FORCE YEAR 8-10

PRE-CONSUMER FOOD WASTE COMPOSTING DEMONSTRATION PROJECT

FINAL REPORT

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FINAL REPORT

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SECTION 1.0
INTRODUCTION

Background and Purpose

In 2010, the Florida Department of Environmental Protection (FDEP) adopted revised regulations for composting facilities. One of the major new aspects of the revised Chapter 62-709, F.A.C. is that it enables registered organic recycling facilities to compost source-separated food materials, yard trash and manure provided that they comply with the design and operating requirements detailed in the rules. The requirements for registered facilities are less stringent that those for permitted organic recycling facilities that handle mixed waste. These revisions to Chapter 62-709, F.A.C. represent a significant opportunity to increase organics recycling in Florida, and thereby help local government boost recycling rates while increasing compost production which in turn can benefit Florida's soil and water quality.

This research and demonstration project (Project) was designed to serve as a model for what can be accomplished under the revisions to Chapter 62-709 F.A.C. The purpose was to (a) demonstrate proper design and operational procedures for composting source-separated food material; (b) evaluate operations, economics, environmental parameters, and compost quality; and (c) share project results with the Florida composting community. In addition, the Project served double duty as a demonstration site for the Compost Education and Training component of the FORCE project.

The Project's specific focus was to incorporate source-separated pre-consumer food scraps from supermarkets into a registered County yard trash operation. There are several benefits of combining food waste and yard trash together in a composting operation. Most importantly, food waste tends to be rich in moisture and nitrogen, while yard trash naturally provides structural porosity and a source of carbon. The simplicity and cost-effectiveness of using these two materials made them excellent feedstocks for composting.

Supermarkets are a major source of pre-consumer vegetative food waste. At the time this project was conducted, there were approximately 270 registered yard trash facilities in Florida, which represents a major un-tapped opportunity for composting source-separated food material under the revised regulations. This Project was designed to help encourage more composting of supermarket food waste in Florida by demonstrating proper design and operations; and evaluating operations, economics, environmental parameters, and compost quality.

Project Overview

The Project involved the following activities:

- Development of a detailed Operating Plan
- Development of a Sampling and Analysis Plan
- Pilot scale composting of source-separated pre-consumer vegetative food waste (PCVW) and yard trash (YT)
- Testing of two different low-technology composting methods
- Testing of two different YT / PCVW mix ratios
- Assessment of potential environmental impacts (leachate and odor) during active composting
- Laboratory analysis of materials during various stages of the composting process
- Assessment of operational requirements (site and facility, equipment and labor, and materials handling)
- Cost / benefit assessment

Throughout the Project, materials handling and composting activities were closely monitored, and data regarding operational procedures, best practices, feedstock and compost quality, and economics were gathered. The information obtained, and the operation itself, demonstrate and help to promote efficient and environmentally-sound composting.

The Polk County Department of Waste Resources provided the site, equipment and personnel to conduct the composting pilot. The Project was established at the County's existing yard trash processing site at the Waste Resource Management North Central Landfill. Polk County operates an integrated facility that includes recycling, yard trash processing, Class I landfill, C&D debris landfill, and other activities. Currently the County processes yard trash to produce mulch that is used for erosion control and cover materials in its landfill operations. The County is considering various opportunities to compost organic waste instead of placing it in the landfill and as a possible expansion of its yard waste operation to help meet the 75% recycling goal.

Publix Supermarkets, Inc., Florida's largest food retailer, provided the source-separated pre-consumer food waste from stores located in Polk County. Publix is actively investigating and implementing recycling programs for its network of retail locations in Florida and the Southeast U.S. PCVW for the Project was source-separated by Publix at three supermarkets located in Polk County. The PCVW was collected by Republic Services of Florida and delivered to the Project site.

Simple low-cost methods were used, specifically outdoor unaerated windrows turned with a front-end loader. Two different mix ratios were evaluated (3:1 versus 2:1 YT:PCVW) as well as two different turning methods (standard turning to meet FDEP disinfection standards versus minimal turning).

Acknowledgements

This Project was coordinated and conducted by Kessler Consulting, Inc. (KCI) on behalf of Sumter County and Florida Organics Center for Excellence (FORCE). KCI wishes to recognize and thank the following parties for their generous contributions to the Project.

- The Waste Resource Management North Central Landfill site in Polk County provided numerous services: the site, YT, equipment and personnel necessary to conduct and monitor the Project.
- Publix Supermarkets provided the food waste material as well as the manpower to separate and collect it, a key component of the Project.
- Republic Services of Florida provided the pickup and transportation of the food waste material from the Publix stores to the compost site.
- Peninsula Equipment provided the use of their 26-foot trommel unit, used to screen the windrows into finished, marketable high-quality compost product.
- Doppstadt US, the manufacturer of the trommel unit, provided on-site technical and operational support throughout the screening event.

SECTION 2.0
METHODOLOGY & RESULTS

Feedstocks and Regulatory Compliance

Feedstocks used in this demonstration project conformed to the definitions in the newly revised 62-709 F.A.C. Criteria for Organics Processing and Recycling Facilities.

Food waste collected from Publix was pre-consumer vegetative waste (PCVW), which means:

> source-separated vegetative solid waste from commercial, institutional, industrial or agricultural operations that is not considered yard trash, and has not come in contact with animal products or byproducts or with the end user. This term includes material generated by grocery stores, packing houses, and canning operations, as well as products that have been removed from their packaging, such as out-of-date juice, vegetables, condiments, and bread. This term also includes associated packaging that is vegetative in origin such as paper or corn-starch based products, but does not include packaging that has come in contact with other materials such as meat. Plate scrapings are specifically excluded from this definition. 62-709.200(17)

The yard trash (YT) handled at the Polk County facility conforms to the regulatory definition of "vegetative matter resulting from landscaping maintenance and land clearing operations and includes materials such as tree and shrub trimmings, grass clippings, palm fronds, trees and tree stumps, and associated rocks and soil. For the purpose of this chapter, it also includes clean wood." 62-709.200(13) The Project required that the County update its FDEP facility registration to include PCVW.

Composting Methods and Mix Ratios

The Operating Plan called for the evaluation of two different methods for composting YT and PCVW using two mix recipes for each method. The two composting methods were:

- Turned Windrow (TW): turned by bucket loader meeting FDEP process control for disinfection (15 consecutive days at 55ºC [131ºF] with 5 turnings).[1]

[1] Chapter 62-709 regulations recently increased from 4 turnings to 5 in compliance with federal PFRP standards.

- Modified Static Pile (MSP): turned by bucket loader twice during active composting on days 15 and 31.

These methods generally produce high quality finished product, while offering the most economically-sound means to control the composting process. Method 1 is the most common composting method utilized for YT. Method 2 is designed to utilize the heat within the windrow to draw in fresh air around the base as it moves upward and outward, effectively aerating the windrow with fewer turnings. This has the potential to reduce operational costs.

The Project also examined two different mix ratios of YT and PCVW.

- Mix 1 (3:1): contained 3 parts YT and 1 part PCVW (3:1) on a volumetric basis
- Mix 2 (2:1): contained 2 parts YT and 1 part PCVW (2:1) volumetrically

The composting process is predominantly influenced by three components: moisture content, carbon-to-nitrogen (C:N) ratio, and porosity. PCVW tends to be high in moisture; the opposite is true for YT, which adds structure to the pile while increasing air flow. In addition, PCVW is rich in nitrogen, while YT provides carbon. Optimal conditions for composting are generally as follows:

- Moisture content: 40% – 60%
- C:N ratio: 20:1 – 40:1
- Porosity: 600 – 800 pounds per cubic yard

Based on literature, KCI anticipated the following feedstock characteristics:

- PCVW:
  - Density in the range of 1,000 to 1,500 pounds per cubic yard
  - Moisture content in the range of 70% to 90% on a weight basis
  - C:N ratio in the range of 15:1 to 20:1
- YT:
  - Density in the range of 400 to 600 pounds per cubic yard
  - Moisture content in the range of 25% to 40% on a weight basis
  - C:N ratio in the range of 40:1 to 60:1

Using these data, KCI planned mix recipes to achieve optimal conditions for composting as summarized in Table 1.

In summary, the Project conducted four separate tests as summarized in Table 1.

Table 1: Four Project Windrows

	Compost Method	**Mix Ratio**
TW 3:1	Turned Windrow	3:1
TW 2:1	Turned Windrow	2:1
MSP 3:1	Modified Static Pile	3:1
MSP 2:1	Modified Static Pile	2:1

One windrow was constructed for each test. The variations in windrow design were intended to address the following research questions:

- The 2:1 mix ratio would have higher moisture content, greater bulk density and lower C:N ratio. The question was whether anaerobic conditions and odor problems would be encountered.
- With the 3:1 mix ratio, there was the question whether the PCVW would provide sufficient initial moisture for optimal composting conditions and provide nitrogen sufficient to accelerate the composting process.
- MSP is not widely practiced in the composting industry and the question was whether it would meet pathogen reduction standards for disinfection.
- Using MSP, there was the question whether fewer turnings would lead to anaerobic conditions and odor problems.

Materials Collection, Receiving and Mixing

Publix implemented PCVW source-separation and collection at three locations in Polk County. The company has significant prior experience with food waste recycling, and Publix personnel oversaw the implementation, training, and oversight of in-store separation and collection procedures. Based on its prior experience, Publix calculated the number of collection rollcarts required for each store. PCVW was collected from the three areas in the stores: Produce, Deli, and Bakery. As part of its agreement to participate in the Project, Publix did not allow KCI or the County to participate in the implementation or monitoring of in-store collection.

Polk County provided 35-gallon rollcarts to Publix for collection of PCVW. Republic Services of Florida – the County's franchised waste collection company – collected PCVW from the

Publix locations three times weekly on Monday, Wednesday and Friday, and delivered it to the Project site. The Operations Plan called for building one windrow each week, i.e. consolidating the mixed materials from three collection events into a single windrow. Thus, PCVW source-separation and collection occurred for four weeks. Republic Services provided cart counts and weight information. Table 2 provides a summary of this information. Detailed data can be found in Appendix A.

Table 2: Summary of PCVW Collection Data

	Carts Collected	Net Weight (lbs.)	Average Weight per Cart (lbs.)
Week 1 (10/25-10/29)	46	4,020	87.4
Week 2 (11/1 – 11/5)	77	6,240	81.0
Week 3 (11/8 – 11/12)	73	5,180	71.0
Week 4 (11/15 – 11/19)	72	5,600	77.8

KCI oversaw and assisted the County with receiving, mixing and windrow construction activities. PCVW was received and mixed with YT on a concrete road surface at the registered YT site. A pad of YT was laid down on the road prior to PCVW delivery to aid in the mixing process. A small berm was constructed around the sides of the YT pad to contain PCVW and any free liquids within the mix pile. PCVW was then discharged onto the YT pad. Next, more yard waste was mixed with the PCVW in order to attain the correct mix ratio.

During the first phase of material receiving, KCI made the decision to construct the first windrow using a 3:1 ratio of YT:PCVW, due to small amount of incoming PCVW. After the first windrow was constructed, the next three were built alternating between ratios of 2:1 and 3:1. To simplify operations for Polk County staff, the first two piles were designated for Turned Windrow composting, leaving the latter two to be composted using the Modified Static Pile method. The photos below depict the receiving and mixing process. The schedule for completing construction of each windrow was as follows:

- TW 3:1 – windrow construction completed on October 29, 2010
- TW 2:1 – windrow construction completed on November 5, 2010
- MSP 3:1 – windrow construction completed on November 12, 2010
- MSP 2:1 – windrow construction completed on November 19, 2010

Food waste discharged onto bed of yard trash.

Food waste held in place by yard trash berm.

Mixing on road surface.

Raw mixture of food waste and yard trash.

Windrow Construction

The four Project windrows were constructed at the County's registered facility. Under direction from KCI staff, County equipment operators took special care to avoid compaction of the materials, maximizing porosity and aeration. When construction was complete, each windrow was capped with a layer of aged YT to suppress odors and hide visible PCVW. This practice can help to prevent the attraction of vectors (birds, rodents, and flies). As summarized in Table 3, it is estimated that the Project composted a total of 100 cubic yards of materials.

Table 3: Windrow Dimensions and Volume – Start of Active Composting

	Units	TW 3:1	TW 2:1	MSP 3:1	MSP 2:1
Base Width	*feet*	12	12	12	12
Top Width	*feet*	1	1	1	1
Height	*feet*	5	5	5	5
Length	*feet*	16	24	23	20
Volume	*cubic yards*	19	29	28	24

Note: measurements and volumes are approximate

KCI collected composite samples from each windrow on the day of construction and shipped them for off-site lab analysis. Samples were sent to Midwest Laboratories in Omaha, Nebraska, which specializes in analytical services for the composting industry.

Table 4 summarizes the analyses performed on the raw mixture by Midwest. Variations in sample results are to be expected due to the heterogeneous nature of the mixture. Detailed lab results are provided in Appendix B.

Table 4: Summary of Lab Analyses – Raw Mixture Prior to Composting

Analysis Parameter	Units	TW 3:1	TW 2:1	MSP 3:1	MSP 2:1
Density	Lb/cy	489	876	725	902
Moisture	%	63	60	56	72
pH	pH Units	5.4	5.0	5.1	5.4
C:N Ratio	x:1	28	32	21	29
Fecal Coliform	mpn/g	164,671	66,127	106,021	9,147
Man-made Materials	%	n.d.	n.d.	n.d.	n.d.

Note: these data are for the raw mixture of food waste and yard trash prior to composting.
n.d. = not detected.

The photos on the next page depict windrow construction.

Addition of water during construction phase.

Ground is readied to accept new windrow.

Berm is created to contain material in designated area.

Finished piles are capped with aged YT.

Density: The density of the samples averaged 607 lbs/cy for the 3:1 mixtures and 826 lbs/cy for the 2:1 mixtures.

Moisture & C:N Ratio: Lab analyses verified that the raw mixture met proper conditions for composting:

- 3:1 mix average = 60% moisture and 25:1 C:N ratio
- 2:1 mix average = 66% moisture and 31:1 C:N ratio

pH: The raw mixtures were acidic (pH 5.0 to 5.4), typical of this type of feedstock blend.

Pathogens: Midwest Labs' pathogen analysis of the raw mixture found fecal coliform in levels ranging from 9,147 to 164,761 MPN/g. The PCVW, based on its origin and frequent collection, would be expected to be free of pathogens. However, upon collection the material was transferred into a garbage truck for transportation and delivery. It is highly possible the truck body contained residues from previous loads of municipal or commercial wastes, which caused contamination. YT can also contain numbers of fecal coliform positive organisms that are usually of environmental, rather than fecal, origin. Several studies have shown that some soil *E. coli* and some *Klebsiella* found indigenous in wood products can test elevated temperature fecal coliform positive and not be organisms of fecal origin.[2]

Man-made Materials: No man-made materials such as plastic, glass, or metal were detected in any of the samples.

Active Composting

The four test windrows remained in active composting for approximately 60 days. County and KCI staff worked collaboratively throughout the composting phase of the Project. Each day Polk County staff recorded temperatures at three points in each pile, and at two depths – one foot and three feet. When necessary, an on-site front-end loader was used to turn the windrows in accordance with the two protocols. KCI staff was on site each week to assist with monitoring, review temperature records, and provide instructions to County staff for managing the composting process (e.g. turning windrows, adding water, re-shaping windrows, etc.).

- *Turned Windrow Trials:* These two windrows were managed to meet the FDEP regulatory procedures for time, temperature and turning for unaerated windrow composting: 15 consecutive days at 55ºC (131ºF) with 5 turnings. The turning schedule was determined by KCI based on the windrow temperature data. Once that was achieved the windrows were not turned for the remainder of active composting.
- *Modified Static Pile Trials:* These two windrows were turned only twice during active composting on days 15 and 31.

Both TWs sustained temperatures above 131ºF for well over two weeks and easily met regulatory time-temperature-turning requirements (see Figures 1 and 2). The two MSP windrows also sustained temperatures well above 131ºF for most of the 60 day active

[2] City of Fort Collins Pollution Control Library, *Fecal Coliform Testing in Biosolids*, 2004, 6

composting phase (See Figure 3 and 4). KCI anticipated sustained high temperatures due the readily available carbon present in the YT which continued to fuel thermophilic microorganisms. Cold ambient temperatures had varying degrees of influence on each of the windrows. On December 28th and 29th ambient temperatures fell to 28˚F and 24˚F respectively, which caused the temperatures in the MSP 2:1 windrow (Figure 4) to fall considerably. Windrow turning events, additional cold spells, and a couple of periods of heavy rainfall, also caused temperatures to fluctuate. Again, each pile reacted differently depending on mix ratios and rate of decomposition (stage of composting). Limited amounts of PCVW resulted in windrows that were a little smaller than ideal, particularly when utilizing a 2:1 mix ratio. The more material placed into a windrow, the better its insulating properties and ability to hold heat. Detailed monitoring logs for each windrow can be found in Appendix C.

Water Addition

Moisture content was maintained at approximately 46% - 60% during active composting. Proper moisture content was assessed weekly using the "squeeze" test employed commonly in the composting industry. As is typical for central Florida during the months the Project was conducted, very little rain fell during the active composting phase of the Project. As shown in Figures 1 through 4, water was added to the windrows when they were being turned. This was accomplished using a high-volume tanker vehicle operated by Polk County.

Water was added to TW 3:1 at the time of turns 1, 2, 3, 5, and 8. For TW 2:1, water was added in conjunction with turns 2, 5, and 8. The MSP windrows received their first watering after one month of active composting.

The TW method required significantly more water addition because the process of turning the windrows releases significant amounts of moisture causing the pile to dry out more rapidly than the MSP method. Windrow TW 3:1 required five additions and Windrow TW 2:1 required three additions in order to maintain acceptable moisture levels. Comparatively, Windrows MSP 3:1 and MSP 2:1 required just two additions and one addition, respectively.

Figure 1: Active Composting Monitoring Results – Turned Windrow 3:1 Mix Ratio

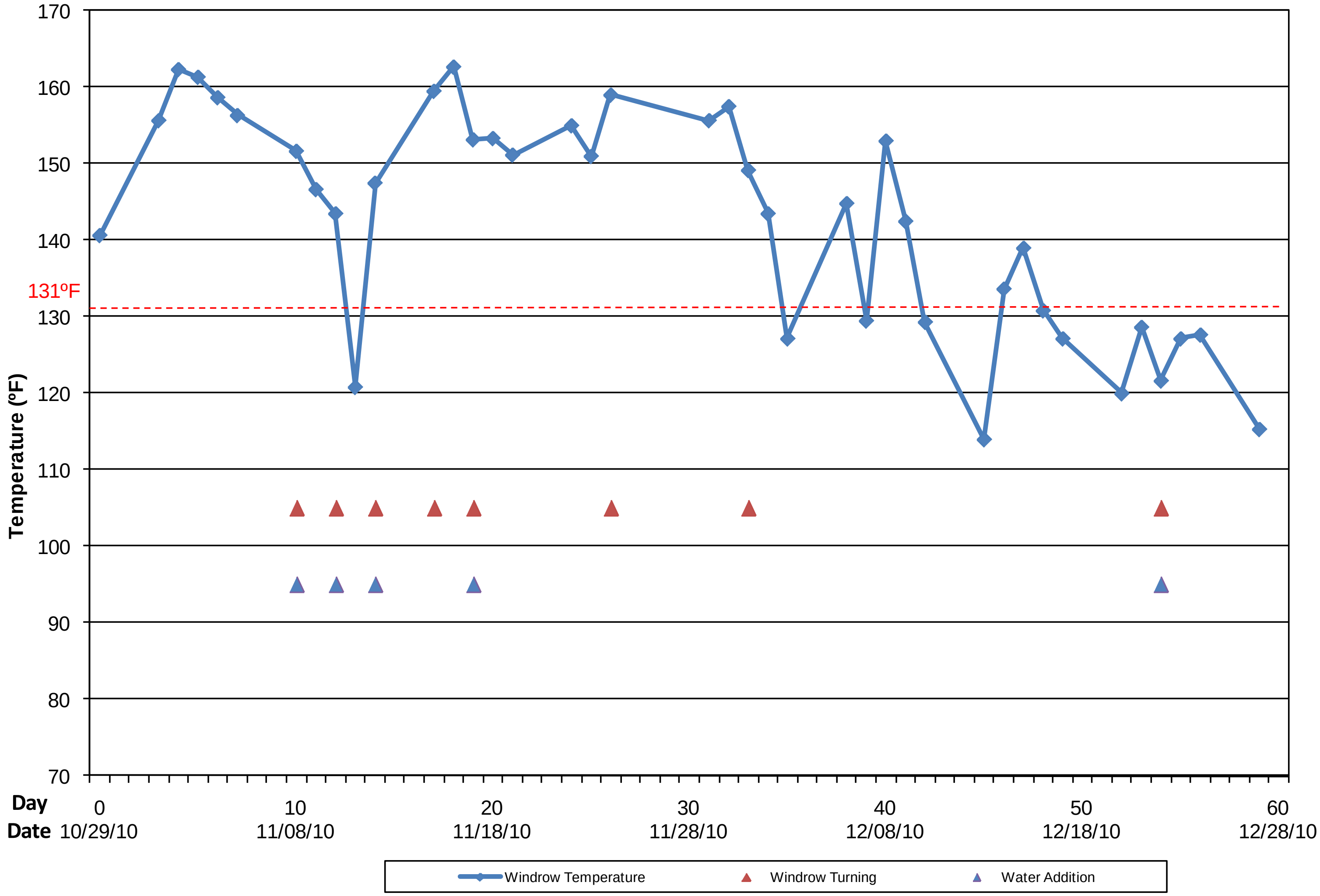


Figure 2: Active Composting Monitoring Results – Turned Windrow 2:1 Mix Ratio

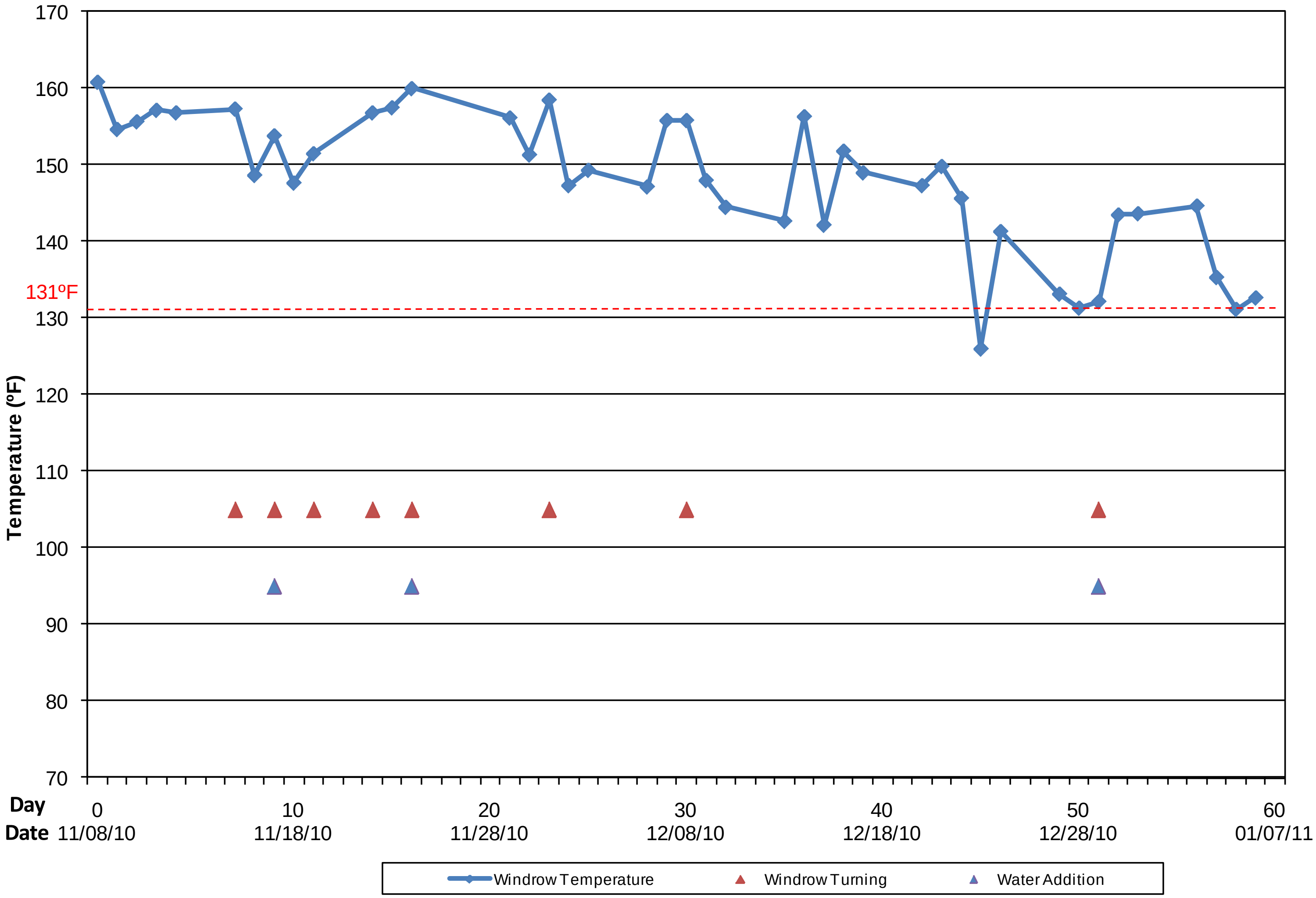


Figure 3: Active Composting Monitoring Results – Modified Static Pile 3:1 Mix Ratio

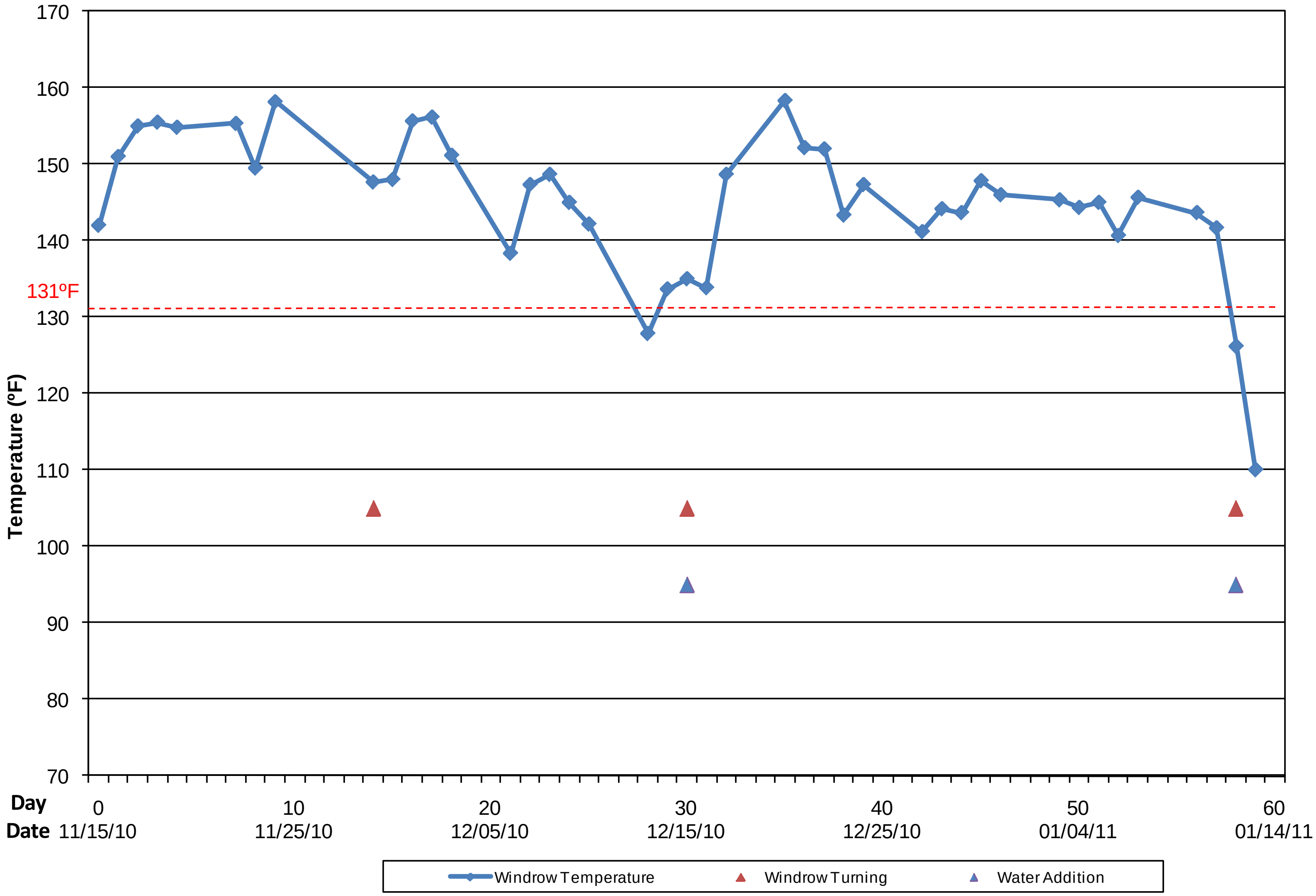
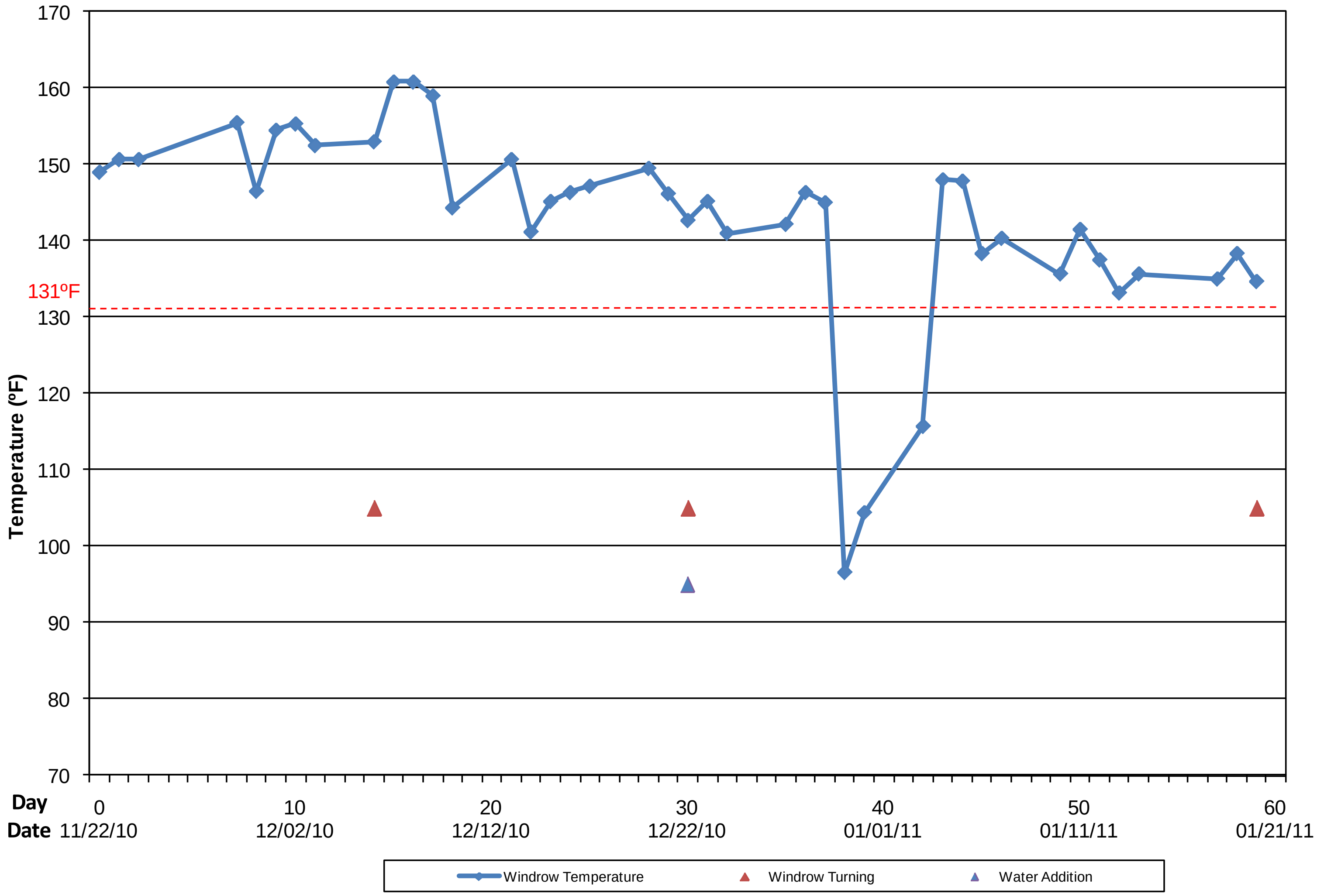


Figure 4: Active Composting Monitoring Results – Modified Static Pile 2:1 Mix Ratio



Leachate

Incoming PCVW contained very little in the way of free liquids and once mixed with YT required the addition of water to achieve the desired moisture content for efficient composting. High temperatures, coupled with good porosity, provided by the YT, ensured a suitable exchange of air and subsequent loss of water vapor. Limited pile size (height) resulted in no compaction issues. Oversized piles can often produce leachate due to compaction from the sheer weight of the material. At no point throughout the project was leachate observed.

Odor

Each time they visited the site, KCI staff qualitatively assessed the windrows' odor. A very slight, non-offensive fermentation/fruit like odor was noticeable on two occasions on the days immediately following windrow construction. This odor was emanating from the windrows with a 2:1 mix ratio. In addition, slightly offensive odors were noted during the initial two or three turnings of the TWs, but were not experienced otherwise. After the initial two weeks of active composting, odors were no longer detected, even during turnings.

Compost Curing

KCI worked collaboratively with Polk County during the compost curing phase of the Project. After 60 days of active composting, each windrow was thoroughly mixed; formed into a separate pile; and allowed to cure and mature for an additional period of time. The four windrows remained separate from each other throughout the curing phase.

KCI visited the composting site weekly to assess progress, review monitoring logs, equipment and labor utilization, and provide diagnostic assistance. The County was responsible for materials handling and operations, and assisted with temperature monitoring. Curing pile temperatures were monitored at three points in each pile. At each point, temperature was recorded at one and three feet deep.

Because the windrows were on a staggered schedule they cured for different lengths of time. Windrows, TW 3:1 and TW 2:1 remained in curing for 70 and 56 days, respectively. Windrows, MSP 3:1 and MSP 2:1 where allowed to cure for 53 and 46 days, respectively. The TWs were turned twice by bucket loader, while the MSP windrows were turned only once. Figures 5 through 8 depict curing temperature and turning data for the four windrows.

Figure 5: Compost Curing Monitoring Results – Turned Windrow 3:1 Mix Ratio

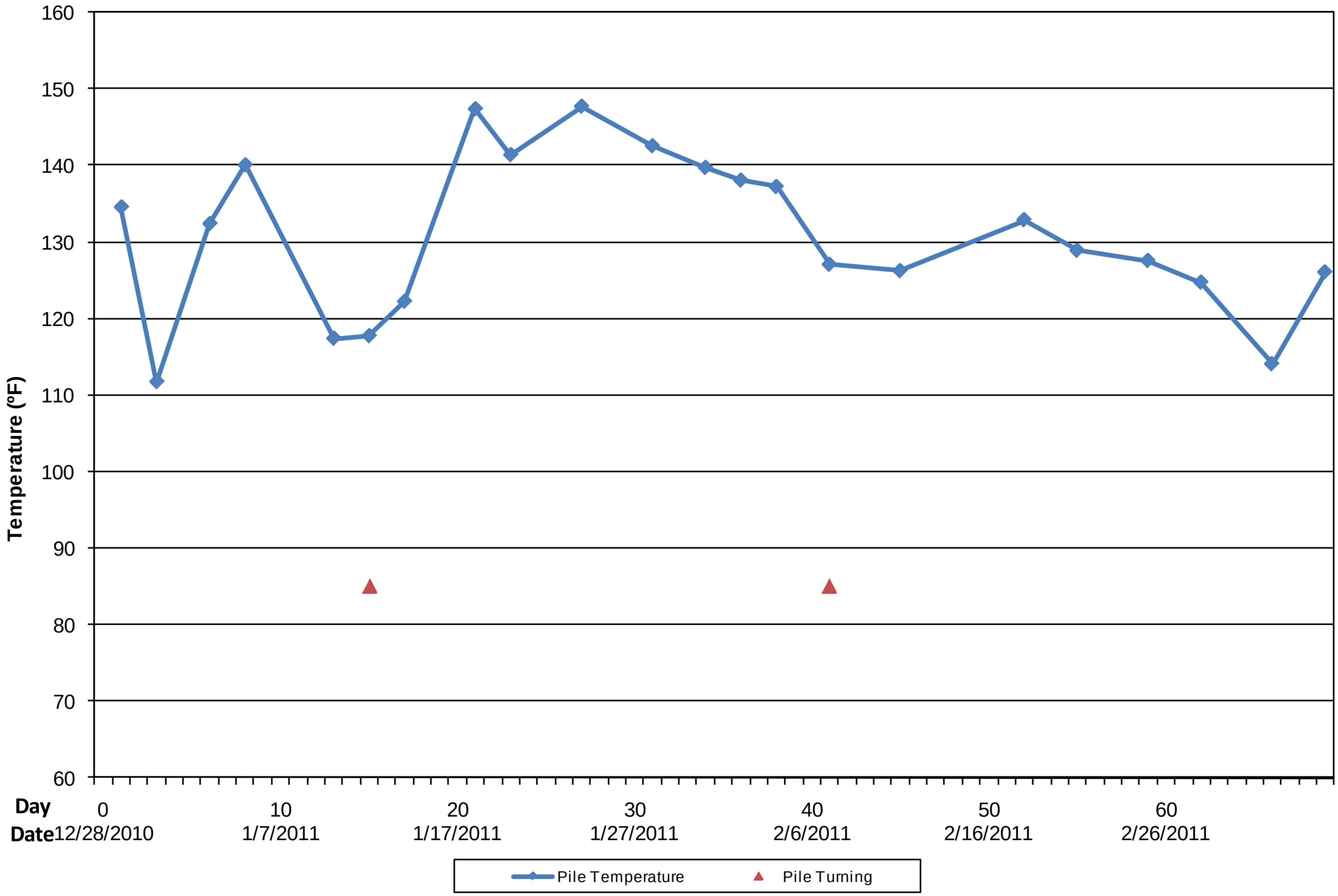


Figure 6: Compost Curing Monitoring Results – Turned Windrow 2:1 Mix Ratio

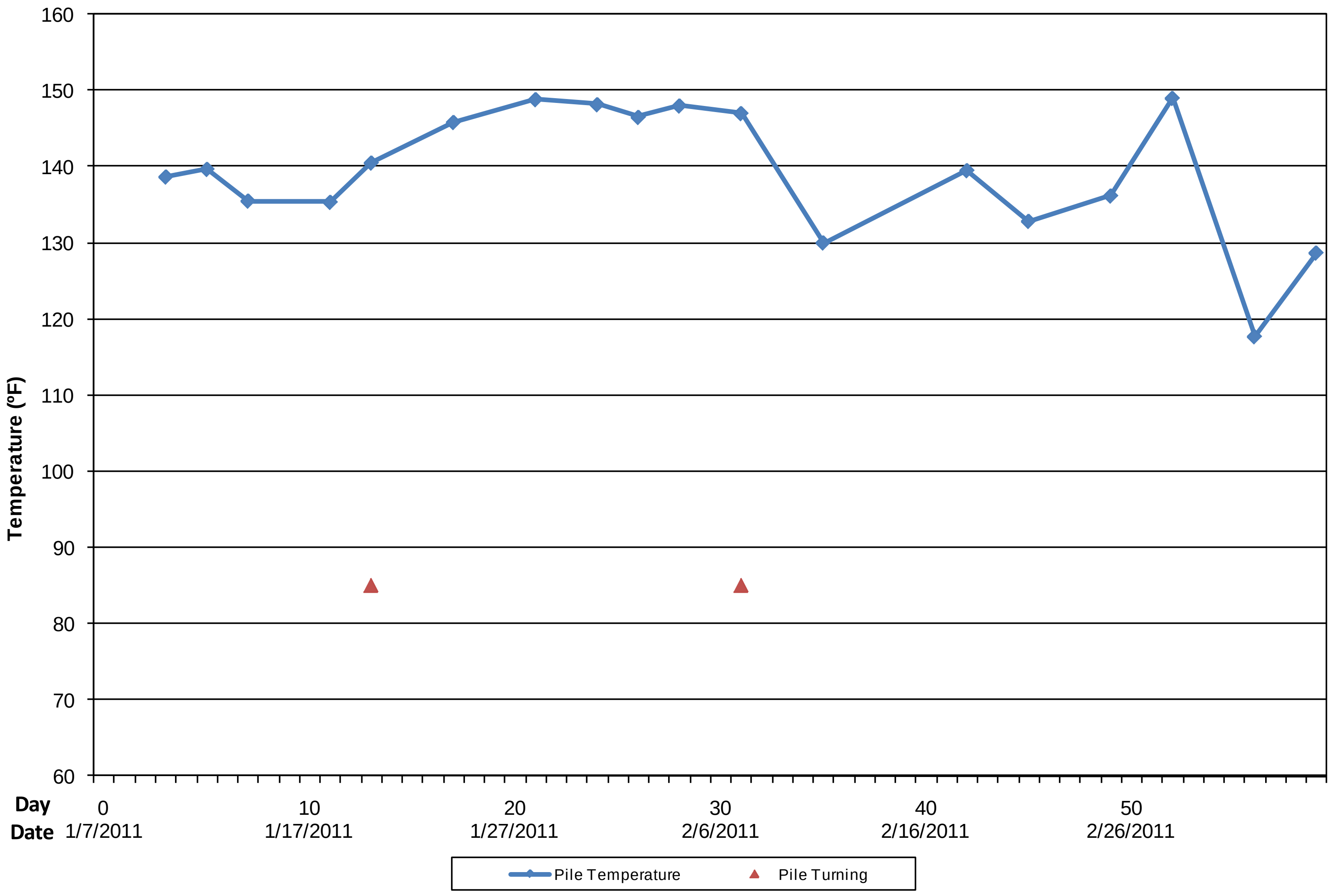


Figure 7: Compost Curing Monitoring Results – Modified Static Pile 3:1 Mix Ratio

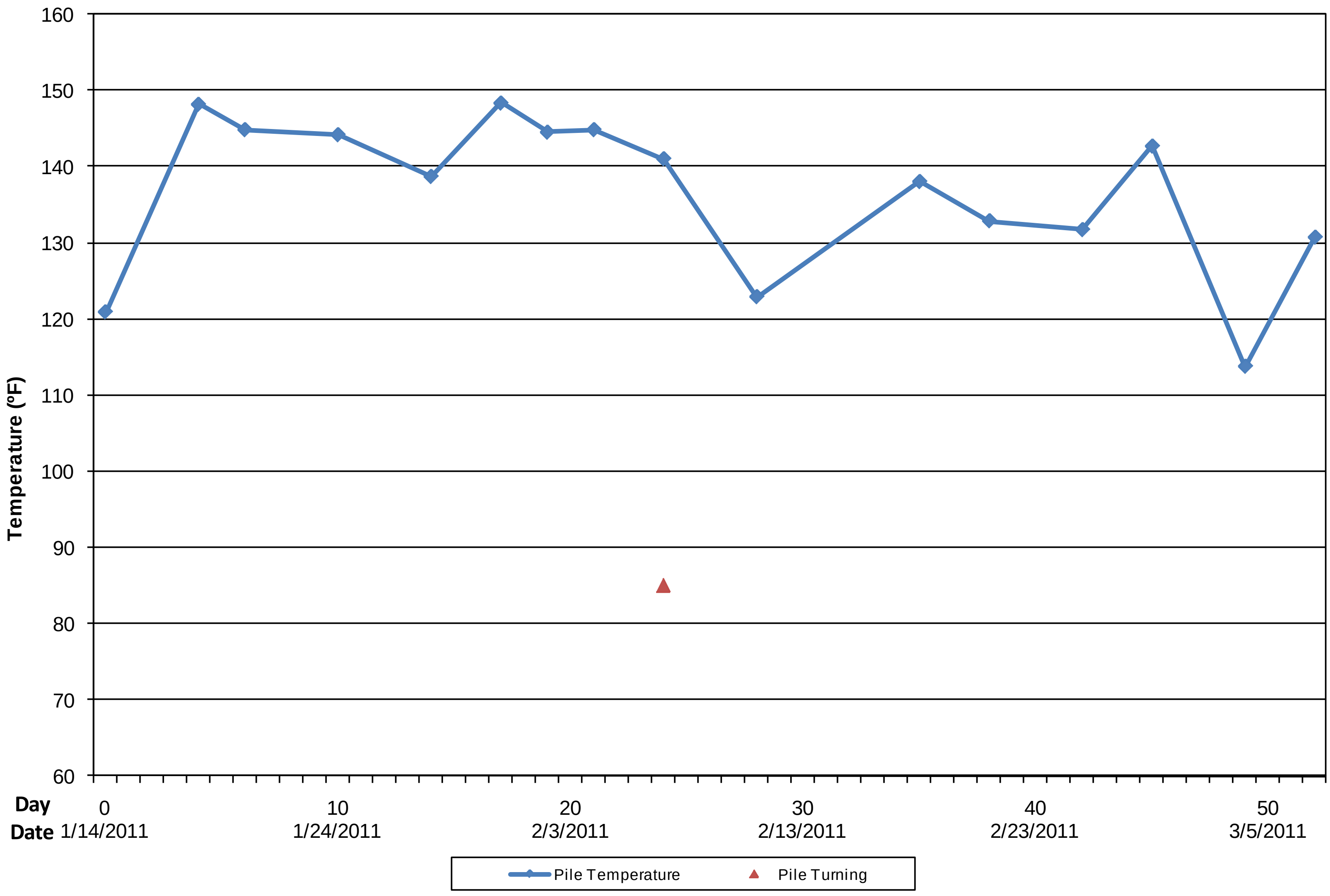
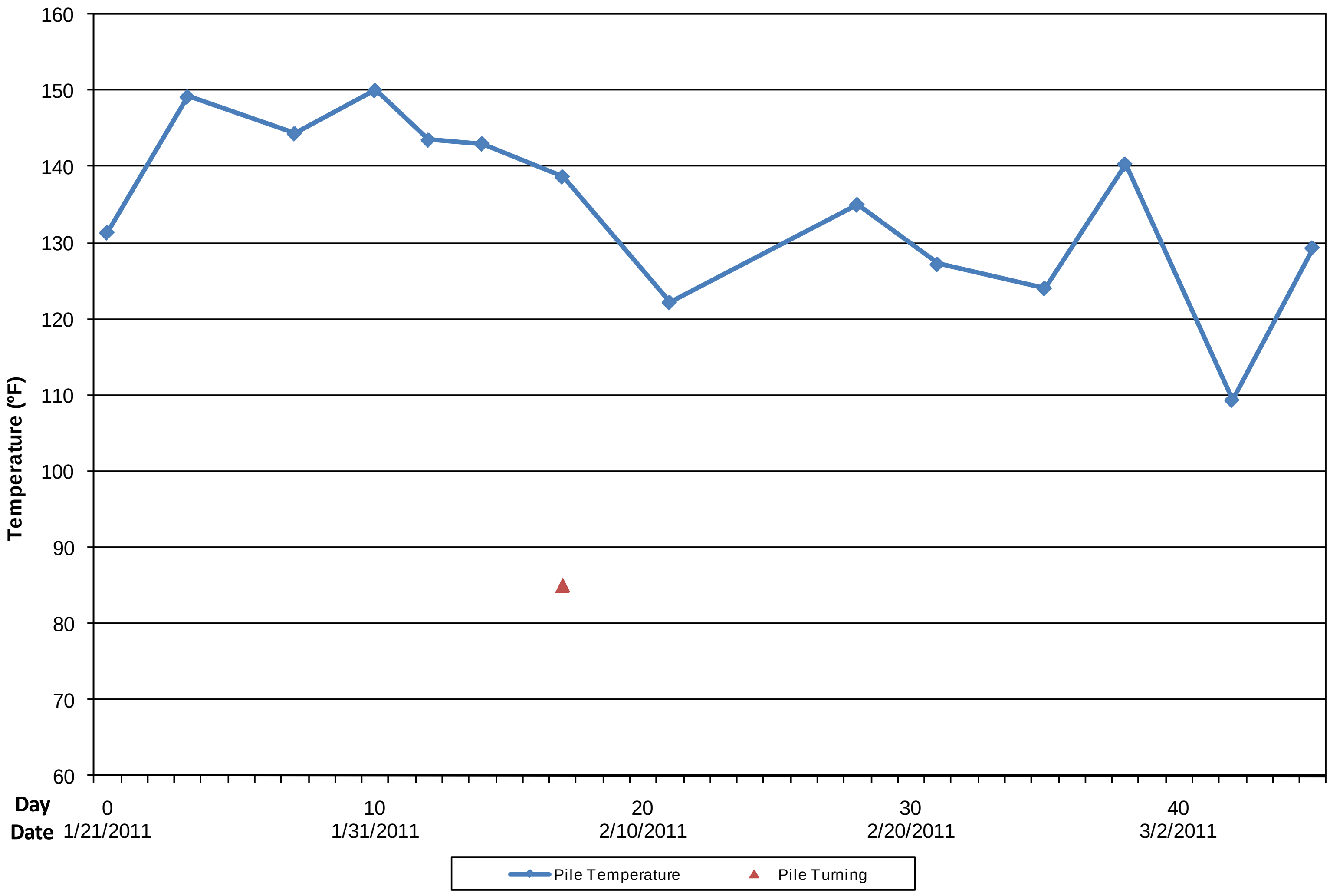


Figure 8: Compost Curing Monitoring Results – Modified Static Pile 2:1 Mix Ratio



Compost Screening

Upon completion of the composting process, all four windrows were screened to remove the larger components, producing four piles of fine-textured, high-quality compost piles. KCI oversaw the screening process which was performed on-site with a Doppstadt 26-foot trommel unit, provided by Peninsula Equipment. Table 5 summarizes the quantities of finished compost processed and produced. The pictures below illustrate the final screening process.

Table 5: Final Compost Generation

	Units	TW 3:1	TW 2:1	MSP 3:1	MSP 2:1
Material Input	*Yd³*	19	29	28	24
Compost Output	*Yd³*	14	16	17	15
Yield	***%***	**74%**	**55%**	**61%**	**63%**

Note: measurements and volumes are approximate

Screening unit is delivered to site.

Loader deposits compost into hopper.

Large particles are screened out for reuse in the future.

Result: Nutrient-rich, marketable compost.

Compost Analyses – End of Active Composting

Several days after screening, KCI collected composite samples from each windrow and shipped them to Midwest Labs for comprehensive analysis including organic solids, heavy metals, pathogens, and agronomic parameters. Each of the windrows met FDEP requirements to be classified as Type YM compost for unrestricted distribution and use. Table 6 provides a summary of the finished compost lab results for parameters of most common concern to regulators and compost markets. Detailed lab results are provided in Appendix B.

Table 6: Lab Analysis – Finished Compost

Analysis Parameter	Units	TW 3:1	TW 2:1	MSP 3:1	MSP 2:1
Moisture	%	35.25	36.06	37.08	40.54
Carbon:Nitrogen	n/a	17.1:1	16.6:1	16.4:1	16.9:1
Total Nitrogen	% dw	0.82	0.71	0.75	0.71
Phosphorus	% dw	0.56	0.39	0.44	0.43
Potassium	% dw	0.40	0.37	0.34	0.36
Conductivity*	mS/cm	1.6	1.4	1.6	1.6
pH	pH units	7.70	8.10	8.00	7.80
Stability Rating	n/a	Very Stable	Very Stable	Very Stable	Very Stable
Cadmium	ppm	n.d.	n.d.	n.d.	n.d.
Copper	ppm	n.d.	26	n.d.	n.d.
Lead	ppm	5.5	n.d.	n.d.	5.6
Mercury	ppm	.05	n.d.	n.d.	n.d.
Nickel	ppm	1.7	1.7	1.6	1.8
Zinc	ppm	64	58	62	65
Fecal Coliform	mpn/g	n.d.	n.d.	n.d.	n.d.
Salmonella	mpn/4g	n.d.	n.d.	n.d.	n.d.
Helminth ova	ovum/4g dry	n.d.	n.d.	n.d.	n.d.
5-day Germination	%	100	100	100	100

*dry weight
n.d. = not detected

Moisture Content: The finished compost samples had moisture content ranging from 35.25% to 40.54%.

C:N Ratio: The four samples were consistent, ranging from 16.4:1 to 17.1:1.

Total Nitrogen, Phosphorus, and Potassium (Macro-nutrients): All four samples contained less than 1% of each of the macro-nutrients.

Conductivity: The samples were consistent, with three of them registering 1.6 mS/cm, and one registering 1.4 mS/cm. The low conductivity indicates a low concentration of dissolved salt.

pH: All four samples were neutral to slightly basic.

Stability: Each of the samples achieved stability ratings of "very stable."

Metals: Nickel and zinc are the only metals to be detected in all samples, with nickel averaging 1.7 ppm and zinc averaging 62 ppm. Cadmium was not detected in any of the samples.

Pathogens (fecal coliform, salmonella, helminth ova): No pathogens were detected in any of the samples.

Markets for Compost Material

Florida's typically poor soils mean that demand for good-quality compost is growing along with the States composting industry. Compost is now commonly utilized as a component of potting soil blends, as a soil amendment for landscaping projects, and as a component of top dressings for the maintenance of golf courses and sports turf. Niche uses in agricultural markets, including disease suppression, are also currently being developed.

Approximately 50 yards of the finished compost from this pilot project was utilized as a component of a blend for a golf course construction project. The compost was blended with sand and utilized for the construction of tee-off boxes. The remaining material is destined for growing trials at a local strawberry farm.

The oversized tailings (Over's) from the screening operation have been stored for possible later use. Polk County is interested in conducting additional composting, which will involve experimenting with additional feedstocks. Over's are an excellent addition to subsequent composting cycles and provide excellent porosity. Eventually, after several cycles, they breakdown and become compost.

SECTION 3.0
FINDINGS AND CONCLUSIONS

The purpose of this on-farm composting project was to research and demonstrate the feasibility and proper design and operational procedures for composting food waste and yard trash at a registered facility in accordance with FDEP Chapter 62-709 F.A.C. Criteria for Organics Processing and Recycling Facilities. The information obtained from the project has been used in other FORCE training and education to promote increased food waste composting throughout Florida and demonstrate efficient and environmentally-sound practices.

The Project evaluated composting of pre-consumer vegetative waste (PCVW) from Publix supermarkets and yard trash (YT) from Polk County's registered facility located at the North Central Landfill. Major findings and conclusions are provided below.

Food Waste Collection and Delivery

It was not possible to directly observe or evaluate the food waste collection implemented by Publix for this Project, due the company's non-disclosure requirements. Nevertheless, KCI was able to observe the outcome of that effort. Namely, the quality of PCVW delivered to the composting site was very high quality. Contamination was very limited and Publix personnel were responsive to requests to address material quality issues when they arose.

Receiving and Mixing

Incoming PCVW was dumped onto a prepared bed of YT designed to absorb any free-flowing liquids and keep round fruits and vegetables from rolling away from the pile. Extra care was taken during the mixing process to manually break such round items (e.g. melons, oranges, etc.) with a hand shovel. The tendency of round items to roll away from the pile illustrates an important design aspect for full-scale operations. Mixing is best handled either in a three-sided bunker or an enclosed mixer. The side walls of a bunker help to keep materials in the mixing area while the back wall provides a push-wall against which the loader can more efficiently work. Enclosed mixing machines are also commonly used in the industry to produce a homogenous mix. One additional benefit of mixers is that they tend to break apart the larger food waste items and prevent the "rolling fruit" problem from occurring during active composting.

The two different YT to PCVW mix ratios utilized, 3:1 and 2:1, both performed suitably well, showing no significant differences. Temperatures climbed rapidly in all four windrows and were maintained for an extended period of time, ensuring efficient composting and pathogen destruction. The 3:1 mix ratio did require more frequent watering however. It is likely that increased porosity provided by the additional YT led to a more rapid loss of moisture through vaporization. During the drier periods of the year a 2:1 mix ratio would be best suited, particularly as adding moisture can be a labor intensive task without adequate equipment. On the contrary, during the wet summer months the additional YT would have a positive effect, helping the windrows to more efficiently shed excess moisture.

Composting and Curing

Windrows composted using the Turned Windrow (TW) method easily met the regulatory process standards for disinfection for time, temperature and turnings, namely 15 days at 131ºF with 5 turnings. While there are no regulatory process standards for the Modified Static Pile (MSP) method with regard to time, temperature and turning, both of these windrows maintained temperatures well above 131ºF for more than 15 days.

The windrows were large enough to maintain the thermal mass and energy for sustained thermophilic composting, however the windrows were much more susceptible to weather conditions. Active composting took place during December and January, and very cold days and nights occurred with temperature dipping into the 20s. As noted previously for Figures 1 through 4, cold temperatures impacted the windrows. A full-scale food waste composting operation would have much larger windrows that would have the thermal mass and energy to be unaffected by cold winter temperatures.

As documented in the temperature records, composting and curing proceeded well throughout the Project. The fact that the MSP method maintained thermophilic temperatures throughout active composting and generated no offensive odors is a clear indication that convective air flowing through the windrows was sufficient to maintained aerobic conditions without frequent turning.

Environmental Control

The three most common environmental and public health issues encountered at food waste composting sites are odors, scavengers and flies, and leachate. At the beginning of active composting, each of the windrows was covered (or capped) with a one-foot layer of well-aged

YT mulch from the County's operation. This capping layer served multiple purposes. First, it covers the food waste – essentially hiding it from potential scavengers until it has sufficiently decomposed to no longer attract scavengers. Despite the presence of many scavenger birds at the County landfill, no bird problems occurred at the Project site. Second, the capping layer serves as an odor filter, again limiting the attractiveness of the windrows to scavengers as well as reducing the potential for malodors impacting people. Odor monitoring recorded minimal malodors during the initial two weeks of active composting (the period when malodors are most likely to occur). Thirdly, the capping layer provides an insulating blanket, which is especially important for the MSP windrows because it allows thermophilic temperatures to occur throughout the raw mixture of PCVW and YT, with high temperatures being achieved all the way to the extreme outside edges of the compost pile.

Compost Testing

The project had an extensive sampling and lab analysis protocol in compliance with FDEP contractual requirements, which included each windrows raw mixture and then the finished compost from each windrow. The lab results demonstrated that both the TW and MSP composting methods effectively destroyed pathogens. Finished compost from all four windrows easily met FDEP regulatory requirement for disinfection. In addition, the finished compost from all four windrows met all other FDEP regulatory requirements to be classified as Class YM compost which can be distributed and sold without any regulatory restrictions. In summary, testing determined that after 60 days of active composting and as little as 45 days of curing, the Project produced finished compost that was very stable and mature, and suitable for a wide range of potential uses and markets.

Economics

In order to assess the economics of composting PCVW and YT, KCI developed generic estimates of the cost based on the Project operations at Polk County and a various assumptions for a permanent small-scale operation. KCI prepared estimates for both composting methods utilized – TW and MSP – in order to assess the potential cost savings that may be realized with the MSP method, which reduces the number of times windrows are turned and water is added.

The following are key factors used to develop the cost estimates:

- Assume 45 cubic yards per week of PCVW composted with processed YT at a 3:1 volumetric ratio (YT:PCVW)

- Assume that the cost for grinding YT is already covered by the County's existing YT processing operation
- Assume the County charges a $12 per ton tip for incoming PCVW, and assume that finished compost is used by the County and no revenue is received from compost sales
- Include the cost to construct a concrete pad with three-side bunker wall for receiving and mixing PCVW with YT

In developing the cost estimate, KCI also utilized a number of performance and productivity metrics based on our prior knowledge and experience with food and yard waste composting operations. These metrics include such items as cubic yard per hour handled by a front end loader; hours it takes for staff to monitor temperatures; cubic yards per hour handled by a trammel screen; etc.

Table 7 provides a summary of the estimated cost for TW compost. The largest line item costs are for the front end load and water truck, which together account for 74% of total annual cost. When taking the revenue from PCVW tip fees into account, the net cost for TW composting is estimated to be $22 per ton of material composted.

Table 7: Estimated Annual Expense – Turned Windrow Composting

Item	Quantity	Units	Unit Cost	Total
Annual Cost of Site Improvements	$26,840	8 yrs	@ 7%	$4,495
Annual Operating Cost				
Front End Loader & Operator	414	hrs/yr	$100	$41,400
Grinder	not applicable			
Trommel Screen	61	hrs/yr	$100	$6,100
Water Truck & Operator	183	hrs/yr	$60	$10,980
Labor – Monitoring & Sampling	223	hrs/yr	$25	$5,575
Equipment and Supplies				$850
Lab Analysis				$1,200
Total Annual Cost				$70,600
Revenue				
Food Waste Tip Fee	1,287	Tons	$12	$15,444
Net Cost (Revenue)				$55,156
Per Ton of Feedstocks	2,551	Tons		$22
Per Ton of Finished Compost	1,641	Tons		$34

As shown in Table 8, the cost of MSP is projected to be significantly lower than TW composting. The primary for this is the reduced hours of front end loader and water truck operations. The net cost for TW composting is estimated to be $15 per ton of material composted.

Table 8: Estimated Annual Expense – Modified Static Pile Windrow Composting

Item	Quantity	Units	Unit Cost	Total
Annual Cost of Site Improvements	$26,840	8 yrs	@ 7%	$4,495
Annual Operating Cost				
Front End Loader & Operator	294	hrs/yr	$100	$29,400
Grinder	not applicable			
Trommel Screen	61	hrs/yr	$100	$6,100
Water Truck & Operator	103	hrs/yr	$60	$6,180
Labor – Monitoring & Sampling	223	hrs/yr	$25	$5,575
Equipment and Supplies				$850
Lab Analysis				$1,200
Total Annual Cost				$53,800
Revenue				
Food Waste Tip Fee	1,287	Tons	$12	$15,444
Net Cost (Revenue)				$38,286
Per Ton of Feedstocks	2,551	Tons		$15
Per Ton of Finished Compost	1,641	Tons		$23

Conclusion

The purpose of this project was to encourage composting operations in Florida that take advantage of the newly revised FDEP compost regulations that allow registration facilities to handle clean source-separated food waste along with yard trash and/or manure.

The project achieved its research objectives of determining the technical feasibility of composting pre-consumer vegetative waste (PCVW) with yard trash (YT) using simple turned windrow (TW) and modified static pile (MSP) composting technologies. The finished compost was of very high quality, meeting the regulatory standards for Type YM compost, and was produced in approximately four months. The compost methods employed met regulatory disinfection standards for pathogen destruction. Based on cost projections, the type of composting operations conducted in the Project can be cost effective when scaled up to permanent operations. The project achieved its demonstration objectives by providing valuable information that was incorporated into FORCE training and educational materials widely distributed to the organics recycling community in Florida.

Appendix A
Pre-consumer Vegetative Waste Delivery Logs

Week #1					
Date	10/25/2010	10/27/2010	10/29/2010	Total	% of Carts
Cart Count					
#11		6	8	14	30%
#1171		12	7	19	41%
#671		7	6	13	28%
Total		25	21	46	100%
Weights					
Gross		23,080	22,560	45,640	
Tare		20,840	20,780	41,620	
Net Pounds		2,240	1,780	4,020	
Net Tons		1.12	0.89	2.01	
Pounds/Cart		89.60	84.76	87.39	
Week #2					
Date	11/1/2010	11/3/2010	11/5/2010	Total	% of Carts
Cart Count					
#11	7	8	8	23	30%
#1171	13	10	11	34	44%
#671	7	7	6	20	26%
Total	27	25	25	77	100%
Weights					
Gross	23,400	22,940	22,540	68,880	
Tare	20,800	20,900	20,940	62,640	
Net Pounds	2,600	2,040	1,600	6,240	
Net Tons	1.30	1.02	0.80	3.12	
Pounds/Cart	96.30	81.60	64.00	81.04	
Week #3					
Date	11/8/2010	11/10/2010	11/12/2010	Total	% of Carts
Cart Count					
#11	8	7	8	23	32%
#1171	12	11	10	33	45%
#671	7	4	6	17	23%
Total	27	22	24	73	100%
Weights					
Gross	23,140	22,460	22,600	68,200	
Tare	20,980	21,000	21,040	63,020	
Net Pounds	2,160	1,460	1,560	5,180	
Net Tons	1.08	0.73	0.78	2.59	
Pounds/Cart	80.00	66.36	65.00	70.96	
Week #4					
Date	11/15/2010	11/17/2010	11/19/2010	Total	% of Carts
Cart Count					
#11	8	8	6	22	31%
#1171	13	10	11	34	47%
#671	7	3	6	16	22%
Total	28	21	23	72	100%
Weights					
Gross	23,140	22,380	22,860	68,380	
Tare	21,000	20,900	20,880	62,780	
Net Pounds	2,140	1,480	1,980	5,600	
Net Tons	1.07	0.74	0.99	2.80	
Pounds/Cart	76.43	70.48	86.09	77.78	

Appendix B

Laboratory Analyses

Raw Mixture Prior to Composting										
		Sample								
Parameter	**Units**	**Mix1a**	**Mix1b**	**Mix2a**	**Mix2b**	**Mix3a**	**Mix3b**	**Mix4a**	**Mix4b**	**Average**
pH	S.U.	5.7	5	5	5	5.1	5.1	5.4	5.3	5.2
Moisture	%	69.88	56.75	60.81	59.82	54.6	57.13	70.22	73.42	62.8
C:N Ratio	x:1	24	31	34	29	12	29	19	39	27.1
Total Carbon	%	7.86	11.31	16.79	13.6	18.84	18.36	8.24	8.09	12.9
Total Nitrogen	%	0.33	0.37	0.49	0.47	1.53	0.63	0.44	0.21	0.6
Bulk Density	g/cc	0.3	0.28	0.5	0.54	0.4	0.46	0.55	0.52	0.4
CO2 OM Evolution	mgCO2-C/gOM/day	2.78	1.25	1.96	2.79	1.3	2.04	0.25	1.93	1.8
CO2 Solids Evolution	mgCO2-C/gTS/day	4.58	1.93	5.37	4.61	3.28	4.9	0.38	4.05	3.6
Conductivity	mS/cm	2.73	3.15	1.85	4.51	6.9	5.1	1.21	2.69	3.5
Fecal Coliform	mpn/g	115900	213442	89154	43100	203956	8086	7993	10300	86491.4
Man-made Materials	%	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Volatile Solids	%	59.14	63.56	80.54	67.62	79.15	76.79	71.13	76.84	71.8
Stability Rating		Stable	Very Stable	Mod. Unstable	Stable	Stable	Stable	Very Stable	Stable	
Total Organic Carbon	%	7.7	11.24	16.07	13.55	18.33	17	7.47	7.71	12.4

Finished Compost After Screening															
		TW 3:1		TW 2:1		MSP 3:1		MSP 2:1		Average - TW		Average - MSP		Average - All	
Parameter	Units	WW	DW	WW	DW	WW	DW	WW	DW	WW	DW	WW	DW	WW	DW
Total Nitrogen (N)	%	0.82	1.27	0.71	1.11	0.75	1.19	0.71	1.19	0.765	1.19	0.73	1.19	0.7475	1.19
Ammonium Nitrogen (N)	%	0.005	0.01	0.004	0.01	0.006	0.01	n.d.	n.d.	0.0045	0.01	0.006	0.01	0.005	0.01
Nitrate Nitrogen (N)	%	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.						
Organic Nitrogen (N)	%	0.82	1.26	0.71	1.1	0.74	1.18	0.71	1.19	0.765	1.18	0.725	1.185	0.745	1.1825
Phosphorous (P205)	%	0.56	0.86	0.39	0.61	0.44	0.7	0.43	0.72	0.475	0.735	0.435	0.71	0.455	0.7225
Potassium (K2O)	%	0.4	0.62	0.37	0.58	0.34	0.54	0.36	0.61	0.385	0.6	0.35	0.575	0.3675	0.5875
Sulfur (S)	%	0.1	0.15	0.09	0.14	0.08	0.13	0.09	0.15	0.095	0.145	0.085	0.14	0.09	0.1425
Calcium (Ca)	%	1.41	2.18	1.31	2.05	1.78	2.83	1.18	1.98	1.36	2.115	1.48	2.405	1.42	2.26
Magnesium (Mg)	%	0.15	0.23	0.13	0.2	0.12	0.19	0.14	0.24	0.14	0.215	0.13	0.215	0.135	0.215
Sodium (Na)	%	0.04	0.06	0.04	0.06	0.04	0.06	0.05	0.08	0.04	0.06	0.045	0.07	0.0425	0.065
Copper (Cu)	ppm	n.d.	n.d.	26	41	n.d.	n.d.	n.d.	n.d.	26	41			26	41
Iron (Fe)	ppm	1192	1841	1090	1705	1060	1685	1123	1889	1141	1773	1091.5	1787	1116.25	1780
Manganese (Mn)	ppm	60	93	55	86	55	87	57	96	57.5	89.5	56	91.5	56.75	90.5
Zinc (Zn)	ppm	64	99	58	91	62	99	65	109	61	95	63.5	104	62.25	99.5
Moisture	%	35.25		36.06		37.08		40.54		35.655		38.81		37.2325	
Total Solids	%	64.75		63.94		62.92		59.46		64.345		61.19		62.7675	
pH		7.7		8.1		8		7.8		7.9		7.9		7.9	
Total Carbon	%	14.03	21.67	11.82	18.49	12.29	19.53	12.02	20.22	12.925	20.08	12.155	19.875	12.54	19.9775
C/N Ratio		17.1:1		16.6:1		16.4:1		16.9:1							
Chloride	%	0.09	0.14	0.08	0.13	0.08	0.13	0.08	0.13	0.085	0.135	0.08	0.13	0.0825	0.1325
Percent Volitale Solids	%		41.44		36.85		37.11		33.3		39.145		35.205		37.175
Organic Matter	%	28.01	43.26	23.44	36.66	22.83	36.28	24.81	41.73	25.725	39.96	23.82	39.005	24.7725	39.4825
Conductivity 1:5	mS/cm		1.6		1.4		1.6		1.6		1.5		1.6		1.55

Heavy Metals		TW 3:1		TW 2:1		MSP 3:1		MSP 2:1		Average - TW		Average - MSP		Average - All	
Parameter	Units	WW	DW	WW	DW	WW	DW	WW	DW	WW	DW	WW	DW	WW	DW
Arsenic	mg/kg	2	3.1	2	3.2	1.7	2.7	1.7	2.9	2	3.15	1.7	2.8	1.85	2.975
Boron	ppm	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.						
Cadmium	ppm	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.						
Chromium	ppm	5.9	9.1	5.3	8.3	5.6	8.9	16	26.9	5.6	8.7	10.8	17.9	8.2	13.3
Lead	ppm	5.5	8.5	n.d.	n.d.	n.d.	n.d.	5.6	9.4	5.5	8.5	5.6	9.4	5.55	8.95
Mercury	ppm	0.05	0.08	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.05	0.08			0.05	0.08
Molybdenum	ppm	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.						
Nickel	ppm	1.7	2.6	1.7	2.7	1.6	2.5	1.8	3	1.7	2.65	1.7	2.75	1.7	2.7
Selenium	ppm	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.						

*Reference 40 CFR Table 1 of 503.13 for Ceiling Concentrations.
*Sample was prepared for EPA 6010 analysis by EPA Method 3050.

Pathogens		TW 3:1	TW 2:1	MSP 3:1	MSP 2:1	Average -	Average -	Average - All
Parameter	Units	DW	DW	DW	DW	DW	DW	DW
Fecal Coliform	mpn/g	n.d.	n.d.	n.d.	n.d.			
Salmonella	mpn/4 g	n.d.	n.d.	n.d.	n.d.			
Enteric Viruses	PFU/4g	n.d.	n.d.	n.d.	n.d.			
Viable Helminth Ova	ovum/4g dw	n.d.	n.d.	n.d.	n.d.			

Other Analytes		TW 3:1	TW 2:1	MSP 3:1	MSP 2:1	Average -	Average -	Average - All
Parameter	Units	WW	WW	WW	WW	WW	WW	WW
5 Day Germination	%	100	100	100	100	100	100	100
7 Day Vigor	%	100	100	100	100	100	100	100
Bulk Density (Loose)	lbs/cu yd	859.9	1011.6	944.2	944.2	935.75	944.2	939.975
Bulk Density (Packed)	lbs/cu yd	1011.6	1095.9	1112.8	1079	1053.75	1095.9	1074.825
Man Made Materials	%	n.d.	n.d.	n.d.	n.d.			
Sieve % Passing 3in. (Dry wt.)	%	100	100	100	100	100	100	100
Sieve % Passing 1.5in. (Dry wt.)	%	100	100	100	100	100	100	100
Sieve % Passing 1in. (Dry wt.)	%	100	100	100	100	100	100	100
Sieve % Passing 3/4in. (Dry wt.)	%	100	100	100	100	100	100	100
Sieve % Passing 5/8in. (Dry wt.)	%	100	100	100	100	100	100	100
Sieve % Passing 3/8in. (9.25mm)	%	100	100	100	100	100	100	100
Sieve % Passing 1/4in. (Dry wt.)	%	99.3	99.1	99	99.5	99.2	99.25	99.225
Sieve Max. Particle Length	Inches	1.5	1.25	1	1.75	1.375	1.375	1.375
CO2 OM Evolution	mgCO2-C/gOM/day	0.32	0.41	0.34	0.3	0.365	0.32	0.3425
CO2 Solids Evolution	mgCO2-C/gTS/day	0.38	0.38	0.34	0.38	0.38	0.36	0.37
Stability Rating		Very Stable	Very Stable	Very Stable	Very Stable			
Total Organic Carbon	%	7	6	6	6	6.5	6	6.25
Water Soluble Phosphorous	ppm	n.d.	n.d.	n.d.	n.d.			

Appendix C
Active Composting and Curing Temperature Charts

Food Waste Composting R&D Pilot

Batch: 1

		Sampling Locations - Temperature (F)										
		1 foot deep			3 feet deep			Windrow Temperature	pH	Windrow Turning	Water Addition	Rain Fall
Date	Day	1	2	3	4	5	6					
10/29/10	1	151	153	149	132	130	129	140.7				
10/30/10	2											
10/31/10	3											
11/01/10	4	154	159	158	150	156	157	155.7				
11/02/10	5	164	164	153	165	162	166	162.3				
11/03/10	6	158	162	160	165	162	161	161.3				slight
11/04/10	7	158	162	150	162	164	156	158.7				
11/05/10	8	151	157	154	159	157	160	156.3				mod. 1"
11/06/10	9											
11/07/10	10											
11/08/10	11	147	149	151	155	154	154	151.7		Yes	Yes	
11/09/10	12	142	148	151	138	147	154	146.7				
11/10/10	13	136	142	142	142	148	151	143.5		Yes	Yes	
11/11/10	14	122	134	117	116	122	114	120.8				
11/12/10	15	149	140	144	157	146	149	147.5		Yes	Yes	
11/13/10	16											
11/14/10	17											
11/15/10	18	151	154	156	165	166	165	159.5		Yes		
11/16/10	19	154	157	164	162	170	169	162.7				
11/17/10	20	145	148	145	162	160	159	153.2		Yes	Yes	
11/18/10	21	149	145	151	158	157	160	153.3				
11/19/10	22	146	147	155	151	148	160	151.2				
11/20/10	23											
11/21/10	24											
11/22/10	25	144	149	151	159	164	163	155.0				
11/23/10	26	124	150	148	160	168	156	151.0				
11/24/10	27	148	153	156	162	167	168	159.0		Yes		
11/25/10	28	Thanksgiving										

Batch 1 Cont'd		*1 foot deep*			*3 feet deep*			*Windrow Temperature*	*pH*	*Windrow Turning*	*Water Addition*	*Rain Fall*
Date	*Day*	*1*	*2*	*3*	*4*	*5*	*6*					
11/26/10	29		Thanksgiving									
11/27/10	30											
11/28/10	31											
11/29/10	32	149	145	149	166	168	157	155.7				
11/30/10	33	151	154	150	168	162	160	157.5				
12/01/10	34	140	142	139	156	155	163	149.2		Yes		
12/02/10	35	111	151	146	136	157	160	143.5				
12/03/10	36	96	114	126	146	136	145	127.2				
12/04/10	37											
12/05/10	38											
12/06/10	39	97	152	147	150	162	161	144.8				
12/07/10	40	68	130	150	108	161	160	129.5				
12/08/10	41	138	154	144	158	164	160	153.0				
12/09/10	42	126	135	138	153	156	147	142.5				
12/10/10	43	95	115	115	158	143	150	129.3				
12/11/10	44											
12/12/10	45											
12/13/10	46	64	68	154	138	100	160	114.0				
12/14/10	47	70	138	141	131	162	160	133.7				
12/15/10	48	137	135	118	155	151	138	139.0				
12/16/10	49	90	126	135	130	144	160	130.8				
12/17/10	50	97	124	127	131	142	142	127.2				
12/18/10	51											
12/19/10	52											
12/20/10	53	100	120	100	128	140	132	120.0				
12/21/10	54	108	118	125	146	132	143	128.7				
12/22/10	55	92	111	121	124	137	145	121.7		Yes	Yes	
12/23/10	56	85	135	125	140	135	143	127.2				
12/24/10	57	90	138	128	130	138	142	127.7				
12/25/10	58											
12/26/10	59											
12/27/10	60	40	115	130	112	145	150	115.3				

Food Waste Composting R&D Pilot

Batch: 2

		Sampling Locations - Temperature (F)										
		1 foot deep			3 feet deep			Windrow Temperature	pH	Windrow Turning	Water Addition	Rain Fall
Date	Day	1	2	3	4	5	6					
11/08/10	1	164	163	162	161	157	158	160.8				
11/09/10	2	158	166	134	168	170	132	154.7				
11/10/10	3	150	159	148	163	165	149	155.7				
11/11/10	4	162	164	140	168	167	142	157.2				
11/12/10	5	157	160	148	162	163	151	156.8				
11/13/10	6											
11/14/10	7											
11/15/10	8	158	160	151	164	161	150	157.3		Yes		
11/16/10	9	157	148	138	156	144	149	148.7				
11/17/10	10	154	152	155	156	154	152	153.8		Yes	Yes	
11/18/10	11	148	146	144	150	149	149	147.7				
11/19/10	12	153	151	149	155	153	148	151.5		Yes		
11/20/10	13											
11/21/10	14											
11/22/10	15	156	159	157	153	161	155	156.8		Yes		
11/23/10	16	155	159	159	158	158	156	157.5				
11/24/10	17	162	164	160	156	160	158	160.0		Yes	Yes	
11/25/10	18	Thanksgiving										
11/26/10	19											
11/27/10	20											
11/28/10	21											
11/29/10	22	152	141	154	165	162	163	156.2				
11/30/10	23	132	150	142	158	162	164	151.3				
12/01/10	24	161	152	154	164	161	159	158.5		Yes		
12/02/10	25	152	148	140	154	146	144	147.3				
12/03/10	26	122	156	148	152	158	160	149.3				
12/04/10	27											
12/05/10	28											

Batch 2 Cont'd		*1 foot deep*			*3 feet deep*			*Windrow Temperature*	*pH*	*Windrow Turning*	*Water Addition*	*Rain Fall*
Date	*Day*	*1*	*2*	*3*	*4*	*5*	*6*					
12/06/10	29	158	121	132	161	151	160	147.2				
12/07/10	30	154	150	152	158	160	161	155.8				
12/08/10	31	142	152	160	155	164	162	155.8		Yes		
12/09/10	32	147	144	145	150	155	147	148.0				
12/10/10	33	144	141	140	160	158	124	144.5				
12/11/10	34											
12/12/10	35											
12/13/10	36	146	150	106	160	162	132	142.7				
12/14/10	37	142	154	152	164	160	166	156.3				
12/15/10	38	106	134	139	151	159	164	142.2				
12/16/10	39	142	146	142	161	160	160	151.8				
12/17/10	40	140	148	135	159	158	154	149.0				
12/18/10	41											
12/19/10	42											
12/20/10	43	142	148	128	157	158	151	147.3				
12/21/10	44	141	138	146	160	154	160	149.8				
12/22/10	45	129	135	140	154	157	159	145.7				
12/23/10	46	138	125	123	122	115	133	126.0				
12/24/10	47	145	139	153	125	131	155	141.3				
12/25/10	48											
12/26/10	49											
12/27/10	50	109	132	106	155	152	145	133.2				
12/28/10	51	117	125	111	145	146	144	131.3				
12/29/10	52	124	118	110	148	151	142	132.2		Yes	Yes	
12/30/10	53	125	125	140	153	158	160	143.5				
12/31/10	54	131	125	140	152	155	159	143.7				
01/01/11	55											
01/02/11	56											
01/03/11	57	143	123	143	149	153	157	144.7				
01/04/11	58	131	144	120	145	146	126	135.3				
01/05/11	59	128	129	122	136	138	134	131.2				
01/06/11	60	134	124	120	146	140	132	132.7				

Food Waste Composting R&D Pilot

Batch: 3

		Sampling Locations - Temperature (F)										
		1 foot deep			3 feet deep							
Date	Day	1	2	3	4	5	6	Windrow Temperature	pH	Windrow Turning	Water Addition	Rain Fall
11/15/10	1	145	142	140	140	141	144	142.0				
11/16/10	2	158	146	153	140	150	159	151.0				
11/17/10	3	158	156	157	159	146	154	155.0				
11/18/10	4	156	154	157	158	153	155	155.5				
11/19/10	5	157	154	155	156	154	153	154.8				
11/20/10	6											
11/21/10	7											
11/22/10	8	153	156	151	157	159	156	155.3				
11/23/10	9	124	150	152	157	154	160	149.5				
11/24/10	10	158	159	153	163	158	158	158.2				
11/25/10	11	Thanksgiving										
11/26/10	12											
11/27/10	13											
11/28/10	14											
11/29/10	15	138	140	140	157	152	159	147.7		Yes		
11/30/10	16	128	152	151	144	159	154	148.0				
12/01/10	17	155	154	149	158	161	157	155.7				
12/02/10	18	154	156	150	159	160	158	156.2				
12/03/10	19	129	150	151	153	164	160	151.2				
12/04/10	20											
12/05/10	21											
12/06/10	22	152	156	80	164	168	110	138.3				
12/07/10	23	154	140	124	164	152	150	147.3				
12/08/10	24	150	124	159	164	130	165	148.7				
12/09/10	25	143	132	137	161	143	154	145.0				
12/10/10	26	125	131	121	162	159	155	142.2				
12/11/10	27											
12/12/10	28											

Batch 3 Cont'd		*1 foot deep*			*3 feet deep*			*Windrow Temperature*	*pH*	*Windrow Turning*	*Water Addition*	*Rain Fall*
Date	*Day*	*1*	*2*	*3*	*4*	*5*	*6*					
12/13/10	29	136	140	70	156	161	104	127.8				
12/14/10	30	140	144	90	158	160	110	133.7				
12/15/10	31	119	117	120	152	149	153	135.0		Yes	Yes	
12/16/10	32	150	128	131	138	132	124	133.8				
12/17/10	33	141	147	151	147	154	152	148.7				
12/18/10	34											
12/19/10	35											
12/20/10	36	144	160	162	156	164	164	158.3				
12/21/10	37	128	156	158	150	161	160	152.2				
12/22/10	38	142	146	149	156	159	160	152.0				
12/23/10	39	132	140	122	163	152	151	143.3				
12/24/10	40	140	141	142	148	155	158	147.3				
12/25/10	41											
12/26/10	42											
12/27/10	43	115	115	140	161	158	158	141.2				
12/28/10	44	135	123	140	156	154	157	144.2				
12/29/10	45	137	125	139	151	153	157	143.7				
12/30/10	46	128	140	139	158	162	160	147.8				
12/31/10	47	129	140	131	160	162	154	146.0				
01/01/11	48											
01/02/11	49											
01/03/11	50	133	142	129	158	155	155	145.3				
01/04/11	51	130	137	142	154	146	157	144.3				
01/05/11	52	127	138	135	156	157	157	145.0				
01/06/11	53	144	144	120	156	152	128	140.7				
01/07/11	54	132	138	140	150	158	156	145.7				
01/08/11	55											
01/09/11	56											
01/10/11	57	132	136	130	156	154	154	143.7				
01/11/11	58	126	130	140	145	150	159	141.7				
01/12/11	59	124	119	121	132	134	127	126.2		Yes	Yes	
01/13/11	60	120	102	100	119	111	108	110.0				

Food Waste Composting R&D Pilot

Batch: 4

		Sampling Locations - Temperature (F)										
		1 foot deep			3 feet deep			Windrow Temperature	pH	Windrow Turning	Water Addition	Rain Fall
Date	Day	1	2	3	4	5	6					
11/22/10	0	139	151	152	144	154	154	149.0				
11/23/10	1	143	152	145	150	158	156	150.7				
11/24/10	2	138	156	155	140	157	158	150.7				
11/25/10	3	Thanksgiving										
11/26/10	4											
11/27/10	5											
11/28/10	6											
11/29/10	7	147	154	152	157	162	161	155.5				
11/30/10	8	146	150	122	160	161	140	146.5				
12/01/10	9	144	156	155	154	160	158	154.5				
12/02/10	10	159	160	139	163	164	147	155.3				
12/03/10	11	137	158	160	134	162	164	152.5				
12/04/10	12											
12/05/10	13											
12/06/10	14	146	122	162	164	158	166	153.0		Yes		
12/07/10	15	158	152	160	170	161	164	160.8				
12/08/10	16	153	160	154	166	168	164	160.8				
12/09/10	17	152	158	149	168	162	165	159.0				
12/10/10	18	150	151	142	150	141	132	144.3				
12/11/10	19											
12/12/10	20											
12/13/10	21	157	140	128	168	160	151	150.7				
12/14/10	22	153	136	112	166	154	126	141.2				
12/15/10	23	133	136	132	160	157	153	145.2				
12/16/10	24	130	152	132	154	160	150	146.3				
12/17/10	25	136	148	133	155	157	154	147.2				
12/18/10	26											
12/19/10	27											
12/20/10	28	142	149	132	158	160	156	149.5				
12/21/10	29	138	130	146	157	146	160	146.2				

Batch 4 Cont'd		*1 foot deep*			*3 feet deep*			*Windrow Temperature*	*pH*	*Windrow Turning*	*Water Addition*	*Rain Fall*
Date	*Day*	*1*	*2*	*3*	*4*	*5*	*6*					
12/22/10	30	132	135	133	151	151	154	142.7		Yes	Yes	
12/23/10	31	123	142	135	161	155	155	145.2				
12/24/10	32	130	128	125	155	155	153	141.0				
12/25/10	33											
12/26/10	34											
12/27/10	35	100	140	135	155	155	168	142.2				
12/28/10	36	135	138	133	157	155	160	146.3				
12/29/10	37	139	135	127	159	156	154	145.0				
12/30/10	38	82	102	93	98	104	100	96.5				
12/31/10	39	90	118	97	94	118	109	104.3				
01/01/11	40											
01/02/11	41											
01/03/11	42	106	135	102	109	120	122	115.7				
01/04/11	43	147	138	142	156	150	155	148.0				
01/05/11	44	140	137	142	158	153	157	147.8				
01/06/11	45	152	130	116	160	138	134	138.3				
01/07/11	46	126	124	140	140	154	158	140.3				
01/08/11	47											
01/09/11	48											
01/10/11	49	112	128	131	151	140	152	135.7				
01/11/11	50	110	138	140	146	157	158	141.5				
01/12/11	51	117	133	133	142	149	151	137.5				
01/13/11	52	99	130	128	145	148	149	133.2				
01/14/11	53	100	130	138	150	153	143	135.7				
01/15/11	54											
01/16/11	55											
01/17/11	56	Not read	Not read	Not read	Not read	Not read	Not read					
01/18/11	57	132	124	122	149	138	145	135.0				
01/19/11	58	114	131	139	140	156	150	138.3				
01/20/11	59	119	128	133	139	145	144	134.7		Yes		
01/21/11	60											

Batch 1 - Curing Log

1 ft. | 3 ft.

Week	Date	Day	Temperature (F) Point 1		Point 2		Point 3		Average	pH	Pile Turning	Rainfall Amt.	Rainfall Date
1	12/29/10	2	121	146	126	135	130	149	134.5				
	12/31/10	4	95	80	122	121	130	122	111.7				
2	01/03/11	7	110	121	123	135	150	155	132.3				
	01/05/11	9	123	157	128	153	131	148	140.0				
3	01/10/11	14	86	137	105	138	108	130	117.3				
	01/12/11	16	85	133	112	136	117	123	117.7		Yes		
4	01/14/11	18	83	125	135	145	123	122	122.2				
	01/18/11	22	131	152	148	161	136	156	147.3				
5	01/20/11	24	128	149	129	146	145	151	141.3				
	01/24/11	28	120	155	146	161	146	158	147.7				
6	01/28/11	32	130	150	142	152	135	146	142.5				
	01/31/11	35	138	154	140	156	120	130	139.7				
7	02/02/11	37	126	147	136	150	125	144	138.0				
	02/04/11	39	122	141	134	152	124	150	137.2				
8	02/07/11	42	134	146	104	132	110	136	127.0		Yes		
	02/11/11	46	118	128	115	130	116	150	126.2				
9	02/18/11	53	124	142	128	140	123	140	132.8				
	02/21/11	56	118	145	106	146	114	144	128.8				
10	02/25/11	60	117	142	112	141	116	137	127.5				
	02/28/11	63	118	132	118	132	113	135	124.7				
11	03/04/11	67		110		114		118	114.0				
	03/07/11	70		124		126		128	126.0				

Batch 2 - Curing Log

1 ft. | 3 ft.

Week	Date	Day	Temperature (F) Point 1		Point 2		Point 3		Average	pH	Pile Turning	Rainfall Amt.	Rainfall Date
1	01/10/11	4	130	140	142	144	130	146	138.7				
	01/12/11	6	128	146	143	150	126	145	139.7				
2	01/14/11	8	115	150	135	155	115	143	135.5				
	01/18/11	12	134	142	110	146	128	152	135.3				
3	01/20/11	14	139	144	124	153	136	147	140.5		Yes		
	01/24/11	18	144	146	148	152	141	144	145.8				
4	01/28/11	22	150	156	148	152	137	150	148.8				
	01/31/11	25	146	150	146	151	145	151	148.2				
5	02/02/11	27	139	147	145	149	143	156	146.5				
	02/04/11	29	142	154	142	155	142	153	148.0				
6	02/07/11	32	150	148	150	160	138	136	147.0		Yes		
	02/11/11	35	122	138	125	145	120	130	130.0				
7	02/18/11	39	132	140	131	153	139	142	139.5				
	02/21/11	42	126	134	116	150	133	138	132.8				
8	02/25/11	46	130	146	123	150	126	142	136.2				
	02/28/11	49	150	150	144	152	148	150	149.0				
9	03/04/11	53		116		123		114	117.7				
	03/07/11	56		123		129		134	128.7				

Batch 3 - Curing Log

			1 ft.	3 ft.									
			Temperature (F)							pH	Pile Turning	Rainfall Amt.	Rainfall Date
Week	Date	Day	Point 1		Point 2		Point 3		Average				
1	01/14/11	1	100	115	120	118	130	142	120.8				
	01/18/11	5	150	156	151	149	135	148	148.2				
2	01/20/11	7	147	152	144	151	130	145	144.8				
	01/24/11	11	150	155	132	160	124	144	144.2				
3	01/28/11	15	130	144	146	156	116	140	138.7				
	01/31/11	18	142	156	145	157	142	148	148.3				
4	02/02/11	20	139	154	133	152	144	145	144.5				
	02/04/11	22	137	157	126	154	142	153	144.8				
5	02/07/11	25	142	144	132	148	140	140	141.0		Yes		
	02/11/11	29	100	132	116	130	119	140	122.8				
6	02/18/11	36	139	143	124	149	132	141	138.0				
	02/21/11	39	127	134	115	136	140	145	132.8				
7	02/25/11	43	126	149	113	143	119	140	131.7				
	02/28/11	46	144	150	126	138	146	152	142.7				
8	03/04/11	50		110		118		113	113.7				
	03/07/11	53		130		134		128	130.7				
9													

Batch 4 - Curing Log

1 ft. | 3 ft.

Week	Date	Day	Temperature (F) Point 1 (1 ft.)	Point 1 (3 ft.)	Point 2 (1 ft.)	Point 2 (3 ft.)	Point 3 (1 ft.)	Point 3 (3 ft.)	Average	pH	Pile Turning	Rainfall Amt.	Rainfall Date
1	01/21/11	1	130	138	128	136	122	134	131.3				
	01/24/11	4	139	154	156	158	140	148	149.2				
2	01/28/11	8	148	160	154	158	114	132	144.3				
	01/31/11	11	140	152	152	156	147	153	150.0				
3	02/02/11	13	136	148	143	150	136	148	143.5				
	02/04/11	15	139	154	135	149	130	151	143.0				
4	02/07/11	18	142	138	124	136	144	148	138.7		Yes		
	02/11/11	22	110	125	110	125	125	138	122.2				
5	02/18/11	29	135	143	125	136	133	138	135.0				
	02/21/11	32	118	127	107	136	131	144	127.2				
6	02/25/11	36	119	143	112	122	114	134	124.0				
	02/28/11	39	144	146	130	130	144	148	140.3				
7	03/04/11	43		112		108		108	109.3				
	03/07/11	46		130		128		130	129.3				
8													
9													