CUMBERLAND COUNTY SOLID WASTE AUTHORITY
CUMBERLAND COUNTY, PENNSYLVANIA

MUNICIPAL YARD WASTE COMPOSTING FACILITY

OPERATOR'S REFERENCE GUIDE AND HANDBOOK

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MUNICIPAL YARD WASTE COMPOST FACILITY OPERATOR'S REFERENCE GUIDE AND HANDBOOK

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MUNICIPAL YARD WASTE COMPOST FACILITY
OPERATOR'S REFERENCE GUIDE AND HANDBOOK

I. INTRODUCTION

A. Purpose and References

This handbook was developed to provide technical assistance to operators of yard waste composting and processing facilities. This handbook includes basic information on the composting process as well as technical information for the proper operation and management of a municipal yard waste composting facility. Recommended operating procedures and conditions, as well as record-keeping guidelines and troubleshooting suggestions are included in this operator's reference guide and handbook.

The information contained in this handbook is based on a variety of references and highly regarded sources. Acknowledgment is given to the following:

Cornell Composting, Tom Richard, Dept. of Agricultural & Biological Sciences, Cornell University, Ithaca, NY, http://www.cals.cornell.edu/dept/compost/Fact.sheets

Composting and Recycling Municipal Solid Waste, Luis F. Diaz...[et. al.], Lewis Publishers, Boca Raton, FL, 1993.

Municipal Yard Waste Composting Reference Manual, Gershman, Brickner & Bratton, Inc., [et.al.] for Pennsylvania Department of Environmental Resources, Harrisburg, PA, October 1991.

Curbside Recycling: How-To Guide for Pennsylvania Local Governments, The Pennsylvania State Association of Township Supervisors for Pennsylvania Department of Environmental Resources, Harrisburg, PA, September 1990.

The BioCycle Guide to Yard Waste Composting, edited by the staff of BioCycle Journal of Waste Recycling, The JG Press, Inc., Emmaus, PA, 1989.

Guidelines for Yard Waste Composting Facilities, Policy Guidance Document, Pennsylvania Department of Environmental Protection, Harrisburg, PA, April 1997.

Guide to Municipal Yard Waste Composting, Pennsylvania Department of Environmental Protection, http://www.dep.state.us/dep/deputate/airwaste/wm/recycle/Compost/Mun1.htm

B. Pennsylvania's Yard Waste Management Regulations

PA Act 101 of 1988, the "Municipal Waste Planning, Recycling and Waste Reduction Act," establishes the framework for separating and recycling components of the municipal wastestream in certain communities in Pennsylvania. Regulations developed by the Pennsylvania Department of Environmental Protection (PADEP) under Act 101 establish requirements for separating and processing leaf wastes. For larger "mandated communities" (there are eleven such municipalities in Cumberland County), leaf wastes must be separated from other residential wastes that are collected for disposal. Further, since September of 1990, no waste disposal facility may accept shipments comprised primarily of leaf wastes, unless provisions are made to compost those leaf loads. These regulatory requirements have stimulated the establishment of over 80 municipal leaf composting facilities in Pennsylvania.

Composting of municipal wastes in Pennsylvania is regulated and permitted under Chapter 281 of PADEP's Municipal Waste Regulations. However, under Section 271.101(h) of the regulations, yard waste composting that is conducted by persons, municipalities or counties within established PADEP guidelines is deemed to comply with the regulations as a "Permit-by-Rule" facility. These guidelines establish minimum siting, operating, and reporting criteria that divert yard wastes from the waste stream for composting in an environmentally safe manner. These guidelines contain a "Yard Waste Composting Facility Application Form" that must be completed and submitted to PADEP for a facility to operate as a permit-by-rule facility. A copy of PADEP's Guidelines for Yard Waste Composting Facilities, including the application form, is contained in Attachment No. 1 of this handbook. PADEP defines yard waste composting as follows:

> **"Yard Waste":** Leaves, grass clippings, garden residue, tree trimmings, chipped shrubbery and other vegetative material.
>
> **"Yard Waste Composting Facility":** A facility that is used to compost leaf waste, or leaf waste and grass clippings, garden residue, tree trimmings, chipped shrubbery, and other vegetative material. The term includes land affected during the lifetime of the operation, including, but not limited to, areas where composting actually occurs, support facilities, borrow areas, offices, equipment sheds, air and water pollution control and treatment systems, access roads, associated on-site or contiguous collection and transportation activities, and other activities in which the natural surface has been disturbed as a result of or incidental to operation of the facility.

Table 1 presents a summary of current yard waste management activities in Cumberland County. All operating yard waste composting facilities in the County are believed to comply with the PADEP guidelines.

TABLE 1

MUNICIPAL YARD WASTE COMPOSTING PROGRAMS

Municipality	Collect Leaves	Collect/Drop-off Other Yard Waste	Leaf Compost Operation	Leaves/Grass Compost	Land Application[3]
Carlisle Borough	X		X		
Camp Hill Borough	X	X	X		
East Pennsboro Township	X				
Hampden Township	X		X		
Lower Allen Township	X	X	X		
Mechanicsburg Borough	X				X
New Cumberland Borough	X				X
North Middleton Township	X				
Shippensburg Borough	X	X	X	X	
South Middleton Township	X	X			
Upper Allen Township	X		X		
Lemoyne Borough	X	X			X
Mt. Holly Borough					
Shiremanstown Borough[1]	X				
Silver Spring Township[2]	X		X		
Wormleysburg Borough					X

(1) Utilizing Camp Hill compost facility.
(2) Designated citizen leaf drop-off only.
(3) Direct land application of leaves only.

Source: From Table 4-4, Cumberland County Municipal Waste Plan Revision, 2/97, updated 6/99.

II. COMPOSTING PROCESS

Composting is a biological process; it is the controlled decomposition of organic matter by microorganisms into a relatively stable humus-like product. The microorganisms responsible for composting are aerobic, or oxygen-loving. Thus, composting occurs in the presence of oxygen. The microorganisms require water and nutrients, and the microorganisms generate heat as they decompose wastes. The illustration on the following page reflects a typical leaf or yard waste windrow composting pile. The key factors and conditions for successful composting are described in the following sections.

A. Key Factors and Conditions

The key conditions for successful composting include substrate, moisture content, oxygen, temperature, and pH. These environmental factors work together to provide the desired extent and rate of decomposition. The key factors for successful composting are based on the waste to be composted, also called the substrate (in this case, leaf and yard wastes). The substrate determines the available nutrients, the particle size and the need for inoculents.

1. **Substrate.** The substrate, or the type(s) of waste to be composted, provides the nutrients necessary for biological decomposition. The nutrients of primary importance in composting are carbon and nitrogen. The size of the substrate may or may not require processing to achieve optimal particle size for microbial decomposition.

   a. <u>Carbon to nitrogen ratio (C:N)</u>. The microorganisms required for composting use carbon sources to obtain energy and consume nitrogen for protein and synthesis of new cellular material (population growth). Carbon sources include leaves and brush. Nitrogen sources include grass clippings, garden vegetation, and digested sewage sludge (although composting of sewage sludge requires a PADEP permit). The ideal proportion of carbon to nitrogen, for optimal aerobic microbial action, is about 30 parts carbon to 1 part nitrogen by weight, although this ratio may need to be adjusted based on the bioavailability of carbon and nitrogen.

      Insufficient nitrogen limits the growth of the microbial population, and the rate of composting will slow down if the C:N ratio is very high. Conversely, excess nitrogen leads to rapid microbial growth and accelerates decomposition, but this can quickly deplete available oxygen, causing the compost mixture to go anaerobic and create serious odor problems .

The C:N ratio of leaves tends to range from 40:1 to 80:1; thus, leaf composting is on the slow side as far as composting operations go. Leaf composting can be improved by reducing the C:N ratio via addition of grass clippings or other nitrogen sources. Keep in mind, however, that most materials with a high nitrogen content require more careful management to ensure adequate aeration and mixing.

b. Surface area/particle size. The microorganisms act on the surface of the substrate. Smaller particles have greater surface area (for the same amount of material) and are broken down more quickly. However, very small particles compress together, limiting porosity and limiting movement of water and oxygen. Furthermore, the size reduction of some fresh vegetation turns the waste into a slurry material which is harder to manage and has a very low porosity.

Some size reduction is recommended for branches and twigs, primarily to make handling easier. Tearing or shredding of leaves may be considered if the composting rate is inadequate (too slow) or if uneven decomposition within the compost piles is evident; usually, leaves compost well without shredding. Little or no size reduction is recommended for fresh, green vegetation.

c. Inoculents. Decomposition is performed by the microorganisms naturally present in leaf and yard wastes. These microorganisms grow rapidly on the organic material, using it as a source of food. Naturally occurring microorganisms are present in sufficient quantities for proper yard waste composting operations. Rarely does composting require inoculums, or the deliberate addition of microorganisms to the substrate.

Although typically not needed for leaf and yard waste composting, should an inoculum be desired, the following sources of microbes can be considered: finished compost, decomposed horse manure, or a rich and loamy soil.

2. **Moisture Content.** Water is essential to the survival of microorganisms.

Moisture aids in dissolving nutrients and provides a suitable environment for bacterial population growth. The optimal moisture content for leaf composting should be between 40 and 60 percent; this is about the consistency of a wrung-out sponge...the leaves should feel damp but with only a drop or two of water expelled when tightly squeezed. Leaves very often require water at the start of the composting process. As a rule of thumb, dry leaves initially need about 20 gallons of water for every cubic yard of leaves. Keep in mind that excessive moisture inhibits the flow of oxygen, and anaerobic conditions start to develop.

Water for compost pile wetting can be provided from potable or non-potable piped sources (such as a hydrant connection), from a stream/pump discharge, from a well supply, or from a tanker truck. Rewetting of the pile during turning may be necessary to maintain optimal moisture conditions. Water can be added to the compost pile by hosing as the windrow is turned, by turning the piles on a rainy day, or by injecting water to the center of the pile via pressurized means.

The shape of the composting pile also has a lot to do with its moisture content. Piles forming a peak tend to shed water, thus minimizing absorption; this is the recommended method of pile construction during wet weather periods. Piles with a depression on top, forming a concave shape, maximize water absorption. Concave piles, however, are a potential breeding ground for mosquitos and insects.

3. **Oxygen.** The microorganisms responsible for composting are aerobic, or oxygen-loving. Thus, composting occurs in the presence of oxygen. An adequate supply of air is necessary for rapid decomposition of organic material. The oxygen content of the air we breathe is about 21 percent. The compost microorganisms can survive at oxygen levels to about 5 percent; below this, aerobic microorganisms die. Below the oxygen level of 10 percent, parts of the compost can become anaerobic. Such anaerobic conditions can lead to decreased composting efficiency and can cause odor problems. Therefore, maintaining an adequate oxygen supply is essential to proper compost operations.

Air can be supplied by forced aeration systems, though these systems are generally suitable (cost justified) only when nitrogen sources are causing frequent odor problems or if the yard waste is being composted with sludge. Air is most commonly added by turning the compost piles with equipment, like a front-end loader or specialized compost turner. This only provides several hours worth of oxygen, but it also loosens the piles allowing air to flow more freely in and through the pile via natural convection. Natural convection is driven by a chimney effect, with cool outside air pulled in from the bottom sides of the piles, while heated air from the pile center/core rises out of the top of the pile. The effectiveness of natural convection depends upon the particle size, moisture content and pile construction.

4. **Temperature.** Heat is generated by the metabolism of the microorganisms as they naturally decompose waste. The optimum temperature range is between 90°F and 140°F (32 - 60°C). Below 90°F, decomposition slows down significantly, and above 140°F, the rate of decomposition rapidly declines as beneficial organisms begin to die or become dormant. The compost piles may also be susceptible to spontaneous combustion at these higher temperatures.

   Compost pile temperature not only depends on the heat generated by the microorganisms, but also by the heat lost through aeration or surface cooling. During periods of cool weather, piles may need to be larger than usual to minimize surface heat loss. In specialized compost operations that process large amounts of nitrogen-high sources like grass clippings or sludge, smaller piles and frequent turning may be needed to both provide oxygen and release excess heat.

   As a key environmental factor affecting biological activity, the temperature should be monitored frequently; ideally, temperature readings should be taken weekly along every 65 to 75 ft section of the pile (i.e. at least 3-4 measurements per windrow). There is an initial high temperature period of a few days to several weeks, followed by a gradual drop in temperature. Turning the piles reintroduces oxygen and exposes new surfaces to decomposition, causing temperatures to rise again. It is important to monitor temperatures and turn the compost when temperatures exceed 140°F to prevent problems previously mentioned. When the compost temperature drops below 70°F (21°C), the composting process is nearly complete. Turning the compost whenever temperatures get above or below the optimum range (90 to 140°F) will help produce a high quality compost in the shortest possible time. The frequency of taking temperature readings can be extended as the windrow pile material stabilizes.

5. **pH.** It is common for the pH of the material to become slightly acidic (i.e., down to 5.0) during the early stages of decomposition because of organic acid formation.

The pH then begins to rise to near neutral conditions, and may reach levels as high as 8.5. Normally, leaf composting operations should not present a pH (acidic) problem, especially when keeping the pile in an aerobic state. Because decomposition takes place most efficiently under neutral pH conditions, the pH of the material should be monitored periodically.

B. Types of Systems

The three main types of composting systems are the mechanical system, the static windrow system, and the turned windrow system. The mechanical system is an enclosed system, where a reactor provides adequate aeration as well as adds moisture. Some reactors rely on tumbling mechanisms while others utilize forced air techniques. The mechanical process is not economically attractive and is primarily for high volume applications. These are cost-prohibitive for yard waste composting operations.

The static system is sometimes referred to as the forced aeration style of composting. It involves the forcing of air through the compost piles, while the composting materials are not moved/disturbed. The static system works best for a substrate of relatively uniform particle size in which the size does not exceed 2 inches in any dimension; static systems are used primarily for sewage sludge composting. Forced-aeration systems are typically not utilized in yard waste composting, as they are cost-prohibitive.

The turned windrow system is the conventional yard waste composting method. The term “turned” refers to the method of aeration used in this windrow system. The basic idea of the turned windrow system is to build the compost pile, tear it down, and rebuild it. The turned windrow system is primarily for yard wastes. The following section of this handbook deals with the operational requirements of the turned windrow method.

1. **Turned Windrow System Technology.** Key aspects of windrow construction and turning are described below, and summarized for quick reference in Attachment No. 2 of this handbook.

   a. <u>Construction</u>. Windrow construction should occur within one week, but preferably within 1-2 days of delivery of the yard wastes. If several different types of waste are to be composted together, they should be thoroughly mixed. Grass clippings are sometimes placed on top of an existing windrow pile and incorporated into the pile. PADEP guidelines require grass clippings to be incorporated in partially decomposed windrow piles within 24 hours of grass delivery, at a ratio of no less than 3 parts leaves to 1 part grass. Mixing of yard wastes can be performed using a front-end loader, but when mixing with grass clippings, which tend to mat together, use of a windrow turner is recommended.

Pile construction is an important watering period. Water should be added to reach the desired moisture content (between 40 and 60 percent for leaf composting).

The form and shape of the windrow affects several key conditions of the composting process. For instance, if the piles are too large, oxygen cannot reach the center, and if the piles are too small they will not reach optimum temperatures. The ideal windrow size varies with the substrate and with seasons of the year. Windrows of autumn leaves can be constructed 6 to 8 feet tall and 12 to 18 feet wide at the base; these piles may be built to 8 to 10 feet tall in mid-winter months. Larger or smaller piles can create problems for leaf composting operations. Windrows of grass clippings with leaves may need to be smaller, often only 5 feet high and 10 feet wide (however, with a 3:1 minimum ratio of leaves to grass, reduction of the windrow pile size is probably not necessary).

Cumberland County owns two Scat-brand windrow turners that can handle piles up to 6-1/2 feet in height and 18 feet wide (the Scat has a 9-foot working face and turns half of the pile in each pass). Certain Cumberland County municipalities share the use of the Scat turners at their yard waste sites under an agreement with the County that outlines the shared operating and maintenance cost responsibilities. Annual use costs per municipality are very reasonable. For sites using the Scat turner, a windrow pile size of 6 feet high by 18 feet wide are optimal.

When constructing the windrow, care should be taken not to drive on or compact the material. The material should be allowed to cascade down from the bucket of a front-end loader to form a loose pile. Space permitting, windrows should be constructed in pairs for later combining of piles (if a Scat turner is used, a 7-foot clearance between piles is necessary for equipment passage).

b. Turning. The main goals of turning the compost pile are to promote decomposition by moving material from the outside to the inside of the pile, and to "fluff" the material so it will be more porous, allowing air to move freely through the pile. Turning the piles increases the rate of decomposition by mixing of materials and exposing new surface areas.

Turning frequency should be based on temperature, since temperature reflects decomposition taking place in the pile. Whenever temperatures drop below 90°F or exceed 140°F, turning should be performed. If the compost is staying within the 90° to 140°F range by itself, turning can still help accelerate decomposition. Windrows may be turned within 1 to 2 weeks after initial windrow construction. Windrows composed entirely of leaves may only need turned a few times a year, and should be left alone during winter months, as severe cold weather may decrease the decomposition rate. Windrows which include grass clippings in the substrate will require more frequent turning to prevent odors caused by anaerobic conditions. However, if a 3:1 grass:leaves ratio is maintained, this should not be a major issue.

Should anaerobic conditions become apparent, turning the pile will temporarily add oxygen but will also create offensive odors. Before turning, try to identify the cause of the problem so remedial action can be taken as the pile is being turned. Common problems and recommended solutions are included the troubleshooting section of this handbook. Turning of piles during breezy days with preferred prevailing wind directions can help dissipate offensive odors safely.

Although several types of equipment are available for turning windrows, front-end loaders may be the only equipment necessary for smaller composting facilities. When turning the piles with a front-end loader, let the compost cascade out of the bucket so that the materials drop through the air to keep it as loose as possible. As in initial construction, when turning/reconstructing the piles care should be taken not to compact the material. As noted earlier, the County's shared Scat windrow turner program provides an economical and convenient means of turning piles.

Windrows may only need to be turned 3-4 times between initial fall delivery (pile construction) and the middle of the next summer.

c. Curing. After a period of 8-10 months, decomposition in the windrows has slowed substantially. At this time, the material can be moved from the windrow composting area and stacked 10-12 feet high in curing piles (height limited by the capabilities of the site's front-end loader equipment). The material will slowly continue to stabilize. Further turning of the pile should not be necessary at this time, as long as the material stacked is stable due to proper windrow decomposition.

d. Screening. Often, finished yard waste compost is used as a mulch, soil amendment or conditioner, without further processing. To improve product quality, a mechanical screen or shredder may be used to size-reduce and/or size-separate various grades of material. This can improve demand and potential end-uses of the material.

e. Limitations. There are two potential limitations associated with the turned windrow system. These are odors and pathogens. Odors can periodically be a part of the composting process, even with appropriate operating procedures. Proper site and operations management will minimize odor occurrences. Pathogens are generally applicable to operations that involve the processing of wastewater sludges or residues from other animals, and should not be an issue in yard waste operations.

C. Health and Safety Precautions.

As with all processing operations, health and safety precautions must be taken to avoid injury or illness at a municipal yard waste composting facility. To avoid injury, care must be taken when heavy equipment is operating. This includes waste drop-off vehicles, front-end loaders, and any specialized mixing, shredding or aeration equipment. Proper safety apparatus may include eye, ear and head protection.

Possible illness due to the potential threat of microorganisms does exist, but depends on the type of waste being composted and on the worker's resistance to disease. Many different types of fungi, mold and bacteria thrive in compost, including municipal yard waste compost. Although few organisms of public health significance are found in yard wastes, it is important to take proper sanitary measures, such as washing hands before touching the face or food, etc. During dry and dusty conditions, Occupational Health and Safety Administration (OSHA)-approved dust masks or respirators should be worn to minimize the risk of infection, especially during windrow turning activities.

Individuals sensitive to mold and fungi may experience allergic reactions when exposed to a composting environment. Exposure to large quantities of airborne endotoxins (noxious substances produced by certain bacteria) can produce flu-like symptoms in humans. Individuals who have allergies, asthma or a weakened immune system (due to cancer/cancer treatments, HIV, organ transplants, among others) should not work in the composting operation. In addition, some medications such as antibiotics and hormones, or a punctured eardrum, can predispose individuals to infection or an allergic reaction; these people should not work in the composting operation.

III. TROUBLESHOOTING

Understanding the basic concepts and limitations of the composting process will help operators run a successful operation. Frequent monitoring of the piles is important, as the pile characteristics are clues to the composting process. Pile characteristics can be used to identify problems within the process. Pile characteristics are included in the monitoring procedures section of this handbook.

Symptoms such as high or low temperature, odor, ponding, leachate discharge and others, are indications of problems. Commonly encountered problems, as well as possible causes and solutions, are included in the troubleshooting guide, included as Attachment No. 3 of this handbook.

IV. COMPOST USE

The key elements determining demand for finished compost are quality and consistency. Yard waste compost typically has a higher and more consistent quality than other types of compost. Yard waste compost is aesthetically pleasing; it has a dark color, relatively small and uniform size, an earthy odor, an absence of contaminants, and a desirable moisture and nutrient content and organic matter. Yard waste compost is easy and safe to handle. The primary users and common uses of yard waste compost are noted in the following table.

TABLE 2
COMPOST USE

Market Segment		Standard Application/Use	Desired Compost Quality
Sector	**User**		
Residential	Home gardeners	Mulch and soil amendment	High
Commercial	Landscape contractors Sod/sodding services Nurseries Soil conditioner services/suppliers	Mulch and soil amendment	High
Public	Parks and recreational areas Landfills, quarries, strip mines Roadside and median strip maintenance	Soil amendment and top dressing; mulch	High for parks and recreational areas; Low for others

V. MONITORING PROCEDURES

The key elements for successful composting include moisture content, oxygen, temperature, pH and substrate. These environmental factors work together to provide the desired extent and rate of decomposition. Frequent monitoring of the compost piles is important, as the pile characteristics are clues to the composting process. Good record-keeping practices allow the operator to study the monitoring results and better address problems and concerns. Standard monitoring parameters and record-keeping requirements are summarized below. Sample forms which may be used for monitoring and record-keeping purposes are included in Attachment No. 4 of this handbook.

A. Monitoring Parameters.

At a minimum, the following parameters should be monitored:

- <u>Moisture</u> - Water is essential to the survival of microorganisms. Excessive moisture, however, inhibits the flow of oxygen and anaerobic conditions start to develop. The optimal moisture content for leaf composting should be between 40 and 60 percent; this is about the consistency of a wrung-out sponge...the leaves should feel damp but with only a drop or two of water expelled when tightly squeezed. Leaves very often require water at the start of the composting process. As a rule of thumb, dry leaves initially need about 20 gallons of water for every cubic yard of leaves.

- <u>Temperature</u> - As a key environmental factor affecting biological activity, the temperature should be monitored frequently; temperature readings should be taken at least two times per week along every 65 to 75 ft section of the pile. It is important to monitor temperatures and turn the compost when temperatures exceed 140°F to prevent problems. Turning the compost whenever temperatures get above or below the optimum range (90 - 140°F) will help produce a high quality compost in the shortest possible time. When the compost temperature drops below 70°F (21°C), the composting process is nearly complete.

- <u>Appearance</u> - Visual inspection of the windrows should be conducted. Items of concern include ponding water and leachate discharges; pile reconstruction or turning may be necessary. When turning the piles, look to see whether the moisture content of the material looks uniform, or if portions are too wet or too dry; watering and/or mixing/turning methods may need to be modified. Look to see whether the decomposition looks uniform, or if portions look like they did when received while other portions look decomposed; again, watering and/or mixing/turning methods may need to be modified.

- pH - Decomposition takes place most efficiently under neutral pH conditions, so the pH of the material should be monitored periodically. It is common for the pH to be low (down to 5.0) during the early stages of decomposition; then the pH begins to rise to near neutral conditions. By keeping the pile in an aerobic state, via proper turning methods, leaf composting operations should not present a pH (acidic) problem. Testing for pH can be done on-site with a soil pH testing kit.

- Odor - Foul odors will develop under anaerobic conditions, and the rate of composting slows dramatically under anaerobic conditions. An adequate supply of oxygen is crucial to efficient composting. Should anaerobic conditions become apparent, turning the pile will temporarily add oxygen but will also intensify offensive odors. Before turning, try to identify the cause of the problem so remedial action can be taken as the pile is being turned. For instance, problems other than lack of oxygen may include windrows that are too large and failure to construct windrows soon enough (i.e., storing leaves).

B. Record-keeping.

Good record-keeping provides the operator of composting operations with readily available site-specific data. Such data can be used to better manage site operations and to address problems which may arise. Records should be kept for all windrows constructed. Information to be collected should include, but is not limited to, the following (also see Attachment No. 4 for sample forms which may be used for monitoring and record-keeping purposes):

Initial Data (to be recorded upon pile construction)

- type and quantity of materials used as substrate
- method of size reduction
- method of mixing
- amount of water added and method of watering
- date of windrow construction
- size and shape of windrow

Process Data (to be recorded periodically or during turning as recommended)

- temperature (3-6 foot long temperature probe)
- pH
- moisture content
- oxygen levels (if equipment is available)
- odor
- texture

ATTACHMENT NO. 1

GUIDELINES FOR YARD WASTE COMPOSTING FACILITIES

(PADEP Document No. 254-5403-100, dated April 30, 1997 is Attachment 1)

ATTACHMENT NO. 2

TURNED WINDROW SYSTEM TECHNOLOGY

ATTACHMENT NO. 2
TURNED WINDROW SYSTEM TECHNOLOGY

This attachment summarizes the two key aspects of the turned windrow system technology, which are construction and turning, as applicable to a municipal leaf composting facility.

The key points of construction include the following:

- Construction should occur within one week, but preferably within one to two days of delivery of the yard wastes.

- If different types of wastes are to be composted together, they should be thoroughly mixed, using a front-end loader, Scat turner, or special equipment as necessary.

- Water must be added to reach the desired moisture content. Desire 50 % moisture content. Add approximately 20 gallons of water per each cubic yard of leaves.

- The recommended form for windrows of autumn leaves is 6-8 feet tall and 12-18 feet wide at the base. These piles can be built to 8-10 feet tall in mid-winter months. Smaller or larger piles can create problems. 6 foot high by 18 foot wide piles are optimal if a Scat turner is to be employed. There is no length limitation on windrow construction.

- Lift and drop the leaves/materials to be composted; don't push or run over the piles. Care must be taken not to compact the material.

- Space permitting, windrows should be constructed in pairs for later combining of piles. If a Scat turner is used, a 7-foot clearance between piles is necessary for equipment passage; a 3-foot clearance is preferred when using a front-end loader.

- Grass clippings must be incorporated into windrows of partially composted yard waste within 24 hours of delivery to the facility, at a ratio not to exceed one part grass to three parts yard waste. One leaf windrow may need to be dedicated to receiving and incorporating grass clippings. Placement of grass on top of the windrow and then mixing/turning the pile in is recommended. The minimum 3:1 leaf to grass ratio should be maintained.

The key points of turning include the following:

- Move material from the outside to the inside and "fluff" the material so it will be more porous.
- Per regulatory requirements, piles shall be turned and reconstructed at least once every three months.
- Turning frequency should be based on temperature. Turning should be performed whenever pile temperatures drop below 90°F or exceed 140°F.
- Windrows composed entirely of leaves may only need to be turned a few times a year, and should be left alone during winter months.
- Water can be added to the compost pile by hosing the windrow during turning or by turning on a rainy day.
- When turning, combining or reconstructing piles, keep the material as loose as possible. Care should be taken not to compact the material.
- Combine and stack stable composted material for final curing (should be stockpiled at designated area on-site).

The following pages illustrate six common steps at leaf composting sites utilizing turned windrow system technology.

ATTACHMENT NO. 3

YARD WASTE COMPOSTING FACILITY TROUBLESHOOTING GUIDE

ATTACHMENT NO. 3
YARD WASTE COMPOSTING FACILITY TROUBLESHOOTING GUIDE

This attachment serves as a troubleshooting guide for the operation of a municipal yard waste composting facility. Commonly encountered problems, as well as possible causes and solutions, are included in this attachment.

Troubleshooting Guide

Problem	**Cause**	**Recommendation**
Foul odor	Anaerobic conditions:	
	Piles too large	Reduce windrow size...no wider than 16-18 ft, no taller than 6 ft.
	Piles too wet or excess grass	Turn or mix windrow; maybe add dry matter.
	Temperature too high	Turn windrow.
	Leaf compaction	Turn windrow or reduce windrow size.
	Surface ponding	Eliminate ponding.
Standing water / surface ponding	Ruts and holes	Regrade or reconstruct; use careful equipment operation.
	Inadequate slope	Regrade at recommended slope design.
	Improper construction	Align windrows to run downslope, not across.
Inadequate composting rate	Insufficient moisture	Add more water initially, or add water while turning.
	Uneven distribution of air, moisture or nutrients	Consider size reduction methods; turn pile, adding water if necessary.
- with low windrow temp.	Windrow too small (heat loss)	Construct piles to min. of 6 ft tall or higher for cold seasons.
	Lack of nitrogen	Mix in a nitrogen source.
- with high windrow temp.	Windrow too large or dense (anaerobic conditions)	Make piles smaller; turn to loosen compacted materials.

Troubleshooting Guide, continued		
Problem	**Cause**	**Recommendation**
Fires / dry piles	Temperature too high Not enough water Stray sparks / embers	Make piles smaller; turn to loosen compacted material. Add water and turn piles. Keep potential fire sources away from piles.
Surface water pollution	Leachate discharge	Configure windrows perpendicular to slope to eliminate surface water accumulation; treat leachate before it leaves the site by approved methods (such as conveying to catch basin or pass through filter area); practice stormwater management methods to divert surface water away from compost or curing piles.
Mosquitoes	Presence of stagnant water	Reconstruct piles to eliminate ponding.
Noise	Equipment operation	Avoid equipment that creates excessive noise; locate facility away from residential areas.
Dust	Turning operations	Avoid turning dry piles on windy days; use standard dust control methods; locate facility away from residential areas and downwind from sensitive areas.

ATTACHMENT NO. 4

YARD WASTE COMPOSTING FACILITY MONITORING PROCEDURES

ATTACHMENT NO. 4
YARD WASTE COMPOSTING FACILITY MONITORING PROCEDURES

This attachment identifies the monitoring parameters recommended for proper operation and management of a municipal yard waste composting facility. The following forms may be used as examples of record-keeping procedures to track the data and characteristics of a yard waste composting operation. The forms include a delivery truck log sheet (one sheet for each yard waste collection truck), a delivery summary reporting sheet (for converting volumes to tonnages of yard wastes delivered to a composting facility, and for reporting totals to Cumberland County), and a compost pile monitoring form (containing pile-building data and process operations information - one sheet for each compost windrow). Good record-keeping is important in correcting problems that may arise with windrow operations, and provides a basis for adjusting operating procedures and planning future operations.

MUNICIPAL YARD WASTE COLLECTION TRUCK LOG SHEET

Municipality: ______________________________

Type of Collection Vehicle: ______________________________

Truck Number: ______________________________

Truck Bed Capacity (cy or dimensions): ______________________________

Driver: ______________________________

Location Delivered to: ______________________________

Trip No.	**Date and Time of Delivery**	**Full or Partial Load (% Full)**	**Estimated Cubic Yards Delivered**	**Type of Yard Waste/Comments**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				

MUNICIPAL YARD WASTE COMPOST MONITORING FORM

Pile Identification/Designation:__________________
Date of Construction:_________________________
General Weather Conditions:____________________

Size and Shape of Windrow:___________________
Length ______________________________
Width ______________________________
Shape ______________________________

Watering Details:
Amount of water added:_________________
Method of watering:__________________________

Details of Pile Construction:

Type of Material(s)	Quantity	Method of Size Reduction (if any)	Method of Mixing

Operation/Process Data:

Date	Pile Characteristics					
	Temp.	Moisture Content	Oxygen Level	pH	Odor	Texture

Pile Activity:

Date	Reason for Activity, routine or other (describe)	Description of Action(s) Taken (include method if applicable)

Comments: ____

MUNICIPAL YARD WASTE DELIVERY SUMMARY REPORT

Municipality: ____

Delivery Location: ____

Load(s)	**Date**	**Type of Yard Waste**	**Total Cubic Yards**	**Total Tons ****
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

TOTAL TONS COLLECTED = ______________________ **(***Please use the following information to convert cubic yards to tons:)*

Cubic yards collected x typical density (from below) x $\frac{\text{1 ton}}{\text{2,000 lbs.}}$ = tons collected

TYPICAL DENSITY OF YARD WASTE		
Material	**Condition**	**Typical Density(lbs/cubic yard)**
Leaves (uncomposted) Leaves (uncomposted)	loose (dry) vacuumed/shredded (dry)	200-260 250-350
Leaves (uncomposted) Leaves (uncomposted)	vacuumed/shredded (moist) compacted (dry)	350-450 300-400
Leaves (uncomposted) Leaves and Brush (mixed)	compacted (moist) dry, co-collected	450-630 100-300
Grass Clippings (uncomposted) Grass Clippings	loose compacted	300-450 500-1500
Yard waste (mixed) Yard waste (mixed)	as collected shredded	350-950 450-600
Compost Wood Chips/Ground Mulch	finished	500-1,200 500-625

Source: Municipal Yard Waste Composting Reference Manual, PADER, 1991, and Converting to the Standard Recycling Rates, USEPA, 1996.