size piles (6 feet high by 12-14 feet wide), then combining two piles after the first burst of microbial activity (which lasts approximately one month). Water addition at the outset is usually necessary to provide adequate moisture.

Using this approach, which is described in more detail in Section VI, it is possible to produce a thoroughly decomposed (finished) compost in 16-18 months. The compost is ready for use in the spring, which is the time of peak demand for the product. Slight odors may be produced early in the composting cycle, but these are usually not detectable more than a few yards away from the windrows. After 10-11 months large curing piles are formed around the perimeter of the site, freeing the original area to accept the new leaf collection. Costs are still quite low, as only three operations with a front-end loader are required after initial windrow formation (one combining, one turning, and the curing pile formation). Despite the fact that more space is required for the actual composting (roughly 1 acre per 3000 to 3500 cubic yards of leaves) compared to the because of the reduced buffer requirement.

C. High-Level Technology

1. Description

If less space is available and completion of composting within one year is desired, a higher level of technology is required. Simply turning the windrows more frequently (for example, once per month) with a front-end loader might produce a finished product in under a year. However, since the original windrows can still be no larger than those of the low level technology if odor problems are to be avoided, little space is saved. While costly specialized windrow turning machines may be used to increase turning efficiency, this actually requires more space, since the starting windrow size is usually even more limited by the machine's working height and width.

In order to approach a maximal rate of decomposition, near optimal levels of temperature and oxygenation are required. This also minimizes odors as the putrescible (odor-causing) materials are quickly decomposed, and anaerobic conditions are minimized. These desired conditions can best be achieved by using an approach originally developed for sewage sludge composting, known as the Rutgers process control strategy. While this strategy has been successfully field tested for leaf composting, exact design and operation details for this application have not yet been developed.

Briefly, this approach consists of using forced pressure aeration of the composting pile, with the blower controlled by a temperature feedback system. When the temperature at a specific monitoring location within a pile exceeds a preset value, usually around 113°F (45°C), the blower automatically comes on to remove heat and water vapor and cool the pile. This control strategy ensures near optimum temperatures in the bulk of the material, and at the same time maintains a well-oxygenated condition. During the start-up period (and at other times, if needed), the blowers also come on under control of a timer (perhaps for 30 seconds every 15 minutes) to provide a minimal level of oxygen. After 2-10 weeks of composting, the aeration system would be removed, and the windrows turned periodically. Additional information on the Rutgers Strategy is provided in some of the papers listed in the Bibliography.

An advantage of this approach is that large windrows can be formed initially, thus using less space, yet extensive anaerobic conditions do not develop because of the good aeration. Therefore, serious odors and slowed decomposition do not occur. The largest pile tested to date was 10 feet high by 20 feet wide, but somewhat larger sizes may be feasible. A second advantage is that as a result of the rapid decomposition which occurs early in the season, composting can be completed within one year.

However, since the incoming leaves may themselves be odorous and since these odors may be released during initial windrow formation and start up, a moderate size buffer zone (as with the low-level technology) is still required. Also, the need for the blowers, timers and controllers (several hundred dollars per set-up) and the additional labor for installation and security requirements will increase the cost of this approach relative to the low-level technology. Still, the overall cost is expected to be moderate.

2. Nitrogen Supplementation

As noted earlier, leaves are nitrogen-deficient, which can slow decomposition. Adding nitrogen is not advantageous in conjunction with minimal or low-level technology because other limitations (temperature, oxygen) are overriding. Also, nitrogen addition could aggrevate odor problems.

Nitrogen addition with high-level technology would speed decomposition without increasing odors. The least costly form of fertilizer nitrogen should be purchased if it is decided to take this approach. As a first approximation, add 5 pounds of nitrogen per ton (about one pound per cubic yd) of wet leaves.

VI. RECOMMENDED LOW-LEVEL TECHNOLOGY

Unless indicated otherwise, the low-level leaf composting technology is recommended. Table 2 summarizes the scheduling and attempts to estimate manpower and equipment requirements for a moderate-sized leaf composting facility (10,000-20,000 cubic yards of leaves per year) employing the low level technology. The individual steps are discussed in more detail below. A summary sheet, meant for distribution to field personnel, is provided in Appendix B.

As indicated, a number of assumptions went into Table 2. The manpower and equipment time estimates, in particular, should be considered only as a general indication of the needs at a specific site, since they may be highly variable.

A. Site Preparation

Prior to each collection season the site must be readied to allow all necessary truck access and front-end loader operation. The one part of the operation which has little scheduling flexibility is delivery of the collected leaves. Once leaves are collected, they must be promptly processed through the staging area and formed into windrows (Sections B-D). It is critical, therefore, to prevent operational bottlenecks, such as an area becoming so muddy that trucks get stuck trying to drop off their loads.

The yearly site preparation should include regrading and road and leachate system (if any) maintenance. Also, all refuse and debris from the previous year's operation should be removed. Normally this step will require at most a few days work. It can be scheduled any time after the active site has been cleared of the leaves from the previous year (by formation of the curing piles), but before the new collection season begins.

B. Delivery of leaves

It is recommended that trucks dump their loads of leaves in a staging area, rather than trying to form windrows directly. Although a staging area involves additional labor, its use is justified for several reasons.

Leaves are normally collected in several ways and delivered in a variety of trucks including garbage compactors, roll-offs, and vacuums. This results in a highly non-uniform compaction in directly formed windrows, which can be minimized by the operations performed in a staging area. Wetting is also virtually impossible in directly formed windrows since most of the water simply runs off the outside. Use of a staging area also leads to a more uniform windrow size and shape, giving both a better appearance and more efficient composting. Keeping trucks on the firmer surfaces, rather than backing into windrows, decreases their chance of getting stuck during wet weather. Even in good weather the staging area can speed the delivery process. It may be feasible to move the staging area periodically (weekly for example), to minimize the distance to the active windrow forming area.

Windrow formation must take place immmediately after leaves are received. If freshly dumped leaves are allowed to sit for more than a day or so in the staging area, odor problems may develop.

Some minimal supervision may be required to prevent dumping in undesired locations. Also, a record of the amount of leaves delivered should be kept, especially to qualify for New Jersey Department of Environmental Protection, Office of Recycling tonnage grants. A daily tabulation of the number of loads for each individual truck of known capacity may be the best accounting method. The recommended collection log developed by the Office of Recycling is included in Appendix B.

At most leaf composting facilities the leaves are delivered in bulk. However, some sites may find it necessary to accept at least a portion of their capacity in plastic bags. These bags can be handled successfully but pose considerable extra problems.

The bags should be dumped in a separate portion of the [sta]ging area. In a very labor intensive process, they must [the]n be slit open and emptied. (Some operations use community service labor.) Any trash must be separated and disposed of along with the bags. If mixed trash is a persistent problem, an educational campaign is recommended and/or leaves might be accepted in transparent bags only. Another difficulty with collection of bagged leaves is the odor released from some of the bags upon opening. One alternative is to open and dump the bags directly into the hopper of the collection vehicle, but this slows the collection itself.

C. Wetting

Wetting of the leaves will be required during much of the collection season. Adequate wetting can only be achieved prior to or during windrow formation or when windrows have been opened up for turning or other purposes. Most of the water applied to the outside of a windrow is simply shed by the leaves. The water should be sprayed in excess on the leaves with a firehose (see Section IV.I) as the loader breaks the masses apart in the staging area, and/or as they are placed in the windrows.

If the moisture content of the delivered leaves is [kn]own, the amount of water that must be added to get any [par]ticular desired moisture content can be calculated (Appendix A). On a more informal level, the rule of thumb is that it should be possible to squeeze a few drops of water from a fistful of the leaves. As a rough approximation, perhaps 20 gallons of water will be required on average per cubic yard of leaves collected.

D. Forming Windrows

Once the leaves have been dropped in the staging area, the front-end loader can be used to break apart and spread the compacted materials to facilitate wetting. Bags, branches, and other refuse can be removed by hand. The front-end loader can then be used to place the uncompacted leaves in windrows.

The windrows should initially be 6 feet high by 12-14 feet wide. Any convenient length can be used. Two windrows can be formed side by side, with only 1-2 feet between, to conserve space. Sufficient aisle space between pairs of windrows (typically 12-16 feet) should normally be allowed for loader operation. Although in some cases it may be [po]ssible to have fewer aisles if space is limited, this [ma]kes turning operations awkward.

Neatly formed windrows with well maintained aisles give a professional appearance to the facility, while messy windrows give the impression of a "leaf dump." Care should be taken that equipment, especially the loader, does not ride up on the windrows, compacting them. Loosely piled leaves are required in order to obtain adequate air penetration into the windrows.

E. Combining Windrows

After approximately one month, much of the inital oxygen demand of the leaves has been exerted and the piles have been reduced to about half their original size through decomposition and self-compaction. At this point, two windrows can be combined to form a single one that is still only about 6 feet high by 14 feet wide (about the same size as each of the initial windrows). Combining the windrows will help conserve heat during the colder weather. Portions of the center of the new, combined windrow may go anaerobic temporarily, but significant odors and acidification are not expected because much of the readily degradable material has already been consumed by the microorganisms.

Combining should be done by moving and turning <u>both</u> piles, not be placing one on top of the other. The maximum degree of mixing and "fluffing" is desired.

To conserve space, combining may begin before leaf collection has been completed. In this way some of space freed by combining windrows (formed with leaves collected in early November), can be used for new windrows made with leaves collected late in the season (mid-December).

F. Turning Windrows

As early as is practical in the spring (March or April), each windrow should be turned. Turning mixes the material, rewets the dry outer edges, reoxygenates the interior, and exposes the formerly cool edges to the hotter internal temperatures. The result is an increased rate of decomposition and improved destruction of any pathogens and weed seeds.

As with the prior combining operation, maximum mixing and "fluffing" is desired during turning. At this time additional water may be added if the material is too dry. (However, every effort should be made to provide sufficient water initially.)

Additional turnings throughout the summer would further enhance composting rate and product quality, but these are optional.

G. Curing

Using the low-level technology described here, much of the material will not be completely stabilized by the end of summer, yet the composting area must be cleared to allow site preparation for the next year's leaves. This does not represent a problem since the material is now moderately well decomposed, has little oxygen demand, and is unlikely to produce odors.

At this time, therefore, the material can be moved and formed into a large curing pile around the perimeter of the site. The curing pile may be made as large as desired (for example, 12 feet high by 24 feet wide) to conserve space, but should not be compacted when formed. Moving the material also provides additional turning and mixing, and exposes a relatively small surface area to drying and freezing conditions. Additional weed and pathogen destruction is achieved at the temperatures reached within the large, well-insulated curing pile. This material is expected to be well stabilized by the following spring but may be left in place longer if convenient.

H. Shredding

Once composting is completed (post-curing), shredding is a final <u>optional</u> step to improve the physical quality and appearance of the finished compost, making it more acceptable for many commercial uses. Our experience to date [is] mainly with various models of the Royer shredder-mixer. [M]ention of trade names does not imply endorsement.) This equipment breaks up clumps and separates out rejects consisting of any uncomposted leaves, branches, rocks, plastic, and other extraneous materials. The "rejects" may be composted for an additional period, then reshredded to minimize the amount requiring disposal.

Shredding is fairly labor intensive. Leaf compost can only be processed at about half the rated capacity of the equipment. A front-end loader is required for filling the hopper, and at least one person is required to operate the shredder itself.

The major advantage of using a shredder is that it yields a more uniform and debris-free final product. It can also be used to mix finished compost with soil. Disadvantages include the labor and equipment requirements, the need to dispose of rejects, and of course the capital cost of the specialized machine (for example, around $60,000 for a model rated at 125 cubic yards per hour). One way to reduce costs is to share a single unit among several sites or communities. Sharing is possible since the specialized [e]quipment is only needed for a month or two per year, and [s]cheduling can be flexible.

Shredding will proceed more rapidly if the compost is not too wet. Moist material to be shredded often can be spread out to dry for a day or two beforehand.

VII. TROUBLESHOOTING

Table 3 summarizes the more common problems at leaf composting sites, their causes, and recommendations for their remedy. Most problems can be prevented by proper facility siting, design, operation, and maintenance.

A. Odor

The major problem encountered at leaf composting sites is odor. Those unfamiliar with handling large masses of leaves may be surprised at how serious a problem it can be. Starting with relatively innocuous leaves, it is possible to generate odors comparable to those of a barnyard.

In general, odor problems develop in four stages: 1) odorous compounds must be present initially or be produced during processing; 2) these odors must be released from the pile; 3) the odors must travel off-site; and 4) they must be detected by sensitive individuals (receptors). If any stage is absent, no odor problem exists.

With the minimal technology described previously, stages 1-3 all occur, but since no receptors are present (stage 4), no problem exists. Except where very large buffer zones are present, however, this approach to odor "control" is not possible.

In most cases, prevention of odor problems can best be achieved by preventing odor formation in the first place (stage 1). For leaf composting this means avoiding prolonged anaerobic conditions. Under anaerobic conditions, volatile organic acids (which have vinegar, cheesy, goaty, and sour odors), alcohols (fruity, floral, alcohol-like), and amines and sulfur compounds (barnyard, rotten) can be produced. In contrast, with aerobic conditions only a mild earthy odor is expected. If excessive ammonia or urea-based fertilizer is added, an ammonia odor may also be produced.

The major cause of odor production at leaf composting sites is making the windrow too large, especially when first assembled. Because of an initial high concentration of readily degradable material, there is a high demand for oxygen. If the piles are too large, sufficient oxygen cannot penetrate from the outside, and a large anaerobic core develops. Decomposition slows down, switching over to the odor-producing acid fermentation described above.

A second important source of odor production is failure to form windrows quickly enough once the leaves are collected. Unless they are very dry, leaves cannot be simply dropped at the site for later composting or collected and stored elsewhere. Although the intention might be to store them, vigorous decomposition will nonetheless begin within one to two days, anaerobic conditions will develop, and odors will be produced.

If odors should be produced at a site, or if odorous materials are dropped off at the site, the second line of defense is to prevent their release (stage 2). Theoretically, this can best be accomplished by leaving the odorous mass undisturbed until oxygen has penetrated sufficiently to destroy the odors, though this may take several months or even years. Shaving off thin (perhaps 1-2 foot) layers from the edges as they become aerobic may help speed this process.

If a long wait is not practical, another approach may be possible. Since many of the odorous compounds are acidic in nature, raising the pH (neutralizing the acids) will convert them to an ionized (negatively charged, dissociated) form. In this form they cannot be released to the air and will remain in the pile.

Application of pulverized limestone is probably the best way to raise the pH. Sprinkling the limestone in powdered form directly onto surfaces from which odors are escaping may be the simplest approach, although a liquid slurry of limestone in water could also be used.

If odors are still produced and released despite these precautions, it may still be possible to minimize their offsite impact (stage 3). This approach relies on timing odor-releasing operations to coincide with favorable wind conditions. A wind sock should be installed at the site to determine wind direction, and odor releasing operations performed only when the site is downwind of residences and other sensitive neighboring land uses. Also, higher winds are preferable to calm and light conditions because the higher the wind speed and turbulence, the greater the dilution of any released odors.

B. Leachate

One way in which leachate may pose a problem is by forming small pools or "ponds." Ponding is a concern because it can create an odor problem (since anaerobic conditions are likely to develop), serve as a place for mosquito breeding, and interfere with operations on the site (soft, muddy areas). Prevention, by properly grading the site, is the best remedy. Also, windrows should run down slopes rather than across, making it easier for the water to run off rather than accumulate between windrows. If ponding occurs and odors are released from the pools, adding pulverized limestone may be helpful.

Pollution of surface waters (lakes, streams) is the other major concern with leachate. While leachate from leaf composting is generally not toxic, it may deplete the dissolved oxygen in the water, possibly even to the point where fish kills could occur. Because of its dark color, it might also lead to a discoloration of the water.

In order to prevent this potential pollution, leachate should not be allowed to enter surface waters without prior treatment. This treatment might consist of simple percolation down into or through the soil, or passage through a sand barrier constructed to intercept the horizontal flow. In passing through the soil or sand, the leachate is both physically filtered and biologically degraded to remove a substantial portion of the pollutants. Contamination of ground water does not appear to be a problem associated with leaf composting.

C. Inadequate Composting Rate

Occassionally composting will seem to progress too slowly in some windrows, usually because the leaves are too dry. Sufficient water should be added initially, before or as the windrows are being formed. Other opportunities to add water are during the combining operation and scheduled or extra turnings. Adequate wetting usually cannot be accomplished simply by spraying water on the outside of the piles. Similarly, rainfall is not effective within the required time frame.

Another cause of slow composting is piles which are too large. Once acidic anaerobic conditions occur, the leaves tend to be preserved ("pickled") rather than decomposed. To avoid this problem, follow the recommendations in Section VI.

D. Other

There are several other potential problems at leaf composting facilities. For example, noise may be a concern depending on the equipment used.

Dust from the windrows can be minimized by proper wetting. Dust from the roads and aisles, however, may be a problem during dry weather.

Leaves as collected may contain low levels of some toxic materials. Lead, for example, is present because of its use in gasoline. Limited testing to date, however, has found only very low levels, well below any threshold of concern. Lead levels in leachate typically meet drinking water standards. Some pesticides may also be present, but again the levels ordinarily will be too low to pose any concern.

The relatively new concern with spores of *Aspergillus fumigatus* has already been noted in Section IV.L in the context of worker safety. The management practices recommended, including wetting and minimal disturbance of composting materials, are expected to minimize off-site effects.

VIII. USE OF LEAF COMPOST

Early in the development of a composting facility, it is desirable to plan for distribution of the end product. The County Department of Solid Waste and Cooperative Extension Service may be helpful in developing outlets. The benefits of using leaf compost as a soil additive or a mulch are summarized in a factsheet (FS117) prepared by the Cooperative Extension Service at Cook College, Rutgers University. A single copy has been included in Appendix B.

While the nutrient content of leaf compost is too low for it to be considered a fertilizer, it does act as a soil conditioner and organic amendment, improving the physical, chemical and biological properties of the soil. Most New Jersey soils benefit considerably from the increase in organic matter content which leaf compost can provide.

Most municipal leaf composting operation managers like to make a portion of their finished compost available to individual users in the community. Some allow the public access to the site itself, while others prefer to make the compost available at some other location, such as the public works yard or recycling center.

The municipality itself may use the compost in place of purchased organic soil amendments. The park and road departments may have the largest requirements. The compost may also be blended with poor soils to produce a good quality topsoil.

Other bulk users may include nurseries, landscapers, and builders. In some cases the compost may be offered to such users at no cost, but in others a modest charge is made.

IX. COMPOSTING OF OTHER YARD WASTES

A. Grass Clippings

Grass clippings represent another significant seasonal solid waste. In some New Jersey suburban communities they may account for nearly one-third of the total municipal refuse loading during peak grass-growing periods. Although grass clippings are readily compostable, the odor problems they pose make this treatment option difficult to implement for most communities. Likewise, State permitting requirements are more stringent, particularly with respect to staging, buffer zones, and odor control. Optimal means of co-composting leaves and grass clippins are not yet fully developed.

Since they are typically still green when collected, grass clippings are relatively high in nitrogen, moisture content, and readily degradable organics compared to the fallen leaves collected in autumn. For these reasons they decompose more rapidly, have a higher oxygen demand, and quickly go anaerobic. Thus they are often highly odorous by the time they are delivered to a composting site. Therefore it is especailly important to properly implement and atricly enforce the odor control measures discussed in Section VII A. Addition precautions such as enlarging the buffer zone will also be necessary.

If the grass clippings could be delivered to a leaf composting site without causing odor problems, they could be incorporated (before the end of the day) into the partially composted leaf windrows. A ratio of 3 volumes of partially composted leaves to 1 volume of grass clippings is recommended, although lower ratios may also be satisfactory in some cases. Good mixing is essential and can be achieved with a front-end loader by working together 20-30 bucketfuls of material at a time, then forming a windrow with the mixture.

Once the material has been mixed in this way, no further odor problem is expected. The partially composted leaves act as a bulking agent to improve penetration of oxygen to the grass clippings. The grass in turn speeds the decomposition of the leaves by providing needed nitrogen. The end result is a higher quality compost product which is ready in a shorter period of time. However, these benefits must be balanced against the increased potential for odor problems.

Other alternatives for handling grass clippings exist but depend on the generator for implementation. Probably the best alternative is not to collect them at all. Turf grass specialists, such as Dr. Henry Indyk at Cook College, recommend mowing frequently enough so that the short clippings filter through the growing grass and return their nutrients to the soil. If the clippings must be collected they can be incorporated in moderate amounts in backyard leaf composting piles or used as a garden mulch. For use as a mulch, the clippings should be dried for a day or two first to minimize any problems with slugs.

B. Woody Materials

Wood tends to decompose very slowly, making composting of woody materials impractical in most cases. Thus woody materials should not be intentionally incorporated in leaf composting windrows. Small amounts of incidentally included branches and twigs pose little problem.

Tree trunks and large branches can usually be easily given away or even sold as firewood if cut to reasonable lengths. For smaller diameter woody materials, chipping usually produces a usable mulch.

X. BACKYARD COMPOSTING

Backyard and municipal leaf composting are complementary activities. Municipalities should encourage backyard composting as a part of their overall yard waste management program. All municipal collection, processing, and distribution costs are avoided for leaves that are composted by homeowners. Additionally, grass clippings and some other wastes can be included in backyard composting, thus reducing handling of these wastes by the municipality as well.

The Cooperative Extension Service at Cook College, Rutgers University, has published a factsheet (FS074) on backyard leaf composting. A single copy is included in Appendix B. For information on obtaining additional copies, contact your county extension agent (in New Jersey) or Cook College, or the New Jersey Department of Environmental Protection, Office of Recycling. The method recommended is much less complex than those suggested by others, and was designed to make it easy for homeowners to get started with composting.

BIBLIOGRAPHY

Clark, C.S., Bjornson, H.S., Schwartz-Fulton, J., Holland, J.W., Gartside, P.S. "Biological health risks associated with the composting of wastewater treatment plant sludge". J. Water Pollution Control Federation 56:1269-1276 (1984).

Finstein, M.S., Miller, F.C., Strom, P.F., MacGregor, S.T., Psarianos, K.M. "Composting ecosystem management for waste treatment". Bio/Technology 1:347-353 (1983).

Strom, P.F., Morris, M.L., Finstein, M.S. "Leaf composting through appropriate, low-level, technology" Compost Science (now BioCycle) 21(6):44-48 (1980).

Finstein, M.S., Miller, F.C., Strom, P.F. "Waste treatment composting as a controlled system". In, Biotechnology: Microbial Degradations, Verlag Chemie (German Chemical Society), In Press.

Finstein, M.S., Miller, F.C., MacGregor, S.T., Psarianos, K.M. "The Rutgers strategy for composting: process design and control". USEPA Report, EPA/600/2-85/059, Available from U.S. Dept. Commerce, National Technical Information Service, Springfield, VA. 22161, accession no. PB85 207 538/AS.

GLOSSARY

Aerobic. Oxygen present.

Anaerobic. Oxygen absent.

Buffer zone. Area between the composting operation and homes or other sensitive land uses.

Compost. Thoroughly decomposed, humified, organic matter produced through composting and suitable for application to soil.

Composting. Process of accelerated organic matter decomposition based on microbial self-heating.

Curing. Late stage of composting, after much of the readily metabolized material has been decomposed, which provides additional stabilization.

Decomposition. The breaking down, or destruction, of dead organic materials such as fallen leaves.

Fermentation. Anaerobic decomposition involving only organic compounds.

Inorganic. Substance in which carbon-to-carbon bonds are absent; mineral matter.

Leachate. Liquid, often highly colored, which has passed through or been in contact with a composting pile.

Metabolism. Chemical processes necessary for life.

Metabolizable substance. A material which can be metabolized, or digested, to the benefit of the organism.

Microbe. Living organism of a size such that it can be seen only with a microscope.

Organic. Substance which includes carbon-to-carbon bonds.

Oxygen demand. The requirement for oxygen exerted in aerobic decomposition.

Percolation. Passage of water down through soil.

pH. A measure of how acid (pH less than 7) or basic (pH above 7) a material is.

Putrescible. Organic materials prone to degrade rapidly, giving rise to obnoxious odors.

Respiration. Metabolic functions consuming oxygen.

Self-heating. Spontaneous increase in temperature of organic masses resulting from microbial action.

Stabilization. Used synonymously with decomposition.

Staging area. Area where newly received leaves are decompressed (if compacted) and wetted, prior to forming windrows.

Windrow. An elongated pile.

TABLE _

APPROPRIATE LEAF COMPOSTING TECHNOLOGY

SPACE*	BUFFER ZONE	TIME+	APPROPRIATE TECHNOLOGY	COST
Abundant	Wide	Long	Minimal	Very low
Adequate**	Moderate	Moderate	Low-level	Low
Little	Moderate	Short	High-level	Moderate

*Including buffer zone.
**Approx. 1 acre per 3000 cubic yards of leaves, plus buffer.
+Approximate times: long = 3 years, moderate = 16-18 months, short = 6-10 months.

TABLE 2

Typical Schedule and Generalized Manpower and Equipment Requirements for a Moderate Sized (15,000 yd³) Low-level Technology Leaf Composting Operation[a]

Operation	Schedule: Months	Schedule: Flexibility	Time Required: Front-end Loader	Time Required: Laborer
P[illegible]e site	Sept.-Oct.	Yes	2 days[b]	2 days
Form windrows[c]	Late Oct.-Dec.	No	6 weeks	6 weeks
Combine	Dec.-Jan.	Yes	2 weeks	--
Turn	March-April	Yes	1 week	--
Form Curing Pile	Aug.-Sept.	Yes	1 week	--
Shred (optional)	March-May	Yes	4 weeks	4 weeks

a
General Assumptions:
(1) site has been prepared to allow all necessary truck access and loader operation under any expected weather and ground conditions.
(2) leaves delivered in bulk (not bagged).
(3) adequate supply of water on site.
(4) daily supervision by a responsible person during periods of activity, regular checks at other times.
(5) manpower required for distribution of finished compost not considered.

b
r equipment such as a grader may be required.

ing leaves - average of 20 gallons per cubic yard.
Windrow size - 6 feet high by 12-14 feet wide.
Aisles - 1-2 feet wide for pairs of windrows, 12-16 feet wide between pairs.
Avoid compaction.

TABLE 3

PROBLEMS ENCOUNTERED AT LEAF COMPOSTING SITES

Problems	Causes	Recommendations
Odor	Piles too large	Initial windrows should be no larger than 6 feet high by 14 feet wide
	Windrows not formed immediately	Allow no more than 1-2 days between collection of leaves and formation of windrows
	Leachate ponding	Eliminate ponding; add lime
Leachate ponding	Inadequate slope, poor grading	Grade site properly
	Improper windrow alignment	Run windrow down slope, not across
Pollution of surface waters	Leachate discharge	Treat leachate before it leaves site by passing it through soil or sand
Inadequate composting rate	Material too dry	Add water initially, or as corrective measure during turning
	Pile too large, leading to acid anaerobic conditions	Make piles smaller, adding limestone if necessary to raise pH and control odors

APPENDIX A

Water Requirement Calculations for Leaf Composting

Let x = wet weight of leaves as received (tons).

Let b = initial moisture content (fraction, wet basis) before wetting.

Let y = wet weight of leaves after wetting (tons).

Let a = final moisture content (fraction, wet basis) after wetting.

Then because the dry weight has not changed during wetting:

$$(1-b)x = (1-a)y; \; y = \frac{(1-b)}{(1-a)} x$$

We wish to know the tons of water which must be added per ton of leaves received; this is:

$$\frac{y - x}{x} = \frac{y}{x} - 1$$

Substituting for y:

$$\frac{\frac{(1-b)}{(1-a)} x}{x} - 1 = \frac{1-b}{1-a} - 1 = \frac{1-b}{1-a} - \frac{1-a}{1-a} = \frac{1-b-1+a}{1-a} = \frac{a-b}{1-a}$$

T[illegible]s the tons of water required per ton of wet leaves as received, to go from moisture content "b" to moisture content "a".

Conversion factor:

1 ton of water is how many gallons?

$$\frac{2000 \text{ lbs}}{\text{ton}} \times \frac{1 \text{ gal}}{8.34 \text{ lbs}} = 240 \text{ gal/ton}$$

1 ton of leaves is how many yd^3?

This varies widely, but let us use as a rough average 5 yd^3/ton.

Then: 1 ton water/ton leaves $= \frac{240 \text{ gal water}}{5 \text{ yd}^3 \text{ leaves}} = 48$ gal water/yd^3 leaves.

Water Requirement Calculations

% Moisture		$\frac{a-b}{1-a}$ (tons water/ton leaves)		Requirement (gal water/yd^3 leaves)	
Initial (before)	Final (after)	a = .5	a = .6	a = .5	a = .6
20	50	0.6	-	29	-
20	60	-	1.00	-	48
30	50	0.4	-	19	-
30	60	-	0.75	-	36
40	50	0.2	-	10	-
40	60	-	0.50	-	24
50	50	0	-	0	-
50	60	-	0.25	-	12

Example

Total Requirement

Assuming equal amounts of leaves coming in at 30, 40, and 50% moisture, and a desired moisture after wetting of 60%.

$$\frac{36 + 24 + 12}{3} = 24 \text{ gal of water needed/yd}^3$$

For a total collection of 15,000 yd^3, this amounts to:

$$15{,}000 \text{ yd}^3 \times 24 \text{ gal/yd}^3 = 360{,}000 \text{ gal}$$

Peak Requirement

Assume 15 yd^3/truck coming in at only 30% moisture, with a desired moisture after wetting of 50%.

$$15 \text{ yd}^3\text{/truck} \times 19 \text{ gal/yd}^3 = 285 \text{ gal/truck}$$

For 20 trucks/day would need:

$$20 \text{ trucks/day} \times 285 \text{ gal/truck} = 5700 \text{ gal/day}$$

RECYCLE BOULDER

BACKYARD COMPOSTING

P.O BOX 791 • BOULDER, COLORADO 80306 • 303-441-3090

ACKNOWLEDGMENTS

The following individuals and organizations were critical to the success of the backyard composting program.

City of Boulder Environmental Affairs
Stan Zemler, Director
Alison Peters, Program Coordinator

Boulder Energy Conservation Center
Mona Newton, Director

Boulder County
Debbie Fyffe, Public Works

U.S. Environmental Protection Agency
Judy Wong, Project Director

Neighborhood Leaders
Bob Howard, Composting Seminar Leader
Jack DeBell
Trish Flaster
Suzanne Gripman
Ann Hooker
Deborra Lillard
Mike Lynn
Jan Morzel
Vickie Paulsen
Alison Peck
Amy Weinstein

TABLE OF CONTENTS

Introduction 1

Design and Planning 2

Implementation 4

Program Operation 6

Budget 9

Conclusions and Recommendations 9

Attachments 14

INTRODUCTION

For communities looking for ways to reduce the amount of solid waste going to local landfills, backyard composting is an appealing option. Particularly in areas of the Rocky Mountain region and the Midwest where landfill tipping fees are not yet driving recycling and composting efforts, the cost of municipal composting may be prohibitively high. Backyard composting, by contrast, requires a relatively small investment for long-term reductions in the waste stream. Once residents learn the basic techniques of composting, they become a permanent component of a community's waste reduction activities by diverting organic waste into a high-quality soil enricher.

In 1989, the City of Boulder received a grant from the U.S. Environmental Protection Agency for a pilot municipal leaf composting program. This program, which is documented in a separate report, was successful but relatively expensive on a per-ton basis. In 1991, with a small amount of funding left over from the project, the City launched a pilot backyard composting program.

The pilot program had two goals. First, the City sought to determine whether backyard composting offers a cost-effective alternative to municipal composting. Second, the program was intended to reach residents who may have an interest in backyard composting but not be motivated to pursue it on their own. If the pilot proved to be both cost-effective and successfully draw in new composters, it could be a valuable component of an integrated yard waste composting program.

This report documents the process and results of Boulder's neighborhood backyard composting program. The program did prove to be less expensive than the municipal composting pilot program, and if done on a large scale, could be comparable in cost to local landfill tipping fees. The program was also successful in bringing composting information to residents who had never composted before, but was judged to be a somewhat time-consuming method for reaching these individuals.

For 1992, Boulder is planning an expanded backyard composting program which incorporates a number of modifications to the pilot program. Additionally, the City is planning a pilot program to begin addressing yard waste generated by apartment complexes and commercial sites, and continuation of a fall leaf collection program begun in 1991.

DESIGN AND PLANNING

Before beginning this pilot program, Boulder already had some experience with backyard composting. Beginning in 1989, three City-sponsored composting seminars have been offered each spring. The seminars have been very popular, attracting an average of 80 people per session. A 1991 follow-up survey of 32 attendees of a 1990 seminar showed that 27 had begun composting and were continuing to do so a year later.

Although the seminars appeared to be successful, we were interested in exploring ways to reach residents who might not be motivated to attend a composting seminar, and in developing a framework for a city-wide program. In designing such a project, we relied extensively on the expertise of Seattle and King County, Washington. These two areas were among the first in the country to develop extensive backyard composting programs.

Resources

The specific resources available in Boulder also played a role in project design. Our budget was relatively small, about $8000, so we decided to limit the program to a small number of households. In addition to the services of a seminar speaker who was knowledgeable and articulate, we were also aware of a small group of composters who had been meeting off and on for a year with the goal of promoting backyard composting in the city.

Legal Issues

The City of Boulder has an ordinance prohibiting compost piles from becoming a nuisance due to odors, rodents, or insects (attachment A). This ordinance did not appear to pose any problem for promoting a backyard composting program, as long as participants were informed of how to keep their piles odor-free and how to deter rodents or other wildlife. Staff also checked with the county and state health departments to find out whether composting of kitchen waste is considered a health hazard. At this time, composting of these materials is not regulated or restricted by either Boulder County or Colorado statute.

No other local regulations affect backyard composting. Some communities prohibit the landfilling of yard wastes, but Boulder does not have such an ordinance.

Structure

A neighborhood-based program appeared to be the best way to offer a small-scale project with a high degree of resident outreach. The final plan for the program was as follows:

- The members of the existing backyard composting group, and additional individuals as needed, would receive complete training in composting techniques, alternatives, and trouble-shooting. They would then be designated as "neighborhood leaders."

- Five to seven neighborhoods would be chosen to coincide with the homes of the neighborhood leaders. Surveys would be sent to about 700 residents of these neighborhoods to invite their participation in the project.

- Based on these surveys, with additional solicitation if needed, 100 households would be selected to participate. As much as possible, the participants would be spread evenly across the neighborhoods, with a goal of up to 20 participants in each neighborhood.

- Each neighborhood leader would contact the residents chosen to participate in his or her neighborhood. If necessary, leaders would leaflet door-to-door to solicit additional participants. Residents would be invited to a training session at the leader's home.

- Bin vouchers would be made available for participants to get a $25 discount on composting bins at participating garden supply stores.

- Residents who were interested in keeping detailed records of volumes and types of materials composted would be offered journal sheets, but this would not be a requirement for participation.

- Leaders would follow up on a regular basis with participants to offer encouragement and further assistance.

- The program would be officially in operation for a four-month period, from May through August. After that time, residents could still contact the leaders with any questions or problems.

IMPLEMENTATION

Neighborhood Leaders

A meeting was held with the composting group and several other interested parties, including the local county extension service, to review the proposed program structure. The group was eager to participate, and offered numerous suggestions which were helpful in designing their training program and determining the role they would play for their neighbors.

The group also addressed the feasibility of requiring record-keeping by participants. Initially we had hoped to determine the amount of material being diverted from the waste stream by this project. After much discussion, however, it was decided that it would be difficult to ensure the accuracy of any records kept and that requiring records might discourage some residents from participating at all. Instead, residents would be offered the opportunity to keep records, and neighborhood leaders would attempt to keep some records of their own activity and determine some averages for participant volumes.

Participant Selection

In March 1991, regions around the homes of the neighborhood leaders were mapped, and 740 surveys (see sample in attachment B) were mailed out to residents in seven areas of town.

Survey response was much stronger than anticipated. 281 residents, or nearly 40%, returned the surveys, and 193 respondents, or 68% percent, said they would definitely or possibly be interested in participating (see summary of results in attachment C). To get to the desired level of 100 participants, a follow-up letter was sent (attachment D) to the 123 survey respondents who had indicated that they were not currently composting, but wanted to begin. These residents were told that they had been selected for the program, and that their neighborhood leader would be contacting them shortly.

School Program

One of the members of the composting group was a parent active at a local elementary school. Although she was willing to serve as a neighborhood leader, she proposed an al...native, which was to work with fifth-graders on a composting project. The City purchased a compost tumbler for the school, and the students composted leaves and grass clippings. A presentation was also made to all the fifth-graders at the school about backyard composting. The project was successful in producing compost, and will be continued in future years, with compost going to a school garden to be cared for by students.

Program Kickoff

In April, the neighborhood leaders attended a regularly scheduled composting workshop. Afterward, they met with the compost educator to discuss specific questions and potential problems their neighbors might face. Leaders were offered a slide show (produced by Seattle Tilth) to use in making presentations, and were given a compost thermometer and a binder of information (see summary page in attachment E) about composting techniques. A key component of this binder was the *Master Composter Resource Manual* developed by the Seattle Tilth Association. Leaders were also provided with bin vouchers, journal sheets, and backyard composting brochures for participants.

Each neighborhood leader was asked to confirm twelve to fifteen participants in his or her neighborhood. Leaders were given a list of all survey respondents in their areas, and asked to contact first those who had indicated definite interest. If these residents were no longer interested in participating, the leaders were to contact the next group, those who had indicated possible interest.

Leaders were to invite the participants to a demonstration meeting to train them in basic composting techniques, then follow up with visits and at least one additional meeting to ensure that residents were composting successfully.

Bins

A great deal of discussion and review was devoted to the bins to be used in the program. Staff and leaders considered whether bins should be provided for free or at a discount to residents, and if so what kind of bins should be offered. It seemed likely that different participants would have different needs; some might prefer a closed bin to deter rodents and speed the composting process, others might have a large volume and want no bin at all, and others might prefer to build their own. Based on these considerations, it was decided to offer a $25 voucher and a list of bin options (attachment F) to all participants. The $25 would cover the cost of the two cheapest options, a wire bin or a bin built from pallets. Four local garden supply stores, a national distributor, and a local entrepreneur agreed to accept the vouchers on all the bins they offered. This included the SoilSaver, the compost tumbler, the wire bin, the Green Cone, and the pallet bin.

Publicity

Aside from the surveys, no publicity was planned for the program. Staff was concerned that citywide publicity would trigger calls from interested residents outside the program areas. The local newspaper, however, did pick the program up from some materials sent to the City Council, and ran a short item about it. As expected, we received a number of calls. Callers not in the program areas were offered a composting brochure and information about the regularly scheduled citywide backyard composting seminars.

PROGRAM OPERATION

Participation

Overall participation was lower than expected. As the table below shows, leaders did not reach the full 123 households, but only contacted 91 residents. Of those, 66 attended an initial meeting, and a total of 46 were composting by the time the program ended in August.

Table I
Participation

Neighborhood	*Residents Contacted*	*Attended Meeting*	*Actually Composting*
North I	12	10	5
North II	12	12	8
North III	12	4	4
East	18	10	10
South I	15	11	7
South II	13	11	4
South III	9	8	8
Total	**91**	**66**	**46**

There are several potential reasons for the high attrition rate. In conversations with the neighborhood leaders, a strong correlation appeared between program drop-outs and leaders who reported having become too busy to do much follow-through. Generally, the leaders who put more time into participant recruitment and assistance had the highest levels of participation.

Less easily addressed, however, is the problem of participant commitment. It appears that individuals who fill out a survey form may not think through until later the time and commitment involved in actual participation. Even residents interested enough to attend an initial training meeting ended up dropping out before beginning the actual compost process. This contrasts with the high follow-through rate of individuals who attend the citywide composting seminars, and suggests a difference in attitude between individuals who are acting on their own initiative and those who are solicited by someone else.

In a telephone survey of 37 participants and non-participants conducted at the end of the program, the majority of those who did not participate cited lack of time as the primary reason for not composting. Other reasons given included physical problems, too small a yard, and lack of communication with the leader. (See survey and summary of results in attachment G.)

A further finding of the survey, however, was that several residents who did not participate in the neighborhood program did go ahead and compost on their own after receiving the brochure. These tended to be individuals who were not able to attend the initial meeting. This could add another five to ten residents as "participants" who began composting as a result of this program.

Role of Neighborhood Leaders

Once the leaders had received their training and instructions, staff kept in touch with them by phone and occasional meetings. One leader moved away, but a resident from his neighborhood stepped in as a replacement.

Some leaders, particularly those in the less responsive neighborhoods, found that the time needed to pin down participants was greater than they had anticipated. Extra phone calls and extra meetings for neighbors who could not attend the initial meeting significantly increased the leaders' time commitments. Several leaders who had expected to spend 3-5 hours per month said that to do a thorough job would have required about twice as much time, and due to other obligations, they were not able to put in the additional time. It was suggested that future leaders be told to expect a ten-hour per month involvement for at least the first two months. In retrospect, leaders probably needed clearer instructions about how to handle attrition, lack of time, or other problems connected with getting and keeping participants.

Several leaders also indicated that although they felt knowledgeable about composting, they could have used more training in presentation skills. Respondents to the post-program telephone survey, however, indicated that the training meeting was helpful and informative.

The neighborhood leaders were asked to keep in touch with their groups, making contact with each participant at least once to ensure that things were going smoothly. Leaders used a variety of follow-up methods, including phone calls and visits. One leader held a composters' barbecue at his home.

Participant Reaction

Several participants who needed extra assistance commented that it was helpful to have an accessible source of help and suggestions. Several set up appointments for house visits by the neighborhood leaders.

One unanticipated benefit of the neighborhood program is that it served as a community-building activity. Composting gave neighbors a common interest and a reason to get to know each other. Many participants commented about how much they enjoyed having a chance to talk with people they had seen over their back fences for years. Additionally, during several of the training meetings, the participants broadened the discussion and began exchanging tips on such things as organic gardening and leaving grass clippings on the lawn.

A number of individuals who decided not to compost their yard wastes arranged to give them to neighbors who were composting. The composting meetings clearly established a forum for neighbors to engage in a wider dialogue and greater interaction than they had previously had.

Product and Volumes

Program participants were very successful in getting usable compost from their efforts. Depending on the size of pile, and frequency of turning and watering, some composted faster than others, but no participants reported difficulty in producing compost. Since it was a summertime program, the largest component of most piles was grass, with most participants adding food scraps, leaves, and garden waste.

A few composting problems were reported to the leaders and in the telephone survey. Occasional problems were reported with smells, but more frequent turning and reducing moisture to prevent anaerobic composting solved these. A few participants had animals trying to get into their piles. These were resolved by increasing the heat of the pile with bioactivator and more frequent turning, and by covering it with a layer of grass to reduce the food odor. Several participants who set up compost piles smaller than the recommended one cubic yard reported low temperatures, but eventually were successful in getting compost.

Volumes of organic matter diverted from the waste stream by backyard composters are notoriously difficult to measure. A few participants kept journals recording the volume of waste composted, or reported volumes to their neighborhood leader. As expected, volumes varied depending on the size of household, size of yard, and participant interest. Participants' estimates of composted kitchen waste ranged from half a gallon per day to 1 gallon a week. Average yard waste was two bags per week, primarily of grass.

The average of total recorded volumes was two to three cubic yards of material, or just over one ton per household. This estimate is somewhat higher than figures used in Seattle. The Seattle Public Works department has been conducting a study of 31 self-selected households, and finding that on average, each household composts about 850 pounds of material per year. Seattle officials have been using 400-600 pounds per household as a conservative average over all participating households. The higher Boulder estimate may be due to the fact that residents with smaller piles were less likely to keep records.

Bins

As it turned out, residents were less concerned about their bins than were the program organizers. Only seventeen vouchers were redeemed. The majority of participants simply piled up the compost, while a few built their own out of materials ranging from scrap wood to sod. The small number of bins purchased may have stemmed partly from the orientation of the compost educator, who stressed that composting could easily be done with no bin.

BUDGET

The pilot program was funded by $6,775 in grant money left over from an EPA-sponsored pilot leaf composting project. The City of Boulder contributed $1,225 (in-kind staff time), for a total budget of $8,000.

Item	*Amount Spent*
Survey mailing	$ 350
Materials and supplies	675
Leader training	125
Bin vouchers	425
City staff time (50 hours)	1,225
Work contracted out (225 hours)	5,200
Total	$8,000

CONCLUSIONS AND RECOMMENDATIONS

The backyard composting pilot program demonstrated that a neighborhood outreach program can bring composting to a fairly broad audience. Individuals who had never composted before learned the techniques they needed to turn their yard and kitchen waste into compost, and all indications are that these residents will continue to compost indefinitely.

The pilot program ended up costing approximately $160 per successfully composting household. However, this cost would be substantially reduced in a larger-scale program. For the pilot program, the number of neighborhoods and participants was intentionally limited. The cost to add neighborhoods to the program would be quite low, since the majority of the additional work would be done by a volunteer neighborhood leader and the main added cost would be for bins. Increasing the size of the program to 500-1000 residents would bring costs down to an estimated $15-20 per participating household.

Even assuming that the average composter diverts only a quarter-ton per year, backyard composting can be continued for many years with no further investment by the sponsoring organization. Thus a backyard composting program can be cost-effective even when compared to the low landfill tipping fees of the Rocky Mountain region. Compared to municipal composting, which is estimated to cost over $100 a ton based on Boulder's pilot program, backyard composting is clearly a less costly diversion method.

The least expensive option in Boulder remains citywide backyard composting seminars. These cost about $350 each to put on, and reach about 80 people each, of whom an estimated 80% follow through. However, one of the initial goals of the neighborhood pilot program was to reach beyond those residents who were already motivated enough to attend a composting seminar. While there will always be a core of residents who will take the initiative to learn about backyard composting on their own, involving the rest of the population requires greater outreach efforts.

A neighborhood program is one way to bring backyard composting to a broader audience. Other options which have been tried elsewhere include a composting hotline, a volunteer master composter program, or a free bin and demonstration by a trained staff person. For a small amount of money, a volunteer-based program is a logical way to expand. The program developed for the City of Boulder has both benefits and disadvantages. These are outlined below, along with specific recommendations.

Use of Volunteers

Enthusiastic volunteers can be a real asset in convincing residents that composting is simple and non-technical, not for experts only. However, as with any volunteer program, two caveats should be kept in mind:

Train volunteers well. Establishing a Master Composter program, as has been done in Seattle, King County and San Francisco, is probably the best way to ensure that volunteers are thoroughly trained and comfortable with composting and training techniques. Boulder will be working with the county extension service next year to develop a more extensive training program for future volunteers.

Devote enough time to volunteer coordination. Making sure that volunteers have all the information they need, are clear about what is expected of them, and are successfully working with residents, is a big job. A volunteer coordinator needs to maintain close contact with the volunteers to keep the program on track. In the Boulder program, we learned after the fact that not all the volunteers knew of all the resources (e.g. the slide show) available to them, and that others were feeling overburdened by unsuccessful efforts to recruit participants.

Neighborhood Outreach

While Boulder's neighborhood outreach program did serve a population that might not otherwise have begun composting, such outreach has its drawbacks. Chief among them is the effort expended to interest citizens who end up not following through with composting. The 50 percent dropout rate in the City's program is likely to be typical even for people who say they want to participate.

There are two ways to address this problem. First, require a significant initial commitment. Residents could be invited to come pick up a bin, a bin voucher, or attend a seminar, rather than just filling out a survey form. Second, minimize staff and volunteer efforts to recruit lukewarm residents. Our volunteers made multiple phone calls to a number of residents who didn't plan to follow through. Even in an outreach program, the focus should be on those who really want to compost. If it is hard to locate participants, then more aggressive promotion may be needed, but start with the enthusiastic individuals.

The neighborhood approach made it possible to target a small pilot area and it clearly gave participants a sense of greater connection with their neighbors. But it requires that a leader be available and trained for each neighborhood, which may not always be feasible. As an alternative, the City experimented with holding the regularly scheduled composting seminars in different areas of the city. However, it appeared that residents attended the seminar that fit their schedule rather than the one closest to them. The best solution may be to have a pool of trained "master composters" who can provide assistance throughout the city, but to attempt as far as possible to match them with residents in their area.

Bins

The bin voucher system that Boulder offered was one solution to a series of complex and often conflicting questions that will face any backyard composting effort. These include:

- Do participants really need bins? (to prevent wildlife from getting in the bin, to comply with local regulations, etc.)
- Do they need a specific type of bin? (e.g. rodent-proof with locking lid)
- Will providing bins be a significant incentive for participants to begin composting?
- What can the program afford to provide?
- Does providing bins create difficulties for the program? (lack of storage space, bookkeeping, competition with local retailers, etc.)

Based on these issues, we believe the voucher system was the best solution for Boulder. It offered participants choice, utilized existing retailers, and ensured that we stayed within our budget without limiting participants to a particular bin. It probably did not provide as much of an incentive to begin composting as handing out physical bins would have. On the other hand, as was emphasized in the training meetings, for many residents bins are not necessary.

Legal Issues

Boulder's minimal nuisance-avoidance law on composting has served the community well, and has only rarely been invoked. We would caution other communities against enacting overly restrictive backyard composting ordinances, as these may tend to discourage composting.

An ordinance prohibiting yard waste from being landfilled, however, would be a strong incentive for backyard composting, and might encourage residents who would not otherwise begin composting to consider doing so.

Record-Keeping

Backyard composting volumes are difficult to track. Quantities are highly variable from one household to the next, and the lack of standardized containers for kitchen and yard waste makes it difficult to assess volumes even within a household. Unless a small study group is willing to keep careful records, it may be necessary to rely on very general estimates.

Backyard Composting in Context

Clearly, backyard composting can play an important role in a community's integrated waste management plan. Depending on how it is presented, backyard composting may serve other community goals, such as greater neighborhood cohesiveness, promotion of organic gardening, and greater awareness of recycling and reuse opportunities.

Communities should be aware, however, that backyard composting is not for everyone. Most of the participants in Boulder's pilot project wanted to compost because they were gardeners who had a use for the end product. Some of those who did not participate cited health or lack of physical strength as a problem. Apartment dwellers are another large group for which backyard composting may be difficult or impossible.

Organizers of any backyard composting efforts need to be aware that lack of interest or opportunity will always limit the total pool of participants. If municipal composting is not an option, community composting projects or other larger-scale composting activities, such as apartment complex composting will be necessary to bring composting opportunities to the entire community. As discussed below, several such initiatives are being considered in Boulder.

The Future of Backyard Composting in Boulder

For 1992, Boulder is developing an expanded backyard composting program with a variety of the features discussed above. These include:

- A Master Composter training module in the Master Gardener program run by the County Extension Service. Master Composters will be assigned a region near their homes and will be referred calls from this region.

- A composting hotline offering residents a brochure and/or a personal visit by a Master Composter. Depending on funding, bin vouchers may also be made available.

- A small bin-testing/volume record-keeping program. Residents who wish to test a particular type of bin and keep track of their compost volumes will be solicited through the newspaper.

- Development of a community demonstration composting site. Community Food Share, a local nonprofit organization, has applied for a grant to do a large composting program. In exchange for some technical assistance from the City in setting up their site, they will provide volunteers to help maintain the demonstration site at the local community garden.

- Expansion of work with schools. The parent who worked with the fifth-grade class in 1991 wants to use volunteers to build gardens to be cared for by the students. Composting will be a part of the gardening program. Other teachers have expressed interest in having classroom worm bins as class projects.

- Apartment complex composting pilot. Several local complexes have expressed interest in composting yard wastes. The City will look for an appropriate site to develop a replicable, self-sustaining composting pilot program for apartment buildings. If successful, this pilot could also be used for commercial buildings.

Backyard composting is an important part of Boulder's integrated waste management efforts. Clearly, it is not a complete solution to the yard waste program, but given its low cost, it will be one of the most vigorously pursued alternatives for the near future. Community composting programs and continuation of the 1991 leaf collection program, in which leaves were tilled into the soil at a local farm, will also be high priorities.

b) mercial or industrial establishment shall fail to dispose of garbage frequently enough so that it does not putrefy on the premises.

6-3-4 Garbage Containers Required.

(a) No owner or occupant of any single-family dwelling; owner or manager of any multiple-family dwelling or private club, or owner, operator, manager, or employee of any commercial or industrial establishment shall fail to provide at all times one or more garbage containers on such premises, of a size sufficient to accommmodate the regular accumulation of garbage from the property.

(b) No owner or occupant of any single-family dwelling; owner or manager of any multiple-family dwelling or private club; or owner, operator, manager, or employee of any commercial or industrial establishment shall fail to secure garbage containers on the premises so that they are not spilled by animals or wind or other elements

6-3-5 Storage and Screening of Garbage and Rubble.

(a) No person shall store garbage except in garbage containers.

(b) No person shall store or locate garbage in plastic bags in alleys.

(c) No person shall store rubble in such a manner as to constitute or create a fire, health, or other safety hazard or harborage for rodents.

(d) No owner or occupant of any dwelling in a MR or HR zone shall fail to screen from view of the street any garbage, garbage container, recyclable materials, or rubble stored on the premises that such person owns or occupies.

(e) Nothing in this section shall be deemed to prohibit any person from keeping building materials on any premises before or during the period of active construction pursuant to a city building permit under Chapter 10-5, B.R.C. 1981, nor to prohibit any person from storing any materials used in the operation of a business located in a zone allowing such use.

6-3-6 Compost Piles Permitted if not Nuisance.

(a) The occupant or owner of any single-family residence and the owner, manager, or operator of any multiple family residence or private club may maintain compost piles that are separated areas containing alternate layers of plant refuse materials and soil maintained to facilitate decomposition and produce organic material to be used as a soil conditioner

(b) No occupant or owner of any single-family residence or owner manager, or operator of any multiple-family residence or private club shall fail to prevent a compost pile from becoming a nuisance by putrefying or attracting insects or animals

6-3-7 City Manager may Require Property Occupant or Owner to Remove Garbage or Compost.

(a) If the city manager finds that any garbage, rubble, or compost exists on any property in violation of this chapter, the manager shall, in addition to any other action permitted under this code, request that the owner and the occupant, manager, operator, or employee obligated under Section 6-3-3 through 6-3-6, B.R.C. 1981, comply with the requirements of this chapter to correct the violation.

(b) The city manager shall notify the owner and the occupant, manager, operator, or employee as prescribed by Section 6-3-3 through 6-3-6, B.R.C. 1981, for the property in question, that such persons have a time to make such corrections determined by the manager to be reasonable under the circumstances, but in no event less than seven days from the date of the notice. Notice under this subsection is sufficient if it is hand delivered or deposited in the mail first class to the last known owner of the property on the records of the Boulder County Assessor and to the last known address of the occupant, man-

CITY
OF
BOULDER

OFFICE OF ENVIRONMENTAL AFFAIRS

March 7, 1991

Dear Resident,

This spring, the City of Boulder is sponsoring a pilot project on backyard composting. Your neighborhood has been selected as a possible site for this project. Before a final choice is made, we need to determine the level of interest in composting in your neighborhood.

As a first step, we would appreciate your sending back the attached survey. Even if you are not interested in composting, we would like to receive your response. These surveys will help us determine the role that backyard composting should play as part of the city's overall Recycle Boulder program.

If selected for the program, your neighborhood would receive the following services:

- A Neighborhood Leader will conduct a backyard composting workshop to demonstrate composting techniques.
- Participants who want composting bins can purchase them at City-subsidized rates.
- Participants will be asked to maintain basic records about their composting activities.
- The Neighborhood Leader will be available for the next six months to assist with any problems or questions that participants may have.

Both new and experienced composters are welcome to participate. If you would like to receive more information about the program, please indicate your interest on the attached survey. **Please return the survey by March 25.**

Thank you for your assistance! We hope to hear from you soon.

Sincerely yours,

Stan Zemler

Stan Zemler
Director

POSTOFFICE BOX 791 • BOULDER, COLORADO 80306 • TELEPHONE (303) 441-3090

CITY OF BOULDER
BACKYARD COMPOSTING SURVEY

Compost is a dark, crumbly and earthy-smelling form of decomposing organic matter. It is made by piling yard, kitchen and other organic wastes in a way that allows naturally occurring microorganisms to break down materials into humus, a type of soil.

1. Do you compost now? _____YES _____NO

2. Do you garden? _____YES _____NO

3. How many bags of the following do you generate each week? (During growing season or year-round)

   ____ Leaves ____ Grass clippings ____ Garden waste ____ Kitchen scraps

4. If you do compost now, please estimate the amount of material you put into your compost pile each year:

   ____ Less than 1 cubic yard ____ 1-2 cubic yards ____ More

5. I would be interested in composting if it could:
   (Check all that apply)

   _____ Improve my garden soil
   _____ Save money on trash bill
   _____ Help protect the environment
   _____ Be used to mulch trees and bushes
   _____ Be low-maintenance

6. If you do not compost now, which of the following is an obstacle? (Check all that apply)

   _____ Lack of time
   _____ Lack of space
   _____ Landlord won't allow
   _____ Too physically demanding
   _____ Lack of interest/too much trouble
   _____ No use for compost
   _____ Problems with wildlife
   _____ Not sure how to do it
   _____ Other:____

7. **Are you interested in participating in the City's pilot backyard composting program?**

   YES, send info **MAYBE, please send info** **NO**

8. If you do not want to compost, would you be willing to give your yard wastes to neighbors who do compost?

   _____ YES _____ NO

Name:

Address:

Phone:

Return to: **Environmental Affairs**
City of Boulder
P.O. Box 791
Boulder, CO 80306

By 3/25

RECYCLE BOULDER • P O BOX 791 • BOULDER COLORADO [illegible]
HOTLINE 303-441-4234

April 12, 1991

Greetings:

Thank you for responding to the composting survey. You have been chosen to participate in the City of Boulder Pilot Backyard Composting Program. Over 20 percent of the surveys we mailed out were returned. We are pleased that so many citizens are interested in composting. The high response rate will enable us to work with a total of 100 people who have not previously engaged in backyard composting.

The purpose of this city-sponsored pilot program is to find out how backyard composting works for citizens, which composting bins work best and what kind of problems might arise.

Here is how the program will work:

1) Contact from the Neighborhood Leader/Neighborhood Meeting.

One or two people in your neighborhood who have been successfully composting for several years will hold a neighborhood training session to present information about composting and answer questions. The leader will be contacting you after Saturday, April 13 to set up a meeting with you and the other people in your neighborhood who are going to participate in this program.

The neighborhood leaders will be available over the next six months to answer questions, troubleshoot and provide more information. They will be checking in with you periodically to see how things are going.

2) Purchase/build a compost bin.

In order to allow participants to experiment with several composting bins, we have made arrangements with several retailers that sell compost bins to offer a discount to you, if you are interested in buying a bin.

As a participant, you will receive a voucher that can be redeemed for a discount on a compost bin. The following retailers are participating in the program:

McGuckin's
The Flower Bin in Longmont
Sturtz & Copeland
Western Field Services
The Green Cone

3) Compost your yard wastes and food wastes, if you desire, during the summer and into the fall.

4) Track your progress, problems and volumes. We will provide you with a sheet so that you can keep a journal of your composting experience. *This would be helpful for us to get a sense of the* volumes that can be diverted from the landfill, how the city-sponsored program works and the success rate of the neighborhood leader idea.

If you have any questions, please call your neighborhood leader or Mona Newton at the Boulder Energy Conservation Center (BECC) at 441-3278.

Good luck and we hope you end up with a good final product that not only enriches your soil, but helps to keep recyclable nutrients out of the landfill.

Sincerely,

Stan Zemler
Director
Environmental Affairs

Neighborhood Leader
____________________ Phone
______________________Best times to call

RECYCLE BOULDER • P O BOX 791 • BOULDER COLORADO [illegible]

HOTLINE 303-441-4234

April 12, 1991

To: Backyard Compost Leaders

Thank you for volunteering your time to help educate your neighbors about backyard composting. We hope this pilot program will be a success and the end result will be 100 piles of finished usable compost.

Binder Contents

This binder has four pieces of information: the compost brochure, the Seattle Tilth Master Composter Resource Manual, two articles, *Cultivating Virtue* and *Recycle Your Garbage With Worms* and a sheet to help you troubleshoot problems. If there are other articles or pieces of information that you find helpful, please share them with us and we will send them out to the other Neighborhood Leaders.

Survey Status

We have received over 100 surveys from people who want to participate in the backyard composting program. Respondents have been separated into three categories in order of priority to participate in the program. The first category, which is the highest priority, consists of those people who currently don't compost and want information. The second category consists of those people who don't compost and "maybe" want information, and the third category consists of those people who do compost and want information about the program.

From thess categories we have developed a list of the names, addresses and phone numbers of those who fall into the first and second categories. The folks in the first category will receive a letter telling them that they have been selected to participate, about the program and how it works, a copy is enclosed.

Those in the "maybe" category will get a letter telling them that they are wait listed in the event we don't get enough participants the first time around.

Contacting Participants

Please contact the people first who fall into the first category and verify that they are going to participate in the program as it is designed. If they don't want to participate, please contact the next group and so on until you have at least 10 participants. We would like to work with at least 100 people for this pilot program, therefore, if you are unable to recruit at least 10 people, please let me know as soon as possible and we will work with you to recruit more people.

Once you have confirmed all the participants, schedule a meeting with the group to discuss the how-to's of composting. This can be anytime from April 13 through May 30.

Bins

Rather than selling compost bins through the BECC, we are arranging, through the retailers, a discount on compost bins for the participants who want to purchase a bin. The participants will need to present a voucher issued by the City of Boulder in order to receive this discount. The voucher can also be used at Sutherland's Lumber to be used toward the purchase of lumber to build a bin.

I will send the vouchers to you to distribute to those people who plan to buy a bin.

Information Tracking

As we discussed at the first organizational meeting, we would like to track information regarding the quantities of yard waste composted, problems, questions, etc. Included are some forms to help the participants or you to keep a "journal" that will help us learn about the different experiences people have. If some participants are really interested, have them keep detailed records. For all others, you can visit with them monthly and roughly track volumes, etc.

Call Mona Newton, at 441-3278 if you have any questions or comments.

Sincerely,

Stan Zemler
Director
Environmental Affairs

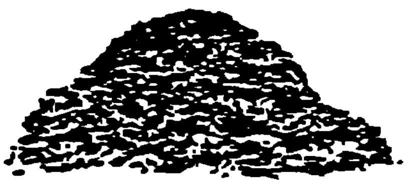
enclosure

WHICH COMPOST BIN IS BEST FOR YOU?

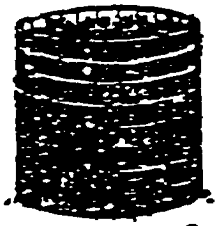
We want you to be able to decide which compost bin will work best for you. There are many bins available to choose from, but not all are appropriate for you. We've designed a checklist to help you.

	1	2	3	4	5
Price--under $30	x	x			
Price--over $30			x	x	x
Easy access for use	x	x	x	x	x
Contain compost		x	x	x	x
Keep out animals			x	x	x
Lots of waste	x		x		
Make fast compost	x	x	x	x	
Want to Build your own			x		

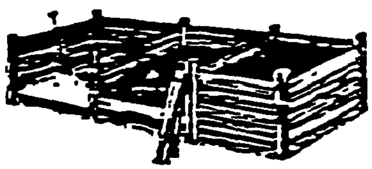
1
No Bin



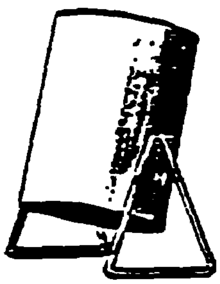
2
The EZ-Compost Bin



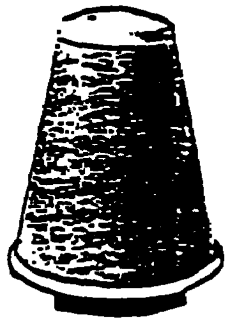
3
Hand Crafted
Turning Unit



4
The Compost Tumbler



5
The Green Cone



NAME OF PERSON:

1. We have you down as having returned a survey in the spring saying you were interested in participating in the City of Boulder's backyard composting pilot program. Is that correct?

2. Did you end up participating in the program? If not, why not?

3. Were you contacted by a neighborhood leader? By phone? By letter? By visit?

4. Did you attend a training seminar? How was it? (If did not attend, why not?) (unless answered in #2)

Following questions only for those who participated:

5. Did you buy a bin? If so, what type; did you use a bin voucher? If not, why not?

6. How did the composting go? Any problems? How was the final product?

7. Can you estimate the volume of a) kitchen waste; b) yard waste?

8. Did the leader follow up with you, check in to see how things were going?

9. Are you continuing to compost? If not, why not?

10. What did you think were the best and worst parts of the program? Do you have any suggestions for improving the program in future years?

Following question for those who did not participate:

11. Do you have any suggestions about what we could have done to make it easier for you to participate?

BACKYARD COMPOSTING SURVEY TABULATION All neighborhoods: 37 responses

Quantitative Questions

Question	yes		no	
participate?	15	40%	22	60%
leader contacted?	32	86%	5	14%
attend seminar?	17	46%	20	54%
buy bin?	5	14%	32	86%
composting problems?	4	(4/15=26%)	11	(11/15=73%)
leader follow up?	11	(11/15=73%)	4	(4/15=26%)
still composting?	13	(13/15=86%)	2	(2/15=13%)

Qualitative Questions
Question

Why didn't participate?

lack of communication w/ leader	4	disability	2
too busy/too time-consuming	5	animals in pile	1
yard waste not compostable	1	composted on own	2
couldn't commit/attend seminar	5	out of town	1
yard too small	1	personal	1

Rate training seminar

great	12	mediocre	2

Use bin voucher? 4

People who were not formal participants in the program, but composted on their own: 4

Participants' comments:

1)	need more focus on building own bins, less on types to buy	1
2)	cooperative purchasing/sharing bins for those without fenced yards	1
3)	instruction should include how composting can be tidy	1
4)	people should be able to participate even though their neighborhoods weren't selected to be in program	1
5)	had trouble using voucher at retailer	1
6)	need more info on other composting products	1
7)	need more leader contact	2

Comments on the best part of program:

good info was supplied
people started composting who never would have otherwise
provided alternative to throwing stuff away
leader's BBQ was informal and encouraged discussion
meeting with neighbors was helpful to discuss experiences

Comments on the worst part of program:

everything was too time-consuming
kitchen scraps smelled up house until special container was found
hard to get results from a low volume of material

Suggestions for improvement:

organize swapping network with neighbors to improve mixture
more detailed info for beginners including knowing when compost is done
try to increase participation

Comments on ways to make it easier for people to participate:

make program less time-consuming
advertise program more
leader should make personal visits to people's homes
have meetings on weekends as well as weekdays
leader should follow up on those who don't attend first meeting
offer varied times for training seminar
provide info for those who don't want to attend training seminar but who want to compost
give people a contact person from the beginning
provide schedule of possible meeting times well in advance
give participants access to variety of composting materials
don't have meetings at confusing places like the University of Colorado

Leaf Compost Program

Falls Township, Pennsylvania

This report was reproduced as part of ICMA's EPA-funded environmental programs.

Distributed by
Research and Information Services
ICMA
777 N. Capitol St., NE, Suite 500
;hington, D.C. 20002-4201
:ARINGHOUSE REPORT #40375
1/90

TABLE OF CONTENTS

1.0 Declaration of Program

2.0 Collection Methods

- 2.1 Collection Machines
- 2.2 Collection Regulations
- 2.3 Collection Routes
- 2.4 Designation of Collection Period
- 2.5 Program Public Notification
- 2.6 Delivery to Compost Facility

3.0 Compost Facility Operations

- 3.1 Facility Description
- 3.2 Compost Facility Operator
- 3.3 Site Security
- 3.4 Operating Hours
- 3.5 Site Operations
- 3.6 Windrows and Compost Piles
- 3.7 Water Supply
- 3.8 Sedimentation and Erosion Control
- 3.9 Facility Maintenance
  - 3.9.1 Residual Waste Disposal
  - 3.9.2 Hazardous Waste Disposal
  - 3.9.3 Fugitive Dust Control
- 3.10 Emergency Response
- 3.11 Alternate Facility

4.0 Processing

- 4.1 Turning Frequency and Method
- 4.2 Determination of Water Application
- 4.3 Lime Application
- 4.4 Facility Inspections
- 4.5 Curing Duration
- 4.6 Proposed Distribution of Compost

5.0 Safety

- 5.1 Personal Protective Equipment

TABLE OF CONTENTS

5.2 Safety Practices
5.3 Training
5.4 Medical Examinations

ATTACHMENTS

FALLS TOWNSHIP LEAF COMPOST PROGRAM

1.0 DECLARATION OF PROGRAM

The Township of Falls Board of Supervisors hereby establishes phase III of the Falls Township Recycling Plan to provide a curb side collection and compost program for residential leaves within the boundaries of the Township The Board's establishment of this program demonstrates their commitment to comply with the Governors initiative to promote recycling and source reduction of Pennsylvania's Solid Waste under the provisions of Act 101.

Beginning October 30, 1989, Falls Township will start collecting leaves from residences required to separate designated recyclables from their normal trash under Falls Township Ordinance 180 subsection 3 (see attachment 1). This program will offset the promulgation of Act 101 sec.1502 (a) which prohibits Municipal Solid Waste disposal facilities from accepting leaf waste for processing or disposal, other than composting, at their facilities

Leaves will be collected and processed by Falls Township employees only. All leaves that are collected will be transported to the Falls Township compost Facility or our designated alternate facility. The cured compost or humus will be distributed back to the residents or other specific designated facilities the spring following collection. Specific collection routes, schedules, and compost facility operation regulations are further contained in this manual.

2.0 COLLECTION METHODS

The collection methods employed by the Township for this program were mutually developed by the Public Works department, the Environmental department and the Manager's office. These methods are designed to achieve the following program goals and objectives:

a.) The program must be easy for participating residents to follow. This will enhance the performance of the program overall, helping us to meet our solid waste reduction objectives.

b.) The program must be carried out in an efficient, professional and safe manner at all times. Meetings with workers representatives to gain operators input is vitally important to successful program development. Periodic updates to this manual will reflect the changes and development of our Program in order to achieve our goals and objectives.

c.) Our collection methods must take into consideration the environmental integrity of our compost site and operations as well as the quality of our final product. Collectors must ensure that items not intended for the compost pile are not picked up.

d.) Our collection methods are designed to ensure the protection of our leaf collection and composting equipment and the personnel who use them. Our collection machines can easily be damaged when our regulations are not followed properly. This can result in increased cost for the Township and unnecessary delays on collection routes.

2.1 COLLECTION MACHINES

Falls Township will employ the use of the Giant Vac 6800-TR-20 Trailer Mounted Leaf Collector vacuum machine as the method of the curbside collection. Five - twenty yard collection machines have been purchased for this program. We will use three to four men to man the operation of the collectors - 1 driver, 1 hose operator and 1 to 2 men to rake the leaves into position Residents will be required to rake their leaves to the curb side at specific times during the program, where the collection crews will use the vacuum unit for the picking up the leaves.

2.2 COLLECTION REGULATIONS

The residents included in this program will be required to follow the collection regulations set forth by the Township. These regulations will be prominently displayed at the Township Municipal Building and advertised in accordance with section 2.5 of this manual. Enforcement of these regulations will be in accordance with Township Ordinance 180 subsection 6 (attachment 1).

These regulations are as follows:

a.) Residents will be required to rake their leaves to the front of their yard piling the leaves **between the curbside and two (2) feet** in from the curb. The leaves should be placed at the curb earlier than one week before pickup.

b.) **Residents may NOT rake leaves into the street at any time!** This can cause; fire hazards when cars park on them; undue traffic hazards and slippery or icy conditions on road surfaces; and potential flooding conditions in the Township storm drains.

c.) **ONLY LEAVES** are included in this program. The Township will **NOT** accept grass clippings, branches, brush, or any food, garbage or trash.

d) Leaf collection equipment will be in each section every other week according to the schedule distributed Collection machines will follow the designated routes and will not return to those sections until its next scheduled pickup

e) There will be **no curbside parking** allowed in the sections scheduled for pickup between the hours of **7 a.m. and 5 p.m.**

f) Daily schedule changes and program information will be available by calling the **Township Information HOTLINE at 736-2210**

2.3 COLLECTION ROUTES

Program collection routes and schedule dates have been posted and advertised in accordance with section 2 5 of this manual The Township has been divided into ten different sections, two sections for each of the five collection machines. Each section is expected to take one week to complete Each machine will alternate between their two sections every week from the start of the program until its completion . The program will typically run from the end of October Through the end of December

Each collection team will be required to keep in periodic contact with the base station during the collection program. This is essential to achieving maximum efficiency during the collection period. **Each team must check in with the base at the following intervals: 1. When arriving at the collection site; 2. When leaving the collection site to dump a load of leaves; 3. When arriving at the compost site; 4. When leaving the compost site; and 5. When arriving back at the collection site**

The Public Works clerk will prepare a daily bulletin ,which must be in the Manager's Office by 8:30 a.m. the following day, describing the progress of work (streets) completed and streets scheduled for the next day. This information will be integrated daily into the announcement/information HOTLINE by the Public Works Clerk. The Public Works director will use this information to make the necessary adjustments to collection routes and schedules.

2.4 DESIGNATION OF COLLECTION PERIOD

The collection period will be determined each season by the Public Works Director. The beginning of the collection period will depend on weather conditions, scheduling of other events, and other operational considerations. **In any case, due and proper notice will be given to the Township residents.** The completion of the collection period will more greatly depend upon weather conditions. The Director will always take into consideration **the safety of the collection teams and the protection of the collection equipment first.**

2.5 PROGRAM PUBLIC NOTIFICATION

The program notification will be accomplished by a variety of methods. There will two separate notices placed in the Bucks County Courier Times, our local newspaper, prior to the start up of the collection period. Additionally, we have used various broadcast media, fliers, posters and posted notices at the Township Municipal Building to make the public aware of our program. We have also set up an information HOTLINE to aid in this program. The HOTLINE is an announcement machine during business hours to give the public information on collection routes, regulations and other recycling events. After hours the machine will be additionally equipped to take messages.

Lastly, we have developed a Recycling Workshop Program for residents to ask questions, offer comments and generally learn about recycling. We have incorporated the leaf program into this agenda. Three work shops have been scheduled for 1989 and will be conducted by the Environmental Department.

2.6 DELIVERY TO COMPOST FACILITY

Each truck load of leaves collected during the program will be delivered to the Falls Township Compost Facility or a designated alternative facility.

When the collection team has filled the vacuum machine and is ready to depart the collection site, radio checks must be made with the base station as per Section 2.3 of this manual. At this time a facility will be designated for the delivery of that truck load of leaves.

When a collection crew is arriving at the compost facility, they must check their load with the facility attendant. **At all times the collection team is at the compost facility they must comply with the operational and safety practices in place at that facility.** In the case of the Falls Township Facility, the team must remain compliant with Chapters 3 and 5 of this manual.

3.0 COMPOST FACILITY OPERATIONS

At the inception of this program in 1989, Falls Township successfully set forth to own, operate and maintain a compost facility within its boundaries. The facility will be used exclusively for the purpose of storage, curing and distribution of vegetative material, including residential leaves, garden residue, and chips shrubbery and tree trimmings. **This facility will not be used for composting grass chippings, sewage**

sludge, or other solid or hazardous waste materials.

The facility operations and practices are contained in the following sections of this chapter All facility operations shall maintain compliance with the Pennsylvania Department of Environmental Resources Municipal Waste Management Regulations under Section 281.2 of that code

3.1 FACILITY DESCRIPTION

Falls Township has required an approximate four and one half (4 1/2) acre site located on Tyburn Road east of Route 13 The site lies behind three (3) currently occupied industrial properties and adjacent to a Warner Co. quarry lake. The property is bound by the lake and berming to the South and a natural berm and tree barrier to the West. The composting operations will be conducted in a two and one half (2 1/2) acre area of level ground with these boundaries . There will be an office trailer and portable sanitary facilities located on site during the collection season.

3.2 COMPOST FACILITY OPERATOR

The compost facility will be operated and maintained by the Township Public Works Department. The Director of Public Works, hereafter called the Director, or his designee shall ensure that this facility is in compliance with all Federal, State and local regulations during the entire course of its operating life. **The Director is empowered to make any necessary changes in operating procedures or practices that he deems necessary to improve the safety, environmental integrity or efficiency of the operation of this facility within the boundary of compliance so noted above.** This manual will be updated periodically to reflect these changes.

3.3 SITE SECURITY

The operating portion of this facility will be secured from vehicular entry during all non operating hours. The site is naturally bounded on the South and West. The Township will maintain a six foot high fencing on the property border securing the remaining two sides of the site.

During operating hours an attendant will be on site to restrict unauthorized entry. **Only Falls Township vehicles shall be allowed to access this site at any time.** This site will be inspected once a week, or as determined by the Director, during non operating periods.

3.4 OPERATING HOURS

This facility will be open for operation during the leaf collection and the distribution of compost periods only. The only other times the site will be occupied are during periodic security and maintenance inspections and during the turning of the windrows.

A sign will be posted at the facility entrance road and front gate showing the Township's name, address, telephone number, emergency phone number and facility operating hours). Normal hours of operation during the collection season will be from 7 A.M. to 5 P.M., Monday through Friday.

3.5 SITE OPERATORS

The facility will be manned by two operators during the periods of collection. The **facility attendant** will check in or accept deliveries to the facility from the collection teams. He will maintain a record of each delivery showing the time of arrival, the amount of the load, the vehicle number and the time of departure. This daily record will be turned in at the end of the operating day to the Director.

The **windrow operator** will maintain the compost piles in accordance with Section 3.6 of this manual. It will be this operators responsibility to maintain the environmental condition of the facility and to perform quality control checks on the incoming material. Any discrepancies found in the material received shall be reported to the Director. Proper corrective actions must be taken in accordance with Section 3.9 of this manual.

3.6 WINDROW AND COMPOST PILES

The facility shall utilize windrows or compost piles when storing or curing the leaf waste on site. The windrow operator shall construct and maintain these piles to the following specifications within 2 days after acceptance at the facility:

a) Compost piles or windrows shall be maintained to a dimension of between six (6) and eight (8) feet in height and twelve (12) to sixteen (16) feet in width.

b) Windrows shall be constructed perpendicular to the ground surface contour.

c) At no time shall there be stored a greater volume than 3,000 cubic yards of compost material per acre. The volume of material stored on the site shall be measured every week, or as determined by the Director, to ensure this condition is met.

The windrow operator shall also ensure that the moisture and sedimentation and erosion controls are maintained in accordance with Section 3 7 and 3 8 during the construction and maintenance of the compost piles.

3.7 WATER SUPPLY

The facility is located adjacent to a quarry lake to its South side. This will be the facility's principal source of water for the compost operations and emergency response.

A portable pump and housing will be utilized to deliver the water to the operation area. The compost piles must be maintained at an optimum moisture content during the curing period (approximately 50%) The windrow operator will wet the compost piles when turning the windrows in the curing season. Additional moisture content control will be conducted under the supervision of the Director.

3.8 SEDIMENTATION AND EROSION CONTROL

The facility shall maintain the sedimentation and erosion control plan as submitted in the Bucks County Soil and Conservation District application . The Director shall submit any change or updates to this plan to the appropriate agencies when applicable.

3.9 FACILITY MAINTENANCE

The facility operators shall maintain the facility in a neat and orderly fashion during all hours of operation. Daily checks must be made on the following areas:

a) Facility grounds are to be checked for residual waste or dumping. Any leaf waste which may have inadvertently blown from the operaing area must be collected.

b) The office trailer and sanitary facilities must be well maintained and presentable. "Clean As You Go".

c) All equipment should be properly stored and cleaned after use.

d) Landscaping and signs should be checked for damages. Report any damages to the Director immediately.

e) The roadway should be free of litter or trash. On muddy days, wash down or turn the stone drive.

Any long term maintenance problems should be reported to the Director. This may include fence damage, rodent problems, drainage problems, water damage, vandalism, etc.

3.9.1 RESIDUAL WASTE DISPOSAL

All residual wastes will be separated from compost area and properly disposed of at the G R O.W.S Landfill on Bordentown Road in Morrisville.

3.9.2 HAZARDOUS WASTE DISPOSAL

The only chemicals stored or entering this facility is the lime used in the composting process. In the event that an unknown or suspicious container or substance is found during operation of the facility, the facility operator(s) must contact the Director and the Environmental Officer immediately **All operations should cease until the determination of safe conditions is made by the Director and Environmental Officer.** The Environmental Officer shall take the necessary steps to determine the hazardous conditions and the appropriate corrective actions to employ. These may include, but is not limited to, sampling and performing appropriate analyses, determination of best disposal methods, decontamination of contacted equipment, removal of associated contaminated soils, notification of proper county, state or federal agencies, and emergency response actions.

3.9.3 FUGITIVE DUST CONTROL

The facility entrance and dump areas have been prepared to control fugitive dust emissions as outlined in . .. Should these measures be insufficient, the facility operator(s) shall employ the appropriate corrective actions designated by the Director to control the fugitive dust emissions.

3.10 EMERGENCY RESPONSE

In the event of an emergency during operating hours the facility operator(s) shall immediately notify the base station dispatcher, giving details of the incident. The dispatcher will then notify or enact the proper responding agency(ies) to the site.

After hours a 24 hour emergency number to our police dispatcher is posted at the front of the facility. The police dispatch will in turn notify the proper responding units and notify the facilities emergency coordinator . . Additionally, the Township has in place a Township wide Emergency Response Plan enacted under Pennsylvania Community Right to Know and Emergency Response Program which will be enacted by declaration of an emergency.

3.11 ALTERNATE FACILITY

Falls Township has designated an alternate compost facility for its Leaf Collection Program. This Facility will be utilized when the Townships Facility has reached capacity or has shut down for operational considerations.

Alternate Facility

Flemming Farm
Stony Hill Road and Route 332
Lower Makefield Township

4.0 PROCESSING

The facility's function, when it is not receiving leaf waste, is to serve as a storage and curing site - developing the leaf waste deposited into a usable mulch compost. The composting or curing season planned for this facility is approximately six (6) months. During this time certain procedures must be followed to ensure the continued environmental integrity of the facility and arriving at a quality compost product. These procedures are outlined in the following sections of this Chapter.

4.1 TURNING FREQUENCY AND METHODS

The windrows at the facility will be turned approximately every six (6) to eight (8) weeks as designated by the Director. Front end loaders and leaf machines will be used to manipulate the windrows. Windrows will be turned from the side, with the operator facing perpendicular to the length of the windrow, starting from the last row first, turn the pile in a counter clockwise rotation until the whole length has been moved back onto itself. Each subsequent row will be turned in the same manor. On the next scheduled turn, rotate the pile clockwise and so one.

Periodically, the Director will visually inspect and monitor temperatures of the windrows to determine optimum turning frequency.

4.2 DETERMINATION OF WATER APPLICATION

Water will be applied to the compost pile before the windrow is turned. Additional water may be applied to the compost pile when unusual circumstances are observed. The Director during his inspection of the facility shall determine the adequacy of the compost moisture content.

4.3 LIME APPLICATION

The facility shall employ the addition of lime to the compost pile (during curing only) for use as odor and environmental controls Lime will normally be applied after the windrows have been turned Again under the supervision of the Director the addition of lime can be more frequent. **However, the lime is not to be over applied or applied directly into a water source.** The run off of the lime has also been addressed in

4.4 FACILITY INSPECTION

The facility shall be inspected at least once a week, or as designated by the Director, during the curing period. Facility inspections shall note the condition of the compost pile, the condition of the sediments and erosion control measures, site security, odor control, site appearance and any items normally serviced and checked daily , Section 3.5. Any discrepancies found by the operator shall immediately be reported to the Director. A log of facility inspections will be kept by the Public Works Clerk.

4.5 CURING DURATION

The facility Director will ultimately determine the time of curing through his regular inspections The typical duration of the compost period will be approximately six (6) months. The time will vary according to weather conditions, turning frequency, the amount of compost, the moisture content, and size of the windrows.

4.6 PROPOSED DISTRIBUTION OF COMPOST

The compost product will be used in several different ways depending upon the demand for the product. **At all times distribution will be supervised by Township employees.** Scheduled pick up days will be by the Director. We have proposed the following avenues of distribution:

a) Compost will be distributed to any resident who wishes it. The compost facility will be opened two to three days a week for residents to pick up the compost. There will be some product available in bags. Others may take the compost out in bulk

b) Additional mulch will be distributed into Township parks and recreation areas.

c) Nurseries or farms will be allowed to schedule pick ups with the Township finally.

d) Left over compost may be used at the landfill for final cover.

The compost will be distributed at the site at no cost to the residents. except compost taken in bags Other contractors may be charged for cost expenditures by the Township for special equipment or operating hours.

5.0 SAFETY

All Falls Township operations must be constructed in a safe and practical manor. Safety is always our First Concern. Employees who do not observe our Safety Practices create a hazard for all employees as well as themselves. **Serious disciplinary actions will be taken against those caught violating the safety practices outlined in this manual.**

5.1 PERSONAL PROTECTIVE EQUIPMENT

All leaf collectors and facility operators will be issued the following safety equipment:

1ea.	**Hard hat**
1pr.	**Ear muff protectors**
1 pr.	**Safety goggles**
1pr.	**Gloves**
1pr.	**Latex over boots (rainy condition)**
1	**Leaf Program Manual**

______________________ ______________________

Employee **Director**

Employees will be expected to provide steel tipped safety shoes for themselves. These must be worn at all times without exception!

All of the safety equipment above must be worn at all times (except latex boots) while the leaf collection machinery or compost equipment is in operation. **The only exception of this rule is the driver of the collection machine who must not wear ear muffs or goggles while operating the motor vehicle.**

FOR MORE INFORMATION, CONTACT:

DEM/
OSCAR
(401) 277-3434 or
1 (800) CLEANRI

University of Rhode Island Cooperative Extension
1 (800) 448-1011

R.I. Solid Waste Management Corporation
(401) 831-4440

FURTHER READING

The Complete Book of Composting, by the staff of Organic Gardening, Rodale Press, Emmaus, PA. 1978.

Let It Rot, The Home Gardeners' Guide to Composting by Stu Campbell, Garden Way Publishing, Charlotte, VT. 1975

How to Grow More Vegetables, by John Jeavons, Ten Speed Press, Berkeley, 1979.

Sunset Guide to Organic Gardening, by the editors of Sunset Books, Menlo Park, 1974.

Organic Gardening, published monthly by Rodale Press, Emmaus, PA.

Worms Eat My Garbage, by Mary Appelhof, Flower Press, Kalamazoo, MI, 1982.

Home Composting, Bulletin #88-13, by the Connecticut Cooperative Extension Service, 1988.

Printed on Recycled Paper
100% [illegible]

WHAT ABOUT BINS ?

Bins are not necessary, but can help large piles stay neat. Use a single bin to hold the compost, or use two or three and turn the compost from one bin into the next as it ages. All bins should allow access for turning and should have holes in the sides so air can circulate into the pile. Bins can be made from:

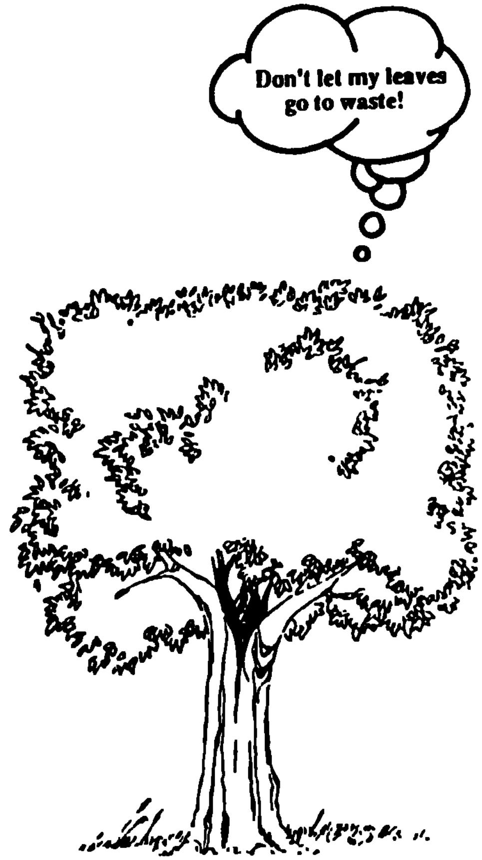
- stakes and chicken wire
- a garbage can with holes in the sides, and no bottom
- cinder blocks (allow space between blocks)
- old pallets or scrap wood

Troubleshooting Common Problems

Symptom	Problem	Solution
Pile has a bad odor.	Not enough air or too wet.	Turn it.
Center of the pile is dry.	Not enough water.	Moisten while turning the pile.
Compost is warm & damp in middle, but nowhere else.	Too small.	Mix in more materials.
Compost froze in winter.	Too small.	Mix in more material in spring.
Pile sweet-smelling, but won't heat up.	Lack of nitrogen.	Mix in grass, urea, blood meal, etc.

OSCAR
Ocean State Cleanup and Recycling
Department of Environmental Management
83 Park Street
Providence, RI 02903-1037

How do I start BACKYARD COMPOSTING?



WHAT IS COMPOSTING?

Composting is the biological breakdown of organic wastes like leaves, brush, grass clippings and even food scraps into a soil-like product called humus. Composting is a form of recycling, returning organic waste to the earth.

WHY SHOULD I COMPOST ?

Composting at home:

- preserves landfill space
- saves waste collection costs
- reduces disposal costs

Adding compost to your soil:

- improves soil structure
- helps retain moisture
- adds organic matter
- reduces the need for fertilizers
- helps regulate soil pH
- improves plant health

WHAT CAN I COMPOST?

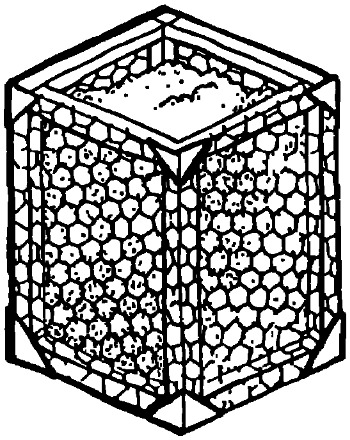
Any organic material will breakdown, but not everything belongs in your compost pile.

Do Use:

- leaves, grass clippings
- garden wastes, weeds
- hedge trimmings
- manures from plant eating animals
- kitchen vegetable and fruit scraps
- tea leaves, coffee grounds
- egg shells, hair, saw dust

Do NOT Use:

- diseased plants
- plants which are toxic to other plants (Ivy, English laurel, rhododendron)
- meats, fish or dairy products
- oily foods, fats or grease
- manures from meat-eating animals



HOW DO I COMPOST ?

Your compost pile will be a little"farm", teeming with "decomposers"-- bacteria, fungi and worms. You must provide them with food, water and air as they work to break down your wastes into compost.

1. Choose a level spot in your yard that is near a water source and that receives about equal amounts of sunlight and shade during the day.

2. Your wastes are the decomposers' food. Place the materials in 2-6 inches thick layers. Try to alternate "greens" (food scraps, grass clippings, manure) and "browns" (leaves, straw, woody material) to help balance the proportion of carbon and nitrogen. The ideal pile size is 4 to 5 feet wide and high. An occasional sprinkle of fertilizer, blood meal or urea will speed the break down by adding nitrogen, but it is not necessary. Cutting or shredding the ingredients helps speed the composting.

3. Now add water. The pile should be kept moist but not soggy -- like a wrung-out sponge. Slowly dripping water onto the pile is the most effective watering method.

4. Keep air in the pile by turning and "fluffing" the pile periodically --once a week if possible, or whenever you can. Frequent turning speeds the composting.

5. As you have more materials, mix them in or start a new pile.

THE RESULTS

As the materials break down, heat is generated. You may see steam rising from the pile, especially when it is turned. If your compost pile is properly prepared, contains no animal fats and is turned periodically, it will not attract pests or create odors. Decomposition will be complete when the compost is a rich dark brown color and has broken down into small particles. Compost is ready to use after it has cooled. You may screen the compost and return unfinished material to the pile.

HOW CAN I USE THE COMPOST?

- mix several inches of it into soil before planting
- top dress lawns with a one-quarter inch thick layer of compost
- work into top layers of soil around established plants and shrubs
- use up to 25% compost in potting soil

NOTES FOR A SHORT COURSE ON PLANNING MUNICIPAL YARD WASTE COMPOST PROJECTS

Developed by:

Michael Simpson, Tellus Institute
&
Betsy Loring, RI DEM

In Conjunction with the:

Rhode Island Department of Environmental Management
&
Rhode Island Solid Waste Management Corporation

WHY COMPOST LEAVES AND YARD WASTE?

* Avoid High Disposal Costs

* Preserve Disposal Capacity

* Reduce Landfill and Incinerator Pollution

* Recycle A Natural Organic Resource

* Produce Valuable Soil Amendment

WHAT IS COMPOSTING ?

COMPOSTING is a waste management option which utilizes the natural process of biological decomposition under <u>controlled</u> conditions to produce a stable end-product.

COMPOST (the end-product) resembles a darkened humus-like material which can be easily and safely handled, stored and applied to land as a valuable soil conditioner.

COMPOSTING: A Process of Aerobic Decomposition

Composting occurs through the breakdown of organic material by macro and micro organisms which require:

AIR

The decomposition process needs adequate oxygen.

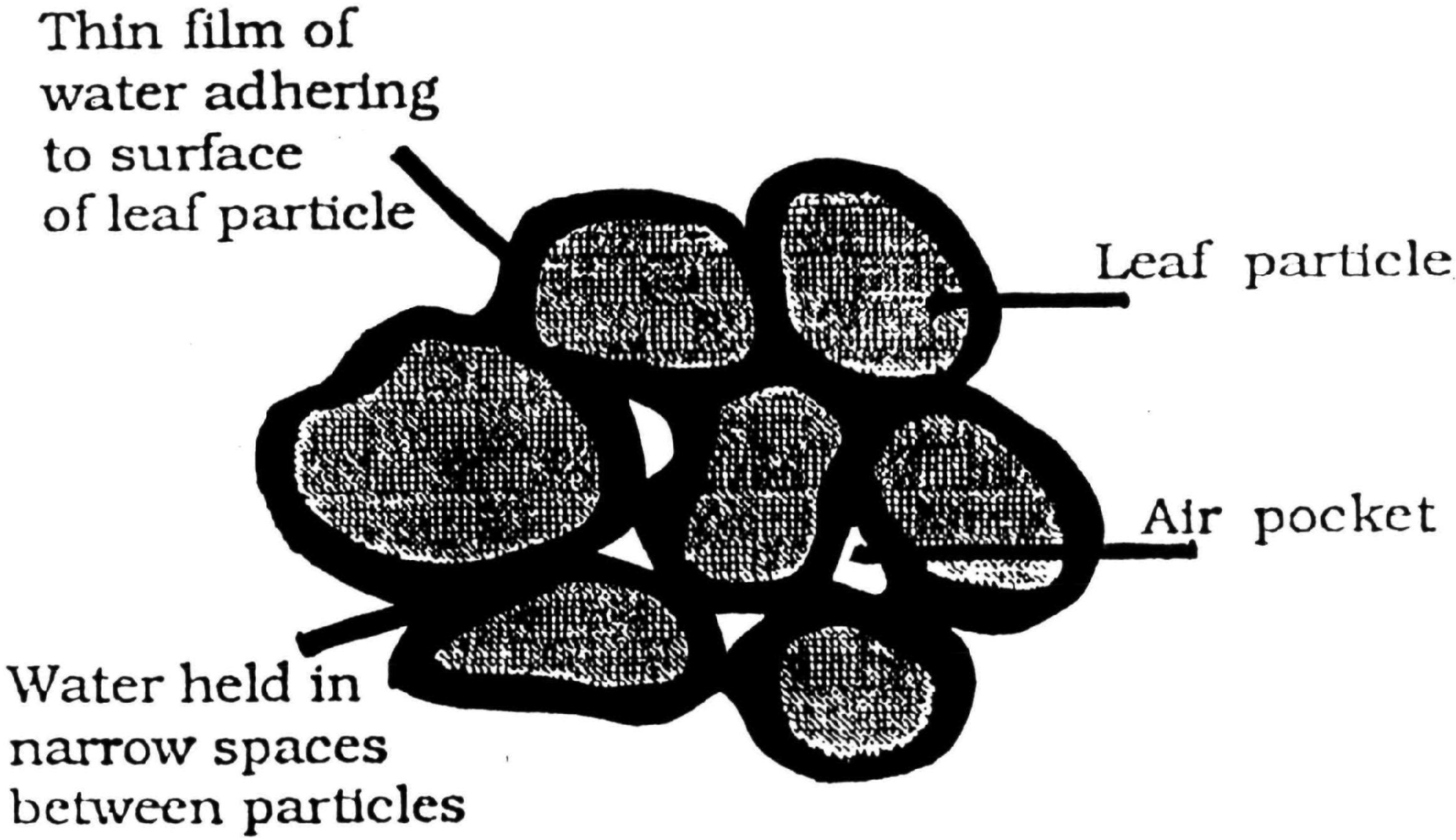
FOOD

The leaves and yard waste (organic material) provides decomposers both energy (carbon molecules) and building blocks (nitrogen molecules) for population growth.

WATER

Decomposers needs water both for the assimilation (in-take) of nutrients from the break-down of the organic material and as a medium in which they live.

Leaf Particles with Proper Moisture

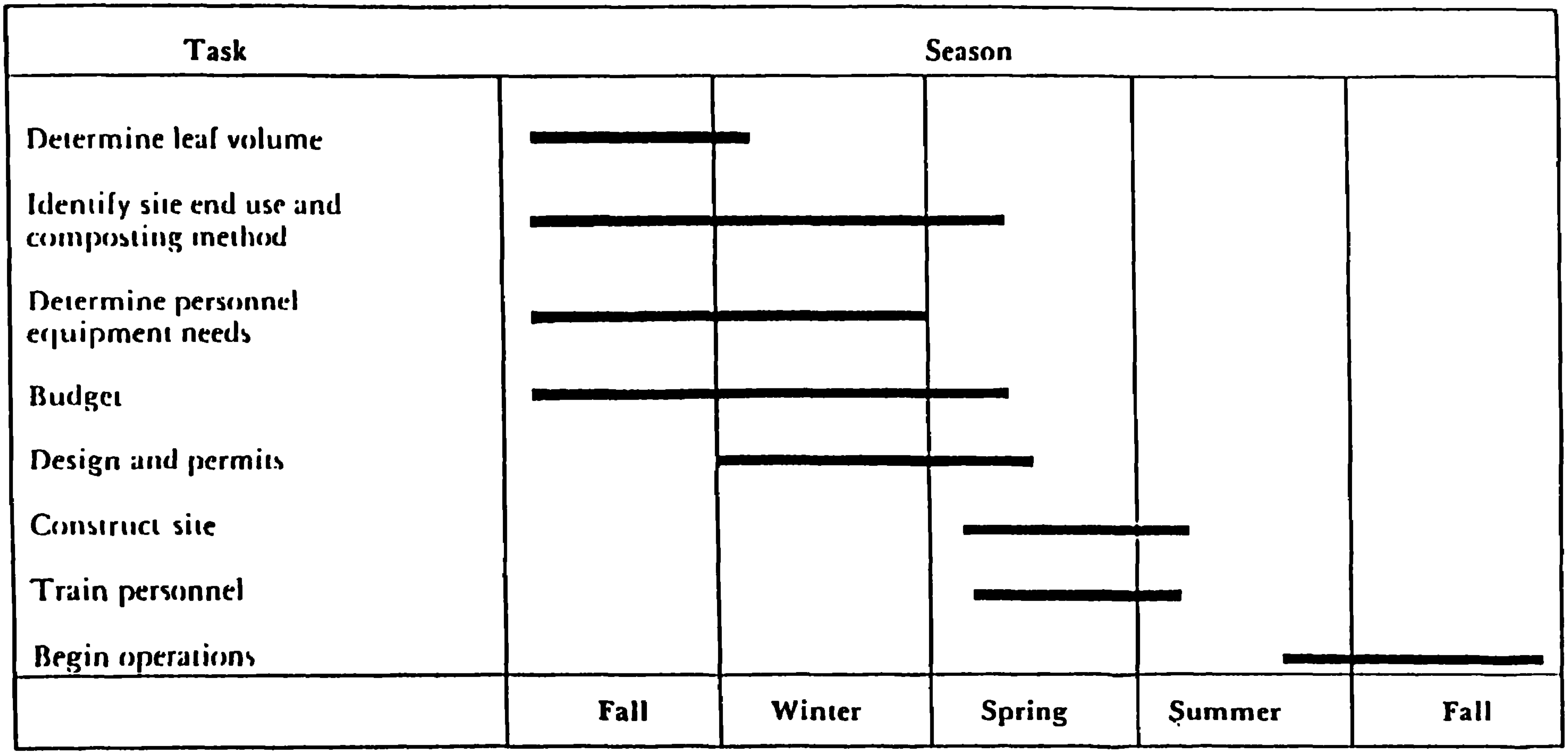


Microbes live in thin film of water around leaf particles

PLANNING FOR A COMPOSTING PROGRAM

* Quantity of Material
* Collection
* Siting
* Equipment
* Staffing
* Public Education
* End Use

PROJECTED TIME LINE FOR IMPLEMENTING LEAF AND YARD WASTE COMPOST



Source (Connecticut DEP, 1989)

ESTIMATING QUANTITY OF MATERIALS

* Existing records of seasonal fluctuation, can provide a reasonably accurate quantity of leaves in the fall that are collected.

* Based on national (EPA) figures, leaves and yard waste comprise 18% of municipal solid waste (MSW). Leaves, by themselves, comprise 6% of the MSW stream. In the fall, leaves can make up to 30 - 50% of the volume of MSW in suburban areas.

* Based on studies of several communities throughout the U.S. composting leaves, collected leaves can range from 50 to 200 cubic yards per curb mile.

ESTIMATING COMPOST PAD SIZE

For every 4000 to 5000 cubic yards of leaves delivered, approximately one acre will be required. This will depend somewhat on the level of operation, such as frequency of turning. Areas for buffers to sensitive neighbors, access into and out of the site, curing, as well as storage for compost and equipment are additional.

One can assume 6 1/2 cubic yards for each ton of leaves (300 pounds/ cubic yard). However this ratio can VARY GREATLY depending upon the amount of yard waste, moisture, sand and grit that are present or whether the leaves were shredded of compacted prior to delivery to the composting area.

The composting pad, at a minimum, should be sized to accept the amount of material that is to be deposited, composted and removed within one year.

INCLUDE SPACE FOR:

- Buffers, Drainage Ditches, Swales, etc.
- Roads
- Drop-Off Area(s)
- Mixing, Shredding, De-bagging, Screening
- Curing, Compost Storage
- Equipment Storage, Workers' Shelter
- (Slower Composting)
- (Future Expansion)
- (Additional Materials: grass, brush)

Average and Peak On Site Volumes

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total on Site	
Oct	[5,000]				*0*	*400*	*500*	*600*	*700*	*800*	*0*	*0*	8,000	Oct
Nov	2,500	[10,000]				*400*	*400*	*500*	*600*	*700*	*0*	*0*	15,100	Nov
Dec	2,250	5,000	[0]				400	400	500	600	0	0	9,150	Dec
Jan	2,000	4,500	0	[0]				*400*	*400*	*500*	*0*	*0*	7,800	Jan
Feb	1,750	4,000	0	0	[0]				*400*	*400*	*0*	*0*	6,550	Feb
Mar	1,500	3,500	0	0	0	[2000]				*400*	*0*	*0*	7,400	Mar
Apr	1,250	3,000	0	0	0	1000	[2000]				*0*	*0*	7,250	Apr
May	1,000	2,500	0	0	0	900	1000	[2000]				*0*	7,400	May
Jun	1,000	2,000	0	0	0	800	900	1000	[2000]				7,700	Jun
Jul	1,000	2,000	0	0	0	700	800	900	1000	[2000]			8,400	Jul
Aug	1,000	2,000	0	0	0	600	700	800	900	1000	[0]		7,000	Aug
Sep	1,000	2,000	0	0	0	500	600	700	800	900	0	[0]	6,500	Sep

Annual total	25000	100% of total incoming material
Monthly average	8188	33% of total incoming material
Peak month	15100	60% of total incoming material

Numbers in boxes like this: [500] = fresh incoming loads.
Numbers below boxed figures represent reductions due to decay of material.
Numbers in *italics* indicate compost remaining from prior seasons
Add numbers across rows to learn total cubic yards on site in any given month.
Oct total cubic yards = 5,000(new) + 400(prior) + 500(prior) + 600(prior) + 700(prior) +800(prior) = 8,000

Average and Peak On Site Tonnages

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total on Site	
Oct	1,000				*0*	*200*	*220*	*240*	*260*	*280*	*0*	*0*	2,200	Oct
Nov	800	2,000				*200*	*200*	*220*	*240*	*260*	*0*	*0*	3,920	Nov
Dec	750	1,600	0				*200*	*200*	*220*	*240*	*0*	*0*	3,210	Dec
Jan	700	1,500	0	0				*200*	*200*	*220*	*0*	*0*	2,820	Jan
Feb	650	1,400	0	0	0				*200*	*200*	*0*	*0*	2,450	Feb
Mar	600	1,300	0	0	0	400				*200*	*0*	*0*	2,500	Mar
Apr	550	1,200	0	0	0	320	400				*0*	*0*	2,470	Apr
May	500	1,100	0	0	0	300	320	400				*0*	2,620	May
Jun	500	1,000	0	0	0	280	300	320	400				2,800	Jun
Jul	500	1,000	0	0	0	260	280	300	320	400			3,060	Jul
Aug	500	1,000	0	0	0	240	260	280	300	320	0		2,900	Aug
Sep	500	1,000	0	0	0	220	240	260	280	300	0	0	2,800	Sep

Annual total	5,000	100% of total incoming material
Monthly average	2,813	56% of total incoming material
Peak month	3,920	78% of total incoming material

Numbers in boxes like this: [500] = fresh incoming loads.
Numbers below boxed figures represent reductions due to decay of material.
Numbers in *italics* indicate compost remaining from prior seasons
Add numbers across rows to learn total cubic yards on site in any given month.
Oct total tonnage = 1,000(new) + 200(prior) + 220(prior) + 240(prior) + 260(prior) +280(prior) = 2,200

SITE CONSTRAINTS

* NEIGHBORS

* WELLS

* WET SOILS (wetlands)

* EXCESSIVELY PERMEABLE SOIL

* FLOOD PLAINS

* SURFACE WATER

* GROUND WATER

* BEDROCK

* PREVIOUS WASTE DISPOSAL SITE

SITE PROBLEMS:

- **Correctable (money can be issue):**

  - grade, pad, drainage
  - buffers, security

- **Rule Out Site:**

  - wetlands, coastal or fresh water
  - landfill

- **"Coin Toss":**

  - politics (site ownership, etc.)
  - NIMBY (neighbors)

SITE EVALUATION ASSISTANCE:

- DEM/ Environmental Coordination
- RISWMC
- USDA/ Soil Conservation Service
- Local

  Conservation Commission

  Planning Commission

  Land Use Plan Committee

  Town "Old Timer"/ "Oral Historian"

OTHER SITE OPTIONS:

- Alter Operations:
    - seasonal site
    - small site
- Several Small Sites
- Regional Site
- Private Compost Project:
    - farm
    - nursery
    - landscaper

COMPOST PAD DESIGN

* DESIGN PAD TO AVOID STANDING WATER.

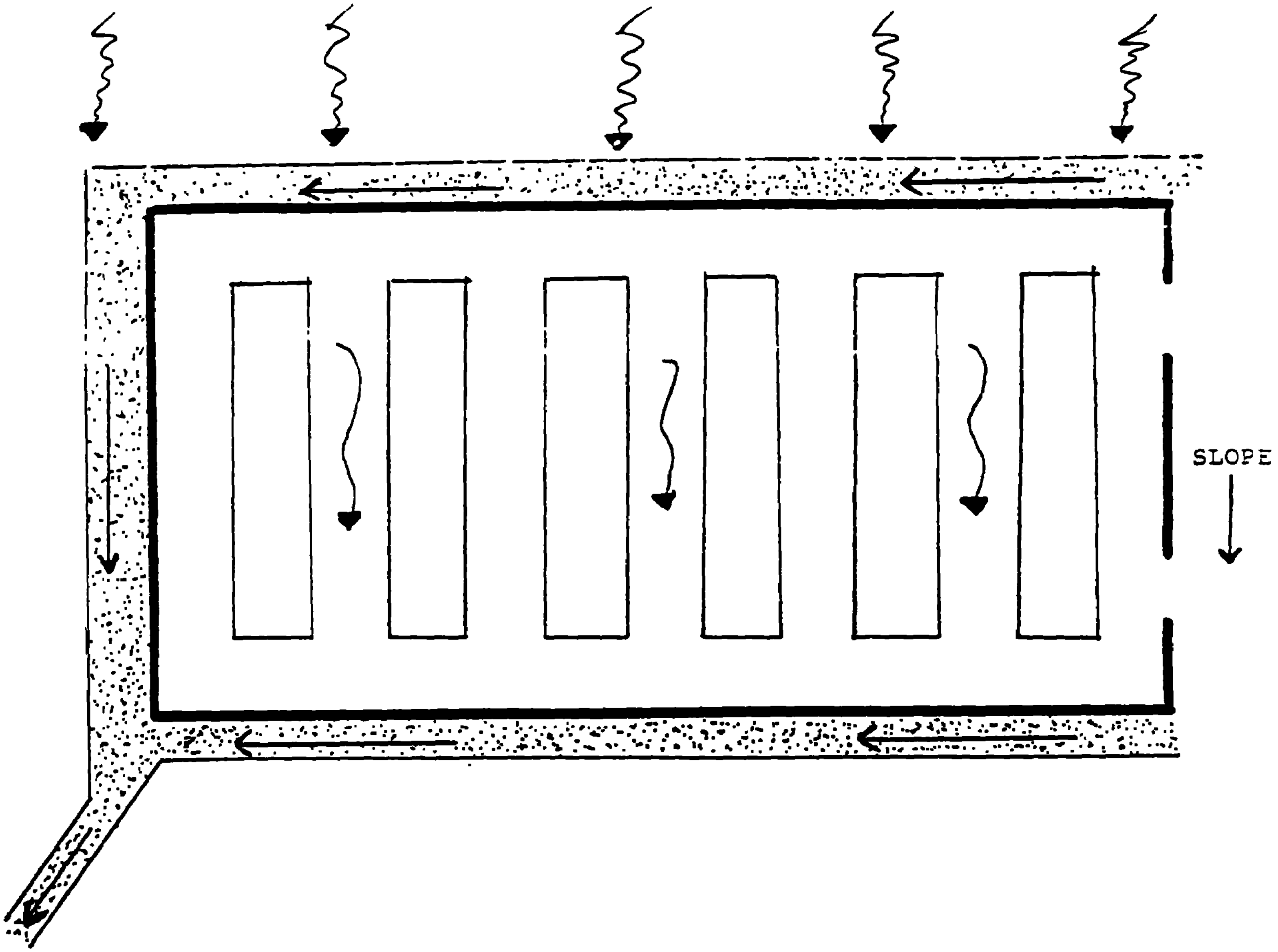
* DESIGN PAD TO SUPPORT MACHINERY FOR ALL SEASONS OF THE YEAR.

Proper pad design and construction is an essential first step for avoiding future problems from nuisance conditions (odor) and/or environmental impact (run-off or erosion).

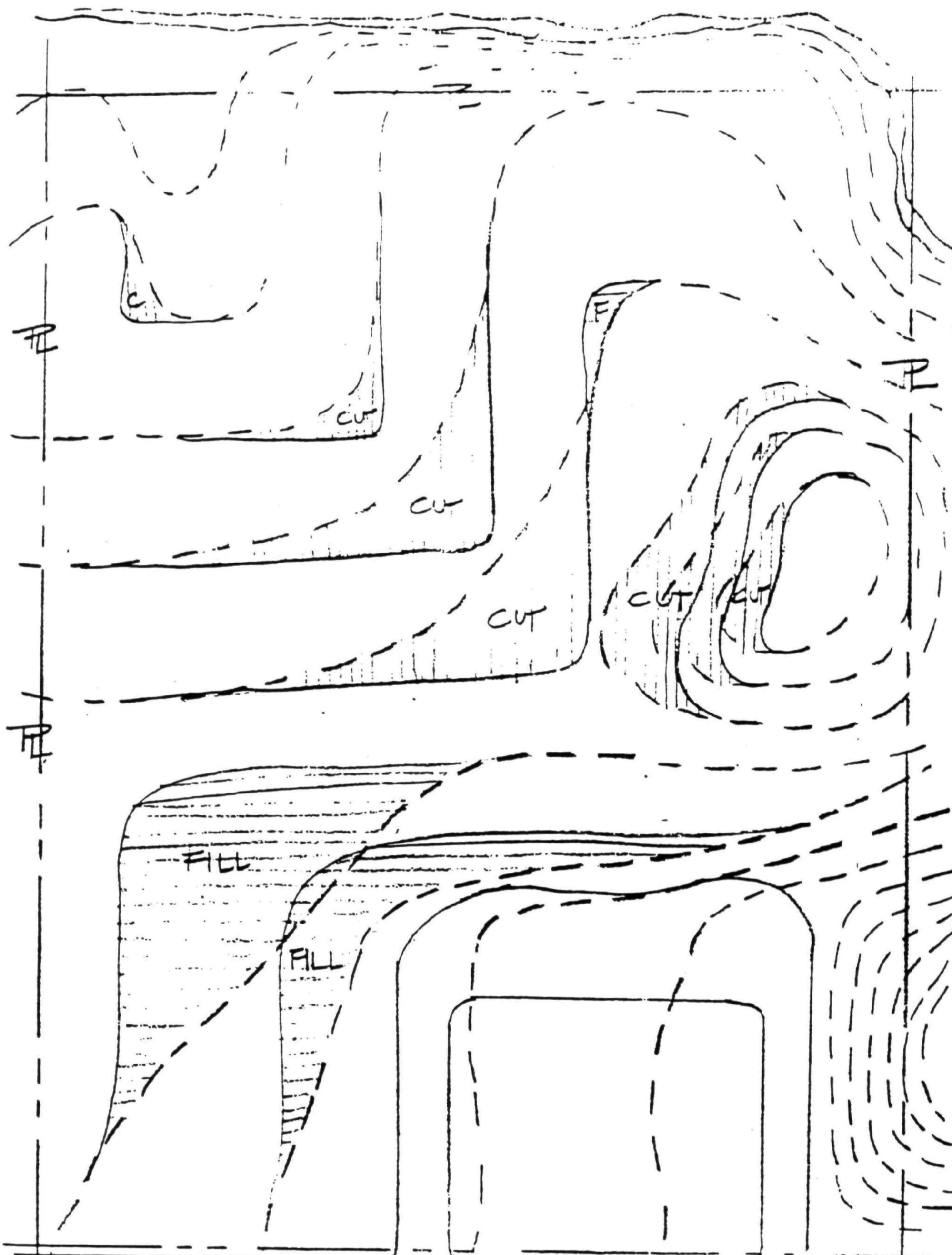
POSSIBLE PAD MATERIALS

- Existing Subsoil
- Gravel, Crusted Stone, Bank Run Gravel
- Clean, Recycled Demolition (non-organic)
- Recycled Stone from Water Projects

Generic Site Plan to Control Run-off

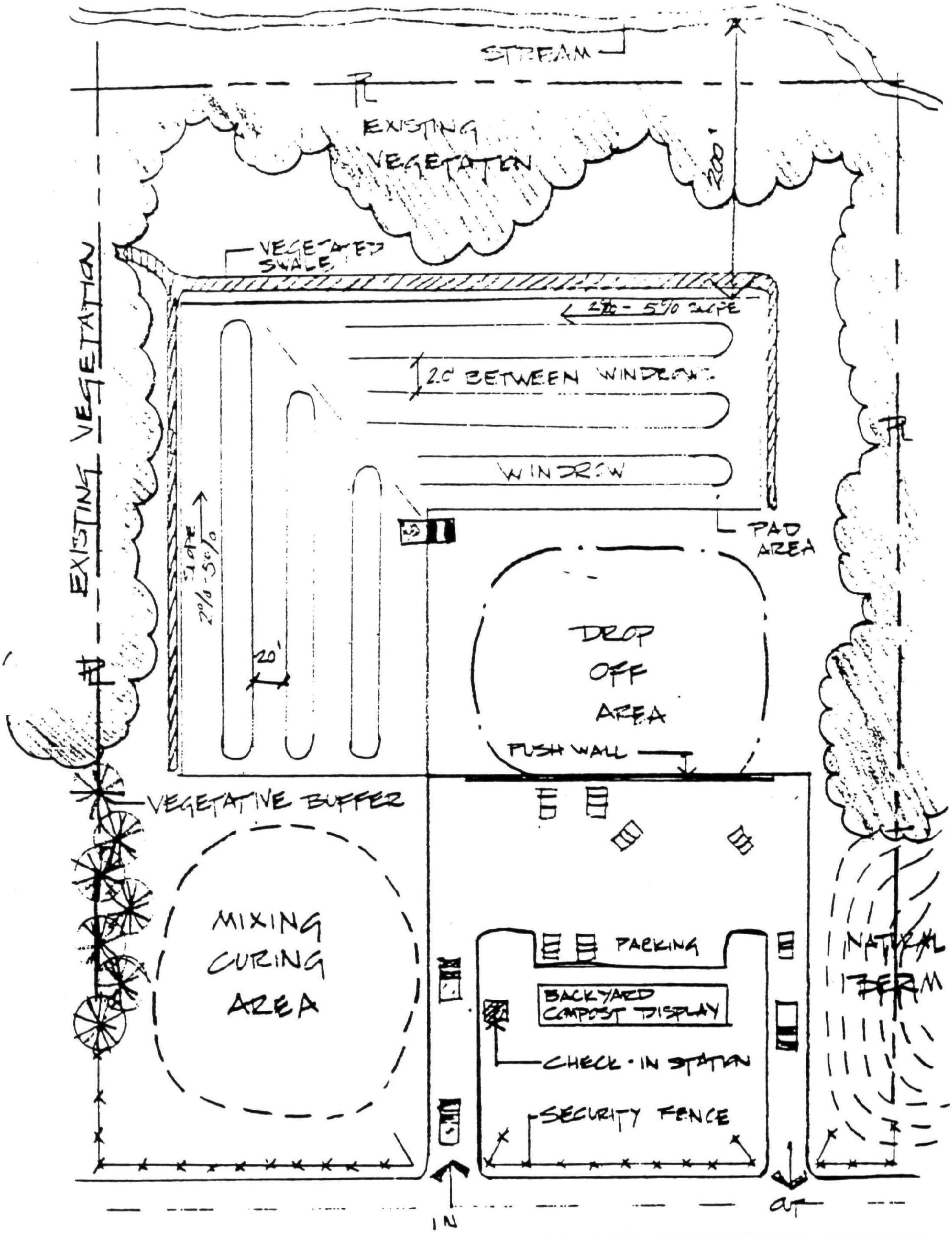


RUNOFF SHOULD BE DIVERTED TO APPROPRIATE METHODS OF TREATMENT.



NOT TO SCALE

SITE PLAN BEFORE YARD WASTE COMPOST PROJECT REGRADING



SITE PLAN FOR GENERIC YARD WASTE COMPOST PROJECT

COLLECTION METHODS

* Drop-off collection

    - residential and/or

    - commercial

* Bulk (loose) collection

    - streets only and/or

    - residential lawn leaves

* Bagged collection

    - plastic bags with debagging or

    - biodegradable paper bags

DROP-OFF

- Permanent or Temporary (mobile)
- Low Participation, Usually
- Can Be Back-Up to Curbside Program
- Quick to Set Up
- Inexpensive
- Good Start for Phased-In Program
- Can Take Landscapers
- <u>Must</u> be Staffed

BAG OPTIONS

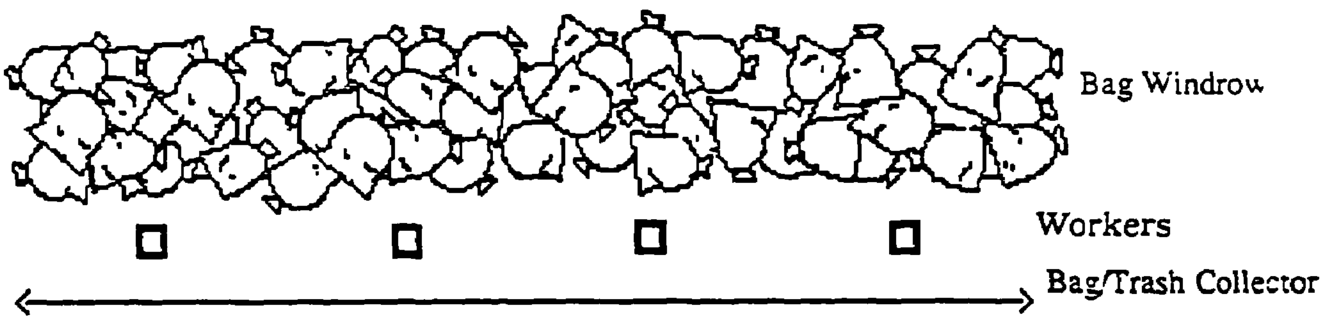
- "Regular" Plastic:
  - "cheap"($.15 - .35), familiar
  - quick start-up of collection system
  - clear preferred
  - requires de-bagging by hand or machine (Coventry: 8 workers x 8 hrs/day x 10 wks; $15/ton)

- Paper:
  - no de-bagging
  - bags can be expensive ($.30 -.50)
  - purchase and distribution planning needed
  - shredding or extra watering/turning may be needed

- "Degradable" Plastic:
  - heavy metals in colored inks & plastic
  - cost similar to paper
  - must be shredded
  - screening required
  - jury still out

- "Biosheet"
  - cost similar to paper
  - sales/distribution planning needed
  - should be easy for homeowner & town
  - unknown operational track record

RECOMMENDED DE-BAGGING METHOD
(Plastic Bags)



1. Leaves must be removed from bags within two weeks of collection to avoid "pickling the bags.

2. Windrow of bags should be no higher than four feet, so that workers can easily reach bags.

3. Debaggers should work along the face of the pile, not at the ends.

4. The best bag-ripping tools are the hands; knives are quickly lost in leaf piles.

5. One worker should constantly walk behind debaggers, removing empty bags and other contaminants. Bags are quickly covered by loose leaves and lost if not removed promptly.

6. When leaves are knee or hip-deep, the debaggers should clear the area, while leaves are watered and then pushed asside by a front-end loader.

BULK COLLECTION OPTIONS

- (Street Sweepers)
- Vacuum Truck or Trailer
- Front-End Loader & Trucks
- Loader with "Claw" and Trucks
- "Homemade System:
  - Dumpster "Dustpan" and Plow
  - Leaf "Buncher"

THE CLAW

NORCIA'S

"Your Single Source for Recycling Equipment"

(201) 297-1101

FAX: (201) 297-8129

R.D. NO. 4, BOX 451, NORTH BRUNSWICK, N.J. 08902

MODEL 520M • MODEL 820M

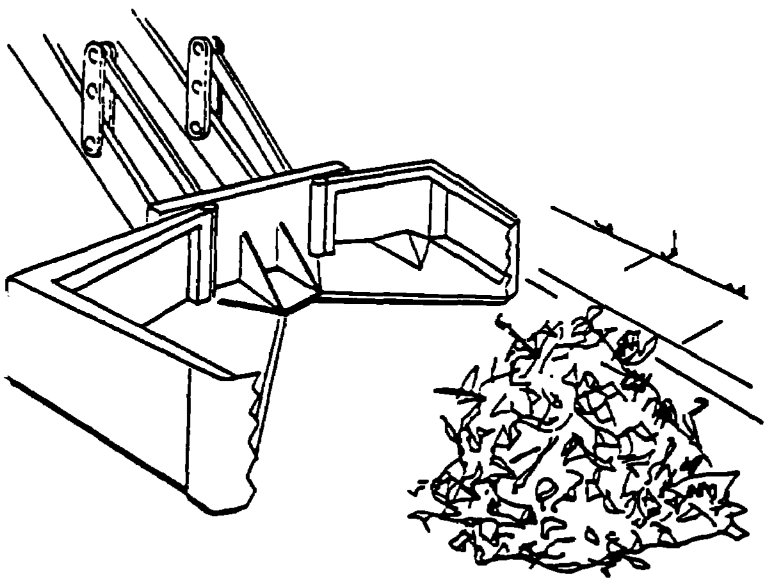


FIG. 1

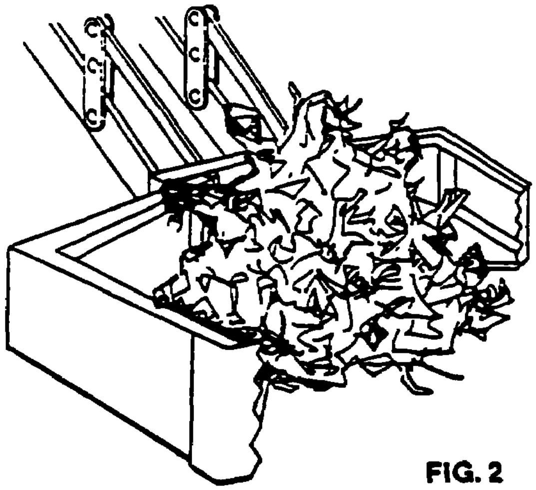


FIG. 2

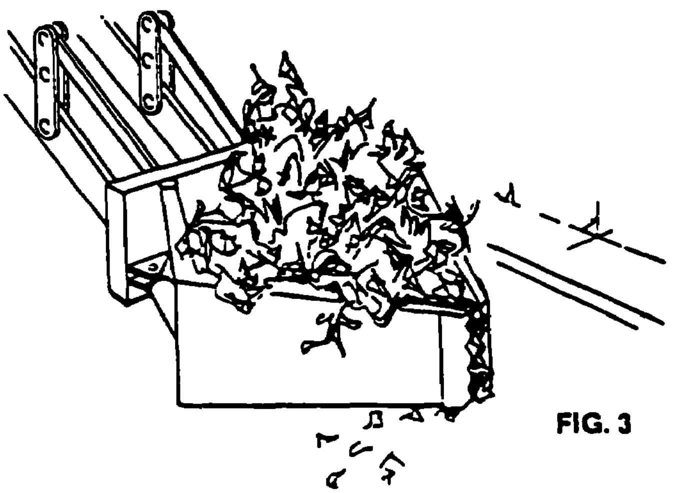


FIG. 3

The **CLAW** operates like two open hands that tightly grasp loose materials and bulky objects. The embraced material can be lifted cleanly from the surface and placed into a rear loading packer's hopper or a dump truck.

Figure 1: The **CLAW** advancing in the "open" position.

Figure 2: The **CLAW** encircling and undercutting a pile.

Figure 3: The **CLAW** has enclosed the pile and will cleanly pick it up

BULK VS DEGRADABLE BAG

BULK	BAG
parking ban	bag ordinance
more contaminants	more turning/watering/ shredding
"mess" in street, danger to kids, fire risk	cost of bags
simple -- just rake	bagging "familiar"
may need special collection equipment	usually need packer (rear-loader)

COVENTRY PAPER BAG LESSONS

- Back-Up Drop-Off Very Helpful

- Purchase & Distribution Planning:

  - Town vs Stores
  - Storage, Handling, Logistics
  - Price

- Price of Bag an Incentive for Home Composting

- Watch Out for Election Years

- Complaints Quieted by:
  - Drop-Off
  - Free Compost
  - Free Bags for Seniors

- Areas for Improved Education:
  - How to Use Bag Fully
  - True Cost of Using Bag
  - Leaves Not a "Donation":
    Keep Home if You Can

CHOOSING A COLLECTION SYSTEM

- Hauling Contract/Union
- Contamination
- Participation
- Incentive for Home Composting
- Compatibility
  - with refuse collection system
  - with existing ordinances
  - with geography/population density
- Equipment Availability
- Impact on Site Operations
- Economics
- Scheduling:
  - at least 3 per house, Nov. - mid Dec.
  - drop-off--weekend hours important
- Planning Timeframe

EQUIPMENT NEEDS

* MATERIAL MOVEMENT
* TURNING (aeration/mixing)
* WATERING
* SCREENING
* MONITORING

STAFF

* A municipal scale composting operation requires "dedicated" staff.

* Staff availability and performance will make a difference between a successful project and a series of potential nuisance and/or environmental problems.

* The staff needs to understand both the material with which they are working and the process by which this material is made into compost.

* Back-up personnel is recommended for those who have direct responsibility for compost operations.

STAFF RESPONSIBILITIES CAN INCLUDE:

* COLLECTION
* DEPOSITION
* COMBINING/TURNING
* MONITORING/RECORD KEEPING
* QUALITY CONTROL
* FINAL PROCESSING
* DISTRIBUTION

EDUCATION NEEDED FOR:

- Site Neighbors
- Citizen Advisory Committee
- Town/City Council:
    - site use/lease
    - equipment use/lease/purchase
    - ordinance(s)
    - budget
- Local Retailers (Bags)
- Kids (Safety)
- Leaf Generators
    - Public
    - Commercial
- Follow Up-- Say Thank You!
- Compost Distribution/Sale

PUBLIC EDUCATION

* Master Composter Strategy

* Community meetings/organizations

* Schools

* Knowledgeable staff at transfer and/or disposal site

* Flyer/Brochure Mailings

* Tax/Water Bill Inclosures

* TV and Radio

* Newspaper

* Posters/Signs

COMPOST END USE

COMPOST IS VALUABLE AS A MULCH, SOIL AMENDMENT AND TOPSOIL SUBSTITUTE.

POTENTIAL COMPOST USERS INCLUDE:

<u>BULK USERS</u>	<u>PROCESSORS</u>	<u>RETAIL/WHOLESALE</u>
Landfill cover	Fertilizer contractors	Garden centers
Land reclamation	Fertilizer manufacturers	Landscapers
Parks		Home gardeners
Cemeteries		Topsoil
Highway maintenance		
Schools		
Nurseries		
Greenhouses		
Sod Farmers		
Orchards		
Forestry Projects		

COMPOST's BENEFIT TO SOIL CONDITIONS

* IMPROVED SOIL AGGREGATION

* IMPROVED WATER INFILTRATION

* IMPROVED WATER RETENTION

* IMPROVED FERTILIZER RETENTION & RELEASE

* IMPROVED SOIL POROSITY

* IMPROVED SOIL AERATION

* DECREASED SOIL CRUSTING

PERMITING

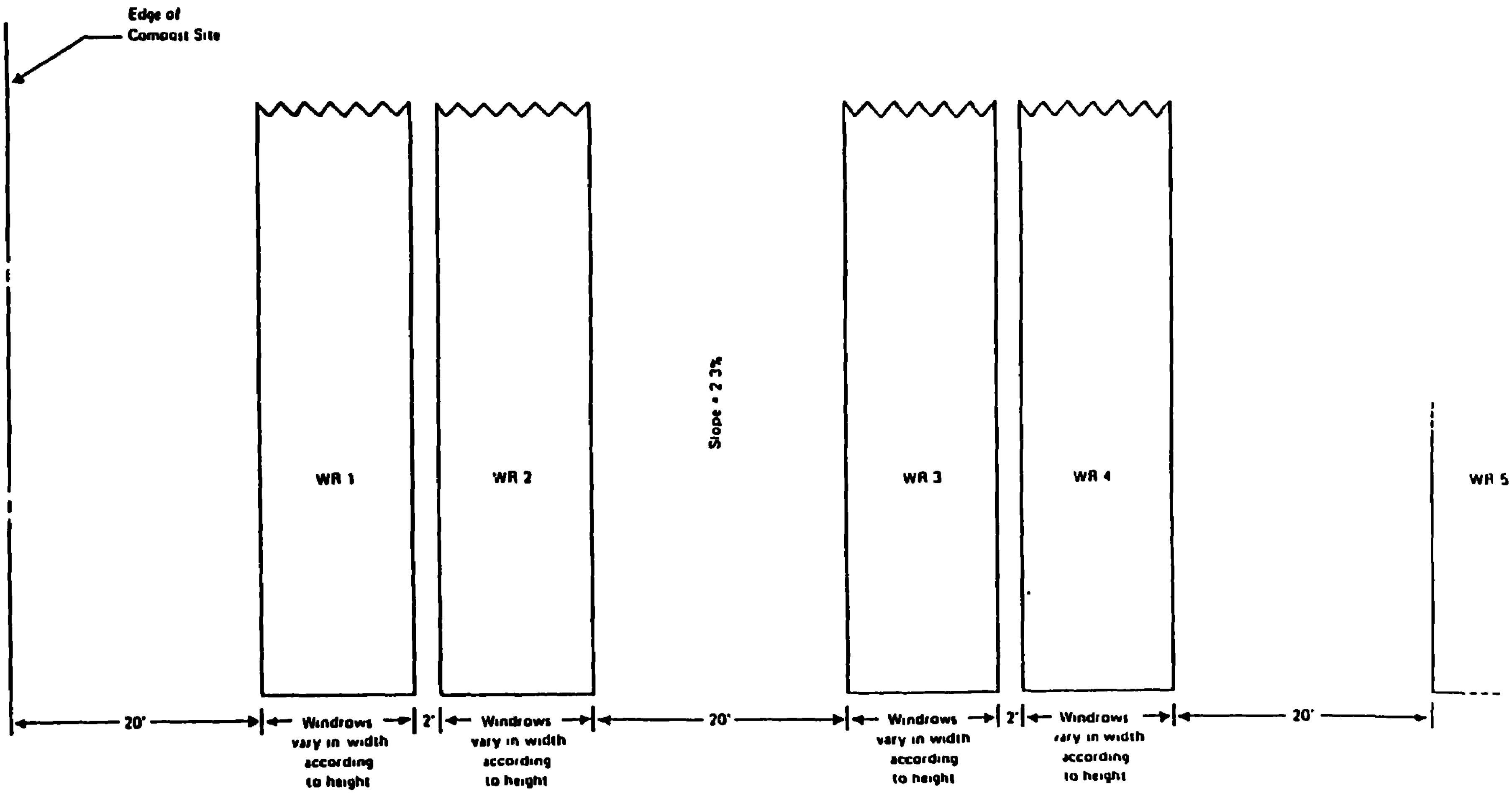
- Local:
  - Zoning
  - Conservation
  - Land Use Plans
  - Fire Codes
  - Department Which "Owns" the Site
- State:
  - DEM Registration
  - (Freshwater Wetlands)
  - (Air & Hazardous Materials)
  - (CRMC)
- Federal:
  - (Army Corps of Engineers)
  - (EPA - Superfund)

BUDGET

- Costs:
  - equipment (existing & new)
  - personnel (planning, collection, site operation)
  - supplies (bags, signs etc.)
  - public education (ads, fliers, etc.)
  - collection
  - site preparation
  - site operation
  - lab testing

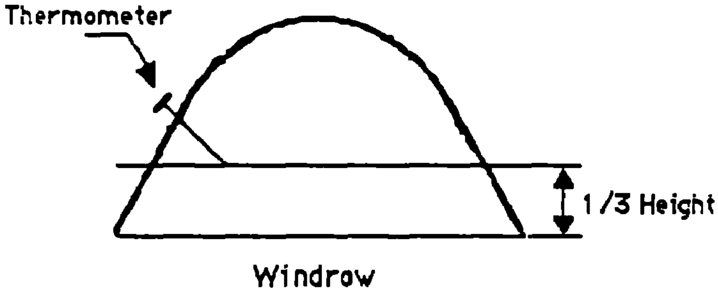
- Revenues/Benefits:
  - (source reduction from backyard composting)
  - avoided disposal costs
  - avoided transportation
  - refuse collection savings
  - compost value
  - tip fee/sticker fee

INITIAL WINDROW SPACING



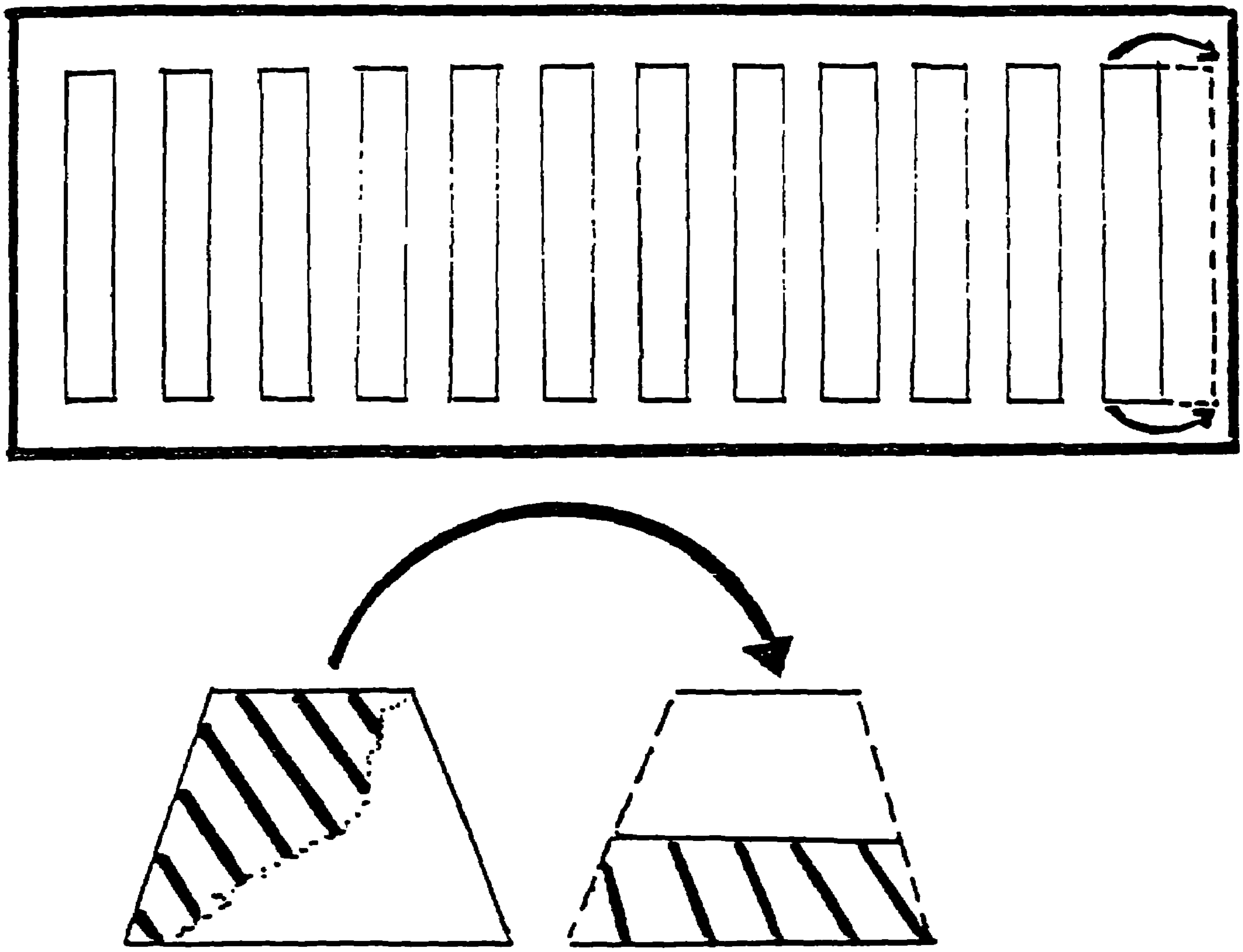
Source (Connecticut DEP, 1989)

Temperature Measurement Technique



Take temperature of bottom third of windrow, where temperatures will go down first, as oxygen is depleted

Turning Procedure



<u>TURNING</u> NOT ONLY AERATES THE PILE BUT ALSO ALLOWS PROPER <u>MIXING</u>. TO ENSURE THAT WINDROW IS MIXED THOROUGHLY, EACH COMPOST PILE SHOULD BE TURNED TWICE IN THE SAME DIRECTION. TURNING TWICE IN THIS MANNER WILL ALLOW THOSE LEAVES ON THE OUTSIDE OF THE PILE TO BE MIXED INTO THE CENTER OF THE WINDROW, WHERE MICRO-ORGANIMS CAN CAN BREAK DOWN THIS MATERIAL. IF PROPER MIXING DOES NOT OCCUR, DECOMPOSITION OF THE LEAVES WILL BE SLOWED, AS SUCH,MATERIAL MAY NEED TO REMAIN ON THE COMPOSTING PAD FOR AN ADDITIONAL AMOUNT OF TIME.

SA[illegible]

MONITORING DATA SHEET

Data collected by: ____________________ Year: __________ Month: __________

Weather Information (Sunny, rain, etc.) ____________________

Wind direction (from Northeast, South, etc.) ____________________

Air Temperature: °F __________ Time of day: __________

Site Observation Comments (Water ponding, dust, etc.) ____________________

____

____

Windrow Moisture ("Hand squeeze" test observation) *circle item:* Needs moisture Satisfactory Excess

Odor *(circle item):* None Minimal Strong

Windrow temperature measurement location:	Temperature Observation, °F								
	Windrow Observation (See Sketch Below)								

Diagram

Actions Taken (turned windrow, graded, etc.): ____________________

____

____

...e: Connecticut DEP, 1989.

GRASS and GREEN WASTE COMPOSTING

Grass and other green waste should be mixed with leaves at a ratio of three parts leaves for one part green waste.

In order to avoid potential odor from the composting of green wastes, the materials need to be mixed thoroughly. If odors appear, increase the ratio to five parts leaves for one part green waste.

If a large volume of green waste is being deposited, build windrows on top of four to six inches of wood chips, carefully monitor temperatures, and turn piles frequently.

Grass and green waste can also be composted with chipped or shredded brush. This combination must be mixed thoroughly and may require a longer period on the compost pad before a stable product is formed.

TROUBLE SHOOTING

* ODOR
* RUN-OFF
* EROSION
* DUST
* FIRE
* VECTORS
* LITTER
* ASPERGILLUS FUMIGATUS

TROUBLE SHOOTING: ODOR

SITING: Provide an adequate buffer

Locate sites down wind of sensitive adjacent uses

DESIGN: Place windrows down the slope rather than across (perpendicular to) slope

Place windrows on a properly designed pad so as to ensure water movement away from piles

OPERATION:

Build windrows to proper height and shape

Leaf and yard wastes should be mixed thoroughly and built into windrows propmtly

Maintain proper temperatures, moisture and oxygen content

Turn piles based on temperature and moisture monitoring

Time piles turnings to coincide with favorable wind conditions

Monitor incoming waste to limit the amount of petrescible material incorporated into windrows

TROUBLE SHOOTING:EROSION

SITING: Avoid sites in close proximity of surface waters

Avoid steep slopes

Choose a site with moderately permeable soils

DESIGN: Grade the site properly, preferably with a 2-3% slope

Retain as much vegetation as possible when clearing the site

Design access and on-site roads properly

Use diversion ditches and baled hay to contain run-off during and after site construction

TROUBLE SHOOTING: DUST

SITING: Provide adequate buffer between the operation and sensitive land uses

Locate the site downwind of sensitive uses

DESIGN: Construct access roads with improved surfaces

OPERATIONS:

Maintain proper moisture content in the windrows

Periodically, wet unimproved surfaces during episodes of extended dry weather

TROUBLE SHOOTING: RUN-OFF

SITING: Comply with Rhode Island Wetland Regulations

Avoid sites adjacent to lakes, rivers, streams, and reservoirs

Avoid sites where high water table is less than 4 feet from the surface

Avoid steep slopes

Avoid both poorly drained and excessively permeable soils

Avoid sites where bedrock is near to surface

DESIGN: Design pads to divert run-off from compost and curing piles

Design pad so run-off does not move off-site and impact adjacent waters or land

OPERATION:

To limit the amount of contaminants, such as heavy metals, which could end up in the run-off, avoid material deposited at the compost site which is collected by street sweepers

Plan for prompt disposable of non-compostable material

TROUBLE SHOOTING: FIRE

SITING: Site near hydrant or fire pond for use by fire equipment

DESIGN: Access and on-site roads should be designed to support fire equipment

Design enough space around and between windrows for fire equipment access

Control access to site in order to avoid vandalism

OPERATION:

Properly moisten leaves before building of windrows

Avoid smoking in areas of deposition and composting pad

Avoid backing delivery trucks with hot exhausts into deposited leaves

TROUBLE SHOOTING: VECTORS

OPERATION:

Maintain an effective composting process

Properly mix and promptly create windrows of the incoming material

Promptly remove and properly dispose putrescibles that have been mixed with the incoming leaves and yard waste

TROUBLE SHOOTING: LITTER
(Blowing Leaves)

SITING: Provide an adequate buffer zone

Locate site downwind from sensitive land uses

DESIGN: Retain perimeter vegetation or design berms to act as wind screen

Install simple fence or screen, e.g. snow fencing, to limit movement of leaves off-site

Control access to site to avoid illegal dumping

OPERATION:

Form leaves and yard waste into windrows immediately

Ensure leaves are of proper moisture content

Regularly collect litter from fences or tree line barriers and along roadways

TROUBLE SHOOTING:
ASPERGILLUS FUMIGATUS

OPERATION:

Adequate wetting and minimum disturbance of windrows

Screen job candidates, who plan to be at the composting site for allergic reactions

Worksheet: Deriving Peak and Average On Site Volume Factors

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total On Site
Oct	1.00 [ ]				0.25 ___	0.25 ___	0.25 ___	0.25 ___	0.30 ___	0.40 ___	0.55 ___	0.70 ___	___
Nov	0.70 ___	1.00 [ ]				0.25 ___	0.25 ___	0.25 ___	0.25 ___	0.30 ___	0.40 ___	0.55 ___	___
Dec	0.55 ___	0.70 ___	1.00 [ ]				0.25 ___	0.25 ___	0.25 ___	0.25 ___	0.30 ___	0.40 ___	___
Jan	0.40 ___	0.55 ___	0.70 ___	1.00 [ ]				0.25 ___	0.25 ___	0.25 ___	0.25 ___	0.30 ___	___
Feb	0.30 ___	0.40 ___	0.55 ___	0.70 ___	1.00 [ ]				0.25 ___	0.25 ___	0.25 ___	0.25 ___	___
Mar	0.25 ___	0.30 ___	0.40 ___	0.55 ___	0.70 ___	1.00 [ ]				0.25 ___	0.25 ___	0.25 ___	___
Apr	0.25 ___	0.25 ___	0.30 ___	0.40 ___	0.55 ___	0.70 ___	1.00 [ ]				0.25 ___	0.25 ___	___
May	0.25 ___	0.25 ___	0.25 ___	0.30 ___	0.40 ___	0.55 ___	0.70 ___	1.00 [ ]				0.25 ___	___
Jun	0.25 ___	0.25 ___	0.25 ___	0.25 ___	0.30 ___	0.40 ___	0.55 ___	0.70 ___	1.00 [ ]				___
Jul	0.25 ___	0.25 ___	0.25 ___	0.25 ___	0.25 ___	0.30 ___	0.40 ___	0.55 ___	0.70 ___	1.00 [ ]			___
Aug	0.25 ___	0.25 ___	0.25 ___	0.25 ___	0.25 ___	0.25 ___	0.30 ___	0.40 ___	0.55 ___	0.70 ___	1.00 [ ]		___
Sep	0.25 ___	0.25 ___	0.25 ___	0.25 ___	0.25 ___	0.25 ___	0.25 ___	0.30 ___	0.40 ___	0.55 ___	0.70 ___	1.00 [ ]	___

a) Annual total incoming cubic yards ______ b) Sum of totals (total of all in last column) ______

c) Monthly average on-site volume (b/12) ______ d) Average volume factor (c/a) ______

e) Peak month on-site volume (select highest in last column) ______ f) Peak volume factor (e/a) ______

Instructions

1. For each month enter the expected incoming cubic yards into the box in the worksheet.
2. For each non-zero month, fill in the column by multiplying the amount received by the volume reduction factor to the left of each space. This shows the volume reduction history of material received in each month.
3. Add up the on-site cubic yards across the row and enter the total in the right hand column. You now know the total net volume of material on site for each month, no matter when it was received.
4. Calculate the annual total incoming by adding up all the entries in the boxes and enter the result in a).
5. Add the on-site totals in the right column. This means nothing by itself; it will be used next to calculate the average volume on site. Enter this in b)
6. Calculate the average on site by dividing item b) by 12. Enter this in c).
7. Calculate the average volume factor by dividing item c) by a). Enter this in d).
8. Find the largest number in the on-site total column; this is the peak month. Enter this in e).
9. Calculate the peak volume factor by dividing the peak month volume by the annual total. divide e) by a); enter result in f)

NOTES FOR A SHORT COURSE ON OPERATING MUNICIPAL YARD WASTE COMPOST PROJECTS

Developed by:

Michael Simpson, Tellus Institute
&
Betsy Loring, RI DEM

In Conjunction with the:

Rhode Island Department of Environmental Management
&
Rhode Island Solid Waste Management Corporation

WHY COMPOST LEAVES AND YARD WASTE?

* Avoid High Disposal Costs

* Preserve Disposal Capacity

* Reduce Landfill and Incinerator Pollution

* Recycle A Natural Organic Resource

* Produce Valuable Soil Amendment

WHAT IS COMPOSTING ?

COMPOSTING is a waste management option which utilizes the natural process of biological decomposition under controlled conditions to produce a stable end-product.

COMPOST (the end-product) resembles a darkened humus-like material which can be easily and safely handled, stored and applied to land as a valuable soil conditioner.

COMPOSTING: A Process of Aerobic Decomposition

Composting occurs through the breakdown of organic material by macro and micro organisms which require:

AIR

The decomposition process needs adequate oxygen.

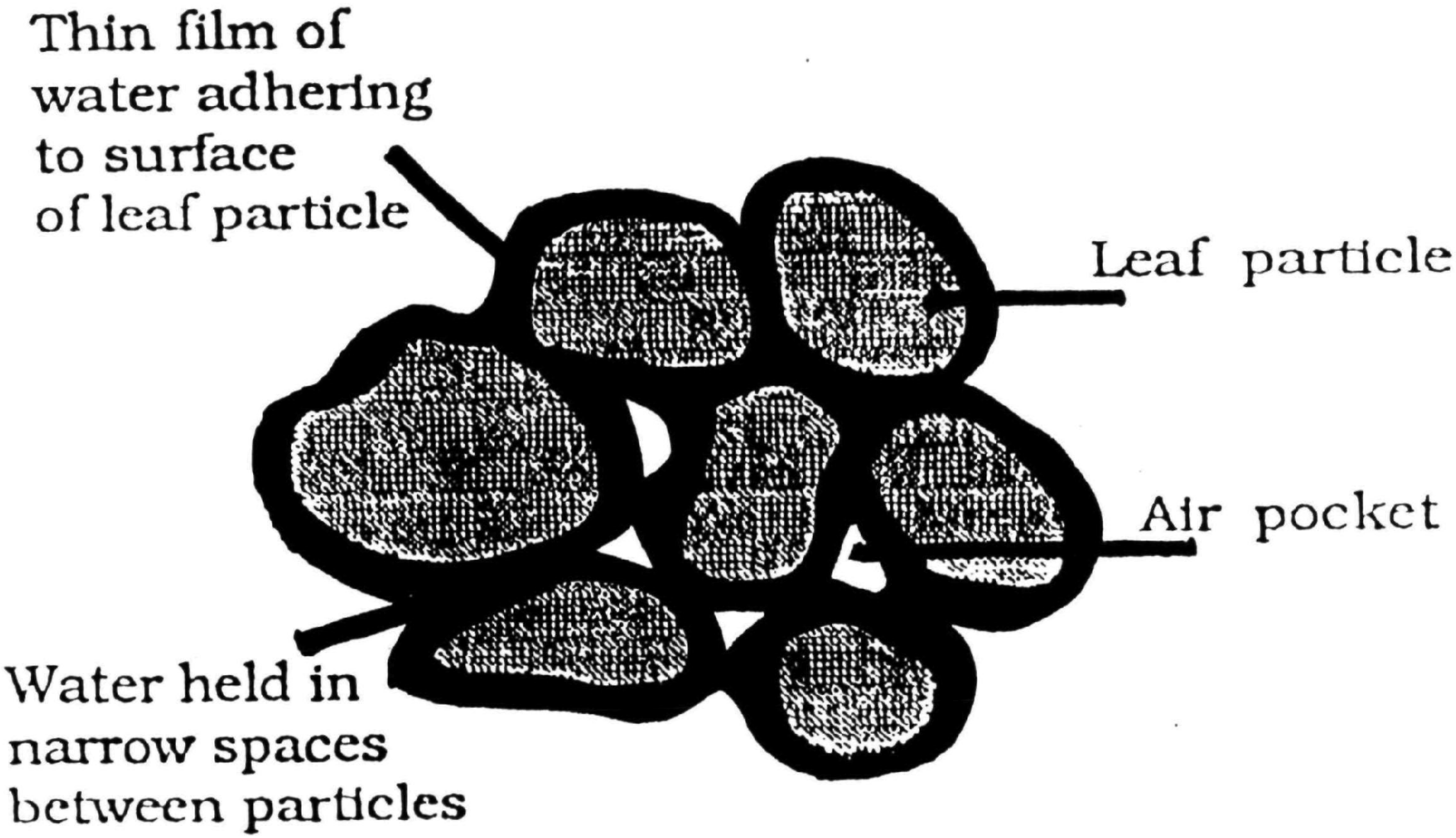
FOOD

The leaves and yard waste (organic material) provides decomposers both energy (carbon molecules) and building blocks (nitrogen molecules) for population growth.

WATER

Decomposers needs water both for the assimilation (in-take) of nutrients from the break-down of the organic material and as a medium in which they live.

Leaf Particles with Proper Moisture

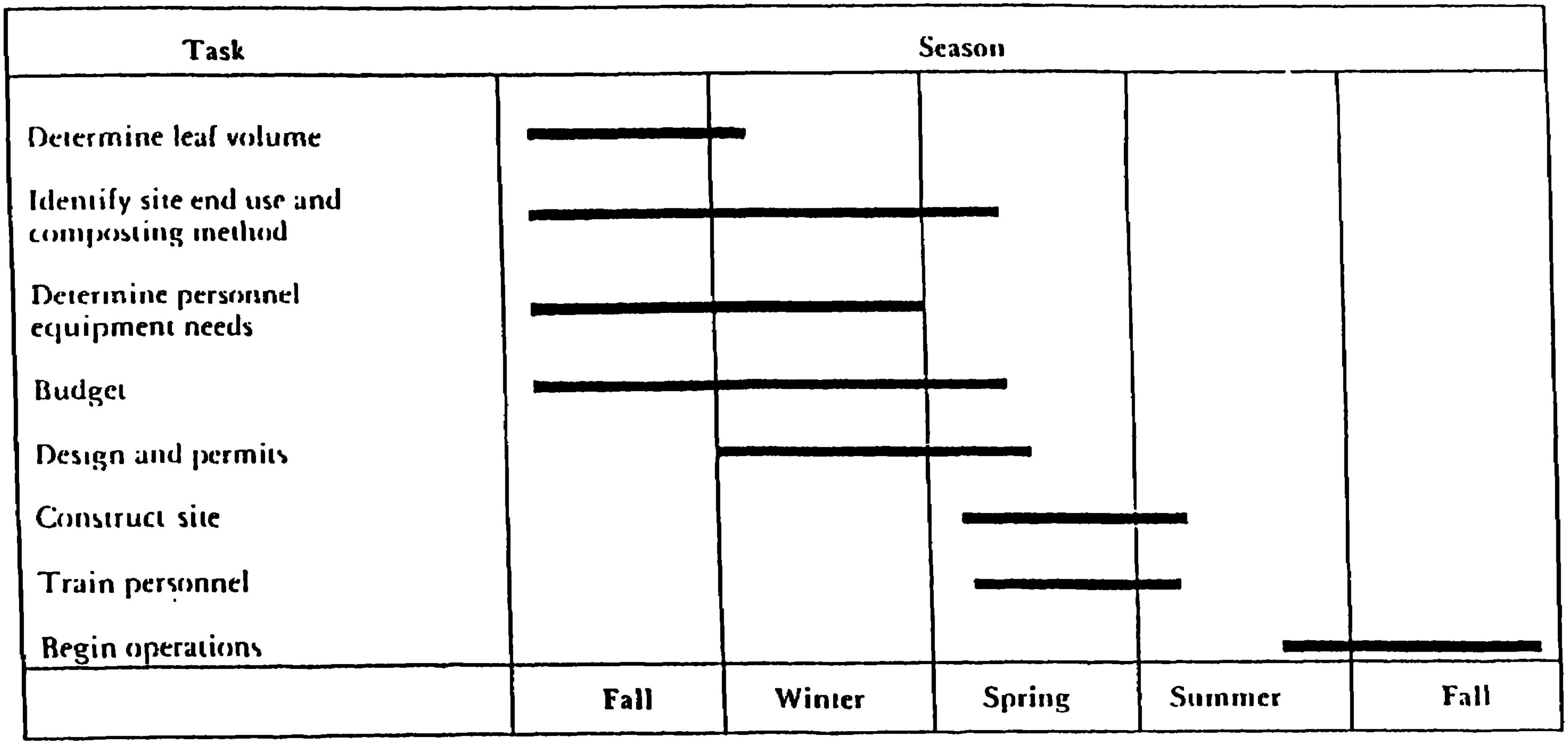


Microbes live in thin film of water around leaf particles

PLANNING FOR A COMPOSTING PROGRAM

* Quantity of Material
* Collection
* Siting
* Equipment
* Staffing
* Public Education
* End Use

PROJECTED TIME LINE FOR IMPLEMENTING LEAF AND YARD WASTE COMPOST



Source (Connecticut DEP, 1989)

COLLECTION METHODS

* Drop-off collection

  - residential and/or

  - commercial

* Bulk (loose) collection

  - streets only and/or

  - residential lawn leaves

* Bagged collection

  - plastic bags with debagging or

  - biodegradable paper bags

ESTIMATING QUANTITY OF MATERIALS

* Existing records of seasonal fluctuation, can provide a reasonably accurate quantity of leaves in the fall that are collected.

* Based on national (EPA) figures, leaves and yard waste comprise 18% of municipal solid waste (MSW). Leaves, by themselves, comprise 6% of the MSW stream. In the fall, leaves can make up to 30 - 50% of the volume of MSW in suburban areas.

* Based on studies of several communities throughout the U.S. composting leaves, collected leaves can range from 50 to 200 cubic yards per curb mile.

ESTIMATING COMPOST PAD SIZE

For every 4000 to 5000 cubic yards of leaves delivered, approximately one acre will be required. This will depend somewhat on the level of operation, such as frequency of turning. Areas for buffers to sensitive neighbors, access into and out of the site, curing, as well as storage for compost and equipment are additional.

One can assume 6 1/2 cubic yards for each ton of leaves (300 pounds/ cubic yard). However this ratio can VARY GREATLY depending upon the amount of yard waste, moisture, sand and grit that are present or whether the leaves were shredded of compacted prior to delivery to the composting area.

The composting pad, at a minimum, should be sized to accept the amount of material that is to be deposited, composted and removed within one year.

INCLUDE SPACE FOR:

- Buffers, Drainage Ditches, Swales, etc.
- Roads
- Drop-Off Area(s)
- Mixing, Shredding, De-bagging, Screening
- Curing, Compost Storage
- Equipment Storage, Workers' Shelter
- (Slower Composting)
- (Future Expansion)
- (Additional Materials: grass, brush)

Average and Peak On Site Volumes

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total on Site	
Oct	5,000				*0*	*400*	*500*	*600*	*700*	*800*	*0*	*0*	8,000	Oct
Nov	2,500	10,000				*400*	*400*	*500*	*600*	*700*	*0*	*0*	15,100	Nov
Dec	2,250	5,000	0				*400*	*400*	*500*	*600*	*0*	*0*	9,150	Dec
Jan	2,000	4,500	0	0				*400*	*400*	*500*	*0*	*0*	7,800	Jan
Feb	1,750	4,000	0	0	0				*400*	*400*	*0*	*0*	6,550	Feb
Mar	1,500	3,500	0	0	0	2000				*400*	*0*	*0*	7,400	Mar
Apr	1,250	3,000	0	0	0	1000	2000				*0*	*0*	7,250	Apr
May	1,000	2,500	0	0	0	900	1000	2000				*0*	7,400	May
Jun	1,000	2,000	0	0	0	800	900	1000	2000				7,700	Jun
Jul	1,000	2,000	0	0	0	700	800	900	1000	2000			8,400	Jul
Aug	1,000	2,000	0	0	0	600	700	800	900	1000	0		7,000	Aug
Sep	1,000	2,000	0	0	0	500	600	700	800	900	0	0	6,500	Sep

Annual total	25000	100% of total incoming material
Monthly average	8188	33% of total incoming material
Peak month	15100	60% of total incoming material

Numbers in boxes like this: [500] = fresh incoming loads.
Numbers below boxed figures represent reductions due to decay of material.
Numbers in *italics* indicate compost remaining from prior seasons
Add numbers across rows to learn total cubic yards on site in any given month.
Oct total cubic yards = 5,000(new) + 400(prior) + 500(prior) + 600(prior) + 700(prior) +800(prior) = 8,000

Average and Peak On Site Tonnages

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total on Site	
Oct	1,000				*0*	*200*	*220*	*240*	*260*	*280*	*0*	*0*	2,200	Oct
Nov	800	2,000				*200*	*200*	*220*	*240*	*260*	*0*	*0*	3,920	Nov
Dec	750	1,600	0				*200*	*200*	*220*	*240*	*0*	*0*	3,210	Dec
Jan	700	1,500	0	0				*200*	*200*	*220*	*0*	*0*	2,820	Jan
Feb	650	1,400	0	0	0				*200*	*200*	*0*	*0*	2,450	Feb
Mar	600	1,300	0	0	0	400				*200*	*0*	*0*	2,500	Mar
Apr	550	1,200	0	0	0	320	400				*0*	*0*	2,470	Apr
May	500	1,100	0	0	0	300	320	400				*0*	2,620	May
Jun	500	1,000	0	0	0	280	300	320	400				2,800	Jun
Jul	500	1,000	0	0	0	260	280	300	320	400			3,060	Jul
Aug	500	1,000	0	0	0	240	260	280	300	320	0		2,900	Aug
Sep	500	1,000	0	0	0	220	240	260	280	300	0	0	2,800	Sep

Annual total	5,000	100% of total incoming material
Monthly average	2,813	56% of total incoming material
Peak month	3,920	78% of total incoming material

Numbers in boxes like this: [500] = fresh incoming loads.
Numbers below boxed figures represent reductions due to decay of material.
Numbers in *italics* indicate compost remaining from prior seasons
Add numbers across rows to learn total cubic yards on site in any given month.
Oct total tonnage = 1,000(new) + 200(prior) + 220(prior) + 240(prior) + 260(prior) +280(prior) = 2,200

SITE CONSTRAINTS

* NEIGHBORS
* WELLS
* WET SOILS (wetlands)
* EXCESSIVELY PERMEABLE SOIL
* FLOOD PLAINS
* SURFACE WATER
* GROUND WATER
* BEDROCK
* PREVIOUS WASTE DISPOSAL SITE

COMPOST PAD DESIGN

* DESIGN PAD TO AVOID STANDING WATER.

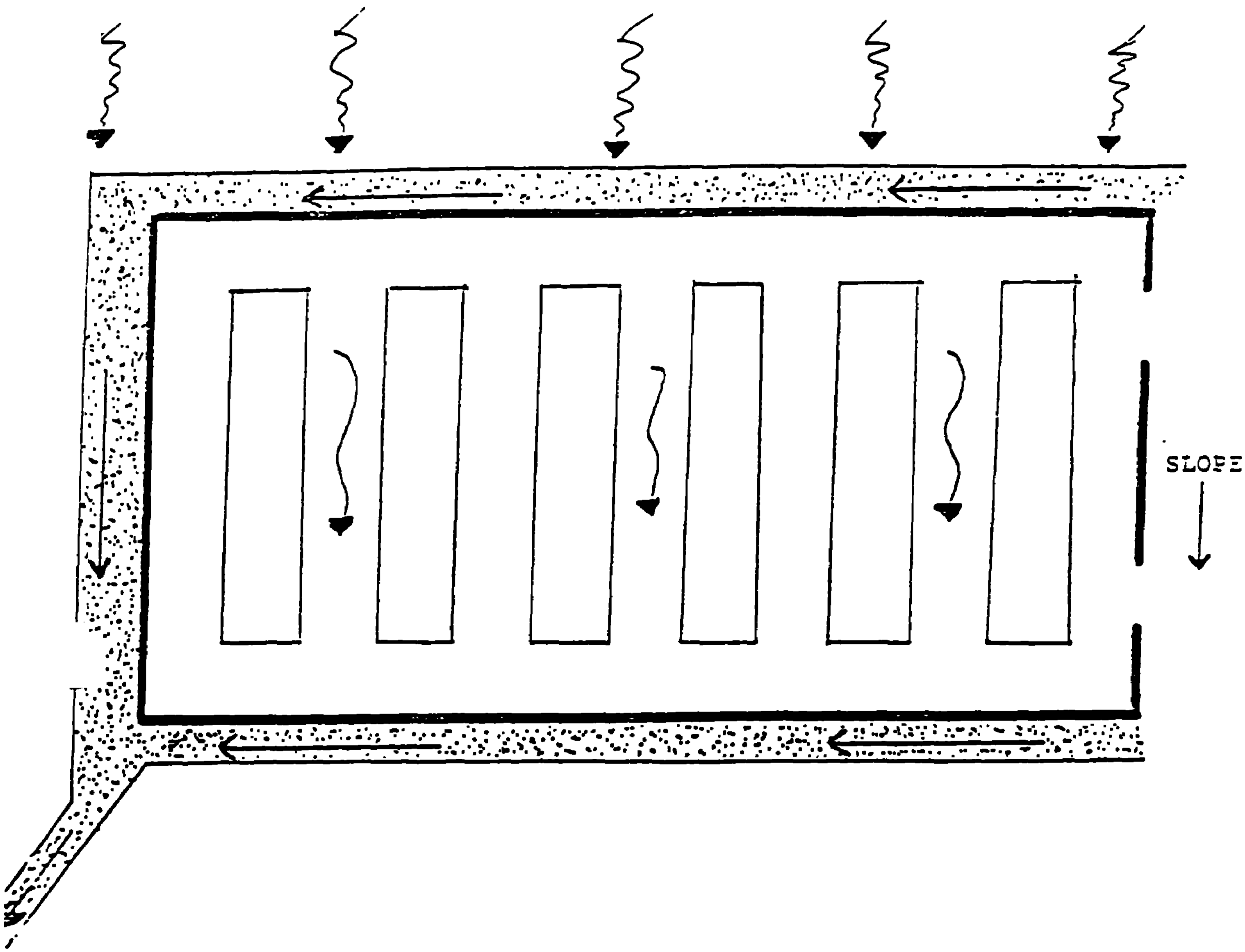
* DESIGN PAD TO SUPPORT MACHINERY FOR ALL SEASONS OF THE YEAR.

Proper pad design and construction is an essential first step for avoiding future problems from nuisance conditions (odor) and/or environmental impact (run-off or erosion).

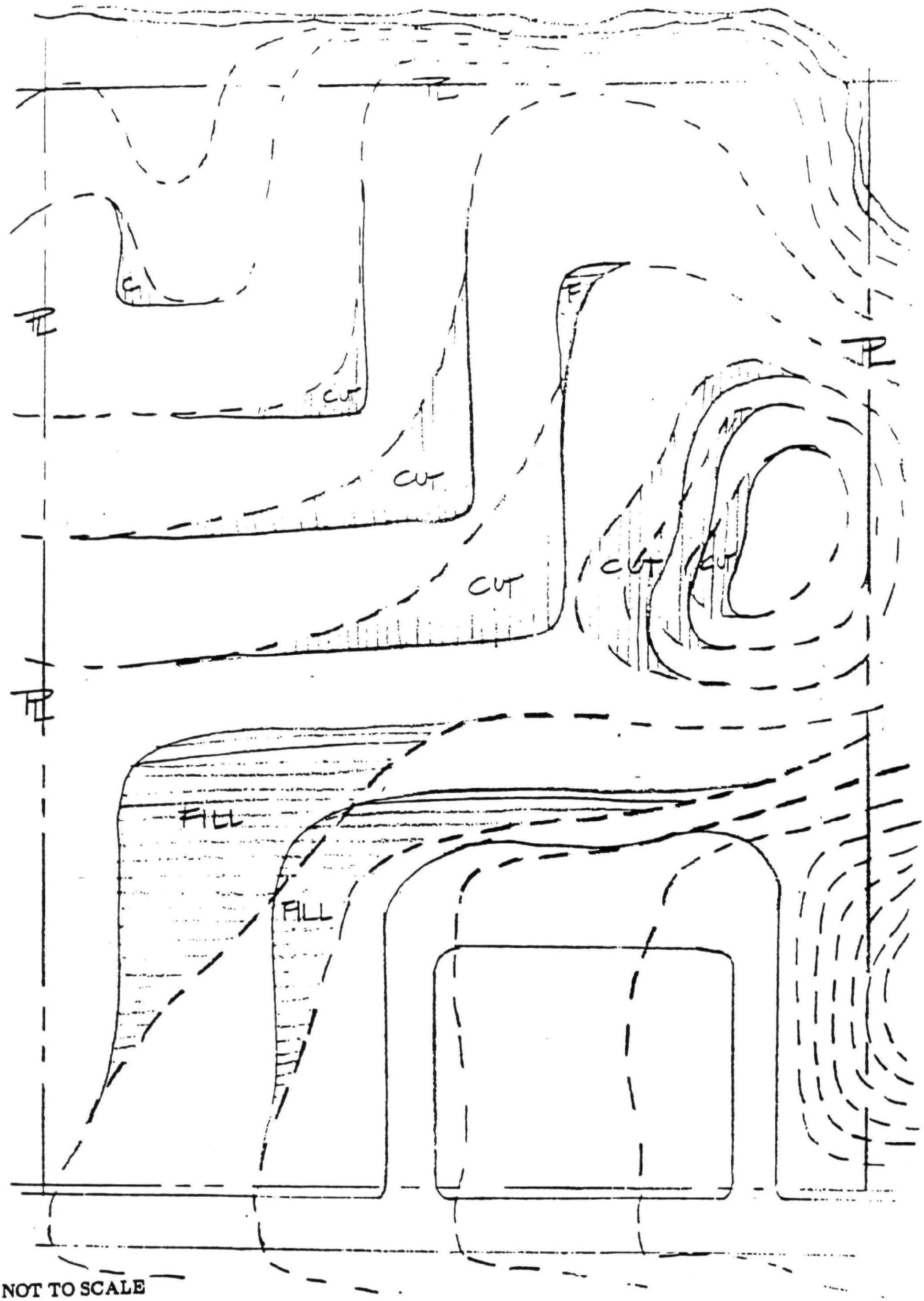
POSSIBLE PAD MATERIALS

- **Existing Subsoil**
- **Gravel, Crusted Stone, Bank Run Gravel**
- **Clean, Recycled Demolition (non-organic)**
- **Recycled Stone from Water Projects**

Generic Site Plan to Control Run-off

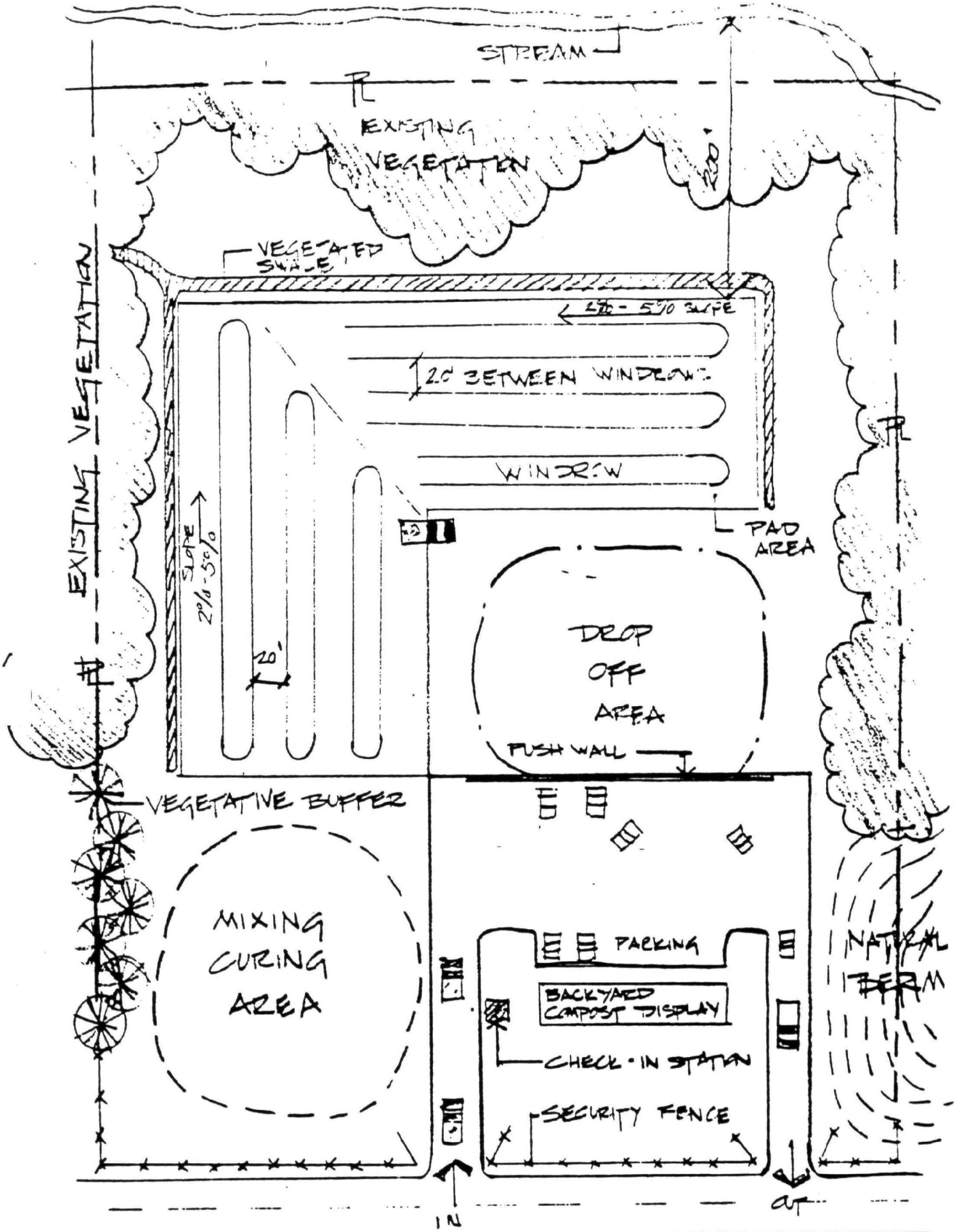


RUNOFF SHOULD BE DIVERTED TO APPROPRIATE METHODS OF TREATMENT.



NOT TO SCALE

SITE PLAN BEFORE YARD WASTE COMPOST PROJECT REGRADING



SITE PLAN FOR GENERIC YARD WASTE COMPOST PROJECT

EQUIPMENT NEEDS

* MATERIAL MOVEMENT
* TURNING (aeration/mixing)
* WATERING
* SCREENING
* MONITORING

STAFF

* A municipal scale composting operation requires "dedicated" staff.

* Staff availability and performance will make a difference between a successful project and a series of potential nuisance and/or environmental problems.

* The staff needs to understand both the material with which they are working and the process by which this material is made into compost.

* Back-up personnel is recommended for those who have direct responsibility for compost operations.

STAFF RESPONSIBILITIES CAN INCLUDE:

* COLLECTION
* DEPOSITION
* COMBINING/TURNING
* MONITORING/RECORD KEEPING
* QUALITY CONTROL
* FINAL PROCESSING
* DISTRIBUTION

PUBLIC EDUCATION

* Master Composter Strategy
* Community meetings/organizations
* Schools
* Knowledgeable staff at transfer and/or disposal site
* Flyer/Brochure Mailings
* Tax/Water Bill Inclosures
* TV and Radio
* Newspaper
* Posters/Signs

COMPOSTING: MANAGED PROCESS

PROCESS STEPS:

Collection

Delivery

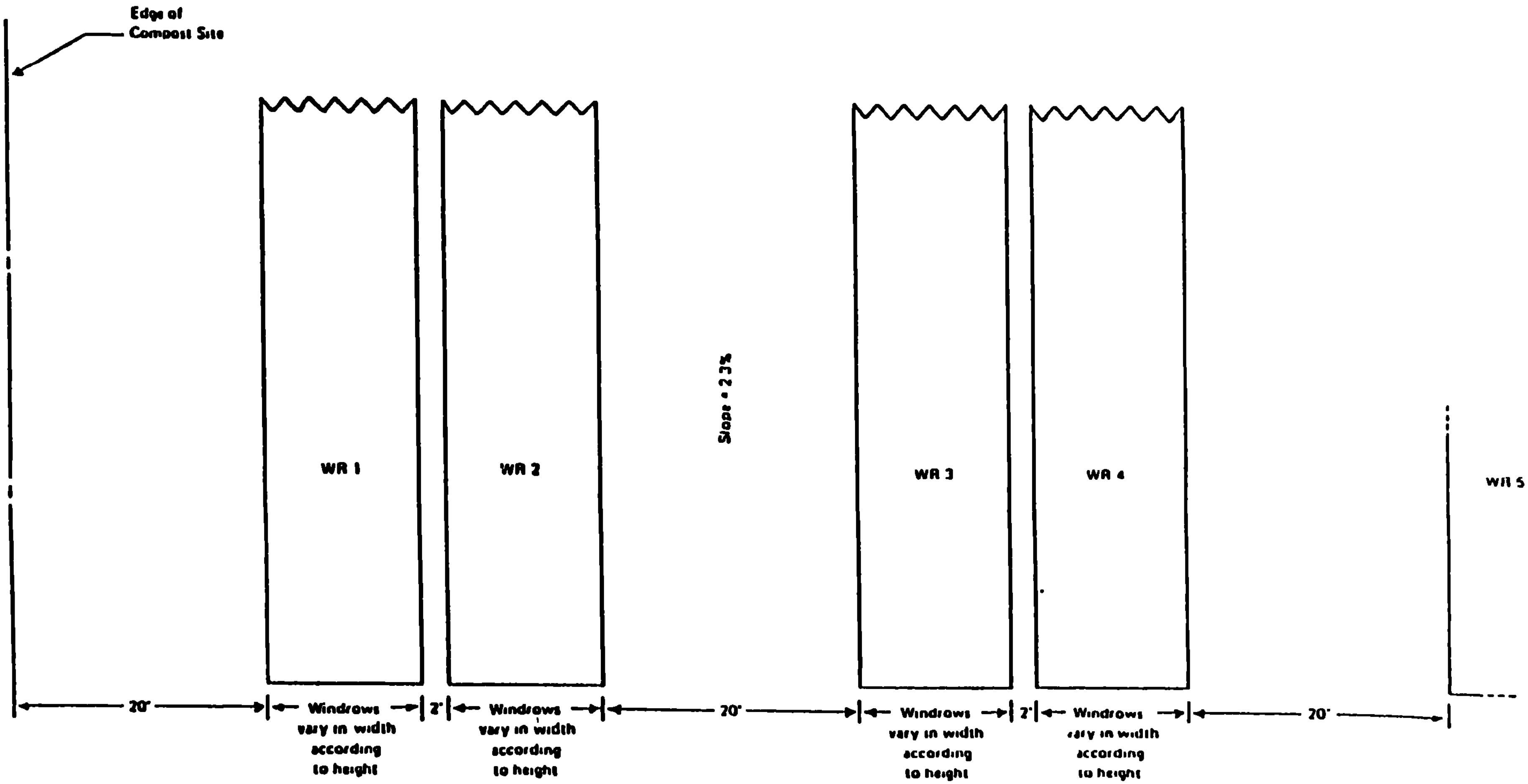
Pre-Process (optional)

Decomposition	Pile Formation Pile Combining Pile Turning Curing	Temp Monitoring

Shredding/Screening (optional)

Marketing (end use)

INITIAL WINDROW SPACING



Source (Connecticut DEP, 1989)

COMBINING

* COMBINE TO INSULATE PILES

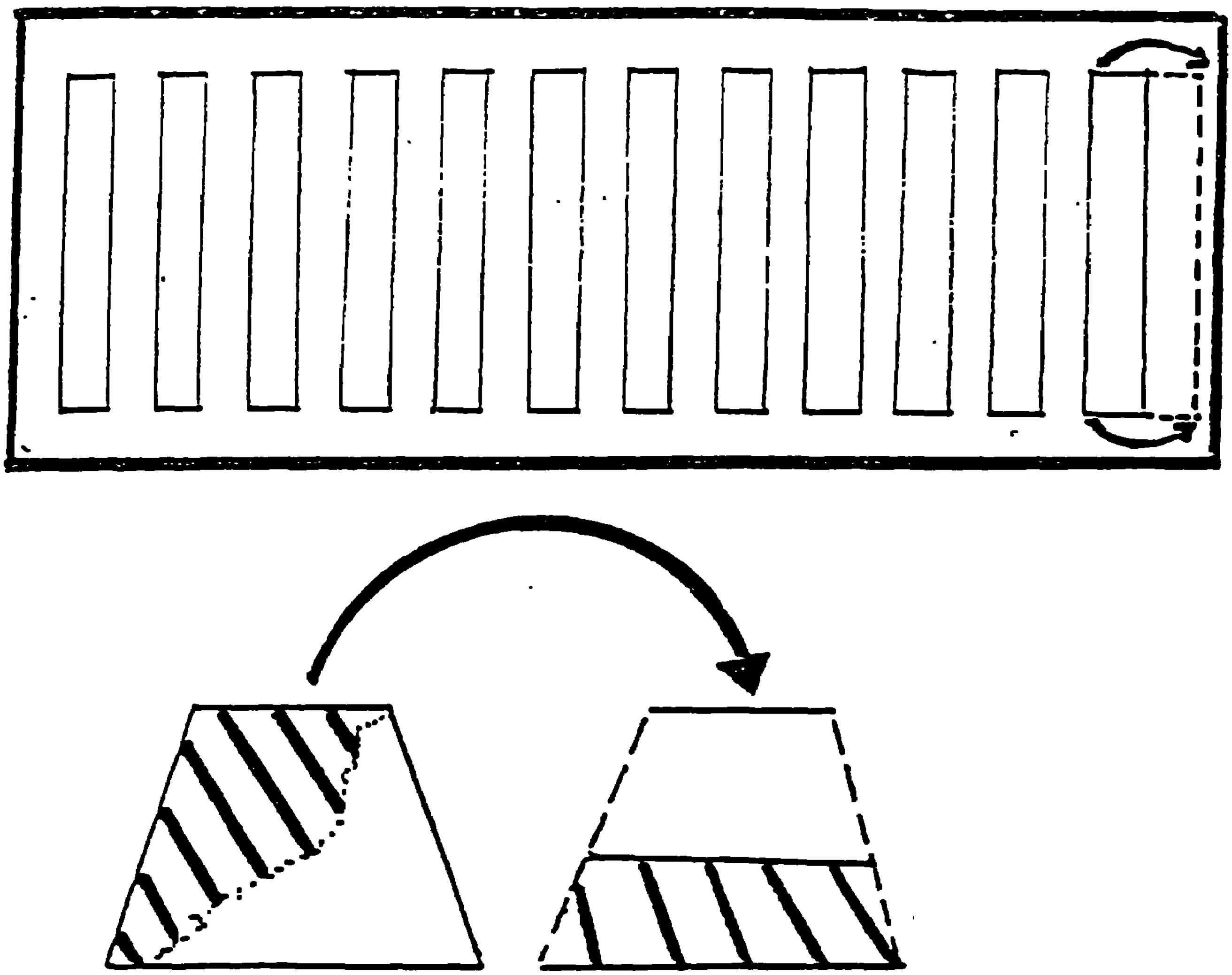
* COMBINE TO FREE UP PAD SPACE FOR NEW DEPOSITION

PILE BREAKDOWN

* BREAK DOWN PILE DUE TO OVERHEATING

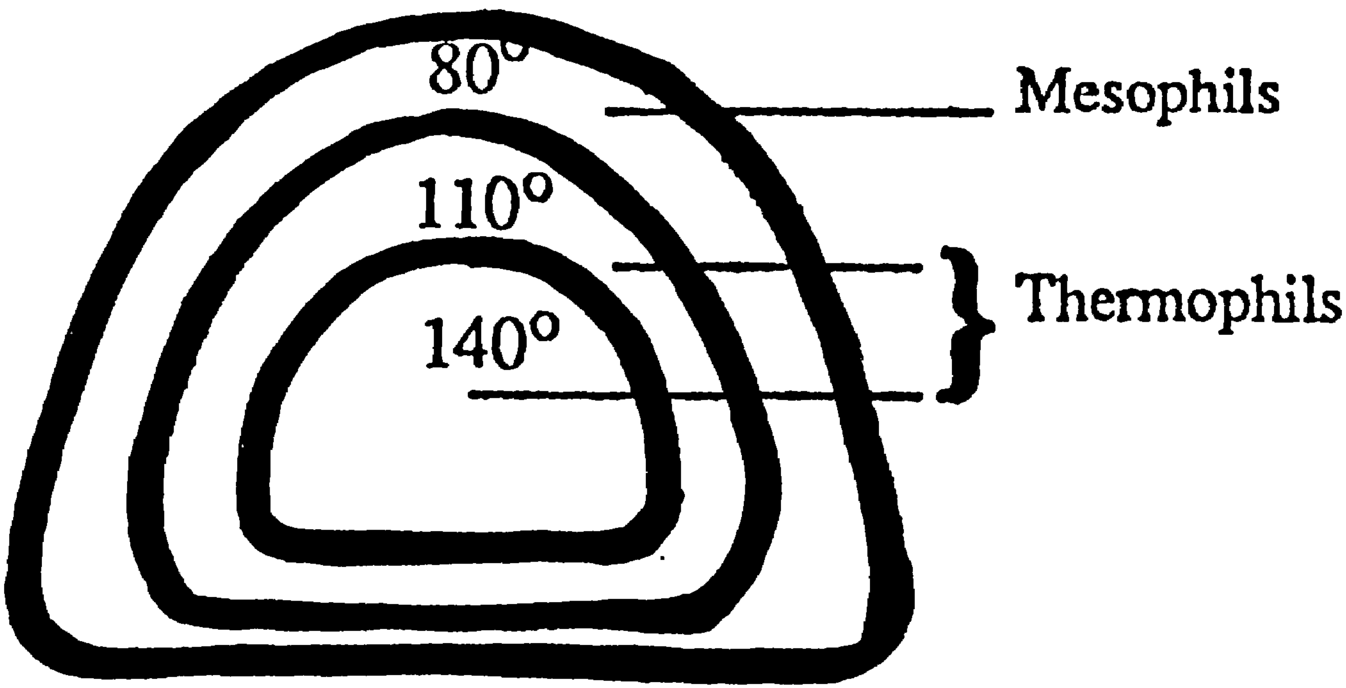
* BREAK DOWN PILE DUE TO COMPACTION

Turning Procedure



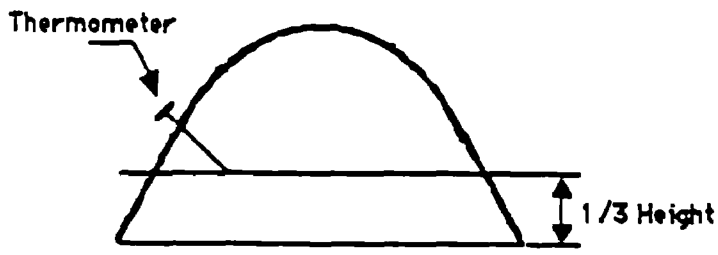
<u>TURNING</u> NOT ONLY AERATES THE PILE BUT ALSO ALLOWS PROPER MIXING. TO ENSURE THAT WINDROW IS MIXED THOROUGHLY, EACH COMPOST PILE SHOULD BE TURNED TWICE IN THE SAME DIRECTION. TURNING TWICE IN THIS MANNER WILL ALLOW THOSE LEAVES ON THE OUTSIDE OF THE PILE TO BE MIXED INTO THE CENTER OF THE WINDROW, WHERE MICRO-ORGANIMS CAN CAN BREAK DOWN THIS MATERIAL. IF PROPER MIXING DOES NOT OCCUR, DECOMPOSITION OF THE LEAVES WILL BE SLOWED, AS SUCH, MATERIAL MAY NEED TO REMAIN ON THE COMPOSTING PAD FOR AN ADDITIONAL AMOUNT OF TIME.

Temperatures and Organisms in an Active Compost Windrow



The inside of the windrow is well insulated, and holds heat that thermophils (warm temperature microorganisms) need to live.

Temperature Measurement Technique



Windrow

Take temperature of bottom third of windrow, where temperatures will go down first, as oxygen is depleted

KEEPING RECORDS

TEMPERATURE: By keeping records of temperature, the operator can see a trend or a general rate at which the decomposition process is moving. This will allow the operator to take the appropriate steps to both ensure an ongoing active decomposition process and avoid potential nuisance or environmental problems.

Thus, temperature should be recorded twice a week in the early stages of windrow decomposition. Each windrow should be monitored at locations approximately 50 to 75 feet apart.