Attachment M

2018

Operations and Maintenance Manual for Phase I of the City of Phoenix

27th Avenue Compost Facility

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Green Mountain Technologies

January 18th, 2018

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I. Introduction to This Manual:

This manual provides the detailed information for the first phase of operations for the City of Phoenix (COP) 27th Ave. Compost Facility located adjacent to the transfer station at 3060 South 27th Ave, Phoenix, AZ 85009.

The Compost Facility's first phase was designed to provide the City's operations contractor with the tools required to compost 110,000 tons per year (tpy) of green waste, food scraps, wood waste and large animal manure. The initial construction undertaken in October 2016 and completed in June of 2017 was to develop one half of Phase 1, and can process 55,000 tons per year. Completion of Phase 1 designs for receiving areas, aerated slabs, and curing pads are pending. This initial constructed capacity will be able to handle over 9,850 tons of compost at various stages of decomposition on site. When Phase 1 is complete, over 19,000 tons of received organic wastes will be actively managed on the site. When operated as designed, the facility will produce a finished-stabilized compost product and a stabilized mulch that meets regulatory and market demands in 45 to 60 days total composting and curing time in the time and space allotted. A second Phase of development was planned for on this site that would, once constructed, be capable of handling 220,000 tons per year.

This manual provides a clear description of the facility layout and expected flow of materials through the facility; a summary of the science and practice of composting that must be applied by the operator to successfully manage the composting and material handling processes; the standard operating procedures for the facility; the equipment and control systems used at the facility; and the safe operations and maintenance procedures required to operate the facility as designed. Additional Information is provided to assist the city and the operator on composting industry norms. Video during start-up training was recorded and is available for review and training purposes.

The City of Phoenix staff responsible for overseeing the facility, as well as the contract operator and their employees, are strongly encouraged to become familiar with this document, the equipment operating and service manuals and the facility as-built drawings. Operations staff members should pay special attention to those areas pertaining to tasks assigned to them. Facility management should document the dates, subjects and workers who have been trained and append the documentation to this manual for record keeping. This should include the initial training and any follow up training that pertains to the operations of the facility. Experience is critical to manage the compost process efficiently. This Operations Manual is intended to be a work in progress, to be changed and elaborated on as more experience is gained by the operator and the City.

Specifically, this version of the manual will also address and provide written documentation of the experiences gained during the commissioning phase. The author of this version, Green Mountain Technologies, Inc., is tasked with including in the operations manual the following:

a) Confirm that all the processing equipment and facilities' mechanical and electrical systems comply with the designed processing capacity and load rates.

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b) Describe the processing equipment vendor training information given for equipment such as the process controls, grinder, turner, watering system, screener and dust control systems. So that the City has documented in this operation manual all pertinent information that was covered during the training sessions and become the source of the key training lessons.
c) Identify the processing targets and settings for the processing equipment.
d) Provide the operation and maintenance of the aeration floor and servicing the cleanout system.
e) Provide the operation and maintenance of the probes, dampers, manifolds and leachate collection vault.
f) Provide the operation and maintenance of the aeration blowers and variable frequency drives.
g) Provide the operation and maintenance of the sedimentation systems, vault, pond and tank aerators, and the water reuse systems.
h) Provide the operation and maintenance of the biofilters and well and city water irrigation systems.
i) Provide the operation and maintenance of the control and data logging system. (Batteries, data handling, climate control in container, cleaning controls container vacuum into bags and exchanger filters).
j) Model how to oversee activities of the operations contractor for the city of Phoenix to see that they comply with the facility operational design and manuals and maintenance requirements.
k) Model how to oversee the sampling and testing of compost and composting parameters.
l) Provide a training protocol to train future city staff to oversee the site and take over the oversight duties when there is a changeover in personnel. Provide an expected training protocol for new City and Contractor staff to accomplish when they start a job surrounding the composting operations.

The overarching message the City, the Operations Contractor, and the Author want to instill in the reader is that SAFETY is the single most important objective in every activity undertaken at the COP 27th Ave. Compost Facility, and must be considered in proceeding with any activities within the facility.

The City and the Operator employees should behave as if they are all on the same team and must do their best to help one another to do the best job they can. If employees see something that is unsafe or could be improved upon to improve safe practices, they should bring it to their manager's attention.

All COP staff, Contract Operations personnel, Equipment Vendors and Service Contractors while at the composting site are REQUIRED to follow all:

- City of Phoenix transfer station safety rules & regulations
- Contract Operations company safety rules & safe work practices
- Equipment Manufacturer safety rules & operation manual instructions
- Federal and State mandated safety rules & regulations

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This Operations Manual does not encompass all the information on safety and safe workplace practices. It is every workers responsibility to know and follow the safety rules for the facility and the actions they undertake.

Listed below are the construction training videos uploaded to YouTube for reference unedited:

A. Site Construction and Operations Training Videos City of Phoenix COP Operations Plan 27th Ave. Compost

Design theory overview large composting system at COP Composting Large Scale 1.1 to 4.0 https://www.youtube.com/user/digitalcarbonzulu/playlists

0055 Contaminants Fluorescent Tube pallets construction waste https://youtu.be/JYimclRBx10

0056 Site operational overview, Irrigation, Grinding, turning, screening with grinder, wireless probes, food waste unloading bed https://youtu.be/kLCLCtgrCvE

40' Controls container overview https://youtu.be/ULxXVrcD38g%20

Nozzles and cleanouts on aeration floor https://youtu.be/sICzRvcBIac

Biofilter operation https://youtu.be/E4pzS08ilQs

Biofilter training https://youtu.be/_r5BNQD5GNM

Biofilter https://youtu.be/ynpHd2JTFD8

Brycon 1 Well https://youtu.be/GVtNK4Jm7Ak

Brycon 2 Well https://youtu.be/eK0pTexRZrg

Brycon 3 Weir https://youtu.be/PQCs0oMSsPA

Brycon 4 Weir https://youtu.be/loYsDvAmVDU

Brycon 5 Pond https://youtu.be/-6JulY1BGYc

Brycon 6 Aerators https://youtu.be/2-i-B1BFYxs

Brycon 7 N. Pond Outfall https://youtu.be/6ArAwMsFb3M

Brycon 8 N. Drainage https://youtu.be/xPYYwoOioH4

Brycon 9 Aerator Controls https://youtu.be/tSRhtQKJ1Jg

Brycon 10 Water Valves https://youtu.be/dyr8w4lVgEQ

Brycon 11 Water tank https://youtu.be/bjHLd2GQmz8

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Brycon 12 Water tank https://youtu.be/0nHGJrPFz-c

Chopper pump 1 https://youtu.be/tPEWIKlBCEc

Chopper pump 2 https://youtu.be/yi3NiWRzvII

Chopper pump 3 https://youtu.be/q2SOY4uaTrY

Chopper pump 4 https://youtu.be/IZ-OFo3P9R4

Control Display Explainer https://youtu.be/mAqexbxBM_I

Control system https://youtu.be/tdVTsuusp6E

Control System 2 https://youtu.be/aihdvxS6Xdc

Control system 3 https://youtu.be/s4A23r0dhHA

Control System 4 https://youtu.be/C3eTYtTFJuU

Control system HMI 2 https://youtu.be/zTLmiQJIv6g

Control System HMI 1 https://youtu.be/aSyOxJjilFM

Drainage observations https://youtu.be/1u0aLswj57A

Dust Boss Intro https://youtu.be/sWULezNhx9U

Dust Boss Controller https://youtu.be/wjE_mCgqXbI

Dust Boss Operation https://youtu.be/Y_a_t8z33RU

Dust Boss Operation 2 https://youtu.be/VU0DTSzIx38

Dust Boss 1 https://youtu.be/vu-bnqJaT8c

Dust Boss 2 https://youtu.be/h8RJKtYpTbo

Dust Boss 3 https://youtu.be/4km2Uocqu8c

Dust Boss 4 https://youtu.be/BqazDI2Aqs4

Dust Boss Hookup https://youtu.be/0GPuYOFnVUA

Field Control panel https://youtu.be/Mg8gJQl6cYQ

Main Panel https://youtu.be/hsYAdzmUVBE

Manhole layout https://youtu.be/wZPtCt9fi-M

Manifold https://youtu.be/fKISLx3BS6U

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Mister Ring	https://youtu.be/I_CxJ51TGcs
Sparger	https://youtu.be/F8SVQ5G_R0c
Sparger drillout	https://youtu.be/9__P14vpfZU
Sparger ring adjust deep	https://youtu.be/PUYtwvwO7lg
Sparger ring adjust shallow	https://youtu.be/mhVtsZzvJAw
Street Sweeper	https://youtu.be/K_fD-nNZRCU

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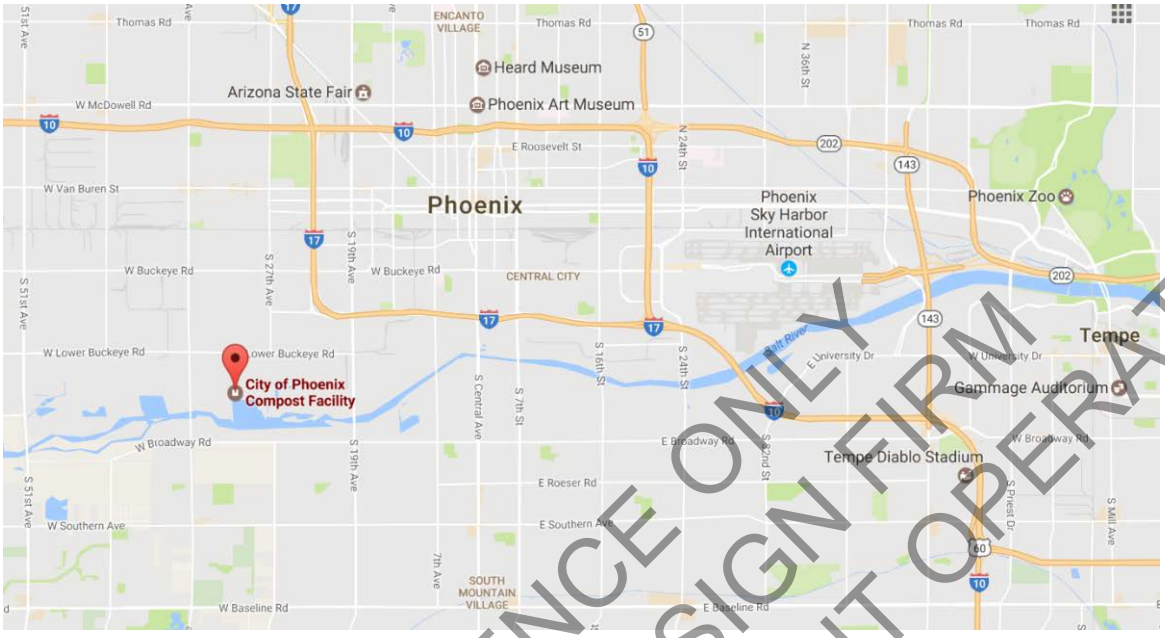
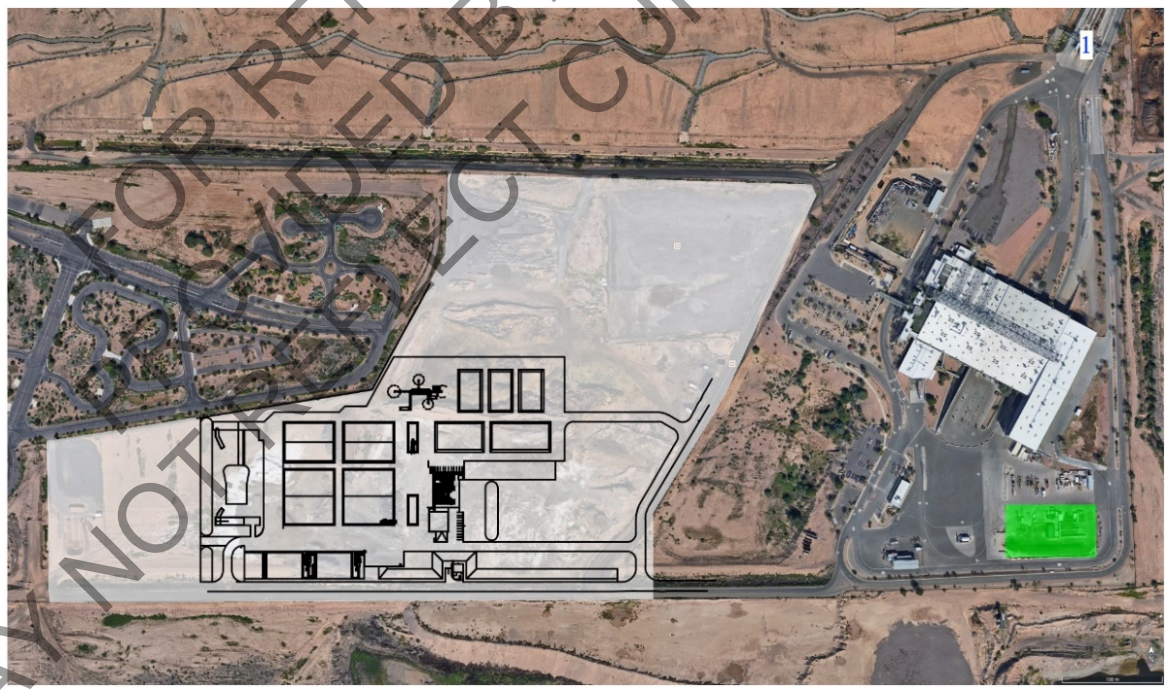
II. Facility Location

The COP 27th Ave. Compost Facility is located southwest of downtown Phoenix along the Salt River west of South 19th Avenue.[1]



The Compost Facility is adjacent to the City's 27th Ave Transfer Station. The following diagram shows the Compost Facility (on a white background) in relation to the Transfer Station and the Pilot Compost Site (shaded green). [2]



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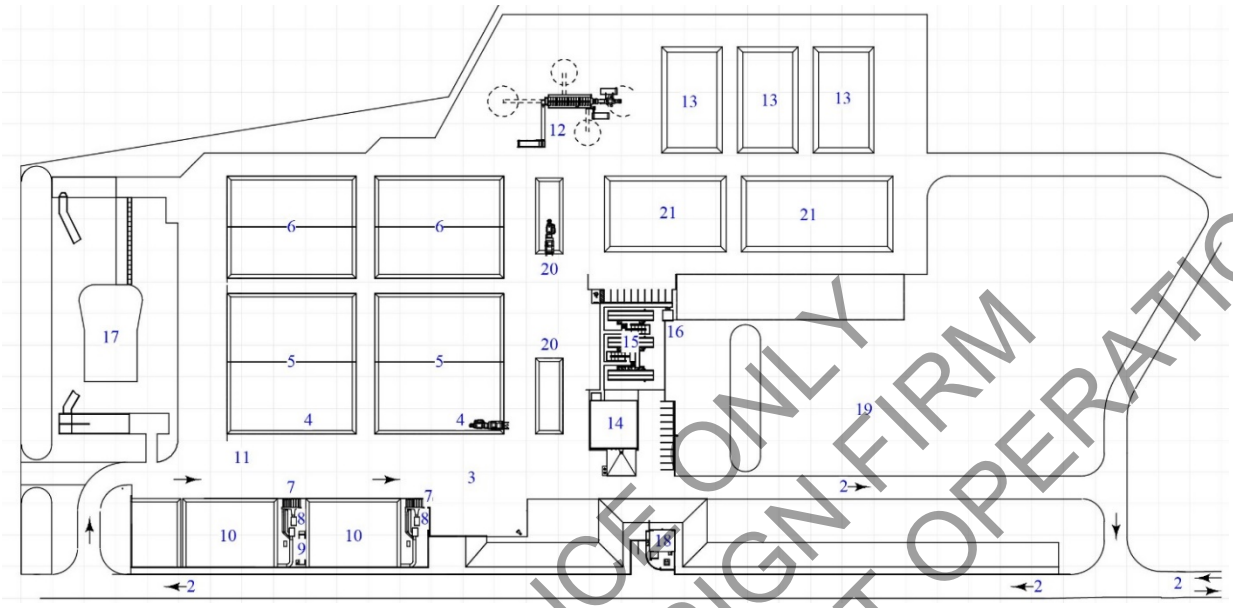
[1] Google Maps
[2] Google Maps with overlay by Digital Mechanics

III. Facility Layout & Processing Capacity

Layout

The facility size and features shown are for the Phase 1 - 110,000 tpy capacity. The numbers locate their expected position on the property. The legend describes their use:



The main components of the site are:

1. Truck scales at 127th Ave. (not shown) shared with the COP Transfer Station for weighing incoming feedstocks and also outbound compost products
2. Roadways leading to and from the COP Transfer Station scale-house, large truck traffic follows the arrowed route, small vehicle traffic comes in the opposite direction, unloads at area number 3 and exits with the large trucks.
3. Paved concrete areas designated for waste deliveries from commercial and residential haulers. Equipment used in this area includes:
    - Cat 950 front end loader
    - Kubota R530 front end loader
    - Sweeper: Laymor SweepMaster 300
    - Dust Boss (2 ea.) one near residential unloading, one near commercial unloading areas
4. Paved concrete areas designated for waste shredding, grinding and mixing operations. Equipment used in this area includes:
    - Shredder: Doppstadt AK-6355A
    - Horizontal Grinder: Vermeer HG8000TX
    - Kifco Small Hose Reel and sprinkler cart
    - Cat 950 front end loader
5. Concrete aeration pads with in-floor air supply and above ground temperature sensors for the active composting process. Equipment used in this area includes:
    - Turner: Vermeer CT-1010TX
    - DariTech Large Hose Reel and sprinkler cart
    - Sweeper: Laymor SweepMaster 300
    - Cat 966M front end loader w/roll-out bucket

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- Cat 950 front end loader and /or thumbed excavator

6. Turned Curing. Equipment used in this area includes
    - Turner: Vermeer CT-1010TX
    - Cat 966M front end loader/roll-out bucket
    - Dari-Tech Large Hose Reel
7. Above ground aeration blowers and dampers, provided by operations contractor as needed
8. Field controls for temperature & pressure sensors and aeration blower dampers
9. Controls building (container) for aeration blowers, compressor and wastewater pumps
10. Concrete biofilter pads with on-floor air supply from aeration blowers
11. Below grade sumps, tanks and pumps for management of process leachate/condensate
12. Millings surface areas for compost screening and refining operations. Equipment used in this area includes:
    - Cat 966M front end loader w/roll-out bucket
    - Trommel: Doppstadt SM-726
    - Mobile Separator Komptech Hurrifex
13. Curing Piles
14. Covered maintenance area
15. Office/Staff Facilities
16. Communications Information Technology Building
17. Storm Water Collection Pond and Sedimentation Weir
18. Electrical Building Main Shut-off
19. Areas set aside for Phase II infrastructure
20. Wood grinding and storage areas
21. Product ship out storage piles

Processing Capacity

The composting facility was designed to receive organic waste material and to sort and grind it within 2 hours of receipt at best and, at a maximum, on the same day as it is received. Bulk density of the received organic waste was expected to average 360 pounds per cubic yard after unloading. Moisture level of 28% as received for green waste and manure, and at 60% for food wastes. The facility capacity numbers are based on 7 days a week operation, even though materials are only received 6 days a week, to reflect the total retention time of materials received in the specific design areas. Within the turned curing area and screened product areas, the bulk density in yellow was adjusted to reflect the expected volume loss during turned aerated processing. The following page has a graphic that includes the receiving area capacity and expected water use by water source.

Phase 0.5 Processing capacity calculations				Based on 7 days a week operations												
	Area			Volume in place		Days	Capacity	Volume	Bulk density Estimate		Capacity	Tons	Annual Tonnage Estimate		
Turned Aerated Processing																
	Width	170	feet	8,264	cubic yards	23	359	cu.yd./day	850	lbs/cu.yd	153	tons/day	55,736	tpy	Average capacity
	Length	175	feet	1.5	Peaking factor										
Initial	Height	7.5	feet	8,264	cubic yards	15	539	cu.yd./day	850	lbs/cu.yd	229	tons/day	83,605	tpy	Peak capacity
Turned Curing															
	Width	130	feet	5,224	cubic yards	22	237	cu.yd./day	1,275	lbs/cu.yd	151	tons/day	55,253	tpy	Average Capacity
	Length	175	feet	1.5	Peaking factor										
Restack	Height	6.2	feet	5,224	cubic yards	15	356	cu.yd./day	1,275	lbs/cu.yd	227	tons/day	82,880	tpy	Peak capacity
Screened Product storage		3	piles												
	Width	72	feet	4,800	cubic yards	20	240	cu.yd./day	1,275	lbs/cu.yd	153	tons/day	55,845	tpy	Average Capacity
	Length	60	feet	1.5	Peaking factor										
Restack	Height	10	feet	4,800	cubic yards	13	360	cu.yd./day	1,275	lbs/cu.yd	230	tons/day	83,768	tpy	Peak capacity
					Avg Retention	65	Total days avg		33%	volume loss shown in Bulk Density estimate					
					Peak Retention	43	Total days peak								

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Phase 0.5 Processing capacity calculations with water use

Receiving grinding

	Area			Volume in place		Days	Capacity	Volume	% moisture	Target %	Water App.	Units	Bulk density Estimate		Capacity		Annual Tonnage Estimate		
	Width	60	feet	867	cubic yards	1	867	cu.yd./day	28%	50%	8,580	gallons/day	360	lbs/cu.yd	156	ton/day	56,940	tpy	Average capacity
	Length	100	feet				1.5	peaking factor	Average initial application		24	gpm	From well or tank water						
	Height	3.9	feet	867	cubic yards	0.6666	1300	cu.yd./day	28%	50%	12,870	gallons/day	360	lbs/cu.yd	234	tons/day	85,410	tpy	Peak capacity
									Peak initial application		36	gpm	From well or tank water						
Turned Aerated Piles		2.00%	/day water loss																
	Width	170	feet	8,264	cubic yards	23	359	cu.yd./day	47%	55%	12,216	gallons/turn	850	lbs/cu.yd	153	tons/day	55,736	tpy	Average capacity
	Length	175	feet		Turning frequency	4	1.5	Peaking factor	Average application/turn		59	gpm	from tank water						
Initial	Height	7.5	feet	8,264	cubic yards	15	539	cu.yd./day	51%	55%	5,495	gallons/turn	850	lbs/cu.yd	229	tons/day	83,605	tpy	Peak capacity
					Turning frequency	2			Peak application/turn		27	gpm	from tank water						
Turned Curing		1.00%	water loss per day																
	Width	130	feet	5,224	cubic yards	22	237	cu.yd./day	51%	55%	6,055	gallons/turn	1,275	lbs/cu.yd	151	tons/day	55,253	tpy	Average Capacity
	Length	175	feet		Turning frequency	4	1.5	Peaking factor	Average application/turn		46	gpm	from well water						
Restack	Height	6.2	feet	5,224	cubic yards	15	356	cu.yd./day	52%	55%	3,738	gallons/turn	1,275	lbs/cu.yd	227	tons/day	82,880	tpy	Peak capacity
					Turning frequency	2			Peak application/turn		29	gpm	from well water						
Screened Product Storage		3	piles																
	Width	72	feet	9,600	cubic yards	40	240	cu.yd./day	52%	42%	0.3%	loss per day	1,275	lbs/cu.yd	153	tons/day	55,845	tpy	Average Capacity
	Length	120	feet				1.5	Peaking factor											
Restack	Height	10	feet	9,600	cubic yards	27	360	cu.yd./day					1,275	lbs/cu.yd	230	tons/day	83,768	tpy	Peak capacity
													50%	reflects 50% volume loss					

Phase 0.5 Water Use					**Total Water demand**		**Tank water demand**		**Well water demand**		**City Water demand**	
	Avg Retention	85	Total days avg	Avg. Gallons used per day	13,148	gallons/day	11,634	tank gpd	1,514	well gpd	0	City gpd
	Peak Retention	57	Total days peak	Peak Gallons used per day	17,163	gallons/day	14,244	tank gpd	935	well gpd	0	City gpd
	Blower mister	Used when ambient temperatures exceed 90 degrees			10,800	gallons/day	0	tank gpd	10,800	well gpd	0	City gpd
	Area mister	2 misters used 8 hours per day			7,200	gallons/day	0	tank gpd	0	well gpd	7,200	City gpd
	Water truck	3	loads/day	5,000 gallons/load	15,000	gallons/day	0	tank gpd	15,000	well gpd	0	City gpd
	Biofilter irrigation				7,344	gallons/day	0	tank gpd	7,344	well gpd	0	City gpd
	Recovered condensate				(4,320)	gallons/day	(4,320)	tank gpd	-	well gpd	0	City gpd
				Total Phase 0.5 Peak	53,187	gallons/day	9,924	tank gpd	34,079	well gpd	7200	City gpd

Phase 1 Processing capacity calculations with water use

Receiving grinding

	Area			Volume in place		Days	Capacity	Volume	Initial % moisture, Target		Water App.	Units	Bulk density Estimate		Capacity		Annual Tonnage Estimate		
	Width	60	feet	1733	cubic yards	1	1733	cu.yd./day	28%	50%	17,160	gallons/day	360	lbs/cu.yd	312	ton/day	113,880	tpy	Average capacity
	Length	100	feet				1.5	peaking factor	Average initial application		47.67	gpm	From well or tank water						
	Height	7.8	feet	1733	cubic yards	0.6666	2600	cu.yd./day	28%	50%	25,740	gallons/day	360	lbs/cu.yd	468	tons/day	170,820	tpy	Peak capacity
									Peak initial application		71.50	gpm	From well or tank water						
Turned Aerated Piles		2.00%	/day water loss																
	Width	170	feet	16,528	cubic yards	23	719	cu.yd./day	47%	55%	24,432	gallons/turn	850	lbs/cu.yd	305	tons/day	111,473	tpy	Average capacity
	Length	350	feet		Turning frequency	4	1.5	Peaking factor	Average application/turn		59	gpm	from tank water						
Initial	Height	7.5	feet	16,528	cubic yards	15	1078	cu.yd./day	51%	55%	10,990	gallons/turn	850	lbs/cu.yd	458	tons/day	167,209	tpy	Peak capacity
					Turning frequency	2			Peak application/turn		26.60	gpm	from tank water						
Turned Curing		1.00%	water loss per day																
	Width	130	feet	10,448	cubic yards	22	475	cu.yd./day	51%	55%	12,110	gallons/turn	1,275	lbs/cu.yd	303	tons/day	110,507	tpy	Average Capacity
	Length	350	feet		Turning frequency	4	1.5	Peaking factor	Average application/turn		46	gpm	from well water						
Restack	Height	6.2	feet	10,448	cubic yards	15	712	cu.yd./day	52%	55%	7,476	gallons/turn	1,275	lbs/cu.yd	454	tons/day	165,760	tpy	Peak capacity
					Turning frequency	2			Peak application/turn		29	gpm	from well water						
Screened Product storage		3	piles																
	Width	72	feet	9,600	cubic yards	20	480	cu.yd./day	52%	42%	0.5%	loss per day	1,275	lbs/cu.yd	306	tons/day	111,690	tpy	Average Capacity
	Length	120	feet				1.5	Peaking factor											
Restack	Height	10	feet	9,600	cubic yards	13	720	cu.yd./day					1,275	lbs/cu.yd	459	tons/day	167,535	tpy	Peak capacity
													33%	volume loss shown in Bulk Density estimate					

Phase 1 Water Use					**Total Water demand**		**Tank water demand**		**Well water demand**		**City water demand**	
	Avg Retention	65	Total days avg	Avg. Gallons used per day	26,296	gallons/day	23,268	tank gpd	3,028	Well gpd	0	City gpd
	Peak Retention	43	Total days peak	Peak Gallons used per day	34,326	gallons/day	28,488	tank gpd	1,869	Well gpd	0	City gpd
	Blower mister	Used when ambient temperatures exceed 90 degrees			21,600	gallons/day	0	tank gpd	21,600	Well gpd	0	City gpd
	Area mister	Used 8 hours per day			3,600	gallons/day	0	tank gpd	0	Well gpd	3,600	City gpd
	Water truck	4	loads	5,000 gallons/load	20,000	gallons/day	0	tank gpd	20,000	Well gpd	0	City gpd
	Biofilter irrigation				15,688	gallons/day	0	tank gpd	15,688	Well gpd	0	City gpd
	Recovered condensate				(8,640)	gallons/day	(8,640)	tank gpd	-	Well gpd	0	City gpd
				Total Phase 1 Peak	86,574	gallons/day	19,848	tank gpd	59,157	Well gpd	3600	City gpd

Equipment Processing Capacity

The essential processing equipment was purchased by the City for Phase 0.5 to process the green waste with a grinder, to turn the compost with a turner, to screen the finished product and systems to water the compost and to suppress dust, finally loaders were purchased to feed the equipment and pack the processed material to the different staging areas. Cleanup tools purchased include the rubber edged bucket on one of the loaders, the construction broom to sweep debris to the piles, and a water truck to wash down drive areas. The sorting equipment for manual inspecting for contaminants in food waste was delayed until Phase 1, however the City purchased a Hurrifex to remove plastics and rocks from the screened overs, and two Airlift Separators to remove plastic film from conveyor belts. Within the Operating contract, the sorting equipment is to be purchased by the operator, and the equipment designed by the facility design team will be shown, but I not required.

During Start-up and Commissioning, several challenges were discovered with the processing equipment purchased and the design processing capacity was seriously questioned. The processing equipment selected was designed for the 110,000 tpy operation. Equipment maintenance was intended to be done in the evenings not during expected production times listed. The production hours and capacity listed in the design capacity table below are for when the machine is actively working on the materials and does not include breaks, communication and other non-production activities like cleaning. The general goal of the design was to be able to process the average design day's material within a 6-hour time frame each day. Peak volume days must have equipment work an additional 3 hours. Proven volume in red shows unable to obtain goals for production at 110,000 tpy

Design Capacity and Startup Experience

Machine	Daily Volume cy/d Phase 1	Hourly Volume Expected cy/hr	Proven Volume	Note:
Grinder Tracked Horizontal	1,733 cy/d	288	523 261	Un-ground density w/excav. Unground with loader & grap
Loader with Grapple	2,600 cy/d	433	391	Grab & load to grinder, push up unground. July 15 trial
Compost Turner	9,000 cy/3d of every 4d	1,500	1,575	3 days turn, one screening, 2,700 tph – 25 min/hr water
Trommel Screener	1,800 cy/every 4th day	300	150 not verified	½" screen, no grinding <42% moisture
Hurrifex	450 every 4th day	75	No info reported	Should not be ground before screening
Loader for Packing	1,800 cy/d	300	No info reported	Pack across divide 1 day, Screen 1 day, Rescreen 1day, Load out last day of 4
Sortline 25% of incoming loads, small loader fed.	433 cy/d	72 cy/hr 13 tph	N/A	Floor sort, Shred, Disc screen, Magnet, Neg. hand sort fines and overs on belt*

* https://www.biocycle.net/2014/12/17/composter-brings-on-residential-food-scraps-stream/
http://www.sfgate.com/green/article/Taking-out-the-trash-Municipal-green-waste-needs-3301750.php

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IV. Summary of the Science and Practice of Composting

Many books, research papers and magazine articles have been written about the science and practice of composting. While this operation manual will refer to many of the basic principles contained in these publications, it will not take their place. More detailed information on the topics presented in this manual can easily be found by conducting a basic literature search. The Compost Operator Manual provides a cogent resource. http://www.transformcompostsystems.com/learn-compost-operator-manual.php

A. What is "Compost"?

Photo: A handful of finished compost product (photo: GMT)

At the COP 27th Ave. Compost Facility, the term "compost" refers to a marketable soil amendment produced by the controlled biological breakdown of select organic waste streams from the City.
These "select" waste streams consist of the materials allowed in page 49 the Operations contract:

E. Acceptable feedstocks for the temporary mulching area include:
   1. Tree Branches, limbs, and stumps not to exceed the length and diameter authorized in the most current version of Chapter 27 of City Code
   2. Flowers, plants and shrubs
   3. Grass clippings and leaves
   4. Fruit and garden waste
   5. Undecorated Christmas and Holiday trees, Lumber, sawdust, wood chips and wood waste (untreated/unpainted) and pallets
   6. Palm Fronds; and
   7. Large Animal (Herbivore) Manure and Bedding

F. Acceptable feedstocks for the compost facility include:
   1. All Green Organics, as identified above
   2. Food Scraps:
      a. Unconsumed food and scraps
      b. Food soiled paper (including paper plates, paper towels, paper "to go" packaging, napkins, tissues and pizza boxes)
      c. BPI Certified Products
      d. Clean construction and demolition wood

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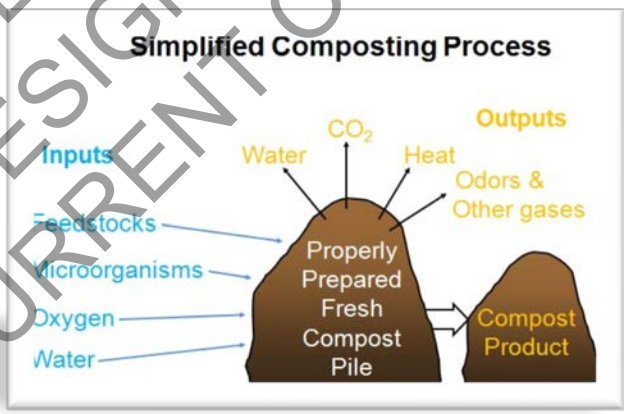
B. What is "Composting"?

The term "composting" at the COP 27th Ave. Compost Facility refers to the **process** used to transform the organic waste materials delivered to the facility into a "compost" **product**. Facility staff must continually focus on managing that process to manufacture a consistent high quality compost product.

Photo: Actively Composting Organic Waste (photo: GMT)

In its most simplistic definition, composting is the process of mixing together the correct amount of organic wastes (feedstocks), microorganisms, oxygen and water under controlled conditions to produce compost. The by-products of that process are water, carbon dioxide, heat and other gases. If the process is well managed, it results in three things; a reduced volume of material, a compost product that is stable and a compost product that is mature. The following diagram represents this basic process.[3]



Until the early 1990's, the composting industry in the U.S. was not well organized. The industry had no national "voice" to respond to national regulatory issues or to promote industry growth. More importantly, the industry had no universally accepted standards or practices on what compost was or how to produce it. Instead, the industry consisted of hundreds of individual compost producers who ran their operations based on everything from individual knowledge and experience to partnerships with university researchers and consulting engineers. In 1992 that began to change with the formation of the United States Composting Council (USCC). During the first 2 years of its existence, the USCC procured funding to hire a consulting firm (R.W. Beck & Associates) to interview hundreds of compost producers with one goal in mind, to establish universally accepted standards and practices to define and document the composting process and compost products. Their two-year effort consisted of site visits, workshops, writing committees, compiling drafts of

[3] Simplified Composting Process diagram courtesy of GMT

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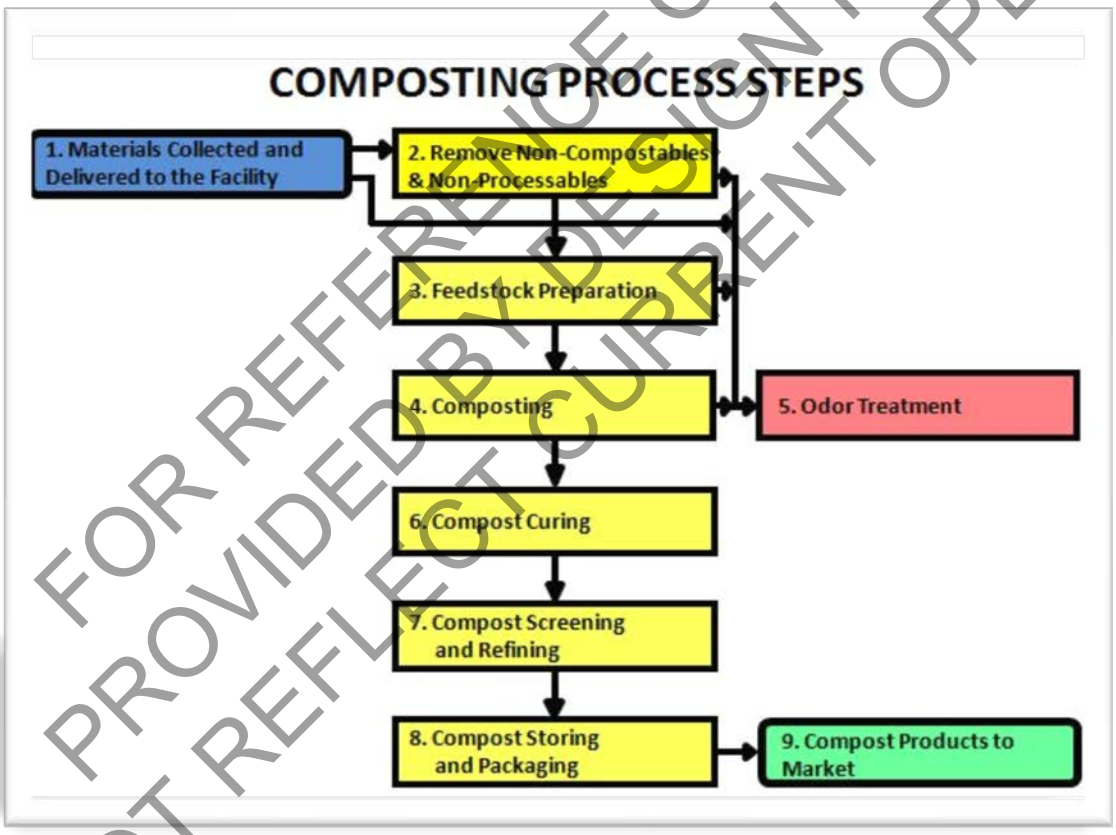
standards and practices and a peer review process resulting in the production of the Compost Facility Operating Guide (CFOG)[4] and other key industry reference materials.

Within the pages of the CFOG, the industry had its first working definitions of:

- the composting "best practices"
- product standards
- composting process with distinct steps
- key process variables affecting that process
- standard Composting Process Steps and their Key Process Variables

The following figure shows the basic steps in the composting process.[5] The steps as presented have been modified slightly to align with the COP 27th Ave. Compost Facility operation. Each step in the composting process has its own inputs and outputs.



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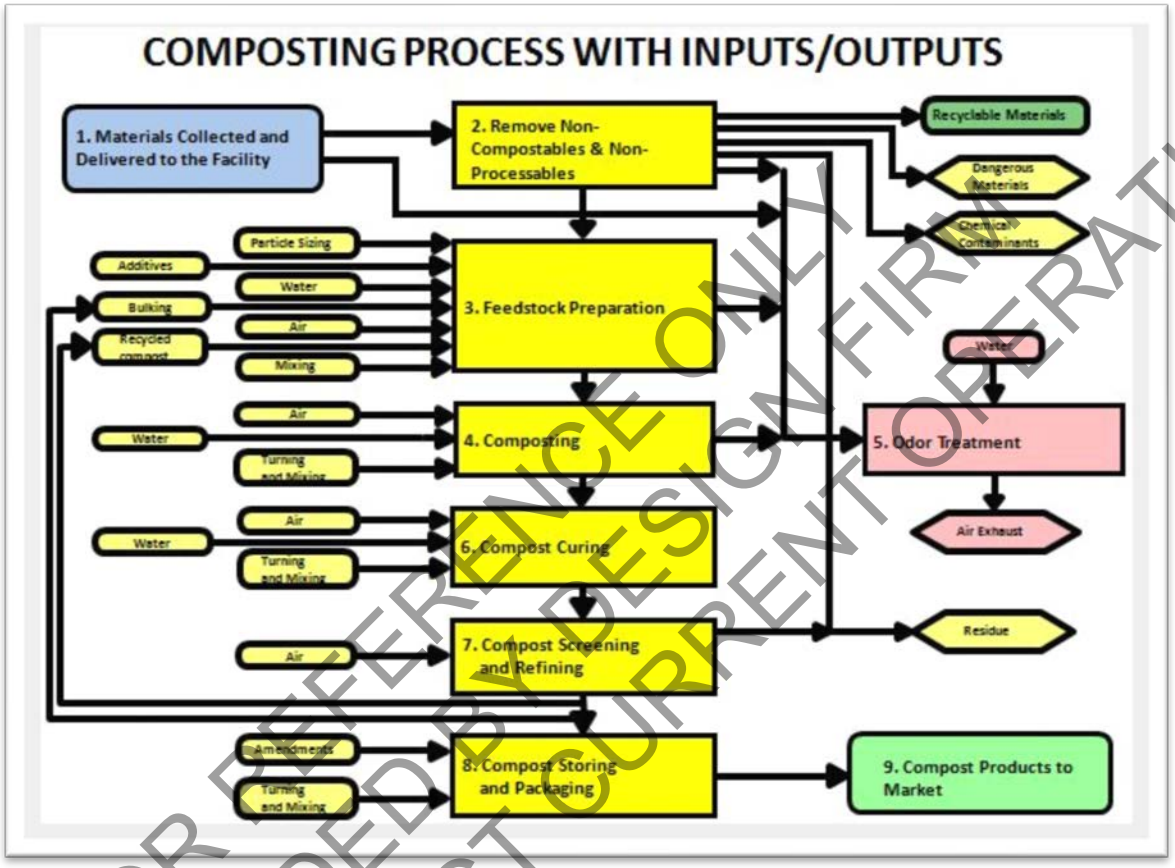
[4] Compost Facility Operating Guide: A Reference Guide for Composting Facility and Process Management. Alexandria, VA: The Composting Council, 1994.
[5] Compost Facility Operating Guide: A Reference Guide for Composting Facility and Process Management. Alexandria, VA: The Composting Council, 1994.

The following diagram includes these inputs and outputs.[6] The steps as presented have been modified slightly to align with the COP 27th Ave. Compost Facility operation.



Priorities for the 27th Ave. Compost Facility are to manage the feedstock preparation process of grinding and watering at the same time, as when dry particles are ground, they have released a bit of moisture and are fractured with the maximum amount of surface area to absorb water. If the ground materials are allowed to dry again before actively being composted, the newly opened pores shrink and can become hydrophobic making it very difficult to get the material wet enough again to efficiently compost.

Porosity is expected to be easily managed due to the woody characteristics of most of the feedstocks. As significant quantities of food waste begin to be introduced, porosity must then become the greatest priority, along with removal of non-compostable materials. Moisture will likely be less important as more moisture will arrive with the food waste. When ground together at an approximate ratio of 75% woody green waste and 25% food waste, moisture and porosity are likely to be adequate during feedstock preparation.

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[6] Compost Facility Operating Guide: A Reference Guide for Composting Facility and Process Management. Alexandria, VA: The Composting Council, 1994.

The following table identifies the key process variables and when each must be managed during the composting process.[7] The steps as presented have been modified slightly to align with the COP 27th Ave. Compost Facility operation.

MANAGEMENT OF KEY PROCESS VARIABLES									
KEY PROCESS VARIABLES	Step 1 Materials Collected and Delivered to the Facility	Step 2 Remove Non-Compostables and Non-Processables	Step 3 Feedstock Preparation	Step 4 Composting	Step 5 Odor Treatment	Step 6 Compost Curing	Step 7 Compost Screening and Refining	Step 8 Compost Storing and Packaging	Step 9 Compost Products to Market
PILE STRUCTURE (POROSITY)	✓	✓	✓	✓	✓	✓	✓	✓	
NUTRIENT BALANCE	✓	✓	✓						
OXYGEN (and pH)			✓	✓	✓	✓		✓	
MOISTURE	✓	✓	✓	✓	✓	✓	✓	✓	
TEMPERATURE				✓	✓	✓			
TIME			✓	✓	✓	✓		✓	

A checkmark in the table indicates a step in the process where that variable must be managed. Notice that porosity and moisture must be managed at each step. Control over these variables is essential at each step until the products are sold.

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[7] Compost Facility Operating Guide: A Reference Guide for Composting Facility and Process Management. Alexandria, VA: The Composting Council, 1994.

C. Composting Process Steps Defined

The following descriptions of the individual steps in the composting process are presented as a general overview. They will be discussed in detail later in this manual as they relate specifically to the COP 27th Ave. Compost Facility.

1. Materials Delivered to the Facility

Scale house operations at the City of Phoenix 27th Ave Transfer Station (photo: Google Maps)

The delivery steps consist of:

- Recording the inbound weight of each vehicle delivering organic wastes to the facility by COP scale operators
- Recording the specific type of organic waste being delivered by each vehicle by COP scale operators
- Recording the outbound weight of each vehicle after dropping off their load by COP scale operators
- Rejecting loads that are observed to contain non-compostables or non-processables by Operations Contractor or City Staff
- Delivery of collected data by the COP scale operators to the Operations Contractor

The data collected during these steps is used to define the amount of:

- Each type of organic waste received each day,
- In-process material in the active composting or curing steps,
- Rejects removed from the feedstock recovery and screening & refining steps,
- Screening overs generated and available for recycle and finished products on site.

The City may intercept loads and direct them to their diversion area to inspect and pick out gross contaminants, then reload them into drop boxes for delivery to the compost facility unloading area. It is intended that the City will be tracking routes and collection customers and engaging in intensive feedback and response training to get clean feedstocks coming in to the compost facility directly. Good communications and cooperation between the Operations Contractor and the City could help to improve the cleanliness of the incoming wastes far into the future.

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Materials that will be processed at the 27th Ave. Compost Facility will include:

- Tree Branches, limbs, and stumps not to exceed the length and diameter authorized in the most current version of Chapter 27 of City Code
- Flowers, plants and shrubs
- Grass clippings and leaves
- Fruit and garden waste
- Undecorated Christmas and Holiday trees, Lumber, sawdust, wood chips and wood waste (untreated/unpainted) and pallets
- Palm Fronds; and
- Large Animal (Herbivore) Manure and Bedding

Food Scraps:

- Unconsumed food and scraps
- Food soiled paper (including paper plates, paper towels, paper "to go" packaging, napkins, tissues and pizza boxes)
- Biodegradable Plastics Institute (BPI) Certified Products

The following materials **will not** be accepted for composting: Plastics, rocks, glass, metal, painted-glued or treated wood, dog or cat manure, kitty litter, rope, twine, baling wire or fencing, fertilizers or pesticides, toys, tools, concrete, grease, petroleum oil, rubber, styrofoam, cans, buckets, hair, carcasses, soil from areas around house or building foundations.

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2. Receiving Delivered Organic Waste

Incoming wastes delivered to the tipping area are inspected by the load spotter for non-processables and non-compostables prior to processing.

Incoming loads determined to contain these non-processables and non-compostable materials will be processed manually and mechanically to remove these items prior to grinding. All non-processables and non-compostables will be set aside for disposal.

3. Removing Non-Compostables and Non-Processables

After removing all non-processable and non-compostable materials, the clean feedstocks will be immediately incorporated into the days "mix" or sent to designated piles based on type to wait for further processing.

In the case of high odor potential deliveries, special procedures will be employed to inspect and potentially reject them. Accepted waste that is determined to have high odor potential, but is considered to be manageable, will be immediately incorporated into the days "mix" or covered to mitigate odors until further processing.

4. Feedstock Preparation – Porosity/Nutrient/Moisture

Feedstock Preparation is one of the most important and demanding steps in the composting process.

To transform organic waste into a marketable compost product in the shortest time possible it must be properly prepared to establish the initial porosity, nutrient balance and moisture content.

At the 27th Ave. Compost Facility, the feedstock's initial porosity, nutrient balance and moisture content will be set by developing and using a mix "recipe". The mix recipe spells out how much of each type of organic waste received will be mixed with the others to end up with the desired mix. The mix recipe is adapted and determined by the Facility Operator to meet their product targets.

a) Porosity

Porosity is the amount of free air space in the material. Porosity is required for air to travel through the compost to deliver oxygen to the microbes and to remove carbon dioxide and heat from the pile. Porosity is established by mixing coarse bulking material, usually wood waste or green waste, with denser materials such as food waste, manure or grass clippings which have a very low porosity. If the porosity is too low, insufficient air passes through the pile and decomposition rates slow or stop. If porosity is too high, the piles dry too fast and stop composting, if the porosity is too low, the piles can become anaerobic very quickly.

The following diagram shows the difference between materials with a high porosity (on the left) with materials having a low porosity (on the right.) While each has the same material, with the same water film, only the one with high porosity will allow air to flow between the particles bringing oxygen to the microorganisms.

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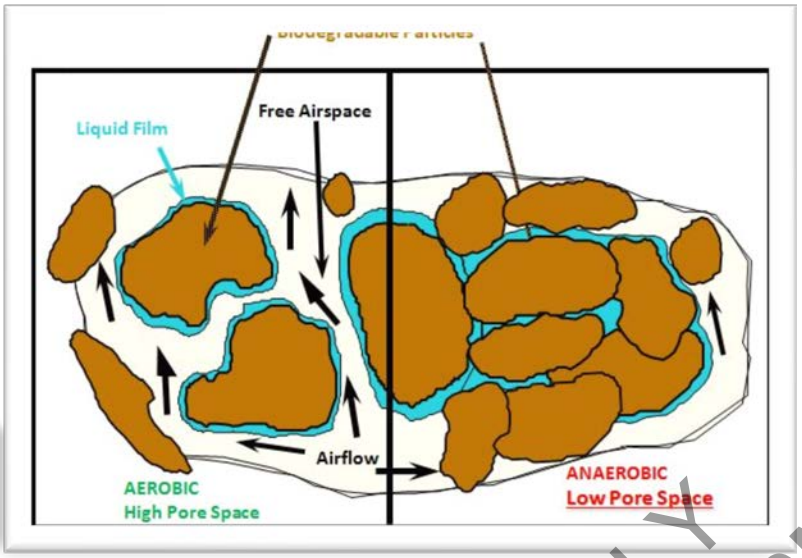
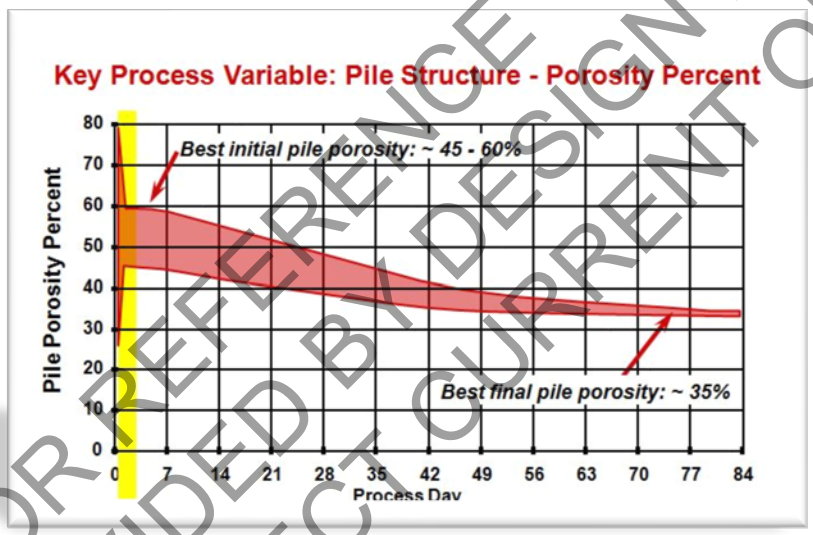


Properly prepared feedstocks should have a free air space of between 45% to 60%. (Slide: from USCC modified by GMT)



Porosity is tested in the field by using a 5-gallon bucket and a weigh scale, using filling and dropping techniques that mimic compost pile conditions, and then filling the weighed and prepared sample with water. The known bulk density of water is used to then calculate the water filled voids in the sample. Porosity changes over time. The best time to manage porosity is in the initial mix where a porosity range between 45% to 60% Free Air Space (FAS) is considered appropriate for setting up good composting conditions. Systems using forced aeration and frequent turning can handle lower levels of initial pile porosity. The 27th Ave. Compost Facility is designed to handle mixes that are lower in initial pile porosity. Bulk density of a known moisture content and compost mix can over time be correlated to free air space and is faster and easier to test in the field. The field test methods is included in the appendix at the end of this operations manual.

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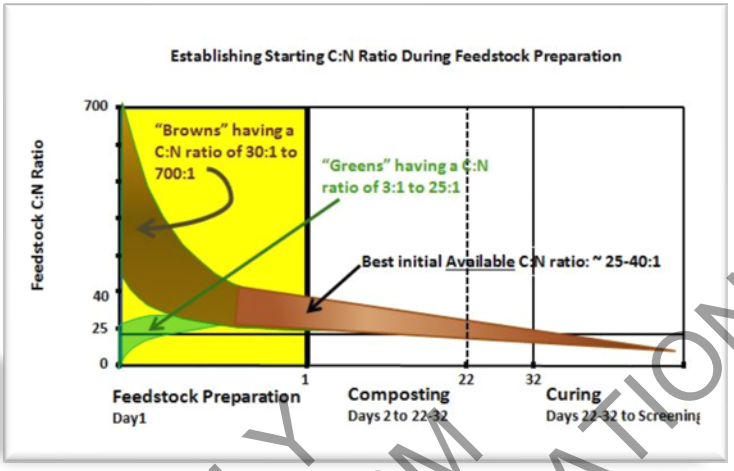
b) Nutrient Balance

Nutrient Balance primarily refers to the ratio of Carbon to Nitrogen in the material. Some materials like grass clippings, food waste and animal manures have very low C:N ratios. Feedstocks with low C:N ratios are often referred to as “greens”. Other materials such as shredded tree limbs have a very high C:N ratio. Feedstocks with high C:N ratios are often referred to as “browns”.



Just as humans need a balanced diet, so do the microorganisms in the compost pile. If the initial C:N is too high, for instance 60:1, then the nitrogen will be consumed before all the carbon is composted. If it is too low, for instance 15:1, then the carbon will be consumed before all the nitrogen is composted and nitrogen can be lost to the air and water.

Properly prepared feedstocks should have a C:N ratio in the range of approximately 25:1 to 40:1. This is best tested using samples of the different feedstock going to a laboratory or using representative book values and C:N calculators.

During startup of the COP 27th Ave. Compost Facility, GMT recommends that the contract operations group use the following “mix recipe” to establish the feedstock C:N ratio. **The mix is based on the volumes of feedstocks** added **to the grinder.** This “recipe” can be adjusted over time as the operations group gains experience with the COP’s unique feedstocks and seasonal variations in waste receipts.

- 5 Parts Green Waste
- 1 Part Food Waste
- 1 Part Wood Waste
- 1 Part Animal Manure

The mix ingredients must be ground together to ensure that all food materials and manure have been broken apart and reasonably homogenized for proper nutrient balance and maximum accessibility by microorganisms. The grinder operator should endeavor to keep the mix going into the grinder as consistent as possible with the feedstocks on hand.

The following graph depicts that “high” C:N ratio feedstocks (“browns”) are mixed with “low” C:N ratio feedstocks (“greens”) to establish the proper C:N ratio during Feedstock Preparation. (Slide courtesy of GMT)

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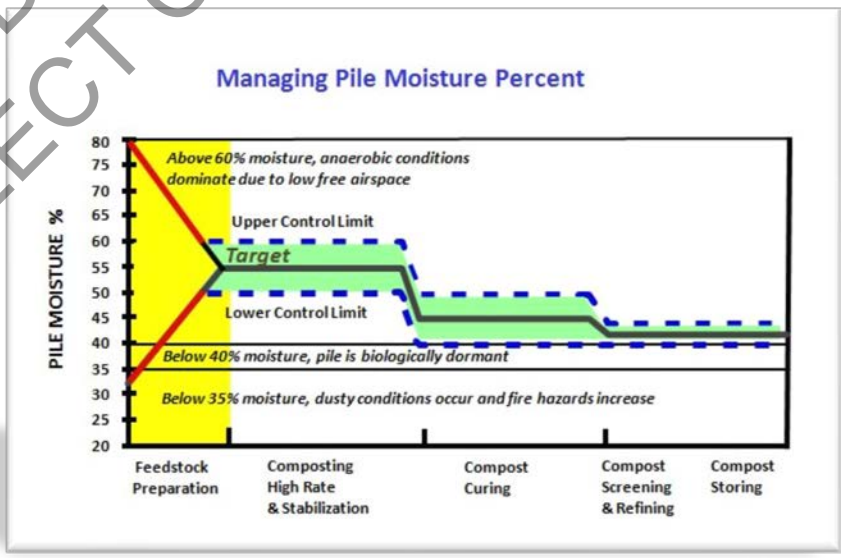
c) Moisture Content

Moisture Content is a measure of how much of a material is made up of water. Some materials like grass clippings, food waste and animal manures may have a very high moisture content. They may have moisture contents as high as 80% or more. Other materials such as shredded tree limbs typically have a very low moisture content. These may have moisture contents as low as 20%. While grinding the incoming feedstocks according to the "mix recipe", water is added to the discharge conveyor of the grinder to insure an initial moisture percent of 50 to 60% in the prepared feedstocks. It is essential to start the composting process with a thin film of water on all the surfaces of the particles to be composted. This is where microbes multiply and move and develop enzymes to break down the organic materials. Thin frequent surface applications work better than saturating the materials to be composted. When materials are moved off a conveyor belt, this provides the perfect location to add enough water consistently to thin layers of the feedstock. The watering system off the end of the grinder conveyor belt, and the compost turner are perfect examples. Turning a pile just after a heavy surface application of water can also work.

Properly prepared feedstocks should have a moisture content of between 50% and 60%. The diagram above depicts the target moisture percent throughout the composting process. During Feedstock Preparation, wet and dry feedstocks are ground together according to the "mix recipe". As the material exits the grinder conveyor, leachate from the tank water or the city or well water is added from the hose reel to make final moisture adjustments. Estimates are made by the operator prior to grinding, and they set the volume of water to add. (Diagram: GMT modified USCC slide)



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5. Composting

Once the feedstock has been properly prepared, composting can begin.

The main objectives of this step are to:

- Break down the prepared feedstocks to reduce its volume and to transform it into a more stable and mature material prior to curing. In general terms, this is done by providing the microorganisms decomposing the material with the proper environment to compost.
- Attain and maintain temperatures at or above 55°C as prescribed by federal biosolids 40 CFR 503 requirements to reduce pathogens and vector attraction in composted products.
- Maintain oxygen levels in the active compost piles above 12% to prevent the formation of anaerobic conditions leading to the production of malodors.
- Periodically turn the material to break up clumps and lumps, re-add moisture as necessary, thoroughly re-mix the material, tear open new surfaces to expose them to the microorganisms and to move the material across the aeration pad as specified.

The composting process is easier to understand by looking at it from the microorganism's perspective. The microorganisms used in composting need fundamentally the same things that humans need to exist: food, water, air and the right temperature. If these needs are met consistently, the microorganisms become efficient at rapidly decomposing the organic materials (food) presented to them.

a) Nutrients (Food)

During the feedstock preparation step the composter has carefully prepared the microorganisms with the food that they like. That is, feedstocks with a C:N Ratio of approximately 30:1, a moisture content of 50-60% and a porosity of 60%. These foods are best mixed together closely and cut bruised or fractured to have a a multitude of exposed surfaces that microorganisms can begin to digest. Sugars, fats, and proteins are eaten quickly and generate a lot of energy early in the process. Cell walls of plants and woody materials are decomposed more slowly. If pile moisture is maintained, nutrients can be conserved and reused by the next stage of microorganisms.

b) Moisture (Water)

During feedstock preparation, the moisture content of the feedstock has been established at 50% to 60%. However, during the composting process, the moisture content of the pile may change quickly (typically going down). If it does, the composter must periodically add more water as necessary to ensure that it remains at 50-60% during the composting process. When organic matter dries, it can become hydrophobic and become very difficult to rewet. Composting occurs in the thin layer of water on the surface of the particles.
It helps act as a solvent and delivers enzymes produced by the microbes to the cells being digested.

c) Oxygen (Air)

Just like humans, aerobic microorganisms require oxygen to live. They use the oxygen to break the carbon chains in a rapid biological/chemical oxidation process. In a properly prepared compost pile however, the microorganisms can use up all the air in a matter of minutes. Once they have done so, they will essentially stop composting until more oxygen becomes available**. At the 27th Ave. Compost Facility air blowers are used constantly** to force fresh air into the pile (positively or negatively) so microorganisms can breathe.

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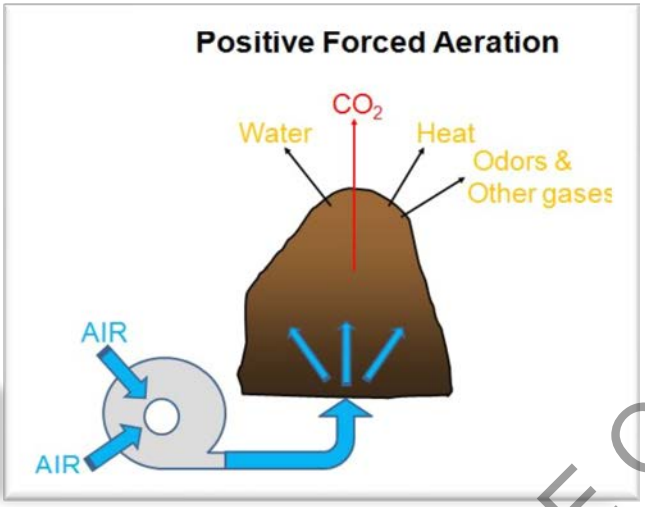
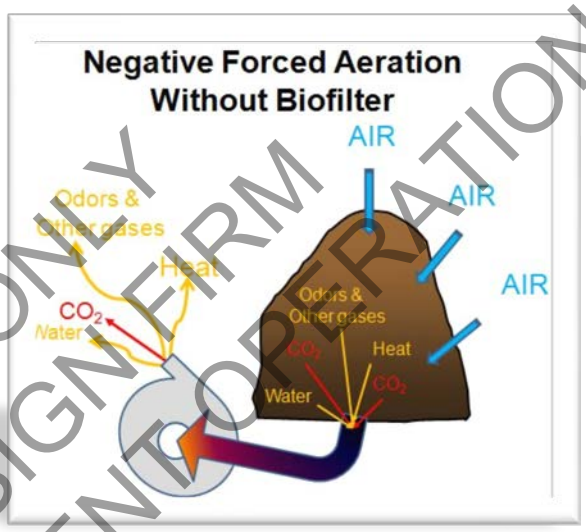
Forcing fresh air into a compost pile to provide microorganisms with oxygen has several side effects within the pile. These side effects include rapid decomposition, releasing odors, removing carbon dioxide, lowering moisture content and reducing temperature. The following diagram depicts this process. (Diagrams: courtesy of GMT)





d) Release of Odors

As fresh, oxygen rich air is forced into the pile, it automatically forces out oxygen deficient air residing in the free air space of the composting pile. Air that has resided inside the pore spaces of the pile becomes concentrated with chemical compounds released by the decomposition of the feedstocks. Many of these compounds can produce malodors. When the oxygen deficient air is expelled from the pile it can carry these chemical compounds to the atmosphere. When released in sufficient volume and concentration, the result can be malodors being detected far from the composting facility. Higher temperatures increases the release rate of odorous compounds.

e) Removal of Carbon Dioxide

As fresh, oxygen rich air is forced into the pile, it automatically replaces oxygen poor (carbon dioxide high) air at the same time. When oxygen rich air is present in the pile, microorganisms use it just like humans do (although not with lungs.) When humans breathe in fresh, oxygen rich air, they use some of the oxygen. When they exhale, they return the unused oxygen to the environment along with one of our body's waste products, carbon dioxide. When the microorganisms use oxygen to break down their food (in this case the compost), the process releases the same waste product that humans do, carbon dioxide.

f) Lowering Moisture Content

When fresh, oxygen rich air is forced into the pile it automatically removes oxygen poor air at the same time. When this air is removed from the pile, it also takes away some of the

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moisture in the pile at the same time. If the moisture content falls below acceptable levels it must be replaced by turning and watering the pile.

g) Changing Temperature

Before fresh, oxygen rich air is forced into the pile, the pile is at a certain temperature. Typically, the ambient temperature outside the pile is lower than the temperature inside the pile. When the air blower draws air from the environment it pushes this (typically cooler) air into the compost pile which in turn expels the (typically hotter) air inside the pile. In most cases this has the effect of lowering the overall temperature in the pile. It takes almost nine times more air to cool a pile, than to just provide adequate oxygen levels in a pile. Lso if there is not enough oxygen pile temperatures can be too low. A compost pile that is hottern near the surface than it is deeper in a pile indicates a lack of oxygen deep in the pile.

In most cases, this is good, as the temperatures in the composting pile can rise above what the microorganisms can tolerate (>145 degrees F).

In other cases, lowering the temperature may not be desirable. Detrimental effects may include:

- Lowering the temperature in the pile so far that the desirable microorganisms slow or cease to function (<104 degrees F).
- Lowering the temperature in the pile below 55ºC (131 degrees F) during time/temperature pathogen reduction requirements.

6. Compost Curing

After managed composting is complete, the fresh compost is removed from the composting area and placed in a curing area (prior to screening and refining).

The main objective of the curing process is to allow the freshly composted material time to age undisturbed allowing it to stabilize and mature.

At the COP 27th Ave. Compost Facility, the curing step has been subdivided into two steps.

First, as the composted material is moved off the aerated pad, it is reformed into a new pile on a non-aerated section of the pad. Here it is still turned periodically to resupply oxygen and manage moisture levels which are now consumed at a much lower rate.

Second, after the curing compost has been turned through the non-aerated pad after the prescribed time, it is transported to the final curing area where it will remain undisturbed prior to screening and refining. Certain organisms like fungus require this undisturbed condition to thrive and multiply. They are responsible for higher levels of stability and maturity being achieved as well as the “earthy-forest like smell” typical of quality compost products.

Cured compost can remain non-aerated unless pile temperatures exceed 165ºF or if odors are generated within the piles.

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The best management practices to respond to curing piles with temperatures above 165ºF is to aerate it. This can be done with front-end loaders, a turning machine or with an above grade aeration pipe system with portable blowers. In both cases the oxygen level should be maintained above 5%. Alternately, the cured compost pile height can be reduced to prevent excess heat build-up and improve natural penetration of air into the piles.

7. Compost Screening and Refining

After the curing phase, the finished compost has become stable and mature. It can now be screened and refined prior to sale. Screening should occur at about 42% to 38% moisture.

The objectives of the screening and refining stage are to:

- Remove all oversized material for recycling back into the composting process as bulking material and inoculant. This objective is achieved using screening systems.
- Remove all plastic, metal and glass from finished product and oversized material. This objective is achieved using air separators, magnetic separators and de-stoners.

Refining the oversized material reduces the amount of physical contaminates that will end up going back into the process.

Refining the finished compost product maintains a consistent quality of contaminant free compost. Management of dust generated from the surface and pile moisture content is still important. The color of the finished compost is usually determined by the moisture content.

8. Compost Sent to Market

After screening and refining, the finished compost can now be sold. Keep track of the batch numbers being sold to customers to allow product use experience to provide feedback to the production controls being used.

The objective of this step is to load customer trucks/trailers with high quality compost while ensuring that only high quality compost is loaded. (It is imperative that the equipment used to load the finished product is clean and inspected for contaminants and unfinished compost or raw feedstocks that may be stuck in the bucket corners prior to loading out.)

Remind drivers to clean their bumpers and cover their loads before leaving the facility to reduce spillage and dust during transportation to the end user. Product use information, compost use demonstration areas and advertising are extremely important at this interaction point. A neat and clean site, well organized product piles, and friendly relations between operators and drivers are essential.

D. Odor Treatment

The number one reason for compost facility closures is odors generated in and around the facility. Therefore, compost plant operators must diligently focus on managing operations to

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reduce odor generation. In two processing steps, odors will be generated in sufficient quantity and intensity to cause off site odor complaints. This will be experienced in:

1. Unprocessed Odorous Feedstocks Received at the Facility

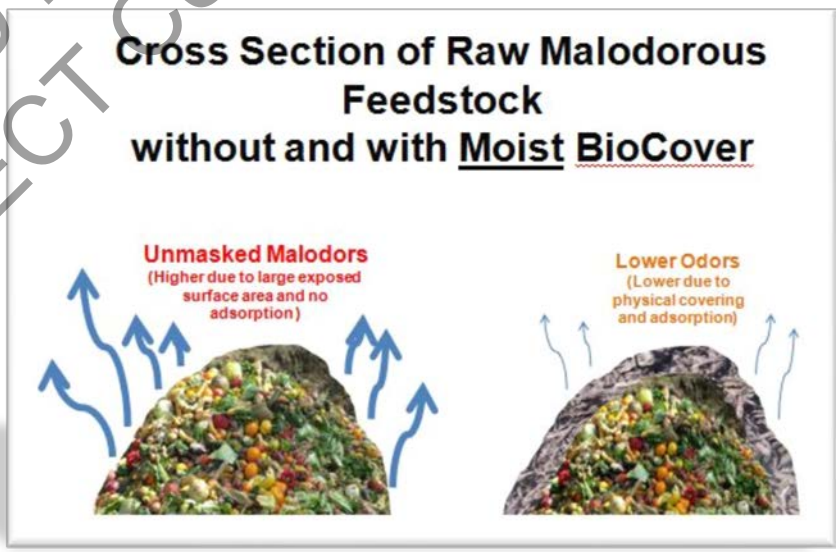
These odors are treated by a combination of mixing them with other feedstocks to establish proper active composting conditions, and, covering them with a "Biocover". A Biocover is a layer of moist, finished, unscreened compost or "overs" (the oversized material screened out of the finished compost), and getting them on a forced aeration system as soon as possible.

These unprocessed odorous loads must be given priority in handling and management. Compost "Overs" (Photo: courtesy of GMT)

Biocovers should be moist and free of plastic or rock contaminates. While compost overs are ideal, with their thin covering of finished compost on the surface, wood chips that are kept moist and sawdust that is kept moist also performs well. It is important to keep the stockpile of biocover material from getting too dry and becoming hydrophobic. Most odor compounds are attracted to and bind easily with water molecules. Proper moisture control improves odor control.

The use of the Area Misters over the stockpiles of biocover, the pile just mixed and covered with biocover and just being used in general about the tipping floor will significantly reduce odors and control dust from carrying odorous material far and wide.

This diagram compares a pile of raw malodorous food waste and the same material that is covered with a Biocover. Testing in California showed over 90% odor reduction using a biocover (Diagram: courtesy of GMT)



2. Process air forced through the fresh material on the aeration pad.

These odors are managed by collecting the process air forced through the fresh compost and filtering it through one of two means as follows:

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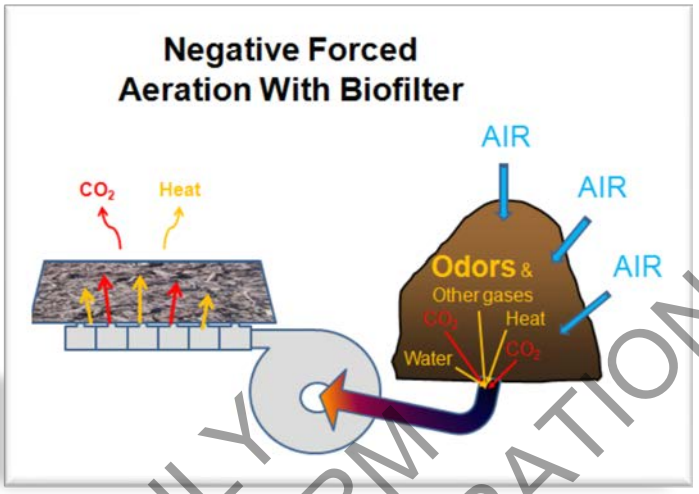
a) In negatively aerated composting systems, a special filter called a “biofilter”.

A biofilter is a large bed of coarse woody material, usually incur porating compost screening “overs”. Biofilters are typically 3’-4’ in depth and are placed on top of a pipe or trench system distributing air that has been sucked down through the active composting piles by an industrial blower.



Biofilter (Graphic courtesy of GMT)

Biofilters are designed to allow odor laden air a specific “residence time” within the biofilter media. This residence time allows odors to adsorb into the water film on the surface of the media and for the microorganisms in the water film time to digest (eat) the odor bearing compounds in the water film.

Biofilters must be kept moist to work properly. Moisture levels in a biofilter can be maintained with fixed irrigation sprinklers frequently applied at rates that keep the biofilter moist from top to bottom. Complete coverage of irrigation water is important to reduce short circuiting of air through dry areas of the biofilter.

Biofilter sprinklers. (Photo courtesy of GMT)

b) In positively aerated composting systems, a special filter called a “biocover”.

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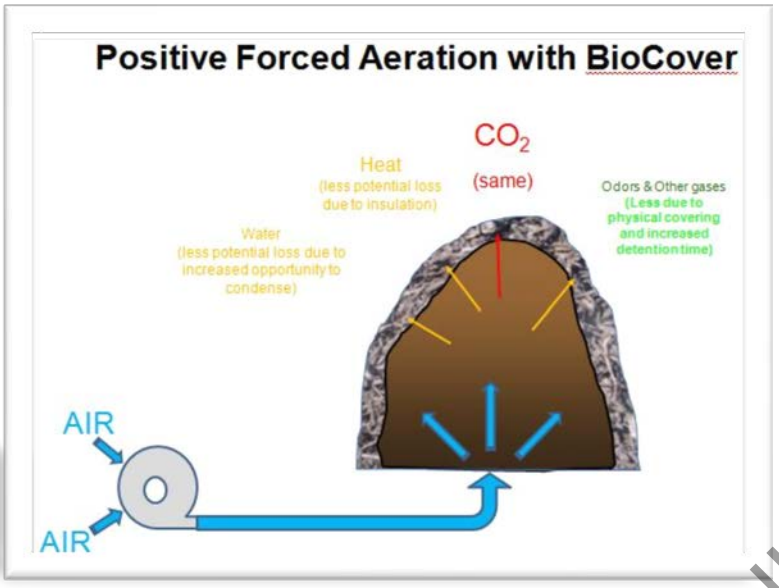

In positively aerated composting systems, a special filter called a "BioCover" acts as a temporary biofilter.

A BioCover is a layer of finished, oversize screened compost or "overs" placed over the positively aerated composting pile and kept moist with an area mister, a sprinkler or occasional water truck. Wood waste can also function as a biocover if kept moist.

3. Odor Prevention

Odors can be created in every physical area and during every processing step at a compost facility. Other than bio-covers for incoming feedstocks and biofilters for aerated composting, the single most effective strategy to manage these odors is to prevent them.

NOTE: There are nine distinct processing steps at the COP 27th Ave. Compost Facility. Each of the nine steps is conducted in a different area of the facility. Most of these areas have their own dedicated processing equipment and roadways. As odors can be generated on any piece of equipment or on any roadway at the COP 27th Ave. Compost Facility, the section "CLEAN EQUIPMENT, ROADWAYS, PAD & PREVENT STANDING WATER" will be repeated for each of the nine processing steps and is intended to be a reminder that cleaning everywhere is important to odor prevention.

a) Odors from Materials Delivered to the Facility:

REJECTING LOADS OR MANAGING THEIR ODORS

Organic waste that is collected over one or more days and held in the same waste collection vehicle can quickly become anaerobic (composting in the lack of oxygen). If this happens, high levels of malodors (bad smelling odors) are generated and are trapped within the material. If these loads are accepted at the facility and dumped in the tipping area they will release these malodors into the air. These malodors may cause odor complaints either from simply being dumped in the tipping area or from the material being processed through grinders, shredders or other equipment. Ideally, these loads should be identified and rejected. Sometimes this can be done at the transfer station green waste unloading area by inspecting suspected loads. Sometimes the load may already have been dumped in the tipping area which would require re-loading it into the haulers truck. In both cases, the best management practice to keep the loads but manage their malodors is to use "area water misters" directly over the malodorous material to quickly remove odors

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from the air. This allows operators enough time to cover and/or mix the malodorous material into an active pile.

PROCESS MATERIAL QUICKLY & USE BIO-COVERS

Organic waste that is collected and transported to the compost facility on the same day typically has minimal or manageable odors. If it is processed soon upon arrival or temporarily covered with a bio-cover (a layer of oversized material from the screening process), odors can be effectively managed. Placing newly received materials on the aeration floor will also help prevent the further generation of malodors, but if left uncovered without a biocover, may still release odors already present.

CLEAN ROADWAYS, PAD & PREVENT STANDING WATER

When commercial or residential haulers deliver their organic wastes in the receiving area roadways can build up with spilled organic waste. When this happens, this material can create dust and odors. In addition, if this material is not managed prior to a rain event, the rain water now flows through the organic waste and ponds. This standing water then becomes an odor source as well. Any debris left on the surface before it rains will wash down into the catch basins and tanks. Once in the catch basins and tanks it is much more difficult to remove the debris.

The best management practice in this area is to wipe the floors with the 950 loader's rubber bucket edge, and use a combination of skid steers, water and sweepers to get the edges clean. The Laymor construction brush is used to sweep the fines out of the grooves and the water truck and man hoses used to wash down water to clean roadways, tipping areas and equipment at the end of each receiving day.

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b) Odors Generated When Cleaning Feedstocks

PROCESS MATERIAL QUICKLY

When feedstocks are recovered, incoming waste is typically spread out in the receiving area for manual, physical examination to remove non-processable and non-compostable waste. This can be done on the ground with rolling stock supporting laborers or on conveyors with a hand sort station. In either case, the material is systematically exposed to the air releasing odors or dropped on the ground where it can build up as in the receiving area. Processing the material quickly reduces the likelihood of the material becoming anaerobic and producing malodors.

CLEAN EQUIPMENT, ROADWAYS, PAD & PREVENT STANDING WATER

As rolling stock transports and moves material through the feedstock recovery area the pad will no doubt collect organics throughout the day. They will most likely be compacted and if

left for long periods, would become anaerobic and produce malodors. The rubber edged bucket on the 950K loader acts as a squeegee to scrape up wet organic debris like food waste and keep the working surface clean.

The best management practices in this area are to use an appropriate combination of wheel loaders w/rubber edged buckets, skid steer, industrial sweeper water truck and wash down water to clean roadways, pad areas and equipment at the end of each receiving day and to prevent standing water.

c) Odors in Feedstock Preparation

PROCESS MATERIAL QUICKLY

During feedstock preparation, the recovered feedstocks are gathered, mixed, ground, moistened and transferred into the active composting process. Since the material is typically processed the same day it is received, it typically has already been handled multiple times. The material is therefore primarily homogenous, aerobic and does not typically produce malodors. However, paying attention to processing the material as received is considered a best practice.

COVER ODOROUS LOADS WITH BIOCOVER IMMEDIATELY AFTER PROCESSING

Odorous materials that are received will continue to emanate odors for a period of hours or days until they are consumed in the aerobic composting process. The best management practice for odourous materials being processed is to immediately place a 6 inch to 12 inch layer of biocover on top of the pile once it is placed on the aeration system.

CLEAN EQUIPMENT, ROADWAYS, PAD & PREVENT STANDING WATER

As rolling stock transports and moves material through the feedstock preparation area and equipment, the equipment and pad will no doubt collect organics throughout the day. They will most likely be compacted and if left for long periods, could become anaerobic and

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produce malodors. Even a thin layer of fresh feedstocks left on the pavement can give off offensive odors for an extended period of time.

The best management practices in this area are to use an appropriate combination of wheel loaders, skid steer, industrial brush and wash down water to clean equipment, roadways, and pad areas at the end of each process day and to prevent standing water.

d) Odors in Composting

In well managed composting operations, even properly prepared feedstocks in the active composting phase will or may generate malodors. At the 27th Ave. Compost Facility process air is forced through the composting material in one of two ways.

POSITIVE AERATION – BIO-COVER
When air is forced from the aeration pad up through the fresh composting material it is then released to the environment. During the first 5 to 8 days of active composting, the air discharged to the environment can carry significant amounts of malodorous volatile organic compounds.

The best management practice to manage these odors is to cover the fresh composting materials in zones one and two with a biocover as soon as possible after placement and turning.

NEGATIVE AERATION – BIOFILTER
When air is drawn down into the aeration pad, air from the environment is drawn down through the composting material and collected in the network of pipes below the pad leading to the suction blower.

In this case, the process air will not be sucked through the blower and released to the environment. Instead, the process air will travel through the blower and into a plenum system on a concrete slab and distributed through the biofilter residing above it.

In a properly managed biofilter over 90% of the odors entering it will be eliminated prior to release to the environment. The biofilter media must have the correct composition, porosity and moisture content. The biofilter must be properly sized to provide an adequate amount of detention time for the air entering it prior to being released to the environment.

The best management practice to maintain a properly constructed biofilter is to keep the biofilter media above 60% moisture content through regular surface watering.

The following diagram represents the flow of air in a negatively aerated compost pile with treatment through a biofilter.

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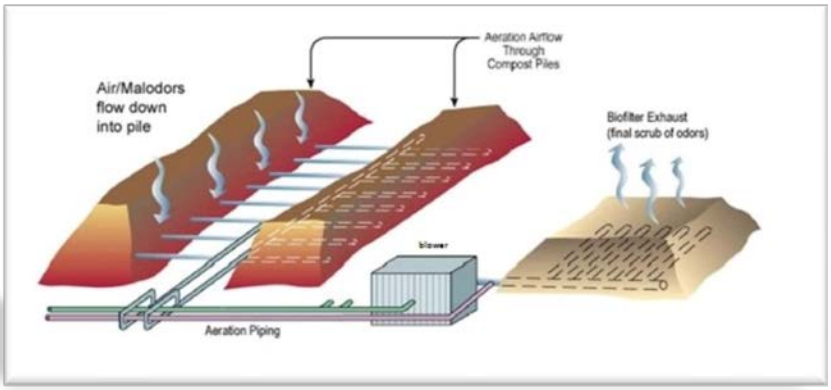

CLEAN EQUIPMENT, ROADWAYS, PAD & PREVENT STANDING WATER

e) Odors in Compost Curing

In well managed composting operations, properly composted materials in the curing phase remain aerobic and therefore do not typically produce or emanate malodors. However, as in all other areas of the facility, equipment, pad areas and roadways are still a concern.

CURING PILE AERATION
Occasionally, operational conditions arise during the composting process which results in unstable material arriving in the curing area. This can be for many reasons such as having inadequate moisture levels during the composting process.

The best management practices to respond to curing pile odors are to aerate it. This can be done with front-end loaders, a turning machine or with an above grade aeration pipe system with portable blowers. In both cases the oxygen level must be maintained above 5%.

CLEAN EQUIPMENT, ROADWAYS, PAD & PREVENT STANDING WATER

It is important to note that compost curing takes place prior to screening and refining. This is done to keep the porosity as high as possible during the curing step to allow for (limited) passive aeration. Curing can be done on the asphalt millings as needed.

f) Odors in Compost Screening and Refining

In well managed composting operations, properly cured materials may be screened and refined without releasing malodors. However, as in all other areas of the facility, equipment, pad areas and roadways are still a concern. Finished compost piles that have not been moved for a long while can create a core of anaerobic material which releases odors when dug into. This is usually temporary and dissipates quickly. If this odor creates concerns, then a very small blower and pipes can eliminate the buildup of anaerobic conditions during product storage.

CLEAN EQUIPMENT, ROADWAYS, PAD & PREVENT STANDING WATER

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g) Odors in the water collection system

Any standing water that has fresh organic waste in it creates a biological oxygen demand which must be satisfied by bubbling or mixing the water to expose the suspended particles to oxygen. Otherwise it very rapidly can change to anaerobic decomposition in the water. Which results in the creation of bad smells and hydrogen sulfide, a very toxic gas. There are two areas where bubbling aeration is provided, the aeration vaults and the underground tank. All the surface water near the receiving or south side of the facility drain into these aeration systems. There is a pressure trap for each of these tanks to keep any odors coming off them going through the biofilter. Keep all catch basins flushed clean to reduce odors from being generated in the water collection system. Finally, there is a sediment weir that is designed to slow down the incoming stormwater collected from the south side of the facility. After the storm event, this weir should be cleaned of collected sediments using the loaders to reduce odors generated in the weir.

h) Odors in Compost Sent to Market

In well managed composting operations, properly finished compost products can be shipped without releasing malodors.

Finished compost shipping areas should be inspected by the end of each day to ensure that no standing water can accumulate which could generate malodors. During and after rain events, scrape up any wet compost along the edge of piles and place it over the fresh incoming compost to help keep the saturated compost aerated. The north side of the facility does not have aeration systems in the drainage system. It is not expected to create significant odors, but keeping the drains clean will assist in reducing odors that may emerge from here.

i) General Site Odor Management

In addition to the odor management procedures and practices mentioned in each of the processing steps above, facility owners and operators should meet all the conditions contained in the air permits. Dust also carries odors, so keeping dust down is essential to good odor control. There is a checklist that must be completed every day to monitor odors at the site. The following should be done consistently:

- Conduct daily site perimeter odor walks documenting any odors detected traveling from the facility itself or through the facility from other generators in the area
- Operate and log data from the facility based weather station to be used to correlate site odors or complaints with wind speed and direction.
- Maintain an odor complaint log to document odor complaints
- Respond to odor complaints and make operational corrections to lower odor exposure and emissions.
- Maintain tree or shrub buffers around the facility perimeter to improve mixing of odorous air with clean air

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V. Technology Overview for Phase I of the 27th Ave. Compost Facility:

Phase I of the 27th Ave. Compost Facility is designed to process up to 55,000 tons per year using a Turned Aerated Pile (TAP) technology. It is in the form of an extended pile or trapezoidal pile. This means the compost piles lay alongside each other and are mixed and re-located across the air floor, as a plug flow, to make room for more new materials shown in tan in the graphic above, and remove the oldest materials shown in dark grey regularly.

There are many details of the facility design that are best understood by viewing a model of the facility design with a narrator describing what is being seen and how it is intended to work. Follow this YouTube hyperlink to view the design connections and features of the facility. https://www.youtube.com/watch?v=Jnw960-4n9A&list=PLoK41_2JS4E9ZS5E9ONPAuhBtMfkeODzs&index=1

The Turned Aerated Pile (TAP) system has created cured finished compost at other facilities in as little as 26 to 35 days, however this facility has a design capacity to compost food waste and yard waste for over 60 days at average flows and 43 days at peak flows. This will help assure that well stabilized materials can be manufactured.

The TAP system at the 27th Ave. Compost Facility uses a concrete air floor to shoot air up into the pile. The air from the pile can also be sucked downward into the air floor by simply moving 2 dampers, one set of dampers in each aeration zone. Reversing airflow allows the top and bottom halves of the pile to be cooled effectively in pile heights up to 8 feet deep. The initial pile depth may go as high as 10 feet deep, if experience shows that pile temperatures are controlled at the higher depth. Proper initial moisture of >55% moisture would be important to controlling temperatures at these higher depths.

Cooling air demand for the compost piles diminish over time. So the facility has the aeration system divided into 8 aeration zones. Each zone is used sequentially as the compost is moved every 2 to 4 days across the air floor using a side discharge compost turner, shown above in yellow. Of these 8 zones, there are 4 high airflow zones, shown in

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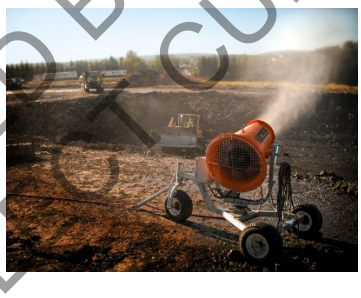
tan, that receive fresh prepared feedstocks blowing a significant amount of air for the first 8 to 16 days of composting providing 4 to 5 CFM/yd³. Then zones 5 through 8, shown in brown, move air through the piles to meet the diminished air demand of the stabilizing compost materials, providing 2 to 3 CFM/yd³. There is a total of 16 to 32 days with the compost being provided cooling air to control pile temperatures from top to bottom. Turned curing shown above in grey, allows the piles to be doubled up and turned every 4 to 6 days. Providing 20 to 30 days of additional curing time with moisture and porosity control.

During each turn, there is the opportunity to water the piles using a hose reel and spray bar connected to the compost turner shown in green behind the turner.

The primary tools for The COP 27th Ave. Compost Facility system are:

1. The combination of a material shredder (a Doppstadt DW 3060 SA) and two material grinders (a Vermeer HG8000TX and a Doppstadt AK-635SA) are used to prepare the incoming feedstocks for composting and wood grinding. Spray bars can be mounted on the end of the discharge conveyors to provide irrigation to get the composting process started on the freshly ground surfaces. A DustBoss area mister provides dust suppression during initial handling in the unloading and grinding area. A second one is placed near the self-haul unloading area and is used to cool customers and settle any dust during unloading. A mobile DustBoss provides the commercial unloading and the grinder to have a method to follow the equipment grinding area and the unloading activities that happen alongside the grinder to have good dust control and improve odor capture. It is important to place the misters up wind of the processing area to allow the mist to intercept dust generating operations in the receiving areas.



The shredder is intended to be used to open bagged material to expose non-compostables and non processables to allow their removal before grinding. It is important to remove manually any glass or garbage that is discovered after bag shredding. Shredding was originally intended to occur below the receiving building wall, which was not constructed for the 55,000 TPY capacity system. For the 55,000 TPY system, bag shredding can occur at any location near the receiving areas as deemed appropriate by the operator.

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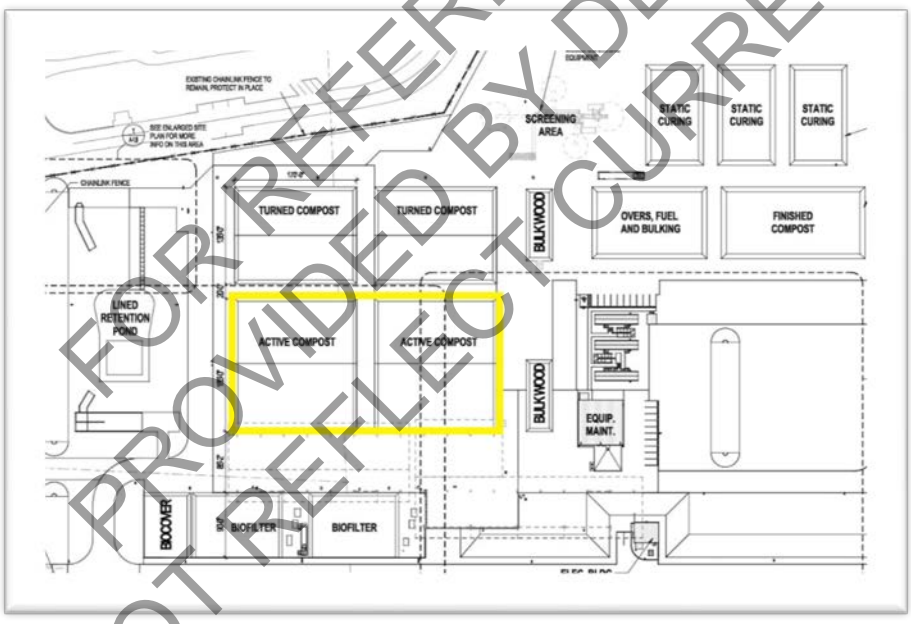
The grinders serve to:

- grind large green waste, food waste and wood waste to a uniform particle size
- mix the ground wood waste, food waste and animal manure together uniformly
- add and mix water with the feedstocks to set the initial moisture content of the material

2. **A GMT Aeration Pad** - Outlined in yellow below is shown the 110,000 TPY capacity configuration. This design consists of two temperature controlled, reversing, aerated concrete slabs used to cool and oxygenate the compost, each with 8 separate aeration zones that progressively reduce air flows over time to match the expected biological air demand from the decomposing feedstocks over time.

Air is supplied to, or taken from the aeration pad by means of blowers controlled by a GMT CompDACS (Compost Data Acquisition and Control System) control system based on temperature sensors placed in the composting material. This CompDACS system is housed in the Controls Container along with motor starters and switch gear.



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The temperature probes in the compost piles are wireless and have a top and bottom sensor to assist in controlling air flow volume and air flow direction.

The graphic on the right shows a plan view of the blowers and manifolds for the pressure blower which looks like the letter T at the top of the graphic. There is below ground manifold for the suction blower which is connected by an inlet pipe to the underground vault located directly below the pressure manifold. The top blower pressurizes the pressure manifold pulling fresh ambient air into the blower and pushing it into the pressure manifold. The lower blower has its inlet coming from the below grade vault creating a suction on the suction vault. There is a third aeration line on the left side of the suction duct called the bypass duct. This allows pressurized air to be sent to the suction blower discharge into the biofilter manifold to cool the biofilter. The biofilter manifold is shown going down and to the left of the graphic. There are pressure sensors in the pressure manifold and the suction duct that are used by the controller to keep manifold pressures at the set point chosen by the operator. The constant pressure is maintained by automatically increasing or decreasing the blower speeds as zone supply duct dampers open or close.

There are two butterfly dampers for each zone supply duct, one connected to the suction vault and one to the pressure manifold. By opening one or the other, the air flow in the zone supply duct goes in either a positive or negative direction through the pile. The position of either damper when opened, controls the total air flow delivered to, or removed from the pile. This position determines the amount of cooling air going through the pile and the pile temperature.

The CompDACS controller system located in the building in the bottom right corner of the above graphic, has many processes to control. The primary control is to keep the pile temperatures on each zone at the set point determined by the operator. The second is to keep the biofilter at a cool temperature, below 104 degrees F.

Below shows the two primary control screens for the CompDACS controller. They include a weather station, the biofilter temperature and the air temperatures entering the biofilter, the biofilter sprinklers, the condensate tank levels, the chopper pump, the compressor for the aeration of the condensate and the blower status screens. The system duct pressures are used to provide an overall level of control over the system. The operator can change the pressure set-points for the suction and the pressure blower manifolds using the setup buttons. The pink setup buttons provide access to the process control afforded to the operator.

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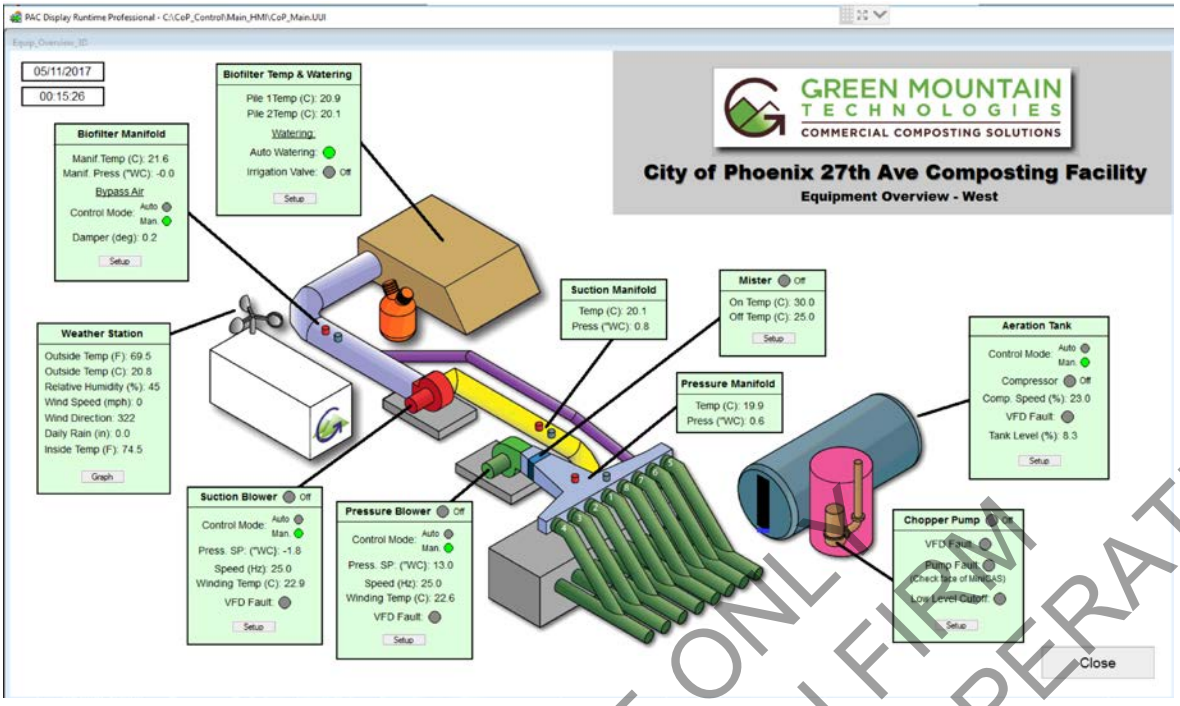
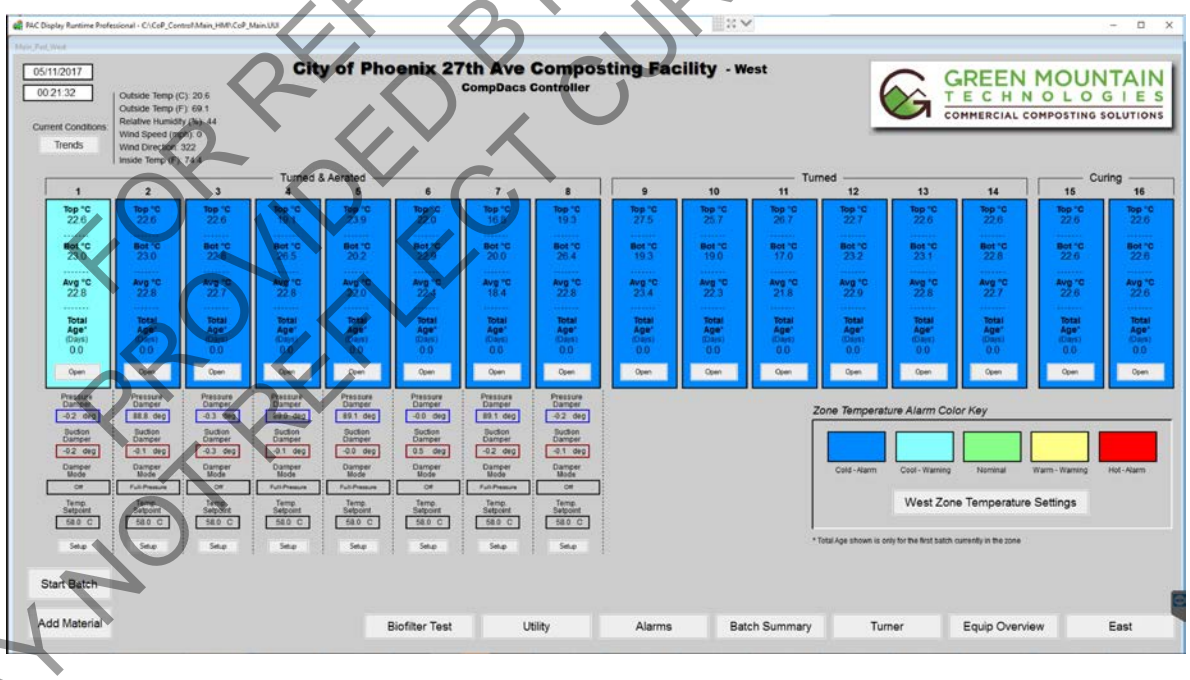


The following screen provides the status of each aeration zone and the batch of materials that reside on it. These are provided in colors that quickly allow an operator to see what the current temperature is for each zone, and whether they are out of the desired range of temperature. Alarms exist for each controlled zone and process that can send messages to designated recipients to let them know if a process is outside of the desired range of operation. Damper settings and batch temperature and damper control history can be accessed on this screen as well.



There are eight initial zones the material moves through that allow temperature control, the following eight zones for the turning and curing piles are simply for monitoring of the conditions in

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the pile and allow the operator notice of ether the pile need turning or further aeration to reduce temperature to the desired range. The CompDACS control system can be accessed remotely.

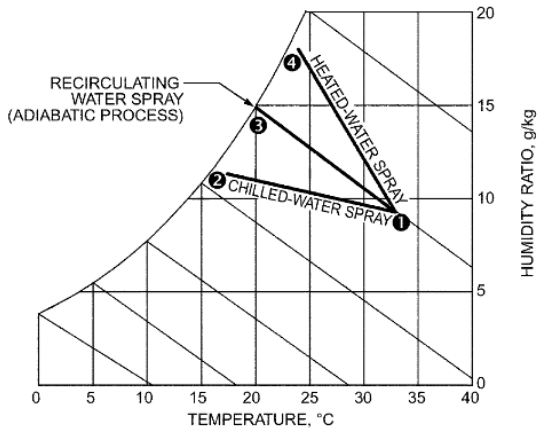

Fig. 3 Direct Spray of Water in Airstream Cooling

There are several tools used to control pile temperatures besides the rate of air flow and turning frequency.

The misting ring uses direct spray of water into the airstream to cool the ambient dry air and to keep the underground pipe cooler. This allows more effective cooling of collected air once the zone goes into negative aeration mode. In the ASHRAE Handbook HVAC Systems and Equipment version 2016, it states the following: "**Direct spray of water in the airstream** (Figure 3), an adiabatic process, uses the latent heat of evaporation of water to reduce dry-bulb temperature while increasing moisture content. Both sensible and latent cooling are also possible by using chilled water. A conventional evaporative cooler uses the adiabatic process by spraying or dripping recirculated water onto a filter pad (see the section on Humidification)."

With all mister nozzles installed, the misting ring will use about 8 gallons per minute of ambient temperature well water. The volume of water used can be reduced by putting plugs in some of the nozzles which will drop the output water flow as a percentage of the total number of nozzles and the 8 GPM designed output of all the nozzles. During start-up in the hottest seasonal weather, the misting system has shown a 40 degrees F reduction in ambient temperature under dry ambient conditions of about 35% RH. The misting nozzles are turned off and on automatically based on a user defined pressure manifold high and low temperature. Overall flow rates can easily be changed by plugging or replacing misting nozzles to increase or decrease the amount of water applied when in the on position to provide the desired cooling effect or to manage water use.

The second cooling tool is to control pile height. By lowering pile height more air can cool a smaller volume of materials. By reducing pile height, you reduce the energy per square foot and you also increase turning frequency. Which improves a temporary level of porosity in the pile.

The third tool is the water added during turning. Water evaporation is the key heat removal mechanism for microbes. Keeping pile moistures above 50% allows the microbes to release water to keep themselves cool and biologically active. The addition of water also increases the total amount of heat that can be absorbed by the pile. However, if a pile gets too wet, and the energy level is too low in a compost pile, you may have difficulty getting the pile up to the optimal temperatures.

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Managing the water balance is key to managing composting temperatures.

Below is provided a screen shot of an Excel spreadsheet tool that can be used during the turning of compost to estimate the amount of water to be added to a pile. The operator is expected to use the hand squeeze moisture estimation test and then estimate the amount of water to be applied before or during turning with the hose reel sprinkler and/or conveyor belt water bar. This spreadsheet is installed on the tablet in the compost turner and on the control room computer.

Water Balance Calculator for City of Phoenix Compost Facility				
All cells shaded blue are for customer inputs				
Daily Pile Size				
Length of pile at the base	188	feet		
Width of Pile at the base	9	feet		
Average height of pile	6	feet		
Calculated total volume of pile to water			363.0	cubic yards
Weight of compost in a properly compacted 5 gal. bucket				
	21.5	pounds		
Calculated bulk density of the pile			860	pounds per cubic yard
Existing pile moisture percentage				
Moisture percentage of 5 grab samples (100 grams total) dried for 35 minutes in silage dryer				
	40%			
Moisture Target	55%			
Constants				
Water weight	8.3	pounds per gallon		
Water volume	202	gallons per cubic yard of water		
Weight of water in the pile			124,872	pounds
Weight of dry matter in the pile			187,308	pounds
Total weight of pile			312,180	pounds
Weight of water to add to pile			28096.2	pounds
Gallons of water to add to pile to reach	55% moisture		3385	gallons
Time to achieve watering goal within a pile				
Valve flow setting	220	gpm of irrigation nozzle		
Range of 100 gpm to 300 gpm				
			15.4	minutes per pile
Turning capacity of compost turner	1,400	cubic yards per hour		
Range of 1200 to 2400 cyh				
Time for adding water during turning a pile				
			15.6	Minutes to turn
Calculator created by Green Mountain Technologies for use by our customers and their contractors on the project they hired us for. All other uses are restricted .				
If there are any questions please call Jeff Gage at +1-360-464-2719 to discuss.				
jeff@compostingtechnology.com				
Or for local support Oley Sheremeta at 520-449-3559				
Oley@compostingtechnology.com				

For any processing system, an understanding of the material flows and watering capacity is needed, as well as identifying the potential sources of water that can be generated and used. Following are two capacity analysis spreadsheets that were used to estimate the likely use of water and aeration at an average and peak processing condition.

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Phase 1W & 1E Processing capacity calculations

Receiving grinding	Area			Volume in place		Days	Capacity	Volume	Est. % moisture	Target moisture	water app.	units	Bulk density Estimate		Capacity	Tons	Annual Tonnage Estimate		
	Width	80	feet	847	cubic yards	0.5	1694	cu.yd./day	28%	50%	16,797	gallons/day	360	lbs/cu.yd	305	tons/day	111,325	tpy	Average capacity
	Length	100	feet				1.5	peaking factor	Average initial application		47	gpm	from well or tank water						
	Height	2.859	feet	848	cubic yards	0.333	2544	cu.yd./day	28%	50%	25,196	gallons/day	360	lbs/cu.yd	458	tons/day	167,170	tpy	Peak capacity
									Peak initial application		70	gpm	from well or tank water						
Turned Aerated Processing	2.00% water loss per day																		
	Width	170	feet	16,528	cubic yards	23	719	cu.yd./day	47%	55%	24,432	gallons/turn	850	lbs/cu.yd	305	tons/day	111,473	tpy	Average capacity
	Length	350	feet		Turning frequency	4	1.5	Peaking factor	Average application/turn		59	gpm	from tank water						
Initial	Height	7.5	feet	16,528	cubic yards	15	1078	cu.yd./day	51%	55%	10,990	gallons/turn	850	lbs/cu.yd	458	tons/day	167,209	tpy	Peak capacity
					Turning frequency	2			Peak application/turn		27	gpm	from tank water						
Turned Curing	1.00% water loss per day																		
	Width	130	feet	10,448	cubic yards	22	475	cu.yd./day	49%	55%	18,166	gallons/turn	1,275	lbs/cu.yd	303	tons/day	110,507	tpy	Average Capacity
	Length	350	feet		Turning frequency	4	1.5	Peaking factor	Average application/turn		70	gpm	from well water						
Restack	Height	6.2	feet	10,448	cubic yards	15	712	cu.yd./day	52%	55%	6,812	gallons/turn	1,275	lbs/cu.yd	454	tons/day	165,760	tpy	Peak capacity
					Turning frequency	2			Peak application/turn		26	gpm	from Well water						
Screened Product Storage		3	piles																
	Width	72	feet	9,600	cubic yards	20	480	cu.yd./day	52%	42%	0.5%	loss per day	1,275	lbs/cu.yd	306	tons/day	111,690	tpy	Average Capacity
	Length	120	feet				1.5	Peaking factor											
Restack	Height	10	feet	9,600	cubic yards	13	720	cu.yd./day					1,275	lbs/cu.yd	459	tons/day	167,535	tpy	Peak capacity
													33%	volume loss shown in Bulk Density estimate					
Phase 2 water use	Avg Retention	65	Total days avg	Avg. Gallons used per day		27,447	gallons/day		22,905	tank gallons/day		4,541	well gallons/day						
	Peak Retention	43	Total days peak	Peak Gallons used per day		33,619	gallons/day		27,943	tank gallons/day		1,703	well gallons/day						

Phase 1E & 1W Processing capacity calculations

	Area			Volume in place		Days	Capacity	Volume	Bulk density Estimate		Capacity	Tons	Annual Tonnage Estimate		
Turned Aerated Processing															
	Width	170	feet	16,528	cubic yards	23	719	cu.yd./day	850	lbs/cu.yd	305	tons/day	111,473	tpy	Average capacity
	Length	350	feet	1.5	Peaking factor										
Initial	Height	7.5	feet	16,528	cubic yards	15	1078	cu.yd./day	850	lbs/cu.yd	458	tons/day	167,209	tpy	Peak capacity
Turned Curing															
	Width	130	feet	10,448	cubic yards	22	475	cu.yd./day	1,275	lbs/cu.yd	303	tons/day	110,507	tpy	Average Capacity
	Length	350	feet	1.5	Peaking factor										
Restack	Height	6.2	feet	10,448	cubic yards	15	712	cu.yd./day	1,275	lbs/cu.yd	454	tons/day	165,760	tpy	Peak capacity
Screened Product Storage		3	piles												
	Width	72	feet	9,600	cubic yards	40	240	cu.yd./day	1,275	lbs/cu.yd	153	tons/day	55,845	tpy	Average Capacity
	Length	120	feet	1.5	Peaking factor										
Restack	Height	10	feet	9,600	cubic yards	27	360	cu.yd./day	1,275	lbs/cu.yd	230	tons/day	83,768	tpy	Peak capacity
						85	Total days avg		33%	volume loss shown in Bulk Density estimate					
						57	Total days peak								

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3. **Condensate and Stormwater Reuse System**

The site stormwater mostly flows into catch basins that flow to the lined retention pond for reuse in the composting process. For each catch basin, there are screen inserts that collect debris larger than 1/16th of an inch to keep that debris from entering the stormwater system.

The lined retention pond has one more line of defense to capture sediment and floating solids called the sediment weir. The sediment weir is designed to slow down the collected stormwater and allow time for it to settle out most of the suspended solids, grit and sand carried off the pads during a storm event and prevent it from entering the lined retention pond. The weir is maintained by using the rubber-edged loader to remove accumulated sediment after each storm event. Floatable materials will generally accumulate on the southernmost weir to be removed in the same way.

The retention pond is lined with clay and a 60 ml HDPE welded pond liner to prevent any leaks to groundwater. The pond is equipped with a floating aeration system to keep the pond from going anaerobic. Water from the pond can be gravity fed to the underground 50,000-gallon water reuse tank system by opening a deep valve near the water weir. Otherwise water in the pond can be allowed to evaporate. The Phoenix area has over 9 feet of water evaporation potential per year for retention ponds.

Near the underground aeration vaults are 8-inch pipes that connect to the base of the two storm water catch basins that are designed to intercept and capture the initial stormwater flows which usually have the greatest amount of sediment and organic matter in it, called the first flush. This first flush water enters the aeration vault, allowing sand and sediment to drop out in one half of the vault, and a compressed air bubbler system is available on the other half of the underground vault to keep the organic matter left suspended in the water from going anaerobic. This bubbler seems to generate foam when used at a high flow rate, so this must be adjusted to the minimum needed to keep the vaults from generating nuisance odors.

Stormwater, condensation and debris collected by the aeration pad pipes also enters the underground vault for pretreatment. Any overflow from the underground vault goes into an underground 50,000-gallon fiberglass storage tank which also has a compressed air line and bubblers located near the bottom of the tank to keep it aerobic.

Connected to the base of the tank is a chopper pump lift station for removing water from the tank and delivering it to several standpipes out on the aeration pad for reuse by the compost turner or grinder. The tank and chopper pump are the lowest point in the stormwater and condensate collection system. The compost turner tablet and the control room computer are used to turn the chopper pump on and off as needed when tank water is being reused.

4. **A Vermeer CT1010TX compost turner** that mixes, moves and waters the compost to keep it porous and biologically active. It also moves large volumes efficiently and extends the active composting area beyond the aerated floor. The DariTech Hose Reel attaches to the back of the turner to supply the water needed. The Hose reel has a spray gun cart that can be used to irrigate the top of the piles before turning to reduce dust generation.

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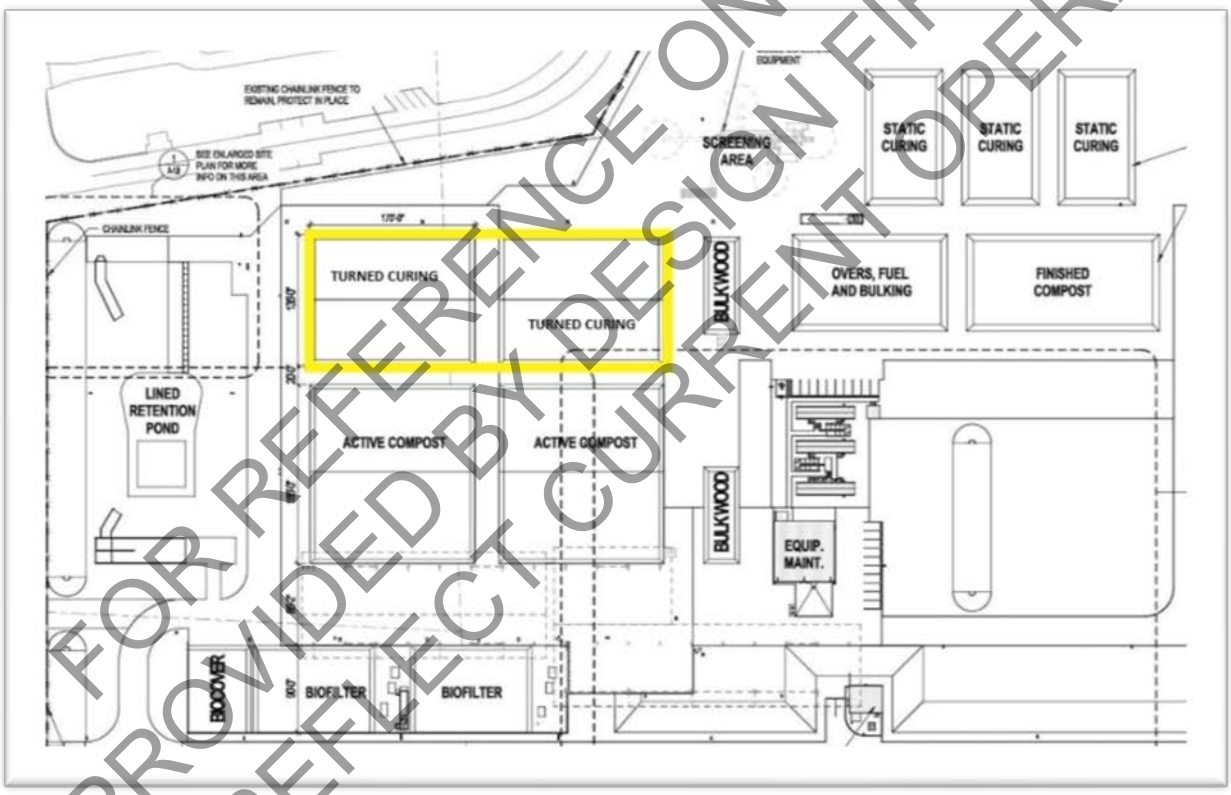
5. **Curing in turned piles**, to keep curing temperatures low. No aeration floor is provided in this area. The operator is expected to manage pile height and turning frequency to control the temperatures below 175 degrees F. The target temperature is 150 degrees F in this area, providing both a furtherance of any required PFRP time as well as keeping oxygen levels above 5% within the piles through convective airflows. By this stage the energy levels of the compost are expected to be only 20% of the initial energy levels, and this style of compost management should be adequate to control pile temperatures.



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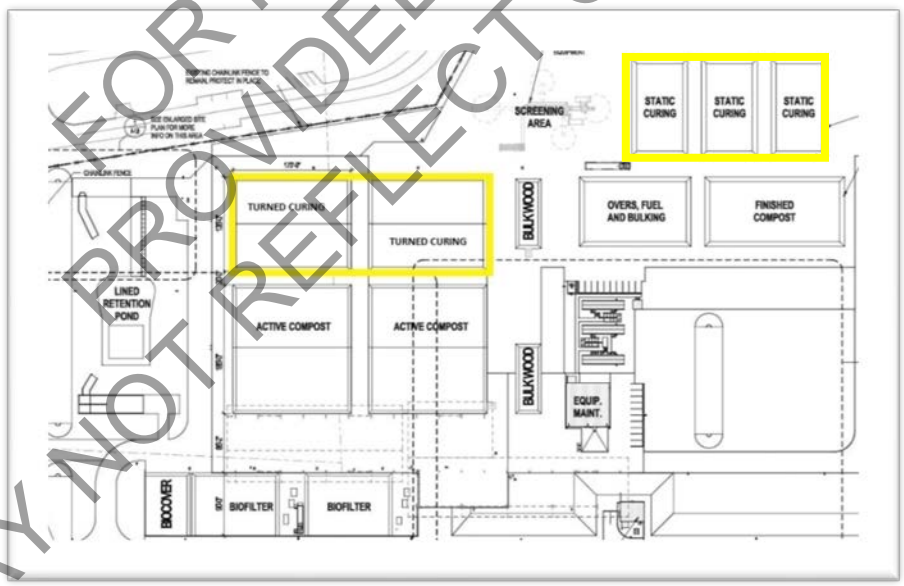
6. **Curing in static piles.** These areas are designated for unscreened compost to further mature with or without turning or forced aeration. Static curing can also be done in the turned curing area if temperature and oxygen control can be maintained without turning. The operator is encouraged to be flexible in how they manage this stage of the process, as the time on the active composting pad is expected to be adequate to reduce the biological aeration demands to a minimum and the further composting activity is minimal and should be truly curing from this point on. If ambient weather makes the piles too hot, then a pipe on-grade aeration system can be installed in the static curing area to keep air flowing through the static curing piles. If the compost is screened prior to final curing, then pile porosity may require forced pipe on-grade aeration blowers to be used to keep oxygen levels above 5%.



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7. **The compost screener/separator** to separate mulch, fine compost and overs while removing rocks, plastic and metal left in the cured compost. The City selected both a Doppstadt SM-726 trommel, an Airlift Separator for producing clean fine compost and a Hurrifex Kingpin Profi air separator for producing clean overs.

Hurrifex stone and plastic separator used on the compost overs coming from the Doppstadt SM720

Airlift separator on the fines conveyor

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8. **Two or more front end wheel loaders** to carry materials between the processing steps. The City selected one Cat 950K and one Cat 966M as the facilities main material handling equipment. The 950K will primarily be used for feeding the grinder and shredder in the receiving area as well as covering the fresh piles with a biocover. This unit will have a rubber cutting edge that can beused to clean the floors effectively while reducing damage to the concrete floors. The Cat 966M will primarily be used for screening finished compost in the screening area and loading finished compost into customer trucks and backing up the 950K in the grinding operation.

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VI. Site Utilities

Utility Provisions

The City of Phoenix expects the compost facility to use a significant amount of electricity, water and diesel to operate the facility efficiently. There are 3 sources of water that are available and provided by the City to the project and two sources of electricity. Electricity must be directly purchased by the operations contractor, as well as diesel for operating the compost facility equipment which needs to be obtained by the operations contractor from an outside contract delivery service.

A. Electricity

The COP has designed and installed the electrical systems necessary for a minimum 110,000 ton per year compost facility, including controllers, blowers, maintenance facility and modular offices. No electrical systems have been developed for a separate sales area or other structures (i.e. bagging house or equipment). The COP may design, construct and install a future photovoltaic system to be connected to the electrical system on site. The monthly invoices for the electrical utility will be transferred to the operator as the start of services of the compost facility. Electricity demand for 55,000 TPY average throughput is expected to be below 1.2 million KWHr per year with a cost of approximately $100,000 per year. Actual demand will depend on the time of use and the operational loads placed on the fixed equipment. Electrical power used by the project will be provided by the local electric utility and billed to the operations contractor. The second source of power is from solar photovoltaic panels mounted on the roof of the receiving buildings. This power will be back fed into the utility lines and is only available through the normal electrical power purchase system and cannot be directly accessed by the operations contractor. An Excel spread sheet for the expected electrical power use is attached as an addendum to this document.

Facility lighting - COP has installed lighting on poles throughout the site. Some poles have additional city camera systems installed. Loaders and trucks are expected to have to use their driving lights to see the work they are doing at night.

Data and telephone - The COP will have data service to their camera and office infrastructure at the compost facility. There is data conduit available for the operator to install telephone and internet service to their facilities. The Operator will be maintaining their own data services to operate the facility and do business.

Photovoltaic - No systems are in place in the phase 1 - 55k TPY facility. The COP may design, construct and install a future photovoltaic system to be connected to the electrical system on site.

Water – The COP has designed and installed two separate water sources to this facility. There is a raw water well located to the west and piping of the raw water into the facility infrastructure. There is a 4” domestic water services meter at the northeast site corner of the site. This meter serves the compost operations, the office modular and the site landscaping irrigation. The monthly invoices for this utility will be transferred to the operator as the end of the commissioning of the compost facility.

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Sewer – The compost facility has no sewer system installed in the 110k tpy facility. All compost process waste is designed and systems in place to collect and reuse any liquid waste generated by compost activities. The oil/water separator at the maintenance facility shall be monitored and maintained. The modular offices, including the restroom building, have a grey water system for direct feed into site irrigation/landscaping. The modular offices, including the restroom building, have a black water system consisting of vaults or tanks with a 10,000 gallon capacity. The operator will be responsible to monitor and maintain both grey and black water systems, including establishing and maintaining an alarm system and disposal (pumping out) for the black water tanks/vaults. COP will verify contractual compliance with these sewer requirements until a time when city sewer service is established to this site.

Fuel - There are no fuel systems installed in the 110k tpy facility. Fuel must be brought in by the operations contractor to fuel the equipment

- Water is a significant utility requirement for this project. On average, over 50 gallons might be used per cubic yard of ground feedstock. The city water system provides all the water that the public will be exposed to. To mitigate the public utility water demand by the composting process, the City of Phoenix is providing well water to be used by the operations contractor to supply the high water demands of the project for irrigating piles, cleaning the site and irrigating the landscape plants. Any stormwater runoff from the facility and process water draining from the aeration system is being captured in the tank and pond system for reuse to irrigate the fresh compost piles. A significant amount of water is recaptured when running in negative aeration, which is done approximately 50% of the aeration time. This mitigates the overall use of water for the facility.
- Diesel is used for all large portable equipment. The use at this facility is typical for transfer station operations, except for the grinder which uses a significant amount of fuel. A compost turner is used to improve the efficiency of pile turning instead of using loaders to significantly reduce the amount of fuel used. The Operations Contractor is responsible for fueling and maintaining all large portable equipment.

13.0 Wastewater Systems

- The Operations contractor needs to manage the water generated on the site from storm events and the composting process to keep from discharging water from the site. The Compost Facility is designed to be a zero-discharge facility and capable of handling significant storm events. The composting process is thirsty and can use up the water generated over time after the storm events. There is over 9 feet of evapo-transpiration losses per year in the Phoenix area. Recirculating sprayers can be used on the side of the stormwater pond to evaporate a significantly greater volume than just the pond surface if needed.
- The Operations Contractor must manage the stored water to limit the production of odor and the accumulation of solids from the treatment process. The water generated on the site from storms is likely to be contaminated with suspended solids, color and Biological Oxygen Demand (B.O.D.) and is unsuitable for discharge offsite as stormwater. While storing the water for reuse, it is likely to require aeration and recirculation to keep the stored water from going anaerobic and creating odor. These aerators are provided for use as needed in the aeration vault, the underground tanks and in the storage pond.

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- The system is designed to collect and reuse all the condensation and rainwater that is generated in the aerated composting areas

VII. Compost Facility Standard Operating Procedures (SOP):

A. Receiving SOP

- Hours of Operation
  - M-F 5:30 a.m. to 5:00 p.m., Saturday 6 a.m. to 3 p.m.
- Load inspection and documentation of loads rejected
- Contamination removal using pick and roll floor sorting or sort line over 98% clean by dry weight
- Dust and odor control using area misters and feedstock pile irrigation
- On time processing of received putrescible wastes, first in first out, process all received wastes within 2 business days
- Covering odorous loads with moist biocover as soon as possible
- Floor and edges kept scraped clean, and slime washed up to prevent track out of odorous material

B. Grinding and Mixing SOP

- Pre-blending available feedstocks with a bucket loader to achieve an approximate C:N ratio 25:1 to 40:1
- Porosity after grinding of 45% to 60% Free Air Space (FAS) or bulk density less than 950 lbs/cubic yard wet weight at 55% moisture. Measure the bulk density and FAS for each batch using the 5-gallon bucket field test.
- Grind to a mostly 5” minus material size. This material size can be produced using grates with larger openings than 5” in steady feed conditions. Contact your grinder manufacturer to get a better estimate of what size grates and cutters will do this job for different feedstocks.
- Suction airborne plastic at the grinder discharge with the airlift separator, or removed by hand
- Add water to feedstocks as they come off the grinder discharge belt to reach >55% moisture
- Place ground feedstocks onto air floor under 7.5 feet tall to meet the designed temperature control. Piles can extend up to 10 feet tall if experience shows temperature control can occur at the higher pile depth.
- Use positive aeration while loading piles, make sure holes are not clogged prior to loading
- Do not drive on spilled organic waste, keep the operational area scraped clean of spilled debris
- Cover the ground feedstocks with a biocover 6” or more for odor and vector control
- Keep biocover materials moist in the stockpile and when covering the piles.

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- Place temperature probe over the third pipe of the aeration zone once there is a section of pile in place. Place the handle within 3 inches of the surface.
- Create a batch stake that has the same date information as the one entered into the computer. This provides a visual confirmation that the correct pile is in the zone showed on the computer.

C. Composting and Turning SOP

- Remove temperature probe and batch stake from pile before turning
- Remove oldest batch from the turned aerated composting area and place it into zone 9 of turned curing
- Check that all aeration nozzles are not clogged and that the aeration system is in positive for the zones being turned from and going into.
- Use the compost turner or loader to place the next pile into the just emptied zone
- Estimate pile dryness and adjust water valve volume during turning to get the pile to be over 55% moisture after turning, document volume of water added.
- Estimate the volume of water stored in the aeration tank and use as much as possible in zones 1 through 4, using only well water or city water for zones 5 through 8
- Place the removed temperature probe back into it's original zone at full depth of the probe
- Place the batch stake back into the pile just turned
- After turning fresh compost from zone one into zone two, cover it with biocover > 6" deep

D. Aeration Control SOP

- Name the batch as soon as materials are being put into zone one.
- Document the amount of material added into zone one, bulk density and moisture levels. (May eventually be transferred automatically directly from City data)
- Check that the proper temperature probes are in the center (north to south) of the proper zone and fully inserted to within 6 inches of the handles immediately after a pile is turned
- Inspect the temperature data log for each zone to assure the automation system is cooling correctly in both positive and negative. Adjust the manifold pressure setting up by 1 " water column if most of the aerated piles are over shooting the temperature set point by over 10 degrees. Adjust the manifold pressure setting down by 1" water column if most of the aerated piles are undershooting the temperature set point by more than 10 degrees. Minimum pressure should be 9 inches water column and during turning, the pressure blower should be set at 12" w.c. or higher. The suction blower should be set at least 2" greater suction pressure than the pressure blower's setting
- Make sure PFRP/VAR is being achieved by inspecting the day counter and estimating the time left for that batch to be under temperature control.
- Inspect the biofilter temperature data log for keeping biofilter temperatures below 104 degrees F (40 degrees C). If too high, either increase the biofilter watering schedule and/or decrease the exhaust duct bypass cooling system temperature set point.

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- Run the biofilter backpressure test once a month and check airflows in the manifold. IF the back pressure gets above 9” w.c. the media must be replaced. Air flows need to be at or above 64,000 cfm in the manifold. Check that the pressure gauges in the ducting match the readings you get with the hand held unit.
- Open the Underground tank lid and visually check the water level in the aeration tank and that the compressor VFD is dynamically adjusting operating pressures in relation to different tank levels and that aeration bubbles are flowing up to the aeration tank water surface. If not, increase the pressure to depth ratio set point. Manually adjust the aeration vault(s) compressed air line to balance the amount of air entering the vault water and bubbling to the surface. Typically the valve to the 50,000 gallon tank is always wide open, so the critical adjustment is to the volume of air allowed to be diverted to the two vaults.

E. Curing and Turning SOP

- Remove temperature probe and batch stake from pile before turning
- Remove oldest pile from the turned composting area and place it in static curing
- Use the compost turner or loader to place the next pile into the just emptied zone
- Estimate pile dryness and adjust water valve volume to get the pile to be over 50% moisture, document volume of water added.
- Use only well water or city water for zones 9 through 15
- Place the removed temperature probe back into its original zone at full depth of the probe
- Place the batch stake back into the pile just turned
- Curing piles may be able to be turned half as often as composting piles by doubling up batches as they are placed by loader into Zone 9. If piles reheat above 165 degrees F before the next turning, discontinue doubling up of batches.
- Place piles to be cured into one of the three static curing pile locations at a height less than 10 feet. Use the light poles or other visual reference pole that has a ten-foot elevation mark placed on it by the operator to visually estimate pile depth from the loader cab.
- Place the batch stake(s) at the end of the part of the curing pile the batch is placed into
- If curing piles reheat above 165 degrees F, they must be turned, or a portable pipe above grade aeration system be installed under the curing pile.
- Prior to all three static curing piles on the millings area being filled, start screening and selling the oldest batches. Keeping the date stake with the piles until they are sold will assist in knowing which is the oldest material.

F. Screening and Stockpiling SOP

- Screen the compost accurately by maintaining an even hopper filling height and avoid gaps
- Adjust the feed belt speed to keep fines from going into the overs and to keep overs from spearing through the screens

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- Refine the overs through the Hurrifex to remove plastic and rocks from the overs. Adjust the fan speeds and suction heights to maximize the removal of plastic and rocks once steady screening operations are achieved.
- Stock pile the cleaned overs in the biocover stockpile area near the biofilter and receiving area. When full, stockpile the cleaned overs in a product pile to sell off site.
- Keep the stockpile of cleaned overs at a height of less than 10 feet. Use the light poles ten-foot mark to estimate pile depth. Use a first in, first out system to keep the overs pile from drying out too much so that could catch fire.
- Stockpile the screened fines in the finished product stockpile location, move the batch stake to the end of the batch placed in the finished product stockpile.
- Keep the screened fines at a height of less than 10 feet. Use the light poles ten-foot mark to estimate pile depth
- If the finished fine product stockpile reheats above 165 degrees F, turn and lower the stockpile height and consider adding an above grade aeration pipe and blower ASP system.

G. Product Loadout and Delivery SOP

- Track sales receipts to the batch name(s) so that customer feedback can be evaluated with processing information.
- Clean off bumpers and side boards, and tarp loads to prevent spillage and dust generation.
- Manage any track out from the loading area by keeping the pavement exiting the site clean.

VIII. Compost Facility Maintenance Procedures

A. Aeration System

- Blowers - The blowers use fan belts to transfer power from the electric motor to the blower fan shaft. The belt tension must be checked and adjusted by moving the motor mount evenly away from the shaft. The blower maintenance manual provides the proper deflection for checking belt tension. The blower fan shafts require greasing monthly, the blower motors quarterly. Check maintenance manual for types of grease and quantity.
- Blower drain lines – The suction blowers have drains in the body of the fan housing and the inlet box. These need to be blown out monthly, and make sure no obstructions are located near the discharge of the drain lines.
- Misting rings – Check that all misters are unclogged and that the water filter is cleaned. Every 2 weeks when in use.
- Butterfly Dampers – Check that the shaft hold down bolts are tight and the shaft is in the proper position in relation to the open or closed status of the Belimo Actuator. Once a month.

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- Air floor - Clean out aeration floor holes (spargers) daily when exposed during turning events by poking them with a stick while wearing eye protection prior to recovering them with compost. Air velocities are 70 mph or more leaving the spargers. This was calculated using 12" w.c. pressures and air volumes.
- Laterals - Flush out the laterals and manifolds once every 3 months to remove accumulated debris down into the aeration vault. Use the cleanouts at the end of each pipe run, put the aeration system in negative. Use a pressure washer with a pecker-head nozzle to scour the inside of the pipes.
- Temperature probes – repair or replace flags as needed, check or change batteries once a year.

B. Drainage System

- Once every 3 months, clean the aeration vault and tank of accumulated solids. Turn off aeration compressor, open aeration vault bottom drain, vactor solids out of vault, use up all the water in the tank by pumping it onto the fresh piles, open tank access door in road, take hose add fresh water to vault and tank to wash solids down to the chopper pump. Closed the valves that were opened and the covers that were removed. Refill the aeration vault with well water and restart the aeration system.

  Aeration Floor and Vault and Tank Maintenance Procedures.
  - Once a quarter initially and then as needed based on amount of sediment removed, clean the aeration pipes underground all the way to the aeration tank of accumulated sediments.
  - Open the lateral cleanouts on one zone. Put the aeration zone in suction at full open and flush each lateral cleanout with water from water truck using a 1.5" diameter hose or greater under pressure from the water tank pump. A high pressure jetter can be used to break up any clogged laterals if needed.
  - Open the Zone Lateral Manifold cleanout on the same zone. Flush with water from water truck. Close all cleanout lids for that zone.
  - Repeat on each Zone. Follow the sequence of turning from zone 8 to 1 to get access to the zone lateral manifold cleanouts which are near the middle North of each Zone.
  - Turn off the suction blower, turn off the vault aeration compressor line, and let the tank settle.
  - Open the vault lids, barricade the openings from entry, start the suction blower to run manually at 25 Hz or less to provide adequate air inflow from the opened lid to limit release of fumes from the tank during inspections or cleanings. WARNING Never place your head within 3 feet of the opening without the suction blower on and adequately removing fumes from the opening.
  - Open the vault drain line to the tank, and let the water level drop until most of the liquid has moved by gravity to the tank.

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- Have a vactor truck suction out the remaining solids from the bottom of the vault using extensions without entering the vault at any time. DO NOT ENTER THE VAULT WITHOUT COMPLETE Self Contained Breathing Aappartus (SCBA), VENTILATION AND HOIST EQUIPMENT. USE ONLY TRAINED AND QUALIFIED CONFINED SPACE CONTRACTORS. This is a Hydrogen sulfide hazardous environment.
- Place a large bed of ground wood or screened biocover down in a 2 foot thick bed with 3 foot side walls to unload the vactor truck solids into for reuse in the composting process.
- Close the vault drain line, and refill with raw water to the overflow level. Close and reseal the vault lids.
- Open the aeration tank access lid and the pump station lid. Pump all the liquid from the tank and apply it to the active compost piles. You will have to use the pump VFD controller to override the automatic level switch to get all the liquid pumped out. Keep the suction blower at 35 HZ or less to maintain good suction flow from the open lids.
- Add water to the aeration tank through the access lid to flush the fine sediment towards the Chopper pump and lift station, continue to run the pump and discharge onto the active compost piles, until most of the fine sediment has been flushed out. **Warning - DO NOT ENTER THE AERATION TANK OR LIFT STATION WITHOUT COMPLETE SCBA, VENTILATION AND HOIST EQUIPMENT. USE ONLY TRAINED AND QUALIFIED CONFINED SPACE CONTRACTORS.**
- Close and reseal the lids. Put all pumps and blowers back into automatic operation

- Once per month inspect and/or clean the sand separator in the maintenance shed. Dispose of any materials removed from this unit. **WARNING - This is a confined space and can only be entered by trained and qualified confined space contractors.**
- Weekly or as needed empty all catch basin debris screens. Catch basins collect water and are fitted with debris screens to catch any debris moved by water. These basins need to be cleaned out of any debris accumulations regularly at least once a week, and before any predicted large storm events.
- Weekly or as needed remove accumulated sediment in the Stormwater Weir with a loader. The storm water systems on the south side of the facility all flow to a sediment separation system called a weir to slow the water speed down to remove settable solids and floatable debris from the storm water before it enters the storage pond for reuse in the aeration tank.

  This weir requires regular removal of sediment and floatable materials to keep the debris to less than 1 foot depth, otherwise the efficiency of the weir is significantly reduced.
- Check and/or replace the Filter Berms in the north drainage system after a major storm event The stormwater on the north side of the facility runs to a paved sloped area as it drains into the stormwater retention basin. Use a filter berm to intercept the water and allow the sediments to drop out within the filter berm before entering the

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pond. Replace and compost the old filter berm material as needed to keep flow rates high.

C. Biofilter System

- Check through season changes that the sprinkler positions are providing complete coverage and the watering schedule adds adequate volumes of water to keep the biofilter wet to the full depth.
- Place the controller into the biofilter back pressure test mode at least once per month. Log the results. Include the air flow rates in the biofilter manifold.
- Replace biofilter media when the back-pressure test exceeds 9” water column, pull pipes out from under the biofilter. Stockpile and reuse the old biofilter media as biocover, relocate the biofilter pipes, check that all drilled holes are clear of debris before covering with new biofilter media.

D. Pre or Post-operational Equipment Inspection/Maintenance Checks

- Grease all lubrication zerks
- Blow out all radiators, coolers, and engine cavities of any organic debris that may clog or burn
- Fuel up and check motor oil, hydraulic oil levels and radiator coolant levels
- Check that wear surfaces have adequate wear left for operations that day or week.
- Check the clearance to the ground on the turning equipment teeth when in the lowest setting is at least 1.5” from the paved surface.
- Wash all windows in the operator cab
- Safe site set up, place traffic control cones and grinder safe area cones in positions that meet the setback requirements for normal deflector closed operation.

E. Equipment Cleanup

- There is a wash-down area at the maintenance shed that is designed to capture debris and grease that may come off equipment being washed. All portable equipment must be cleaned in this area.
- At the end of each day, dig out material in the loader bucket corners, belt pulleys, and flat surfaces that may accumulate materials or dust, and remove any accumulated debris at the pin/pinch points.
- Pressure wash or hose wash the engine area, and other locations on the equipment to remove any leftover debris that was not removed by digging out, with special focus on exhaust systems, greasing points, pinch points and pins.
- Pressure wash turner tracks, truck and loader tires and buckets before returning to the turned curing area or product load out area

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F. Process Equipment Maintenance

- Inspect wear surfaces and teeth and replace or rebuild the wear surfaces to meet the manufacturer's allowed tolerances.
- Change all filters and fluids at the recommended intervals by the equipment manufacturer
- Check any limit switches for debris buildup and proper function
- Blow out radiators and engine compartments with special focus on hot surfaces. Several times a day or as needed to prevent fires near the engines.

G. Site Cleanup

- Daily or several times a day, scrape, sweep and wash down exposed paved surfaces near operations and the traffic areas.
- Daily blown trash removal should be done to keep the site fence lines looking good. It is good practice to do a surface removal of blowable plastic debris from the composting piles after each turn as well.

IX. How the Facility is Designed to Meet Key Regulations:

A. Meeting Air Quality Regulations

The air regulation permits are contained in the appendices and must be read and conditions met by the operator for meeting the dust and other air emission standards including odor. This section describes the use of the tools provided to meet those regulations

- Forced aeration systems for keeping oxygen levels high, above 13%, and keeping composting temperatures controlled, between 40 degrees C (104 degrees F) and 65 degrees C (149 degrees F) in all the active compost. This provides the most significant odor reduction by maximizing the number of composting microbes that can survive, and keeping more volatile organic compounds from being driven off by higher temperatures or from being created by having anaerobic conditions or a low pH in the fresh piles. pH can change from acidic to basic by keeping feedstocks cool and aerated in the first few days of composting.
    - Reversing air flow directions allows tall piles to be cooled effectively at both the top and then the bottom. Active compost will over heat the passing air in less than 4 feet of media depth. Reversing allows cooling air to reach all parts of the pile

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- The design intent is to keep zones 1 and 2 at temperatures near 125 degrees F. Zones 1 and 2 are provided with a 5 cfm/cubic yard of air flow at a pile depth of 7.5 feet to assist in meeting these ideals. This cooling rate can be increased even more if necessary by lowering pile heights to no less than 5 feet in these zones.

- Zones 3 and 4 are provided with a 4 cfm/cubic yard aeration rate. Temperature set points here are intended to be between 131 degrees F and 145 degrees F which allow the initiation of pathogen management. However, if odors are still being generated by compost in these zones, then the set points can be lowered to 125 degrees F to 131 degrees F in zone 3 and setting zone 4 up for meeting PFRP with temperatures above 131 degrees F.

- Zones 5 and 6 are provided with a 3 cfm/cubic yard aeration rate and is adequate to control temperatures at 131 to 145 degrees F. This is the point where PFRP the process to further reduce pathogens begins for certain, allowing five more turns before the batches leave the temperature controlling aeration system.

- Zones 7 and 8 have been provided with an aeration rate of 2 cfm/cubic yard which at this stage of composting is more than adequate to keep the temperatures between 131 and 145 as the piles have very little consumable organic waste to keep temperatures high.

- Misting Ring for dropping ambient temperatures within the ducts and keeping the biofilter cooler during excessively hot weather also this maintain the relative humidity for the air going to the piles and the biofilter to keep them from over drying.

- Power and landing pad for a ten-ton chiller that can be rented and plumbed to the inlet of the positive aeration blower. This may be necessary in the middle of the hottest weather to keep the piles and biofilter cool, but is not certain at this point. The misting rings may be enough

- Biocovers for odor treatment in the first 4 to 7 days of active composting (note California testing) while in positive aeration. After turning each pass from zone 1 into zone 2, a loader can reapply the biocover from the aisle the turner just made directly over the top of the pile just turned.

- Biofilters for odor control while in negative aeration at any time that the piles are on the aeration slab. Biofilters can remove over 90% of odors captured in the aeration

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system before release. If malodors are present in materials after zone 2, those zones can be run in negative full time whenever necessary.

- Dust control area misting systems – in addition to good housekeeping, directional heavy misting can keep dust down and be used to keep the customers cool during excessively hot weather. Sometimes dusty loads arrive on site or the sun is so hot that any dirt delivered dries quickly and gets blown away, either way the area misters can be directed by the loader operators to be turned on and pointed at a processing area or the unloading area. For this reason, there are two area misters that can be separately controlled near the receiving and grinding areas. One of them is portable and can be taken to other operational sites that have power.

- The Laymor construction broom and water truck are good tools to move fine sediment to the base of the piles or to the drains to keep driving surfaces from generating dust.

B. Meeting Water Quality Regulations

The water regulations and permit conditions are in the Appendix, the following tools have been designed into the facility and processes to meet those requirements. These pertain to both process condensate water and to stormwater. All the site that receives solid wastes are paved with asphalt or concrete pavement which directs stormwater to a catch basin and storage system with treatment of the water along the way to reduce solids and Biological Oxygen Demand (BOD). The site is designed to be a zero-discharge facility. The permits require regular maintenance of the catchment systems and removal of sediment and debris. Each of the water features have been designed for easy regular maintenance.

Zero discharge is the primary way the facility will meet the groundwater quality requirements of the ADEQ. The HDPE lined storage pond has been increased in size to handle the largest storm as required by the permits. IF any discharges occur to the soil or groundwater, it must be reported to ADEQ Groundwater Section. Sampling and reporting requirements are contained in the attached permits in the appendix.

Water quality in the pond and tanks is improved by keeping the operating paved surfaces clean using the Laymor construction broom and the piles consolidated into the specified stockpile areas.

C. Meeting the Solid Waste Regulations

Solid waste regulations require that products meet vector and pathogen control and limit the chemical contaminant levels so that products produced from solid waste do no harm.

- Chemical and physical contaminants must be eliminated at the source by not accepting such contaminants for processing into compost or mulch at this site. Load inspectors must be trained in what the contaminant items are and how to identify them, educate and exclude them from acceptance.

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- Rats and mice will either discover the compost facility and /or be delivered in incoming feedstocks. Rodent bait boxes managed by a pest control company are needed around the receiving area, biofilters and biocover storage areas. If nests are found, baiting should be done near the nest.
- Birds are also expected vectors. With proper covering and cleaning of received feedstocks, this vector will be reasonably controlled. If perching areas are discovered, these should be covered with bird spike strips
- Flies are expected to be delivered, and will lay eggs in any wet and food like materials that are warm and wet. House flies have a 5 to 8-day egg to pupae period between laying of eggs and maggot maturation. Fly reproduction can be interrupted by exposing any suspect maggot ridden materials to the heat of composting, so turning any fresh piles completely every 4 days or less will significantly reduce fly hatching onsite. Along with excellent focus on cleanliness.
- Compost pathogen management is supported by the CompDACS controller and efficient management by operators to get all putrescible feedstocks through the designed composting steps sequentially. The procedures for meeting the Process to Further Reduce Pathogens (PFRP) and Vector Attraction Reduction (VAR) must be followed during the composting process. These include both windrow or Aerated Static Pile (ASP) composting methods for biosolids as described in 40CFR Part 503, and either approach can be used at the COP 27th Ave. Compost Facility. For the ASP method, one aeration zone is chosen to build an insulated compost pile and to accomplish temperatures over 131°F or 55°C for 3 days.
  For the Windrow method, the last zone that tank water is put in is zone 5. After that, the temperature settings for the subsequent zones are put above 131°F or 55°C for over 15 days and five turns. All of this is monitored and recorded by the CompDACS system.

  PFRP stands for the Process to Further Reduce Pathogens. This process is synonymous with sanitizing, specifically for biosolids. However, this process has been adopted for other organic wastes undergoing composting by most State's solid waste composting regulations.

  PFRP is the initial process that the compost pile needs to go through; followed by and concurrent with VAR.

  VAR stands for Vector Attraction Reduction. VAR is a process that reduces the food value in the composting materials so that rats, birds and other vectors are no longer attracted to the composting wastes. VAR requires composting temperatures to stay above 45 degrees C for 14 days. The time is cumulative and can be interrupted by turning and reheating, but only the time above 45 degrees C is accumulated in the data.

  PFRP can be achieve in one of two ways; in an Aerated Static Pile (ASP) or Turned Windrow (TW). The preferred method is the Turned Windrow method, however

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most facilities need the ability to do PFRP as an ASP if problems occur in the TW method.

The Aerated Static Pile (ASP) PFRP method means the temperature must be greater than, or equal to, 131 degrees F or 55 degrees C for a period of 3 days in an insulated pile. One foot thick of insulation material is added over the top of the material to be sanitized using compost that has already achieved PFRP. Any drop in temperature below 131 degrees F or 55 degrees C, within those 72 hours, in any spot within the pile, nullifies the accumulated time data, and the time clock restarts once the temperature rises above the required minimum temperature for both the top and bottom sensors. Typically designers use a set point that they know they can control to without small dips below that minimum. GMT initially will use 62 degrees C as the target set point for ASP PFRP controls, that way if the P&ID undershoots the target, it has time to recover without going below 55 degrees C.

The Turned Windrow (TW) PFRP method means the temperature must reach over 131 degrees F or 55 degrees C for 15 days and encompass 5 (or more) turns during that time. These piles are not insulated, and they depend on the number of turns to assure that all parts of the pile are subjected to the sanitizing temperatures at least once. This procedure as codified was less clear insofar as the duration the pile needs to be at or over 131 degrees F or 55 degrees C between turns. In practice, composters want the pile core temperatures to reach the target temperature again within one day after turning, and then stay there for 2 to 3 days before turning again. Thus, this method usually takes over 18 days to be accomplished in total time and may easily continue well into the turned curing areas of our process if we start the process in zone 5. What is good about this method is that the time above PFRP can just be accumulated up to 15 days and does not go back to zero if the temperatures drop during the process. Typically designers use a tighter target temperature of 59 or 60 degrees C when using TW PFRP.

PFRP will likely start in Zone 2, and may be restarted as needed if leachate is applied to the batch over the next several turns. GMT has put in a Start PFRP/VAR function (reset the timers for PFRP and VAR to zero for that batch) so that the operator can put leachate onto the piles up to its placement into Zone 5. After an operator applies leachate, they would hit the PFRP/VAR start button for the batches they applied leachate to.

The default is the TW PFRP method. Each batch can be changed to the ASP method of PFRP achievement, in case there is failure to maintain the energy in the pile for that long, or a need to speed up the PFRP/VAR process to be less than 15 days.

- The critical issue for pathogen management is that **any equipment** that goes over to the north side of the facility must be cleaned before it heads over the

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"continental divide", that means the tires, wheels and buckets are washed out with high pressure water nozzles to remove any debris.

D. Meeting the Fire Regulations

The fire regulations are new for composting facilities in Maricopa County, and require fire access roads to remain clear and pile sizes to be limited and pushout areas remain empty of stockpiles and fixed equipment. These areas are clearly delineated in the Facility construction permit drawings. It is suggested that these areas be marked in paint to assist the operator in maintain the clearances needed. Pile heights are limited as well to 20 feet of any pile and 10 feet of fresh receiving piles. The operator will establish elevation markers on the light poles or walls to assist the operators to keep pile heights below those maximum heights. Pile temperatures must be controlled to be less than 175 degrees F in all piles including those in curing. Temperature probes are provided for monitoring for these high temperatures and provides text notification to the facility operators that a piles condition has exceeded the alert temperature set point, so they can act immediately to reduce pile temperatures. Ignition sources such as smoking and welding are forbidden in the material stockpile areas. Machines with hot surfaces > 200 degrees F must be cleaned of dust and organic material. A fire plan must be created by the operator and shared with the Fire department and the City of Phoenix.

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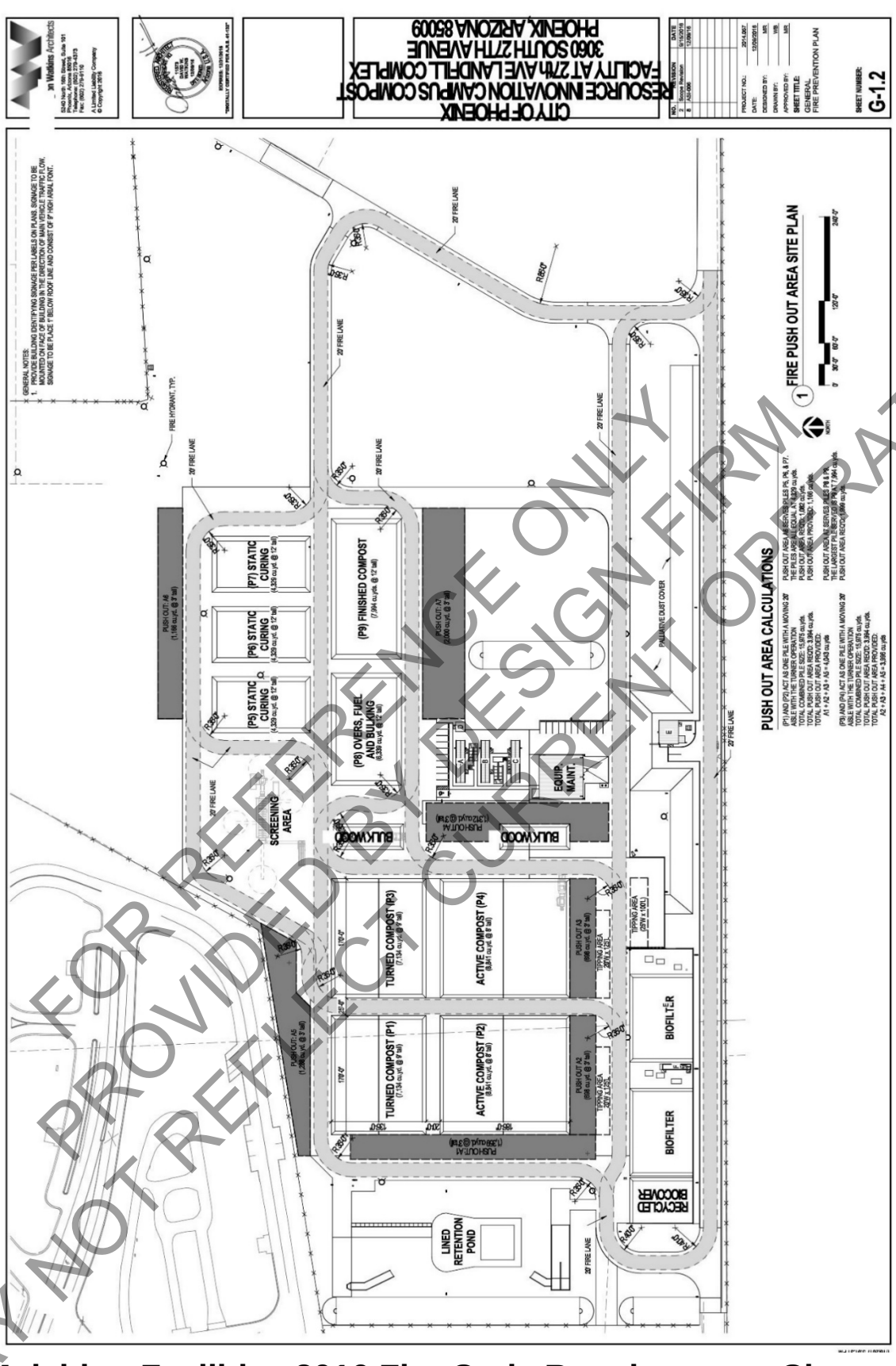

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Mulching Facilities 2016 Fire Code Requirements Cheat Sheet

Permit Required
Combustible material greater than 2,500 cubic feet

105.6.1, Agro-industrial and solid biomass facilities.

(Note: Permit is specific to type of materials being stored, i.e. green waste, logs, pallets, etc..)

Assessment Fees

Outside storage of 3,000 square feet (278 square meters) or less	$0
Outside storage of 3,001 to 15,000 square feet (278 to 1393 square meters)	$400
Outside storage of 15,001 to 30,000 square feet (1393 to 2787 square meters)	$800
Outside storage of 30,001 square feet (2787 square meters) or more	$1250

(Note: Square footage is measured by material stored not size of property. If assessment is paid, all permit fees pertaining to that assessment are included.)

Fire apparatus access roads

- 20ft wide
- No Dead ends
- Within 200ft of all combustibles
- Approved turning radius

(Note: Fire access roads can be normal use or emergency only areas, but must be capable of supporting a fire engine. Roads must be maintained for use in any weather.)

Fire Protection Plan

- Site Plan: Buildings, pile locations and sizes, separation distances, water sources, and fire department access lanes.
- Pile Contents: Raw green waste, mulch, hogged material, lumber, etc.
- Max Pile Dimensions: Intended heights not code requirements
- Monitoring Procedures: Narrative of how pile temperatures are maintained.
- Employee Training: Fire prevention training given to employees
- Equipment available: Equipment available for emergencies including through contract.
- Equipment contract: Letter from equipment company showing available equipment and account set up for emergency use.

(Note: Fire Protection Plan is intended to be a tool for both the fire department and the customer to reference.)

Site identification

Posted at main Fire Department entrance:

- Facility name
- Address
- 24-hour emergency contact numbers

(Note: Emergency contacts must be kept up to date to be notified in an emergency.)

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Water Supply

Supply capable of providing the required fire flow for fire protection
Within 400ft of all combustibles
(Note: Fire hydrants are required throughout. Appeals to location of hydrants or alternative water sources will be done through official Fire Department Appeal Process)

Material-handling equipment

Equipment able to move materials onsite.
(Note: Front loaders, Bull Dozers, or any other specialty equipment must be onsite to move materials in an emergency. A separate contract is required for additional equipment if needed.)

Size of piles

Hogged Material

- 60 feet in height, 300 feet in width, and 500 feet in length.
- Piles separated by not less than 40 feet

Mulch

- 25 feet in height, 150 feet in width, and 250 feet in length.
- Piles separated by not less than 20 feet

Green Waste

- 20 feet in height, 20 feet in width, and 150 feet in length.
- Piles separated by not less than 20 feet

(Note: This does not take into account any other departments max heights for material storage.)

Pile height indicators.

Height Indicator posts provided throughout
(Note: These indicators can be placed anywhere that provides an easy reference for pile heights. I.e. side of building, telephone pole, or piece of equipment.)

Static pile protection.

Piles must be checked for temperatures
Actions required at certain temperature
(Note: Piles shall be turned at 160 degrees F, and pushed out at 180 degrees F.

Delivery & Tipping Area

Feedstock and raw materials separated from other piles

- 12 feet in height, 50 feet in width, and 50 feet in length
- Piles separated by not less than 20 feet
- Water System nearby

(Note: New material delivered to site will be kept separate to prevent already overheated material starting a fire)

Push-Out/Clear Area.

Push-out or clear areas provided for pile storage.

- Located not more than 250 feet from the pile
- 20ft separation from building or combustibles
- Hold no less than a quarter of the size of the single largest pile it serves at a maximum depth of 3 feet
- Water shall be immediately available to aid in cooling.

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(Note: Push out areas can be used by more than one pile, but shall be kept clear of any materials or equipment. Area must be sized appropriately, and have water available to cool off material being pushed out.)

Security.

Approved fence.
Fences at least 6 feet in height.

E. Meeting new Product Regulations or Specifications

Sampling products and getting tested: The contractor is responsible for sampling compost and sending in for testing to assure it meets product quality and public safety standards. First is to enroll in the US Composting Council Seal of Testing Assurance (USCC STA) Program found on the following page.

How to take a sample is important as well and there are industry standards contained in the Test Methods for the Examination of Compost and Composting (TMECC) for this. Every STA Lab uses these test methods to test the samples you send and you should also take samples the proper way as well, to make sure the samples are representative of the materials you are sampling. This is contained below in the next two pages.

After the sample is taken, it needs to be sent to a STA Lab by overnight Mail. I suggest Soil Control Lab in Watsonville California as the best compost testing lab I have found.

Once you get the test results the information must be made public, provided to any one who requests it. Have a copy of the most current test available to all sales staff, and keep track of the earlier tests so that the levels of nutrients and contaminants can be compared over time. Where are you getting better, where are you starting to dis-improve?

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- **STA PROGRAM PARTICIPANT CHECKLIST**

1. Using the “Collecting Field Samples” document directions, collect a 1 gallon sample of compost.

2. Following the “Chain of Custody” form submit the 1 gallon compost sample to the testing lab of your choice. (STA approved labs can be found in the Lab section of this web site).

- Both of forms are needed in order to properly collect and submit your compost sample.
- Testing a sample can that 3-4 weeks, so you need to build that into your time frame.

3. Include with this sample the following information:

- Completed chain of custody form (check BOTH STA AND 503 analyses, as well as any state DOT form that is required)
- Fully complete the form listing; composting facility name, contact information, feedstock, state DOT requirements (if any), etc. This information must be the same contact information that is posted on the STA website and on any STA literature that is created.

4. The key pieces of the contract that need to be completed, signed and returned are listed below.

- Please return the original and retain a photocopy for your records.
- Complete and submit the following forms and items to the STA Program Administrative/Technical Manager (see address below):
  a. The STA Program cover page
  b. Appendix D – The entire logo use agreement
  c. Appendix F-1 – The application form (Please complete a separate form for each compost product that you want included in the STA program)
  d.Your product use instructions, with **specific compost application rates** (these are often forgotten). Please provide specific use information that includes either volume or depth of compost application. Compost test results will be provided directly by the STA lab.
- Provide a 1 quart sample of your compost product(s). This does not require any special packaging or shipping.
- PLEASE also include a current copy of your composting facility operating permit cover page showing facility name and current dating.

5. Please see the STA annual participation fee schedule page here.

Please submit all of the above to the STA Program Manager:

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Al Rattie

29 E. Ridge Avenue

Sellersville, PA 18960

Test Method: Selection of Sampling Locations for Windrows and Piles							**Units:** *NA*	
Test Method Applications								
Process Management							**Product Attributes**	
Step 1: Feedstock Recovery	*Step 2:* Feedstock Preparation	*Step 3:* Composting	*Step 4:* Odor Treatment	*Step 5:* Compost Curing	*Step 6:* Compost Screening and Refining	*Step 7:* Compost Storing and Packaging	*Safety Standards*	*Market Attributes*
		02.01-B	02.01-B	02.01-B	02.01-B	02.01-B	02.01-B	02.01-B

02.01-B SELECTION OF SAMPLING LOCATIONS FOR WINDROWS AND PILES

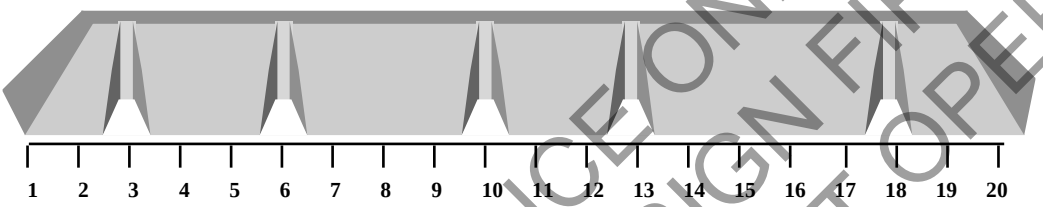

Fig 02.01-B1 Hypothetical sample collection pattern from a compost windrow.

NOTE 1B—In this example, a scale from 1-20 is superimposed on the long dimension of a compost windrow. Five distances (3, 6, 10, 13 and 18 m) are randomly selected to each side of the windrow, (e.g., numbers randomly pulled from a hat), to assign sample collection locations. Point-samples are collected from within three zones at each cutout.

NOTE 2B—The illustrated cut-outs are depicted on one side of the windrow; in a real operation, the cut-outs must be randomly assigned to each side of the windrow. Cone-shaped piles have a circular base. Measure around the base of a cone-shaped pile and randomly assign cutout positions along the pile's meridian, or circumference.

10. Apparatus for Method B

10.1 *Sampling Container*—five 16- to 20-L (4- to 5-gal), plastic (HDPP), glass.

10.1.1 *Organic Contaminant Tests*—For samples to be analyzed for the presence of organic contaminants, please refer to Table 02.01-6 Organic Contaminant Tests: Sampling containers and conditions for compost and source ingredient testing. Modify sample packaging steps presented in this section accordingly.

10.2 *Sampling Device*—silage auger, tilling spade, or other appropriate sampling device.

10.3 *Tractor Loader*—with loader, (e.g., Bobcat, etc.).

10.4 *Trowel*—high-density polypropylene (HDPP), for stirring and mixing composite sample.

10.5 *Pail*—16- to 20-L (4- to 5-gal), square pails, Use standard 5-gal plastic pails for shipping only when square pails are not available (e.g., square pails are available through Cleveland Bottle & Supply Co.; 850 East 77th Street; Cleveland, OH 44103; telephone: 216 881 3330; Fax: 216 881 7325; URL: http://www.clevelandbottle.com/squrpail.html).

11. Reagents and Materials for Method B

11.1 *Plastic Bags*—three 4-L (1 gal) durable bags with seal, (e.g., Ziploc® **Freezer** bags).

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11.2 Plastic Gloves.

11.3 *Tarp*—clean plastic, canvas, or other type of mixing surface if feedstock is liquid sludge.

11.4 *Cold Packs*—chemical ice packs, or 4-L plastic bags (e.g., heavy duty Ziploc® freezer bags) filled with approximately 0.5 L of water and frozen flat. One ice pack per 4-L sample container of compost to be shipped, (e.g., three ice packs are recommended for three compost 4-L samples).

11.5 *Aluminum Foil*—lining for plastic shipping pail, and

11.6 *Packing Material*—newspaper or other appropriate bulking material to be used as packing or fill to minimize sample movement within the shipping container (square pail) during shipping.

11.7 *Adhesive Tape*—duct tape, 5-cm (2-in.) width.

12. Procedures for Method B

12.1 *Cut into Finished Compost*—Using tractor skid-loader, bobcat or shovel, or sample boring device, cut into the finished compost pile or windrow at five or more randomly selected positions. Collect samples from the full profile and breadth of the compost windrow or pile. Refer to Fig 02.01-B1.

12.2 *Collect Point-Samples*—Samples of equal volume are extracted from the compost pile at three depths or zones measured from the pile's uppermost surface. Collect no less than five point-samples from each of the three depths or zones illustrated in Fig 02.01-B2. The five point samples for each zone must be collected in a manner to accurately represent the horizontal cross-section of the windrow or pile. Use a sanitized sampling tool (a gloved hand, clean shovel or auger) when collecting samples and when transferring samples to the 5-gal sample collection pail.

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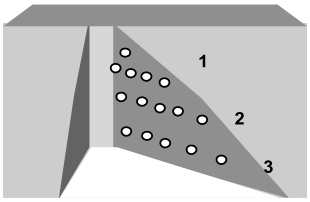

Fig 02.01-B2 Five horizontally dispersed point-samples are collected from each of three depths or zones within each cutout.

NOTE 3B—(1) upper $^1/_3$ of compost profile height; (2) middle $^1/_3$ of compost profile height; and (3) lower $^1/_3$ of compost profile height, where compost pile does not exceed the recommended overall height of 3 m. Create more than three sampling depths or zones within each cutout when the curing pile exceeds a height of 3 m, relative variability is high or the property of interest is found at very low concentrations, near the laboratory detection limit.

12.3 *Composite Point-Samples*—Place all 15 point samples from one cutout together into one sanitized plastic pail. Completely mix the point samples by stirring thoroughly with a sanitized wooden stick or lath, and by covering and shaking the pail to further mix the samples.

12.3.1 Repeat the blending process at least four times until all point samples are thoroughly blended to form one composite sample that accurately represents the compost for the cutout.

12.3.2 Proceed to the next compost sample cutout and repeat this process to collect one thoroughly blended composite sample from each of the five cutouts.

12.3.3 *Composite Sample*—Transfer the five composite samples from the sample collection pails onto a mixing tarp or other appropriately sanitized surface or container, such as into a large pail where all samples can be mixed, blended and then covered to minimize moisture loss. Thoroughly blend the five composite samples to form one large sample that represents the average condition of the entire batch or windrow in question.

12.3.3.1 Quarter the composite sample and thoroughly mix and quarter again. Continue to subdivide and split the sample into quarters and mix as described until sample size reaches approximately 12 L (3 gal).

12.4 *Stratified Sampling*—This sample collection strategy is used to evaluate for the presence of spatial variations or gradients in compost characteristics across and through a windrow or pile.

12.4.1 *Stratified Samples across Cutouts*—Use this sampling strategy to test for differences in compost characteristics between sample cutouts and along the longer dimension of a windrow. Do not composite materials from the five separate cutouts when monitoring for the presence of gradients along the longer dimension of a windrow. Pack and prepare five separate samples (i.e., five separate composite samples, one from each cutout) for shipment as described in step 12.5.

12.4.2 *Stratified Samples within Cutouts*—Use this sampling strategy to evaluate for the presence of spatial variations or gradients that occur with changes in pile depth or distance from the windrow core to its surface.

12.5 Prepare for Shipment and Storage:

12.5.1 Transfer the blended compost to three 4-L (1-gal) sample bags, (e.g., plastic Ziploc® *freezer* bags).

12.5.2 Line the shipment pail with aluminum foil or other reflective material to minimize sample heat-gain. Place the sample bags containing the compost sample into the plastic pail and interleave with ice packs for shipping (refer to Fig 02.01-B3).

12.5.3 Cover the pail with its lid. Seal and secure the lid with a packing tape. Send the sample pail by one- day express delivery service to your selected laboratory for analysis. Include a chain of custody information sheet with environmental regulatory samples (Refer to Method 02.01-E).

NOTE 3B—Maintain cool samples at 4°C (39.2°F) to diminish microbial and chemical activity prior to and during sample shipment.

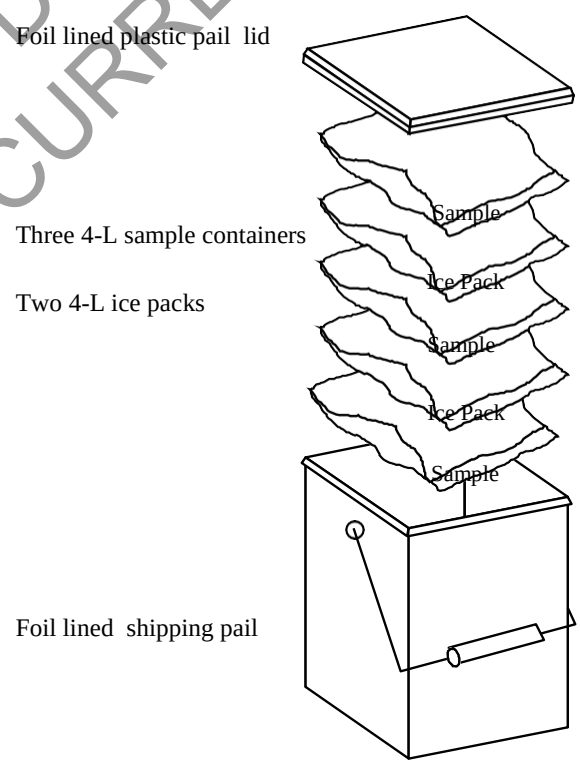

Fig 02.01-B3 Preparation for shipment.

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There are no compost product quality specifications in place in Arizona that should improve the growth and marketability of a compost product. Included here is an example of compost specifications from the City of Seattle Standard Specifications for Road, Bridge and Municipal Construction, 2017 Edition, this 758 page document has a section on compost product requirements that are based on over 25 years of compost product use and specification development by the Washington State Department of Transportation and working with many compost producers to establish what is important to accomplish for the city projects. Implementing this into local codes could be a good starting point to help develop a mature compost market in the greater Phoenix area. The entire document also has several end uses for a variety of construction activities that use compost such as erosion control, topsoil, mulch, that can be found in the whole document at
http://www.seattle.gov/util/cs/groups/public/@spu/@engineering/documents/webcontent/2_035032.pdf

The operator needs to understand the testing requirements and documentation issues and work with city officials to help develop construction permit based compost markets in the greater Phoenix area.

City of Seattle Standard Specifications for Road, Bridge and Municipal Construction, 2017 Edition

9-14.4(8) COMPOST
Procure compost manufactured by facilities which have an active solid waste handling permit from the local jurisdictional Health Department as per WAC 173-350-220 or WAC 173-308.
Compost production and quality must comply with Chapter 173-350 WAC, and with the criteria below:
Compost products must be the result of the biological degradation and transformation of feedstocks as specified below, under controlled conditions designed to promote aerobic decomposition, per WAC 173-350-220, which is available at
http://apps.leg.wa.gov/wac/default.aspx?cite=173-350-220 .
The Contractor must submit the following information and samples to the Engineer for approval:
1. A copy of the Solid Waste Handling permit issued to the Supplier by the Jurisdictional Health Department as per WAC 173-350 (Minimum Functional Standards for Solid Waste Handling).
2. A copy of the producer's current Seal of Testing Assurance (STA) certification as issued by the U.S. Composting Council.
3. Two 1-gallon samples of the compost, gathered per STA protocol available from the U.S. Composting Council, Phone: (631) 737-4931, http://www.compostingcouncil.org.
4. A written statement from the producer and lab analysis reports from an independent STA Program certified lab, demonstrating that the Materials comply with the processes, testing, and standards specified in WAC 173-350 and
the parameters listed below.

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SECTION 9-14 EROSION AND LANDSCAPE MATERIALS PAGE - 9-67
2017 Edition of City of Seattle Standard Specifications for Roads, Bridges, and Municipal Construction Acceptance will be based upon a satisfactory Test Report from an independent STA program certified laboratory and the sample submitted to the Engineer. The Engineer may inspect any loads of compost on delivery and stop placement if it is
determined that the delivered compost does not appear to match the submitted sample and documentation, and require sampling and testing of the delivered compost, before authorizing compost placement. If testing demonstrates the delivered compost does not match the submitted material, or is not as specified in 9-14.4, the Contractor is responsible for all testing costs.
The compost Supplier must test all compost products within 90 Calendar Days prior to application, at the Suppliers expense.
Required test parameters to be reported in the submittal documentation include:
1. Compost must meet the following size gradations when tested per the U.S. Composting Council Testing Methods for the Examination of Compost and Composting (TMECC) Test Method 02.02-B, Sample Sieving for Aggregate Size Classification:
a. Fine Compost, typically used for soil amendment, must meet the following gradation by dry weight:

	Min.	Max.
Percent passing 2”	100%	--
Percent passing 1”	99%	100%
Percent passing 5/8”	90%	100%
Percent passing 1/4”	75%	100%

b. Medium Compost, typically used either for soil amendment, erosion control, or surface mulching, must meet the following gradation by dry weight:

	Min.	Max.
Percent passing 1”	100%	100%
Percent passing 5/8”	85%	100%
Percent passing 1/4”	70%	85%

c. Coarse Compost, typically used for erosion control or surface mulching, must meet the following gradation by dry weight:

	Min.	Max.
Percent passing 3”	100%	--
Percent passing 1”	90%	100%
Percent passing 3/4”	70%	100%
Percent passing 1/4”	40%	60%

2. The pH must be between 6.0 and 8.5 when tested per TMECC 04.11-A; 1:5 Slurry pH.
3. Manufactured inert material (such as concrete, ceramics or metal) must be less than 1.0 percent by weight as determined by TMECC 03.08-A percent dry weight basis. Film plastics must be 0.1 percent or less, by dry weight. The Engineer may approve use of Medium or Coarse Compost up to 0.25 percent film plastic, subject to the limitations in WAC 173-350-220.
4. Salmonella must be less than 3 MPN (Most Probable Number) per 4 grams of total solids, by dry weight.
5. Metals must be at levels below those specified in WAC 173-350-220, table 220B

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6. Minimum organic matter content must be 40 percent by dry weight basis as determined by TMECC 05.07A; Loss-On Ignition Organic Matter Method.
7. Soluble salt contents must be less than 5.0 mmhos/cm tested per TMECC 04.10-A; 1:5 Slurry Method, Mass Basis.
8. Maturity must be greater than 80 percent per TMECC 05.05-A; Germination and Vigor. The Engineer may also evaluate compost for maturity using the Solvita Compost Maturity Test at time of delivery. Compost must score a number 6 or above on the Solvita Compost Maturity Test.
9. Stability must be 7 or below per TMECC 05.08-B; Carbon Dioxide Evolution Rate.
10. The compost product must originate from a minimum of 65 percent by volume from recycled plant waste as defined in WAC 173-350-100 as yard debris, wood waste, crop residues, and bulking agents. A maximum of 35 percent by volume of pre- or post-consumer food waste as defined in WAC 173-350-100 may be substituted for recycled plant

PAGE - 9-68 SECTION 9-14 EROSION AND LANDSCAPE MATERIALS
2017 Edition of City of Seattle Standard Specifications for Roads, Bridges, and Municipal Construction waste. The Engineer may approve compost products containing up to 35 percent biosolids or manure feedstocks for
specific projects or soil blends, but these feedstocks are not allowed unless specified, and not allowed in compost used for bioretention soils. When allowed, feedstock sources by percentage must be reported.
11. Fine compost must have a carbon-to-nitrogen ratio of less than 25:1 as determined using TMECC 04.01 Total Carbon and TMECC 04.02D; Total Kjeldhal Nitrogen. Medium compost must have a carbon-to-nitrogen ratio between 18:1 and 25:1. Coarse Compost must have a carbon-to-nitrogen ratio between 25:1 and 45:1. The Engineer may specify a
carbon-to-nitrogen ratio in medium or coarse Compost of up to 35:1 for projects where the plants selected are entirely Puget Sound native species. Compost may be mixed with fir or hemlock bark as specified in Section 9-14.4(3), or clean wood chips or sawdust, to raise the carbon-to-nitrogen ratio above 25:1.

X. Documentation and Reporting:

To be completed when finished with construction and scalehouse updates

A. Construction As-built Documentation from Brycon

The cut sheets and maintenance manuals for all the installed equipment are received still waiting for facility drawings

B. Scale House Weights from City Scale House

Waiting for City procedures to generating feedstock documentation and accounting
Data that can be transferred directly to the CompDACS batch data information.

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C. Process Control Documentation

The CompDACS system records and stores all process control information for each batch of compost, including feedstocks, temperature, moisture and composting time. This data can be printed at the end of each batch and should be stored in a binder offsite of the computer used to store the data. This should be easily accessed in the sales or site manager's office. Test results of finished products should also be stored in the same binder for easy cross referencing. Monthly Data back-up procedures should be used to duplicate and store electronic data in a different area than the controller or interface computer.

D. Product Quality and Sales Documentation

Compost product testing must be frequent enough to meet the Seal of Testing Assurance requirements from the US Composting Council. Product quality and end use information must be available for every customer purchasing compost. Product sales should include batch information in case there are complaints of product quality. Then the processing data can be inspected and procedures adjusted to improve product quality even further. Sales data must be recorded and provided to the city as per the contract.

E. Regulatory Reporting

Checklists and recorded data must be kept on-site and ready for inspection by the regulatory agencies. It is recommended that a hard cover bound daily logbook be used to document all activities at the site each day, with special notations of changes, problems and corrections to operations or equipment.

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XI. Appendix 1 – COP 27th Ave. Compost Facility Operational Design

Note; This is the original operational design document provided to bidding operations contractors. It was used to give them an idea of the expected way the facility would work. It contains many of the features included in the Operations Manual and some great overview of the process components at its fully envisioned development for 110,000 tons per year, including a sorting system and large finished product screening system, which are no longer included in the immediate operation. However, they are still likely to occur in the future. There were videos of the design model that accompanied this information and are still available for review however they no longer accurately represent the constructed facility.

City of Phoenix Compost Facility Operational Design
1.0 General Description

This document concerns a 20-acre Compost Facility that is designed for a positive and negative aeration process using frequent turning, watering and temperature control to produce a stable and cured compost in less than 45 days.

The City of Phoenix (COP) Compost Facility is designed to provide the essential tools for an operations contractor to convert over 110,000 tons per year of green organics, food scraps and large animal manure into a finished stabilized compost product that meets sanitation and market demands for a clean and effective biological soil amendment.

The facility and systems are designed to produce high quality compost; however, the City encourages the Operations Contractor to produce a variety of products that will maximize marketing revenue.

1.1 Overview of Operational Requirements

There are 11 important factors that were incorporated into the operational design.

1. On-time management of incoming feedstocks to conserve nutrients and moisture
2. Removal of contaminants at every handling step
3. Control of moisture in the piles using irrigation during turning
4. Automated pile temperature feedback control using high airflow in alternating directions
5. Keeping oxygen concentration above 13% in the interstices of the fresh piles
6. Covering fresh piles with bio-covers, and using biofilters to treat collected air
7. Mixing and turning frequently to provide porosity and accelerate decomposition
8. Water collection, treatment and reuse systems to reduce odors, pathogens and water use
9. Dust control for all onsite activities; receiving, grinding, turning, screening and delivery.
10. Pathogen management through temperature control and process equipment segregation
11. Screening products well to meet market requirements for a diversity of soil amendments

These operational factors require a combination of good design, good equipment, knowledgeable operators and diligent maintenance of all these systems. This document is intended to instruct the facility owners, their operations contractor, facility regulators and interested public on the operational concepts built into the facility, and the flexibility and ability to respond to challenging feedstocks, excessive weather, and odor complaints.

1.2 Site Plan

The site over view on the following page shows the general layout with the stormwater/leachate pond to the west, the receiving unloading area to the south, the aerated and turned composting area in the center, and the screening and curing area to the north. The area to the east is reserved for a future development of either expansion of the composting operation and/or an anaerobic digestion system for food wastes. These reserved areas cannot be used for operational activities. The office area and product demonstration garden in the northeast provides a safe public receiving area where classrooms are available for training, lab work and breakrooms, as well as several offices and restrooms, providing the amenities needed to operate a business and entertain customers and community members.

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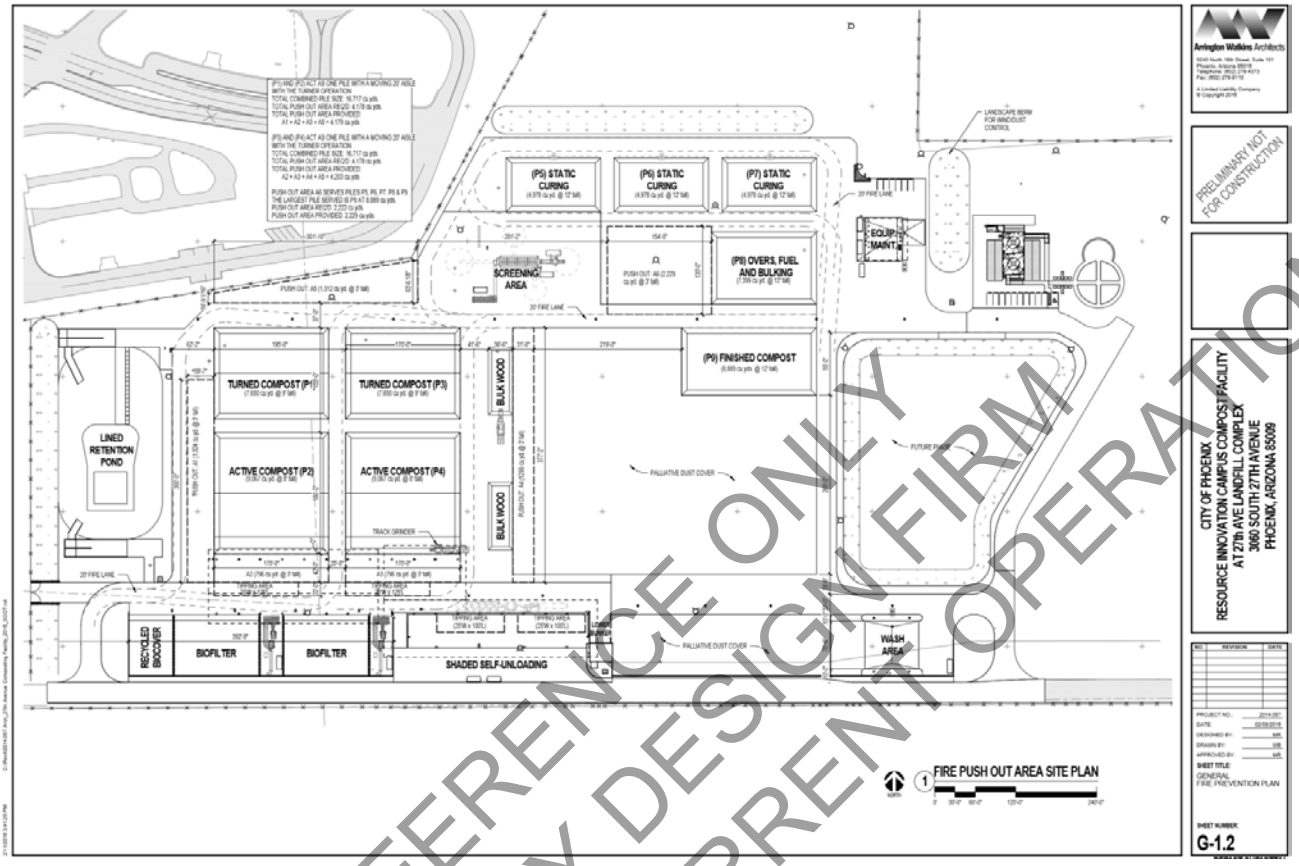

2.0 FeedStock Recieving

Compost Facility Receiving Hours align with the 27th Avenue Transfer Station receiving hours M-F 5:30 a.m. to 5:00 p.m., Saturday 6 a.m. to 3 p.m.

- Responsibility for the feedstocks rests on the Operations Contractor once received at the facility. Management responsibility starts once the vehicle leaves the scale house.

- Load spotters must be assigned to the self-haul unloading area at all times during the facility's receiving hours.

- Sufficient equipment operators must be assigned to ensure same day grinding of inbound food scraps and other odorous materials to get those materials under full operational control.

- Each load is inspected visually during unloading. Immediate feedback is given to the delivery person on the quality of the feedstocks delivered, and they are encouraged to remove any debris visible in the load. Low quality loads are documented by the contractor's staff with pictures, source or route information, with notification given to the company or customer of the necessity of keeping future loads clean. The contractor can prepare this notification either:

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- Immediately and copy the City of Phoenix representative
- By letter and/or e-mail and copy the City of Phoenix representative

- Contractor notifies the Certified Clean Green Customer about contamination, they must also notify the City's representative and include the back-up documentation for the City to conduct additional review and follow-up. Removal from the program may be implemented or charges may be incurred up to the cost of garbage disposal and handling fees for loads that do not meet the acceptance criteria for the facility.
- Break apart received materials, with a bucket, to identify large or difficult to find contaminants.
- Contaminated material is loaded into the pick-line or placed in a drop box for disposal. If the pick-line is not available, a floor sort is required.
- Dry loads are unloaded under the misting system to eliminate fugitive dust. The receiving operator monitors unloading operations and directs the spray system so fugitive dust is managed. Leaf blowers cannot be used to sweep beds.
- Dry piles are watered before grinding to reduce the dust load.
- Provide an unloading bed for wet loads of biocover or ground wood to absorb liquids and are immediately mixed together so that liquids are absorbed.
- All received materials except wood are ground up and covered before the end of the business day, ideal is in less than 2 hours after delivery. In no case shall materials that emit malodors be allowed to remain unprocessed or uncovered for more than 30 minutes.
- Biocover layers will be used to absorb odors as needed at any point in the receiving area and during initial processing.

3.0 Pick- line

- Shred to open bags
- Pre-Screen 3" minus materials to segregate and spread materials on the picking belts
- Remove metal and plastic by magnets and suction devices

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- Sort out remaining contaminants by hand

4.0 Grinding of Green Waste

- Grind green waste feedstocks to 5-inch minus for composting. This allows good porosity and reasonable material flow through buckets and turners, while reducing wear on grinding surfaces and reducing energy costs.

- Evenly proportion the received materials so there is no need for further mixing after grinding. Feedstock mixing training will be given to operators to make the fresh piles consistent in mixture, porosity and moisture content.

- Water during grinding to eliminate dust, and adjust the water volume to assure at least 50% to 60% initial moisture is in the processed feedstocks. Check moistures by hand squeeze estimation backed up with a field test for gravimetric moisture/drying.

- First materials received must be the first materials processed. First in first out.

- Keep the mix porous. The porosity goal is to be between 40% and 60% Free Air Space after grinding. Or a bulk density around 750 to 950 lbs. /cubic yard wet weight. Biocover or wood can be added during grinding if incoming loads are too wet or dense. 5-gallon bucket field bulk density testing procedures for these parameters are included in the facility Operations Plan.

4.1 Grinding of Woody Loads

- Woody Loads are directed to the wood stockpile if wood is not needed in the mix to meet the porosity goal.

- The wood stockpile is ground at least 2 times a week, or whenever the pile approaches the wood stockpile volume limits as shown on the fire push out area plan.

- Ground wood waste is kept above 38% moisture in all stockpiles to prevent spontaneous combustion. (Excluding the top 6 inches.)

- Positive aeration mode is used anytime the air floor is loaded or turned.

Positive aeration creates a void near the nozzle or sparger to prevent clogging. It is essential that these holes are cleared prior to loading. Nozzles can blow debris forcibly upward so eye protection

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is required during clearing. Keeping spilled feedstocks scraped up before driving on them will reduce this effort significantly. Nozzle exit velocity is designed at >70 miles per hour.

- All ground and mixed composting feedstocks are placed immediately on the active compost pad at a height of no more than 8 feet. Keep temperatures below 104° F for the initial 6-12 hours after grinding. Low oxygen and high temperatures in the beginning of composting can sour a pile, multiplying odors 10 fold later in the process. Good initial aeration increases oxygen, lowers temperatures and minimizes odors.

5.0 Bio-cover Placement

- Fresh piles are covered with a 6-inch to 12-inch layer of biocover to absorb odors in the received materials. Bio-covers must be moist to get the best performance. The misting system is designed to assist in keeping the bio-cover moist after placement; however, it is important that the biocover has at least 50% moisture when placed on the piles.

- After the first turn, cover the fresh pile again with bio-cover. This allows the fresh compost to be contained for 4 to 8 days keeping odors treated during positive aeration over the time period when volatile organic compounds are emitted in the largest quantities.

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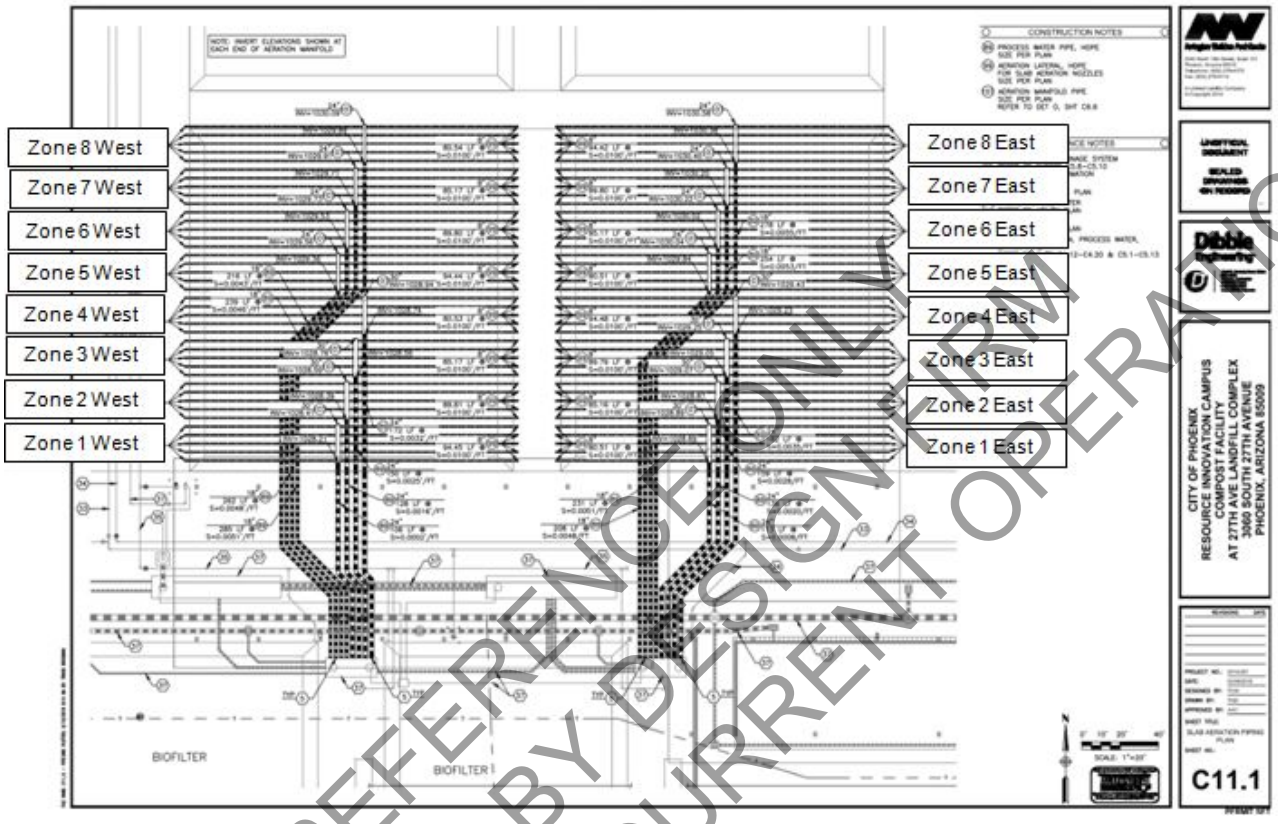
6.0 Management of Compost Temperature, Moisture and Porosity by Forced Aeration & Turning



- There are 8 aerated zones that the piles are moved through laterally in the active compost area, each zone is 22.5 feet wide and 170 feet long, approximately the throw of the compost turner. Composting is done on air for 22 to 32 days to quickly reduce the volatile solids within the feedstocks using optimum conditions for aerobic biological activity.

- Probes must be removed before turning an aeration zone, and replaced after turning. Temperature control is automatically managed between 125 to 140 degrees F in the aerated areas, but <u>must</u> be kept below 150 degrees to assure rapid decomposition. Lower the pile loading heights if temperatures exceed 150 degrees F. While the air floor is designed to effectively cool piles 7.5 feet deep, feedstocks change seasonally, and adjusting pile height is the most practical way to keep the system within the proper temperature range when the piles are dense, porosity is low and/or the piles are wet.

- There are another 6 zones north of the forced aeration zones that require an additional 5 turns that are not on the aerated slab, but composting continues in this area. At this stage, regular turning can provide adequate porosity to maintain oxygen in the piles, but cooling air is not important, as this area provides the final sanitation step, and higher temperatures (>131 degrees F) are essential. Pile height can be increased here to assure sanitation temperatures are maintained. However at least 2% oxygen

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must be maintained. Oxygen is measured twice a week in the turned piles using a hand held Demista Oxygen Meter or equivalent. Temperatures are monitored and documented by wireless probes same as the aerated zones. Lower the pile height if minimum oxygen levels are not achieved. Raise the pile height if temperature goals are not achieved.

6.1 Aeration System Operations and Maintenance

- Daily – Make sure all temperature probes are fully inserted in the piles, and located in the correct aeration zone, and turned to automatic. Empty zones can be switched off manually at the computer to reduce power consumption. Check recorded temperatures in each zone and biofilters to make sure the system is operating properly. Assign a name and fill in the requested batch information for the daily batch of feedstocks placed on the first zones, Zones 1E and 1W.

- Twice weekly - Move the icon for each batch on the computer screen to the proper zone location immediately after turning and the probes are switched to automatic.

- Weekly – Check moisture levels in the biofilter and adjust watering schedule to assure wet conditions.

- Monthly – Check airflow entering each biofilter and adjust biofilter manifold pressure settings to assure that full flow conditions meet design standards. Check the flow of air to each aeration zone and the delivered pressure when the zone damper is at 100% open. Generate processing data reports for each batch of compost processed that month.

6.2 Turning

- Piles in the Active Compost and Turned Compost zones should be turned twice per week whether the zone is full or not. Turning is used to both re-establish porosity and to remoisten the compost to make up for lost moisture during forced aeration. Pile build height should be lowered to keep the holes covered evenly throughout the aeration zone prior to turning. Piles should always be taller than 5 feet. Please see the zone illustration on the following page to see the layout.

- Temperature probes (2 per zone) are placed in the piles at full depth as soon as possible after turning or stacking to allow the automation system to control pile temperatures and/or document pile temperatures.

- Pile aeration is designed to alternate between negative and positive direction to cool the upper and then the lower sections of the pile. Upper and lower temperature sensors on each wireless probe send data to the automatic process controller to determine whether to change airflow direction.

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- If odors are emanating from the aerated compost piles even with proper biocover placement, the aeration system for that zone can run in negative only, so that air coming out of the pile always runs through the biofilter for odor treatment before release.

- To turn the piles, remove the oldest edge of the turned piles 25 feet from the toe of the pile, and place in curing piles or the screener. Turn the next wall of material 22.5 feet north using the CT1010 Compost Turner or equivalent. Continue moving slices of the pile the same way until you get to the aerated piles. Turn the next 2 slices twice to maintain the 20' roadway.

6.3 Compost Irrigation

- While turning, moisture must be estimated by the compost turner operator and adjusted to be above 50% moisture using the hose reel and the compost turner spray bar. An electric actuator switch for the valve is in the cab of the turner to allow the operator to adjust the volume of water being applied and to shut the valve when stopping the turner. Turner operators who are new must be trained in proper water management.

- Treated facility tank water should be used to irrigate the newest recently ground piles that are under forced aeration. Clean raw well water only should be used to irrigate the unaerated compost piles to prevent pathogens from being reintroduced.

- Turning equipment and hose reels, after finishing a turning of the aerated piles, must be emptied and cleaned with fresh water before being used for handling the oldest compost.

6.4 Management of Pathogens

Using heat to treat compost piles, washing equipment, and isolation of the product areas

- Pathogens (microorganisms that can cause disease in plants or animals) and weed seeds are delivered in the feedstocks from all over the collection area. The City of Phoenix compost operations contractor is required to manage the incoming materials in a way that limits the spread of pathogens and to treat all the materials received to reduce the level of pathogens and weed seeds to a level that meets regulatory requirements and market expectations. Pathogens can move in fresh un-composted materials, water, and wind, so water flow and dust control are essential to keep on the south side of the operation.

- The contractor must keep all materials and equipment likely to carry weed seeds or pathogens on the south side of the property's continental divide of the composting pad. Before equipment travels to, or is moved, north of this high point or off the site, they must be cleaned with fresh water or swept so no visible

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compostable material is in the buckets, bumpers, wheel wells or tires/tracks. A wash area is provided near the exit in the southeast corner of the facility, where all the water is recovered, treated and stored for irrigation of the active turned compost piles. The compost turner, sweeper and water truck will be the most likely process equipment to cross this high point and must be washed before proceeding from South to North. Customer trucks delivering feedstocks and then wanting to reload with finished product must use the wash area before being loaded.

- All compostable materials going north over the high point off the air pad must have met a Process to Further Reduce Pathogens (PFRP) method as codified in Federal Code 40 CFR Part 503. After PFRP is achieved, no tank or process water or unwashed equipment is allowed to handle that material. This means there is a loader dedicated for handling the Post-PFRP compost, on the North side of the facility and one loader dedicated for the Pre-PFRP compost and the South side of the facility. The compost turner always starts a turning event having been washed from the prior turning event that ended on the South side of the compost facility. The water truck and the sweeper will always start on the North side of the facility to wash roads and water piles, and then stay on the South side once it crosses the high point, until it has washed itself off before reentering the North side of the facility.

- There are 3 sources of water for the Operations Contractor to use in the process to manage pathogens:

  - The city water is potable and must be used for all equipment wash down and misting operations where customers and employees are likely to be splashed, ingest or inhale the water droplets.

  - The water well or raw water is reasonably safe, but is not tested and is non-potable, but it can, and should be used, for the water truck, biofilter irrigation and pile irrigation. The operators and laborers for the facility must be trained that this is non-potable and should wash up with city water or sanitizer before touching their face, eating or shaking hands when they have been in contact with the raw water.

  - The tank water or pond water is contaminated with organic debris from all areas of the facility, and is likely to be carrying pathogens and can only be used to irrigate the fresh compost piles. The grinder and turner operator are likely to be coming in contact with this water while managing the irrigation reel. They are required to wash with City water and soap or raw water and soap and sanitizer after contact with tank water. Coveralls, gloves and a face splash guard are recommended for handling the tank water. Any inadvertent ingestion should be reported to the site manager and employee's health monitored if any signs of illness appear within 48 hours. All clothes used by employees operating the compost facility should be laundered or bagged before they leave the site.

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- Dust can carry pathogens and weed seeds and must be managed to meet the air permits held by the City for the compost site. This information is covered in the section on dust control.

6.5 Dust Control

Dust control is essential as the city holds the air permits for the compost facility. The Operations Contractor is required in the contract to not violate the permit conditions. Trained dust control operators must be on-site during operations, and must manage the facility so that it does not violate the air permit conditions.

- Dust control will be achieved at the site by the use of area misters, initial watering of feedstocks, makeup watering during composting of the active piles to achieve a minimum of 45% moisture by weight during processing and handling, the immediate scrape up of spilled materials and daily broom sweeping and watering of roadways to remove fine particles of compost, and watering of pile surfaces exposed to the sun as needed with the water truck.
- Primary strategies for dust control are proper moisture management of organic materials and regular misting and sweeping during facility operations. On the receiving floor, DustBoss area misting towers and construction broom help control fugitive dust from lower moisture materials that are being received. On the compost floors, the CT1010X turner carries a 3" hose reel through the piles during turning, dumping 350 gallons/minute of process reuse or well water onto 2,400 cubic yards/hour of compost coming off the discharge conveyor. This adds 5% to 10% moisture back into the compost that is lost from evaporative cooling between turning events. During screening, the water truck and DustBoss misting system are used to minimize fugitive dust. The facility maintains a water truck with front and rear spray capabilities on-site with at least 5,000 gallons of water during operational hours for dust control purposes.
- Per the permit application, all operations of hauling/transporting, loading, unloading, bulk material stacking will cease if the wind picks up (e.g. flag is blowing), and the operations will return after the wind is calm.

7.0 Management of the Curing Process -

- Curing is accomplished by encouraging the growth of fungal roots throughout the pile and allowing them to further break down woody structures and form humic acids. This requires at least 50% moisture, and adequate oxygen >13% and not turning the piles. The goal is to keep these piles below 105 degrees F, and remove about 10% of the initial moisture before it is ready to be screened. During the Phoenix summer this temperature goal may not be possible, so temperature is considered the least critical control goal for curing.
- Normally this curing process will take place in the aerated curing piles. If blowers are not available, the materials should be cured before screening. If blowers are available, screening can be done before curing the compost.
- Depending on the efficiency of the composting process, curing may take place in the turned composting area, but pathogen reduction (5 turns over 15 days > 131 degrees F, or 3 days in an insulated pile >131 degrees F) will have to happen earlier in the turned aerated composting area, without tank water being used during that process. So the need to use process water must be balanced with when PFRP is done. If required by the state, Vector Attraction Reduction (VAR), the process that needs the piles to meet for 14 days a temperature averaging above 45 degrees C, can be accomplished anytime after PFRP and

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even during curing. Based on current uses of this system, the expected time frame to produce a finished cured product is expected to be around 45 days for the green organics, food scraps and large animal manure feedstocks.

- Odors can be formed during curing if the piles are not managed for porosity and pile height or forced aeration. If odors develop, the handling procedures must change so that bad odors do not form in this process. Maintaining high oxygen levels >13% throughout the curing pile will assure no bad odors.
- It is absolutely essential that no equipment or materials enter the curing area that have not met PFRP or other approved cleaning steps, as this product can be reinnoculated with pathogens and weed seeds and regaining temperatures to kill them is very difficult.

8.0 Screening Operations Management

- The art of getting the right size compost particles to come through screens consistently requires operator diligence. Starting and stopping the screen feeding system creates the most problems with product quality, and uneven feeding in the feed hopper is the second most problematic issue. By this stage of the process, the compost materials are generally consistent in character, including moisture if proper care in watering has been done.
- The West Salem Machinery Titan Trommel Screen is the largest capacity compost trommel screen produced on the market at this time. Large diameter trommels have a larger effective screening area than smaller diameter mobile units, and this unit can produce over 350 cubic yards an hour of screened products if all the compost materials are at the right moisture (38 to 42%) and the materials are fed consistently and heavily so that some fines come out of the next larger screen size.
- The trommel is set up with screens that start larger and then narrow down within each gathering conveyor section. It is intended to be flooded with materials and will create greater production without significant spearing or oversize materials making it into the cut. Because of this, heavy feeding of this trommel is required to get good product quality.
- During start-up and shut down, spearing will happen, so moving the stacking conveyors out of the way of the main pile at start-up and shut down is essential to prevent oversize materials from making it into the piles.
- It is essential that the trommel screen brushes are checked for the proper depth of penetration and adjusted as frequently as necessary to just tickle the inside of the wire mesh. This is generally checked once every two weeks by a mechanic.
- Overly moist compost will build up on the flights inside the trommel, and workers will have to shovel off impacted wet compost from the flights inside the trommel every day after screening or the material will continue to build up.
- **Lock out - tag out procedures must be followed** during any cleanup or maintenance for any equipment on the site, especially the trommel, as you cannot see someone inside the drum or under the conveyors.
- Plastics and rocks are removed using the Hurrifex for the overs and an airlift separator for the mulch. These machines require adjustment to get the most materials removed possible.
- Send the clean overs to the grinder for resizing and reuse as biocover, bulking agent or fuel

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- Sell the coarse mulch, or use it for biocover
- Stockpile the fine and coarse compost for sale and distribution. It is best to sell immediately after screening to improve customer satisfaction with the product.
- Driving onto any finished compost, or stacking it too high (>6 feet) ruins the fluffy nature and compacts it into a valueless product. Rescreening of old un-sold piles of screened product is recommended before sale. It is ideal to sell products right off the screen if possible.

9.0 Product Quality Standards

- The finished compost sold from this facility must meet market standards and follow the testing and product reporting protocols of the US Composting Council's Seal of Testing Assurance program. It must be sold in accordance with the State of Arizona's Fertilizer and Soil Amendment rules. The Operations Contractor is responsible for paying all fees and dues to meet these requirements for the proper sale of the products generated and sold from the facility.

10.0 Site Cleaning and Maintenance

- The facility is to be clean at the end of each working day to reduce dust generation and to maintain the site as a model compost facility.
- Broken damaged or malfunctioning parts of the facility and the equipment will be repaired and kept in good working order by the Operations Contractor quickly to assure that the facility is maintained in good repair through the life of the contracted period. Normal wear and tear and replacement schedules will be determined by the city as to whether the damage is acceptable or not.

11.0 Staffing Requirements

The facility requires enough people to perform the necessary tasks described in this document and to increase and decrease in number as material flows change over the seasons and years. Initially it is thought that there be the following minimum staff positions:

- Spotter whose job is to direct customers to an empty spot, ask about any garbage in the load, and direct customers to the wash station who need to clean their vehicles. Also, documenting any problem loads and then communicate to the scale house on any excessively contaminated loads that were rejected. Assist in cleaning loads as needed.
- Pick-line and Equipment Cleaning Laborer whose job is to remove contaminants from the feedstocks, clean the pick-line, grinders, turner, screener after each daily use,
- Self-haul Loader Equipment Operator whose job is to back blade loads, identify and separate clean and dirty loads, place clean loads into the bunker and dirty loads into the shredder/pick-line, control dust by directing area sprayers and keeping the south side of the facility clean using sweeper, assisting large receiving loader to move loads and cover piles, and water the access roads and piles as needed with the water truck, fuel and grease their equipment.
- Large Receiving Loader Equipment Operator whose job is to monitor the quality of the loads delivered below in the large truck unloading area, communicate with driver and scale house about poor quality loads

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and extra charges, mix feedstocks and grind clean loads, place dirty loads in shredder/pick-line, place ground materials on air and cover with biocover, control dust with the area mister and back-blading the receiving areas, fuel and grease their equipment.

- Turner, Screener and Loader Equipment Operator whose job is to load out finished product into customer's trucks, screen finished compost, mix soil blends, deliver bio-cover to the receiving area, remove and replace temperature probes, turn and water the active and curing compost piles every 3 to 4 days with the compost turner and hose reel, scrape and sweep the north side of the site to control dust, fuel and grease their equipment.
- Mechanic whose job it is to monitor, perform and record all regular and emergency maintenance for the site's portable and stationary equipment. This position could be subcontracted.
- Site Manager whose job is to manage, train and direct the workers to perform the required tasks described in this document, and is responsible to meet or exceed the expectations of process control, site maintenance and product quality embodied in this document. The Site Manager will do the testing of products and feedstocks and document the results for regulatory and customer uses. The site manager will be responsible for the operation and maintenance of the process controllers and documentation of the process variables site conditions and all required maintenance reporting. The site manager will arrange for the sale of compost and other products manufactured at the facility, do site tours and be the point of contact for the City, regulators and the general public. The Site manager responds immediately to odor complaints and oversee the strategy and remediation of odor problems at the facility in a timely manner.
- Administrative staff whose job it is to assist the Site Manager, answer phones, address customer questions and complaints and process sales.

12.0 Estimate of Utility Usage

The City of Phoenix expects the compost facility to use a significant amount of electricity water and diesel to operate the facility efficiently. There are 3 sources of water that are available and provided by the City to the project that can be used and two sources of electricity that will be available but requires purchase by the operations contractor, and diesel for the compost facility needs to be obtained from an outside contract delivery service by the operations contractor.

- Electricity demand is expected to be below 1,380 HP, as this is the capacity built into the system. Actual demand will depend on the time of use and the operational loads placed on the fixed equipment. Electrical power used by the project will be provided by the local electric utility and billed to the operations contractor. The second source of power is from solar photovoltaic panels mounted on the roof of the receiving buildings. This power will be back fed into the utility lines and is only available through the normal electrical power purchase system and cannot be directly accessed by the operations contractor.

Electrical –

Facility lighting - COP has installed lighting on poles throughout the site. Some poles have additional city camera systems installed and Wi-Fi repeaters installed.

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Data and telephone - The COP will have fiber service to their infrastructure at the compost facility. There is data conduit available for the operator to install telephone and internet service to their facilities.

Photovoltaic - No systems are in place in the phase 1, 55k tpy facility. The COP may design, construct and install a future photovoltaic system to be connected to the electrical system on site.

Water – The COP has designed and installed two separate water sources to this facility. There is a raw water well located to the west and piping of the raw water into the facility infrastructure. There is a 4" domestic water services meter at the northeast site corner of the site. This meter serves the compost operations, the office modular and the site landscaping irrigation. The monthly invoices for this utility will be transferred to the operator as the start of services of the compost facility.

Sewer – The compost facility has no sewer system installed in the 110k tpy facility. All compost process waste is designed and systems in place to collect and reuse any liquid waste generated by compost activities. The oil/water separator at the maintenance facility shall be monitored and maintained. The office modulars, including the restroom building, have a grey water system for direct feed into site irrigation/landscaping. The modular office , including the restroom building, have a black water system consisting of vaults or tanks with a 10,000 gallon capacity. The operator will be responsible to monitor and maintain both grey and black water systems, including establishing and maintaining an alarm system and disposal (pumping out) for the black water tanks/vaults. COP will verify contractual compliance with these sewer requirements until a time when city sewer service is established to this site.

Fuel - There are no fuel systems installed in the 110k tpy facility.

- Water is a significant utility requirement for this project. On average, over 50 gallons might be used per cubic yard of ground feedstock. The city water system provides all the water that the public will be exposed to. To mitigate the public utility water demand by the composting process, the City of Phoenix is providing well water to be used by the operations contractor to supply the high water demands of the project for irrigating piles, cleaning the site and irrigating the landscape plants. Any stormwater runoff from the facility and process water draining from the aeration system is being captured in the tank and pond system for reuse to irrigate the fresh compost piles. A significant amount of water is recaptured when running in negative aeration, which is done approximately 50% of the aeration time. This mitigates the overall use of water for the facility.
- Diesel is used for all large portable equipment. The use at this facility is typical for transfer station operations, except for the grinder which uses a significant amount of fuel. A compost turner is used to improve the efficiency of pile turning instead of using loaders to significantly reduce the amount of fuel used. The Operations Contractor is responsible for fueling and maintaining all large portable equipment.

13.0 Wastewater Systems

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- The Operations contractor needs to manage the water generated on the site from storm events and the composting process to keep from discharging water from the site. The Compost Facility is designed to be a zero-discharge facility and capable of handling significant storm events. The composting process is thirsty and can use up the water generated over time after the storm events. There is over 9 feet of evapotranspiration losses per year in the Phoenix area. Recirculating sprayers can be used on the side of the stormwater pond to evaporate a significantly greater volume than just the pond surface if needed.
- The Operations Contractor must manage the stored water to limit the production of odor and the accumulation of solids from the treatment process. The water generated on the site from storms is likely to be contaminated with suspended solids, color and Biological Oxygen Demand (B.O.D.) and is likely to be unsuitable for discharge offsite as stormwater. While storing the water for reuse, it is likely to require aeration and recirculation to keep the stored water from going anaerobic and creating odor. These aerators are provided in the aeration vault, the underground tanks and in the storage lagoon.
- The system is designed to collect and reuse all the condensation and rainwater that is generated in the aerated composting areas

14.0 Management of the Biofilter

Biofilter media should achieve the following parameters at the time of construction; >75% porosity, < 5.5' tall, 50%-70% moisture content, 12,600 ft² in area, 52,000 cfm inflow of air per biofilter

- Media for biofiltration - Below is a table from Roger T. Haug's Compost Engineering book providing general description of a biofilter media for performance measurements to check whether material that is found locally for biofilter media will likely perform well. The operations contractor will source and/ or manufacture the biofilter media and the subsequent replacement media as needed to meet performance criteria.
- The biofilter, once in use, should be irrigated regularly (2x/day) and the drainage returned to the underground vault for reuse and aeration. A misting ring in the pressure blower discharge is used to pre-moisten the cooling air to help keep the biofilter from drying out.
- Temperatures in the biofilter must be kept below 45 degrees C (113 degrees F) to allow microorganisms that degrade odors to survive. Temperature probes in the biofilter manifold and biofilter send information to the biofilter cooling damper to adjust the amount of fresh air forced into the biofilter manifold.
- The biofilter media should be replaced annually unless tests show it's use can be extended. The back pressure in the biofilter manifold will increase over time. Airflow measurements must be made monthly in the biofilter with all zones 100% negative and the biofilter cooling damper 100% open. Air flow should be at least 52,000 cfm in the biofilter manifold. If not, the biofilter manifold pressure setting should be increased. At no time should the back pressure in the manifold exceed 11" w.c. If the air flow cannot be attained at an 11" pressure setting, then the media must be replaced within a month.

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Table 16.12. Recommended Design and Operating Parameters for Organic Media Biofilters

Filter media	Biologically active, but reasonably stable Organic content >60% Porous and friable with 75–90% void volume Resistant to water logging and compaction Relatively low fines content to reduce gas headloss Relatively free of residual odor Specially designed mixtures of materials may be desirable to achieve the above characteristics
Moisture Content	50 to 70% by weight Provisions must be made to add water and remove bed drainage
Nutrients	Must be adequate to avoid rate limitations Usually not a problem with composting gases because of the high NH_3 content
pH	7 to 8.5
Temperature	Near ambient, 15–35 or 45°C
Gas pretreatment	Humidification as necessary to achieve near 100% inlet gas humidity Dusts and aerosols should be removed to avoid media plugging
Gas loading rate	<100 $m^3/h\text{-}m^2$, unless pilot testing supports higher loadings
Gas residence time	30 to 60 sec, unless pilot testing supports a shorter residence time
Media depth	>1 m or 3 ft
Elimination capacity	Depends on media and compound (about 2.2 mg H_2S/kg media VS per min for H_2S)
Gas distribution	The manifold must be properly designed to present a uniform gas flow to the filter media

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XII. Appendix 2 - Regulations & Permits that Pertain to the Compost Facility

A. Air Quality Regulations & Permits

Dust regulations require that dust control trained operators be onsite always during facility operations.

B. Water Quality Regulations & Permits

These documents will be provided as attachments

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

DISCHARGE AUTHORIZATION
FOR A TYPE 3.01 GENERAL AQUIFER PROTECTION PERMIT

Inventory No. 512259
LTF No.: 65573
PLACE ID No. 150634

Permittee Information:

Name: City of Phoenix – Public Works Department
Address: 200 W. Washington Street
Phoenix, Arizona 85003

Permitted Facility Information(if different from above):

Name: City of Phoenix Stormwater and Composting Condensate Retention Basin
Address: 3060 South 27th Avenue
Phoenix, Arizona 85009

Latitude: 33° 24' 54.28" North Longitude: 112° 07' 32.9" West

Determination is based on the Notice of Intent (NOI) received February 28, 2017.

Discharge Authorization. Your submittal satisfies the requirements in Arizona Administrative Code (A.A.C.) R18-9-A301(A)(3) and R18-9-A301(B). This Discharge Authorization is No. P-512259. Effective on the date of signature, the permittee is authorized to discharge from the facility at the location specified in the NOI under the terms of A.A.C. R18-9-D301. The permittee must comply with all design, installation, operation, monitoring, recordkeeping, reporting and closure requirements specified in this general permit. The permittee must also comply with all other applicable requirements of 49 A.R.S. 2, and 18 A.A.C. 9, including the General Provisions of Article 3. This Authorization is effective on the date of signature and expires **FIVE (5) YEARS** from that date. If you wish to renew this Discharge Authorization and no changes have been made to the discharging facility, an NOI must be submitted no later than 30 days before March 3, 2022 otherwise, the authorization to discharge will expire (see R18-9-A303(B) and (C)).

This authorization can be revoked and an individual permit required in the event the permittee fails to comply with the terms of the general permit described in the rules or if the discharge activity causes or contributes to the violation of an Aquifer Water Quality Standard at the applicable point of compliance.

Jerry H. Smit, Section Manager
Groundwater Section
Water Quality Division

March 3, 2017
Date

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C. Solid Waste Regulations & Permits

Following is a link to the State of California Solid Waste Permit requirements for green waste composting facilities which are comprehensive and provide operational and product requirements that the City of Phoenix has indicated a desire for the City of Phoenix Composting Facility and its Operator to achieve. They are placed here for reference but hold no authority over the operations or the site requirements in Arizona.
(I cannot find any reference to composting regulations for the state of Arizona online, I am waiting for input from Joy on this)

http://www.calrecycle.ca.gov/laws/regulations/title14/ch31a5.htm

D. Product Quality Regulations & Permits

The following section is an excerpt from the State of California Solid Waste Regulation above that has to do with plastic contamination limits which the City desires to be used for the Operations Contract. The term EA is the local Environmental Agency who implement the solid waste regulations in California
Section 17868.3.1. Physical Contamination Limits.
This section shall become operative January 1, 2018.

(a) Compost shall not contain more than 0.5% by dry weight of physical contaminants greater than 4 millimeters; no more than 20% by dry weight of this 0.5% shall be film plastic greater than 4 millimeters. Compost that contains physical contaminants in excess of either one or both of these limits shall be designated for additional processing, disposal or other use as approved by local, state or federal agencies having appropriate jurisdiction. Verification of physical contamination limits shall occur prior to the point where compost is removed from the site or beneficially used on-site. Test results of samples must be received by the operator prior to removing compost from the composting operation or facility where it was produced.

(b) The operator of a compostable material handling operation or facility shall sample every 5,000 cubic-yards of compost produced and determine the percentage of physical contaminants greater than 4 millimeters in the sample using a method that provides accurate results and has been approved by the EA. If the compostable material handling operation or facility produces less than 5,000 cubic-yards of compost in a 12 month period, the operator shall analyze at least one composite sample of compost produced every 12 month period.

(c) If the EA has reason to believe, based on the EA's visual observation or otherwise, that a determination of percent physical contaminants made pursuant to section 17868.3.1(b) is not accurate, the EA may require an operator of a compostable material handling operation or facility to take a composite sample of compost in the presence of the EA and send the sample to a laboratory at which physical contaminants greater than 4 millimeters shall be collected and weighed to determine the percentage of physical contaminants by dry weight using the following protocol:

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(1) Determine the total dry weight of the composite sample as obtained in section 17868.3.1(d);

(2) Separate the physical contaminants greater than 4 millimeters from the composite sample and determine the dry weight of the physical contaminants;

(3) Determine the percentage of physical contaminants by dividing the dry weight of the physical contaminants by the total dry weight of the composite sample.

(d) Any sampling conducted to comply with this section shall require a composite sample. A composite sample shall be representative and random, and may be obtained by taking twelve (12) mixed samples as described below.

(1) The twelve samples shall be of equal volume.

(2) The twelve samples shall be extracted from within the compost pile as follows:

(A) Four samples from one-half the width of the pile, each at a different cross-section;

(B) Four samples from one-fourth the width of the pile, each at a different cross-section; and,

(C) Four samples from one-eighth the width of the pile, each at a different cross-section.

(e) Alternative methods of compliance to meet the requirements of this section may be approved by the EA if the EA determines that the alternative method will ensure the physical contamination limits requirements of this section are met.

Note:

Authority cited: Section 40502, 43020 and 43021, Public Resources Code.
Reference: Sections 43020 and 43021, Public Resources Code.

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E. Fire Control Regulations & Permits

Mulching Facilities
2016 Fire Code Requirements Cheat Sheet

Permit Required

Combustible material greater than 2,500 cubic feet

105.6.1, Agro-industrial and solid biomass facilities.

(Note: Permit is specific to type of materials being stored, i.e. green waste, logs, pallets, etc..)

Assessment Fees

Outside storage of 3,000 square feet (278 square meters) or less	$0
Outside storage of 3,001 to 15,000 square feet (278 to 1393 square meters)	$400
Outside storage of 15,001 to 30,000 square feet (1393 to 2787 square meters)	$800
Outside storage of 30,001 square feet (2787 square meters) or more	$1250

(Note: Square footage is measured by material stored not size of property. If assessment is paid, all permit fees pertaining to that assessment are included.)

Fire apparatus access roads

- 20ft wide
- No Dead ends
- Within 200ft of all combustibles
- Approved turning radius

(Note: Fire access roads can be normal use or emergency only areas, but must be capable of supporting a fire engine. Roads must be maintained for use in any weather.)

Fire Protection Plan

- Site Plan: Buildings, pile locations and sizes, separation distances, water sources, and fire department access lanes.
- Pile Contents: Raw green waste, mulch, hogged material, lumber, etc.
- Max Pile Dimensions: Intended heights not code requirements
- Monitoring Procedures: Narrative of how pile temperatures are maintained.

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- Employee Training: Fire prevention training given to employees
- Equipment available: Equipment available for emergencies including through contract.
- Equipment contract: Letter from equipment company showing available equipment and account set up for emergency use.

(Note: Fire Protection Plan is intended to be a tool for both the fire department and the customer to reference.)

Site identification

Posted at main Fire Department entrance:

- Facility name
- Address
- 24-hour emergency contact numbers

(Note: Emergency contacts must be kept up to date to be notified in an emergency.)

Water Supply

Supply capable of providing the required fire flow for fire protection
Within 400ft of all combustibles

(Note: Fire hydrants are required throughout. Appeals to location of hydrants or alternative water sources will be done through official Fire Department Appeal Process)

Material-handling equipment

Equipment able to move materials onsite.

(Note: Front loaders, Bull Dozers, or any other specialty equipment must be onsite to move materials in an emergency. A separate contract is required for additional equipment if needed.)

Size of piles

Hogged Material

- 60 feet in height, 300 feet in width, and 500 feet in length.
- Piles separated by not less than 40 feet

Mulch

- 25 feet in height, 150 feet in width, and 250 feet in length.
- Piles separated by not less than 20 feet

Green Waste

- 20 feet in height, 20 feet in width, and 150 feet in length.
- Piles separated by not less than 20 feet

(Note: This does not take into account any other departments max heights for material storage.)

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Pile height indicators.

Height Indicator posts provided throughout

(Note: These indicators can be placed anywhere that provides an easy reference for pile heights. I.e. side of building, telephone pole, or piece of equipment.)

Static pile protection.

Piles must be checked for temperatures

Actions required at certain temperature

(Note: Piles shall be turned at 160 degrees F, and pushed out at 180 degrees F.

Delivery & Tipping Area

Feedstock and raw materials separated from other piles

- 12 feet in height, 50 feet in width, and 50 feet in length
- Piles separated by not less than 20 feet
- Water System nearby

(Note: New material delivered to site will be kept separate to prevent already overheated material starting a fire)

Push-Out/Clear Area.

Push-out or clear areas provided for pile storage.

- Located not more than 250 feet from the pile
- 20ft separation from building or combustibles
- Hold no less than a quarter of the size of the single largest pile it serves at a maximum depth of 3 feet
- Water shall be immediately available to aid in cooling.

(Note: Push out areas can be used by more than one pile, but shall be kept clear of any materials or equipment. Area must be sized appropriately, and have water available to cool off material being pushed out.)

Security.

Approved fence.

Fences at least 6 feet in height.

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XIII. Appendix 3 – Facility Drawings and Plan Details

NOTE: This Operations Manual does NOT include a complete set of:

- Issued for Construction Drawings
- As-Built Drawings

These drawings have been provided by Brycon or Arrington Watkins under separate cover.

XIV. Appendix 4 – Equipment Manuals

NOTE: This Operations Manual contains a thumb drive containing vendor supplied PDF Operations and Maintenance Manuals for each piece of equipment on the COP 27th Ave. Compost Facility to include:

A. Cat 950K Wheel Loader

B. Cat 966M Wheel Loader

C. Kubota R530 Wheel Loader

D. Bobcat GRPL 74 INDL BKT (grapple for Kubota R530 Wheel Loader)

E. Sweeper: Laymor SweepMaster 300

F. Shredder: Doppstadt DW 3060 SA

G. Control Screen for Doppstadt DW 3060 SA

H. Grinder: Doppstadt AK 635 SA

I. Grinder: Vermeer HG 6000 TX Horizontal Grinder

J. Dust Boss:

K. Hose Reel:

L. Compost Turner:

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M. Aeration Blower (Positive):

N. Aeration Blower (negative):

O. Control Dampers:

P. Pressure Sensors:

Q. Temperature Sensors:

R. CompDACS System:

S. Chopper Pump:

T. Trommel Screen: Doppstadt SM 726 Profi

XV. Field Tests for Moisture and Porosity Estimations

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Hand-squeeze Quick Test for Pile Moisture

By Jeff Gage, Green Mountain Technologies, January 2015

Goals for this activity:

- To learn the "hand squeeze" method for estimating moisture levels in a compost pile.
- To practice estimating moisture in composting materials.
- To make each person operating the facilities make similar estimates when checking piles and recording estimates.

After a certain amount of practice, your hand becomes "calibrated" to what a drying test proves, thus allowing you to evaluate moisture without other equipment.

The hand-squeeze method is good for quick tests out in the field, but *should not replace periodic drying tests*. I suggest that these drying tests be done monthly until all hand squeeze estimates by all participants come within 5% of the actual tests. Ask each one to make their estimate, write down their estimate and then run the sample through a dryer and weigh scale and calculate the actual moisture results. Whoever's estimate is closest to the actual results wins. I usually provide the winner with a nominal prize to encourage serious contemplation of what the right number might be.

Procedures for Hand-squeeze Quick Test and Estimate Calibration

1) Reach into the pile (or bucket) and grab a handful of composting material.

2) Squeeze the material <u>hard</u>, check for drips.

3) Release your grip and allow the material to stay in your hand, smear some between finger and thumb.

4) Inspect the material and the moisture on your hand.

5) Use the "Rules of thumb" to estimate % moisture.

6) Record your observations and your own % moisture estimate.

7) If doing this as a team or group, talk to your group and reach an agreement for a group estimate. Record results.

8) Repeat the test for each of the piles you are making estimates on.

9) Put sample in a plastic bag and seal it for testing with a dryer to calibrate the hand squeeze estimates with actual dryer and scale test results.

10) Run the dryer test on each sample, record the percent moisture, and let the estimators know if they were too high, too low or just right!

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Interpretation – "Rules of Thumb" for Estimating Moisture

Observations	**% Moisture (estimation)**
Material feels dusty	42 % or less
Material feels mostly dry with a hint of moisture	42% - 47%
Material feels tacky and sticks together	47% - 52%
Material feels moist, but no water comes out	52% - 58%
Material leaves a wet sheen on hand	58% - 63%
If one to two drops of water come out during squeezing	63% - 68%
If many drops of water come out during squeezing	68% - 73%
Stream of water from material when squeezed or pudding texture	73% or more

Note: adjust the moisture range based on your feedstock, and actual dryer tests

Estimating % Moisture

Pile Number	**Bucket Number**	**Observations that would tie what you experience with this hand squeeze to use in an updated interpretation chart**	**My Estimate % Moisture**	**Dryer test result % Moisture**

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Active Compost Moisture Ranges:

- Researchers report that the ideal moisture range for active composting is from 52% to 58%.
- Composters consider 40% to 65% a "reasonable range"; ideal is 55% for "average mix." *(For this training, this is the range we will focus on.)*
- Gardening professionals report that around 50% is the ideal soil moisture for planting and growing crops in.
- True ideal moisture "depends on the substrate"! Different particles hold moisture in different ways, e.g. clay-like particles vs. woody particles.

Water loss in composting happens because of:

- Air flow in the pile
- Evaporation in the air flow
- Differences in relative humidity and temperature (gradient between pile and surrounding air)
- Excess heat in a pile triggers microbial cell "sweating" or release of water vapor

Ways to monitor moisture and the expected accuracy for that method:

Visual – how dry or wet does it look	+/- 10 % accuracy
Hand squeeze – how wet /dry does it feel	+/- 5% accuracy
Koster silage dryer – hot air and scale	+/- 2% accuracy
Microwave oven - use defrost mode, scale	+/- 2% accuracy
Oven dryer test methods	+/- 0.1% accuracy

Koster Silage Dryer

When using the Koster dryer, be sure to weigh the material, dry, check it; then repeat until the sample has no weight loss. http://buykoster.com/

Oven dryer

Use methods outlined in the US Composting Council's *Test Methods for the Examination of Composting and Compost*.

Notes about adding moisture to compost piles:

How you add water is very important to the composting process:

- Water in thin layers. Do it just before each turn when needed.
- Water during turning when possible. Or turn immediately after watering or a rain event.
- Moisture for good composting processes must be balanced with the need to reduce moisture for screening. Stop watering once the pile becomes stable.

Why is moisture so important for composting?

- Supports microbial cells who live (cells consists of >90% water) in thin water films.
- Water provides for replication of bacteria, nutrient transfer and absorption
- Evaporative cooling takes place to keep bacteria active in hot piles.
- Water loss equals work done in a compost pile, the more volatile solids to compost in a mix, the more water is used to reach stability.

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Pile Bulk Density and Free Air Space

Procedures for Measuring Pile Bulk Density and Free Air Space

Bulk density
The procedures for measuring pile bulk density simulate the compaction of materials one would expect under normal composting operations. Dropping the bucket 10 times helps to keep the measuring process uniform.

(1) Weigh empty bucket. Record weight.

(2) Fill bucket 1/3 full with material (compost or feedstock)

(3) Raise bucket 6” above firm surface and let it drop 10 times.

(4) Fill bucket with an additional 1/3 of material.

(5) Raise bucket 6” above surface and let it drop 10 times.

(6) Fill bucket level to the brim and repeat dropping sequence.

(7) Top off the bucket with material level to the brim. Do not drop.

(8) Weigh the bucket with material.

(9) Record weight and complete calculations on the data collection sheet.

Free Air Space
Use the same bucket and materials from the bulk density test to complete the free air space test.

This test uses water to approximate the amount of voids (free air space) in a bucket full of compost materials.

(1) Place the bucket with material on level ground.

(2) Fill the bucket with water completely without overflowing.

(3) Weigh the filled bucket. Use caution – the bucket will be heavy!

(4) Record weight and complete calculations on the data collection sheet.

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Pile Bulk Density

	Example				
Material measured					
1. Weight of bucket with material (lb)	20.5				
2. Weight of empty bucket	2.0				
3. Weight of material (line 1 – line 2)	18.5				
4. Convert to lb./yard (line 3 x 40)	740				

- **Pile Free Air Space**

	Example			
Material measured				
1. Weight of bucket with material + water (lb)	46.5			
2. Weight of bucket with material	20.5			
3. Weight of water (line 1 – line 2)	26			
4. Convert to % free air space (line 3 x 2.4)	62 %			

Bulk Density Notes:

- 5 gallons of water weighs approx. 42 lbs.
- 6 yd/ton incoming yard debris yields about 2.5 yd/ton ground yard debris
- # lbs feedstock in a 5-gal bucket multiplied by 40, equals # lbs in a cubic yard (it's magic math!!)

Free Air Space Notes:

- Target free air space for compost piles = 40% to 60% or greater (not less than 40%)

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Pile Bulk Density

	Example				
Material measured					
1. Weight of bucket with material (lb)	20.5				
2. Weight of empty bucket	2.0				
3. Weight of material (line 1 – line 2)	18.5				
4. Convert to lb./yard (line 3 x 40)	740				

- **Pile Free Air Space**

	Example			
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