NPB FINAL RESEARCH GRANT REPORT

Compost Turner for Swine Mortality Management: Proof of Concept Project

NPB PO-00
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November 29, 2023

Industry Summary:

Carcass management is an important challenge in any livestock industry, as management is often expensive and time-consuming. Composting has become an acceptable alternative to rendering and burial for some operations. Integrators have constructed compost facilities, but many continue to have limited success with this process. Often, limitations are the result of improper use of a constructed facility, lack of carbon, or both. Notably, the amount of carbon required can be significant and costly.

This proof-of-concept project focused on identifying methods to improve compost efficiencies for both routine and catastrophic events through the implementation of various equipment and methodologies. Compost turners and horizontal grinders were both found to improve the compost process and reduce carbon inputs. Turning or grinding early—including as early as 7 days after windrow construction—accelerated the rate of carcass decomposition. The orientation of carcasses in a windrow had no observable influence on the compost turning, grinding, or composting process. For this project, carcasses were placed randomly in a single layer with some overlapping of legs, heads, and abdomens. The project demonstrated that a compost turner or a horizontal grinder would be advantageous for continuity of business during a disease outbreak. However, additional work on the aerosolization of particles from these operations, especially grinding before composting, needs to be explored.

Key Findings:

- A compost windrow turner can be successfully employed to manage sow and boar mortality in a compost pile as soon as 7 days after construction.
- Turning swine mortality compost windrows with a compost turner does not require additional carbon for windrow reconstruction or capping, at or after the turn.
- For static pile composting, tissue degradation was similar at all dates: 7, 14, and 28 days from the construction of the windrow. Very little soft tissue was visible after 7 days.
- Carcass size or orientation in the windrow had no impact on compost performance.
- Particle reduction with grinders significantly reduced the presence of bones. Only small bone fragments were found after 7 days.
- Both particle reduction and early windrow turning reduced the management time of large swine from 6-12 weeks to 2-4 weeks, without an increase in carbon resources, and poses little risk of disease spread.
- Particle reduction reduced carbon inputs but was not directly measured. The reduction is the result of body fluids being adsorbed during the grinding process, fewer large voids in the windrow core, and less required cap depth.

Keywords:
Carcass management, particle reduction, grinding, compost turner, animal tissue decomposition, compost, temperature, remote sensors, carbon resources.

Scientific Abstract:

Composting for routine and catastrophic mortality management has become an accepted practice in the United States. Compost provides an environmentally and economically sustainable method to recycle nutrients from the animals into the agricultural system. To date, composting of whole carcasses has been the primary methodology for both routine and catastrophic events. Four issues have been identified with whole animal composting during a foreign animal disease (FAD) event: disease inactivation, length of time for composting, bone management, and carbon quantities.

African Swine Fever (ASF) is a disease of major concern for the swine industry, potentially causing severe economic loss (You, 2021). Research has shown the inactivation of ASFv occurred within 3-7 days using whole carcasses in compost piles through both PCR and live cell culture (Gabbert et al., 2023, Hutchinson, et al. 2023, and Fisher, et al. 2020). The USDA Livestock Mortality Composting Protocol (USDA, 2017) provides guidelines for static windrow composting, a 6-12 weeks process that would significantly impact business continuity during a FAD event. Prior work has shown that particle reduction accelerates tissue degradation during the compost process. Particle reduction has been primarily accomplished by using large horizontal grinders. An alternative would be to use a compost turner after a period of pre-composting.

In this proof-of-concept project, the researchers used a compost turner in windrows with whole sow carcasses to determine when and if turning reduces particle size and soft tissue degradation. Very little carcass soft tissue was found after the turning process, including just 7 days following initial composting. There was no significant difference in soft tissue presence when turned at 7, 14, or 28 days. However, large bones were still present at all times. The turner was compared with a horizontal grinder after 14 days of composting. Soft tissue degradation scores were 5 (no soft tissue or bones present) and 4 (no soft tissue; some bone present) for grinding and turned windrows, respectively. The difference in the scores is a reflection of the large bones present when a compost turner is used, whereas horizontal grinding eliminates bone presence. The amount of carbon material required for composting if carcasses are pre-conditioned and turned vs. round was reduced, but not quantitatively measured. The largest reduction in carbon requirements was the result of no additional carbon being required for capping the windrows. Reducing the particle size significantly reduces the time needed for the compost process. Particle reduction could potentially decrease the loss of production time to 14-21 days, reducing carbon inputs with minimal risk of virus spread.

Introduction:

Carcass management is an important challenge in any livestock industry, as management is often expensive and time-consuming. Rendering is often the preferred option, if available. However, there are many cases where rendering may not be accessible because of the distance to a facility or facility capacity, such as during a heat wave or an FAD event. Composting has become an alternative for some operations. Integrators have constructed compost facilities, but many continue to have limited success with this process. Often, limitations are the result of improper use of a constructed facility, lack of carbon, or both. The amount of carbon required is significant and expensive. Finding methods to decrease carbon inputs and improve the compost process will significantly benefit swine producers in both routine and catastrophic carcass management.

Particle reduction has been identified as a method to improve the composting process, potentially reducing carbon inputs and the risk of leachate. Particle reduction with horizontal grinders has been shown to accelerate the compost process and reduce carbon inputs (National Pork Board Shelby County Report, 2023). However, there are concerns about aerosolization of the virus when using a horizontal grinder. Compost windrow turners may provide an alternative, as they are less expensive to purchase and operate, and more mobile.

At present, there is no documented use of a turner as means to accomplish particle reduction, speed up the composting process, and decrease carbon inputs. However, our field experience with turners and carcass management has shown that it may be possible. The aim of this project was to prove that turners can be used in place of large horizontal grinders to achieve similar outcomes. Another alternative is to pre-condition the carcasses in a compost windrow before grinding to reduce the risk of virus aerosolization. This proof of concept could improve on-farm carcass management by reducing carbon input, improving the compost process, and decreasing concerns about virus aerosolization.

Objectives:

- Objective 1: Determine the time a compost turner could be used to mix static windrow piles of swine mortality.
- Objective 2: Determine if a compost turner can reduce carbon inputs when composting swine carcasses.
- Objective 3: Prove that the orientation of carcasses in a compost windrow has no significant impact on windrow/compost turner performance.
- Objective 4: Pre-compost and then grind hogs to reduce carbon input and decrease concerns about virus aerosolization.

Materials & Methods:

This project took place on a 4-acre hayfield in Jefferson, Greene County, Iowa. An Iowa Department of Natural Resources waiver request was granted for a proof-of-concept project on this site (Appendix 1).

Trial 1, a randomized complete block design with 3 replications and 3 different core materials over 3 different time periods (for a total of 27 individual piles), began in May of 2023. A base of coarse ground mulch 8' x 15' x 12" was laid out using a frontend loader for each pile. Equipment specifications are provided in Appendix 2. The mulch had been ground through a horizontal grinder with 3" x 4" upper and lower screens. Parks of Iowa provided 76 sows for the proof-of-concept project with an average weight of 422 pounds, for a total carcass weight of 32,080 pounds. Each carcass pile was constructed with approximately 1,180 pounds of animal tissue randomly placed on the carbon base. Most piles had 3 carcasses, and several piles had 2 larger carcasses.

Three different carbon materials were used for the core material: ground mulch, corn stover, and kiln dry shavings. Approximately 7,500 gallons of water were added to bring the moisture content of these feedstocks to an estimated moisture content of 50%. Approximately 1.5 cubic yards of core material were used to cover the carcasses per linear foot of windrow. An 8-inch cap of double-ground mulch was added to each pile as a biofilter. After construction, temperature monitoring was conducted daily with analog thermometers. Additionally, automatic temperature probes from BMP Logic, Inc. were installed in 5 piles to evaluate the technology.

On Days 7, 14, and 28, a block of windrows was turned using a Backhus Compost turner. Windrows were turned in both directions each time. By the end of the project, Block 1 (Day 7) had been turned 3 times, Block 2 (Day 14) had been turned twice, and Block 3 (Day 28) turned once. Before and after the turn, each pile was evaluated for carcass degradation. Degradation was determined by collecting 3 random 5-gallon samples from the pile core. Samples were then screened using a 2" x 3" screen. The volume of material remaining on the screen was measured by the research team. The remaining material was then screened through a 1" screen. Both the overs and material that passed through the screen were measured. Observations of soft tissue, bones fragments, and other identifiable carcass pieces were noted. No additional carbon was added after the windrows were turned, as no soft tissue was observed.

Trial 2, a precondition and turn project, was initiated in July of 2023. Three carcass compost windrows, 16' wide and approximately 140' long with a base 12" in depth, were constructed. The base was comprised of a single-ground mulch material. Windrow 1 had 44 sows, Windrow 2 had 61 sows, and Windrow 3 had 50 sows. Carcasses were placed tightly, but with no specific orientation on the base. The average weight of a carcass was 471 pounds. Double-ground mulch material was added to the core of the windrows. Water (approximately 5,000 gallons) was added to the core material prior to adding that material to the windrow. Each windrow was then capped with 6-8" of double-ground mulch or finished compost to act as a biofilter.

This cap material does not affect the compost process. The material used in the windrow core lacked energy. After construction, temperature monitoring was conducted daily with analog thermometers.

All windrows were left static for a minimum of 14 days. On Day 14, 5 random sites in the core of each windrow were selected for the evaluation of carcass degradation. An excavator cut and laid out the windrow material down to the base. Five evaluators used the degradation scoring sheet to assess each cut. After, the evaluation material was pushed back into the windrow. On Day 14, Windrow 1 was ground through a Vermeer horizontal grinder, Windrow 3 was turned with a Backhus windrow turner, and Windrow 2 was evaluated but left static for an additional 14 days. Carcass degradation was evaluated on Days 14 and 28 for each windrow by excavating 5 locations in each windrow. Core material was removed and laid out for the evaluators using a small excavator with a thumb. A degradation scoring sheet (values 1-5) was used (Brown, 2007) (Appendix 3). After evaluation, all material was placed back in the windrows and the windrows were reshaped in those areas.

At the end of the project, all composted material was stacked for curing. The material will be field applied at agronomic rates in the spring before the field is cropped.

Results and Discussion:
Trial 1 windrows were evaluated for both time of turning and core feedstock material. The results for both factors were encouraging. The initial compost windrow turning after just 7 days revealed very little soft tissue. Large bones were still present, as would be expected with the dense, ossified bones of older hogs. There was no significant difference in the amount of tissue material collected on Days 7, 14, or 28. Soft tissue on Days 14 and 28 was also minimal. Bones were still present, but many had been broken by the turner. The windrow turner sheared the ends of many bones, particularly the larger bones—the femur, humerus, and skull. Smaller bones including vertebrae appeared to remain mostly intact (Figures 1 and 2). Therefore, turning the windrows at Day 7 is strategically beneficial to the compost process and decreases the composting time.

In Trial 1, the different core material did not seem to impact the amount of carcass decomposition. This is important, as a variety of feedstocks will be necessary during a large FAD event. It was noted that these feedstocks were combined with high-energy material and water to make an active blend. This may not be possible or realistic during a larger FAD event. Additional trials with less active initial materials need to be conducted to determine the impact of the high-energy materials.

Temperature profiles of the windrows (Graphs 1 and 2) were as expected, with early temperatures reaching well over 131°F in most piles. Compost temperatures decreased before turning in all piles during Trial 1, and all piles responded with increased temperatures after turning. This result was expected, as moisture is blended and there is an induction of oxygen. Microbes are also exposed to new food sources after turning.

Ten BMP Logic data loggers were used in conjunction with analog thermometers. Data loggers were placed in 5 piles at 18” and 36” depths. A receiver/transponder unit was placed on the north fence line. The unit was not obstructed by trees or buildings. Temperature data was accessible through BMP Logic’s web-based system. Data loggers continued to present challenges with temperature monitoring, as they were inconsistent in recording data due to factory settings. Once this issue was resolved, the data logger temperatures were comparable to the analog thermometer readings. If only data loggers had been used, there would not have been temperature data for the initial 3-4 days of the trial. This would not be acceptable in a FAD event. However, the technology continues to improve and should be considered for use in future projects. Vector activity was minimal, as there was only one coyote strike on a single pile. This was remedied by adding additional cover material.

In Trial 2, the precondition windrows all had large bones, soft tissue, fat, and hair at Day 14, prior to any mechanical manipulation. No discernable carcasses were observed, but stomach content was still intact in some areas. The tissue was hot and fell apart easily when handled. Because the material used in the construction of the windrows had very little initial energy, the compost degradation rate was slower than with the Trial 1 piles.

The turner uniformly blended the material. Small amounts of soft tissue and hair were observed on the surface after turning, and the carbon material was greasy to the touch. This is noteworthy, as the windrow piles became dense—placing an analog thermometer to a depth of 36” was not possible 5 days after the turn. However, when this material was handled, it would easily crumble. This phenomenon was observed in both Windrows 1 and 3. The researchers theorize that the fat and alkaline water may have had a chemical reaction, creating this dense material. More research is necessary to confirm this theory, as this has not been observed in other compost research. Large bones were still present after turning. These may cause concern to producers that wish to field apply the finished compost.

The horizontal grinder used for particle reduction was also successful. The ground material was uniform, with no identifiable soft tissue or hair. Bones were finely chopped. Carbon again felt greasy, and the pile became dense after several days.

Summary of windrows:

- Windrow 1: Notably dry. No soft tissue, bone, or discernable parts.
- Windrow 2: Static windrow for 4 weeks. Significant soft tissue, no noticeable liquid or leachate, bones disarticulated but still surrounded by some soft tissue. Could still determine the outline of the carcass. Partially decomposed carcasses seemed to be restricting airflow in the core. Mat of wet, slimy material. The original feedstock was still intact. Very little composting occurred, other than right around the carcass. No skin, which indicates there was a lack of energy in the core material. Recommendation: if static windrows are to be used in managing carcasses, core material needs to have materials added with proper moisture and energy.
- Windrow 3: Dry with no soft tissue, but partial bones were present. The bones had been ruptured/ broken by the turning action. Some of the bones were brittle, but the majority of the compost process had slowed considerably because of the lack of moisture. These bones would likely not break down further unless moisture was added. Bones were generally femurs, partial skulls, jaws, and ribs.

Compost temperatures indicated that turning or grinding accelerated microbial activity. Windrow temperatures responded almost immediately after the mechanical turning (Graphs 3 and 4). Both manipulated windrows exhausted the feedstock energy in the piles before the static pile. This was expected, as the static pile had a slower overall response as indicated by lower temperatures, resulting in a longer active composting time.

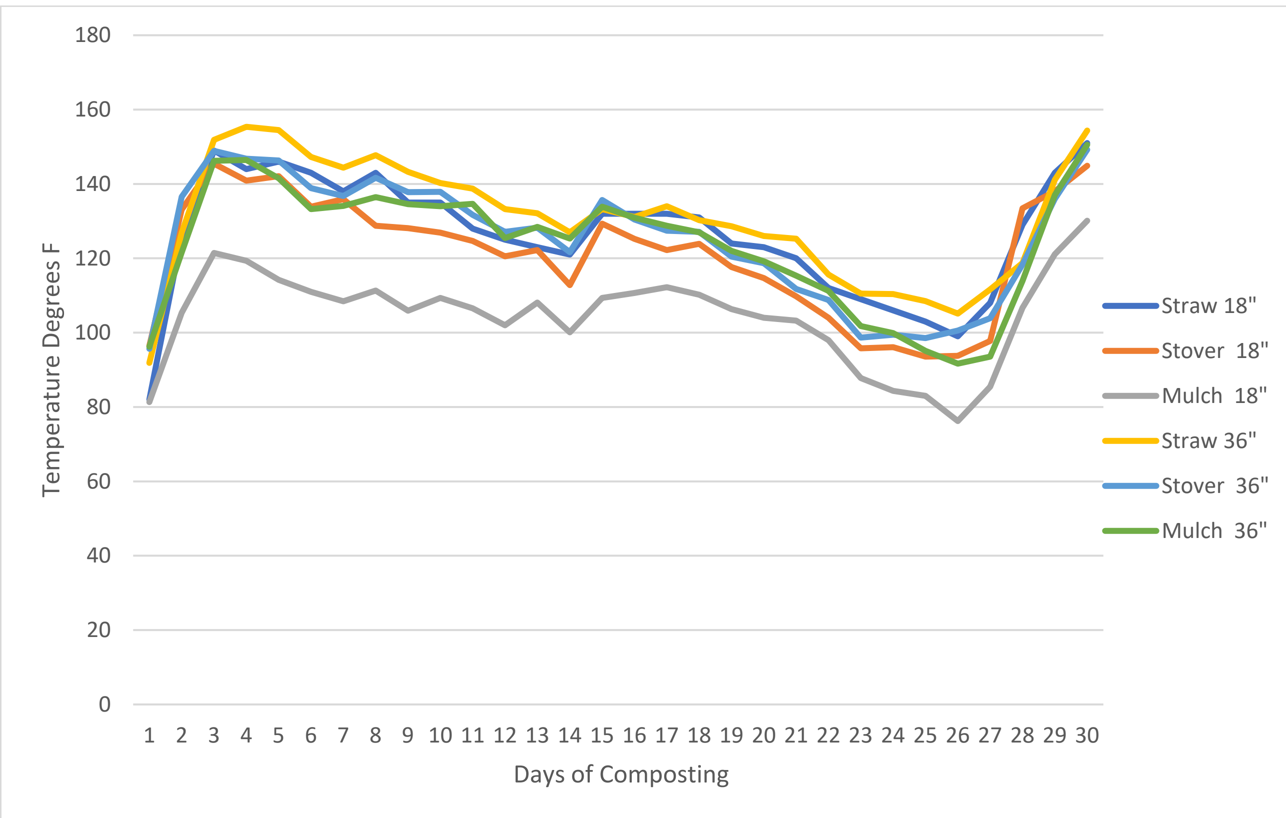
No capping was required for either the compost turner or particle reduction windrows. This reduced the carbon requirement by approximately 25% from a loader-turned system. Prior work (unpublished data) has shown that the carbon base depth can be reduced when carcasses are ground prior to adding them to the windrow. However, because the carcasses were added whole in this scenario, there was no reduction in the carbon base material. The overall amount of carbon saved was not measured.

There was no observed difference in performance with the carcasses randomly oriented on the windrows (Figure 3) as determined by temperature performance and degradation scoring. The degradation scores (Table 1) indicate that without mechanical manipulation, there was little additional decomposition after Day 14. The researchers recommend ensuring that the compost feedstock has proper moisture and energy prior to windrow construction. This will accelerate the decomposition process.

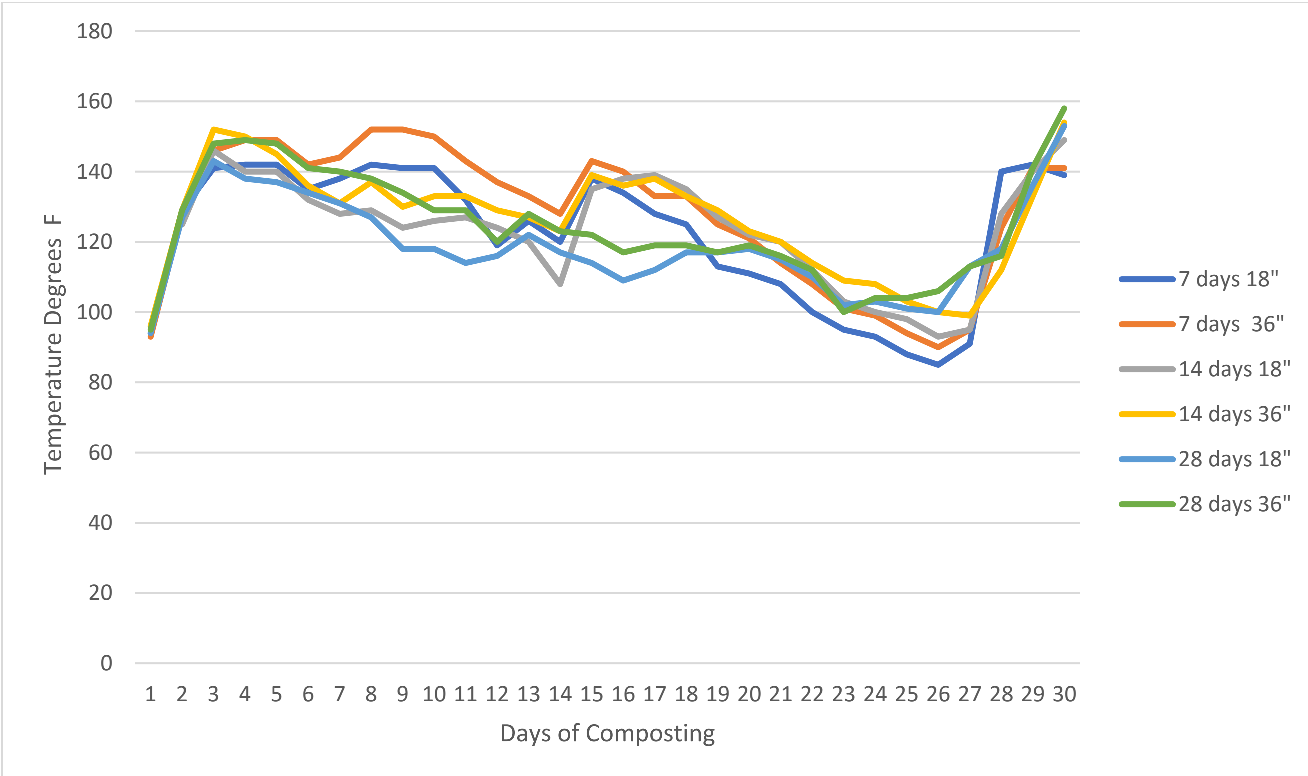
Turning a swine carcass windrow at 7 days would be an acceptable practice for routine carcass management. Research on African Swine Fever virus (ASFv) inactivation in compost demonstrated that the virus is inactivated in 3-7 days (Gabbert et al., 2023, Hutchinson et al., 2023). Therefore, the risk of viral transmission from windrows turned at 7 days is minimal. However, a conservative recommendation would be to turn at 10 days, with an additional 10 days of static composting. At the end of the 20-day cycle, the material could be relocated and cured. This timeframe is significantly less than current USDA livestock protocols, which call for turning static piles at 6-12 weeks. The accelerated timeframe decreases the loss of production time with minimal risk. With particle reduction, the compost disease inactivation process could be completed in 14-21 days.

Windrow Number	Pre-Mechanical Manipulation (Day 14)	Post-Manipulation (Day 14)	Final (Day 28)
1. Ground at 14 days	2.1	5	5
2: Static for 28 days	2.2	NA	2.3
3. Compost Turner at 14 days	2.0	4	4.5
N=	5	5	3

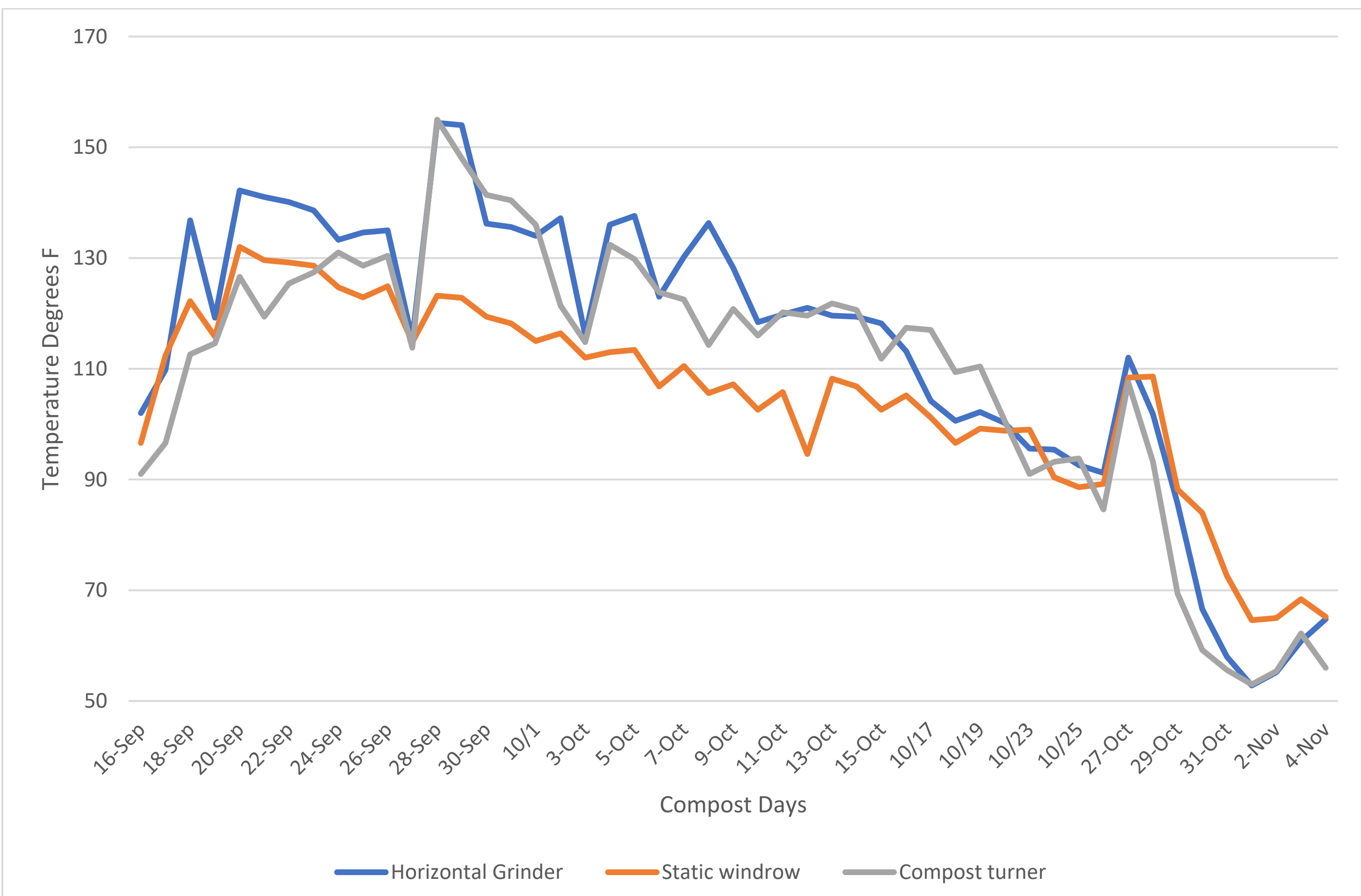
Table 1. Carcass Degradation Scores Averages.



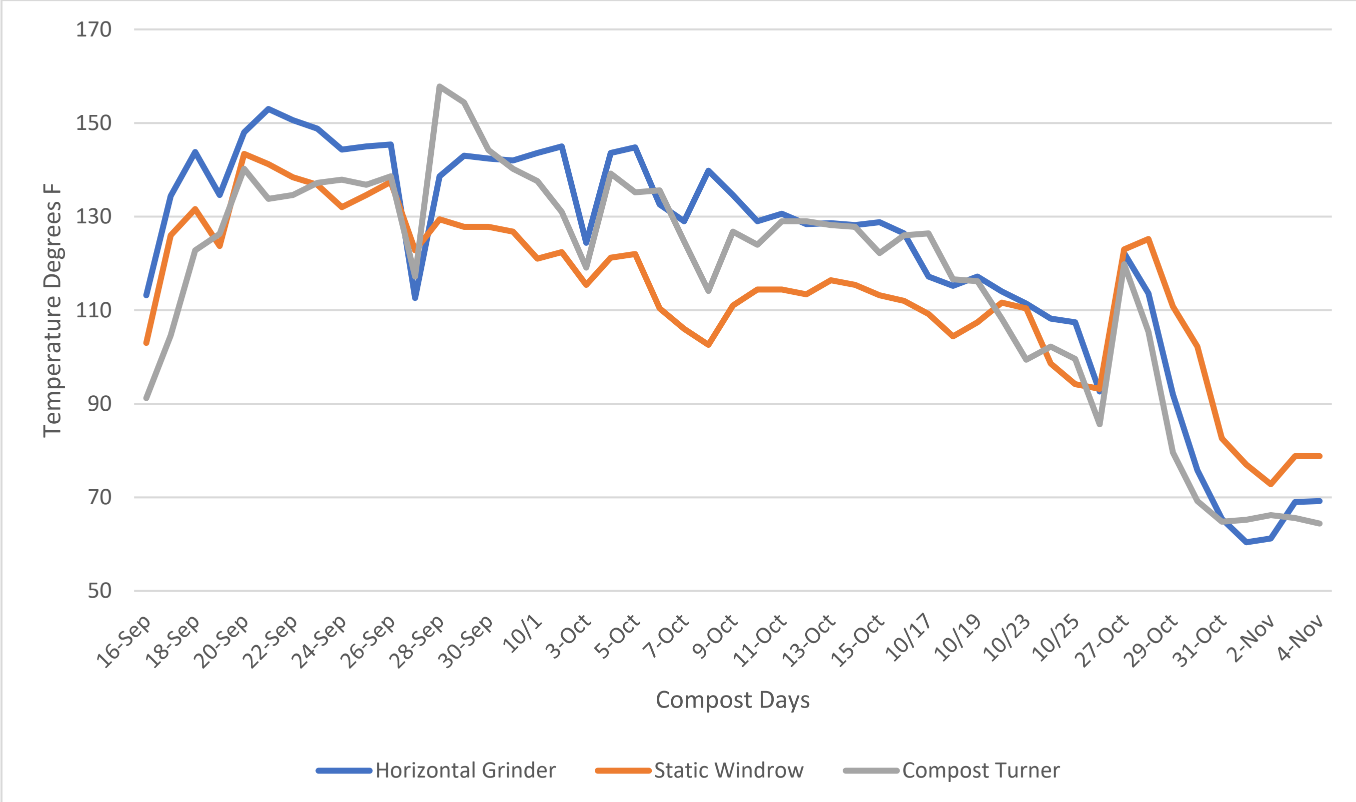
Graph 1. Compost Pile Average Temperature Profile by Core Material



Graph 2. Compost Pile Average Temperature Profile by Turning Date



Graph 3. Windrow Temperature Profile for Precondition 18”



Graph 4. Windrow Temperature Profile for Precondition 36”

Figure 1. Bones Fragmented by Compost Turner

Figure 2. Bones after 7 Days of Composting

Figure 3: Placement of Carcasses on Windrow

Appendix 1:

Iowa Department of Natural Resources Waiver Request

WAIVER REQUEST NOTIFICATION
Iowa Department of Natural Resources

All Fields are Required

1.	Reviewer/Engr.:	Theresa Stiner	7.	Decision:	Approved
2.	Date Received:	March 20. 2023		Date:	March 23, 2023
3.	Facility Name:	Robert William Thorpe			
4.	Program Area:	Solid Waste			
5.	Subject Area:	Compost			
6.	Rule Reference:	IAC 567-105.6			

8. Description of Waiver Request: Summarize (250 characters)

The National Pork Board in collaboration with Gary A Flory Consulting and Black Bear Agricultural Services (Mark Hutchinson) is requesting a waiver to conduct a proof of concept project for swine carcass composting without a compost facility permit.

9. Department's Justification: Summarize (250 characters)

In lieu of obtaining a compost facility permit, the applicant will comply with IAC 567-105.3 and 567-105.6. This proof of concept will provide important information for managing carcasses in the event of a foreign animal disease outbreak.

10. Type name:

Digitally signed by Michael Sullivan
Date: 2023.03.23 11:37:26 -05'00'

Supervisor/Bureau Chief/DA | Date

*The original, approvals, letters, code and other supporting documentation is to be maintained by the program in accordance with the Records Retention Schedule.

To Submit: Attach this form to an email and send it to Webmaster@dnr.iowa.gov with the subject line: Waiver Submittal (542-0541) within 14 business days of issuance.

Appendix 2:

Equipment Specifications:

- Backhus 21:55 Self-propelled Compost Turner:
- Horizontal belt grinder to simultaneously grind carcasses and mix ground tissues with mulch
    - Vermeer® Model HG6800TX
    - 950 hp
    - Track-driven, self-propelled, radio remotely controlled
    - Equipped with Vermeer® SmartGrind system "which automatically controls grinding speed based on engine rpm levels"
    - Heavy duty infeed system
        - Table 60 inches wide, 19 feet long, and 6 feet above the ground
        - Welded slat chain conveyor
        - Infeed conveyor was operated at 70% of the manufacturers speed
    - Feed opening 38 inches high and 56.4 inches wide
    - Drum was operated at 60% of the 1200 rpm manufacturer's speed
    - Two screens, upper and lower, each with 7" square openings
    - Discharge conveyor 60 inches wide and 19 feet long
        - Discharge conveyor was operated at about 60% of the manufacturers speed of 877 ft/min
    - Custom drop curtain chute
- Excavator to load carcasses onto grinder infeed conveyor, lay windrow base, shape windrows, maintain carcass staging area
    - Hyundai® Model 330HX
    - 275 hp
    - Track-driven
    - Equipped with a root rake (Teran, Miami, FL) and hydraulic thumb attachment (Werk-Brau Co., Inc., Findlay, OH)
- Loader with 2 yd^3 bucket to load mulch onto grinder infeed conveyor
    - Ensign YX638
    - 160 hp
- Loader with 10 yd^3 bucket to receive the tissue-mulch mixture as discharged from the grinder, move it, and place it into compost windrows (Photo 3)
    - Volvo® Model L150E
    - 295 hp
    - 60,000 lb. payload

Appendix 3:

Carcass Decomposition Scoring Criteria

Windrow Number Pre	**Carcass Decomposition Score**				
	1	**2**	**3**	**4**	**5**
Sample 1					
Sample 2					
Sample 3					
Sample 4					
Sample 5					
Windrow Number Post					
Sample 1					
Sample 2					
Sample 3					
Sample 4					
Sample 5					
Windrow Number Pre					
Sample 1					
Sample 2					
Sample 3					
Sample 4					
Sample 5					
Windrow Number Post					
Sample 1					
Sample 2					
Sample 3					
Sample 4					
Sample 5					
Windrow Number Pre					
Sample 1					
Sample 2					
Sample 3					
Sample 4					
Sample 5					
Windrow Number Post					
Sample 1					
Sample 2					
Sample 3					
Sample 4					
Sample 5					

Score	Criteria
1	Large amounts of flesh, hide and hair present. Internal fluid still visible. Carcass still discernible.
2	Flesh, hide and hair still present in smaller amounts. Carcass no longer discernible. No internal fluid visible.
3	Slight amounts of hair and hide present. Numerous large and small bones present.
4	No hide present. Minimal hair visible. Flesh completely degraded and only large bones present.
5	No flesh, hide, or hair present. Few to no large brittle bones present.

Acknowledgments:

We would like to recognize and thank the contributions made by many to the success of the project. It is with appreciation we recognize:

Billy Thorpe, Sarah Thorpe, William Thorpe, Paul Thorpe, Bill Thorpe, Alissa Puffett, Keith Warren, Roger Pressley, Kaitlyn Cain, Marguerite Tan, Parks of Iowa (Levi Rupe), and National Pork Board Summer Interns.

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Gabbert, L., Marignette, L., Zurita, M., Barrera, J., Neian, J. Evaluation of Whole Carcass Composting as a Mortality Disposal Option for African Swine Fever Virus-Infected Swine Volume 2023 | Article ID 9926250 | https://doi.org/10.1155/2023/9926250

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