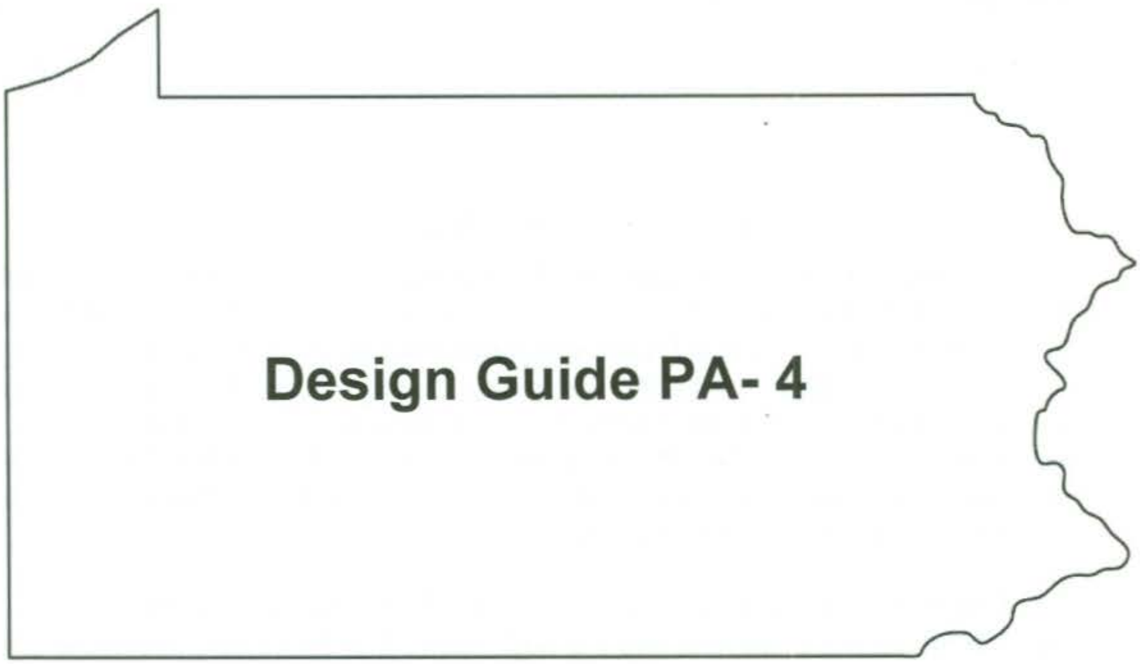
Animal Mortality Composting



Design Guide PA- 4

Natural Resources Conservation Service
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PREFACE

Composting livestock and poultry mortality in agricultural operations is a legal option for disposal in Pennsylvania. This design guide, used in conjunction with the Pennsylvania Technical Guide standards PA316, Animal Mortality Composting, and PA317, Composting Facility, make it possible to safely and legally compost livestock mortality. This technology expands the options for animal mortality disposal and improves the efficiency and profitability of agricultural enterprises. Material will be appended as additional information becomes available, and as new procedures are developed and approved.

The Pennsylvania Department of Agriculture, Bureau of Animal Health and Diagnostic Services, administers the regulations that determine allowable methods of livestock disposal, such as incineration, burial, rendering or composting.

This design guide includes information applicable to composting of routine and catastrophic mortality losses, except those resulting from infectious diseases. If a dangerously infectious disease is discovered on any farm, PDA will determine the allowable method of disposal.

This design guide was adapted from the Ohio Livestock and Poultry Composting Manual.

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ANIMAL MORTALITY COMPOSTING PRINCIPLES AND OPERATION

Composting of animal mortalities differs from composting of most other materials which are processed in a consistent, thoroughly mixed pile. A pile in which animal mortalities are composted is an inconsistent mixture. Therefore composting animal mortalities must be approached in a different way and with greater care.

Figure 1 is a schematic showing the process followed for composting animal mortalities. This approach has been successful on thousands of farms throughout the United States. The compost pile (either open or in a bin) is an inconsistent mixture with a large mass of material (the animal) having a low C/N ratio, a high moisture content, and nearly zero porosity surrounded by a material (the carbon amendment) with a high C/N ratio, moderate moisture levels, and good porosity. The animal and amendments are layered into the pile and no mixing is done in this process until after the high rate stage of composting has occurred and the animal has fully decomposed. Composting livestock mortalities (primary stage) can be described as "above ground burial in a bio-mass filter with pathogen kill by high temperature."

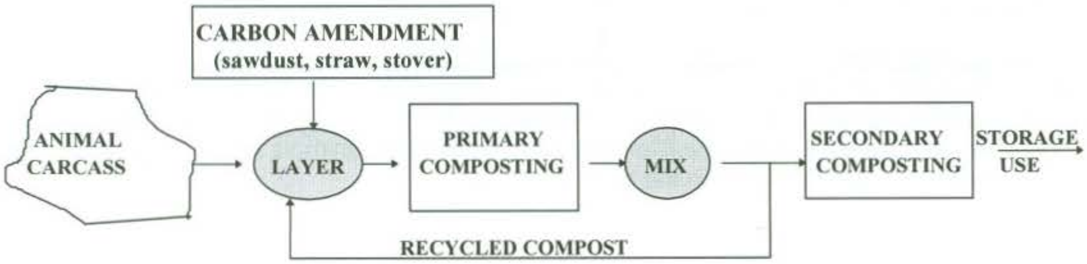

Figure 1. Material flow in livestock mortality composting. Forced aeration is not used. Materials are not mixed until flesh of the animal body is completely decomposed. Time can vary from 10 days (poultry) to over 100 days (large animals).

Figure 2 is a cross section of the compost pile for animal mortality. The decomposition process is anaerobic (lacking oxygen) in and around the animal mortality. But as gasses are produced and diffuse away from the mortality, they enter an aerobic zone. Here the gasses are trapped in the surrounding material, ingested by the microorganisms, and degraded to CO_2 and H_2O. Thus the surrounding material supports bacteria to form a biological filter, or a biofilter.

With this scenario, turning the pile is to be avoided until the mortality has been decomposed. For small to moderate size animals (poultry, pigs, sheep, etc.) this period is generally less than three months after the last mortality has been placed into the pile. After this time the compost is moved to a secondary area where it is allowed to compost for an additional time period of 10 days to several months. Moving the pile for secondary composting and storage introduces air back into the pile and mixes the contents of the pile, leading to more uniformity in the finished compost. The secondary pile is then turned and placed in a storage/curing pile for 30 days or more. When composting large mature animals, bones sometimes remain after completion of the secondary/storage process. These are usually quite brittle and pose no health risks or danger to equipment when land applied. In some instances it may be desirable to recycle the larger bones back into the compost to allow more decomposition.

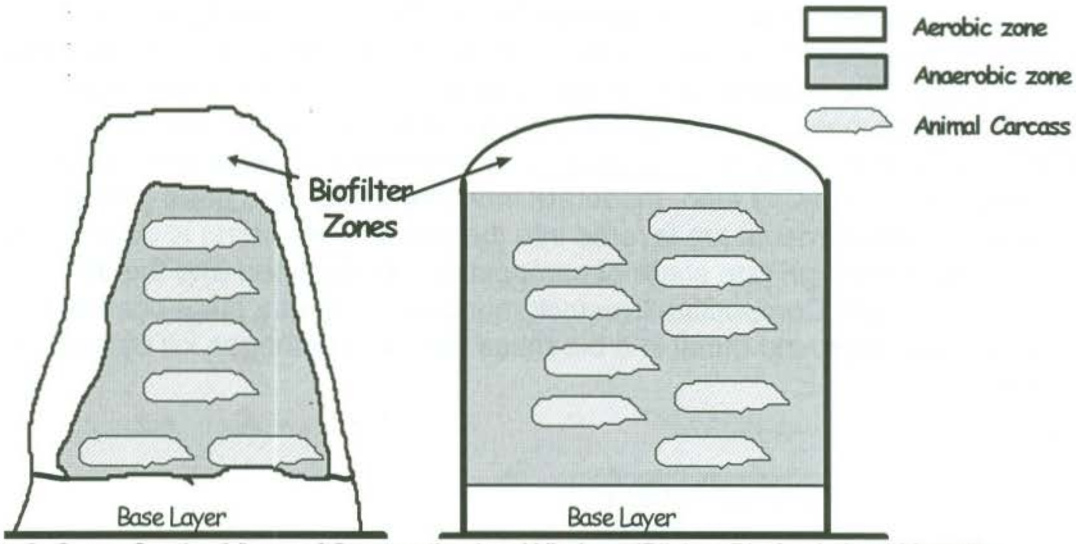

Figure 2. Cross-Section Views of Composting in a Windrow (Pile) or Bin for Animal Mortality. Layering of animal mortalities surrounded by material which not only provides carbon (energy) for the microorganisms, but also acts as a Biofilter. Pile is not turned until animals are decomposed. Pile shape will depend on whether done in the open or in a bin.

Data Collection

In order to monitor the composting process, it is necessary to measure and record temperatures of the compost pile. Pathogen kill can be monitored by measuring the internal pile temperature. Progress of the pile can also be assessed from temperature records. Temperatures should be taken at several points near the animals in the pile. Temperature recording can be done easily with a three foot probe thermometer (1/4 inch probe diameter is recommended). Data recorded should include date, size, number of animals added, and the internal temperature of the pile.

Managing the Composting of Livestock/Poultry Mortality

There are two general approaches to livestock mortality composting: enclosed or bin systems and open windrow or pile systems. The following discussion of the overall management illustrates some of the basic ideas involved in either approach. More details are given later for each species.

Sawdust is widely used for composting animal mortality. It works well as a biofilter, allows high temperatures to be achieved and sustained during the primary stage, and promotes bone breakdown when doing large (>400 lb.) animals. Because of its ability to shed rainwater, sawdust works well for outside piles where exposure to rain and snow could result in high moisture levels leading to leachate or odors. When using sawdust, it is recommended 25-50% of the material be recycled compost from the storage pile as this reduces cost, improves the composting process, and leads to a higher quality finished compost. Recycle rates should not exceed 50% as this may limit carbon availability, thus interfering with the composting process.

Studies in Ohio have shown that (1) mixtures of sawdust and straw (or cornstover) can be used both under cover or in outside piles and (2) straight straw or cornstover can be used in roofed piles, but require periodic water addition during composting to prevent inhibiting the process. If straw or cornstover are used in the mix, the amount of recycled material will need to be reduced. For poultry mortality, poultry litter and straw work very well.

The following table lists potential materials for use in composting animal mortality. Discussion of materials suitable for each species is detailed in the later chapters of this manual.

Table 1. Carbon sources/carbon amendments identified for possible incorporation into animal mortality composting operations.

Corn Stover	Chopped Soybean Stubble
Peanut Hulls	Wood Shavings/Chips
Sawdust	Recycled Paper/Cardboard
Yardwaste	Leaves
Hay	Chicken Litter
Rice Hulls	Manure & Bedding (Horse, Sheep, Swine)
Straw	

Source: National Pork Producers Handbook

Practices of composting animal mortalities are very simple. The recommended methods are:

1. Construct a base layer of dry sawdust, finished compost, or other acceptable absorbent material. Sawdust, compost or similar fine textured material can be mixed with equal amounts of chopped straw, corn stover, or soybean stubble. This base layer should be at least 1 ft. thick for carcasses weighing 50 pounds or less, 18 inches thick for carcasses between 50 and 250 pounds, and 2 ft. thick for carcasses over 250 pounds. The base layer in a windrow or pile system should extend 2 ft. beyond the area to be covered with carcasses. It will collect liquids that are released during mortality decomposition. It also permits air movement and microbial action underneath the mortality. If liquids

begin to leach out of the pile, spread sawdust around the pile to absorb the liquids, and increase the depth of the base when constructing new piles.

2. Place a layer of animals on the base layer. A single layer of animals should be centered on and evenly spaced across the base. Do not stack animals on top of one another (with the exception of very small animals where mortalities can be layered up to 4 inches thick). Space animals larger than twenty pounds at least six inches apart in the layer. Four to six inches of amendment is necessary between layers of mortality for the compost system to work effectively.
3. Cover the animals with 2 ft. of damp sawdust or other amendment from Table 1. This cover acts as the biofilter for odor control around the pile and insulates the pile to retain heat. Odors may be released when an inadequate cover is used or when it is too dry or too wet. The released odors may also attract scavenging animals and pets to the pile. Maintaining a 2-ft. cover prevents this.

When additional animals are placed in the pile the following steps should be followed.

4. Hollow out a hole in the 2 ft. of cover material. Maintain 4 to 6 inches of amendment over animals already in the pile.
5. Place a new layer of animals in the pile.
6. Cover new layer of animals with 2 ft. of damp amendment.

Pile (bin) management is a simple cycle, based on a primary stage (primary stage compost time = T1), secondary stage (T2), and storage stage (T3). A minimum of two primary piles (bins) is required. The secondary pile (bin) is the same volume as the primary pile (bins). The storage pile size is dictated by the longer of 30 days or how long the compost will be stored before land application.

Each pile is constructed for T1 days, composted for T1 days after the last animal is added, and then is turned and composted for T2 days. Finally the material is placed in the storage area where it is kept for T3 days. Each primary bin gets filled at (2 * T1) intervals.

ANIMAL MORTALITY COMPOSTING FACILITY ALTERNATIVES

This section was adapted from OSUE Extension Factsheet AEX 712-97, Swine Composting Site Selection by Mescher, Wolfe, Stowell and Keener, 1997; OSUE Extension Factsheet AEX 713-97, Swine Composting Facility Design by Mescher, Wolfe, Foster and Stowell, 1997; and the NPPC Composting Module, McGuire (ed), 1997.

Mortality composting is commonly conducted in one of two primary facility types: a bin or windrow. Each facility type has unique advantages and disadvantages and producer choice is driven by a number of concerns, including:

1. Ability to meet the objectives of a compost system.
2. Type of production unit serviced.
3. Economic costs associated with startup and operation of the bin or windrow.
4. State regulations and/or restrictions on facility type and design specifications.
5. Access to economical sources of carbon amendment.
6. Access to appropriate loading, unloading and handling equipment.
7. Appropriate land area for application of compost material.

Given these driving factors, producers must make informed decisions based upon the specific advantages of each facility option.

Bin Composting

Composting in a bin usually involves construction of a facility with a concrete floor, wood sidewalls on at least 3 sides, and a roof over the facility to eliminate water infiltration and leachate.

Advantages to Bin Composting	Disadvantages to Bin Composting
+ Reduced risk of weather affecting the compost process.	- Initial investment in facilities.
+ More aesthetically pleasing appearance.	- Difficult to load large animals into bins
+ Reduced risk of scavenging animals.	
+ Compost moisture content is consistent and controllable.	
+ Many carbon amendments can be used in the process.	
+ Leachate risk is reduced and easily contained.	
+ Existing facilities, barns, etc. may be easily modified to meet the needs.	

Windrow Composting

Windrow composting is established on a concrete, geo-textile fabric lined gravel base or low permeability soil to control water infiltration. In this system, walls and roofs are not used, so the windrow is accessible from all sides to load, unload and mix the compost material. Producers can load the animal mortalities for a specific time period while continually extending the length of the compost windrow and mound the compost material to shed rainfall, control moisture loss and maintain adequate biofilter cover. Turning of any portion of the pile is delayed until that portion has met acceptable times for stage 1 (T1) or stage 2 (T2) or storage (T3). Specific size and number of windrows and management will be based on animal sizes, loading rates, and site parameters of layout. These topics are discussed in greater detail below.

Pile composting is a variation of windrows except the pile is not extended in length. Turning of any pile is delayed until it has met acceptable times for stage 1 (T1) or stage 2 (T2) or storage (T3). With pile composting there will be three active piles in operation at any given time. (2 primary and 1 secondary).

Advantages to Windrow and Static Pile Designs	Disadvantages to Windrow and Static Pile Designs
+ Low initial investment in facilities.	- Exposure of the compost to the elements (wind and rain) increases risk of leachate and runoff.
+ Better suited to large animals	- Acceptable carbon amendment more limited than bin system.
	- Scavenging animals, if present, may be difficult to eliminate.

ANIMAL MORTALITY COMPOST FACILITY SIZING

This section presents the formulas along with worksheets and tables for sizing and specifying the design of composting facilities for poultry and livestock enterprises.

Sizing Guidelines

Sizing of a mortality composting facility is critical for its successful operation. Composting facilities that are undersized will lead to problems with odor and flies, and possibly scavengers and leachate. Proper sizing will make the management and operation of the composting process easier. Sizing is based on:

- Three stages for composting mortality - primary, secondary, and storage;
- Weight of the largest animal in the primary composting stage;
- Daily mortality rate and composting time determining total loading for each primary pile (bin);
- All systems having a minimum of two primary piles (bins) or equivalent; and
- All primary piles (bins) using a biofilter cover of 2 ft. and a thickness of base material suitable for the animal size.

Analysis of the mixing ratios and specific volumes of materials and livestock mortalities, based on the guidelines for C/N ratio and biofilter cover as described under Animal Mortality Composting Principles and Operation, were analyzed by Keener et al. (1999) for poultry, swine and cattle. From that analysis equations were developed for primary stage time and volume, secondary stage time and volume, and storage time and volume. Those equations are shown on the next page, and are incorporated into the worksheets at the end of this section.

Table 2 summarizes the steps in sizing of a composting facility. For large animals and low average daily loss (ADL), the volumes needed for primary, secondary and storage are better calculated using equations 2a, 4a and 6a.

Design of the composting facility is easy, but requires knowledge of death losses. Table 3 summarizes the average death losses for poultry, swine, cattle/horse and sheep/goats and can be used in the design process for new facilities. **However, actual death loss data from the operation should be used in sizing the composting facilities whenever possible for existing facilities**.

Worksheets for calculating the poundage of annual and ADL are PA-ENG-316a for poultry, PA-ENG-316b for swine, and PA-ENG-316c for other livestock.

Dimensions of windrows and the size of the composting area for a windrow system are determined using worksheet PA-ENG-316d. For a bin composting system, sizes and numbers of bins are determined using PA-ENG-316e. If animal size and mortality rate (lb/day) are known, Tables 4, 5, and 6 can be used directly to find required stage times and windrow or bin volumes.

Annual volume of sawdust or other amendment, assuming no recycling of material, is based on the equation: V_a = lbs. loss/yr. x 0.0069 = cu. yd./yr.

In practice, up to 50% of the amendment can come from finished compost.

Equations for Primary, Secondary and Storage Stage Time and Volume

Primary stage time, T_1, is calculated using

$$T_1 = 5 \times \sqrt{W_1} \geq 10, days \quad (1)$$

W_1 is the design (usually largest) body weight of mortality (lb). ADL is average daily loss (lb) and is calculated using mortality rates, animal numbers and batches per year.

Primary composter volume, V_1, is calculated using

$$V_1 \geq 0.2 \times ADL \times T_1, \ ft^3. \quad (2)$$

With large animals and infrequent deaths, equation 2 will sometimes underestimate the primary volume needed. Equation 2a is a modification of equation 2 that correctly calculates primary volume and is applicable for any animal size.

The modified version of equation 2 is

$$V_1 = 0.2 \times W_1 \times Integer(ADL \times T_1 / W_1), \ ft^3 \quad (2a)$$

where Integer(ADL x T_1 /W_1) is the product of (ADL x T_1 /W_1) rounded up to the next whole number.

Studies (Brodie and Carr, undated; Elwell et al., 1998) on composting mortality indicated secondary composting time does not need to be equivalent to the primary stage time. Instead, it should be based on heating and cooling of the pile. Usually, this stage lasts from 10 to 30 days. For design and operational purposes, an estimate of secondary stage time, T_2, and volume, V_2, is calculated using

$$T_2 = 1/3 \times T_1 \geq 10, \ days; \quad (3)$$

$$V_2 \geq 0.2 \times ADL \times T_2, \ ft^3. \quad (4)$$

The use of a minimum of 10 days or 1/3 the primary time is based on approximating minimum times found in poultry mortality composting and the times of sustained re-heating in the secondary bin for larger animals. A modified version of equation 4 for use with large animals or infrequent mortality cases is

$$V_2 = 0.2 \times W_1 \times Integer(ADL \times T_2 / W_1), \ ft^3. \quad (4a)$$

Equation 4a avoids underestimating windrow or bin size. One secondary bin can often handle the contents from up to three primary bins, due to reduced volumes and holding time. The secondary bin should not be smaller than a primary bin.

Because land application may not be feasible at all times, storage time for compost needs to be considered. A minimum of 30 days is recommended. Volume of storage, V_3, can be calculated using

$$T_3 \geq 30, \ days; \quad (5)$$

$$V_3 \geq 0.2 \times ADL \times T_3, \ ft^3. \quad (6)$$

A modified version of equation 6 for use with large or infrequent mortality cases is

$$V_3 = 0.2 \times W_1 \times Integer(ADL \times T_3 / W_1), \ ft^3. \quad (6a)$$

Equation 6a will avoid underestimating windrow size. The storage bin is always equal to or larger than the size of the secondary bin.

Table 2. Design procedures for animal mortality composting system.

Step	Description
1	Determine the average daily weight of animal mortalities to be composted: 1. Multiple livestock species can be composted together, unless a dangerously contagious or reportable disease is suspected. Biosecurity measures must be considered in the siting and operation to prevent disease transmission. 2. Use farm records for building capacity, animal sizes and livestock production values and loss records when possible; or calculate the livestock mortality rates (from PA-ENG-316a, 316b, or 316c). 3. For swine facilities the following assumptions should be used if operator records are not available: • Each sow yields 2.5 litters of pigs per year • Each litter = 10 pigs • For finish operations, the number of hogs = 2.7 x farm building capacity 4. The average daily death loss should be determined for each growth stage on the farm. 5. Pounds of mortality produced from operations in one year using "**average weight**". 6. Average daily loss in pounds per day to be composted. For some livestock operations the mortality rate is not constant throughout the year. See PA-ENG-316c.
2	Determine the Composting Stage times for the **"design weight"** to be composted in each windrow or bin. Note that the time for Primary Composting as well as the needed composting volume increases as the animal weight increases. For an operation with different growth stages, segregated bins or windrows should be evaluated for feasibility. Consider separate facilities for animals within these weight ranges: less than 50 lb., 50 to 250 lb., and greater than 250 lb. For animals exceeding 500 to 600 pounds the windrow composting method is preferred because individual primary bins would be large and the placement of animals would be difficult. For mature cattle or horses, a pile on a composting pad for each individual animal is preferred. The following equations are solved in section 1 of PA-ENG-316d (for windrows) or PA-ENG-316e (for bins). 1. Primary Stage Time (in days) = 5 x (Design Animal Weight)$^{1/2}$, Minimum Time $\geq$ 10 days 2. Secondary Stage Time (in days) = 1/3 Primary Stage Time, Minimum Time $\geq$ 10 days 3. Storage Time $\geq$ 30 days (Needs to be considered when land application is not feasible immediately following completion of secondary stage)
3	Determine the needed composter volumes using the following equations in PA-ENG-316d or 316e. 1. Primary Composter volume (in ft^3) = 0.2 x Average daily loss (ADL, in lb./day) x Primary Stage Time (days) 2. Secondary Composter Volume = 0.2 x ADL (in lb./day) x Secondary Stage Time (days) 3. Storage Volume = 0.2 x ADL x 30 days *Note: For large animals use alternate equations in PA-ENG-316d or 316e.*
4	Determine the dimensions of the compost facility, bin dimensions, and windrow size or number of bins using PA-ENG-316d or 316e. Note, in a bin system, the minimum front dimension (width) should be 2 ft. greater than the loading bucket width. Also as an alternative to building individual secondary bins, a large area to accommodate more than one primary bin can be used. This bin is generally directly behind the primary bins.
5	Determine the annual sawdust requirement for the composting system using PA-ENG-316d or 316e. This calculation assumes all sawdust needs are met with fresh sawdust. In practice, it is recommended that up to 50% of the fresh sawdust needs be met with compost that has completed the secondary cycle.

Table 3. Livestock mortality rates and design weights.

Poultry[1]

	Average Weight[3] (pounds)	Loss Rate (%)	Flock Life	Design Weight[4] (pounds)
Broiler (mature)	4 - 8	4.5 - 5	42 - 49 days	Up to 8
Layer	4.5	14	440 days	4.5
Broiler, breeding hen	4 - 8	10 - 12	440 days	8
Turkey, female (meat)	15 - 25	6 - 8	95 - 120 days	25
Turkey, male (meat)	25 -42	12	112 -140 days	35
Turkey, breeder replace.	15 (birth - 30)	5 - 6	210 days	20
Turkey, breeding hen	28 - 30	5 - 6	180 days	30
Turkey, breeding tom	70 - 80	30	180 days	75

Swine[2]

Growth Stage	Average Weight[3] (pounds)	Loss Rate (%)			Design Weight[4] (pounds)
		Excellent	Good	Poor	
Birth to Weaning	6	<10	10 - 12	>12	10
Nursery	24	<2	2 - 4	>4	35
Growing - Finishing	140	<2	2 - 4	>4	210
Breeding Herd[5]	350	<2	2 - 5	>5	350

Cattle / Horses[6]

Growth Stage	Average Weight[3] (pounds)	Loss Rate (%)			Design Weight[4] (pounds)
		Excellent	Good	Poor	
Birth	70 - 130	<8	8 - 10	>10	130
Weanling	600	<2	2 -3	>3	600
Yearling	900	<1	1	>1	900
Mature[5]	1400	<0.5	0.5 - 1	>1	1400

Sheep / Goats[6]

Growth Stage	Average Weight[3] (pounds)	Loss Rate (%)			Design Weight[4] (pounds)
		Excellent	Good	Poor	
Birth	8	<8	8 - 10	>10	10
Lambs	50-80	<4	4 - 6	>6	80
Mature[5]	170	<2	3 - 5	>8	170

[1]Adapted from Ohio Poultry Association Information; [2]Adapted from Pork Industry Handbook - 100 [3]Average weight used to calculate pounds of annual mortality; [4]Design weight used to calculate composting stage periods; [5] For mature animals the % loss is an annual rate for the average number of head on the farm; [6]The design weight and mortality rates for cattle, horses, sheep and goats need to be verified with the producer, the table figures are estimates from OSU livestock specialists. The mortality rate for these species will not likely be constant throughout the year.

Table 4. Primary volume (ft^3) vs. body size and mortality rate

body size (lb)	3.0	4.5	10	35	50	100	150	220	300	350	500	1000	1500
Stage time (days)	10	11	16	30	35	50	61	74	87	94	112	158	194
mortality rate (lb/day)	Vol.[1]												
1	2	2	3	7	10	20	30	44	60	70	100	200	300
5	10	11	16	30	35	50	61	74	87	94	112	200	300
10	20	21	32	59	71	100	122	148	173	187	224	316	387
25	50	53	79	148	177	250	305	371	433	468	559	791	968
50	100	106	158	296	354	500	610	742	866	935	1118	1581	1936
75	150	159	237	444	530	750	915	1112	1299	1403	1677	2372	2905
100	200	212	316	592	707	1000	1220	1483	1732	1871	2236	3162	3873
150	300	318	474	887	1061	1500	1830	2225	2598	2806	3354	4743	5809
200	400	424	632	1183	1414	2000	2440	2966	3464	3742	4472	6325	7746
300	600	636	949	1775	2121	3000	3660	4450	5196	5612	6708	9487	11619
400	800	849	1265	2366	2828	4000	4880	5933	6928	7483	8944	12649	15492
750	1500	1591	2372	4437	5303	7500	9150	11124	12990	14031	16771	23717	29047
1000	2000	2121	3162	5916	7071	10000	12200	14832	17321	18708	22361	31623	38730
1500	3000	3182	4743	8874	10607	15000	18300	22249	25981	28062	33541	47434	58095

[1] Shaded values are minimum volumes based on animal size.

Table 5. Secondary volume (ft^3) vs. body size and mortality rate

body size (lb)	3.0	4.5	10	35	50	100	150	220	300	350	500	1000	1500
Stage time (days)	10	10	10	10	12	17	20	25	29	31	37	53	65
mortality rate (lb/day)	Vol.[1]												
1	2	2	2	7	10	20	30	44	60	70	100	200	300
5	10	10	10	10	10	20	30	44	60	70	100	200	300
10	20	20	20	20	24	33	40	49	60	70	100	200	300
25	50	50	50	50	59	83	100	124	144	156	186	264	323
50	100	100	100	100	118	167	200	247	289	312	373	527	645
75	150	150	150	150	177	250	300	371	433	468	559	791	968
100	200	200	200	200	236	333	400	494	577	624	745	1054	1291
150	300	300	300	300	354	500	600	742	866	935	1118	1581	1936
200	400	400	400	400	471	667	800	989	1155	1247	1491	2108	2582
300	600	600	600	600	707	1000	1200	1483	1732	1871	2236	3162	3873
400	800	800	800	800	943	1333	1600	1978	2309	2494	2981	4216	5164
750	1500	1500	1500	1500	1768	2500	3000	3708	4330	4677	5590	7906	9682
1000	2000	2000	2000	2000	2357	3333	4000	4944	5774	6236	7454	10541	12910
1500	3000	3000	3000	3000	3536	5000	6000	7416	8660	9354	11180	15811	19365

[1] Shaded values are minimum volumes based on animal size.

Table 6. Storage volume (ft^3) vs. body size and mortality rate

body size (lb)	3.0	4.5	10	35	50	100	150	220	300	350	500	1000	1500
Stage time (days)	30	30	30	30	30	30	30	30	30	30	30	30	30
mortality rate (lb/day)	Vol.[2]												
1	6	6	6										
5	30	30	30	30	30	30	30						
10	60	60	60	60	60	60	60	60	60				
25	150	150	150	150	150	150	150	150	150				
50	300	300	300	300	300	300	300	300	300				
75	450	450	450	450	450	450	450	450	450				
100	600	600	600	600	600	600	600	600	600				
150	900	900	900	900	900	900	900	900	900				
200	1200	1200	1200	1200	1200	1200	1200	1200	1200				
300	1800	1800	1800	1800	1800	1800	1800	1800	1800				
400	2400	2400	2400	2400	2400	2400	2400	2400	2400				
750	4500	4500	4500	4500	4500	4500	4500	4500	4500				
1000	6000	6000	6000	6000	6000	6000	6000	6000	6000				
1500	9000	9000	9000	9000	9000	9000	9000	9000	9000				

[2] Shaded area is minimum volume based on animal size.

Examples of Design

Examples for Poultry, Swine and Cattle are presented here to illustrate the use of the equations 1-6 and Worksheets PA-ENG-316d and 316e.

Example 1- Poultry (bin).

Given: W1 = 3 lbs. and Average Daily Loss (ADL) is 30 lbs/day. Design a composting bin system.

Solution: From equations 1-6 find:

T1 = 10 days, T2 = 10 days and T3 = 30 days; and

V1 = 60 ft^3, V2 = 60 ft^3 and V3 = 180 ft^3.

From Worksheet PA-ENG-316e for bin depth = 5 ft select a bin volume of 80 ft^3. (A bin of 4 ft x 4 ft x 5 ft).

Solving for bin numbers following procedure in step 2 gave: two primary bins, one secondary bin of 4 ft x 4 ft x 5 ft and one storage bin (or multiply bins) > 180 ft^2.

Example 2- Swine (bin).

Given: W1 = 450 lbs. and ADL is 75 lbs/day. Design a composting bin system.

Solution: From equations 1-6 find:

T1 = 106 days, T2 = 35 days and T3 = 30 days; and

V1 = 1590 ft^3, V2 = 525 ft^3 and V3 = 450 ft^3.

Equations 2a, 4a and 6a give:

V1 = 1620 ft^3, V2 = 540 ft^3 and V3 = 450 ft^3.

From PA-ENG-316e for bin depth = 5 ft select a bin volume of 800 ft^3 (16 ft x 10 ft x 5 ft). Solving for bin numbers following procedure in step 3 gave: three primary bins and one secondary bin 16 ft x 10 ft x 5 ft and one storage bin of 16 ft x 10 ft x 5 ft.

Example 3- Swine (windrow).

Given: W1 = 450 lbs. and ADL is 75 lbs/day. Design a composting windrow system.

Solution: From Equations 1-6 find:

•T1 = 106 days, T2 = 35 days and T3 = 30 days; and

•V1 = 1590 ft^3, V2 = 525 ft^3 and V3 = 450 ft^3.

•From PA-ENG-316d for windrow height = 7 ft., find windrow section area = 56 ft^2 and base width is 15 ft.

This implies the primary windrow length = 28 ft; secondary windrow length = 10 ft (assuming 56 ft^2 cross section) and storage windrow length = 8 ft. The design windrow length would be 28 ft. Therefore, pad length is 38 ft. Pad width is = 60 ft (10 ft + 15 ft + 10 ft + 15 ft + 10 ft). Compost pad area is (38 ft x 60 ft) 2280 ft^2 or 0.052 acres.

Example 4- Cattle (windrow).

Given: W1 = 1400 lbs. and ADL is 20 lbs/day. Design a composting windrow system.

Solution: From Equations 1-6 find:

•T1 = 187 days, T2 = 62 days and T3 = 30 days; and

•V1 = 748 ft^3, V2 = 248 ft^3 and V3 = 120 ft^3.

Equations 2a, 4a and 6a give:

•V1 = 840 ft^3, V2 = 280 ft^3 and V3 = 280 ft^3.

Use alternate volumes from equations 2a, 4a and 6a. From PA-ENG-316d for a windrow height = 7 ft, find windrow Section area = 56 ft^2 and base width = 15 ft. This implies: primary windrow length = 15 ft; secondary windrow length = 5 ft (assuming 56 ft^2 cross section); and storage windrow length = 5 ft. The design windrow length is 15 ft. Therefore, pad length is 25 ft. (15 ft + 10 ft). Pad width is 60 ft. (10 ft + 15 ft + 10 ft + 15 ft + 10 ft). Compost pad area is 1500 ft^2 (25 ft x 60 ft).

Comments: Composting large animals requires additional evaluations to ensure adequate sizes. In this problem, over a 187 day time period, 3 (2.7 calculated) animals would need to be composted. Using the alternate calculation for primary bin volume gave 840 ft^3 which translated to a total pad size of 25 ft x 60 ft.

Poultry production and death loss calculations. PA-ENG-316a

Designer: ______________ Checker: ______________
Date: ___________ Date: ___________

Typical Mortality Losses for Poultry Production (%)

	Poultry[1]			
	Average Weight[3] (pounds)	Loss Rate (%)	Flock Life	Design Weight[4] (pounds)
Broiler (mature)	4 - 8	4.5 - 5	42 - 49 days	Up to 8
Layer	4.5	14	440 days	4.5
Broiler, breeding hen	4 - 8	10 - 12	440 days	8
Turkey, female (meat)	15 - 25	6 - 8	95 - 120 days	25
Turkey, male (meat)	25 -42	12	112 -140 days	35
Turkey, breeder replace.	15 (birth - 30)	5 - 6	210 days	20
Turkey, breeding hen	28 - 30	5 - 6	180 days	30
Turkey, breeding tom	70 - 80	30	180 days	75

Source: Ohio Poultry Association Information

Poultry Type: ____________________

B = Number of birds on farm (or farm building capacity) = ____________________

M = Anticipated mortality for flock (as a decimal) = _______________

T = Life of flock (days) = _________________________

W_b = Weight of birds near maturity (lb)= ________________

ADL = Average Daily Loss during flock life (lb/day) = $B \times [(M/T) \times W_b]$

ADL = _________ x [(_______ / ________) x ________] = ___________ lb/day

Go to form PA-ENG-316e to size the bins (*poultry compost bins should have a roof*)

Recipe of Material Proportions for Poultry Composting

Material	Parts by Weight
Poultry Carcasses	1.0
Poultry Litter	1.2
Straw	0.1
Water	0.75

Swine production and death loss calculations. PA-ENG-316b

Designer: ______________ Checker: ______________
Date: __________ Date: __________

Typical Mortality Losses for Swine Production (%)

Stage of Growth	Average Wt. (Lbs.)	Design Wt (Lbs.)	Excellent	Good	Poor
Birth to Weaning	6	10	Under 10	10 - 12	Over 12
Nursery	24	35	Under 2	2 – 4	Over 4
Growing / Finishing	140	210	Under 2	2 – 4	Over 4
Breeding Herd	350	350	Under 2 / yrs.	2 – 5 / yrs.	Over 5 //yrs.

Source: Pork Industry Handbook - 100

PRODUCTION

NUMBER OF PIGS BORN PER YEAR (Pre-Weaning):

______________ X ______________ X ______________ = ______________
(#sows) (litters/yr.) (pigs/litter) #pigs born/year

NUMBER OF NURSERY PIGS PER YEAR:

______________ - (______________ x ______________) = ______________
(#pigs born/yr.) (#pigs born/yr.) (% loss/100) #nursery pigs/yr.

NUMBER OF FINISHING HOGS PER YEAR

______________ - (______________ x ______________) = ______________
(#nursery pigs/yr.) (#nursery pigs/yr.) (% loss/100) #finishing hogs/yr.

TOTAL POUNDS DEATH LOSS PER YEAR (use "**average weight**" to calculate death loss)

______________ x ______________ x ______________ = ______________
(# sows) (Avg. Wt.) (% loss/100) (Lbs. loss/year)

______________ x ______________ x ______________ = ______________
(# pigs born/ yr.) (Avg. Wt.) (% loss/100) (Lbs. loss/year)

______________ x ______________ x ______________ = ______________
(# nursery pigs/ yr.) (Avg. Wt.) (% loss/100) (Lbs. loss/year)

______________ x ______________ x ______________ = ______________
(# finish hogs/ yr.) (Avg. Wt.) (% loss/100) (Lbs. loss/year)

TOTAL LBS DEATH LOSS/YEAR = ______________

AVERAGE DEATH LOSS PER DAY = ______________ / 365 = ________ (LBS DEATH LOSS/DAY)
(TOTAL LBS DEATH LOSS/YEAR)

Mortality calculations for general livestock.[1]

PA-ENG-316c
Sheet 1 of 2

Designer: ______________ Checker: ______________
Date: __________ Date: __________

Cattle, Horses, Sheep, Goats, Other (list)__________ (Poultry use 233a, Swine use 233b)

Complete one form for each livestock species. When the composting facility will include multiple livestock species, calculate daily losses by animal growth stage for each species, then sum the species worksheets to determine daily farm loss (see bottom of this form).

TOTAL POUNDS DEATH LOSS PER YEAR (use "**average weight**" to calculate death loss)

BIRTH STAGE:

(______________) X (______________) X (______________) = ______________
Number of Births | Average Weight | (% loss/100) | Lbs. of annual mortality

WEANLING STAGE:

(______________) X (______________) X (______________) = ______________
Number of Animals | Average Weight | (% loss/100) | Lbs. of annual mortality

YEARLING STAGE:

(______________) X (______________) X (______________) = ______________
Number of Animals | Average Weight | (% loss/100) | Lbs. of annual mortality

MATURE STAGE:

(______________) X (______________) X (______________) = ______________
Number of Animals | Average Weight | (% loss/100) | Lbs. of annual mortality

TOTAL SPECIES ANNUAL MORTALITY / YEAR (AM) = __________ lb

AVG DAILY LOSS[1] (ADL) = ANNUAL MORTALITY / 365= ______ / 365 = _______ lb/ day

Note:
For animals weighing less than 500 to 600 pounds, a bin composting system should initially be evaluated. For larger animals a windrow or compost pile for an individual mature animal will likely be the most practical.

[1] For poultry and swine, normal daily death loss can be assumed as a constant throughout the year. However in some livestock operations, high seasonal death rates are the norm (during calving and lambing), where the majority of annual death loss occurs during a short period of time. The other circumstance is where specific growth stages are moved off the farm at less than a year old (lambs sold at 120 days). In these instances, the average daily death loss calculation is modified as shown on page 2:

DAILY DEATH LOSS (ADL) = [(AM x P) / t] = ____________ lb/day

AM = total annual mortality, for species or growth stage (lb)
t = duration of seasonal high loss period, or duration, less than a year, species are on the farm (days)
P= percentage of total annual loss that occurs during seasonal peaks (decimal)

OPTIONAL ADL CALCULATION METHOD
(select largest ADL from either method)

BIRTH STAGE:
(ADL) = [(_______ X ______) / ________] =_____________ lb/day
AM P t

WEANLING STAGE:
(ADL) = [(_______ X ______) / ________] =_____________ lb/day
AM P t

YEARLING STAGE:
(ADL) = [(_______ X ______) / ________] =_____________ lb/day
AM P t

MATURE STAGE:
(ADL) = [(_______ X ______) / ________] =_____________ lb/day
AM P t

TOTAL ADL / SPECIES =____________ lb/day

Total Farm ADL (complete for last form used)

Species	Daily Mortality (ADL) from forms 316a, 316b or 316c
Cattle/ Dairy	lb/day
Goats	lb/day
Poultry	lb/day
Sheep	lb/day
Swine	lb/day
Horses	lb/day
Other (list)	lb/day
Sum (total farm)	lb/day

Go to forms PA-ENG-316d (windrow) orPA-ENG-316e (bin) to size the composting facility

Composting worksheet for windrows. PA-ENG-316d

Designer: ______________ Checker: ______________
Date: __________ Date: __________

1. Calculate Primary, Secondary & Storage Volumes (or use Tables 3.7 to 3.9):

Primary Volume = 0.2 x ______________ (lbs. Loss / Day) x ______________ (Primary Stage Time) = ______________ Cu Ft

Secondary Volume = 0.2 x ______________ (lbs. Loss / Day) x ______________ (Secondary Stage Time) = ______________ Cu Ft

Storage Volume = 0.2 x ______________ (lbs. Loss / Day) x 30 days = ______________ Cu Ft

Alternate: (use with large animals)

Primary Volume = 0.2 x W1 (lbs.) x Integer (ADL * T1/ W1) = ____________ Cu Ft

Secondary Volume = 0.2 x W1 (lbs.) x Integer (ADL * T2/ W1) = ____________ Cu Ft

Storage Volume = 0.2 x W1 (lbs.) x Integer (ADL * T3/ W1) = ____________ Cu Ft

2. Indicate the windrow height and resulting windrow area used.

Assume a windrow height of 7 ft. and continue. Windrow Height = ______________ Ft
Windrow Section area and base width assume 1 ft. top width and 1:1 side slopes

Windrow Height (Ft)	Windrow Section Area (Sq. Ft.)	Windrow Base Width (ft)	Pad Width (ft)
5	30	11	52
6	42	13	56
7	56	15	60

3. Calculate the length of the Primary, Secondary and Storage windrows. **The Design Windrow Length is longer of the primary windrow length or sum of the secondary and storage windrow lengths. Then calculate the pad length.

Primary Windrow Length = (______________ (Primary Volume))/(______________ (Primary Windrow Area)) = ______________ (nearest ft.) Ft

If the composting windrow length is less than twice the windrow height, reduce the height and go back to step 2. This indicates the composting configuration will be a compost pile versus a windrow.

Secondary Windrow Length =(______________ (Secondary Volume))/(______________ (Primary Windrow Area)) = ______________ (nearest ft.) Ft

Storage Windrow Length =(______________ (Storage Volume))/(______________ (Primary Windrow Area)) = ______________ (nearest ft.) Ft

Pad Length = **Design Windrow Length + 10 ft. = ________________ Ft (nearest ft.)

4. Calculate Composting Pad Area

Pad width = 10 ft + primary windrow base + 10 ft. + secondary windrow base + 10 ft (See Table in step 3)

Compost Pad Area = __________ (Pad Length) x __________ (Pad Width) = ______________ Sq. Ft.

5. Calculate annual sawdust requirements. (This assumes no reintroduction of finished compost to the primary windrow, however it is recommended that up to 50% of fresh sawdust requirements be met with finished compost.)

Cubic Yards Sawdust = ______________ (lbs. Loss / Yr.) x 0.0069 = __________ Cu. Yds. / Yr.

Composting worksheet for bins. PA-ENG-316e
Sheet 1 of 2

Designer: ______________ Checker: ______________
Date: __________ Date: __________

1. Calculate Primary & Secondary Times:

Primary cycle $T1 = 5 \times \sqrt{\_\_\_\_\_\_\_\_\_\_} = \_\_\_\_\_\_\_\_\_\_\_\_\_\_ \ days$ time

Design Weight (W_1,) largest animal anticipated (10 day min)

Secondary stage time (T_2) = 1/3 x ______________ (Primary stage time) = __________ days (10 day min)

2. Calculate Primary, Secondary & Storage Volumes (or use Tables 1 through 3):

Primary Volume = 0.2 x ______________ (lb loss / day (ADL)) x ______________ (Primary Stage Time (T_1)) = ______________ cu ft

Secondary Volume = 0.2 x ______________ (lb loss / day(ADL)) x ______________ (Secondary Stage Time (T_2)) = ______________ cu ft

Storage Volume = 0.2 x ______________ (lb loss / day (ADL)) x 30 days (T_3) = ______________ cu ft

Alternate: (use with large animals): W_1 = weight of largest animal[1]

Primary Volume = 0.2 x W_1 (lb) x Integer (ADL * T_1/ W_1) = ____________ cu ft

Secondary Volume = 0.2 x W_1 (lb) x Integer (ADL * T_2/ W_1) = ____________ cu ft

Storage Volume = 0.2 x W_1 (lb) x Integer (ADL * T_3/ W_1) = ____________ cu ft

[1] Bins should not be used to compost large animals, and should be considered cautiously with animals over 250 pounds

3. Calculate number of bins with a minimum of two primary, one secondary, and one storage bin required. *In doing calculations always round up to whole number, i.e. 2.1 bins = 3 bins (or) increase the bin size and refigure.*

Bin Volumes versus width and length. Depth of compost = 5 ft.

Width / Length	4	6	8	10	12	14	16
	Bin Vol. (ft^3)						
4	80	120	160				
6	120	180	240	300	360		
8	160	240	320	400	480	560	640
10		300	400	500	600	700	800
12		360	480	600	720	840	960
14		420	560	700	840	980	1120
16		480	640	800	960	1120	1280

Number of Primary Bins - Choose bin dimensions within the capability of the loading equipment. Also account for the size of the animals to maintain 6" to 12" clearance between the carcasses and the bin walls (Minimum vol.). The bin width should be at least 2 ft greater than the loader bucket width. The minimum bin width should be at least 2 feet larger than the length of the largest animal. The equation for calculating the number of primary bins includes one additional bin to allow placing additional carcasses during the primary curing stage. *A minimum of two primary bins is required.*

Trial Bin Volume = ________ x ________ x 5 ft = __________ cu ft
Width (ft) length (ft)

Number of Primary Bins = ______________ / __________ + 1 Bin = __________ Bins
Primary Volume (step 2) Trial Bin Volume

Number of Secondary Bins - Select secondary bin volume. *Each secondary bin must be ≥ to the volume of the primary bin since volume reduction during the compost stage is neglected.* Minimum of 1 secondary bin per 3 primary bins (The 3:1 ratio requires immediate utilization or separate storage of compost following the secondary stage.)

Number of Secondary Bins = Secondary volume (step 2) / selected secondary bin volume

Number of Secondary Bins = ______________ / ____________ = __________ Bins
Secondary Volume. (step 2) Secondary Bin Volume

Number of Storage Bins - Select storage bin size. *Volume of each storage bin must be ≥ to secondary bin volume.*

Number of Bins for Compost Storage = Storage volume (step 2) / selected storage bin volume

Number of Storage Bins = ______________ / ______________ = __________ Bins
Storage Volume (step 2) Storage Bin Volume

4. Calculate annual sawdust requirements. (This assumes no reintroduction of compost that has completed the secondary cycle to the primary bin, however it is recommended that up to 50% of fresh sawdust requirements be met with this compost.)

Cubic Yards Sawdust = ____________ x 0.0069 = __________ cu. yd. / yr.
lb. loss / yr.

Additional bin(s) for fresh sawdust storage = _________

Summarize Bin Sizes and numbers:

	Primary	Secondary	Compost Storage	Sawdust Storage
Number of Bins				
Size (w x l)				

MANAGEMENT OF THE COMPOST FACILITY

This section presents the procedures to follow in operating and maintaining the mortality composting facility, either bin or windrow systems.

Successful mortality composting is dependent on the operation and maintenance of the process. As with any composting, the right combination of ingredients goes a long way toward assuring this success.

Sawdust is the best amendment for use in animal mortality composting, and is essential for windrow composting. Generally dry sawdust is better since dryer sawdust can absorb more water and contains more air space. Producers have reported success using green sawdust for some or all of the fresh sawdust requirements. Sawdust containing excessive moisture may freeze in the winter, making it difficult to handle and place around the animals. A compost windrow with greater than 60% moisture content increases the risk of leachate, anaerobic activity, and fly production. Aged sawdust of 40-50% moisture content is recommended, especially for windrow composting.

The following pages contain separate sample operation and maintenance plans for windrow and bin composting operations. The sample plan for bins includes a section on poultry composting, which uses poultry litter and straw instead of sawdust as the standard amendments.

SAMPLE OPERATION & MAINTENANCE PLAN
for
LIVESTOCK MORTALITY COMPOSTING
Windrow Composting With Sawdust

Owner ______________________________ County ________________________ Date __________

Type of Livestock: Dairy/Cattle Horses Poultry Sheep/Goats Swine

Design Mortality (lb/day): __________ Design Carcass Weight (lb): _______

Primary Stage ________ days (10 day min), Secondary Stage ________ days (10 day min)

1. Composting is a controlled natural process in which beneficial microorganisms reduce and transform organic wastes into a useful end product (compost). It is an aerobic process that does not produce offensive odors, and does produce a final product that is safe and is valuable as a crop fertilizer.

2. This method utilizes sawdust as the carbon amendment and allows the dead animal to supply the necessary nitrogen and water for the composting process to take place. This will satisfy the requirements of certain readily available bacteria and fungi to convert these materials to an inoffensive and useful product. The volume of the mass will be reduced 25 to 30 percent by the process. The composting process consists of a primary and secondary stage. The primary stage is to reduce the carcass to where only larger bones remain. The secondary stage is to allow complete decomposition of the carcass and for the compost to stabilize. The composting time is dependent upon the size of the carcass. Therefore it is best to group similar sized carcasses into the same windrow. The time for secondary composting should generally be about 1/3 the time of primary composting. The following table can be used to estimate the stage times for various sized animals.

Carcass size (lbs).	4	10	50	100	220	350	500	1000	1500
Primary stage (days)	10	16	35	50	75	95	115	160	195
Secondary stage (days)	10	10	12	15	25	30	40	55	65

3. Start a composting windrow by placing a minimum one foot of sawdust on the base of the area for the windrow; if the carcass weight exceeds 200 Lbs, use at least 1½ feet of sawdust at the base. Carcasses placed directly on soil, gravel, or concrete floors will NOT compost. Place one layer of dead animals on the sawdust and cover with a minimum of 2 foot of sawdust. Place no animals closer than 2 foot from the sides of the windrow. The 2 foot cover on the sides and on top is important to eliminate scavenging animals and minimize odors. Most problems in animal mortality composting arise when insufficient sawdust is used in covering carcasses. Small animals less than 20 pounds may be grouped. Larger animals may need to be recovered as the sawdust settles around the carcass. Shape or round the windrow so that it will shed rainfall. Do not allow pockets to form in the windrow and eliminate any areas that will trap water. As large carcasses begin to decompose the windrow will settle and form pockets; as this occurs the windrow must be reshaped. To place additional carcasses, "hollow-out" a cavity in the existing windrow, place the carcasses one animal thick and cover with a minimum 2 foot sawdust. If finished compost is available, it should be used to cover the carcass to provide additional heat and bacteria to start the process. Sawdust should then be used to provide the final cover. Use a pointed dowel or rod to measure the thickness of the sawdust cover. Do not put carcasses on top of carcasses. Maintain 1/2 to 1 foot between carcasses to prevent a large anaerobic mass.

4. It is recommended to monitor the temperature in the windrow with a long stem, dial type thermometer. When composting is proceeding properly, temperatures will reach 130 to 160 ° F. Other than testing, this is the best way to prove pathogen kill and identify problems. Primary windrows started during cold weather may not begin composting immediately. As temperatures warm up, composting will begin. There is usually enough heat in active compost to continue composting through cold weather, regardless of the ambient temperature. If sawdust is used as recommended, the insulation effect is sufficient to minimize the effects of ambient temperature. However during cold weather, incorporate mortalities into the compost as soon as possible. *Frozen carcasses will take very long to compost.*

5. After the primary windrow has composted for the "primary stage time" (after adding the last animal), turn the contents into the secondary windrow. This step provides mixing and aeration of the material so it will reheat and compost through the secondary stage. When composting animals in excess of 600 lb each, it is recommended that a separate pile be managed for each mortality to assure that the primary stage time is reached before the pile is turned.

6. After the secondary stage has completed, the compost should appear as a dark humus type material with very little odor. Some resistant parts such as teeth may still be identifiable, but should be soft and easily crumbled. If not, reintroduce them to the primary windrow. After completion of the secondary stage, the compost can be restaged. or spread as per the utilization plan. Storage of compost for at least 30 days following completion of the secondary stage will give additional management flexibility. This is particularly important where the primary plus secondary stage is less than 90 days since land application may not be possible immediately following the secondary stage.

7. Use the finished compost for a starter material over the new carcasses being composted in the primary area. This provides heat and bacteria to kick start the process. Experience has shown that up to 50% of the sawdust requirements can be filled using recycled, finished compost. However, plan to use sawdust in the amounts noted for starting up the operation until sufficient finished compost is available. It is important to recognize that as finished compost becomes available, 50% of the fresh sawdust requirement must be maintained for the system to function effectively.

8. Keep sawdust relatively dry. Generally, sawdust between 40 and 50 percent moisture works best. Sawdust will shed rainfall reasonably well if the windrow is mounded, with no pockets or depressions. Positive drainage must be maintained. All leachate and runoff must be collected and stored or treated in a manure storage system or filter area. However in a properly maintained windrow leachate will generally be absorbed into the sawdust surrounding the carcass. During dry periods of the year the surface of the windrow can become too dry and sawdust can easily be blown off by the wind. A water source needs to be available to re-hydrate the windrow to prevent sawdust loss. If other carbon amendments such as corn stover or chopped straw are used in the windrow, moisture loss will be more prevalent than with sawdust. A supplemental water source will be necessary to maintain the proper moisture content necessary for composting.

9. Keep the area around the windrows mowed and free of tall weeds and brush. Watch for any leaching that may occur. Using sawdust for the foundation of the primary windrow will help eliminate leaching.

10. Finished compost should be applied to supply N, P_20_5 and K_20 requirements. The nutrient requirements for any particular crop should be based on a current soil test. Compost application rates should be calculated on its nutrient content according to a recent laboratory analysis. In the absence of a laboratory analysis the nutrient content of the compost is estimated to be:

Total Nitrogen -	20 lbs/ton
Ammonia Nitrogen -	4 lbs/ton
Phosphorus	2 lbs/ton
Potassium	6 lbs/ton

Finished compost shall be applied as per the compost utilization plan.

11. In order to assure desired operation of the composting facility, daily records should be kept during the first several compost batches. This can be helpful in identifying problems that may occur. Record keeping can be discontinued when a desirable level of operation has been achieved. It is suggested to record daily, the amount of sawdust added, the weight of the dead animals, and the temperature of the compost.
12. Occasionally, composters will not heat up, or will produce odors or seepage. Composting is a biological process that depends on providing nutrients and an environment favorable for vigorous bacterial growth. Common mistakes are, failure to provide all the materials needed for energy and aeration, sloppy loading, insufficient cover over the animals, insufficient sawdust between the animals. These mistakes typically result in a dense, anaerobic mass and one in which energy is limiting. Turning the pile and adding DRY sawdust will remedy these problems. An exposed windrow will not need additional water. Daily records are the best way to diagnose problems.
13. Maintain a DRY, well drained, solid base for the windrow for two reasons; the base of the windrow will not turn anaerobic, and an all weather access can be maintained for daily loading. A wet compost area will be prone to failure.
14. Animals digging into the compost windrow CAN be a problem. Measures must be taken if this occurs to maintain biosecurity and a positive public perception. The easiest way to prevent this from occurring is to maintain two feet of cover over all dead animal parts. It may become necessary to fence or build a structure to eliminate scavengers from the windrow if they cannot be kept out. It is easier to maintain two feet of cover than to incur the additional cost of a fence or structure. Operation and management will determine the needs of the system.
15. Inspect compost area or structure when the structure is empty. Replace any broken or badly worn parts or hardware. Patch concrete floors, curbs, or gravel areas as necessary to assure proper operation and integrity. Examine roofed structures for structural integrity and leaks.
16. Keep all trees, shrubs, and flowers healthy in order to maintain a positive rural image.

The following is an acknowledgement by the landowner and operator of the operation and maintenance requirements.

Signature(s)

Landowner____ Date_______________

Operator____ Date_______________

SAMPLE OPERATION & MAINTENANCE PLAN
for
LIVESTOCK MORTALITY COMPOSTING
Bin Composting With Sawdust
(Includes poultry composting section)

Owner ____________________________ County ______________________ Date _________

Type of Livestock: Dairy/Cattle Horses Poultry Sheep/Goats Swine

Design Mortality (lb/day): ________ Design Carcass Weight (lb): ______

Primary Stage _______ days (10 day min), Secondary Stage _______ days (10 day min)

1. Composting is a controlled natural process in which beneficial microorganisms reduce and transform organic wastes into a useful end product (compost). It is an aerobic process that does not produce offensive odors, and does produce a final product that is safe and is valuable as a crop fertilizer.

2. This method utilizes sawdust as the bulking agent and allows the dead animal to supply the necessary nitrogen and water for the composting process to take place. This will satisfy the requirements of certain readily available bacteria and fungi to convert these materials to an inoffensive and useful product. The volume of the mass will be reduced 25 to 30 percent by the process. The composting process consists of a primary and secondary stage. The primary stage is to reduce the carcass to where only larger bones remain. The secondary stage is to allow complete decomposition of the carcass and for the compost to stabilize. The composting time is dependent upon the size of the carcass. Therefore it is best to group similar sized carcasses into the same bin. The time for secondary composting should generally be about 1/3 the time of primary composting. The following table can be used to estimate the stage times for various sized animals.

Carcass size (lbs).	5	10	25	50	100	220	350	500	1000	1500
Primary stage (days)	10	16	25	35	50	75	95	115	160	195
Secondary stage (days)	10	10	10	12	15	25	30	40	55	65

3. Start a composting bin by placing a minimum one foot of sawdust on the floor of the primary bin; if the carcass weight exceeds 200 Lbs, use at least 1½ feet of sawdust at the base. Carcasses placed directly on soil, gravel, or concrete floors will NOT compost. Place one layer of dead animals on the sawdust and cover with a minimum of 1 foot of sawdust. Place no animals closer than 1 foot from the side of the bin. The 1 foot cover on the sides and on top is important to eliminate scavenging animals and minimize odors. Most problems in animal composting arise when insufficient sawdust is used in covering carcasses. Small animals less than 20 pounds may be grouped. Larger animals may need to be recovered as the sawdust settles around the carcass.

   To place additional carcasses, "hollow-out" a cavity in the existing compost, place the carcasses one animal thick and cover with a minimum 1 foot sawdust. If finished compost is available, it should be used to cover the carcass to provide additional heat and bacteria to start the process. Sawdust should then be used to provide the final cover. Use a pointed dowel or rod to measure the thickness of the sawdust cover. Do not put carcasses on top of carcasses. Maintain 1/2 to 1 foot between carcasses to prevent a large anaerobic mass.

4. It is recommended to monitor temperatures in the bin with a long stem, dial type thermometer. When composting is proceeding properly, temperatures will reach 130 to 160 °F. Other than testing, this is the best way to prove pathogen kill. Primary bins started during cold weather

may not begin composting immediately. If carcasses are buried with the proper amounts of sawdust, they will begin composting as temperatures warm up. There is usually enough heat in active compost to continue composting through cold weather, regardless of the ambient temperature. If sawdust is used as recommended, the insulation effect is sufficient to minimize the effects of ambient temperature. However during cold weather, incorporate mortalities into the compost as soon as possible. Frozen carcasses will take very long to compost.

5. After the primary bin has composted for the "primary stage time" (after adding the last animal), turn the contents into the secondary bin. This step provides mixing and aeration of the material so it will reheat and compost through the secondary stage.

6. After the secondary stage has completed, the compost should appear as a dark humus type material with very little odor. Some resistant parts such as teeth may still be identifiable, but should be soft and easily crumbled. If not, reintroduce them to the primary bin. After completion of the secondary stage, the compost can be recycled. or spread as per the utilization plan. Storage of compost for at least 30 days following completion of the secondary stage will give additional management flexibility. This is particularly important where the primary plus secondary stage is less than 90 days since land application may not be possible immediately following the secondary stage.

7. Use the finished compost for a starter material over the new carcasses composted in the primary area. This provides heat and bacteria to kick start the process. Experience has shown that up to 50% of the sawdust requirements can be filled using recycled, finished compost. However, plan to use sawdust in the amounts noted for starting up the composting operation until sufficient finished compost is available. It is important to recognize that as finished compost becomes available, 50% of the sawdust requirement must be maintained for the system to function effectively.

8. Keep fresh sawdust as dry as possible. Sawdust in the range of 40 to 50 percent moisture is recommended. If other bulking agents such as corn stover or chopped straw are used in the bin, moisture loss will be more prevalent than with sawdust. A supplemental water source will be necessary to maintain the proper moisture content necessary for composting.

9. Keep the area around the bins mowed and free of tall weeds and brush. Watch for any leaching that may occur. Using sawdust for the foundation in the primary bins will help eliminate leaching. There should be no leaching in a covered bin composting system.

10. Finished compost should be applied to supply N, P_20_5 and K_20 requirements. The nutrient requirements for any particular crop should be based on a current soil test. Compost application rates should be calculated on its nutrient content according to a recent laboratory analysis. In the absence of a laboratory analysis the nutrient content of the compost is estimated to be:

Total Nitrogen	-20 lbs/ton
Ammonia Nitrogen	-4 lbs/ton
Phosphorus	- 2 lbs/ton
Potassium	- 6 lbs/ton

Finished compost shall be applied as per the compost utilization plan.

11. In order to assure desired operation of the composting facility, daily records should be kept during the first several compost batches. This can be helpful in identifying problems that may occur. Record keeping can be discontinued when a desirable level of operation has been achieved. It is suggested to record daily, the amount of sawdust added, the weight of the animals, and the temperature of the compost.

12. Occasionally, composters will not heat up, or will produce odors or seepage. Composting is a biological process that depends on providing nutrients and an environment favorable for

vigorous bacterial growth. Common mistakes are, failure to provide all the materials needed for energy and aeration, sloppy loading, insufficient cover over the animals, insufficient sawdust between the animals. These mistakes typically result in a dense, anaerobic mass and one in which energy is limiting. Turning the compost and adding DRY sawdust will remedy these problems. Daily records are the best way to diagnose problems.

13. Maintain all runoff control to keep the site high and dry. A wet composting facility will be prone to failure.

14. Animals digging into the compost CAN be a problem although usually not a problem in bins. Measures must be taken if this occurs for biosecurity reasons and maintaining a positive public perception. Maintaining 1 of cover over all animal parts in the bin will eliminate scavenging animals. NEVER allow animal parts to be exposed. Once an animal finds an exposed part, they are more likely to come back and dig into the compost. It is important to maintain continuous cover. Operation and management will determine the needs of the system.

15. Inspect the compost structure when it is empty. Replace any broken or badly worn parts or hardware. Patch concrete floors and curbs as necessary to assure proper operation and integrity. Examine roofed structures for structural integrity and leaks.

16. Keep all trees, shrubs, and flowers healthy in order to maintain a positive rural image.

Additional Considerations for Poultry Mortality Composting

1. The process uses a simple mixture of poultry manure, poultry carcasses, straw, and water. This will satisfy the requirements of certain readily available bacteria and fungi to convert these materials to an inoffensive and useful compost. The volume of the mass will be reduced 25 to 30 percent by the process.

Recipe of Material Proportions for Poultry Composting

Material	Parts by Weight
Poultry Carcasses	1.0
Poultry Litter	1.2
Straw	0.1
Water	0.75

2. Once the weight of a day's poultry carcasses is determined, the other elements can be weighed out according to the recipe. The elements should be weighed in buckets on scales for the first few batches. For subsequent batches, a loader can be used once the weight of a full loader bucket has been determined for each element except water. A hose can be used to deliver the correct amount of water based on the time necessary to deliver the required weight of water through the hose. The moisture content must be maintained between 40 and 60 percent, equivalent to that of a "damp sponge." This is an important part of the composting process, since a mixture that is too wet can become anaerobic and cause severe odor problems. Additional water may not be needed if sufficient moisture is available from other recipe ingredients.

3. For primary composting, the material is placed in the bins in layers in the following sequence: (Note: see Figure 1)

a. One foot of dry poultry manure should be placed on the concrete floor to absorb the excess moisture that is added. This manure weight is not part of the recipe.

b. A 6-inch layer of loose straw is placed on top of the manure layer to allow aeration under the carcasses.

c. Add a layer of carcasses. Do not mound the birds. Use a rake to spread the birds in a single layer. Keep birds at least 6 in. away from the walls so the carcasses are not exposed.

d. Add water to each layer of carcasses. Add water only when needed to ensure the mixture is damp. The mixture should be about as moist as a damp sponge. Proper water content is important to success. Less water may be needed as the birds approach maturity. DO NOT ADD TOO MUCH WATER.

e. A layer of manure is placed over the carcasses according to the recipe. The manure must completely cover the chickens. This completes the first batch.

f. The second and each subsequent batch continues by repeating steps b through e above until the bin is full.

g. When the last layer of chickens is added to a bin, cap the pile with an extra layer of manure. The extra layer will insulate the pile and will also help prevent scavenging animals from digging into the top.

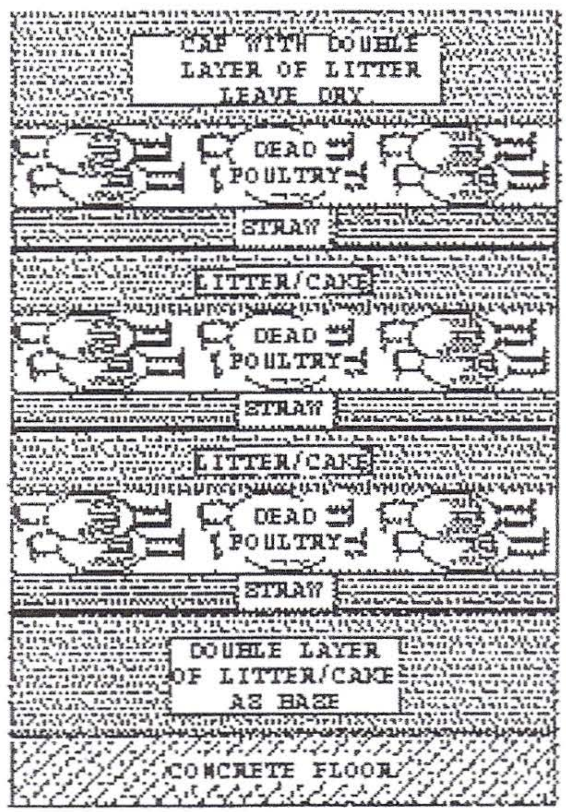

Figure 1

4. Temperature shall be monitored on a daily basis using a 36-inch probe-type thermometer with a rigid protective covering. Temperatures should peak at 130 to 140 ° F after 5 to 7 days of composting. If temperatures of 130 ° are not achieved during the composting process, the resulting compost shall be incorporated immediately after land application. If temperatures exceed 160 ° F, the compost shall be removed from the composting bin, spread on the ground to a depth not to exceed six inches in an area away from buildings, and saturated with water to prevent spontaneous combustion.
5. The primary composter shall be unloaded as peak temperatures begin to decline after 5 to 7 days, optimally at 10 days for chickens. For larger birds such as mature male turkeys the primary composting stage will take from 25 to 30 days (see table on page 1). Unloading the primary composter and loading the secondary composter shall be done in a manner that assures maximum mixing of the composting material. . Moving the material aerates the mixture and revives the bacteria, allowing them to begin another stage of heating. Temperature should rise again and peak in about 7 days.
6. Moisture and temperature requirements discussed in paragraphs 4 and 5 above, also apply to the secondary composting process. The compost removed from the secondary composting process should be stored for 30 days before land application. Storage depth shall not exceed seven feet to reduce the potential for spontaneous combustion (see Preventing Fires in Litter Storage Structures discussion). In addition, the compost should not come in contact with any manure stored in the same facility. Storage will allow the compost to dry allowing greater ease in handling.
7. Compost shall be applied to supply N, P205 and K20 requirements. The nutrient requirements for any particular crop should be based on a current soil test. Compost application rates should be calculated on its nutrient content according to a recent laboratory analysis. In the absence of a laboratory analysis the nutrient content of the poultry compost is estimated to be:

Total Nitrogen	-	40 lbs/ton
Organic Nitrogen	-	28 lbs/ton
Phosphorus	-	20 lbs/ton
Potassium	-	25 lbs/ton

8. To utilize the nutrients in compost for crop production in an environmentally safe manner, it is important to follow the waste utilization details outlined in your Waste Utilization Plan.

9. Inspect compost structure at least twice annually when the structure is empty. Replace any broken or badly worn parts or hardware. Patch concrete floors and curbs as necessary to assure water tightness. Examine roof structures for structural integrity and leaks.

10. As discussed in paragraph 3 above, maintaining the moisture content between 40 and 60 percent is vitally important. The primary and secondary composters and the storage or "resting" area should be protected from outside sources of water such as rain or surface runoff.

11. In order to assure desired operation of the composting facility, daily records should be kept during the first several compost batches. This can be helpful in identifying problems that may occur. Record keeping can be discontinued when a desirable level of operation has been achieved. It is suggested that daily records be kept on the attached "Poultry Composting Record Worksheet."

Occasionally, composters will not heat up, or produce odors or produce seepage. Composting is a biological process that depends on providing nutrients and an environment favorable for bacterial metabolism. Common mistakes are failure to provide all the materials needed for food and aeration, or sloppy loading of primary boxes so that materials are not "sandwiched." Too little straw (or alternate carbon source" results in a dense, anaerobic mass and one in which energy (from cellulose) is limiting. Too much water is a common problem. Saturated compost piles are anaerobic and will not support the desired aerobic, thermophilic metabolism needed for rapid, odorless digestion of carcasses. If the mixture is too wet or too dry, the decomposition rate is greatly reduced. Too-wet, too dry, improperly mixed or incomplete mixes of compost materials can be amended. When primary compost is turned, dry manure or straw may be added to too wet compost, water can be added to "dusty-dry" compost, and improperly mixed materials can be remixed. A little experience and perseverance usually give good results in a short time.

The following is an acknowledgement by the landowner and operator of the operation and maintenance requirements.

Signatures

Landowner____ Date_______________

Operator____ Date_______________

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