Composting Livestock 2017

Livestock Mortality Composting Protocol

August 15, 2017

Please note: These procedures may be revised as circumstances change.

Executive Summary of the Method

Composting is a biological heating process that results in the natural degradation of organic resources (such as animal carcasses) by microorganisms. Composting mortalities, including sheep, goats, deer, pigs, cattle and horses, has been successfully used throughout the United States for nearly two decades to control animal disease outbreaks and to respond to natural disasters.

Microbial activity within a well-constructed compost pile can generate and maintain temperatures sufficient to inactivate most livestock pathogens. The effectiveness of this pathogen inactivation process can be assessed by evaluating compost temperatures, i.e., the shape of the time and temperature curve, visually observing carcass decomposition, and evaluating the homogeneity of the compost mix.

Successful mortality composting requires the following:

1. **A qualified composting expert to guide windrow construction.**
2. **Trained equipment operators.**
3. **Sufficient carbon, water, and space.**

If any of these components are lacking, composting is NOT recommended.

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Compost Pile Monitoring (photo by Gary Flory)

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KEY ELEMENTS FOR SUCCESSFUL COMPOSTING

Photo 1. Proper PPE for deployment during a disease outbreak (photo by Josh Payne)

Successful mortality composting requires the following:

1. A qualified composting expert to guide windrow construction.
2. Required equipment, supplies, and trained equipment operators.
3. Sufficient carbon, water, and space.

If any of these components is lacking, composting is NOT recommended.

The role of the qualified mortality composting Subject Matter Expert (SME) is to ensure that these key elements are followed in the construction of compost windrows:

1. Windrows (typically 6 to 8 feet high and 12 to 16 feet wide) are constructed on an adequate and uniform base layer (18 to 24 inches thick) of a sufficiently porous and absorbent carbon material. Carbon material in the context of this document is defined as a dry bulking agent that generally consists of woody, organic material with a high carbon to nitrogen ratio as detailed in Appendix A.
2. The base layer and windrow are not compacted or driven on with equipment.
3. Carcasses are vented/ lanced appropriately to prevent bloating and rapid, pressurized release of gases.
4. To prevent disease transmission: CARCASSES ARE NOT GROUND/CRUSHED/MACERATED THE DURING CONSTRUCTION.
5. Windrows are constructed to ensure adequate distribution of moisture throughout and are capped with sufficient carbon materials (18 to 24 inches thick) to cover exposed carcasses and minimize odors and incoming pests.
6. Windrow dimensions, including the base and cap, may be reduced for smaller carcasses, but overall windrow should have a height of at least 4.5 feet.

LABOR, EQUIPMENT, SUPPLIES AND MATERIALS

- Skilled equipment operators and general laborers;
- Skid loaders, pay loaders, excavators with thumb, dump trucks, rakes, and other similar equipment;
- Proper personal protective equipment (PPE) in response to specific event, i.e., natural disaster or disease outbreak (shown in Photo 1);
- Compost thermometers (36 or 48 inches stem length);

- Woodchips, wood shavings, corn stover, active compost, sawdust, bedded pack manure, rice, seed and nut hulls, or other carbon material (see Appendix A).

PROTOCOL

Prior to Windrow Construction

- Consult with Disposal Team Leader or other appropriate official on the nature of the event and determine what control parameters will affect the construction of composting processes, including biosecurity requirements, appropriateness of outdoor or in-building windrow construction, and any other pertinent requirements or restrictions.
- Evaluate and determine the required scale and type(s) of composting possible for this farm operation. Determine what, if any, feedstocks are needed for composting in addition to mortalities, e.g., solid manure, bedding, affected feed, water, and/ or other infected organics.
- Verify that any state or local environmental approvals and/ or site preparation permits are in place before beginning construction.
- To assess outdoor sites, see Appendix B.
  - Site considerations;
    - Is the property large enough to accommodate the required composting system and associated support areas?
    - What control structures may be needed to contain or collect runoff or leachate?
    - Will working space be safe and efficient for movement of equipment on the site?
    - Where will the storage and mixing areas for the bulking material be located?
- Where in-building composting is desirable or possible:
  - Evaluate building size and configuration to determine what space is available for windrow construction.
  - Other considerations:
    - Are the livestock carcasses in the building or do they need to be transported?
    - Is the building large enough to accommodate necessary equipment movement during windrow construction?
    - Will bedding and/or manure be composted with the carcasses, composted separately, or disposed by another method?

  - Evaluate the ventilation within the proposed facility. In-building composting requires proper ventilation to reduce the risk of disease transmission while balancing safe air quality levels for workers (ammonia safety shown in Appendix G).

- For all composting windrow construction:
  - Minimize the number of movements and mixing of ingredients/feedstocks to reduce disease spread.
  - Evaluate type and quantity of materials to be composted on the farm site:
    - Carcasses: Species, weight, number and condition (i.e., fresh, desiccated, degraded)
    - Manure solids/bedding: volume, moisture content, density
    - Feed: Types, quantity (by volume), moisture content
    - Clean bedding, feed or other organic materials which can be used in constructing windrows.
    - Milk and liquid manure composting and disposal are not addressed in this SOP.
  - Remove exposed/ contaminated feed from feed storage for use in the core of the windrows. This material can be distributed evenly through a pre-compost mix of bulking materials and added to the windrows with the carcasses.
- Calculate the amount of carbon needed for composting:
  - See Appendix D for calculations.
  - For every animal unit, defined as 1,000 lbs of carcass, add 3- to 6-cubic yards of carbon bulking agent.
  - The characteristics of various carbon materials are listed in Appendix J.
- Evaluate the need for and availability of supplemental water:
  - Source
  - Application method available.
- Evaluate on-farm equipment and determine supplemental equipment needs.

Typical Windrow Construction Protocol

Once all labor, equipment, supplies, and materials are on the premises, composting can begin.

Three critical elements of windrow construction are: 1) a base layer that provides absorbency, structure and airflow (porous carbon material), 2) a windrow core containing a mixture of carcasses, manure, and feed, and 3) an adequate cap (shown in Figure 1). These steps may be done concurrently or as separate steps.

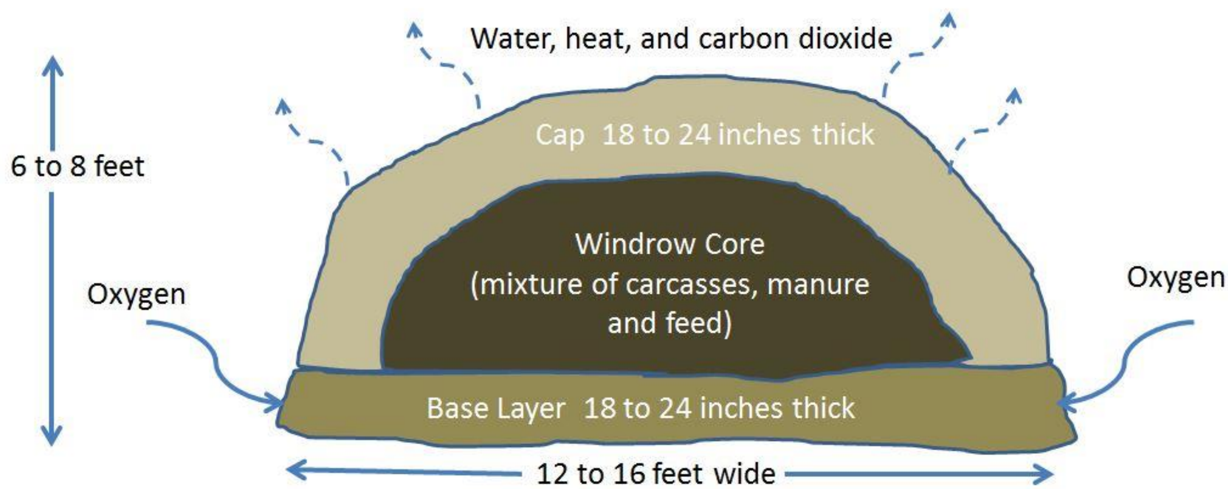

Figure 1. Cross section of compost windrow (Illustration by Gary Flory)

Windrow Base Construction

- For outdoor composting, an adequate site must be identified (See Appendix B).
- For in-building composting, clear carcasses and bedding from the proposed windrow location(s) to have room for the windrow base(s) and alley ways. Distribute the material from either side of the pathway. (See Appendix C for in-building variations.)
- Use a loader to begin building the windrow base.
- The windrow base should be 12 to 16 feet wide with a depth of 18 to 24 inches. (Note: base will compress over time and with the weight of animals)

Photo 2. Cattle placed on adequate base (photo by Josh Payne)

- To maintain the base's porosity and to avoid compaction, do not drive equipment on the base.

Carbon material for the base should be porous yet absorbent to allow adequate air flow into and through the windrow while absorbing any liquid or leachate that may be generated from carcasses. Coarse woody material >2 inches in size should be avoided to ensure that the finished compost can be land applied as a soil amendment. For a full description of desirable physical properties and suitable carbon material see Appendix A.

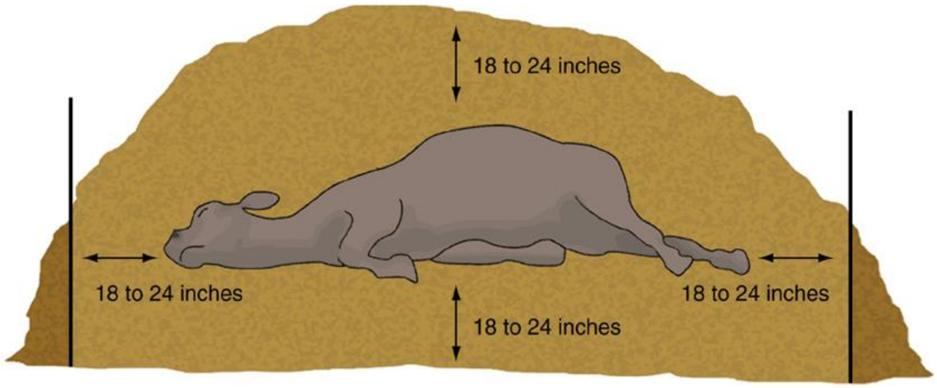

Figure 2. Dimensions of carcass in windrow (Illustration by Josh Payne)

Construction of the Core

The windrow core may consist of a mixture of carcasses, manure, feed, or other carbon material. Apply a bucket of manure to the carbon bed and then lay a carcass on top of the manure, followed by another bucket of carbon material placed on top of the carcass. This process is then repeated until all of the carcasses and carbon are layered in the windrow. Alternately, premises may choose to place the carcass on the carbon bed first, followed by several buckets of carbon. In either case, it is important that all of the infected materials are incorporated into the windrow core. If the manure is too wet, it should be mixed with carbon separately, and composted in a separate windrow. Often, additional absorbent carbon material may be needed to help bulk up the wet manure (for viable options, see Appendix A). Be sure to move infected material as little as possible.

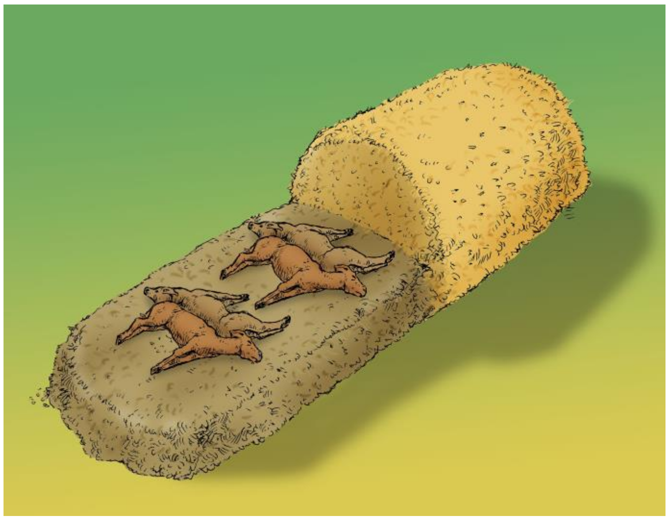

Figure 3. Placing carcass back-to-back in core
(Illustration by Jean Bonhotal)

Construction of windrow core:

- Place the carcasses, manure, and other infected material on the center of the windrow base.
- Possible carcass placements are back-to-back, back-to-leg, or nose to tail (shown in Figure 3, 4, and 5).
- Avoid compacting the base with the tires or tracks of equipment.
- The windrow core should be constructed such that it is domed-shaped and no carcasses are over the edge of the base (shown in Figure 2).
- To avoid expansion, it is important to vent/ lance ruminant animals before composting.

Continue building the core until all of the carcass, manure, and waste feed have been placed on the base.

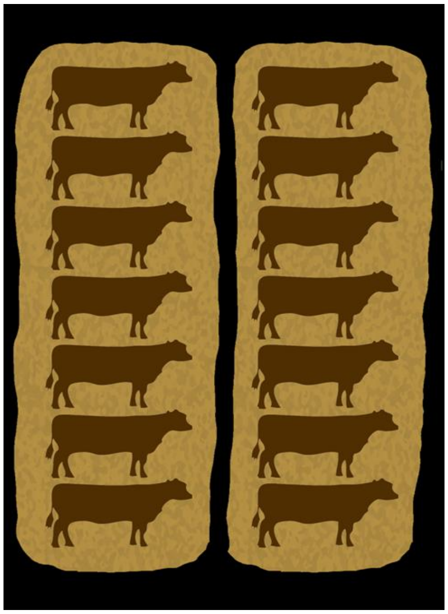

Figure 4. Placing carcass back-to-feet (Illustration by Josh Payne)

Figure 5. Placing carcass back-to-feet (Photo by Mark Hutchinson)

Capping the Windrow

- Prior to capping the windrow, ensure no carcasses are over the edge of the base (Shown in Figure 2 and Photo 3).
- Cap the windrow with 18- to 24-inches of a suitable carbon material.
- Ensure that the entire core is uniformly covered with cap material with no carcasses exposed.
- Avoid compacting the windrow. Do not operate the loader's tires or tracks onto the sides of the windrow while capping.
- Add water if the carbon used to cap the carcasses is too dry (See Appendix A)

- Ensure the completed windrow is approximately 6- to 8-feet high.
- Number each windrow and draw a sketch showing the numbers.
- Place a minimum of 10 flags spaced equidistantly the length of each windrow, to designate the temperature monitoring locations.
- Number the flags and note the numbers on the sketch.

Photo 3. Tractor capping windrow (photo by Jean Bonhotal)

Layering Method

As an alternative to the core construction method described previously, the windrow core can be constructed by layering carcasses and carbon material. Base and cap construction is the same as in the standard protocol. Following base construction, proceed in the following manner:

- Add a 15- to 18-inch layer of manure and carcasses (shown in Figure 6).
- Cover the layer of carcasses with 12- to 18-inch layer of wood chips or other carbon material.
- Add another layer of manure and carcasses, then cover with 12- to 18-inch of carbon material, until the windrow is to the recommended height and as long as needed.
- Assure no carcasses are over the edge of the base.
- Cap the windrow with 18- to 24-inches of wood chips or other carbon material. The finished pile should be 6- to 8-feet high.

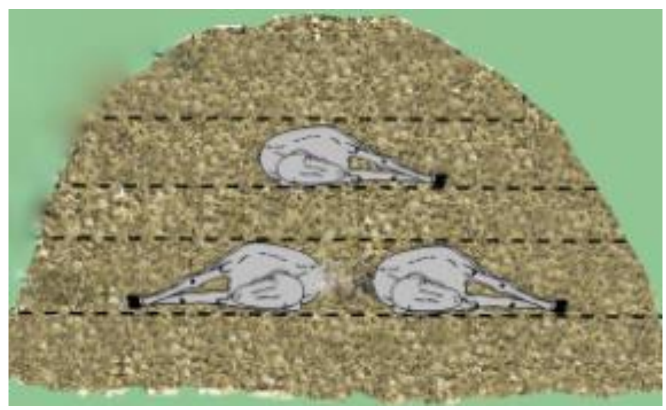

Figure 6. Cross section of layering livestock in a windrow pile. (Illustration by Langston University Research & Extension)

The SME may choose to use either or both of these construction techniques depending on site conditions and size of carcasses.

Validation of Windrow Design

The SME or other designated official should evaluate the windrows to ensure that they have been constructed consistently with this protocol, and document observations on the Compost Windrow Construction Evaluation Checklist in Appendix H.

Temperature Monitoring

Daily temperature monitoring is performed in accordance with the temperature monitoring SOP found in Appendix E. Temperature data is collected on the temperature log found in Appendix F or in a comparable electronic format. Ammonia safety procedures to prevent occupational hazards when conducting temperature monitoring, especially for in-building composting, is found in Appendix G.

Photo 4. Temperature probe in windrow (photo by Ken Powell)

When the Initial Windrow Construction Evaluation Checklist is signed (see Appendix H), temperatures are monitored daily for the first 14-days of Phase 1 (at both 18- and 36-inches). If the SME or other designated official determines that thermophilic temperatures have been met and maintained through the end of this monitoring period, then the SME may recommend the frequency of temperature monitoring be reduced for the remainder of Phase 1, which is between 6 to 12 weeks depending on the size of the affected carcasses. Once Phase 1 is completed, the compost windrow piles may be turned and observations documented on the Phase 1 Windrow Evaluation Checklist (see Appendix H).

If the standard of ≥131° F for 72 consecutive hours has not been reached, an SME will determine if any corrective action is required for the windrow(s). The corrective action will be documented, implemented and verified using the windrow construction approval checklist, and the initial 14-day period will restart.

For Phase 2, the frequency of temperature monitoring remains the same as the end of Phase 1, but the duration will be established by the APHIS National Incident Coordination Group, in consultation with the Composting Technical Team. This phase should be at least 2 weeks, depending on each incident based on the type of livestock affected, the pathogen of concern, the extent of decomposition of carcasses after the turn, and other incident-specific circumstances. Upon the completion of Phase 2, the composting process is completed and observations are documented on the Phase 2 Windrow Evaluation Checklist (see Appendix H). This checklist verifies that the compost windrow process is completed and may be moved without restriction on the premises or may leave the premises with appropriate permit.

Turning the Windrows

Turning decisions will be made on a case-by-case basis by the onsite SME and will depend on a number of factors including: initial size and physical condition of the carcasses being composted, temperature profiles achieved during the initial compost process and overall windrow performance. In most cases, turning will occur between 6 to 12 weeks of composting activity, depending upon the size of the carcasses. However, all turning decisions will be made based on the recommendations of the assigned SME following an onsite evaluation of pile/windrow performance data and physical examination of windrows. When turning the windrow contents, care should be taken to ensure thorough mixing of the core, base, and cap materials, while maintaining adequate porosity and structure post turning. If soft tissue is observed on the windrow surface or excessive odors continue after turning, a 4- to 6-inch carbon material cap will be applied. See Appendix I for turning equipment and methods.

Release of the Compost

If the designated animal health official accepts the SME's recommendation to release windrows from quarantine, the compost may be moved without restriction around the premises or may leave the premises with any appropriate permits.

Photo 5. Bones and remains after second compost cycle (photo by Josh Payne)

Photo 6. Steam from pile when thermophilic temperatures are achieved (photo by Josh Payne)

Manure and Waste Feed

During a livestock emergency, there may be a need to compost the solid manure and waste feed. This may occur when the producer has chosen to dispose of their livestock mortalities by a method other than composting—such as on site burial, incineration, or landfilling—or because there was more manure and waste feed on the farm than could be practically composted with the carcasses. Fortunately, the compost process used for these materials is identical to the windrow construction process described above. However, because of the density of the manure and feed, it is imperative that the material be thoroughly blended with carbonaceous materials to help ensure proper porosity within the windrows. In other words, manure can be composted with a 1:1 mix of manure and carbonaceous material. Manure may have a high moisture content or be extremely dry depending on manure management, consequently the moisture content of the windrows may need to be adjusted. This mixture then forms the core, and is placed on the base material, and covered with cap material, as described previously.

TROUBLESHOOTING

The table below describes some of the most common composting problems encountered during composting of large animals and possible solutions. The SME will perform the troubleshooting evaluation and document it on the appropriate form.

Problem	Issue	Solution
Excessive flies or odor	Exposed carcasses	Add additional cap material.
Leachate from windrow	Mixture too wet	Add additional carbon material around the edge to soak up leachate. Otherwise early in process pile may have to be taken apart and rebuilt. After all flesh is gone, aerate or mix pile.
Temperature does not reach 131 ºF	Mixture too dry (< 40% moisture)	Add water to pile, through a soaker hose or other slow watering method.
Temperature does not reach 131 ºF	Mixture too wet (> 60 % moisture)	Early in process pile, maybe have to be taken apart and rebuilt. After all flesh is gone, aerate or mix pile.
Temperature does not reach 131 ºF	Not enough oxygen	Early in process pile, may have to be taken apart and rebuilt After all flesh is gone, aerate or mix pile.

APPENDIX A
CARBON SOURCES FOR WINDROW CONSTRUCTION

Note: These procedures may be revised as the situation develops; this is a list of generally acceptable materials that may be used as carbon sources for windrow composting of livestock related mortalities. The carbon source resource needs for the premises, i.e., quantity and type, should be determined by a compost Subject Matter Expert and will depend on site-specific conditions and circumstances.

Suitable Materials:

- Wood chips about 2” or less in size
- Wood shavings
- Yard/brush trimmings 2” or less in size
- Partially composted leaf and yard waste (still hot)/active compost
- Sawdust (not used alone)
- Chopped hay/straw
- Chopped corn stover
- Oat/sunflower hulls
- Small grain hulls
- Straw
- Dry mammalian bedding or manure
- Ground pallets (2” or less) if fasteners have been removed
- Class A biosolids, in accordance with local and state requirements for land application
- Other material listed in APHIS Composting Protocol or as recommended by APHIS-recognized Subject Matter Expert and approved for use on agricultural land by the state

Not Suitable Materials:

- Rocks
- Glass
- Plastic
- Large logs/branches
- Grass clippings >5%
- Ground construction and demolition debris (CDD)
- Regulated pests (emerald ash borer, etc.)
- Rubber
- Metal/baling wire
- Chemicals
- Concrete
- Painted/pressure treated wood
- Soil/sand carbon source with free liquid or excessive leachate

APPENDIX B
CHOOSING AN OUTDOOR COMPOSTING SITE FOR DISPOSAL OF LIVESTOCK CARCASSES

Selection and siting of environmentally suitable and appropriate locations for composting of livestock carcasses is an important consideration for livestock mortality emergency response. Livestock mortalities, beyond those created through typical daily farm operations, might be the result of any number of causes. For example, mortalities may be a byproduct of a natural disaster affecting farm operations, be caused by welfare culling associated with local or regional emergency animal movement restrictions, be associated with a highly contagious or foreign animal disease, or result from an on-farm emergency such as a structural collapse or barn fire. Additionally, due to the relative putrescibility of the carcasses and any associated bedding it is critical to choose sites that will not be adversely impacted by potential releases of nutrient-laden leachate nor will result in nuisance complaints in the event that odors, flies, or scavengers begin to appear on-site.

Photo 7. Completed windrows (photo by Ken Powell)

In situations where highly contagious or foreign animal disease causes mass mortalities, stringent biosecurity rules may impact entry to and exit from the site, may impact how carcasses will be handled and may affect some aspects of the composting process.

Access point(s) for the site must be structurally capable of supporting heavy vehicle and equipment traffic and allow for biosecurity control stations at the points designated on the sites perimeter by the controlling authority. Some areas on the site may require structural reinforcement.

In general, emergency mortality composting sites should be large enough to accommodate all of the generated carcasses, manure, waste feed, and potentially other organically based contaminated or waste materials that are compostable. The site must also have the capacity to store any additional amendment materials that may be needed for composting and provide adequate room for vehicles to maneuver and turn. Also, determine what, if any, state or local regulations may impact site selection, such as grading permits, sediment and erosion controls, and/or environmental approvals.

Outdoor Mortality Composting Sites

In many instances, outdoor mortality composting will be the primary choice, because most livestock in the U.S. either are managed in facilities not compatible with compost construction or will already have been moved from their housing before composting has begun. There may be exceptions to this situation and indoor composting may become the preferable practice. It is also desirable to locate the composting site as close as practicable to the animal housing to reduce the risk of biological contamination on the site.

If outdoor composting is chosen, a review of the proposed site should be completed. The following guidelines should be considered in determining the suitability of the suitability of the site. The ideal site should:

- Be located such that the prevailing wind directions do not travel to nearby residences and uninfected farms and communities (whenever possible);
- Be located at the top of the slope of the field, on moderately-well to well drained soils (usually land that is used for crop production);
- Have a gentle 2% to 4% slope to encourage on-site drainage;
- Contain on-site soil depths or be modified, such as create a thicker base layer, to achieve at least 24-inches to seasonal high-water tables;
- Contain on-site soil depths in excess of 36-inches to bedrock;
- Not be located on a flood plain;
- Have (or construct) diversion ditches, terraces, or berms to direct surface water flows and storm water away from active compost piles. (Note that if piles are located between production houses, then roof and surface drainage should be directed away from the compost area); and
- Meet state-specific setback requirements, which should be no less than (Shown in Figure 7):
    - 200-feet from a water supply well used for drinking;
    - 200-feet from water bodies, including: ponds, lakes, streams, rivers;
    - 200-feet from a nearby residence (not owned by the premises);
    - 50-feet from a drainage swale that leads to a water body (see above); and
    - 25-feet from a drainage swale that does not lead to a water body.

- Determine if any or all of the site is tile drained and if tile mapping is available. Due to the risk of leachate reaching the tile and causing a nutrient release, composting windrows should not be laid perpendicular to and over the tile lines. If information concerning the location of tile lines at the site is available, windrows can be laid parallel to the tile lines in the space between them.

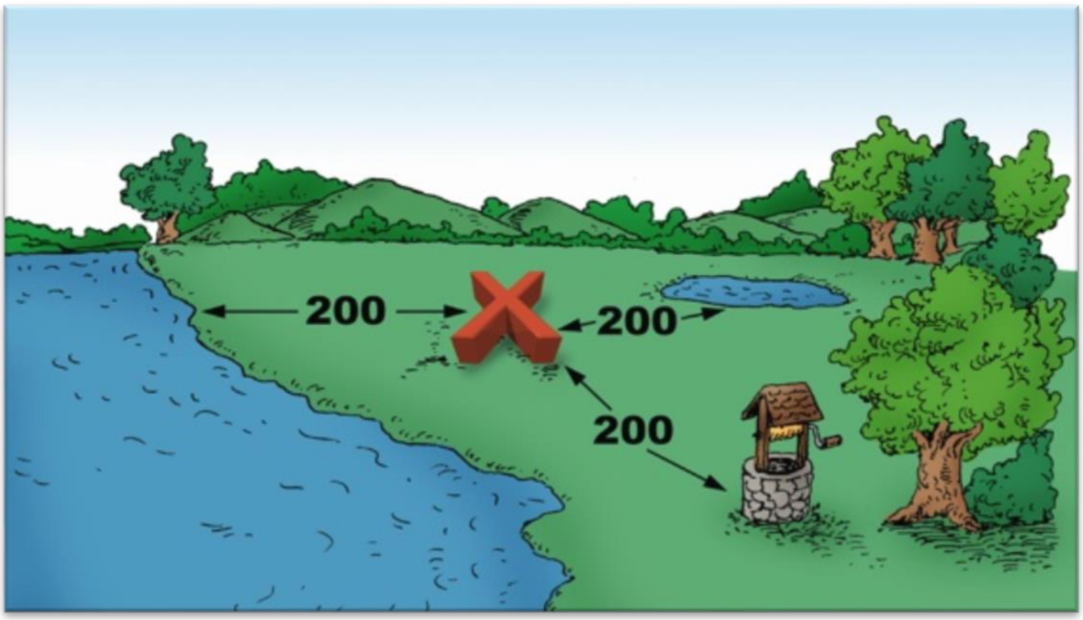

Figure 7. Distances from bodies of water (Illustration by Cornell Waste Management Institute)

APPENDIX C
COMPOSTING WITHIN A FARM STRUCTURE

Benefits of Composting within a Structure

For large livestock mortality events composting activities will often occur outside of livestock confinement structures. However, in-building composting offers several benefits. First, it offers more protection from inclement weather. For example, during heavy rain storms, water can flow under the windrows, saturating the base and inhibiting the flow of oxygen into the windrows. During extremely cold weather, buildings help maintain core temperatures. Second, composting within a structure will minimize disease transmission risks and the runoff of leachate from the windrows into surface water or groundwater

Regardless of where the windrows are constructed, the three critical elements are a porous and absorbent base layer, a windrow core containing a mixture of carcasses, manure and feed and an adequate cap.

Indoor Mortality Composting Sites

Where animals are group housed within truss roofed buildings or where other large open floored structures are available, construction of the compost system can take place within the structures.

Some issues to consider when determining whether to compost indoors or outdoors.

- Is there a specific reason, such as a biosecurity concern, for choosing in-building composting? Example: The carcasses in question result from a foreign animal disease (FAD) response. Does indoor composting enhance disease management activities or reduce the risk for spreading the pathogen?
- Can all the mortalities be encapsulated within an optimally functioning composting system and still fit within the building? If not, is there any advantage or disadvantage to splitting composting between indoors and outdoors?
- Will the management of the bedding and manure already present in the building interfere or negatively impact the composting process or the cleaning and disinfection stage of the response?
- Will there be adequate floor space and ceiling height within the building for the needed equipment to move around and still construct the required windrows?

Variations Based on Building Design

Pole Supported Structures

- Although the support poles may limit the maneuverability of the loaders, the windrow construction protocol remains the same.

- Avoid constructing windrows against wooden support poles.
- Additional time will be required to construct windrows in this type of structure due to space and structural constraints.
- Due to structural constraints and limited maneuverability, experienced and skilled loader operators are required to minimize damage to the building and equipment.

Free Span Structures

- Free span structures offer more room to maneuver equipment however attention must be given to ceiling height and low-hanging equipment like fans, heaters and lights.
- More than one windrow can often be constructed within a free span structure.
- To maximize the number of carcasses that can be composted within a structure, windrows can be constructed toe to toe. Care should be taken to build distinctive windrows so that the flow of oxygen into the windrow is not blocked (Shown in Photo 8 and 9).

Photo 8. Compost windrows constructed toe to toe within a closed structure (photo by Gary Flory)

Photo 9. Compost windrows constructed within a closed structure (photo by Josh Payne)

APPENDIX D
METHODS OF ESTIMATING CARBON (BULKING AGENT) NEEDS

Methodology

Whether dealing with routine mortalities or catastrophic losses resulting from natural disasters and/or foreign animal disease outbreaks, it is important to accurately determine the amount of carbon material (bulking agent) to properly compost all mortalities and their associated manure and feed. The most common method for calculating the total required volume of bulking agent is through the estimated weight of livestock mortalities in pounds. Below are two methods that help calculate carbon needed for livestock mortality composting based on overall weight of mortalities.

Method 1. Weight Based Estimate

Another good general rule of thumb is to add 3- to 6-cubic yards of carbon bulking agent for every 1,000 pounds of carcass to ensure proper covering of all carcasses with a thick blanket of carbon material[1,2,3].

Method 2. Computerized Estimator

a. First, use the Spartan Emergency Animal Tissue Composting Planner v1.03 to estimate the total amount of carbon material needed.
b. Then use the Spartan Compost Recipe Optimizer v1.04 to estimate the proportions of various types of carbon material available (poultry manure, poultry litter, sawdust, bark, etc.).
c. The computerized estimator can be found at: http://msue.anr.msu.edu/program/info/managing_animal_mortalities and then select “Composting Tools.”

Manure Management

Often manure may need to be added to the compost pile due to disease issues or to add extra nitrogen, moisture and/ or additional biological activity. Because manure is generally considered a high nitrogen source, extra carbon may be necessary to balance the C:N ratio, while additionally absorbing excess moisture to reduce odors.

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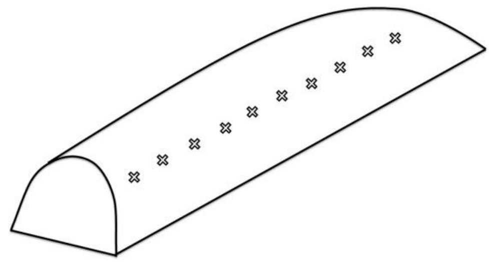
[1] Auvermann, Brent W., Saqib Mukhtar, and Kevin Heflin. “Composting large animal carcasses.” Texas FARMER Collection (2006).

[2] Morse, Debra E. “Composting animal mortalities.” St. Paul, MN: Agricultural Development Division, Minnesota Dept. of Agriculture (2001). Updated in 2009.

[3] Seekins, Bill. Maine Department of Agriculture. *Best Management Practices for Animal Carcass Composting* (2011).

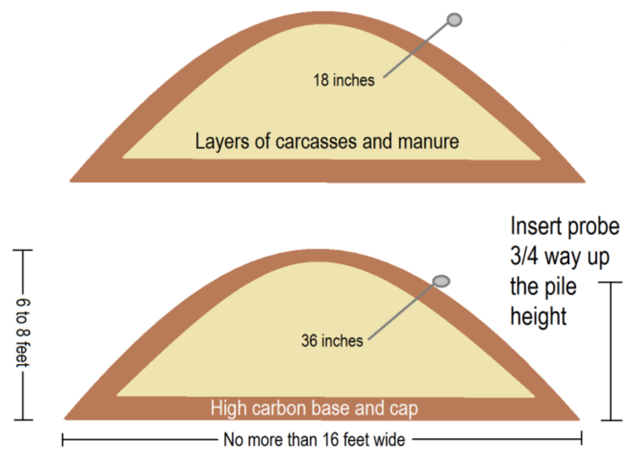
APPENDIX E
TEMPERATURE MONITORING PROCEDURE



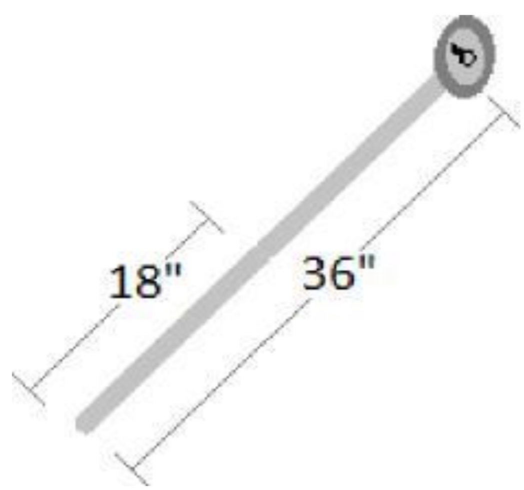
Example temperature monitoring locations

The windrow temperatures are monitored at a minimum of 10 locations flagged by the SME. The 10 locations should be spaced equidistantly the length of each windrow. Take two temperature readings at each flagged location within a foot of the flag; one reading at a depth of 18-inches and another reading in the core of the windrow, which is approximately a depth of 36-inches. To ensure consistent temperature monitoring to the same depth, mark the thermometer probe at 18- and 36-inches (core of the windrow). Place the temperature probe ¾ of the way up the windrow at a 45-degree angle. Ideally, temperatures should be monitored by a single individual for consistency. Temperature probes should be calibrated before use.

Instructions



- Place the stem of the thermometer approximately 18-inches and then 36-inches (core of the windrow) into the compost pile ¾ of the way up the pile at a 45-degree angle.
    - Note: When taking the core temperature (~36 inches) the thermometer may strike the carcass. Adjust the probes so it is just below the carcass.
- Leave the thermometer at each depth and point for at least 60 seconds.
- Log the reading from the thermometer from each flag and at both depths.
- Compare readings to previous day's readings.
- Calculate the average temperature for each pile by averaging both depths and note it on the Composting Temperature Log.
- Windrows should reach an average temperature of 131°F for a minimum of 72 hours at both the 18- and 36-inch (core of the windrow), depths or be assessed by a SME for possible corrective measures.
- Disinfect the thermometer and return it to its protective case.



- Each thermometer will be kept at the respective premises being monitored. Do not take a thermometer from one premise to another.
- If 3 days after initial windrow construction, compost temperature **averages** are consistently (more than 3 days) below 100°F or greater than 160°F, a SME should be consulted immediately.
- Additional precautions should be considered if composting inside a closed building.
    - Open doors, curtains and turn on ventilation fans to properly ventilate the facility. Compost and dead carcasses can create excessive buildup of ammonia.
    - Use the buddy system: entering a structure with active compost or dead carcasses requires a two-person team.

APPENDIX F
TEMPERATURE MONITORING LOG SHEET

COMPOSTING TEMPERATURE LOG				
County:		Site Number:		
Street address, city, state:				
Farm Name:				
House/Windrow Number:		Date Started:	Date Finished:	Date Turned:

Use the cells below to record the temperatures each day at 18 inches and at 36 inches.

Date	Depth	Flag #1	Flag #2	Flag #3	Flag #4	Flag #5	Flag #6	Flag #7	Flag #8	Flag #9	Flag#10	Avg
	18”											
	36”											
	18”											
	36”											
	18”											
	36”											
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APPENDIX G
IN-BUILDING COMPOSTING AMMONIA SAFETY

Background

Ammonia is produced naturally from decomposition of organic matter, including plants, animals and animal wastes and can become concentrated in enclosed structures. This guidance is for ammonia produced from these natural sources, NOT from compressed gas cylinders or other sources which may produce very high air concentrations.

Signs of Exposure to Ammonia

Strong odor provides adequate early warning of its presence, but prolonged exposure can be hard to detect due to olfactory fatigue and adaptation. High concentrations can cause airway destruction resulting in respiratory distress or failure. Signs of exposure include the following:

- burning of the nose, throat and respiratory tract;
- coughing; and
- skin and eye irritation.

How to Reduce Ammonia Exposure

- Increase ventilation when possible.
- Reduce the amount of time spent in areas where levels of ammonia are high.
- Wear proper PPE (personal protective equipment) gloves, half face with goggles or a full-face respirator with at least a particulate/ammonia cartridge (green) or a multi-gas cartridge, and cloth coveralls or disposable coveralls (Tyvek).
- If possible, measure levels of ammonia in work area with an air gas meter before entering, or know recommended exposure times based on the ammonia levels in work area.

Exposure Guidelines (NIOSH)	
Long term exposure (8 hours)	25 ppm
Short term exposure (15 minutes)	35 ppm
Short term exposure (5 minutes)	50 ppm

If exposed:

- Seek fresh air.
- Flush irritated skin or eyes with water.
- If needed, seek immediate medical attention.
- Contact your supervisor or the Safety Officer if irritation of skin, nose, throat, or respiratory tract is persistent.

APPENDIX H
COMPOST EVALUATION CHECKLISTS

INITIAL COMPOST WINDROW CONSTRUCTION CHECKLIST

Farm Name:		**County:**	
Farm Address:			
Farm Contact:		**Contact Phone:**	
Date Windrows Started:		**Date Windrows Completed:**	
Windrow #:		**Premises County & #:**	
Who constructed windrow?		**Contact Info:**	

	WINDROW DESIGN	***Yes***	***No***	***N/A***	***Comments/Description***
1	Height between 6 and 8 feet.				
2	Width between 12 and 16 feet				
3	Base between 18 and 24 inches				
3	Dome shaped without significant irregularities				
4	No soft tissue visible on the surface of the windrow				
5	A minimum of 18 inches of carbon cover material				
6	Photos taken				
7	Sketch of flag locations with dimensions attached				

Recommendations:

☐ I have observed the windrows at this site and in my professional judgment they have been constructed consistent with the criteria outlined in the Mortality Composting Protocol for Livestock.

☐ I have observed the windrows at this site and in my professional judgment they have **NOT** been constructed consistent with the criteria outlined in the Mortality Composting Protocol for Livestock. The following corrective actions are recommended:

____

____

____

Signature of Composting SME: _________________________________ Date: ______________

Print name of Composting SME: ____

The corrective actions recommended above were completed on : _________________________

Signature of Composting SME: _________________________________ Date: ______________

PHASE 1 WINDROW EVALUATION CHECKLIST

Applicability: This checklist is to be used 6 to 12 weeks after windrow construction to verify that they have been constructed in accordance with the protocol and have reached temperatures necessary for virus inactivation. Upon completion, turning the windrow will occur.

Farm Name:		**County:**	
Farm Address:			
Farm Contact:		**Contact Phone:**	
Date Windrows Started:		**Date Windrows Completed:**	
Windrow #:		**Premises County & #:**	
Who constructed windrow?		**Contact Info:**	

	PHASE 1 WINDROW EVALUATION	*Yes*	*No*	*N/A*	*Comments/Description*
1	Height between 6 and 8 feet				
2	Width between 12 and 16 feet				
3	Dome shaped without significant irregularities				
4	No soft tissue visible on the surface of the windrow				
5	A minimum of 18 inches of carbon cover material				
6	Moisture adequate				
7	Leachate present				
8	Excessive flies				
9	Vector activity observed				
10	Odor observed: VOA, putrid				
11	Temperature measured at 18 inches and 36 inches				
12	Temperatures reached 131° F for 3 consecutive days				
13	Photos taken				

Phase 1 Recommendations of State Animal Health, APHIS or IMT Official:

☐ I have observed the windrows at this site and in my professional judgment they have been constructed consistent with the criteria outlined in the Mortality Composting Protocol for Livestock. Additionally, windrow temperatures have reached the average temperature of 131°F for a minimum of 72 hours. The compost windrow pile is ready for turning.

☐ I have observed the windrows at this site and in my professional judgment, they have **NOT** been constructed consistent with the criteria outlined in the Mortality Composting Protocol for Livestock. The windrows should be evaluated by a composting Subject Matter Expert to recommend corrective actions if necessary.

☐ Windrow temperatures have **NOT** reached the average temperature of 131°F for a minimum of 72 hours. The windrows should be evaluated by a composting Subject Matter Expert to recommend corrective actions if necessary.

Signature of State Animal Health
Official, APHIS Official or IMT Official: ______________________________ Date: _______________

Print name of signing official: ____

Phase 1 Recommendations of Subject Matter Expert:

☐ I have observed the windrows at this site and based on their construction and my review of the temperature logs, the windrows have performed in a manner demonstrated to inactive the livestock pathogen. The compost windrow pile is ready for turning.

☐ I have observed the windrows at this site and based on their construction and my review of the temperature logs, the windrows have **NOT** performed in a manner demonstrated to inactive the livestock pathogen. The following corrective actions are recommended:

Date of windrow evaluation: ____

Signature of Composting SME: ____________________________________ Date: ________________

Print name of Composting SME: ____

The corrective actions recommended above were completed on: ___________________________

Phase 1 was complete on: ____

Signature of Composting SME: ____________________________________ Date: _______________

PHASE 2 WINDROW EVALUATION CHECKLIST

Applicability: This checklist is to be used after Phase 1 was completed to verify that the composting process is completed and may be moved without restriction on the premises or may leave the premises with appropriate permit.

Farm Name:		**County:**	
Farm Address:			
Farm Contact:		**Contact Phone:**	
Date Windrows Started:		**Date Windrows Completed:**	
Windrow #:		**Premises County & #:**	
Who constructed windrow?		**Contact Info:**	

	PHASE 2 WINDROW EVALUATION	***Yes***	***No***	***N/A***	***Comments/Description***
1	Height between 6 and 8 feet				
2	Width between 12 and 16 feet				
3	Dome shaped without significant irregularities				
4	No soft tissue visible on the surface of the windrow				
5	A minimum of 18 inches of carbon cover material				
6	Moisture adequate				
7	Leachate present				
8	Excessive flies				
9	Vector activity observed				
10	Odor observed: VOA, putrid				
11	Temperature measured at 18 inches and 36 inches				
12	Temperatures reached 131° F for 3 consecutive days				
13	Photos taken				

Phase 2 Recommendations of State Animal Health, APHIS or IMT Official:

☐ I have observed the windrows at this site and in my professional judgment, they have been constructed consistent with the criteria outlined in the Mortality Composting Protocol for Livestock. Additionally, windrow temperatures have reached the average temperature of 131°F for a minimum of 72 hours during the second composting phase. The windrows may be moved without restriction on the premises or may leave the premises with appropriate permits.

☐ I have observed the windrows at this site and in my professional judgment they have **NOT** been constructed consistent with the criteria outlined in the Mortality Composting Protocol for Livestock. The windrows should be evaluated by a composting Subject Matter Expert to recommend corrective actions if necessary.

☐ Windrow temperatures have **NOT** reached the average temperature of 131°F for a minimum of 72 hours during the second composting phase. The windrows should be evaluated by a composting Subject Matter Expert to recommend corrective actions if necessary.

Signature of State Animal Health
Official, APHIS Official or IMT Official: ______________________ Date: ________________

Print name of signing official: ____

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Phase 2 Recommendations of Subject Matter Expert:

☐ I have observed the windrows at this site and based on their construction and my review of the temperature logs, the windrows have performed in a manner demonstrated to inactive the livestock pathogen. The windrows may be moved without restriction on the premises or may leave the premises with appropriate permits.

☐ I have observed the windrows at this site and based on their construction and my review of the temperature logs, the windrows have **NOT** performed in a manner demonstrated to inactive the livestock pathogen. The following corrective actions are recommended:

____

____

Date of windrow evaluation: ____

Signature of Composting SME: ______________________________ Date: _____________

Print name of Composting SME: ____

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The corrective actions recommended above were completed on: _______________________

Phase 2 was complete on: ____

Signature of Composting SME: ______________________________ Date: ____________

APPENDIX I
WINDROW TURNING EQUIPMENT AND METHODS

Windrow turning should occur at the intervals described in the above protocol to prevent the possibility of aerosolizing the disease pathogen from insufficient pathogen inactivation or carcass decomposition. There are several types of equipment that can be used to turn compost windrows. Common examples include skid loaders, telehandlers, articulated loaders, dozers, and mechanical compost turners. A skilled operator is required to increase efficiency and avoid damaging buildings and equipment.

Photo 10. Skid loader turning compost pile (photo by Gary Flory)

The purpose of turning the windrow is to homogenize of the core, base and cap materials while exposing the microorganisms to additional oxygen through pile aeration. This process results in increased microbial activity, a rise in pile temperature, and accelerated carcass degradation. When turning the windrow, physically mix and aerate the material as much as possible with the equipment available (such as cascading the material from a loader bucket). If soft tissue is observed on the windrow surface, additional carbon material should be applied as a cap.

Photo 11. Self-propelled compost turner (photo by Gary Flory)

Photo 12. Tractor-pulled compost turner (photo by Mark King)

Photo 13. Brown Bear compost turner (photo by Gary Flory)

APPENDIX J
CHARACTERISTICS OF RAW MATERIAL

Material	Type of value	% N (dry weight)	C:N ratio (weight to weight)	Moisture content % (wet weight)	Bulk density (pounds per cubic yard)
Crop residues and fruit/vegetable-processing waste					
Apple filter cake	Typical	1.2	13	60	1,197
Apple pomace	Typical	1.1	48	88	1,559
Apple-processing sludge	Typical	2.8	7	59	1,411
Cocoa shells	Typical	2.3	22	8	798
Coffee grounds	Typical	—	20	—	—
Corn cobs	Range	0.4–0.8	56–123	9–18	—
	Average	0.6	98	15	557
Corn stalks	Typical	0.6–0.8	60–73[a]	12	32
Cottonseed meal	Typical	7.7	7	—	—
Cranberry filter cake	Typical	2.8	31	50	1,021
(with rice hulls)	Typical	1.2	42	71	1,298
Cranberry plant (stems, leaves)	Typical	0.9	61	61	—
Cull potatoes	Typical	—	18	78	1,540
Fruit wastes	Range	0.9–2.6	20–49	62–88	—
	Average	1.4	40	80	—
Olive husks	Typical	1.2–1.5	30–35	8–10	—
Potato-processing sludge	Typical	—	28	75	1,570
Potato tops	Typical	1.5	25	—	—
Rice hulls	Range	0–0.4	113–1120	7–12	185–219
	Average	0.3	121	14	202
Soybean meal	Typical	7.2–7.6	4–6	—	—
Tomato-processing waste	Typical	4.5	11[a]	62	—
Vegetable produce	Typical	2.7	19	87	1,585
Vegetable wastes	Typical	2.5–4	11–13	—	—
Fish and meat processing					
Blood wastes (slaughterhouse waste and dried blood)	Typical	13–14	3–3.5	10–78	—
Crab and lobster wastes	Range	4.6–8.2	4.0–5.4	35–61	—
	Average	6.1	4.9	47	240
Fish-breading crumbs	Typical	2.0	28	10	—
Fish-processing sludge	Typical	6.8	5.2	94	—
Fish wastes (gurry, racks, and so on)	Range	6.5–14.2	2.6–5.0	50–81	—
	Average	10.6	3.6	76	—

Material	Type of value	% N (dry weight)	C:N ratio (weight to weight)	Moisture content % (wet weight)	Bulk density (pounds per cubic yard)
Mixed slaughterhouse waste	Typical	7–10	2–4	—	—
Mussel wastes	Typical	3.6	2.2	63	—
Poultry carcasses	Typical	2.4[b]	5	65	—
Paunch manure	Typical	1.8	20–30	80–85	1,460
Shrimp wastes	Typical	9.5	3.4	78	—
Manures					
Broiler litter	Range	1.6–3.9	12–15[a]	22–46	756–1,026
	Average	2.7	14 a	37	864
Cattle	Range	1.5–4.2	11–30	67–87	1,323–1,674
	Average	2.4	19	81	1,458
Dairy tie stall	Typical	2.7	18	79	—
Dairy free stall	Typical	3.7	13	83	—
Horse-general	Range	1.4–2.3	22–50	59–79	1,215–1,620
	Average	1.6	30	72	1,379
Horse-race track	Range	0.8–1.7	29–56	52–67	—
	Average	1.2	41	63	—
Laying hens	Range	4–10	3–10	62–75	1,377–1,620
	Average	8.0	6	69	1,479
Sheep	Range	1.3–3.9	13–20	60–75	—
	Average	2.7	16	69	—
Swine	Range	1.9–4.3	9–19	65–91	—
	Average	3.1	14	80	—
Turkey litter	Average	2.6	16 a	26	783
Municipal wastes					
Garbage (food waste)	Typical	1.9–2.9	14–16	69	—
Night soil	Typical	5.5–6.5	6–10	—	—
Paper from domestic refuse	Typical	0.2–0.25	127–178	18–20	—
Pharmaceutical wastes	Typical	2.6	19	—	—

Material	Type of value	% N (dry weight)	C:N ratio (weight to weight)	Moisture content % (wet weight)	Bulk density (pounds per cubic yard)
Refuse (mixed food, paper,	Typical	0.6–1.3	34–80	—	—
and so on)					
Sewage sludge	Range	2–6.9	5–16	72–84	1,075–1,750
Activated sludge	Typical	5.6	6	—	—
Digested sludge	Typical	1.9	16	—	—
Straw, hay, silage					
Corn silage	Typical	1.2–1.4	38–43[a]	65–68	—
Hay-general	Range	0.7–3.6	15–32	8–10	—
	Average	2.10	—	—	—
Hay-legume	Range	1.8–3.6	15–19	—	—
	Average	2.5	16	—	—
Hay-non-legume	Range	0.7–2.5	—	—	—
	Average	1.3	32	—	—
Straw-general	Range	0.3–1.1	48–150	4–27	58–378
	Average	0.7	80	12	227
Straw-oat	Range	0.6–1.1	48–98	—	—
	Average	0.9	60	—	—
Straw-wheat	Range	0.3–0.5	100–150	—	—
	Average	0.4	127	—	—
Wood and paper					
Bark-hardwoods	Range	0.10–0.41	116–436	—	—
	Average	0.241	223	—	—
Bark-softwoods	Range	0.04–0.39	131–1,285	—	—
	Average	0.14	496	—	—
Corrugated cardboard	Typical	0.10	563	8	259
Lumbermill waste	Typical	0.13	170	—	—
Newsprint	Typical	0.06–0.14	398–852	3–8	195–242
Paper fiber sludge	Typical	—	250	66	1140
Paper mill sludge	Typical	0.56	54	81	—
Paper pulp	Typical	0.59	90	82	1403
Sawdust	Range	0.06–0.8	200–750	19–65	350–450

Material	Type of value	% N (dry weight)	C:N ratio (weight to weight)	Moisture content % (wet weight)	Bulk density (pounds per cubic yard)
	Average	0.24	442	39	410
Telephone books	Typical	0.7	772	6	250
Wood chips	Typical	—	—	—	445–620
Wood-hardwoods	Range	0.06–0.11	451–819	—	—
(chips, shavings, and so on)	Average	0.09	560	—	—
Wood-softwoods	Range	0.04–0.23	212–1,313	—	—
(chips, shavings, and so on)	Average	0.09	641	—	—
Yard wastes and other vegetation					
Grass clippings	Range	2.0–6.0	9–25	—	—
	Average	3.4	17	82	—
Loose	Typical	—	—	—	300–400
Compacted	Typical	—	—	—	500–800
Leaves	Range	0.5–1.3	40–80	—	—
	Average	0.9	54	38	—
Loose and dry	Typical	—	—	—	100–300
Compacted and moist	Typical	—	—	—	400–500
Seaweed	Range	1.2–3.0	5–27	—	—
	Average	1.9	17	53	—
Shrub trimmings	Typical	1.0	53	15	429
Tree trimmings	Typical	3.1	16	70	1,296
Water hyacinth-fresh	Typical	—	20–30	93	405

[a] Estimated from ash or volatile solids data.
[b] Mostly organic nitrogen.