Composting with Food Waste
USCC Workshop 2023

Michael Bryan-Brown, Jeff Gage, Jake Saavedra & Orion Black-Brown

Green Mountain Technologies, Inc.

Aurel Lübke

CEO

Compost Systems, GmbH

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Workshop Goals

Help composters understand the implications of adding food waste (FW) to their facility

- *Permitting*
- *Design and process train modifications*
- *Equipment upgrades*
- *Odor management*
- *Product Quality*

Adding Food Waste Program 2023

1. Introduction **(9 am start promptly)**
    1. About us - 8 min OBB, Aurel
    2. About you - 15 min Jeff
    3. The Significance of Wasting Food – 5 min Jeff
    4. How FW composting is different -10 min MBB
    5. European Approach to Adding FW - 10 min Aurel
    6. Green House Gas (GHG) from Composting = 10 min MBB
2. Permitting and Financial Considerations
    1. Permit Changes for Adding FW– 15 min Aurel JPG
    2. Financial pros and cons of Adding FW– 15 min MBB or OBB

(break)

3. Operational Considerations
    1. Windrow vs ASP vs TAP vs In-Vessel – OBB 15 min
    2. Assessment of feedstocks/recipes – 15 min MBB
    3. Managing FW receiving - 20 min JPG
    4. Contamination Removal Front End – 10 min JPG- Dirt Hugger case study
    5. Contaminant Removal Back End– Aurel 10 min – (example)
    6. Temperature Monitoring – 15 min Jake

(Lunch)

4. Facility Design Considerations **(1pm restart)**
    1. Facility Layout and Process Flow – JPG 20 min
    2. Managing Leachate, Stormwater, water reuse – OBB 15
    3. Aeration System Design - OBB 15 min
    4. Turning Equipment - Aurel 10 min
    5. Working Surfaces – OBB 10 min
    6. Odor Control Design – JPG 20
    7. Tunnels and building Enclosures – MBB 10 min
    8. Controlling the composting process – Jake 20

Case studies 3 pm – Austrian Example (Aurel)
Salinas (OBB), Dirt Hugger (JPG), Sun-Peaks (JS/MBB)

Conclusion

1. Takeaways JPG
2. Question and Answers

(Finish at 4:30 pm)

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1.1 About US

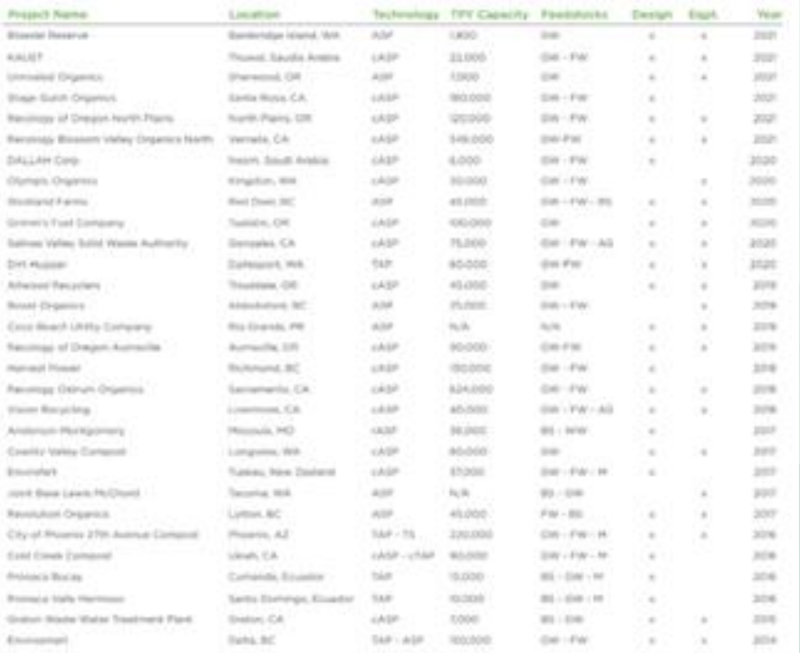
Green Mountain Technologies, Inc.

Orion Black-Brown	Jeff Gage
Jake Saavedra	Gaelan Brown
Michael Bryan- Brown	Karl Gage

CONTAINERIZED COMPOST SYSTEM

EARTH FLOW

AERATED FLOORS



EARTH CUBE

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Compost
Systems

Success
is our nature.

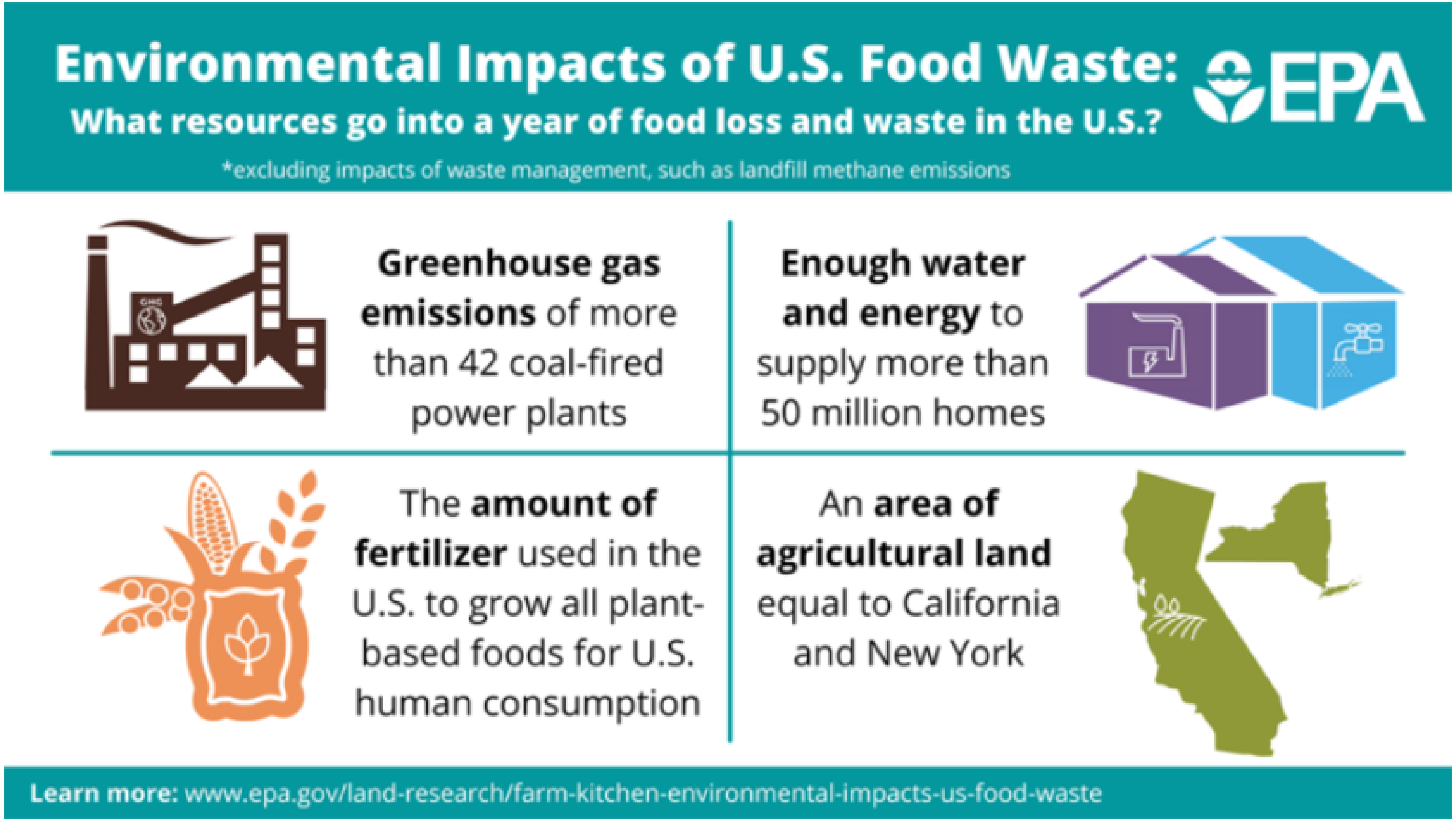
Aurel Lübke
System Design and Training
Windrow Turners, covers, cover handlers
In-building ASP systems
Aerated windrow systems

1.2 About You: Name, Organization, Location, Biggest FW challenge

Wendell	Minshew	wminshew@trihydro.com	Trihydro Corporation
Thania	Flores	Thania.floressoto@lacity.org	LASAN - Los Angeles, CA
Miguel	Carrillo	miguel.carrillo@lacity.org	City of Los Angeles-Bureau of Sanitation
Miguel	Zermeno	miguel.zermeno@lacity.org	City of Los Angeles - LA Sanitation and Environment
James	Greenfield	jmgrnfld@gmail.com	City of Los Angeles Sanitation - Solid Resources Processing and Construction Div.
Rodger	Hill	rodger.hill@lacity.org	LASAN
Caleb	Adams	caleb@yieldrmg.com	Yield RMG
Alyssa	Howard	tgheiderman@gmail.com	Ocean Compost
Christine	Wittmeier	christine.wittmeier@ncdenr.gov	North Carolina Department of Environmental Quality
Brendan	Andrews	brendan@texasorganicsoil.com	Texas Organic Enterprises, Ltd DBA: Texas Organic
Raymond	Taylor	raymond.taylor@fccenvironmental.com	FCC Environmental
Paula	Luu	paula@closedlooppartners.com	Closed Loop Partners
Daniel	E Collins	dancollins1224@gmail.com	MWRDGC - RETIRED
Shay	Starr	jennifer.richardson@mesacounty.us	Mesa County Solid Waste Management
James	Grimm	jgrimm@springfieldmo.gov	City of Springfield Missouri-ES/Solid Waste
Kevin	Turner	kturner@springfieldmo.gov	City of Springfield Mo
Gilbert	Mojica	gilbert.mojica@colostate.edu	Colorado State University
Italo	Cariola	icariolas@gmail.com	REYCOMP
Steven	Hirsch	shirsch@sterling-group.com	The Sterling Group
Michael	Bridgman	mbridgma@calpoly.edu	Cal Poly State University, Agricultural Operations
Tom	Wright	tomw@table2farms.com	Table2Farms
Patti	Stacey	patti.stacey@co.kittitas.wa.us	Kittitas County Solid Waste
Garvey	Heiderman	info@thehobbitrestaurant.com	The Hobbit Restaurant

1.3 The Significance of Wasting Food

Over one-third of the food produced in the United States is never eaten, wasting the resources used to produce it…



https://www.epa.gov/system/files/documents/2021-11/from-farm-to-kitchen-the-environmental-impacts-of-u.s.-food-waste_508-tagged.pdf

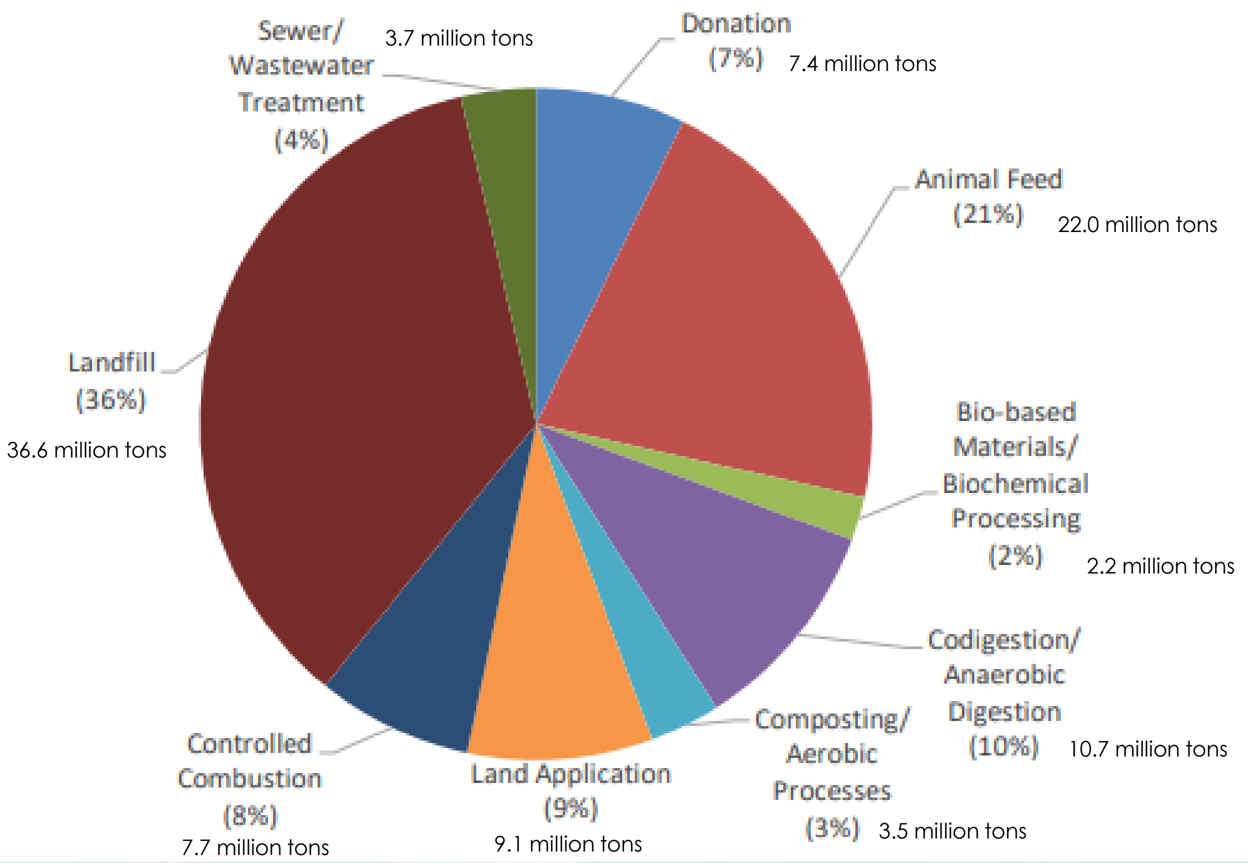
Figure 1. Resources attributed to U.S. FLW. Source: U.S. EPA

Wasted Foods Collection and Destination

- Agricultural & Food Processing Residuals
- Institutional, Commercial, Industrial (ICI)
- Food Organics, Green Organics (FOGO)
- Source Separated Organics (SSO)
- FW slurries from grocery stores

2018 EPA Wasted Food Report: 103 million tons Collected

Figure 3. Percentage Distribution of Wasted Food Management, Including the Industrial Sector (2018)



https://www.epa.gov/sites/default/files/2020-11/documents/2018_wasted_food_report.pdf

1.3

State	Windrow	SP[1]	ASP[2]	I-V[3]
Alaska	0	0	4	1
Arizona	5		1	
Arkansas	8	10		
California	151	0	12	13
Colorado	23	8	1	1
Delaware	1	1	3	0
Georgia	11	10	1	5
Idaho	3		2	
Iowa	25	6	48	1
Kansas	165	21		
Kentucky	33			
Louisiana	150	15	25	25
Maine	25	80	11	3
Maryland	16		2	
Minnesota	5	0	4	2
Mississippi	3	8		
Montana	13	27	1	1
Nebraska	8			
Nevada	5		1	
New Mexico	20	19	1	1
N. Carolina	14	2	4	2
N. Dakota	23	57	0	0
Ohio				10
Oklahoma	13		1	1
Oregon	32	13	8	0
Rhode Island	22	1		1
S. Carolina	7		1	
S. Dakota	16	126	0	1
Tennessee	7	0	1	
Texas	15	1	2	
Vermont	9	0	1	0
Virginia	18	0	4	5
Washington	24	4	30	8
Wisconsin	265	0	1	
Total	**1,135**	**409**	**170**	**81**

ASP Systems are only 1/10 of all compost facilities in the USA

Biocycle annual survey of compost facilities 2018

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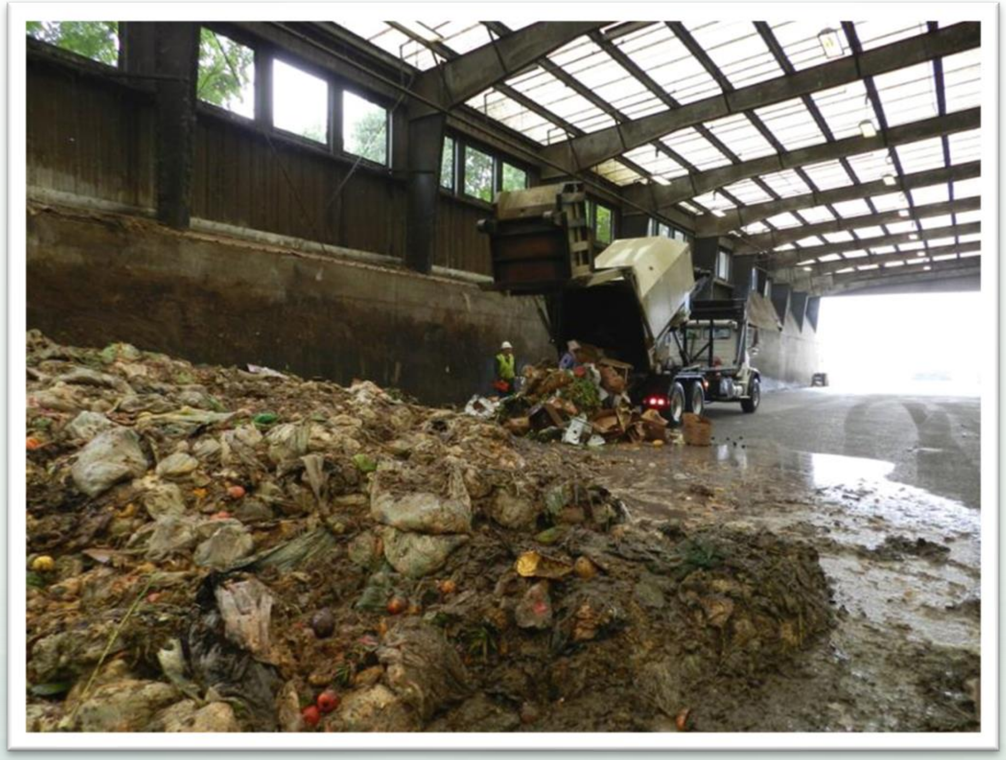
Why is Food Waste Composting Different?

Bob Spencer, Windham Solid Waste Vermont



Portland Metro Transfer Station

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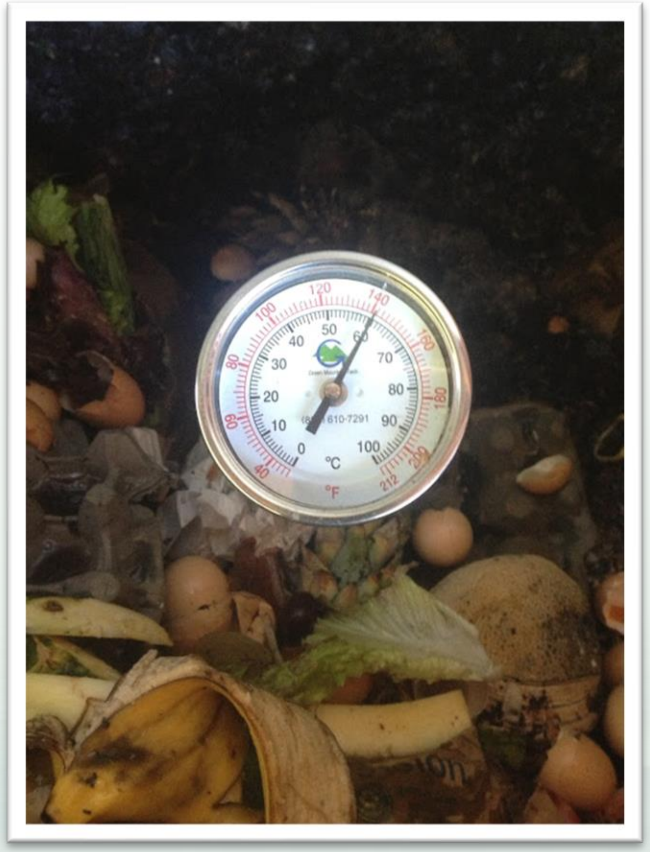
1.4 # What Does Food Waste Look Like?

How is FW Composting Different from GW, Manure, or Biosolids Composting

1.4 FW Chemical and Physical Characteristics

- Energy density and increased aeration demand
- Odors and organic acids
- Slow-release moisture
- Rate of moisture release
- Contaminants primarily plastic
- Fats, salts, pH, heterogeneity



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1.4

Contamination and Product Quality

- FW increases contamination
- Taking biodegradables increases contamination and confusion
- Back vs front of house separation for restaurants
- Many states now strictly limit the amount of plastic in compost

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Food Waste Composting in Austria

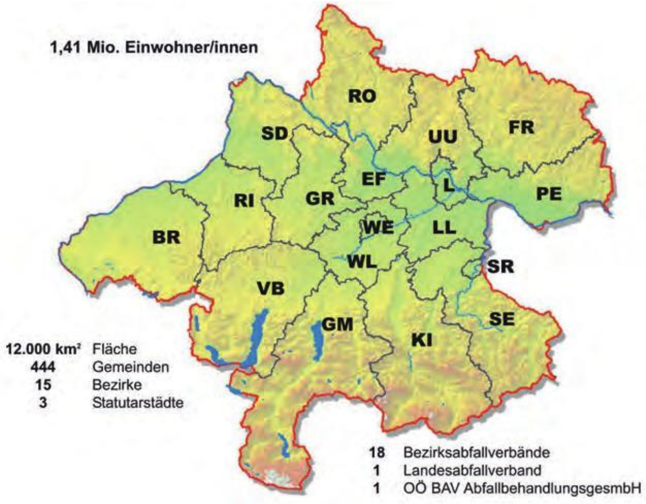
- Collection started in 1987
- Plant requirements
- Integration of agriculture
- Public acceptance

Austria, 9 provinces, 9 million people

- 9 provinces
- 10 waste districts

- Waste ownership on municipal level

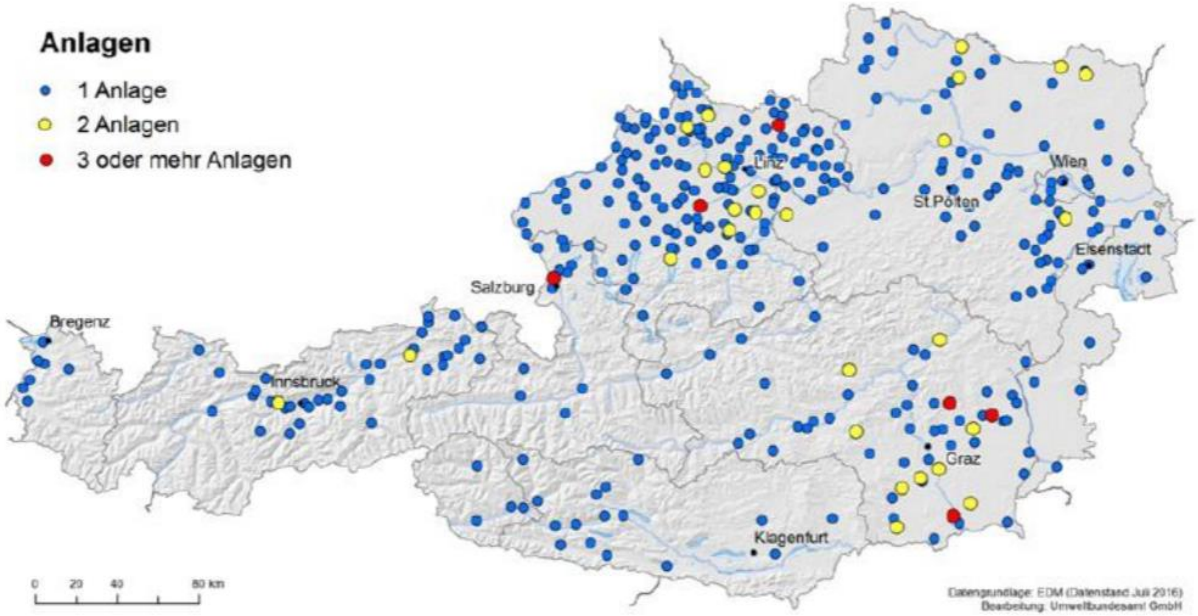
- Waste management on county level
  - Bezirksabfallverband = County waste management authority



Austrian Composting Plants

- Total of ~ 420 plants
- 1.56 million tons raw material
- < 5 % plants closed

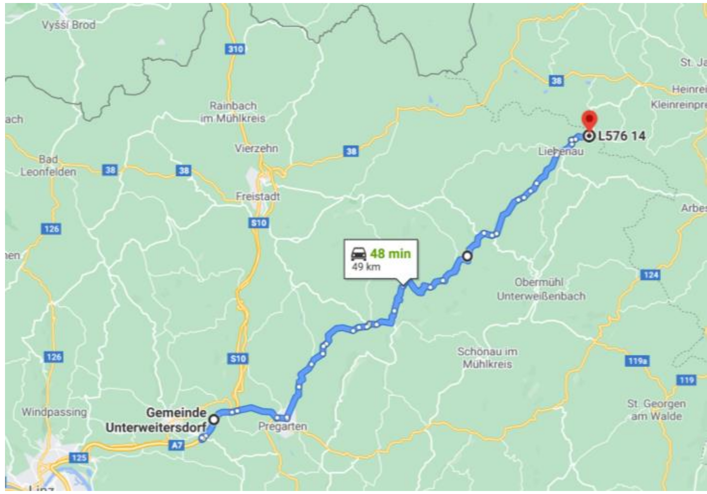
- Maximum size: 80,000 t/year
- Minimum size: < 1,000 t/year



Example: Decentralized composting

- County Freistadt

- 66,000 inhabitants
- 12,635 t organic waste composted
- 67 inhabitants / km^2
- 27 municipalities



Collection by Farmers

1.5

Composting on Farms

Seiringer Wieselburg (medium size composting plant)

- Biowaste
- Green waste
  - 25,000 t/year

- Products:
  - Compost
  - Garden soil
  - Turf soil
  - Growing media

City of Vienna, MA48 (large size composting plant)

- 80,000 t/year
- Green waste
- Garden waste

Regulations applicable

- First Compost Ordinance 2001 (state of the art compost guideline 2006)
  - Updated version currently under review (expected release by government by Q2 2023)

  - Changes:
    - Obligatory inspection of compost production by outside audit (not only by lab for heavy metals)
    - Turning minimum once a week
    - Measuring of temperature
    - Measuring of windrow gas (aerobic conditions mandatory)
      - $< 1\ \%\ CH_4$, $> 12\ \%\ O_2$ (low peak $8\ \%\ O_2$), $< 12\ \%\ CO_2$, $O_2 + CO_2 < 23\ \%$
    - Plastic
      - Film plastic finished product $< 15\ cm^2$ / liter of compost
      - Raw material: 12 % plastic upon arrival unsorted, 5 % upon arrival with presorting
    - Table pile composting not state of the art (not accepted, only for maturation!)
    - Minimum turning once a week (loader turning not accepted, only mixer or turner!)
    - Open windrow technology covered under ABPR Animal By-Product Regulation (continuous online measuring of temperature)

Animal By-Product Regulation ECN 1774/2002

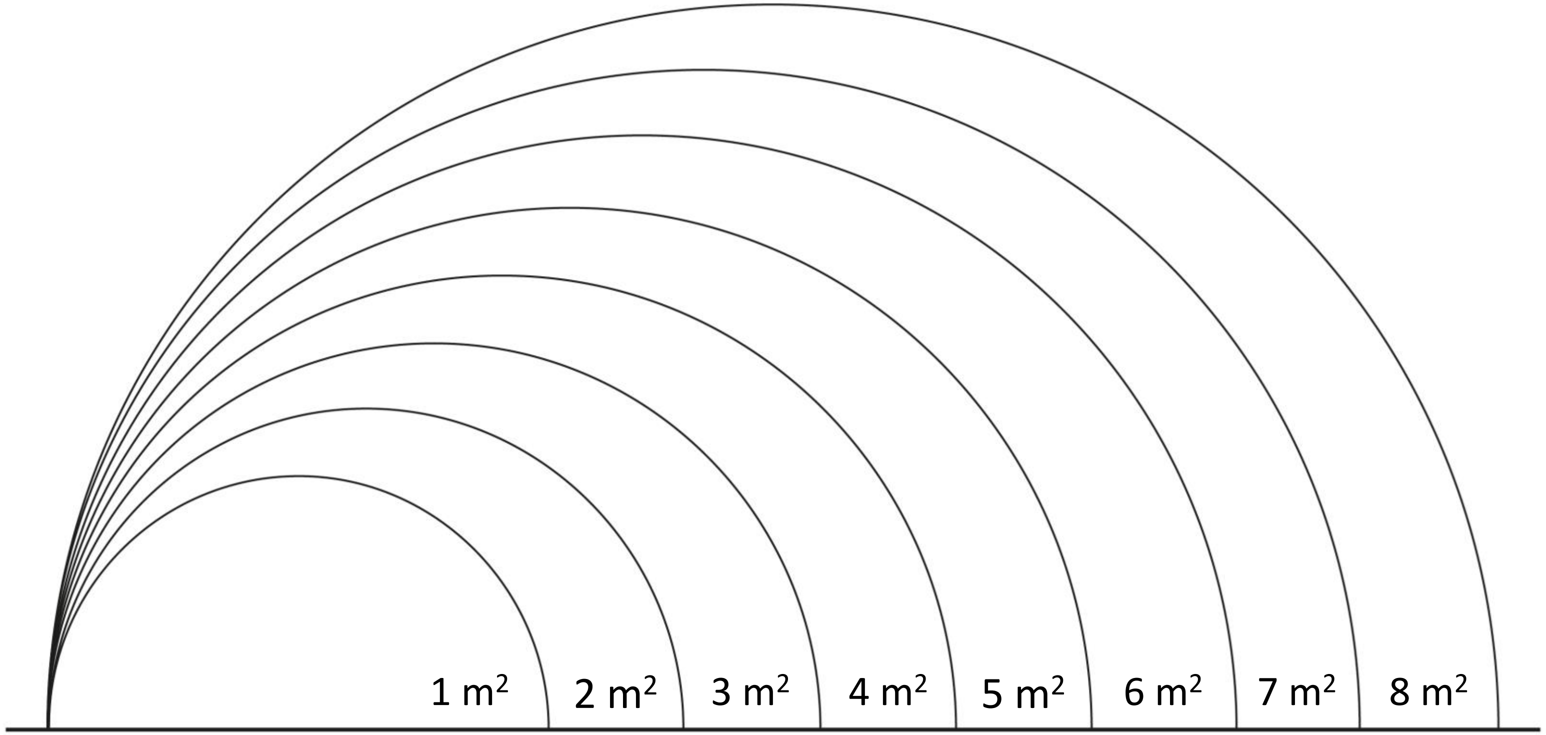
- Meat (potentially) containing raw material
- Closed collection
- Closed sanitization
- Distance to neighbors (animals)
- < 24 h on site without treatment
- Prevention of product recontamination by leachate addition
- Time temperature treatment requirements
  - 60 °C, 24 h, repeat 3 times in windrows
  - 70 °C, 1 h in closed reactor, < 12 mm particle size

Technological aspects

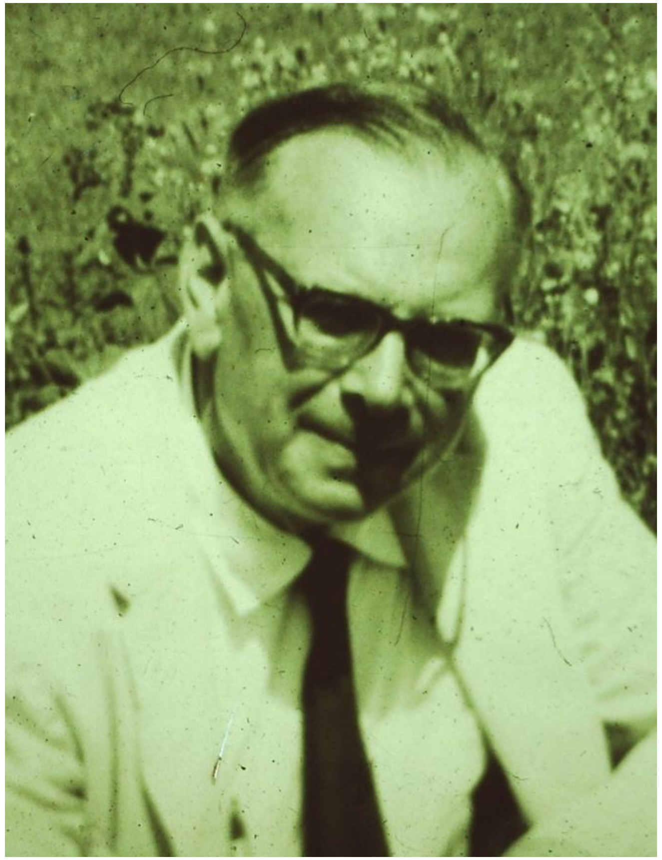
- Maximum recycling rates
- Minimum emissions of GHG (carbon footprint)
- Odour emission prevention, reduction and management
- Plastic / contamination management
- Minimum Product Quality Standards requirements

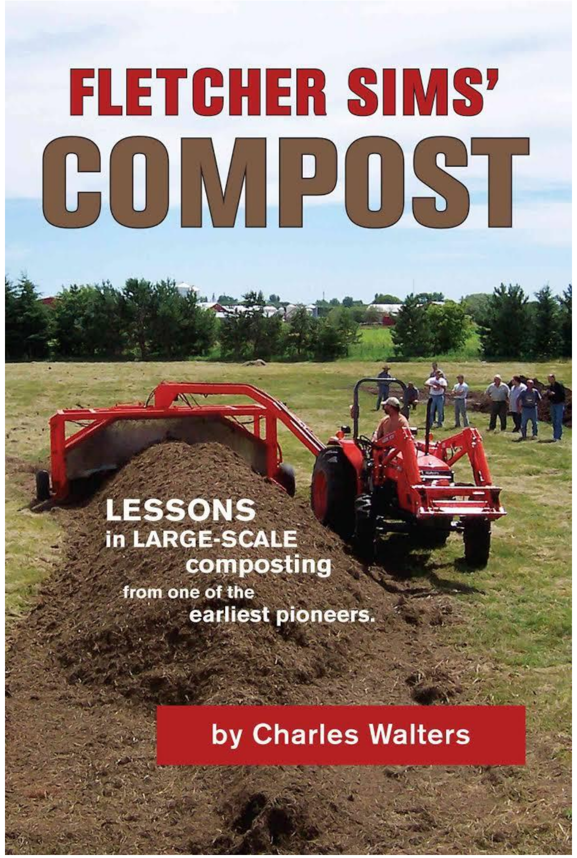
Selecting the right pile size (technology)

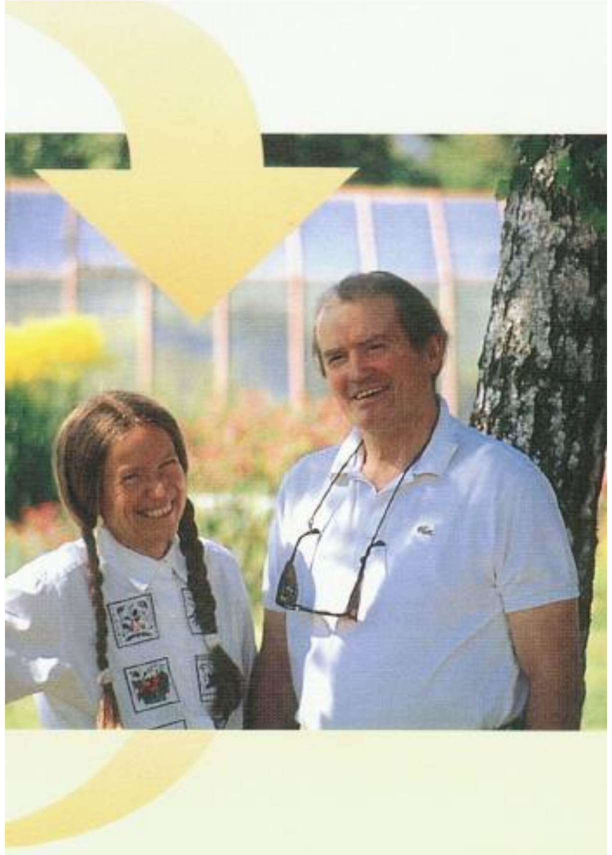
- Density
- Energy
- Moisture content
- C : N ratio



What did the pioneers say?







Study (by University of Applied Sciences Wels)

Are there aerobic conditions in frequently turned windrows?

Height	Width	Aerobic conditions
1.5 m	3 m	YES
2.5 m	5 – 6 m	???

„Comparison of aerated and non-aerated windrows“

Experiment

- 2 windrows, cross-section approx. 6 - 7 m^2
- Aerated vs. non-aerated
- Weekly turning
- Duration: 4 weeks
- Measurements:
    - Gas composition (CH_4, CO_2, O_2)
    - Odour concentration
    - Temperature

Gas composition

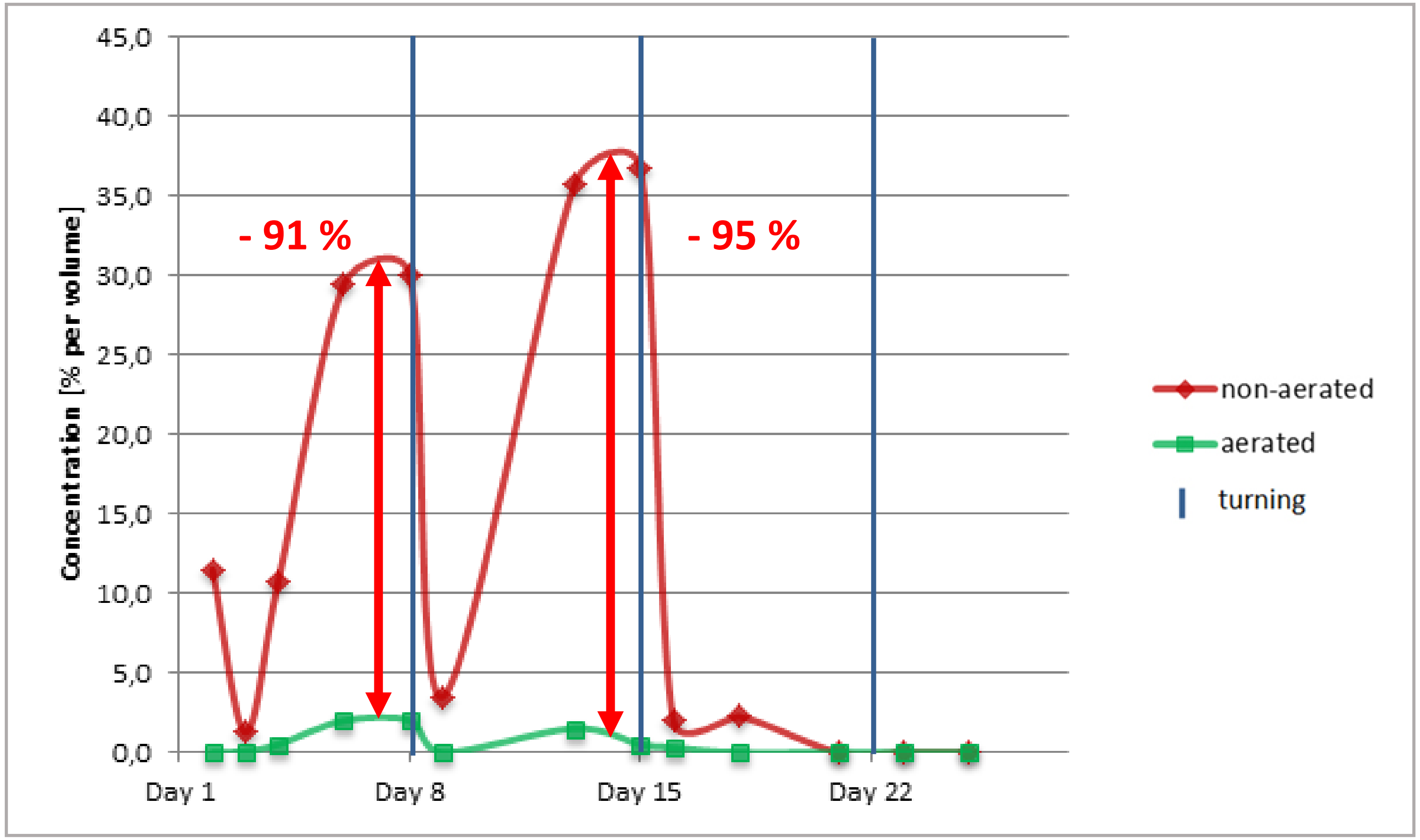
Odour sampling

Odour analysis

- Olfactometer
  - 4 person test
  - Odour threshold is determined

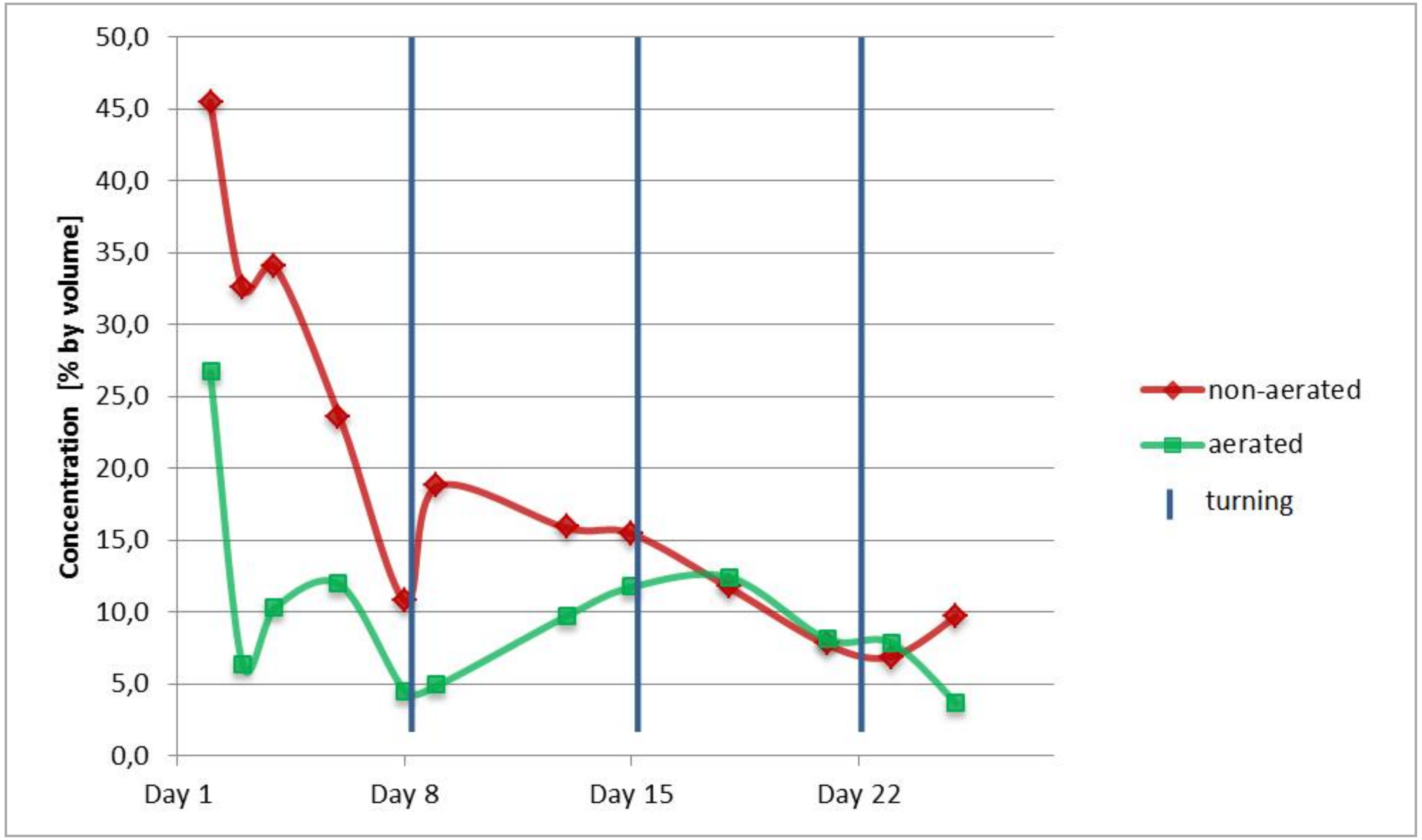
Results CH_4

Biowaste



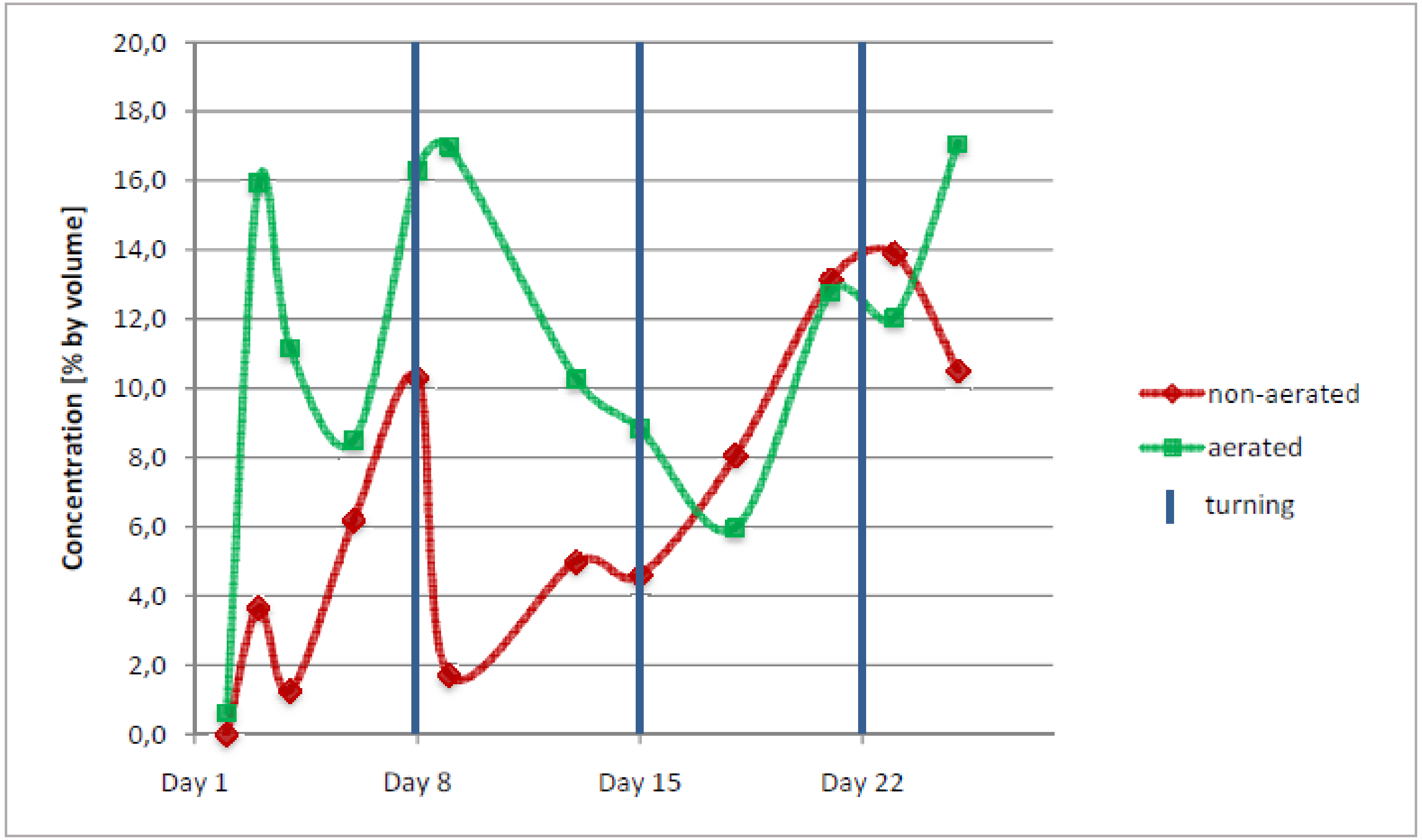
Results CO_2

Biowaste



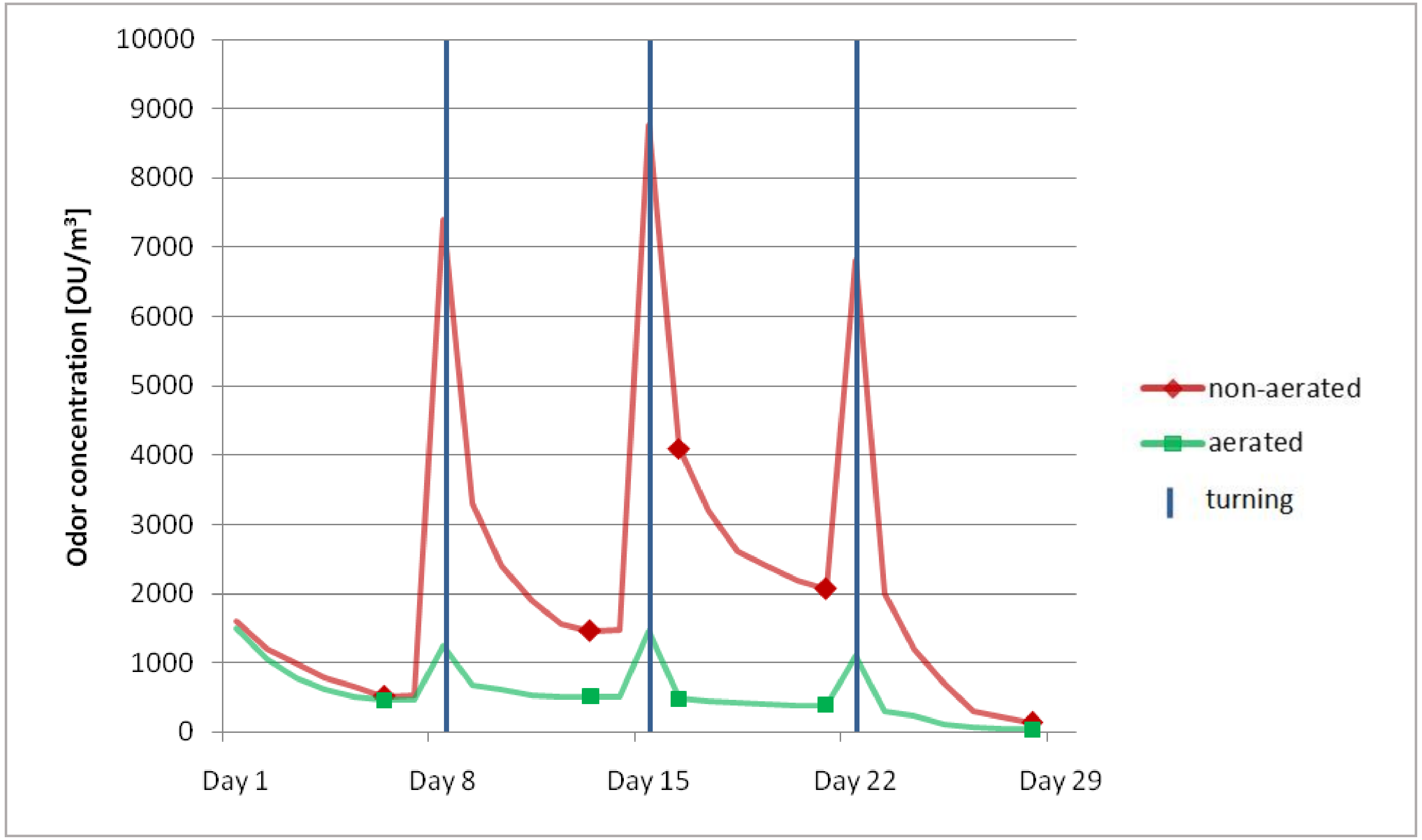
Results O_2

Biowaste



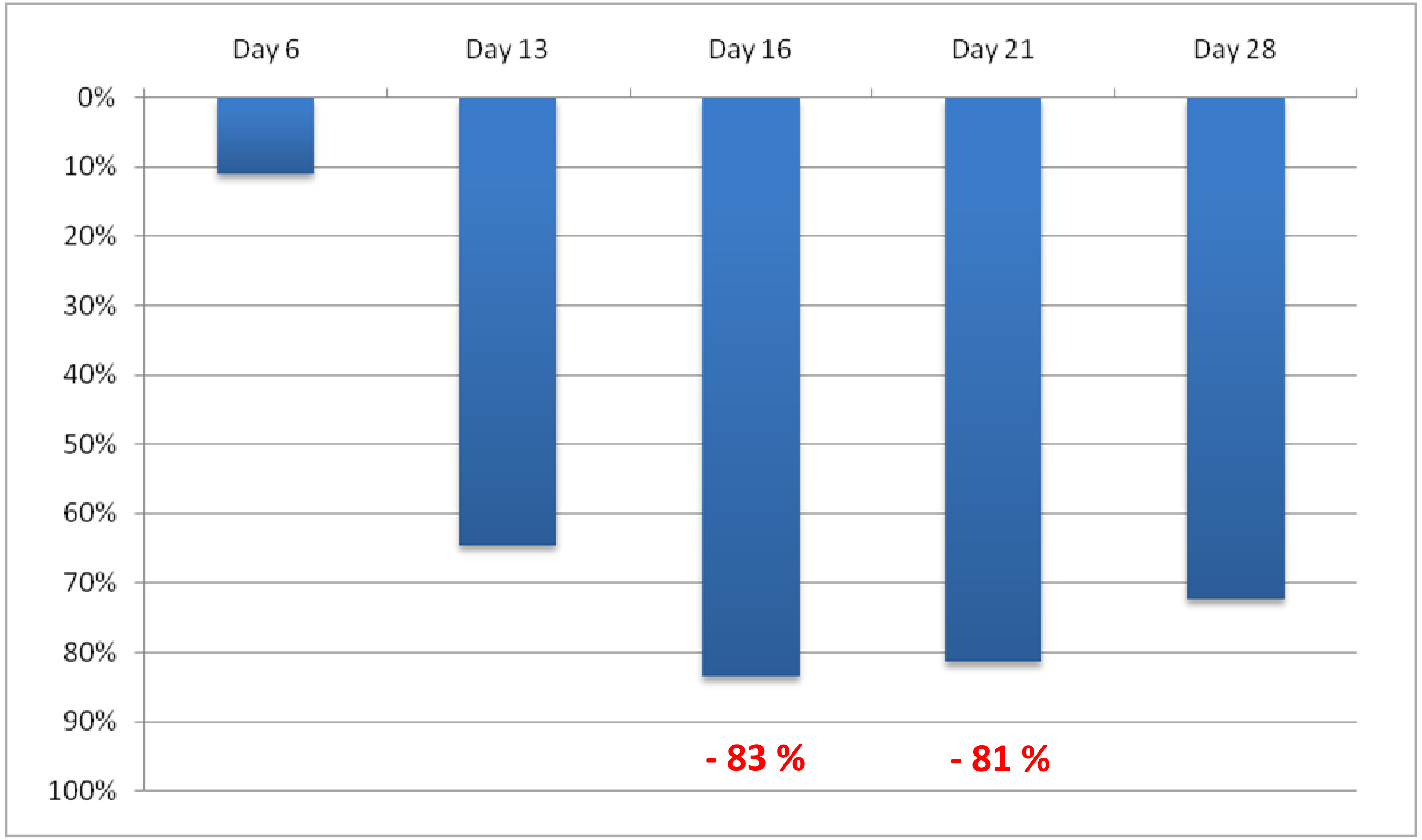
Results Odour

Biowaste



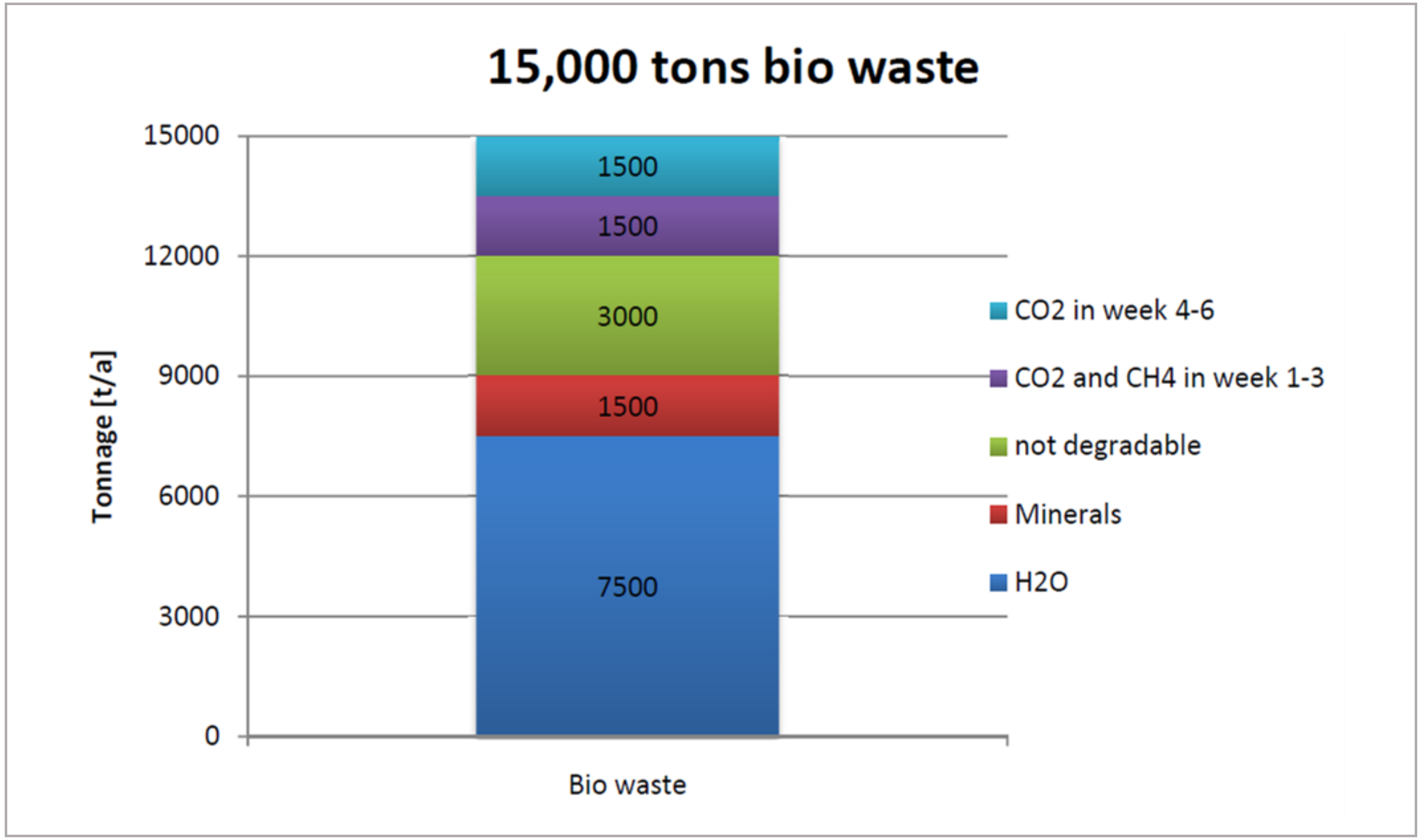
Results

Odour reduction



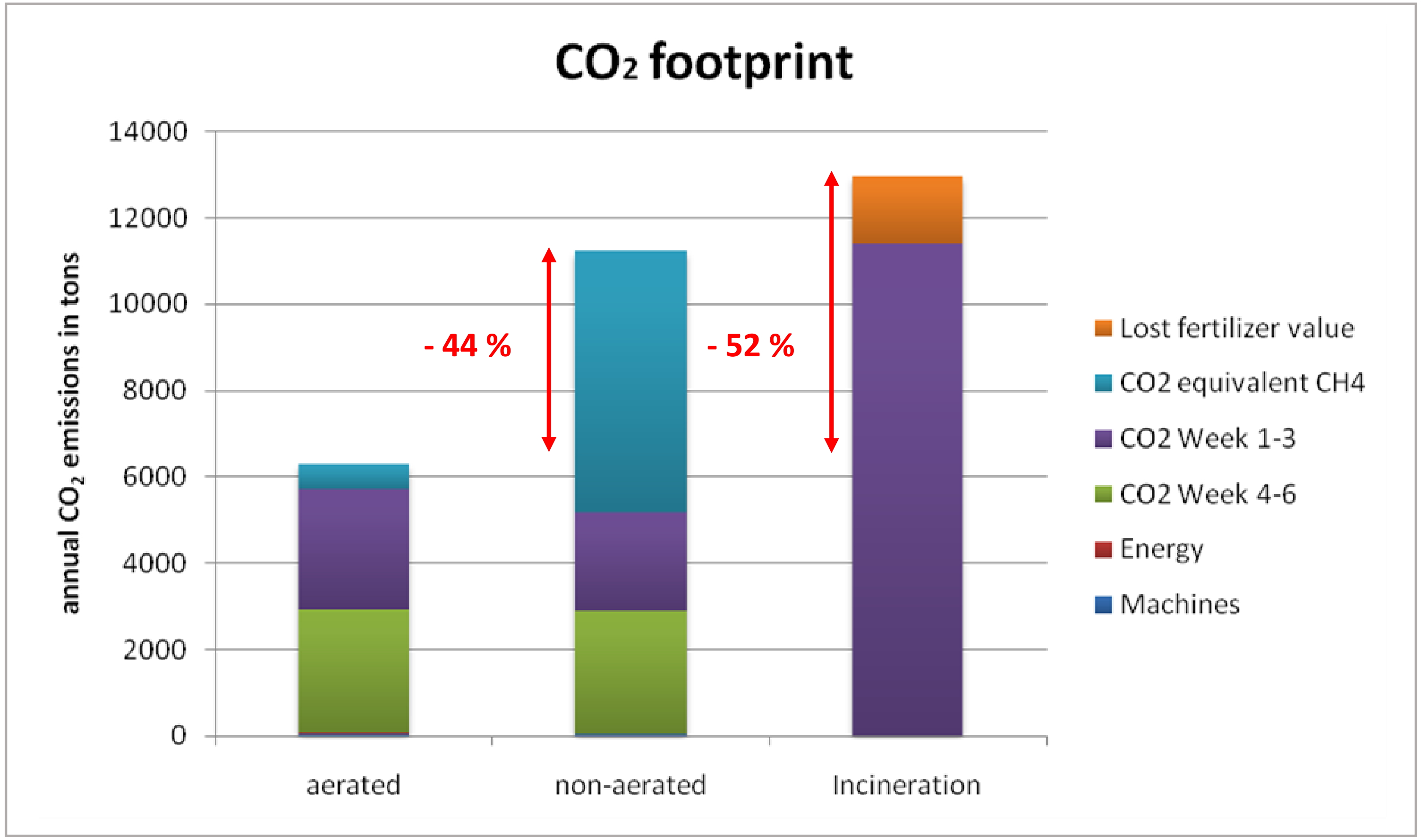
Results

CO_2 footprint



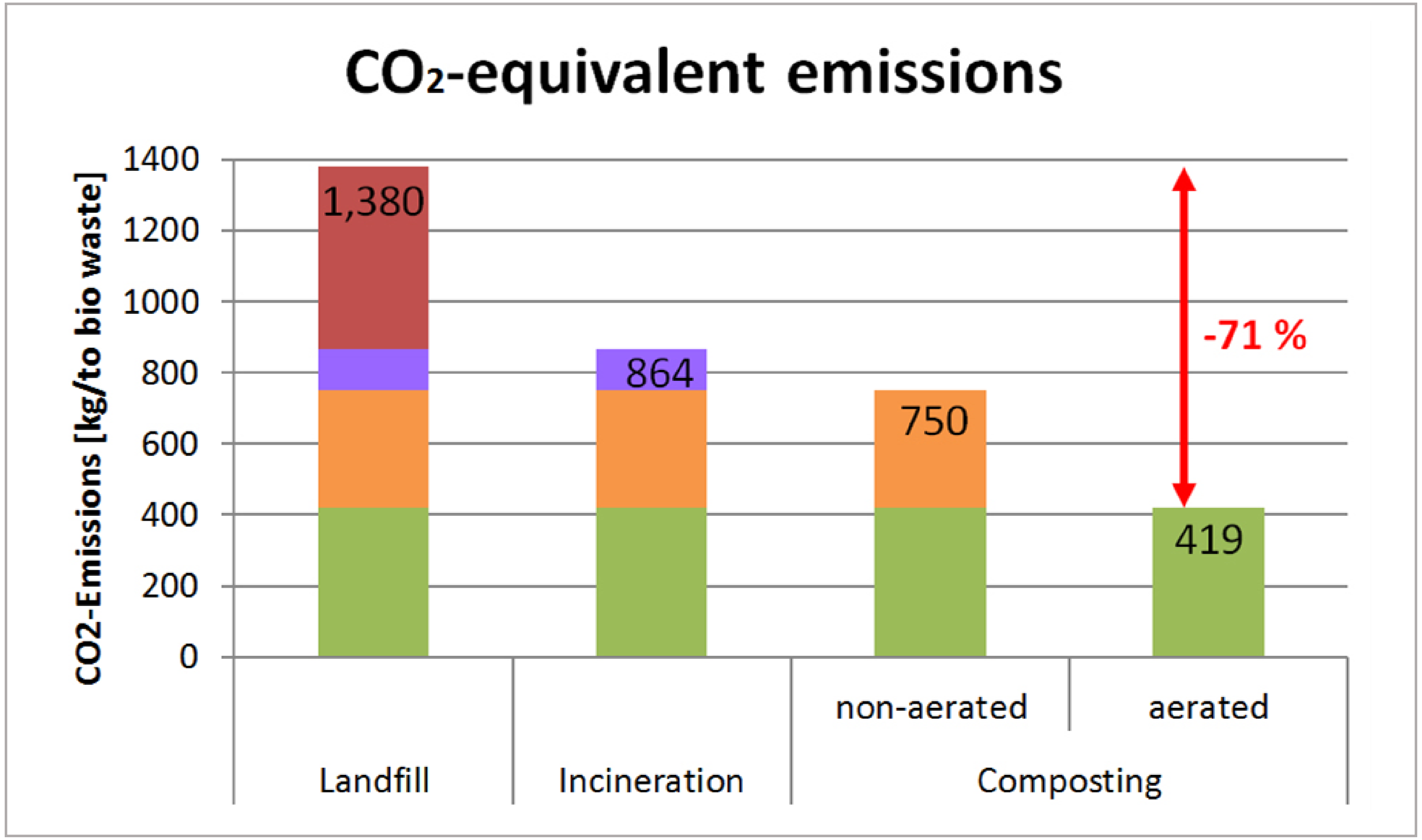
Results

CO_2 footprint



Results

CO_2 footprint



Results

Illustration

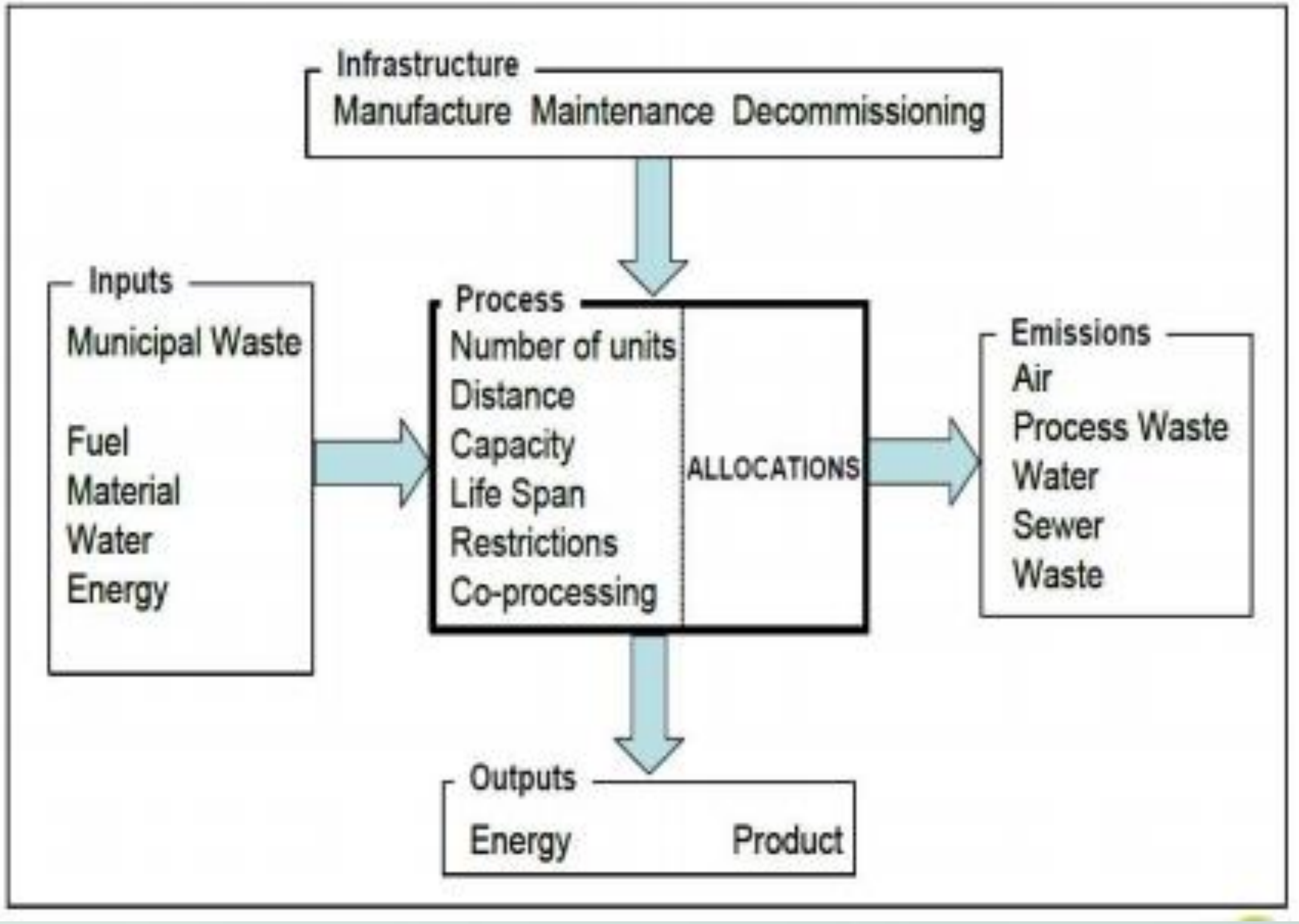
= 28.8 million km
= 17.9 million miles

= 720 circumnavigations

= 138,229 km
= 85,882 miles

GHG Emissions Are Driving FW Diversion from Landfills

- Composting reduces GHG by 10x compared to landfills
- Life Cycle Analysis (LCA)
- EPA WARM Model (US) LCA modelling for waste managers
- (WRATE) Waste and Resource Assessment Tool for the Environment from UK



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300,000 TPY GW/FW Compost Facility

Waste Reduction Model (WARM)

Summary Report (MTCO2E)

GHG Emissions Analysis - Summary Report

GHG Emissions Waste Management Analysis for **Green Mountain Tech**
Prepared by: **Michael Bryan-Brown**
Project Period for this Analysis: to

Material	Baseline Scenario						Alternative Scenario							
	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Anaerobically Digested	Total MTCO2E	Change (Alt-Base) MTCO2E
Food Waste	N/A	100000.00	0.00	0.00	0.00	54216.22	0.00	N/A	0.00	0.00	100000.00	0.00	-17601.20	-71817.42
Yard Trimmings	N/A	200000.00	0.00	0.00	0.00	-35971.44	N/A	N/A	0.00	0.00	200000.00	0.00	-29262.41	6709.03
						18244.78							-46863.61	

a) For explanation of methodology, see the EPA WARM Documentation

b) Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.

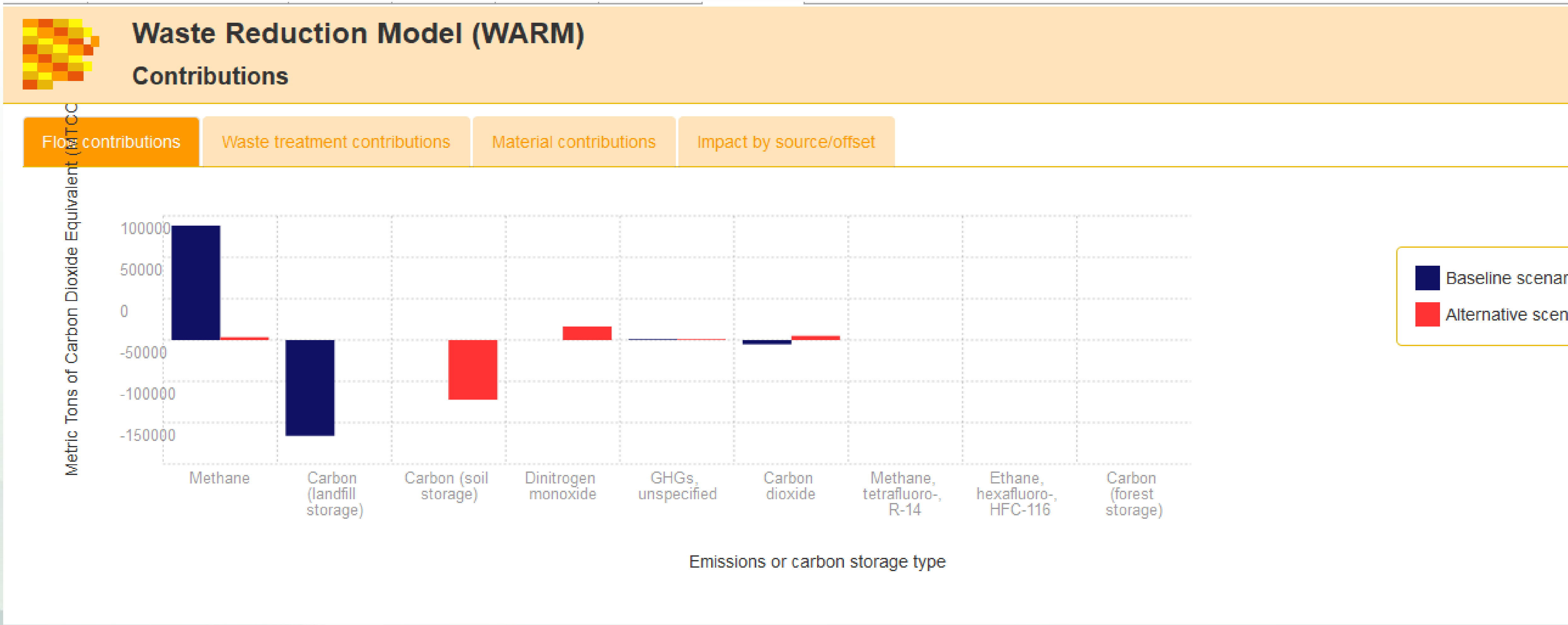
c) The GHG emissions results estimated in WARM indicate the full life-cycle benefits waste management alternatives. Due to the timing of the GHG emissions from the waste management pathways, (e.g., avoided landfilling and increased recycling), the actual GHG implications may accrue over the long-term. Therefore, one should not interpret the GHG emissions implications as occurring all in one year, but rather through time.

d) The equivalency values included in the box to the right were developed based on the EPA Greenhouse Gas Equivalencies Calculator and are presented as an example of potential equivalencies. Additional equivalencies can be calculated using WARM results at the Greenhouse Gas Equivalencies Calculator website or using alternative data sources.

Total Change in GHG Emissions (MTCO2E): **-65108.39**

This is equivalent to...
Removing annual emissions from **13823** Passenger Vehicles
Conserving **7326250** Gallons of Gasoline
Conserving **2712849** Cylinders of Propane Used for Home Barbeques
0.00004% Annual CO2 emissions from the U.S. transportation sector
0.00004% Annual CO2 emissions from the U.S. energy sector

200,000 ton GW and 100,000 ton FW



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2.1 # Permit Changes when Adding FW - Jeff Gage

- Air Permits
  - Emission factors
  - Control Technology permits and measurement approaches.
- Solid Waste Permits
  - Acceptance criteria
  - Sanitation req.
  - Odor Impact Man. Pln.
- Water Discharge Permits
  - Treatment and reuse

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2.1

Understand Local Regulations

- Washington State Solid Waste http://app.leg.wa.gov/wac/default.aspx?cite=173-350-220
- Washington State Clean Air Agencies http://www.pscleanair.org/regulated/composting/default.aspx
- Oregon DEQ https://www.oregon.gov/deq/mm/swpermits/Pages/Composting.aspx
- California Solid Waste http://www.calrecycle.ca.gov/organics/Processors/
- California Air Board http://www.arb.ca.gov/cc/compost/compost.htm
- California Water Board https://www.waterboards.ca.gov/board_decisions/adopted_orders/water_quality/2020/wqo2020_0012_dwq.pdf
- Federal EPA Guidance for States http://epa.gov/composting/laws.htm

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Air Permits – VOC Emission Factors

- Volatile Organic Compounds are emitted at a significantly higher rate with FW feedstocks, due to proteins and sugars breaking down under acidic conditions. Most of these emissions occur in the first 7 to 10 days. Pickling must be avoided otherwise VOC emissions can increase 10 - fold.
- Emission Factors (EF) are used by Air Agencies to determine whether a facility will likely exceed Federal Title V emission limits of 100 tpy of VOC's contained in the Clean Air Act.
- California leads the way to develop compost facility EF's. Other states adopt them to determine emissions per ton. EF is based on both feedstocks and management methods. WA found lower and regional differences in Speciation of VOC's
- Local Odor Regs based on nuisance standards in most states, but some use odor concentrations in Dilutions to Threshold (DT) at property lines. Manage by contain, treat, dilute, and disperse.

[Source- https://www.biocycle.net/emissions-and-air-quality-compliance-its-not-just-about-odors/](https://www.biocycle.net/emissions-and-air-quality-compliance-its-not-just-about-odors/)

2.1 Control Technology Air Permit Conditions May Include

- Biofilters for negative aeration, receiving building enclosures – Biofilters require >30 seconds residence time, loading rate of 5 cfm/ft^2, irrigation 2x/day, Ammonia pre-scrubbing to protect microbes. Easy to sample for emission reductions.
- Covers are used for positive aeration, biocovers or selective fabrics for 7 to 20 days to control odors. Sample in areas that represent avg. surface outflow
- Turning frequency, porosity and size are used for windrows. Islip, NY every 3 days turning reduced odors. Biocovers provide odor control but need to be reapplied. These can become permit processing conditions.
- Misting systems, oxidisers, reactants and surfactants some of these work and have their place at different stages of the handling especially receiving/processing areas.
- Distance and disturbance within air sheds, modelling and measuring Dilutions to Threshold (DT). Check source concentrations and perimeter concentrations using a field olfactometer or adsorption tube designed for low concentrations, or Tedlar bag for odor panel work or gas mass

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Local Odor Control Requirements

- No Federal Odor Control Regulations, But Federal guidance exists:
  - Biosolids Guidance- EPA 832-F-00-067 - September 2000
  - Odor Control - Environmental Odors - ATSDR (cdc.gov)
  - Bioreactors Guidance- USING BIOREACTORS TO CONTROL AIR POLLUTION (epa.gov)
- 44 states currently have Odor Regulations in place
- Find the updated odor regulations and events regarding European standards https://www.olores.org/en/odours
- European Odour Units Standard is EN 13725
- There are a few standards on the calculation of odour intensity in ambient air such as the ASTM E544-18 or the much-used VDI Guideline 3882 sheet 1.

2.1

Solid Waste Permits – What's Added for FW

- Vector control –
  - Rodents-Harbourage reduction, bait boxes, clean surfaces end of day
  - Birds -enclosure for receiving materials and covering all outdoor fresh piles, using galv. wire on poles and landing zones, popguns, downdraft doorways, hawks
  - Insects – Washdown end of each day, move cool wet edges into hot piles twice a week, control wasp nests and yellow jacket nests.
- Operational controls –
  - On-time handling for FW upon receipt, sorting out contaminants, add bulking
  - Mixing, covering and significant aeration to raise pH above 6.5
  - Backup equipment and procedures if breakdowns occur
- Pathogens – Full PPE (splash guards)for employees and visitors, wash stations, laundry services, Break rooms with HOT water to wash hands, boots, gloves, tools

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2.1

Water Discharge Permits for Leachate, Stormwater, or Sewer Disposal Permissions

- The Clean Water Act and RCRA require containing and treating leachate. (Contact water) from putrescible wastes
  - Sealed surfaces include Clay liner below gravel surface, Concrete, Asphalt with sealants for edges/transitions or holding areas, Tanks and Ponds
  - Water should be collected and treated as soon as it is generated to reduce odors. Use site sweeping, sediment traps, grease traps, and then aeration and sedimentation techniques to reduce the BOD to reasonable levels
  - Store for reuse or disposal.
    - Disposal to sewerage systems must also treat the water further to meet discharge standards. There will be testing requirements before discharge to sewer.
    - Reuse storage must work with seasonal process water needs to assure zero discharge. Use only prior to starting sanitation requirements.

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2.2 Michael Bryan-Brown

Financial Impacts of Adding Food Waste

- Food waste is a consistent revenue stream
- Additional equipment costs required for processing FW
- Permit changes and possible Title V air monitoring costs
- Pro Forma analysis spreadsheet for different feedstocks
- Potential impacts on product quality and marketability
- Risks associated with odors and threats to the business

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Food Waste Increases Revenue

- Food waste typically provides higher tip fees
- Minimal seasonal variation in FW volume provides more consistent cash flow compared to GW
- Not accepting food waste may cause the loss of contracts for GW as more municipalities have comingled collection routes
- Adding FW may be eligible for Carbon Credits or grant funding to improve infrastructure

2.2

How FW Adds Cost to Your Operation

- Increased permit costs
- Cost for receiving upgrades
- May require an impermeable surface for leachate collection and treatment
- Adding aeration pad and odor control
- Plastics removal

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2.2

Tabs Feeding Pro Forma Spreadsheet

	Tip Fees		
	Tons/year	Price $/ton	$/year
wood waste	10,746	$ (36.00)	$ (386,856.00)
Yard Waste	10,000	$ 35.00	$ 350,000.00
grass	-	$ 40.00	$ -
sod & dirt	-	$ 30.00	$ -
Xmas trees	-	$ 100.00	$ -
Biosolids	-	$ 500.00	$ -
Foodwaste	15,000	$ 75.00	$ 1,125,000.00
Grease trap	-	$ 90.00	$ -
Digestate	-	$ 18.75	$ -
Tons per year	**35,746**		

For every ton in 40% loss in mass 55% loss in volume during aging

5%				
Item	**Principle**	**Interest Rate**	**Term in months**	**Monthly Payment ***
Horizontal Grinder	$ 750,000	5%	84	$ 12,500
Telestacker	$ 350,000	5%	84	$ 6,605
Mulch hopper	$ 275,000	5%	84	$ 5,065
Cat 960 loader		5%	84	$ -
Screener	$ 350,000	5%	84	$ 6,605
Misc Conveyor	$ 30,000	5%	84	$ 566
Loader	$ 250,000	5%	84	$ 4,718
Blocks	$ 60,000	5%	84	$ 1,132
Storage Shed building	$ 1,670,440	5%	84	$ 31,523
Aerated floor POG	$ 500,000	5%	84	$ 9,436
Blowers and controls, manifolc	$ 650,000	5%	84	$ 2,763
Pavement	$ 567,555	5%	60	$ 1,105
Pond	$ 90,000	5%	84	$ 1,355
Total Debt	$ 5,542,995			$ 83,373

Selling General and Administrative Expenses			
Operating & Safety Supplies	$ 300.00	eye wash stations, ear plugs	
Advertising	$ 1,250.00	Web site and print	
Blank	$ -		
Telephone	$ 350.00	cells for 3 workers	
Computers internet	$ 150.00		
Insurance liability	$ 1,071.46	Estimate based on 0.25% of ca	
Office Supplies	$ 300.00		
Total	**$ 3,421.46**		
Permits yearly costs			
County Health Dept.	$ 2,000.00		Waste water DOE
Clean Air Agency	$ 12,000.00		
City Business Licenses	$ 250.00		
Chamber of Commerce	$ 1,000.00		
Total Annual Permits	$ 15,250.00		
Monthly Average	**$ 1,270.83**		
Product Testing & Certifications	**$ 250.00**		
Total SG&A Monthly	**$ 4,942.29**		

Operations Labor Proforma								
Overhead Load	25%							
Positions	**FTE**	**Rate/hr**	**Benefit%**	**Loaded Cost/hr**	**Hours/wk**	**Payroll/wk**	**Monthly**	**Annual**
Office								
Owner Management	0						$ 3,000.00	$ 36,000.00
bookkeeper/MGMT	0.5	$ 23.00	0%	$ 23.00	40	$ 460.00	$ 1,991.80	$ 23,901.60
	0	$ 15.00	0%	$ 15.00	40	$ -	$ -	$ -
Operators/drivers								
	1	$ 23.00	0%	$ 23.00	40	$ 920.00	$ 3,983.60	$ 47,803.20
	0	$ 23.00	25%	$ 28.75	40	$ -	$ -	$ -
	0	$ 13.00	25%	$ 16.25	40	$ -	$ -	$ -
Operations Support								
Maintenance/Laborer	1	$ 23.00	0%	$ 23.00	40	$ 920.00	$ 3,983.60	$ 47,803.20
Mechanic	0.5	$ 23.00	0%	$ 23.00	40	$ 460.00	$ 1,991.80	$ 23,901.60
Total						**$ 2,760.00**	**$ 11,950.80**	**$ 143,409.60**

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2.2

Pro Forma Spreadsheet

Proforma Growth	Revenue	Labor	Ops Costs	SG&A
	5%	3%	3%	2%

Composting Proforma P&L Projections

Year #1													Total	
Revenue	$ (54,193)	$ (24,129)	$ (23,829)	$ 3,377	$ 6,471	$ 6,471	$ 6,471	$ 6,471	$ 6,471	$ 6,471	$ 6,344	$ 6,344	**$ (47,260)**	100%
Labor	$ 12,070	$ 12,190	$ 12,190	$ 12,070	$ 12,190	$ 12,190	$ 12,190	$ 12,190	$ 12,190	$ 12,190	$ 11,951	$ 11,951	**$ 145,561**	-308%
Ops Costs	$ 14,155	$ 14,296	$ 14,296	$ 14,155	$ 14,296	$ 14,296	$ 14,296	$ 14,296	$ 14,296	$ 14,296	$ 14,015	$ 14,015	**$ 170,705**	-361%
Net	$ (80,418)	$ (50,614)	$ (50,314)	$ (22,848)	$ (20,014)	$ (20,014)	$ (20,014)	$ (20,014)	$ (20,014)	$ (20,014)	$ (19,622)	$ (19,622)	**$ (363,526)**	769%
SG&A	$ 4,942	$ 4,942	$ 4,942	$ 4,942	$ 4,942	$ 4,942	$ 4,942	$ 4,942	$ 4,942	$ 4,942	$ 4,942	$ 4,942	**$ 59,307**	-125%
B&O Taxes	$ (542)	$ (241)	$ (238)	$ 34	$ 65	$ 65	$ 65	$ 65	$ 65	$ 65	$ 63	$ 63	**$ (473)**	1%
EBITDA	$ (84,819)	$ (55,315)	$ (55,018)	$ (27,824)	$ (25,021)	$ (25,021)	$ (25,021)	$ (25,021)	$ (25,021)	$ (25,021)	$ (24,628)	$ (24,628)	**$ (422,361)**	894%
Debt Service	$ 77,478	$ 77,478	$ 77,478	$ 77,478	$ 77,478	$ 77,478	$ 77,478	$ 77,478	$ 77,478	$ 77,478	$ 77,478	$ 77,478	**$ 929,736**	-1967%
Net	$ (162,297)	$ (132,793)	$ (132,496)	$ (105,302)	$ (102,499)	$ (102,499)	$ (102,499)	$ (102,499)	$ (102,499)	$ (102,499)	$ (102,106)	$ (102,106)	**$ (1,352,097)**	2861%
Year 2														
Revenue	$ 6,728	$ 6,728	$ 6,728	$ 6,728	$ 6,794	$ 6,794	$ 6,794	$ 6,794	$ 6,794	$ 6,794	$ 6,661	$ 44,549	**$ 118,887**	100%
Labor	$ 12,432	$ 12,556	$ 12,556	$ 12,432	$ 12,556	$ 12,556	$ 12,556	$ 12,556	$ 12,556	$ 12,556	$ 12,309	$ 12,309	**$ 149,928**	126%
Ops Costs	$ 14,580	$ 14,724	$ 14,724	$ 14,580	$ 14,724	$ 14,724	$ 14,724	$ 14,724	$ 14,724	$ 14,724	$ 14,436	$ 14,436	**$ 175,826**	148%
Net	$ (20,285)	$ (20,552)	$ (20,552)	$ (20,285)	$ (20,485)	$ (20,485)	$ (20,485)	$ (20,485)	$ (20,485)	$ (20,485)	$ (20,084)	$ 17,804	**$ (206,866)**	-174%

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Windrow vs ASP vs TAP vs In-Vessel – Orion Black Brown

Source: https://www.researchgate.net/figure/Large-scale-commercial-composting-process-Reprinted-from-Polymer-International-57_fig14_299767774

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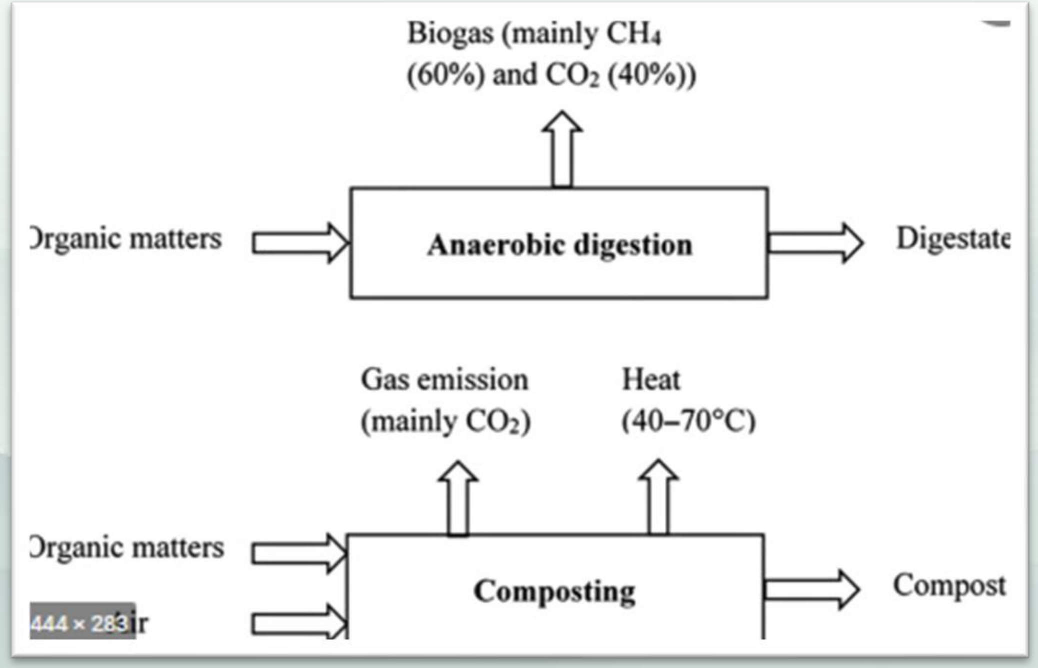
3.1



Aerobic vs Anaerobic

- Anaerobic bacteria release methane (CH4), nitrous oxid (N2O) and other VOC's
- Aerobic bacteria release carbon (CO2) dioxide and heat
- N2O is 296x more powerful GHG then CO2
- CH4 is 84x more powerful GHG then CO2

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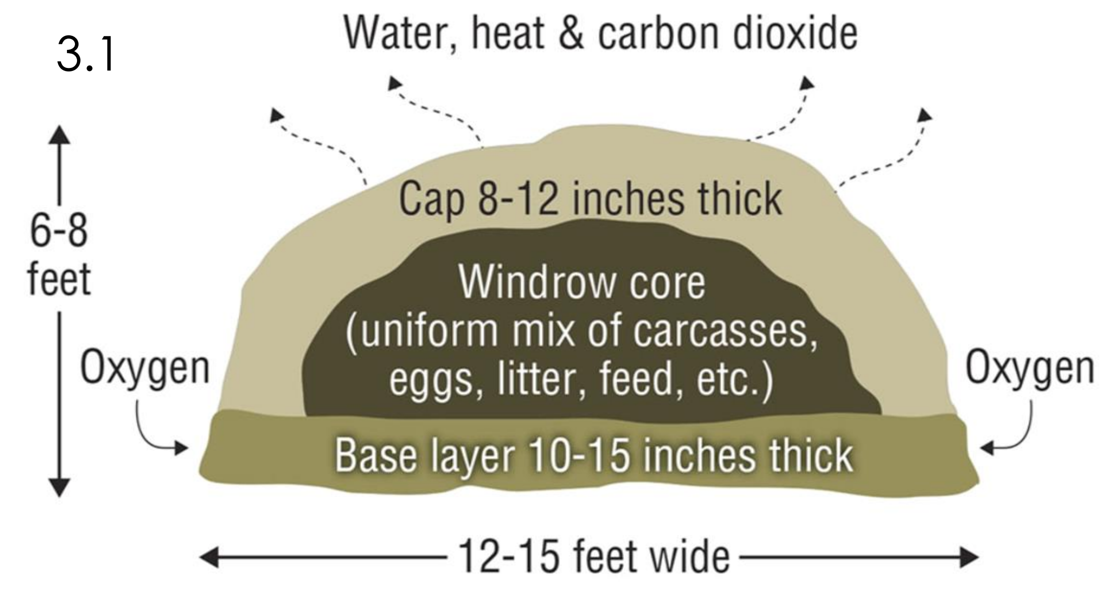
3.1



Static Pile Composting

Capitol Cost	Low
Operational Cost	Low
Retention Time	8+ Months
Emissions	High
Odor Potential	High
Fire Potential	High
Public Perception	Bad
Suggested TPY	100 to 1,000
Viable for FW	No

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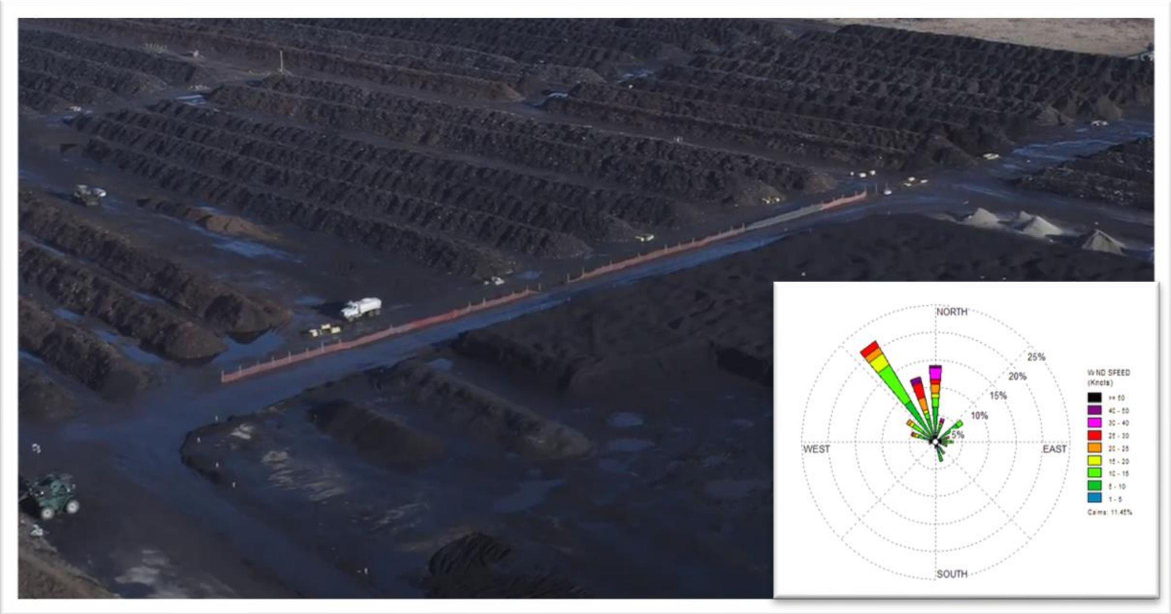
Turned Windrow Composting

- Aerated via natural convection
- Low bulk density (800 lb/Yd^3) but more agitation – comparable fines to ASP
- Turned every 3 to 5 days
- Anoxic degradation
  - Try to maintain 5% Oxygen content
- Medium speed medium heat
- Largest footprint
- Align Windrows with "Wind Rows"



Turned Windrow Composting

Capitol Cost	Low to High
Operational Cost	Medium
Retention Time	4+ Months
Emissions	High
Odor Potential	High
Fire Potential	High
Public Perception	Ok
Suggested TPY	5,000 to 30,000
Viable for FW	Sometimes

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Pipe on Grade vs Pipe Below Grade

- Both can run in positive, negative, or reversing
- On grade, pipes sit on working surface
  - Must be pulled and reinserted during loading and unloading
  - Pipe wasting is inevitable
- Below grade, pipes are encased in concrete
  - Need cleanouts
  - Need pressure traps

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COMMERCIAL COMPOSTING SOLUTIONS

3.1

Extended Aerated Static Pile Composting – Pipe on Grade

Capitol Cost	Low to Medium
Operational Cost	High
Retention Time	3+ Months
Emissions	Low to Medium
Odor Potential	Low to Medium
Fire Potential	Low to Medium
Public Perception	Good
Suggested TPY	500 to 20,000
Viable for FW	Yes

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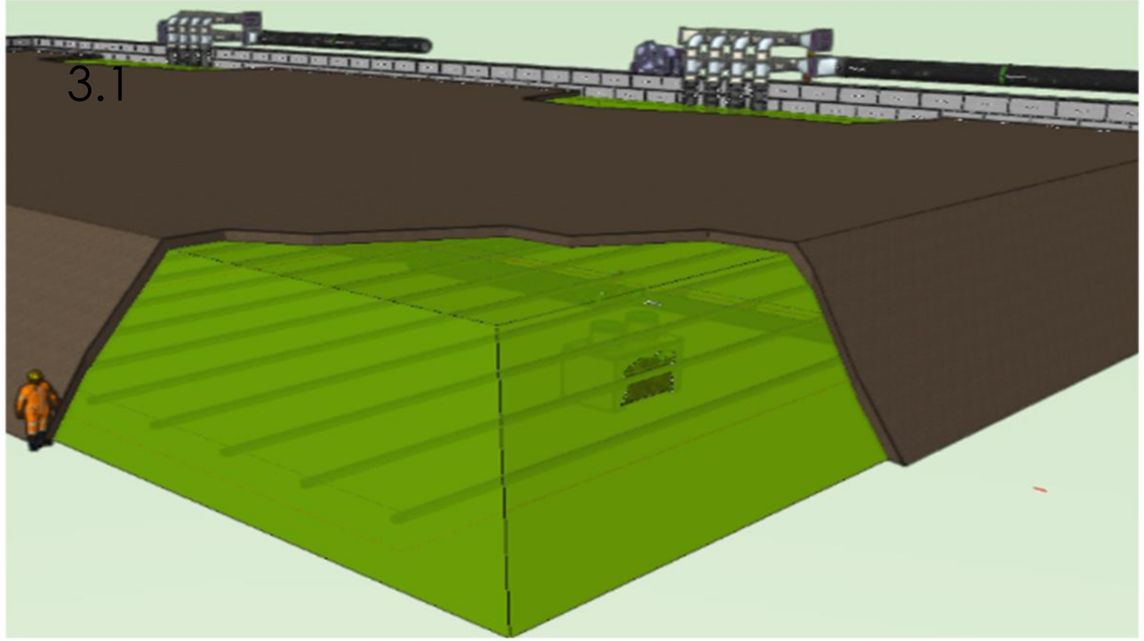
COMMERCIAL COMPOSTING SOLUTIONS



Aerated Static Pile (ASP) Composting

- Air is forced into the piles (positive aeration) or pulled through the piles (negative aeration)
- Min 10% oxygen or 1 CFM/Yd^3
  - Usually 2.5 to 5 CFM/Yd^3
- Completely aerobic
- Hot and fast
- Low footprint

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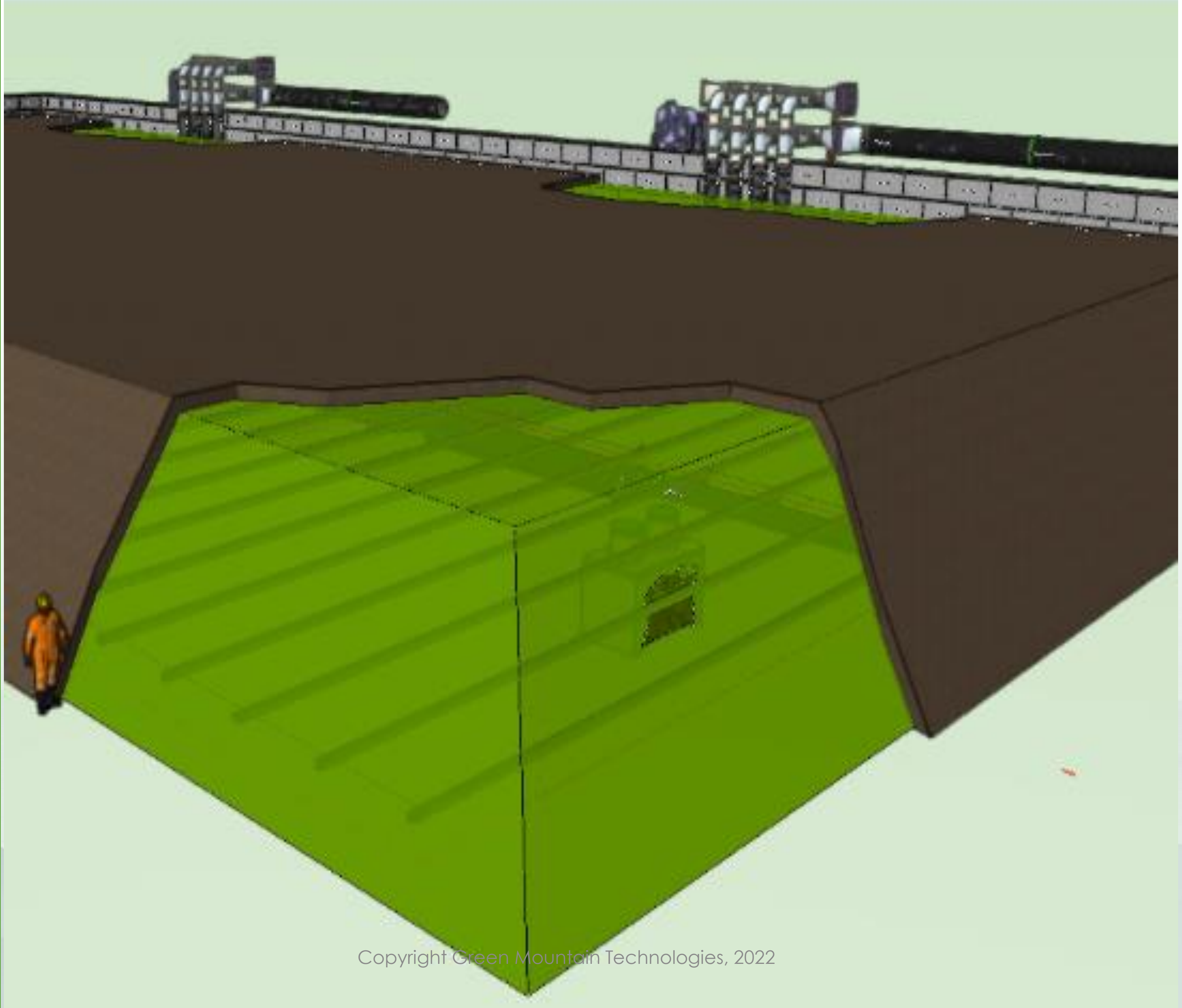

Covered Aerated Static Pile Composting

Capitol Cost	Medium
Operational Cost	Medium
Retention Time	2+ Months
Emissions	Low to Medium
Odor Potential	Low to Medium
Fire Potential	Low
Public Perception	Good
Suggested TPY	10,000+
Viable for FW	Yes

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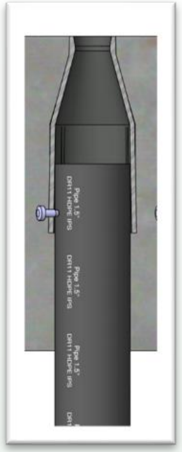
COMMERCIAL COMPOSTING SOLUTIONS

3.1

Below Grade Aeration Strategies: Sparger vs Pipe at Grade vs Trenches

Parameter	Sparger	PAG	Trench
Capital Cost	$$$	$$	$$$$
Electrical Expenses	$$$	$	$$
Maintenance Cost	$	$$	$$
% Clogged (Positive)	10% - 30%	40% - 70%	40% - 70%
Loses in Negative	30% - 60%	20% - 50%	10% - 40%



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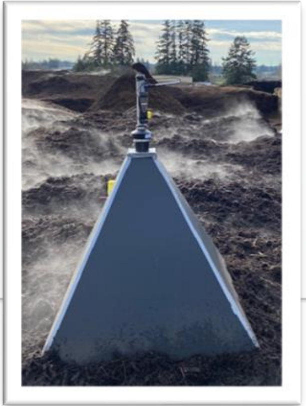
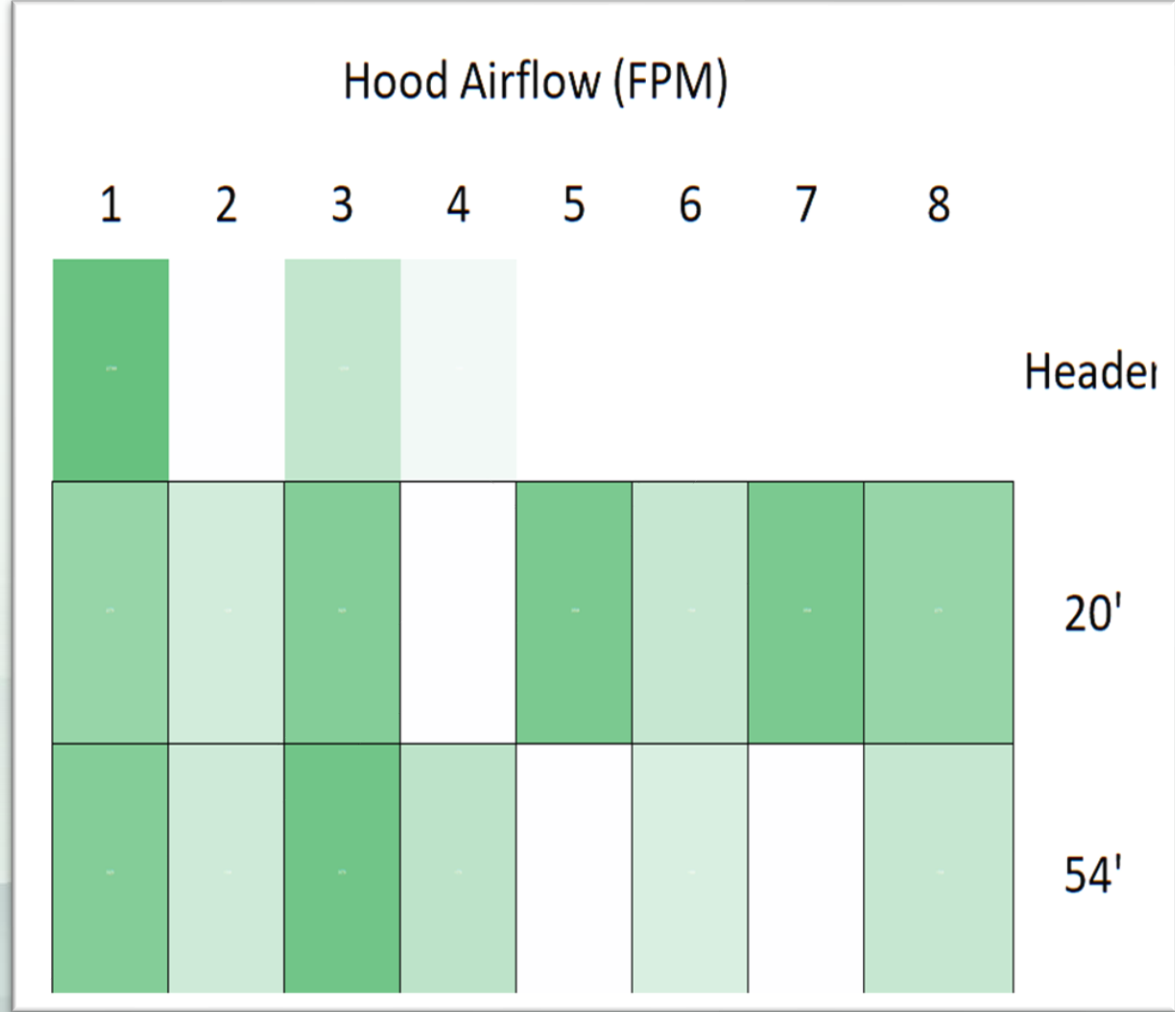
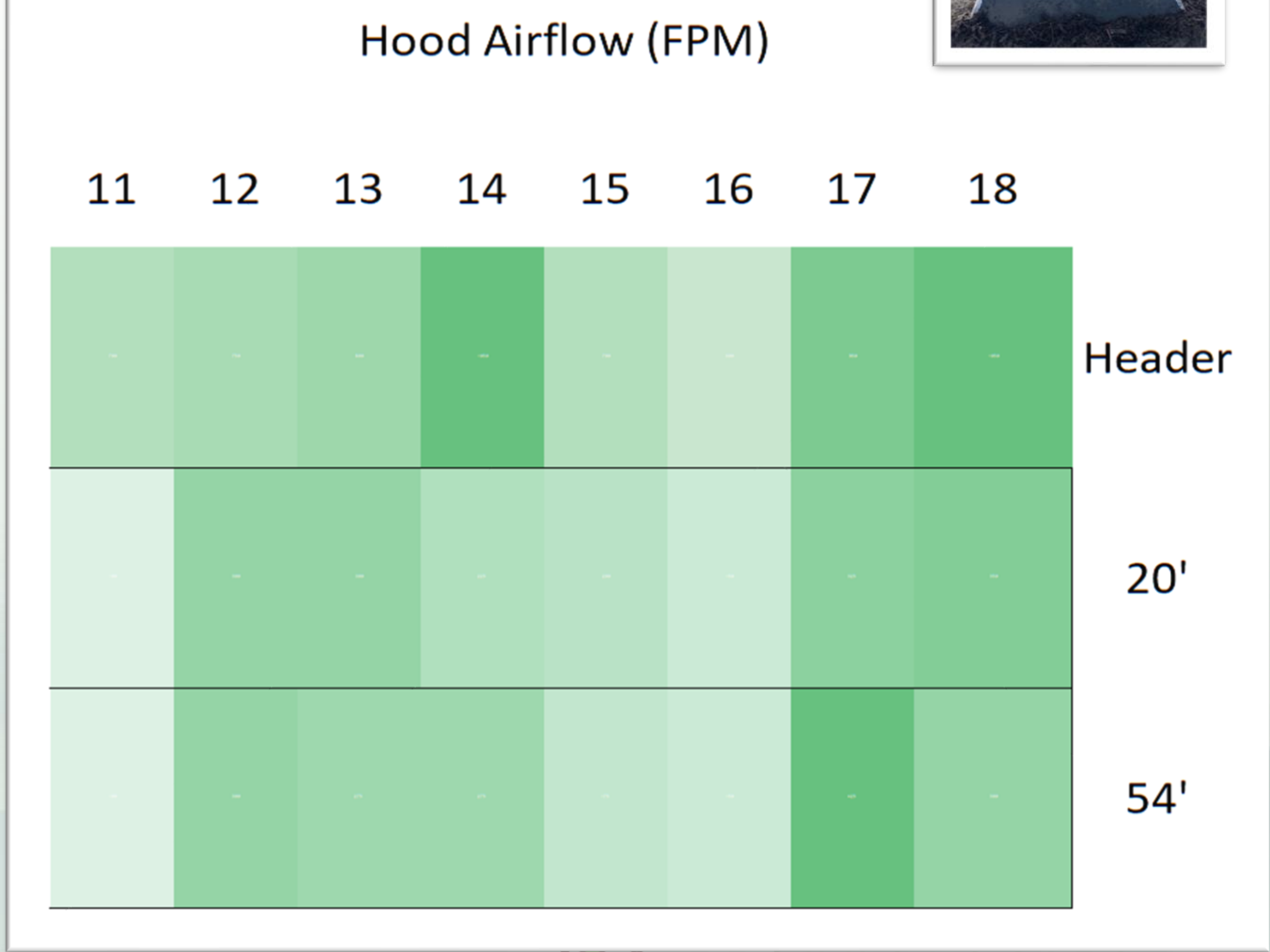
Pipe At Grade vs Sparger







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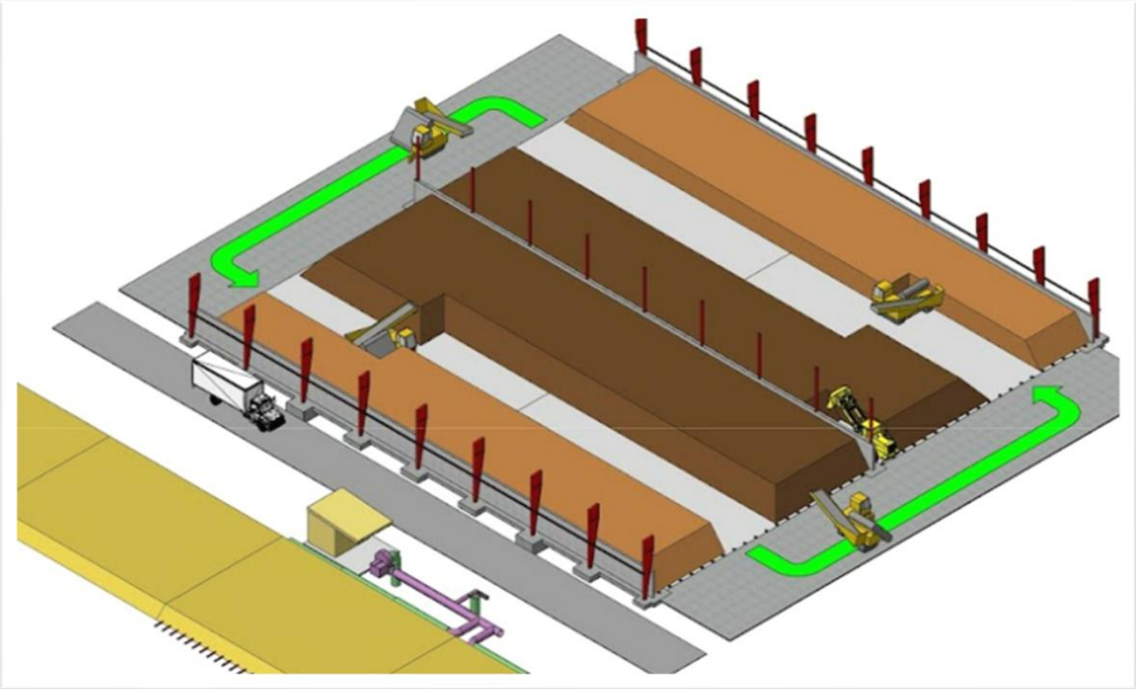

Turned Aerated Pile (TAP) Composting

- Like ASP with turning every 3 to 7 days
- Faster throughput due to mechanical wear, homogenization, fluffing, and moisture distribution
- Side Discharge Turners 1000 to 2000 Yd^3/Hour
- Loaders 100 to 300 yd^3/Hour
- Smaller blowers and higher bulk density
- Most fines

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Turned Aerated Pile Composting

Capitol Cost	High
Operational Cost	Medium
Retention Time	1.5+ Month
Emissions	Medium
Odor Potential	Low to Medium
Fire Potential	Low
Public Perception	Good
Suggested TPY	50,000+
Viable for FW	Yes

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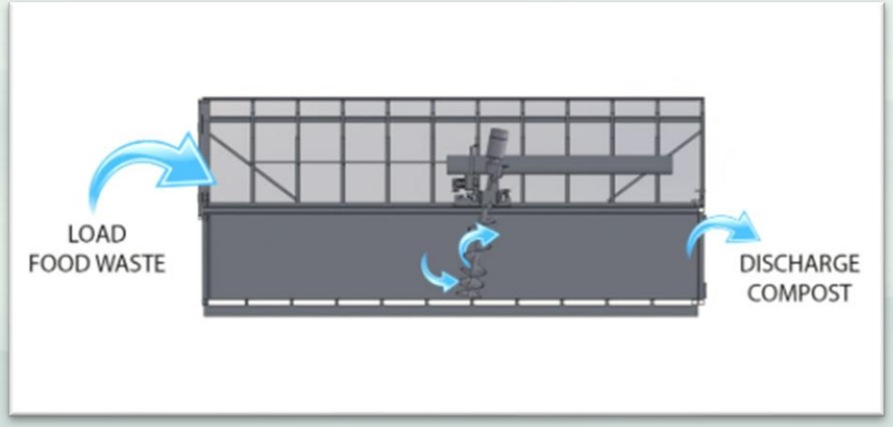
3.1

In-Vessel Composting

- Composting happens in box or drum
- Often more automated
- Low footprint
- Great process control
- These ideas can be scaled
  - Edmonton Compost Facility



1. https://ecodrumcomposter.com/

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3.1

In-Vessel Composting

Capitol Cost	Medium to High
Operational Cost	Low to High
Retention Time	1.5+ Months
Emissions	Low
Odor Potential	Low
Fire Potential	Low
Public Perception	Good
Suggested TPY	100 to 10,000
Viable for FW	Yes

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3.1

	100 to 5,000 Tons Per Year				20,000 to 100,000 Tons Per Year			
	Windrow	cASP	TAP	In-Vessel	Windrow	cASP	TAP	In-Vessel
Capitol Cost	$	$$ - $$$	$$$$	$$	$$-$$$$$	$$$	$$$$	$$$$$
Operational Cost	$$	$$	$$	$	$$$$	$$	$$	$$-$$$$
Retention Time	16+ Weeks	8+ Weeks	6+ Weeks	6+ Weeks	16+ Weeks	8+ Weeks	6+ Weeks	6+ Weeks
Odor	Bad	Good to Great	Good	Great	Bad	Good to Great	Good	Great
Emissions	Bad	Good to Great	Ok to Good	Great	Bad	Good to Great	Ok to Good	Great

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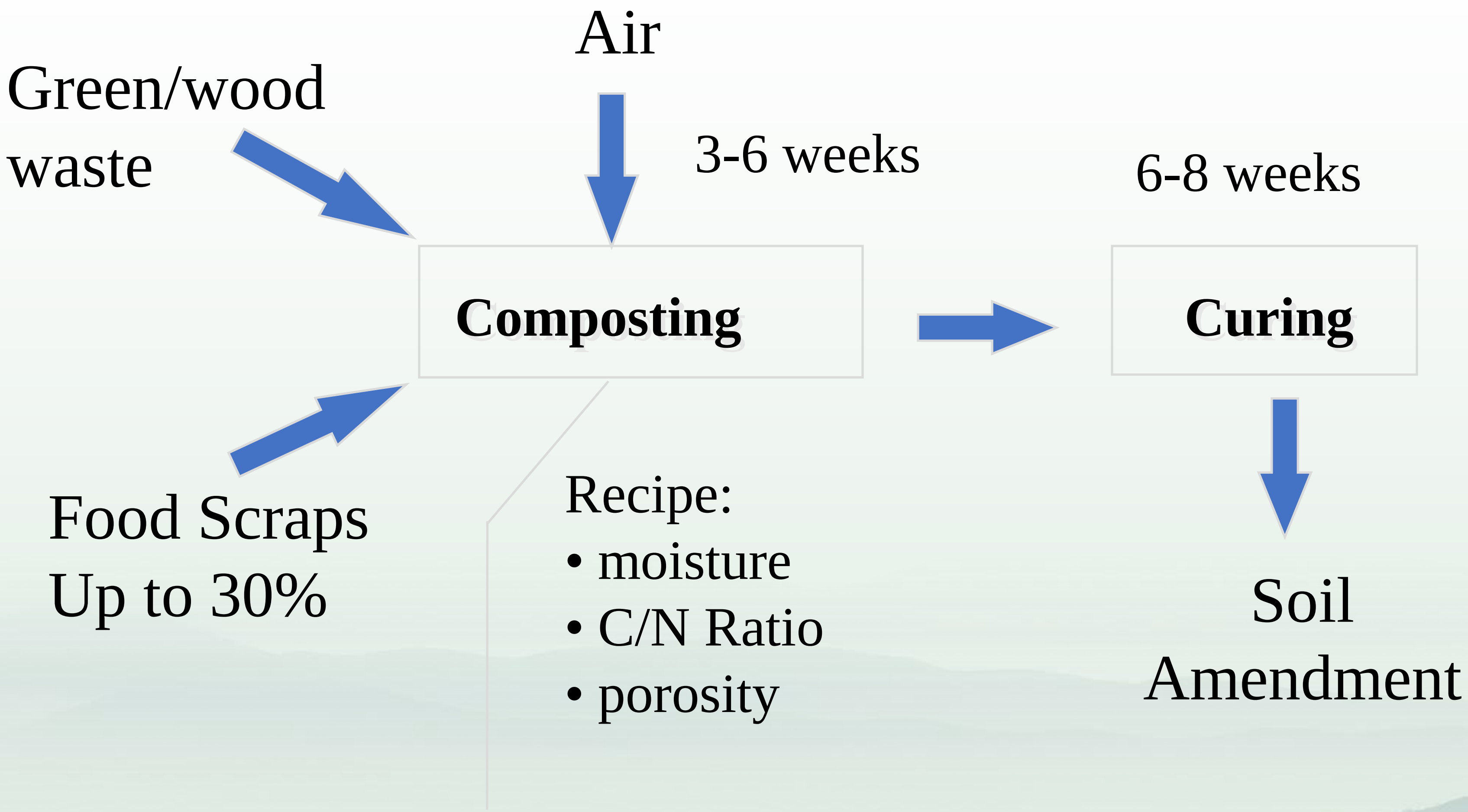
Knowing your Feedstocks and Recipes






Aerobic Food Waste Composting Process



Target ranges for key parameters

Bulk Density	800-1000 lbs/yds
Moisture	50-65%
C/N Ratio	20-30:1
C/P ratio	75-150:1
pH	6.5-8
FAS (free air space)	40-60%

In 1934, Alfred Redfield discovered that the ratio of carbon to nitrogen to phosphorus is a nearly constant **106:16:1** throughout the world's oceans, in both phytoplankton biomass and in dissolved nutrient pools.

3.2

How do you calculate a compost recipe?

- Cornell or WSU Excel Spreadsheet
- GMT CompostCalc Software
- The Compost Handbook
- Compost UMH(Spanish only)

Compost Mixture Calculation Spreadsheet

You can download spreadsheets with built in equations to solve compost

- MS Excel 2010 (updated March 2014)

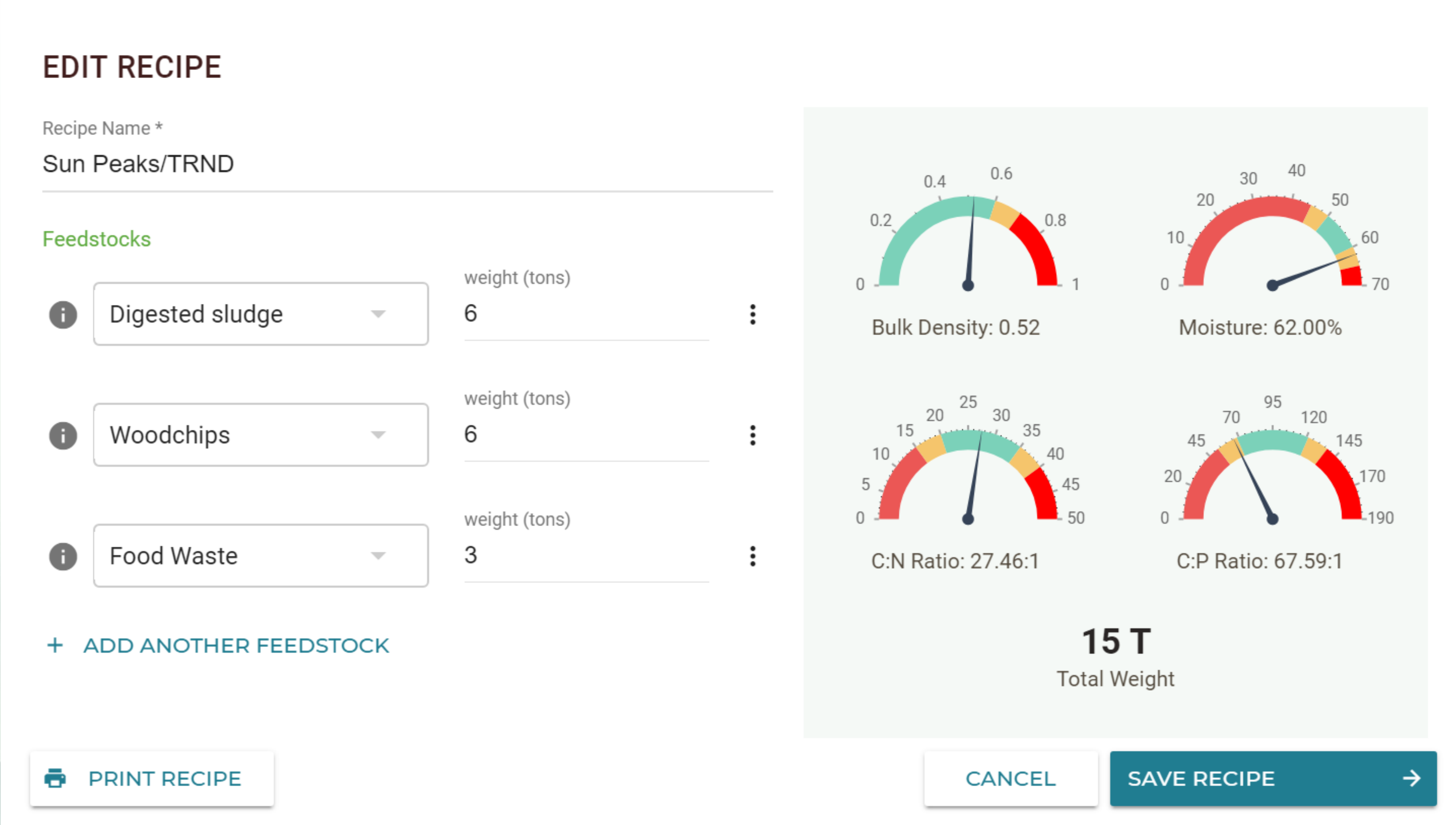
WASHINGTON STATE UNIVERSITY

Select characteristics fo

	Feed Stock Type	Material
1	crop residues & processing wastes	Apple filter cake
2	crop residues & processing wastes	Apple pomace
3	crop residues & processing wastes	Apple-processing sludge
4	crop residues & processing wastes	Cocoa shells
5	crop residues & processing wastes	Corn cobs
6	crop residues & processing wastes	Corn stalks
7	crop residues & processing wastes	Cranberry filter cake
8	crop residues & processing wastes	Cranberry filter cake (with rice hulls)

3.2

CompostCalc Recipe Calculator



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Compost Calc

File View

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COMPOST CALC

RECIPES

FEEDSTOCKS >

SETTINGS

HELP

ADD NEW FEEDSTOCK +

↑ MATERIAL TYPE	FEEDSTOCK	DENSITY	MOISTURE	CARBON	NITROGEN	PHOSPHORUS
Crop Residuals, fruits, vegetables	Apple filter cake	0.70	60.00%	15.60%	1.20%	0.06%
Crop Residuals, fruits, vegetables	Apple, Pomace	0.91	90.00%	52.80%	1.10%	0.06%
Crop Residuals, fruits, vegetables	Apple, process sludge	0.84	60.00%	19.60%	2.80%	0.06%
Crop Residuals, fruits, vegetables	Cocoa shells	0.47	8.00%	50.60%	2.30%	0.66%
Crop Residuals, fruits, vegetables	coffee grounds	0.90	70.00%	30.00%	1.50%	0.06%
Crop Residuals, fruits, vegetables	corn cob	0.33	15.00%	60.00%	0.60%	0.00%
Crop Residuals, fruits, vegetables	corn stalks	0.02	12.00%	47.25%	0.70%	0.00%

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3.2

FW Recipe Testing for FW/GW Mixes

- 2 vessels side-by-side 2’x2’
- 8’ Deep Column of Compost
- 1 Cubic Yard Capacity Each
- 2” Foam Insulation
- Corrugated plastic liner
- 2’x2’ Perforated floor
- 6” Deep Sump Below Floor

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3.2

Trial One10% & 20% Food Waste

- Test performed from Nov 19-30
- Negative aeration used for both reactors
- 10% food waste by weight in right Reactor
- 20% food waste by weight in left Reactor

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Time/Temp Curve for 10% Food Waste

City of Phoenix 27th Avenue Compost Facility Project Program Document

Arrington Watkins Architects

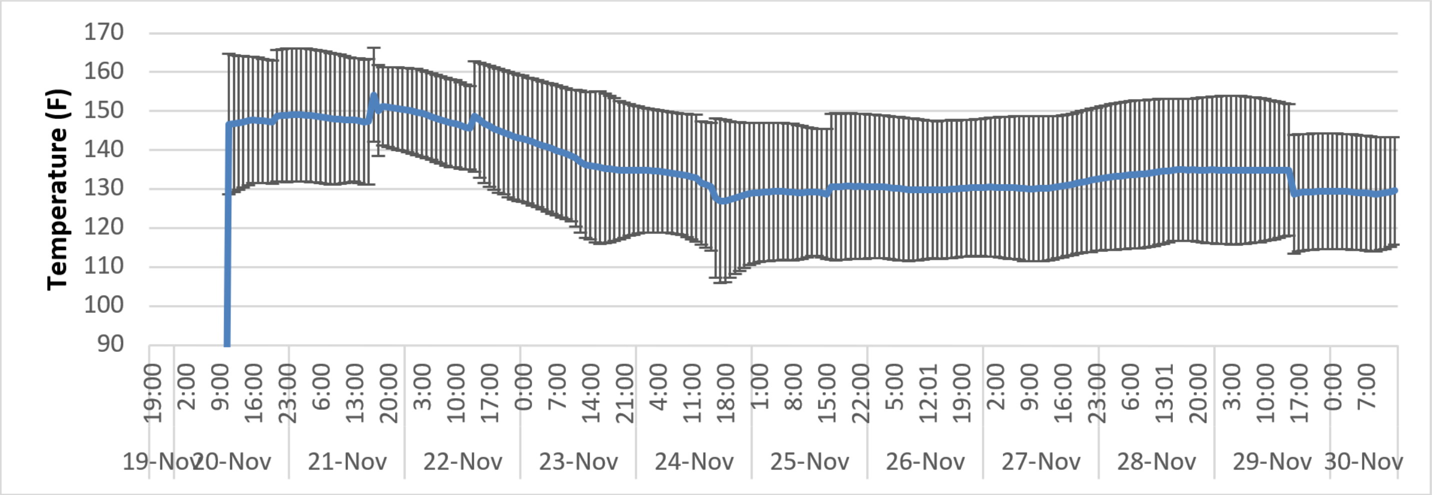

Figure 6 Temperature Profile for 10% food ratios and City green waste feedstocks with negative aeration ASP. Standard deviation bars show the temperature differential of the probes at various depths in the pile.

3.2

Time/Temp Curve for 20% Food Waste

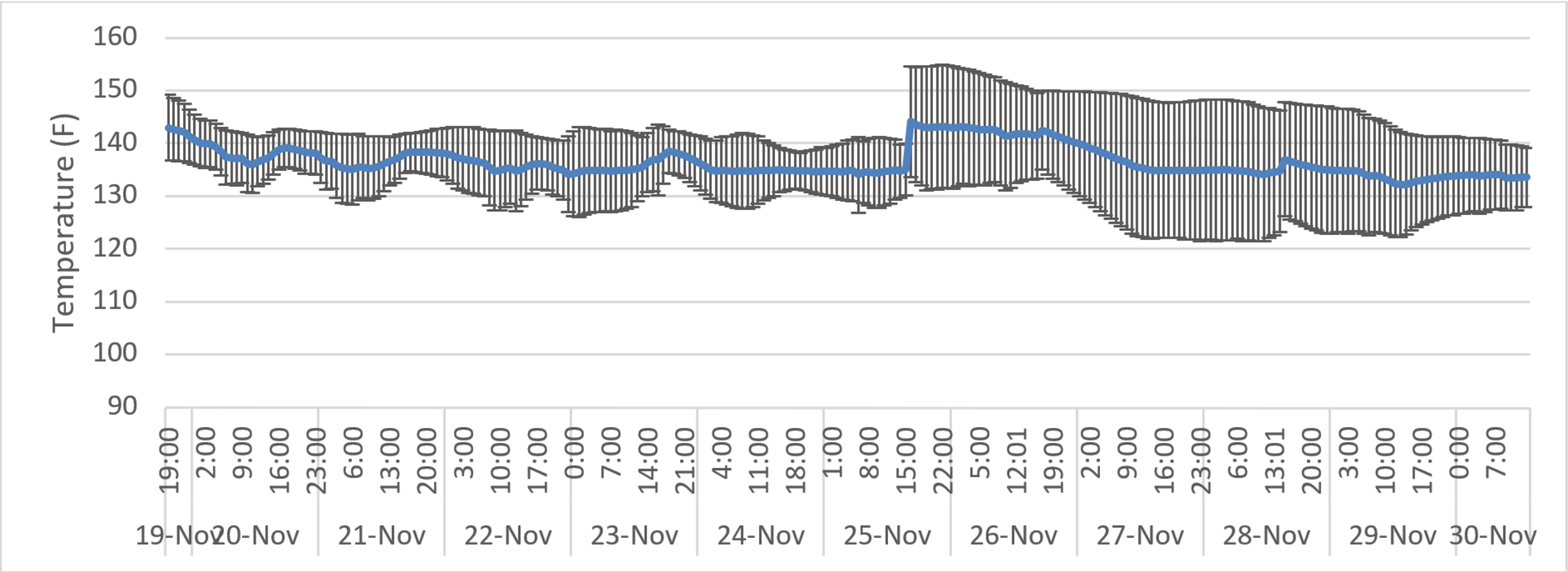

Figure 7 Temperature Profile for 20% food waste and City green waste feedstocks with negative aeration ASP. Standard deviation bars show the temperature differential of the probes at various depths in the pile

Front Panel Removed after 14 days

Top 4’ of Test Reactor

20% foodwaste 10% foodwaste

Bottom 4’ of Test Reactor

20% foodwaste 10% foodwaste

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Solivita Test After 28 Days

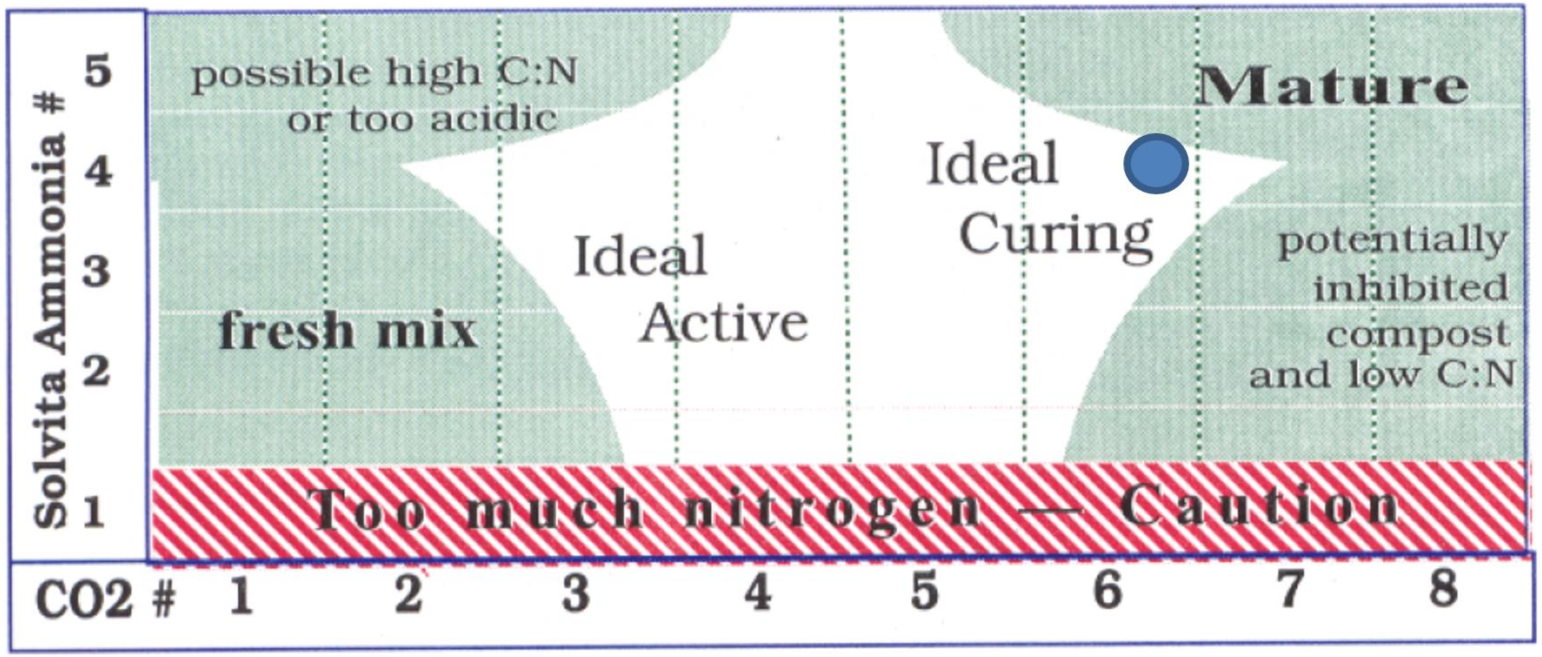

Figure 9 Solvita results for 10%/20% FW on negative aeration for 14-days (blue dot) on Solvita maturity graph

Moisture Loss Over First 14 Days

Table 4 Moisture in 10% and 20% FW mix

DAY	10% FOOD	20% FOOD
1	59%	57%
4	59%	47%
6	50%	49%
9	49%	**41%**
12	**44%**	**37%**
14	**38%**	**36%**

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Conclusions for Trial One

- Moisture loss was fairly similar @1.5% loss per day over 14 days for both mixes
- Higher Aeration Demand with 20% food waste
- 2.6 cfm for negative aeration was insufficient for cooling 20% mix from days 1-4
- Settling was higher with more food waste
- Still some short circuiting issues with the left reactor

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3.2

Trial Two 20% & 33% Food Waste by Weight

- Test performed from Dec 1-Jan 4
- Attempt to simulate TAP conditions
- Reversing aeration used for both reactors
- Air direction reversed every 2-3 days
- Compost remixed and wetted every week
- 33% food waste by weight in right reactor
- 20% food waste by weight in left reactor

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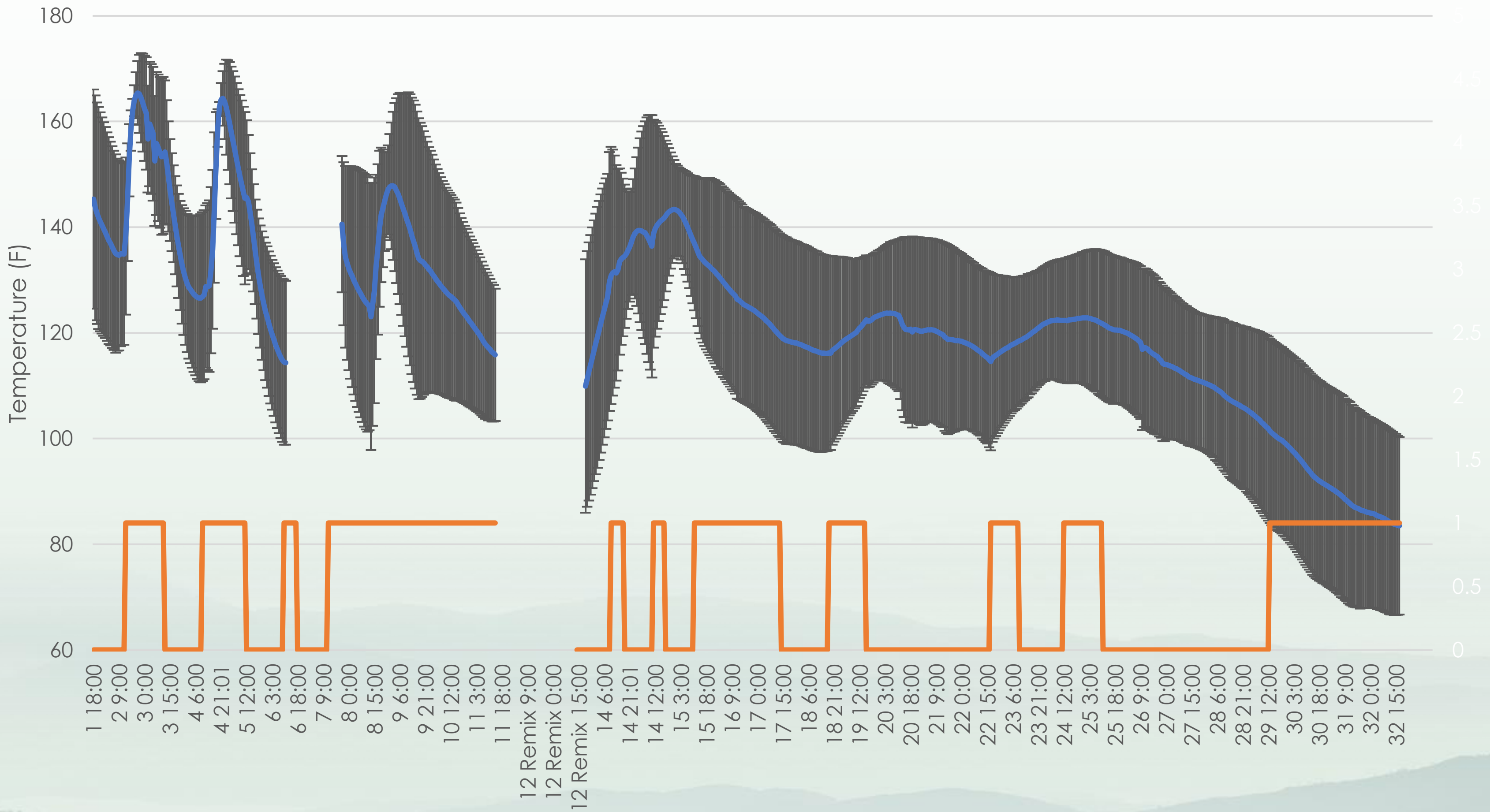
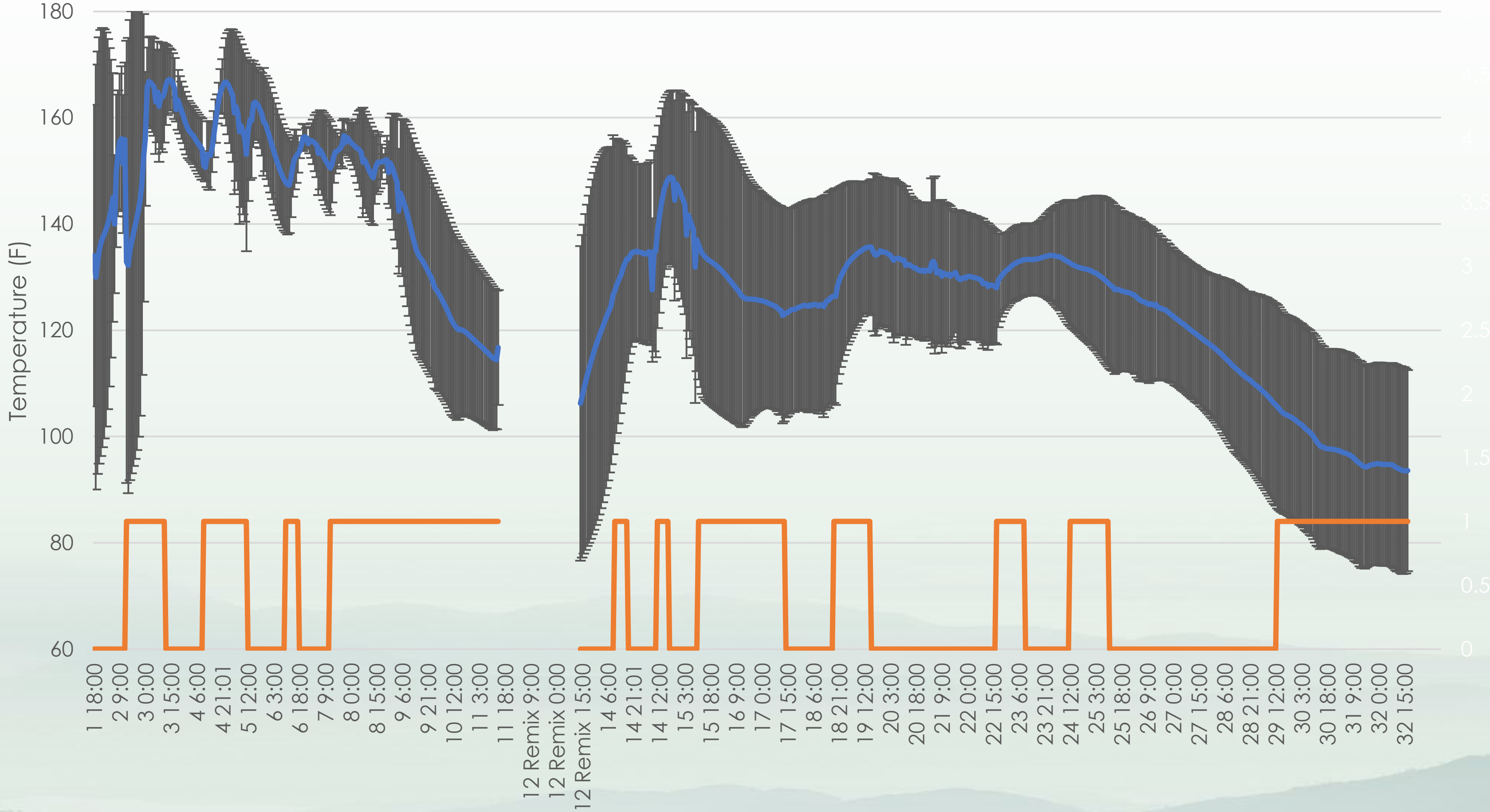
3.2

Time/temp graph for 20% food waste



3.2

Time/temp graph for 33% foodwaste



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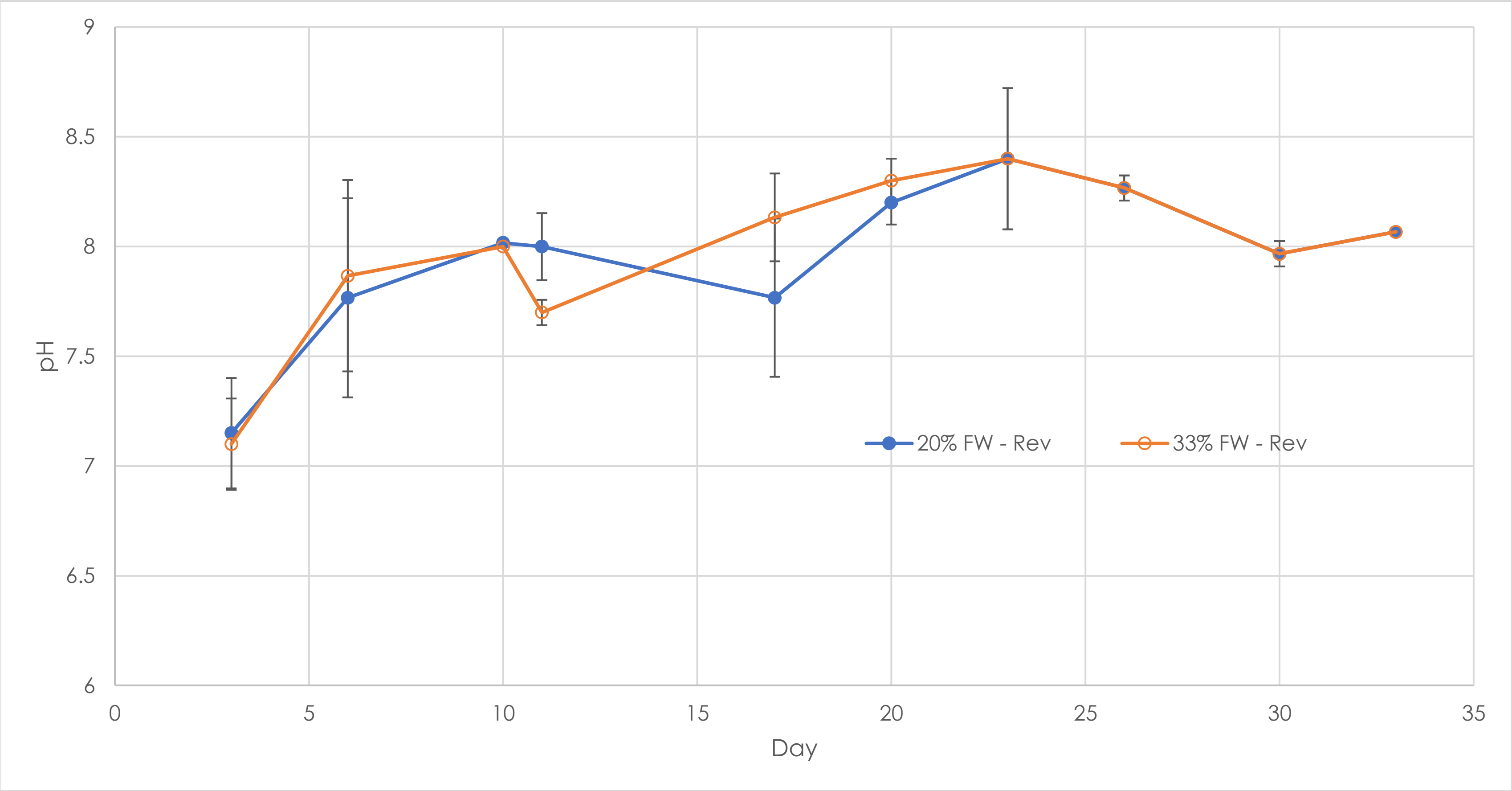
3.2

pH Profile for 20-33% FW



3.2

Solivta Test After 33 Days

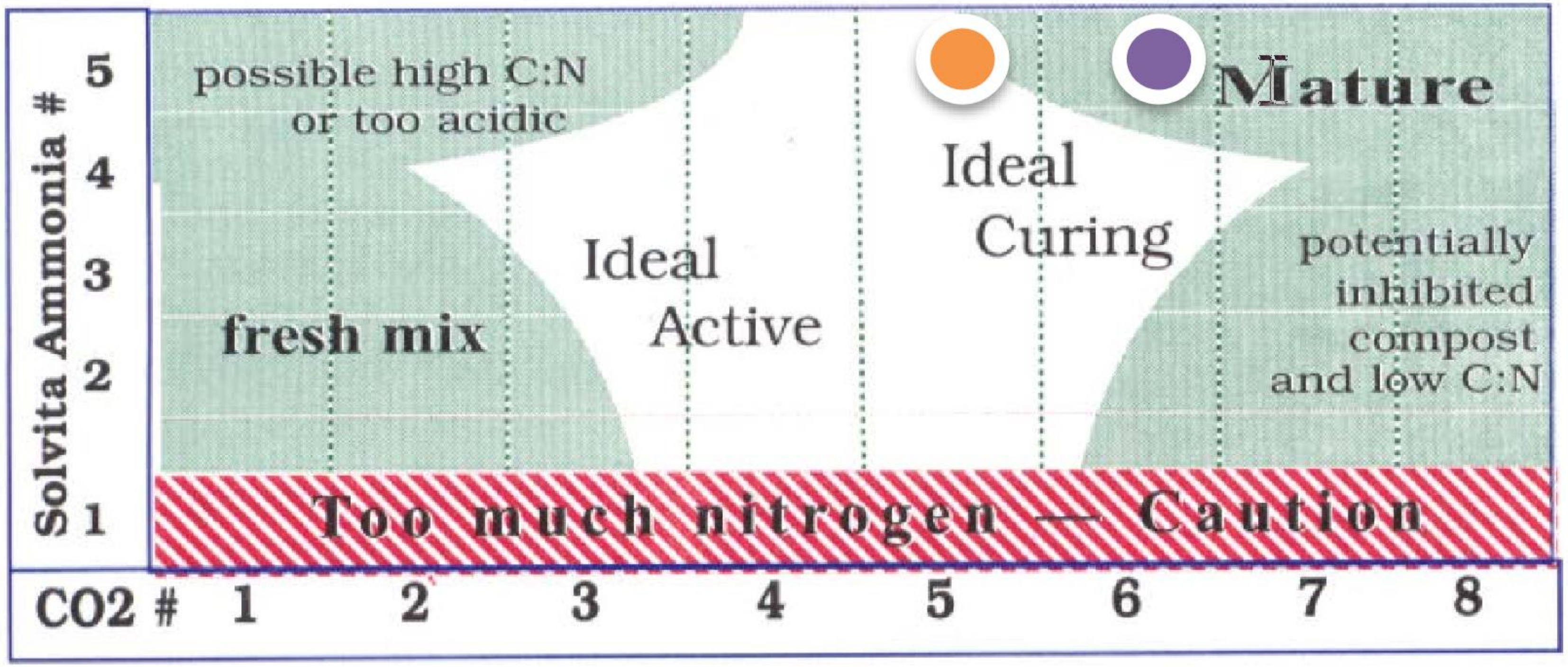


Figure 12 Solvita results for reversing system after 33-days. 33% FW is orange and 20% FW is purple.

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Moisture Loss for Trial 3

TABLE 4. MOISTURE CONTENT FOR 33-DAY TAP REVERSING AERATION TRIAL

DAY	**20% Food**	**33% Food**
INITIAL WET/MIX 1	57%	59%
3	48%	51%
6	49%	47%
10	42%	38%
REWET/MIX 11	61%	57%
17	54%	51%
20	47%	52%
23	52%	52%
26	49%	49%

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3.2

Pilot Project Conclusions

- Phoenix green waste will only hold 50-52% moisture so food waste is a good method to add more moisture to the mix
- Optimal food waste ratio was 20% by weight for the objectives of the City of Phoenix
- Higher food waste content took longer to cure and had higher odor potential and leachate generation
- Moisture losses were 1.5-2% per day @ 70F average ambient temperatures
- Aeration Rate of 4-5 cfm/yd required to control temps at 20-33% food waste mix
- Acidification from food waste organic acids does not appear to be an issue with Phoenix feedstocks

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3.3

Managing FW Receiving - Jeff Gage

- Source reduction
- Acceptance policy
- Floor Monitoring
- Pre-screening
- Shredding, turning, moisture control
- Sort lines
- Design for wind directions
- Overs Reuse

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Handling Food Waste After Sorting

- Add 10-20% recycled compost, sawdust or other dry fines by weight
- Mix well and add more dry materials like shredded mulch or green waste to get initial moisture to <65% and free air space above 50%
- Consider high-carbon wood ash admixtures or Lime for pH adjustment
- Place the mixed materials on an aeration system
- This can all be done while on conveyors using hoppers and conveyor metering systems. Mulch goes first on the belt, then food mix then to a pug mill then discharged with radial stacking conveyor to be placed on an aeration system.

Source https://www.mclanahan.com/solutions/mixing-blending

3.3

Manage Feedstock Receiving

- Control your receiving hours. Don't accept materials 10 minutes before your staff go home for the day.
- Process it quickly! Don't let raw feedstocks sit around.
- Have contingency plans in place for equipment breakdowns, foul weather, etc.
- Unload wet feedstocks directly onto a bed of bulking agents.
- In an ideal situation, feedstocks that decompose rapidly should be receiving inside an enclosed facility with odor control.
- In an outdoor operation, cover incoming feedstocks with compost or bulking agent as soon as possible.

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3.3 Being Ready For Food Loads

- Design floor space for peak delivery times retention of 10 to 15 minutes to pull large contaminants
- Pull as much garbage as possible before processing.
- Mix to a recipe with bulking and amendments as soon as sorted,
- Cover piles to exclude vectors and adsorb odors.
- Use forced aeration to keep piles below 104 degrees F and over 13% oxygen.
- Keep at least one slot available for filling

Source https://www.biocycle.net/facility-design-food-waste-preprocessing/

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3.3 Wet Feedstock Strategy

- Absorption bed – Dry fines with high available carbon content, enough volume to get below 70% moisture when mixed.
- Add basic pH amendments if acidic. Lime, ash or recycled compost
- Add structural bulking materials to support design pile depth
- Unloading area slope 2% to drain, debris screens in or around the drains.
- Rubber cutting edges on loaders squeegee liquids back to the pile
- Blend as soon as possible with mixer, windrow turner or loader

Source https://www.waste360.com/food-waste/eref-study-digs-risks-food-waste
WSU https://tfrec.cahnrs.wsu.edu/organicag/compost-2/compost-images/other-management-aspects/

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3.3 Tankers and Sludge trucks

- Tankers without pumps
  - Receiving/mixing pit below grade to discharge
  - Pre-load pit with amendment
  - Mixing in the pit, loaders slip a lot, better to automate
- Tankers with Pumps
  - V slot in top of mixing windrow, boom arm on tanker to reach V
  - Tanker can be attached to windrow turner irrigation and following during mixing
  - Pump directly into receiving tank for mixing later agitation, pumping or gravity flow needed to mix pit.

The Walking Floor system at the Agawam ORF maintains a consistent flow of material into the twin-screw hopper of the Turbo Separator. Photos courtesy of Vanguard Renewables

Illustration of a truck on grade unloading onto the Walking Floor bin that is below grade. Rendering courtesy of KEITH Manufacturing

Source https://www.biocycle.net/food-waste-facility-opens-in-massachusetts/

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3.3

Clean Surfaces Daily to Reduce Odors and Available Food for Rodents

- Scrape the floor with a rubber edged loader hourly during operation
- Construction broom sweeping daily to move embedded materials back into the compost piles.
- Weekly incorporate the cool pile edges into the pile (flies)
- Hose down all surfaces and processing equipment daily
- Pressure wash areas with significant build up of dried slime
- Clean all drains of trapped solids and flush drain lines.
- Check for exposed food and cover with amendment to reduce dinner for evening scavenging rats

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3.3

Personal Protective Equipment and Amenities

- Personal Protective Equipment (PPE) needed for FW handling
  - non-slip muck boots,
  - Dust masks,
  - Face shields,
  - Gloves, grabbers
  - Coveralls,
- Facilities for workers
  - Handwashing with soap and hot water
  - Eye wash stations
  - Shower/locker rooms
  - Laundry equipment or services are recommended.

Source https://www.mcrsafety.com/blog/waste-management

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3.3

On-time Odor Control

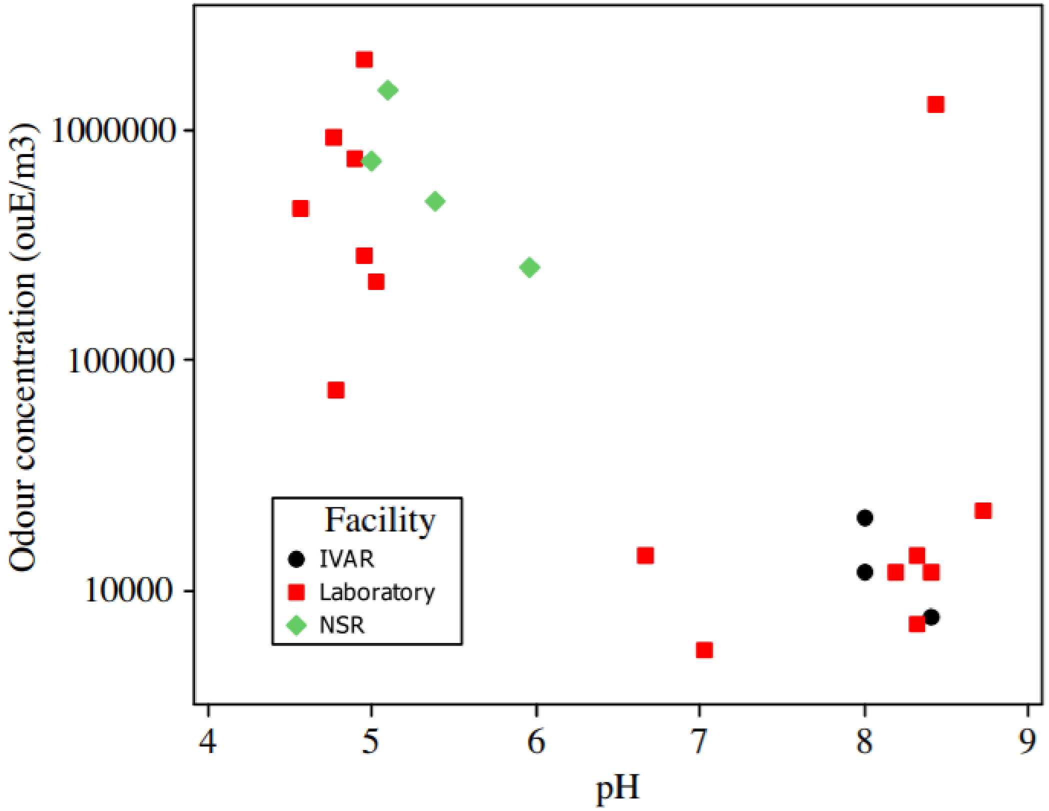

Fig. 1. Odour concentration as a function of pH at IVAR, NSR and in the laboratory reactor, with group A samples clustering in the lower right and group B samples in the upper left.

- Get the received materials under control as soon as possible,
- Goal to complete all preparation and mixing before next load arrives.
- No stockpiling of unmixed putrescible wastes.
  - Discuss Canadian FW company experience

"An important strategy for reducing odour from food waste composting is to rapidly overcome the initial low-pH phase. This can be obtained by a combination of high aeration rates that provide oxygen and cooling, and additives such as recycled compost." Sundberg, 2013

Source
https://reader.elsevier.com/reader/sd/pii/S0956053X12004564?token=88FA986A890ACC43CA32740B3DBE9E61F53793347EF1262F6714BD346D7BAE832FD4A946798F555EAD9289D48CA81073&originRegion=us-east-1&originCreation=20220124000906

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3.3

HAVE CONTINGENCY PLANS READY

- Be ready to adapt your schedule to changing weather conditions.
- Use biocovers or surface enzymes as a temporary solution.
  - 6 inches of unscreened finished compost
  - 8 to 12 inches of wood chips or screening overs.
- Masking agents can hide odors temporarily (but don't become "chemically dependent").
- Remove the offending material(s) from the site.
- Stop accepting problem feedstocks.

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3.4

Contamination Removal Front End

- Public Education on “wishful recycling” and Non-compostables
  - Graphic and multi-lingual bin labels, RAA consistency message on bin colors and acceptance practices
  - Billing inserts, collection calendars, magnets, ReCollect apps
  - Enforcement - picture geo tagging of dirty loads in pay as you throw with bin RFID, or simple bin inspection tags
  - Primary classrooms - focus on what, why and where Food Waste processing is done in their community.
- Commercial Education
  - Graphic and bin wording support with hauler or utility
  - Contamination surcharges? Diversion of non-compliant loads. Tablet for photos/communication at unloading point
  - Hauler feedstock quality reports

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3.4 Acceptance policy, Biodegradables and Compost Manufacturing Alliance

- Clear messaging about what is allowed – Be SURE you want it!
- Run test batches with odor and product quality evaluations
- Compostable Products are not all created the same or work in all systems, it is TOUGH to identify the differences!
- CompostManufacturingAlliance.com provides support and testing and lists of products you may want to allow by processor type.
- Cedar Grove list https://cedar-grove.com/compostable/residentially-accepted-items

Source Biocycle https://www.biocycle.net/compostable-plastics-discourse/ and Cedar Grove

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3.4

Floor Monitoring and load rejection, floor sort large items and glass.

The number of workers on the sort line varies from two to six, depending on the origin of the loads, e.g., multifamily routes versus routes in single-family households. Workers at the picking station achieve about 70 to 80 percent contaminant removal. Pre-shred?

Source : https://www.biocycle.net/composter-brings-on-residential-food-scraps-stream/

3.4

Pre-screen using trommels and disc screens to segregate for sort lines, de-packagers for gunk

- 3" round or square openings on a trommel, 8-foot diameter minimum, flights and screen cleaning needed
- 3" openings metal disc screener angled upwards with second deck to flip and spread with faster rotation
- De-packagers for Grocery - Packing house wastes – Expired products https://www.youtube.com/watch?v=bRR_ezDNyKM https://www.youtube.com/watch?v=52AmYd1qxXM

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Contaminant Removal Back End - Plastic Management

Plastic presorting

- Expensive
- Time consuming
- Not effective

Plastic post process sorting

- Particle size
- Capacity
- Moisture
- Technology available

3.5

Keep the plastic big!

- Never mill plastic
- Use low rotor rpm

Prepare for perfect screening moisture

- Dry material ~ 35 – 40 % H_2O
- Protect if required
  - Fleece (2 – 3 USD / m^2)
  - Membrane (35 – 100 USD / m^2)
  - Roof (100 – 200 USE / m^2)

3.5

Combined screen and windsifter (to remove film plastic)

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3.5

Stand alone windsifter (to remove film plastic)

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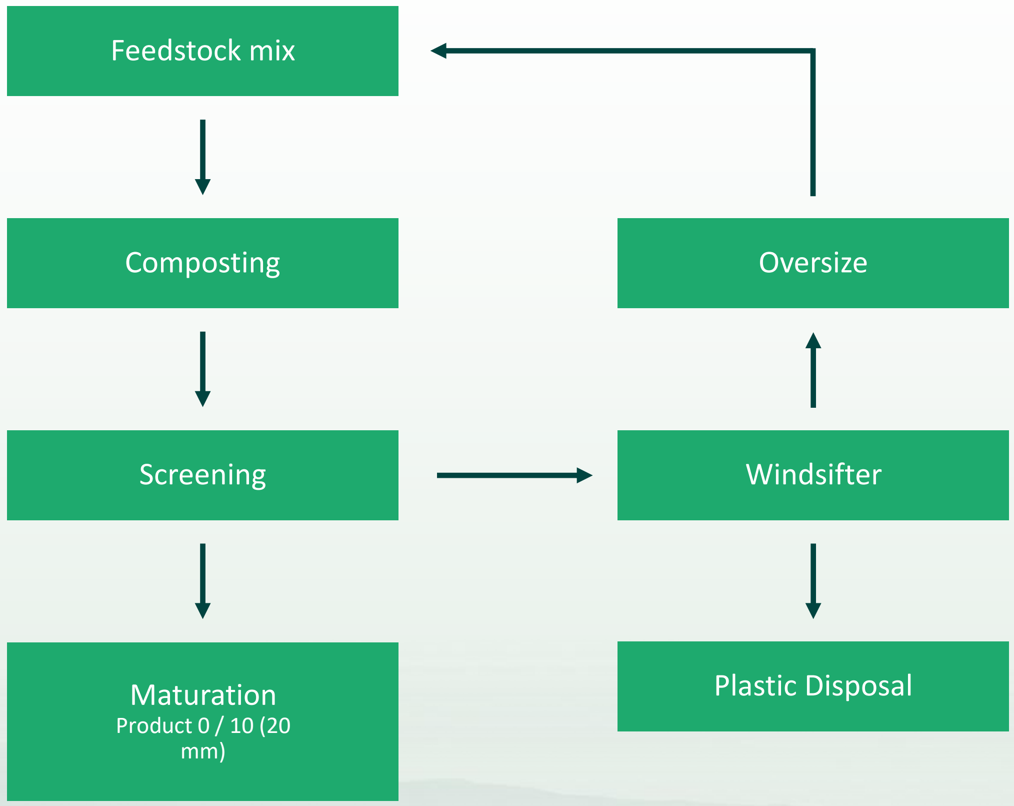
3.5

Plastic removal

- Bill in the work required!
- DO NOT MILL PLASTIC!
- Air separation requires:
  - Constant material flow
  - Water content of 35 – 40 %
  - Slow process
- Watch accumulation (bottletops)
- Watch flying plastic
- (Ingoing feedstock almost impossible to sort)



Screen Size -

Susan Thoman, director of business development at Cedar Grove Composting, shows off the company's finished product. Photo by JOHN LOK / THE SEATTLE TIMES

- To keep your fines free of contamination, Make opening sizes smaller and be precise with feed-rate/moisture content
- Remove fines with a ¼" to 5/16" screen opening – send test samples to screen manufacturer or use a hand screen of varying sizes at target finished moisture until no visible contaminants
- Mids without fines can be put across air and density classifier
- Overs without mids and fines should go across a separate air and density classifier

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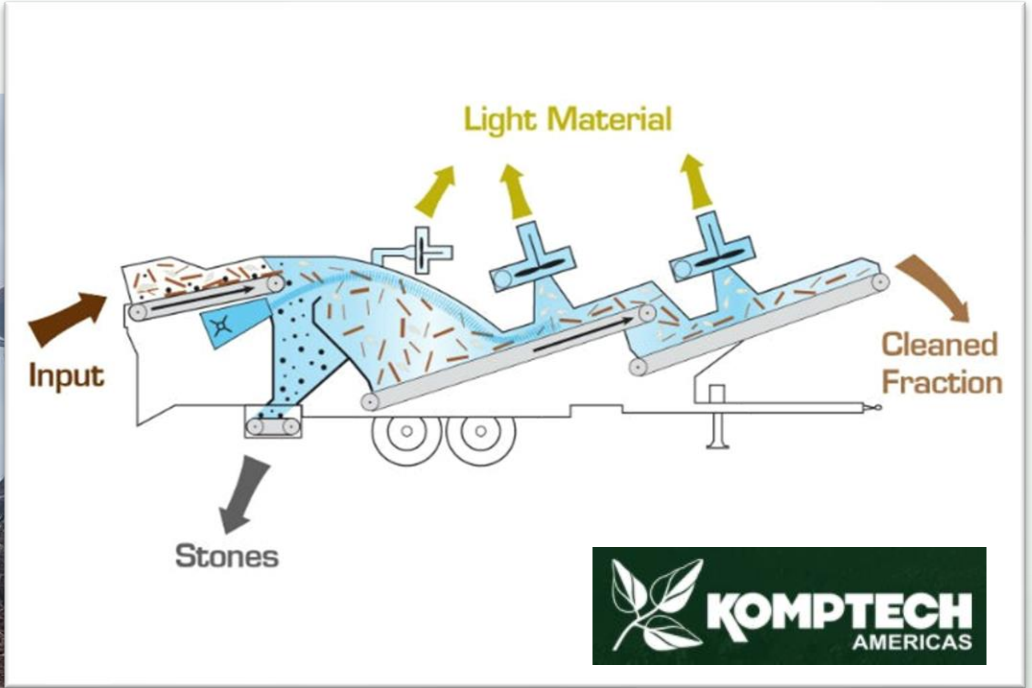
Wind-sifting overs

- Moisture content of screening material should be around 40% to remove plastics and limit loss of fines to wind-sifter suction devices
- Feed rate must be very consistent with even filling of belt to an even depth to dial in the air knife air speed and suction devices for consistent density separation



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All incoming food scraps and yard trimmings are processed in a Komptech Crambo 5000 with 8-inch and 12-inch screens, and a magnet. Photos courtesy of the SMSC Organics Recycling Facility.

Vermeer horizontal grinder at Living Earth

3.5 Shredding, turning, moisture control at process end to reduce plastic contamination

- Shredding or Grinding? Speed and Grate size matters to contaminant removal. The largest particle size possible to keep plastics intact. 6" to 8" is typical.
- Turner tip speeds should be as low as possible, fixed knife/paddles work best to lift and throw to keep glass and plastics from being pulverized.
- Consider Aerated Static Pile for 2 weeks to dry and sanitize initially » then screening to remove contaminants » then windrowing to re-water and turn
- Target 40% to 42% moisture when screening to get good separation with less product loss

https://www.biocycle.net/art-and-science-of-contaminant-management/ Source

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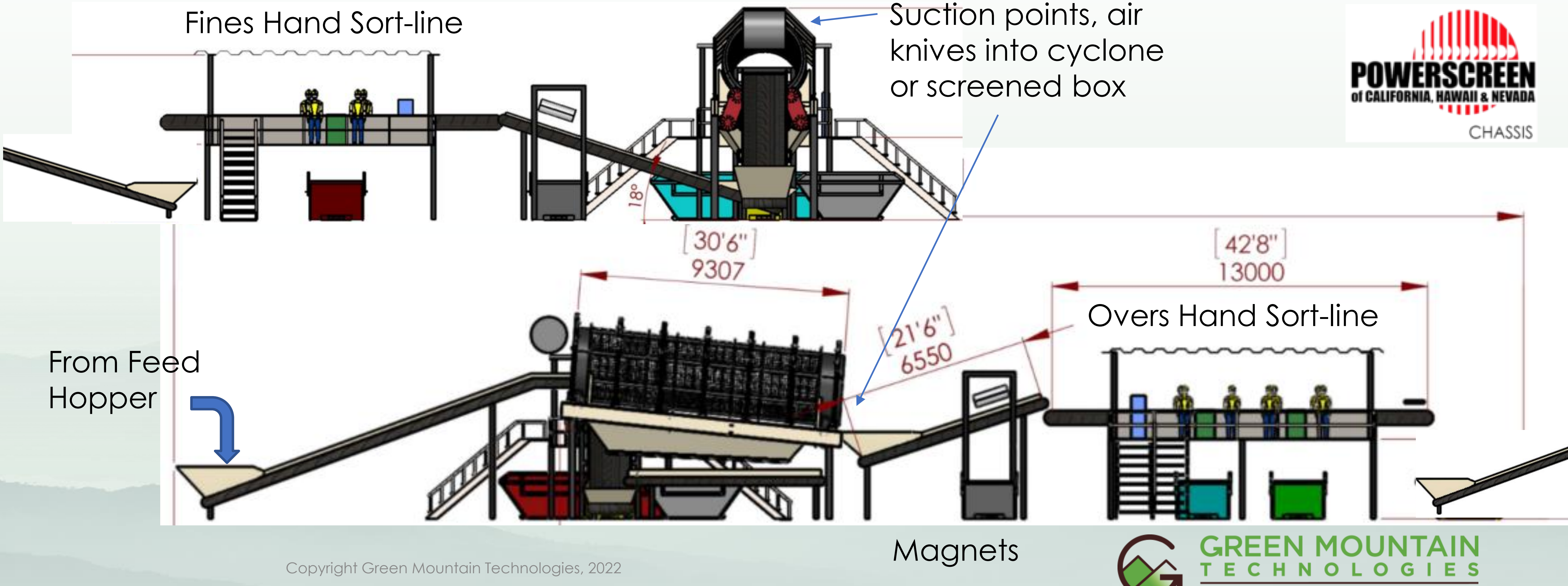
3.5

Hand sort lines, air knives, suction points, dust cyclones, magnets



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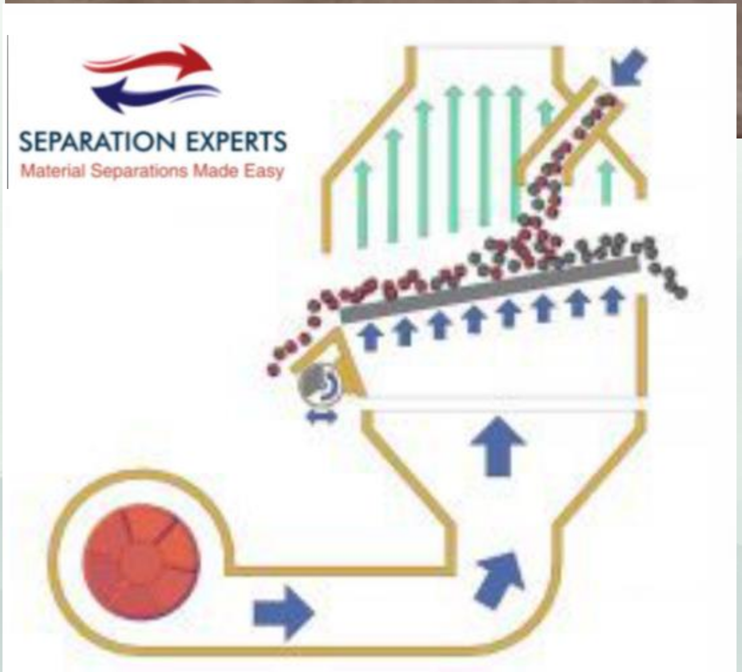
3.5

Finished product size separation/wind sifting and density separation



- Air separation pulls light plastics using a variable speed suction blower and a variable speed air knife to loft plastic film off a moving mesh belt or drop point.
- Density separation can either be a grain destoner for fines, or a flinger for mulch or overs.
- Fine screen openings around 5/16" to 3/8" produces very good quality compost, if glass is a problem density separation is needed.
- Second screen size up to 7/8" for mulch with air separation and density separation
- Overs will need air separation, metal separation, and density separation and finally hand picking

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3.5

Design for wind directions, windrow riffles, driving range screens, enclosure

- Plastics are recycled forever without an efficient capture and disposal method
  - Ambient winds are a giant wind-sifter with no recovery system!
  - Windrows laid 90 degrees to wind direction collect significant amounts of blowing plastic
  - Portable screens downwind of grinding, turning, screening, enclose on 3 sides.
  - Sweeper with vacuum run daily along vertical screens and between windrows
  - Use a backpack vacuum to pull plastic off of the screens
- Consider buildings for sorting and screening with good dust collection and high air exchange rates.

Overs Disposal or Reuse

- A mountain of contaminated overs costs money by sitting there. (Visual pollution, space and fires, etc.)
- Excellent machines exist to remove contaminants from overs. You will have to invest in them or hire them to run your overs through. Processing costs may be as high as your own tipping fees on a per ton basis.
- If you cannot clean them, then contaminated overs must be disposed of properly. This can be 10% to 15% of your total tonnage per year.
- Discounted rates may apply as it can be used for temporary roads and daily cover at a landfill.
- Reusing contaminated overs in the composting process is not recommended.

Photo Source SF Chronicle

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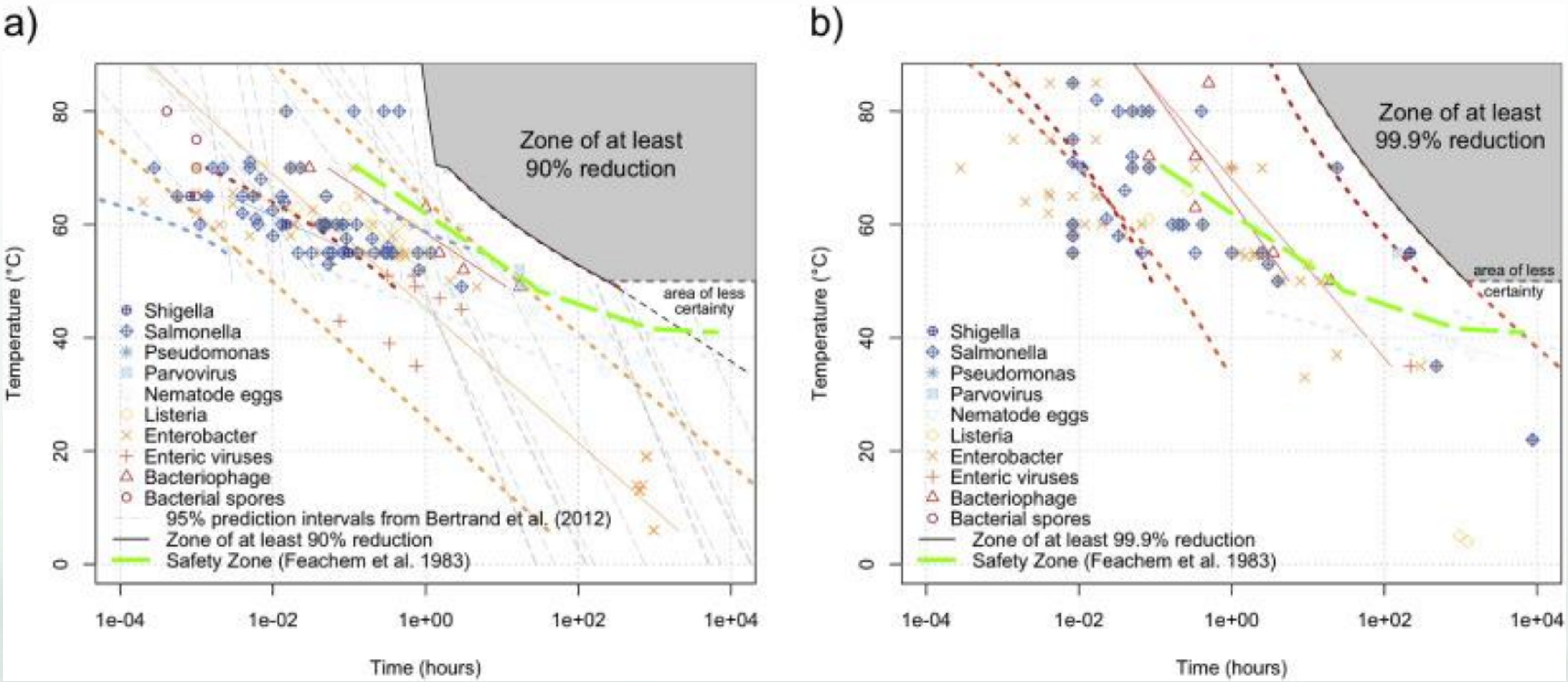
Pathogen Reduction & Temperature Monitoring

- Why monitor temperature?
  - Proof you achieved PFRP (Process to Further Reduce Pathogens)
- EPA 503 regulations developed for Biosolids are typically applied as the standard for FW
  - All facilities are required to log 1 reading per 200 cubic yards of material per day
  - 3 **consecutive** days at or above 131°F/55 °C
  - No leachate can be applied during or after the 3 consecutive days logged

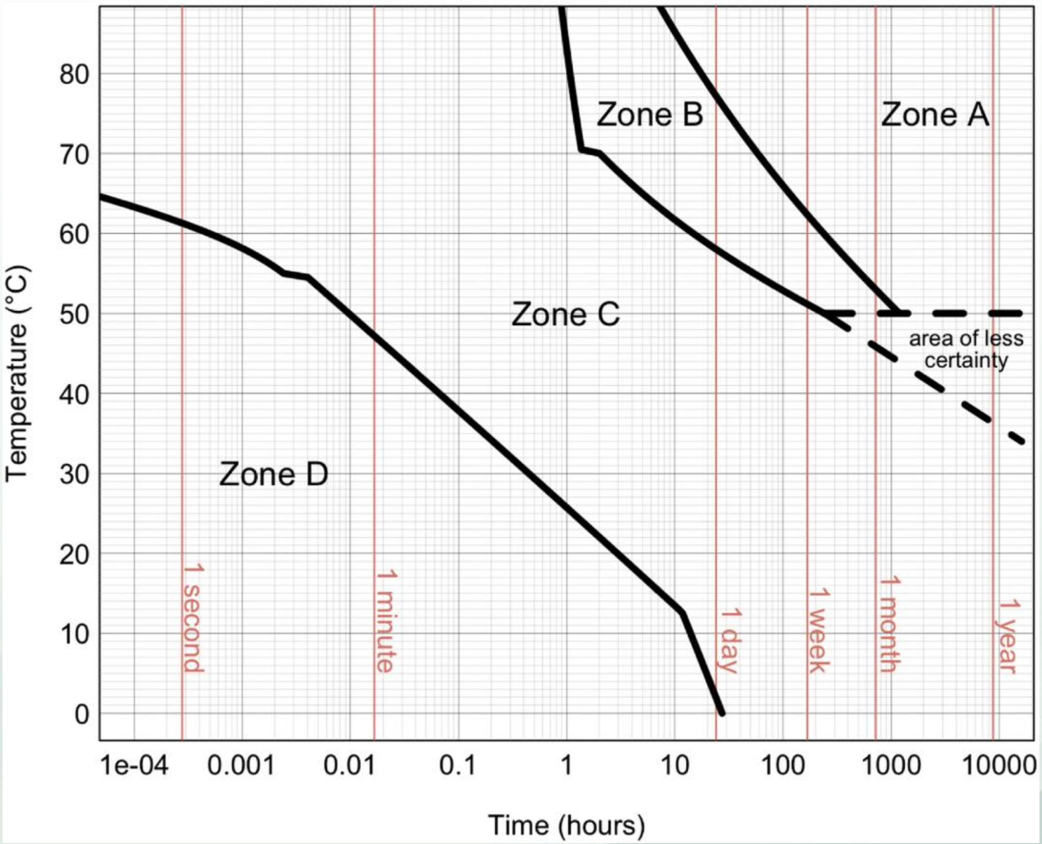
Pathogen Reduction vs Sterilization



* Espinosa et al. Systematic review and meta-analysis of time-temperature pathogen inactivation International Journal of Hygiene and Health

What is PFRP Achieving?

- Zone A is 99% reduction
- Zone B is 95% reduction
- Zone C up to 90% reduction
- EPA 503 standard of 55C for 3 days is Zone C



Temperature vs Biological Activity

- Ideal temperature is 40-50C in the first 9 days and 35-40 C after 9 days for maximum biological activity
- The number of thermophilic species drops off quickly above 135F
- Vapor pressure goes up with temperature and so do odor emissions
- Oxygen saturation goes down with higher temperatures

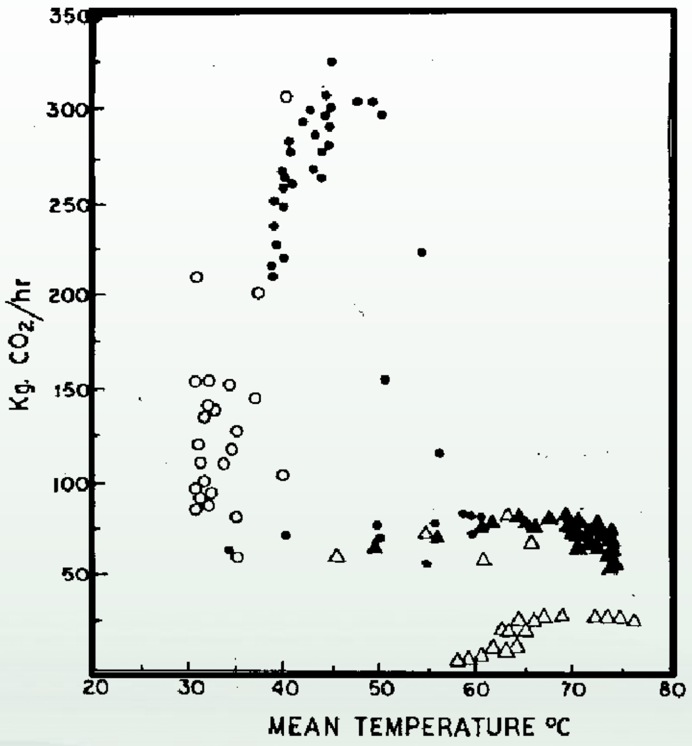


Figure 5—Relationship between CO_2 evolution and mean compost temperature. Readings taken every 4 hrs from cool section before turning, Days 1–9 (●); after turning, Days 9–15 (○); and from hot section before turning (▲); and after turning (△).

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Oxygen Saturation vs Temperature

Figure 1. Saturation O_2 concentrations in water mg/l (ppm)

O_2 partial pressures (%) vs. temperature (C)

O2	20ºC	25ºC	30ºC	35ºC	40ºC	45ºC	50ºC	55ºC	60ºC	65ºC	70ºC	75ºC	80ºC
20%	9.17	8.32	7.57	6.91	6.33	5.81	5.35	4.94	4.57	4.24	3.94	3.67	3.42
19%	8.71	7.90	7.19	6.57	6.01	5.52	5.08	4.69	4.34	4.02	3.74	3.48	3.25
18%	8.25	7.49	6.82	6.22	5.70	5.23	4.82	4.44	4.11	3.81	3.54	3.30	3.08
17%	7.80	7.07	6.44	5.88	5.38	4.94	4.55	4.20	3.88	3.60	3.35	3.12	2.91
16%	7.34	6.66	6.06	5.53	5.06	4.65	4.28	3.95	3.65	3.39	3.15	2.93	2.74
15%	6.88	6.24	5.68	5.18	4.75	4.36	4.01	3.70	3.43	3.18	2.95	2.75	2.57
14%	6.42	5.82	5.30	4.84	4.43	4.07	3.75	3.46	3.20	2.96	2.76	2.57	2.39
13%	5.96	5.41	4.92	4.49	4.11	3.78	3.48	3.21	2.97	2.75	2.56	2.38	2.22
12%	5.50	4.99	4.54	4.15	3.80	3.49	3.21	2.96	2.74	2.54	2.36	2.20	2.05
11%	5.04	4.58	4.16	3.80	3.48	3.20	2.94	2.72	2.51	2.33	2.16	2.02	1.88
10%	4.59	4.16	3.79	3.46	3.16	2.91	2.68	2.47	2.28	2.12	1.97	1.83	1.71
9%	4.13	3.74	3.41	3.11	2.85	2.62	2.41	2.22	2.06	1.91	1.77	1.65	1.54
8%	3.67	3.33	3.03	2.77	2.53	2.32	2.14	1.98	1.83	1.69	1.57	1.47	1.37
7%	3.21	2.91	2.65	2.42	2.22	2.03	1.87	1.73	1.60	1.48	1.38	1.28	1.20
6%	2.75	2.50	2.27	2.07	1.90	1.74	1.61	1.48	1.37	1.27	1.18	1.10	1.03
5%	2.29	2.08	1.89	1.73	1.58	1.45	1.34	1.23	1.14	1.06	0.98	0.92	0.86
4%	1.83	1.66	1.51	1.38	1.27	1.16	1.07	0.99	0.91	0.85	0.79	0.73	0.68
3%	1.38	1.25	1.14	1.04	0.95	0.87	0.80	0.74	0.69	0.64	0.59	0.55	0.51
2%	0.92	0.83	0.76	0.69	0.63	0.58	0.54	0.49	0.46	0.42	0.39	0.37	0.34
1%	0.46	0.42	0.38	0.35	0.32	0.29	0.27	0.25	0.23	0.21	0.20	0.18	0.17
0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	(options)
kH for O2 in H2O	0.0012
0.0013	0.0013
(l atm / mole)	
	(options)
van't Hoff constant	1500
1700	1700
(ºK)	1800

- 6 ppm and above
- 5 to 5.99 ppm
- 4 to 4.99 ppm
- 3 to 3.99 ppm
- 2 to 2.99 ppm
- 1 to 1.99 ppm
- 0 to 0.99 ppm

Biocycle "How to measure Oxygen in Compost 2013 Crouch et al

Achieving PFRP at Different Facility Types

- Windrow
  - 15 **total** days at or above 131°F/55 °C
  - Does not need to be consecutive
  - Must be turned 5 times
  - No leachate can be applied during or after the 15 days logged
- ASP/TAP (Aerated Static Pile/Turned Aerated Pile)
  - 3 **consecutive** days at or above 131°F/55 °C
  - Pile must be insulated to achieve this (typically achieved with a bio-cover)
  - No leachate can be applied during or after the 3 consecutive days logged
- In-Vessel
  - 3 **consecutive** days at or above 131°F/55 °C
  - Vessel must be insulated
  - No leachate can be applied during the 3 consecutive days 3 consecutive days logged

Manual Data Logging to Meet Regulations

- The simplest method is to monitor temperature daily with a simple probe and a written log
- You must log locational shifting and any time you combine piles
- Can be time consuming for operators

Compost Monitoring Log

Pile Identification:			Pile Location:							Date Pile Built:
Feedstocks and Mix Proportions:										
Date	Pile Temperature					Air Temp	MC	Odor	Visual	Notes (management, weather, vectors):
	1	2	3	4	5					
	1'/3'	1'/3'	1'/3'	1'/3'	1'/3'					

Log originally developed by Highfields Center For Composting

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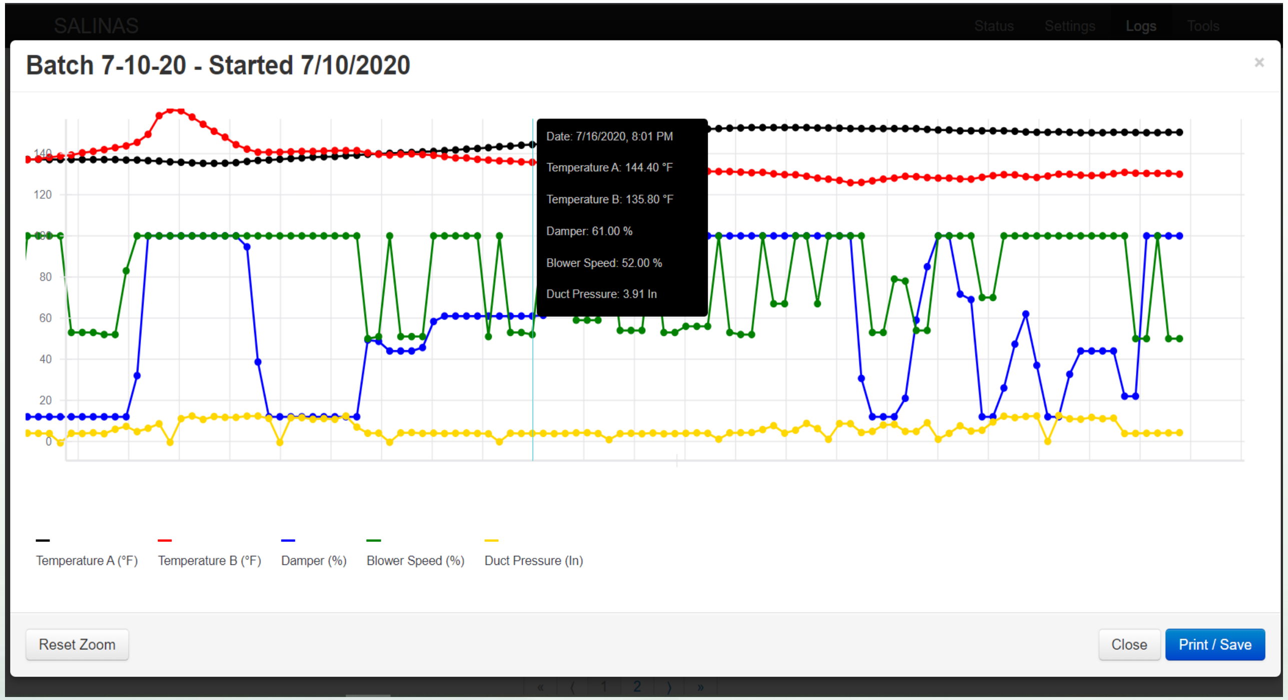
3.6

Automated Data Logging to Meet Regulations

- Digital data loggers are the most efficient for this task
- Automates the logging process so operators can focus on other tasks
- Potentially provide temperature data for a control system to use



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Lunch

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Facility Layout and Process Flow – Jeff Gage

- Layout considerations
  - Pathogens and debris – Track-out, work material upslope, keep debris downwind
  - Handling reduction – multiple functions per touch, short loops, backing with < 90° turns, conveyors
  - Grade breaks and piping to separate reuse from treatment or infiltration
  - Weather protected sort lines, screeners and finished product
- Receiving
  - Enclosure – Wind stops, roli-poli stops, cleanable floors, hydrants and reels top of grade break, misting
  - Handling - First in-first out, post-processing aeration, dewatering and liquid soak pits, bulking/cover storage
  - Speed doors, separate customer type unload areas, provide waste bins
- Composting
  - Airflow in pipes same direction as water flow on surface, cleanouts high and pressure traps low
  - Move up slope, gaps or push walls between stages, grade breaks, radial stacking conveyors, rewatering
- Curing
  - Temperature, moisture and aeration control

4.1

Key facility Design Steps

1. Feedstock Characterization
2. Market Analysis
3. Identify Regulatory Requirements
4. Characterize Site
5. Mass Balance and Sizing
6. Master Plan for Process Flow/Layout
7. Develop Cost/Revenue Model
8. Repeat - Adjust:
   - Location
   - Size
   - Process/Technology
   - Margin of Safety for markets and environmental impacts

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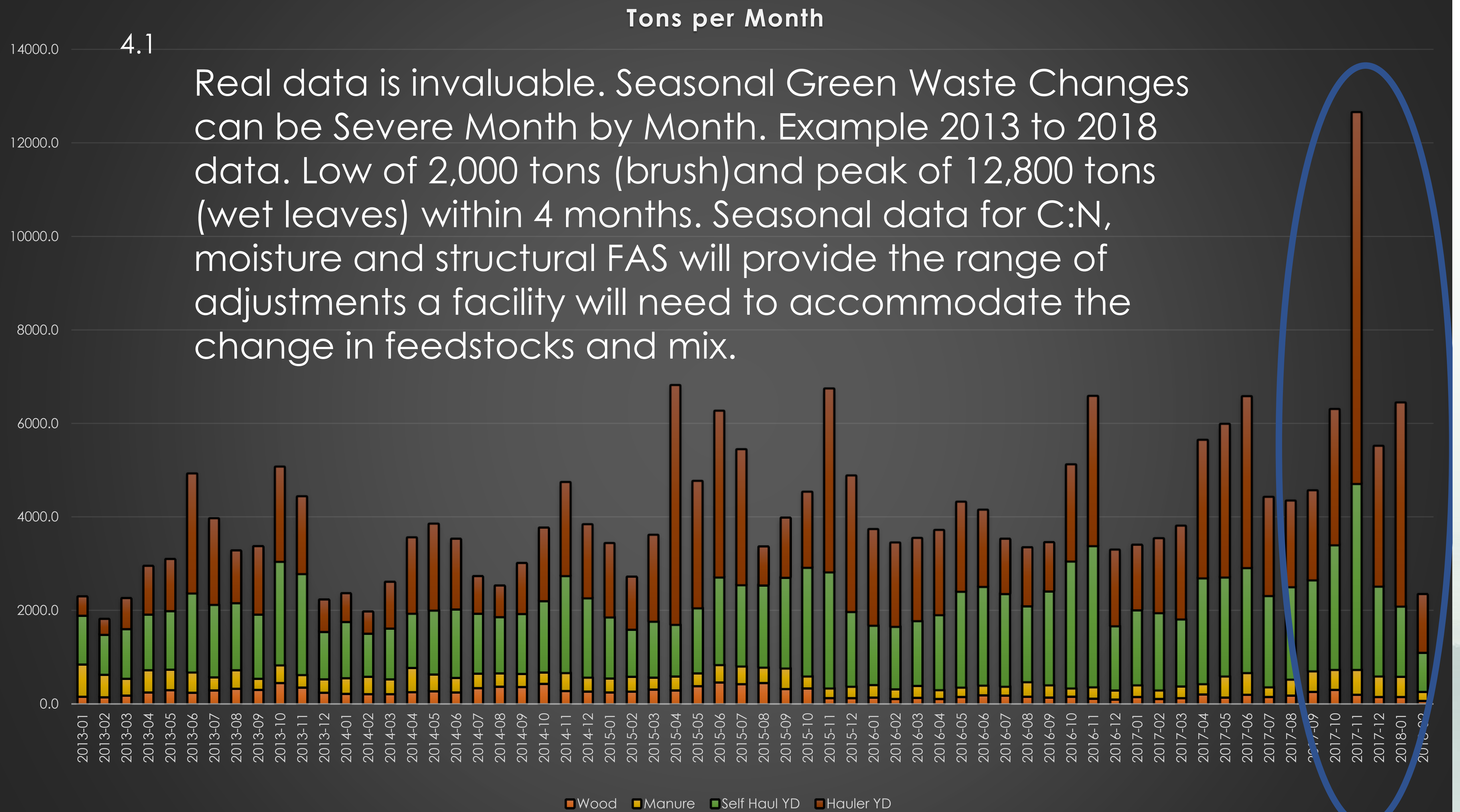
Characterize Feedstocks: Data for Mass Balance

- Monthly tonnage for each feedstock
- Mix analysis and amendments needed per season
- Peak daily tonnage to size equipment and space
- Bulk density, as received, and after processing
- Process volume reduction. (.5% to 1% per day)
- Establish holding times; i.e. Feedstocks 2-4 days, Composting 14 to 28 days Curing 20 to 40 days, Product Storage 30 to 90 days.
- Estimate pile height at each stage to keep aerobic, it depends on FAS, structure, forced air capacity.
- Model each scenario by weight then by volume and map the areas needed at each step

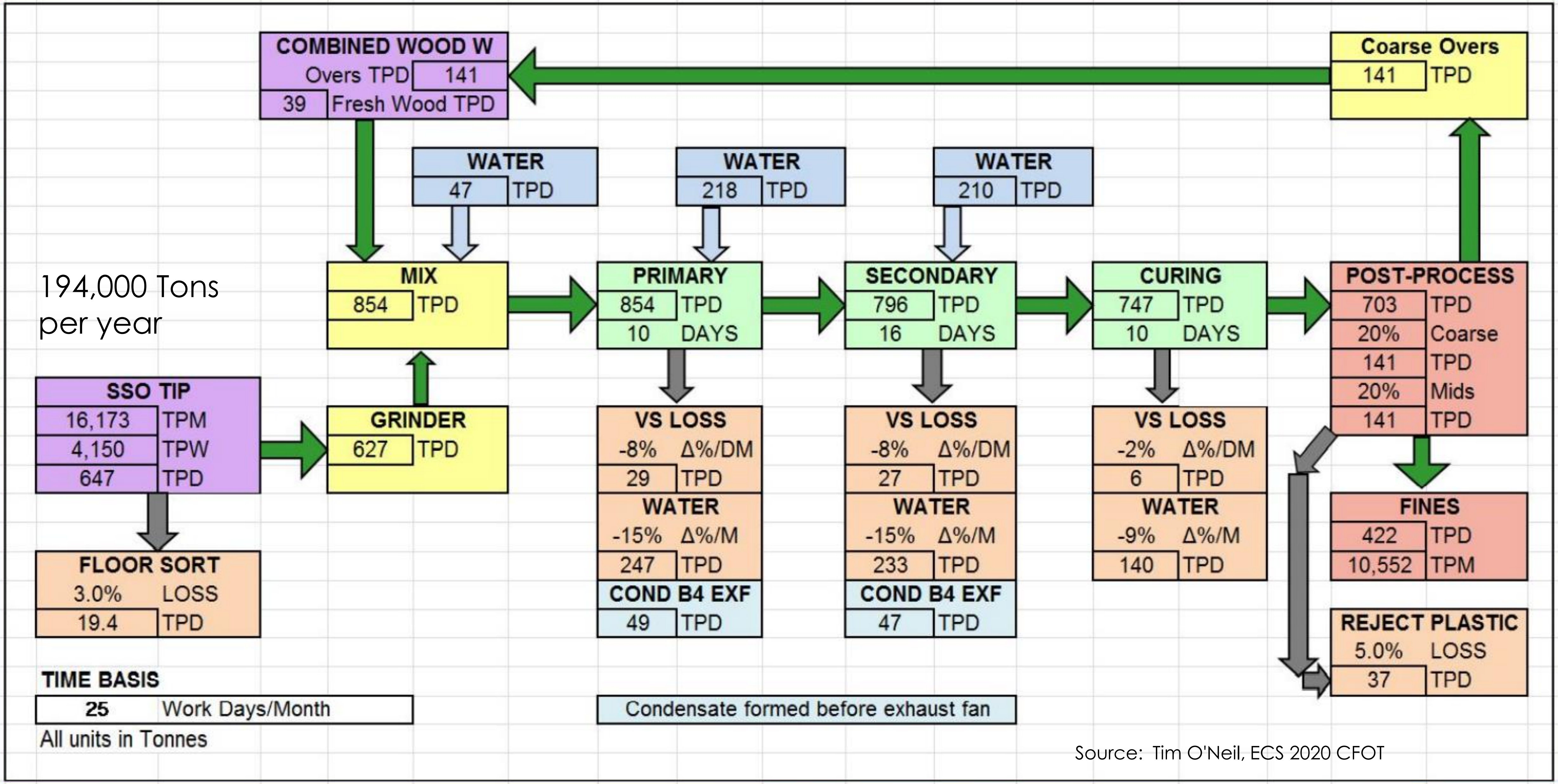
4.1

Real data is invaluable. Seasonal Green Waste Changes can be Severe Month by Month. Example 2013 to 2018 data. Low of 2,000 tons (brush)and peak of 12,800 tons (wet leaves) within 4 months. Seasonal data for C:N, moisture and structural FAS will provide the range of adjustments a facility will need to accommodate the change in feedstocks and mix.



4.1 Mass Balance Tons In = Tons Out +Tons on Site

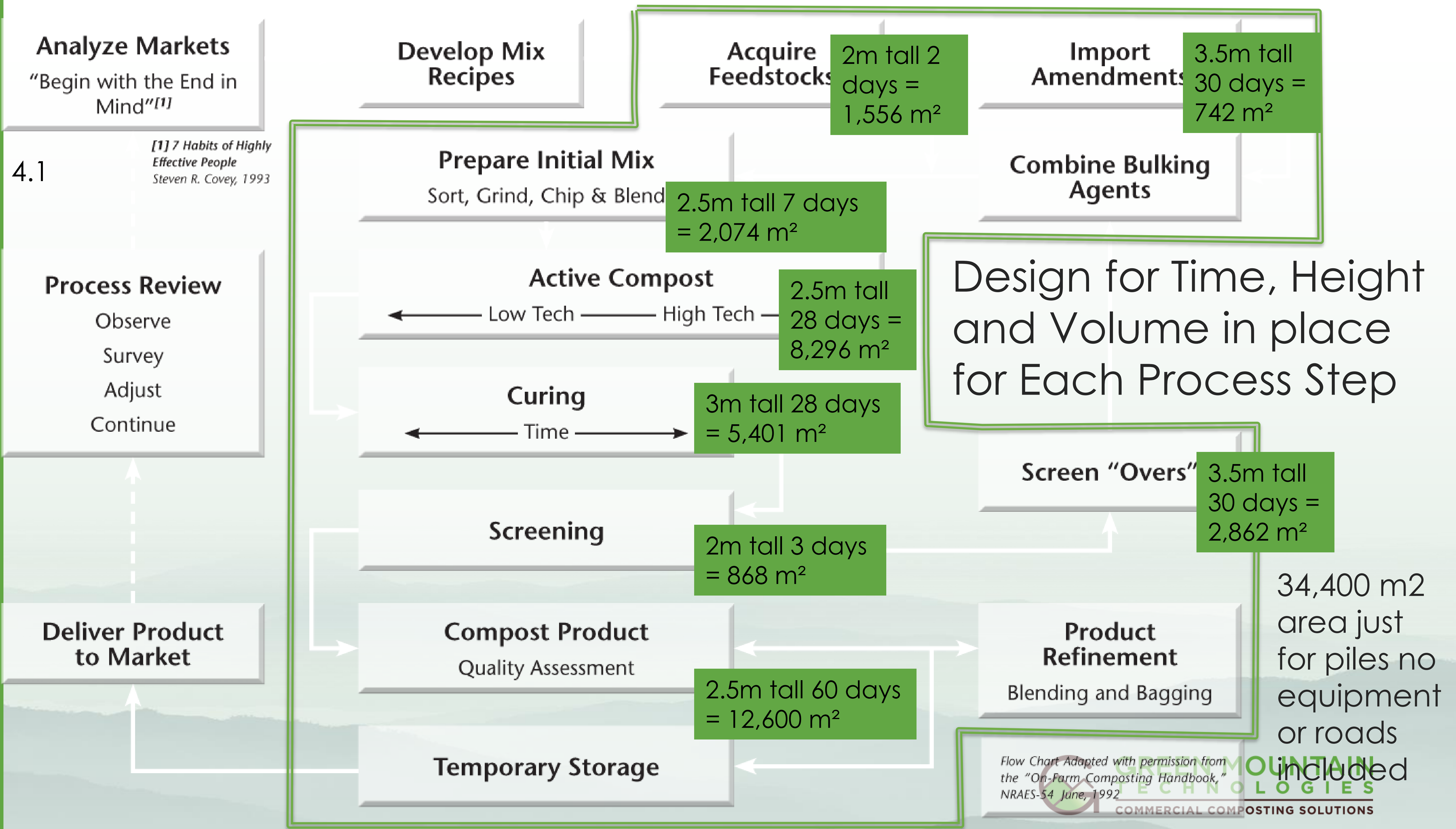
194,000 Tons per year



Source: Tim O'Neil, ECS 2020 CFOT

Design for Time, Height and Volume in place for Each Process Step

34,400 m2 area just for piles no equipment or roads included



4.1 Example: Minimum Areas Estimated for Processing 194,000 TPY

Process	Pile footprint/1,161m2 max per fire code	Fire access 7.5m wide	Equipment area	Total
Unloading/ Feedstock	1,556 m2 = 1 pile	34m x 4 sides x 7.5m = 1,020 m2	4,000 m2 for 10 trucks	6,572 m2
Amendments/ Overs	3,604 m2 = 3 piles	34m x10 sides x 7.5m = 2,550 m2	1200 m2 for loader moves on two sides	7,354 m2
Pre-processing	2,074 m2 = 2 piles	34m x 7 sides x 7.5m = 1,785 m2	1,300 m2 Floor sort, screen, grind, mix	5,159 m2
Composting	8296 m2 = 7 piles	34m x17 sides x 7.5m = 4,335 m2	1,071 m2 loader approach 7 sides	13,702 m2
Curing	5401 m2 = 5 piles	34m x15 sides x 7.5m = 3,825 m2	765 m2 loader approach 5 sides	9,991 m2
Screening	868 m2 = 2 piles	46m x 4 sides x 7.5m = 1,380 m2	4,000 m2 screener and plastic sep.	6,248 m2
Product storage	12,600 m2 = 11 piles	34m x31 sides x 7.5m = 7,905 m2	1,683 m2 loader approach 11 sides	22,188 m2
Totals	**34,400 m2**	**22,800 m2**	**14,019 m2**	**71,214 m2 17.6 acres**

Market Analysis

- The Quality Requirement Drives Design:
  - Contaminants
  - Stability
- Seasonality
- Market Size
- $/CY

Capacity Design Rules of Thumb

- Material processing areas can range from 2 to 2.7 tons per year per square meter for large facilities over 60,000 TPY
- 4-foot tall biofilters are sized between 4 to 5 cfm per square foot

Random Design Suggestions

1. Minimize Handling and Maximize Effect of Each Handling
2. Move materials upslope and upwind to limit pathogen and weed seed spread.
3. Design pile heights to the mix's structural capability "Lower, faster, better"
4. Capture and treat leachate and storm water separately
5. Limit exposure of fresh feedstocks to vectors and workers. (compost first, pick second.)
6. Scrape, sweep and rinse working surfaces regularly and cover fresh piles
7. Design for Worst Case Scenarios (you won't be disappointed)
8. Design to expand without disrupting the process

Understand the Regulations

- Washington State Solid Waste http://app.leg.wa.gov/wac/default.aspx?cite=173-350-220
- WA State Clean Air Agencies http://www.pscleanair.org/regulated/composting/default.aspx
- Oregon DEQ https://www.oregon.gov/deq/mm/swpermits/Pages/Composting.aspx
- California Solid Waste http://www.calrecycle.ca.gov/organics/Processors/
- California Air Board http://www.arb.ca.gov/cc/compost/compost.htm
- California Water Board https://www.waterboards.ca.gov/board_decisions/adopted_orders/water_quality/2020/wqo2020_0012_dwq.pdf
- Federal EPA Guidance http://epa.gov/composting/laws.htm

Managing Leachate, Stormwater, Water Reuse - Orion Black Brown

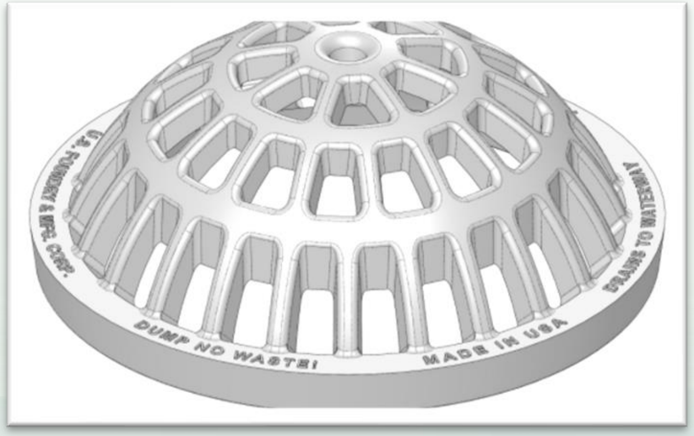
- Sources of leachate
  - Condensate, contact water, stormwater, and rainwater
- Zero Discharge or Water Treatment
- Retention pond and tanks
- Leachate Trench drains and catch basins
  - Separating solids and oils from contact water
- Managing Leachate and Odors
  - Pond aerators, evaporators, floating pond covers, removing settled solids
- Reuse Techniques
  - Impact sprinkler systems
  - Water Trucks
  - Spray Bars on portable equipment w/ hose reels
- Opportunities for reusing contaminated water

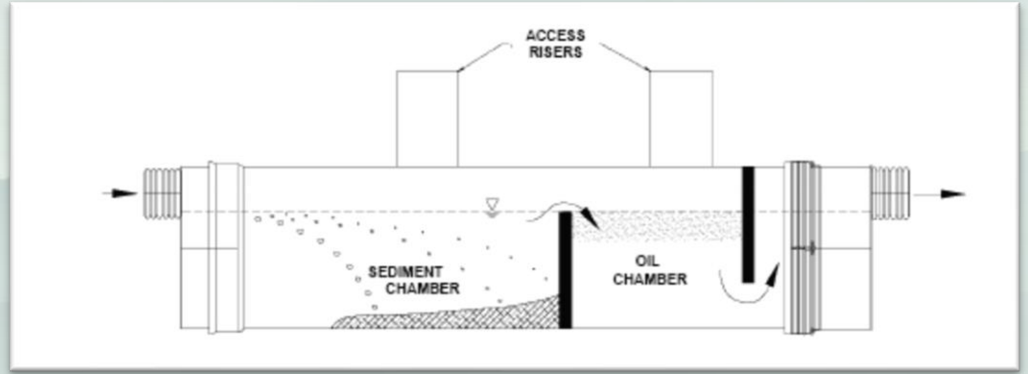
Leachate Sources

- **Condensate**: Generated by saturated air entering aeration lines and cooling
- **Contact Water**: Water coming off an "unstable" pile
- **Stormwater**: Stormwater is clean water from "stable" piles, clean roads, roofs, parking lots etc…
- What is a stable pile ? Depends on your regulator. Typically, cured and sterilized.

4.2

Leachate Collection





- Guide water to collection points with site grade
- Ways to collect and divert water
  - Pressure Traps !
  - Trench drains
  - Catch Basins
    - We love catch basins
  - Sediment weirs
  - Trenches
- Separate suspended solids and oils from water
- Avoid pumps, gravity is your friend !
  - Chopper pumps are best if pumping

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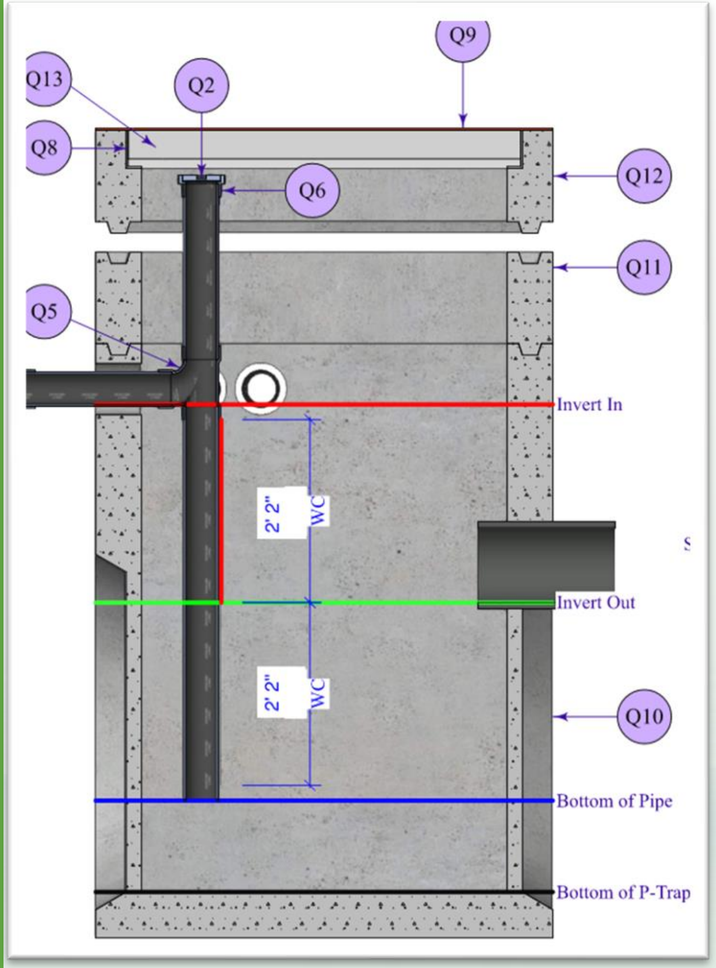
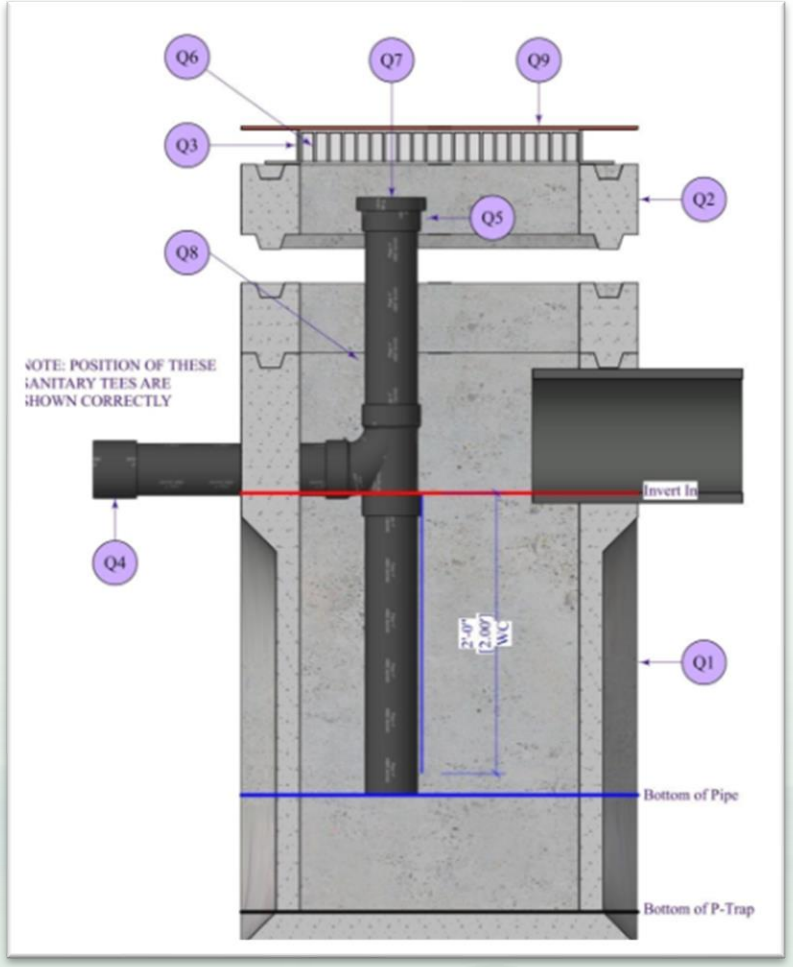
PRESSURE TRAPS !!





- Allows aeration system to stay pressurized while draining condensate and leachate
- Designed to max pressure of blower +2 in. w.c.
- Pressure trap is "reversed" for positive and negative aeration
- If airflow is reversing, pressure trap depth doubles
- Poorly designed P-traps is one of the easiest ways to botch a design !

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Leachate Storage

- Collected Water is guided to:
  - Lined pond
  - Tank
    - Below grade: Concrete, plastic septic, concrete septic, or fiberglass
    - Above grade: Rotomolded, frac tank
- Leachate from FW will generate odor
  - Lagoon aerators
  - Diffusion hose and compressor
  - Aeration will generate foam
  - >5 ppm O2 in leachate, aerate heavily early
- Evaporators are great if hot, dry and cheap electricity
- Pond covers prevent rainfall directly into the pond, great for high rainfall shallow ponds.
- **Key Challenge**: Remove solids and oils prior to storage

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Zero Discharge vs Treatment vs Sewer Discharge

- Most states require enough storage for a 24-hour 25-year-storm at minimum
- Zero-Discharge requires enough on-site storage to handle generation throughout the year
  - Stored water is then used up during dry months
  - Must consider rainfall, seasonal water usage, evaporation rates
  - Even in Washington, sites will burn through reserves by July or August
- Excess water can be trucked to a WWTP
- Excess water can be treated to drinking water standards onsite and discharged to environment
  - Usually only financially feasible if the site already has treatment capabilities

Zero Discharge vs Treatment vs Sewer Discharge

- Excess may be discharged direct to sewer line, or aerated to reduce BOD's and then discharged
  - Typically pay a surcharge for water above 300 BOD's
  - Leachate from fresh material is typically 20,000 BOD's
  - 4 to 7 days of aeration in a lagoon will typically bring leachate to acceptable levels.
- **Challenge**: Lagoons and ponds outdoors entrap 100% of the rainwater that falls on them!
- **Key Question**: What does it cost to treat off site?
- **Key Question**: Is it worth covering unstable material?
- **Key Question**: If there is a large storm, will a WWTP accept your water?
- **Key Question**: Is it cheaper to discharge directly into sewer or reduce BOD's then discharge water?

Leachate Reuse: Opportunities

- Applied while grinding/mixing feedstocks
- Applied to un-sanitized compost piles
  - Consider meeting PFRP and VAR later in the process (longer window for reuse)
- Dust suppression on roadways
- Evaporation
  - Directly from pond
  - Maximize surface area and airtime when applying
  - With an evaporator

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Leachate Reuse: Techniques

- Impact sprinkler systems
- Water trucks
- Spray bars
- Operator with a hose
- Hose reels

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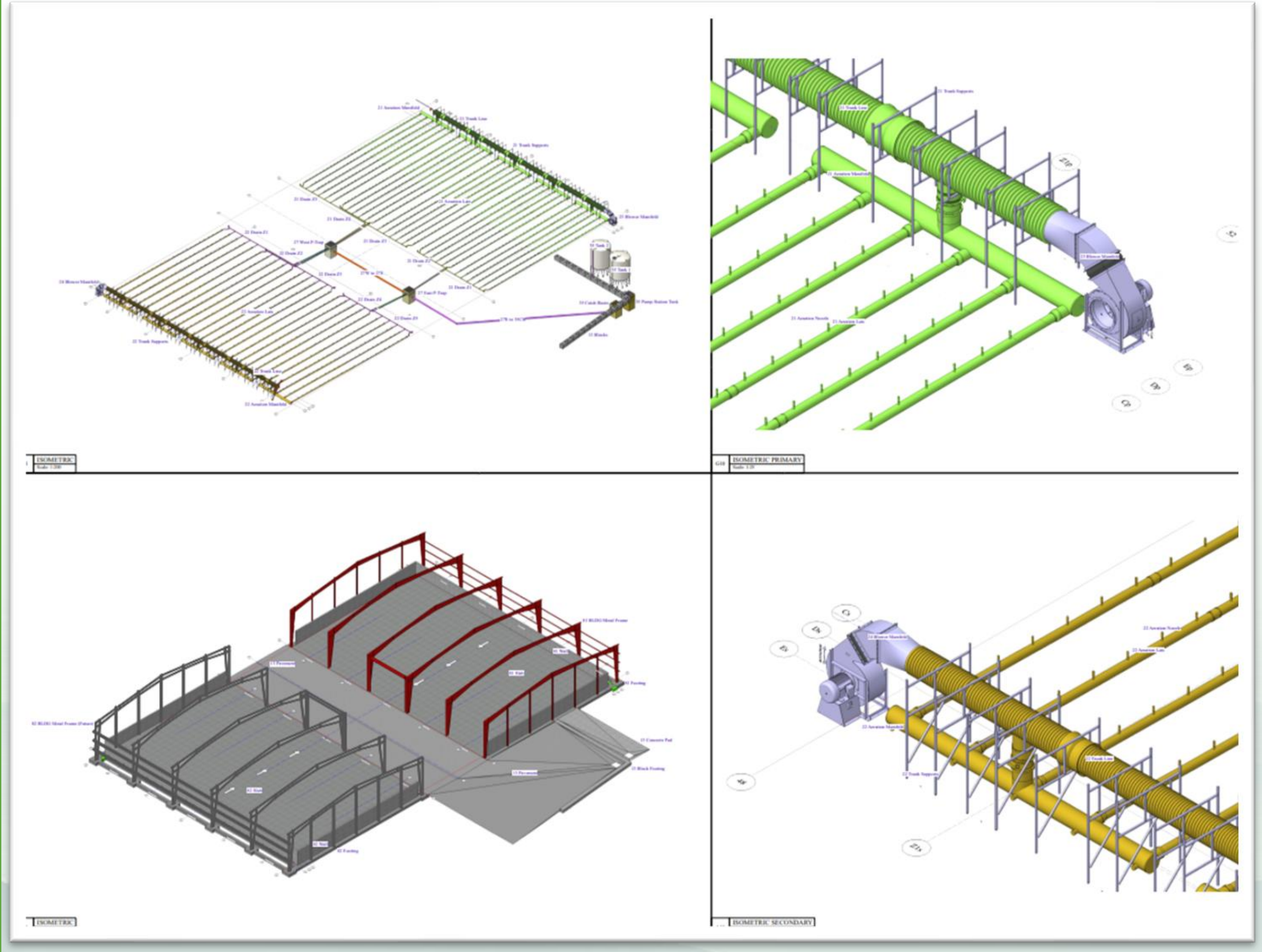
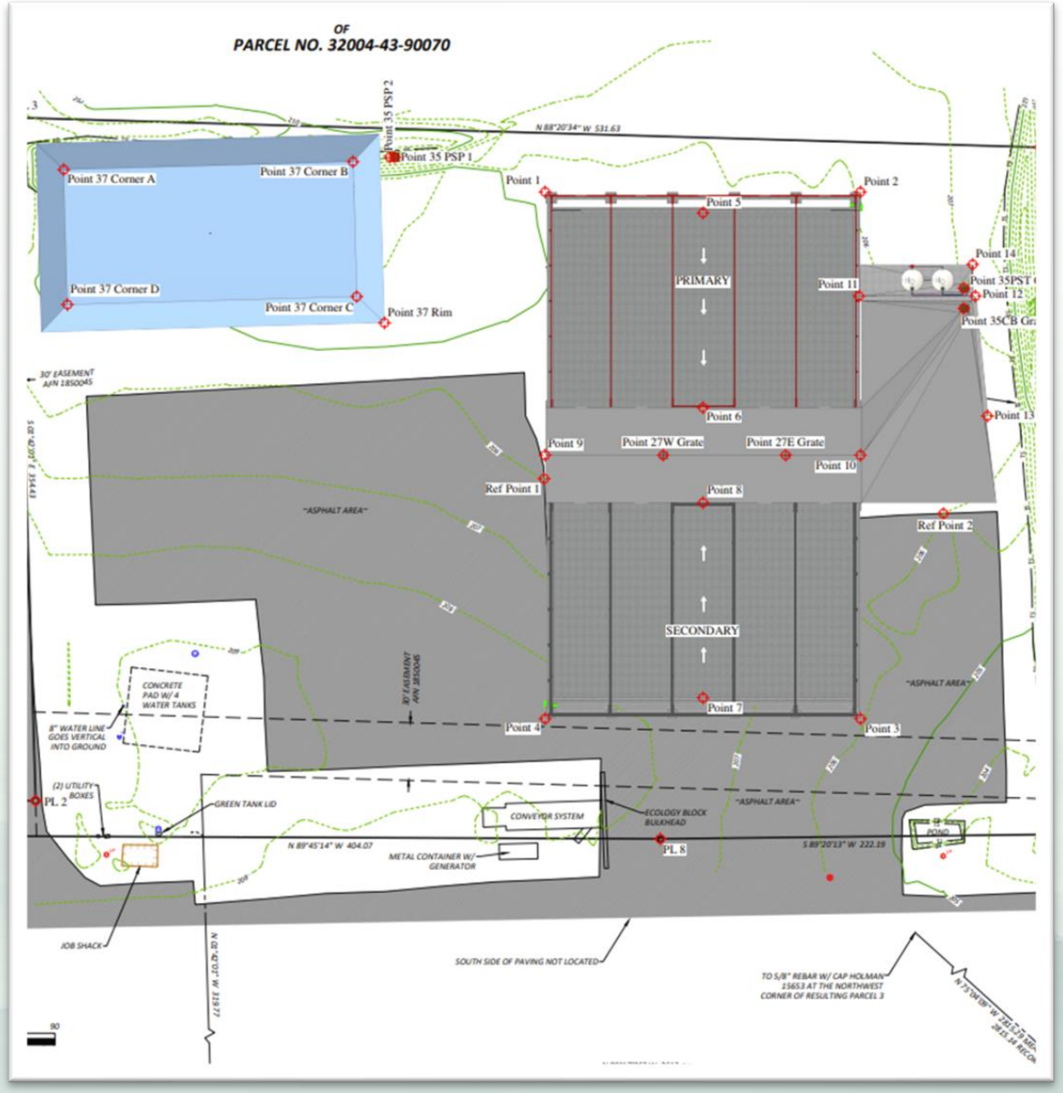
Aeration System Design – Orion Black Brown

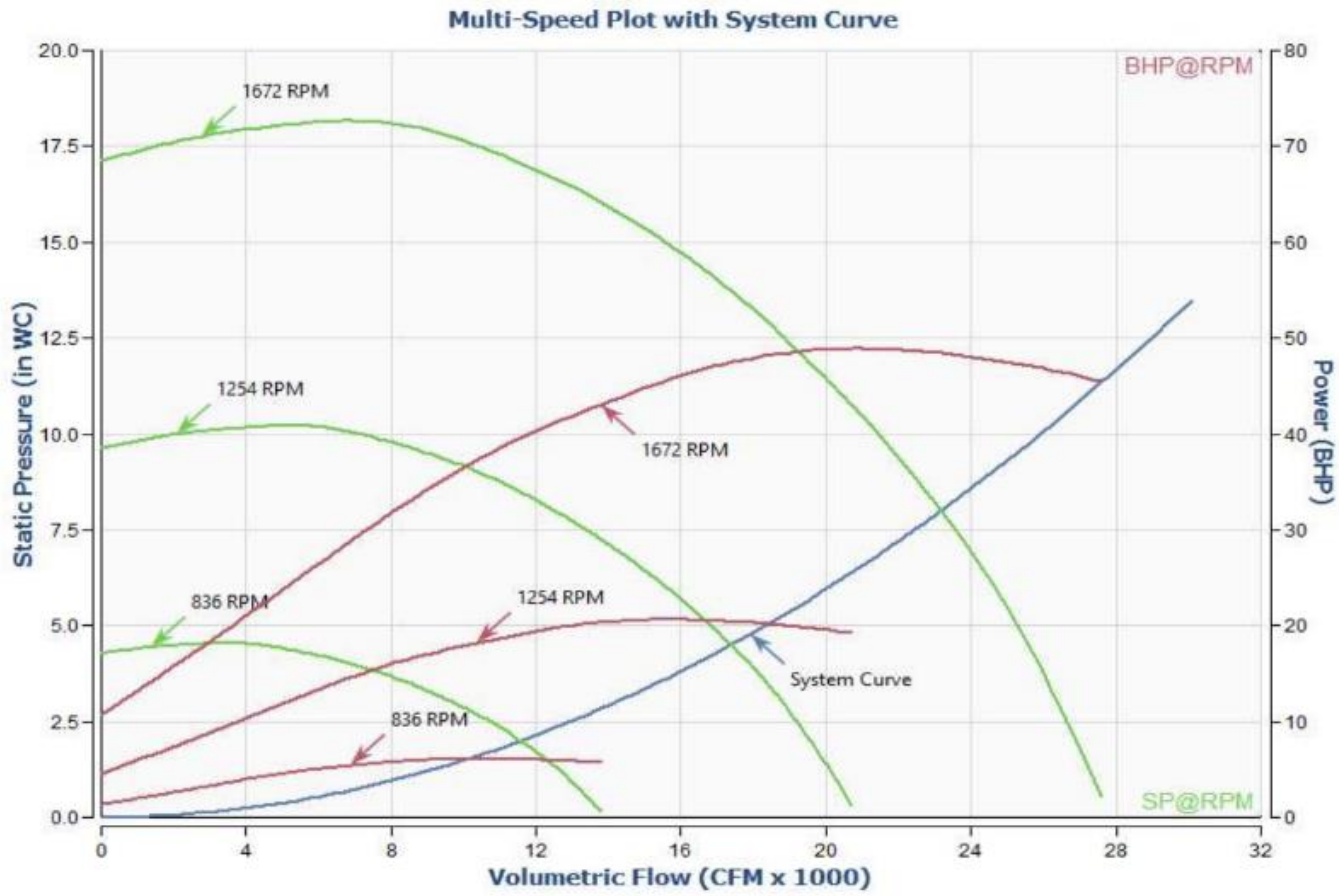
- Layout Example
- Blower Selection
  - Reading Blower Curves
- Friction Loses: Through ducting and the pile
- Positive, Negative and Reversing
- Affects of settling and age
- Affects of pile depth

Layout Example





Reading Blower Curves



- CFM - Cubic Feet Per Minute
- In w.c. – inches water column
- BHP – Brake horsepower
- If using VFD, blower must be able to operate at lower RPM's
- Min requirement FW 4 CFM/yd^3

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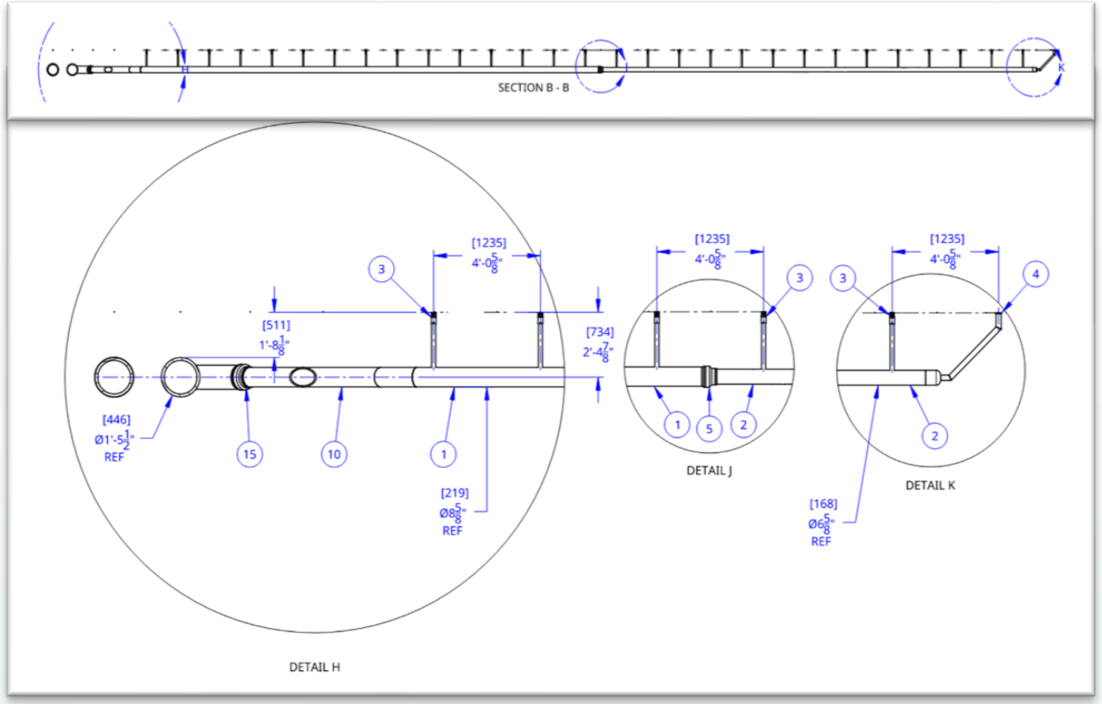
Blower Selection

- Higher pressure means deeper piles but also more expensive blowers and electrical cost
- Need to up-size blower by 25%-50% if going negative or reversing.
  - Blowers need to be stainless $$$$



Duct Loses

- Loses in the US are measured by inches water column (in w.c.)
- Try and keep duct loses for entire system below 2'' at design pressure
- As air leaves the system, constrict the diameter of the pipe that the air travels through.
  - Constrict to keep pressure loses the same or
  - Keep pipe air speed consistent

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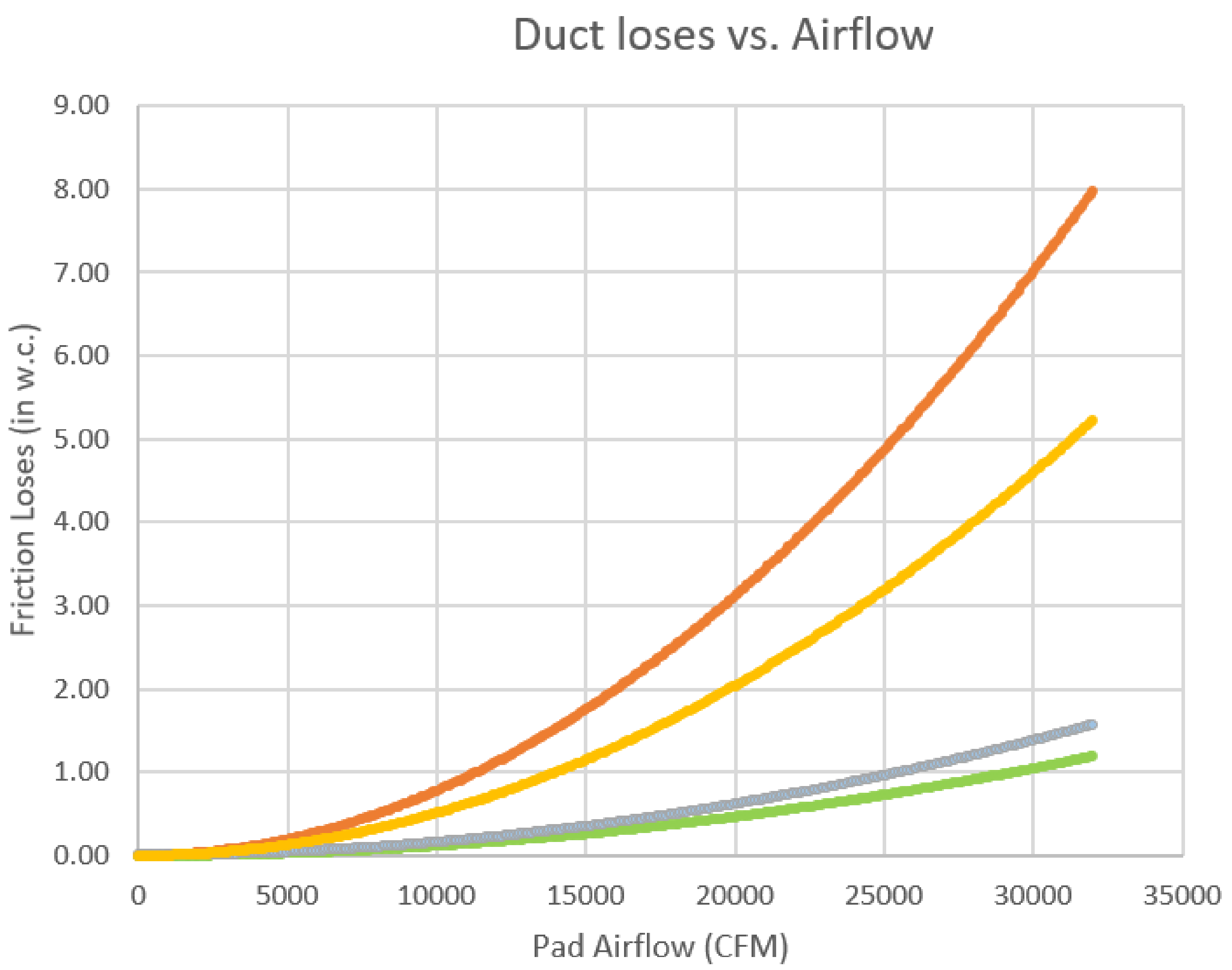
4.3

Duct Loses: Proper Design



	Header	Lateral	Sparger
Length	125	113	0.1
Diameter	24	8	0.9375
Quantity	2	26	1200
# 45 Bends	2	0	1
# 90 Bends	1	0	0

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Duct Loses: Undersized Header

	Header	Lateral	Sparger
Length	125	113	0.1
Diameter	15	8	0.9375
Quantity	2	26	1200
# 45 Bends	2	0	1
# 90 Bends	1	0	0

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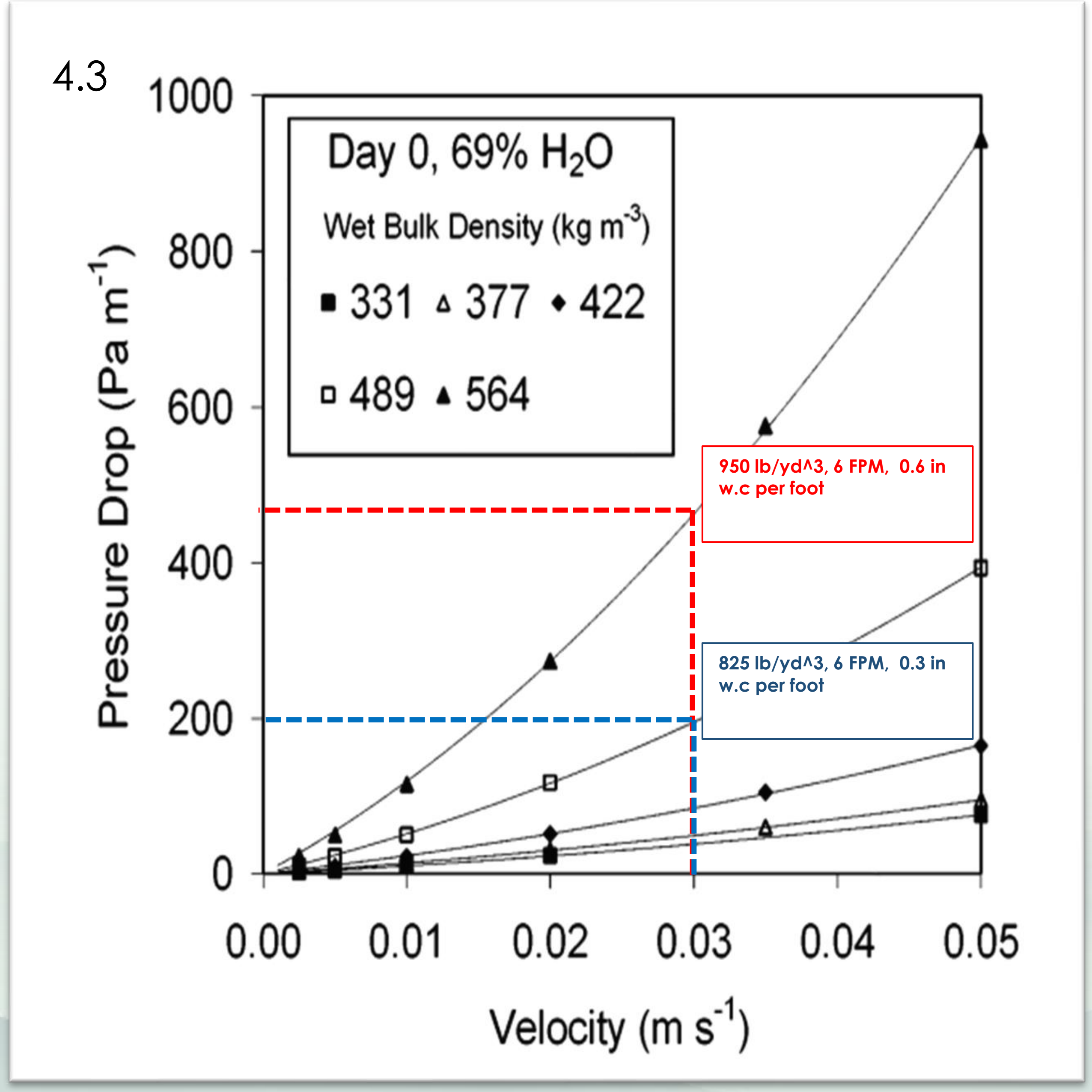

Pile Loses

- Piles loses are much higher then duct loses (4'' to 20'' through pile)
  - Especially for FW as it is denser and wetter
- Pile loses are directly related to feedstock;
  - Density
  - Depth
  - Structural integrity
- Graph shows pile loses for a chicken manure hay mix at different bulk densities - day zero 69% moisture content

https://www.researchgate.net/publication/296814369

Positive, Negative, and Reversing Aeration -

Orion Black Brown

	Positive (w/ Biocover)	Negative (w/ Biofilter)	Reversing (w/ Biocover and Biofilter)
Capitol Cost	$$	$$$	$$$$
Operational Cost	$$	$$$$	$$$
Odor and emissions	Great	Great	Great
Public Perception	Good	Great	Great
Temperature Control	Good	Good	Great

Manifolds – Go Stainless !

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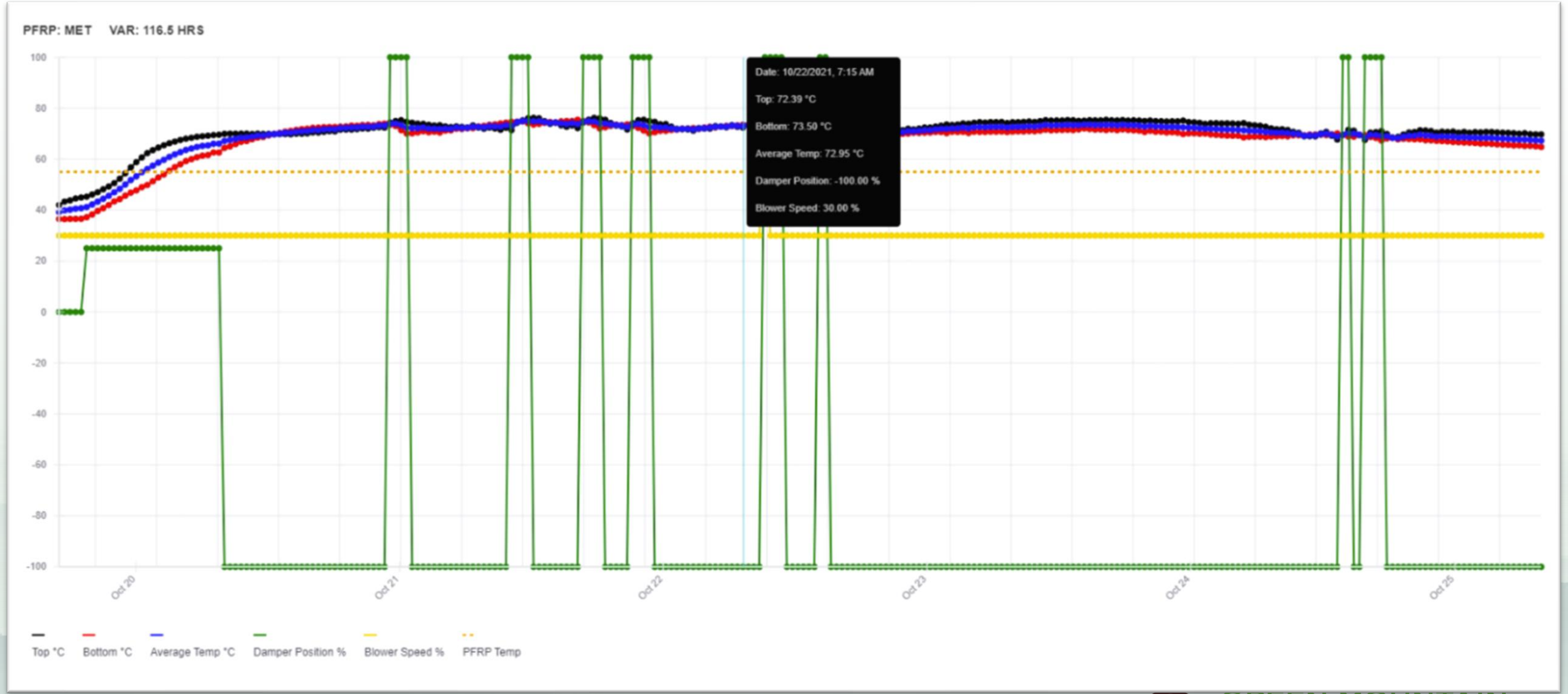
Temperature Profiles



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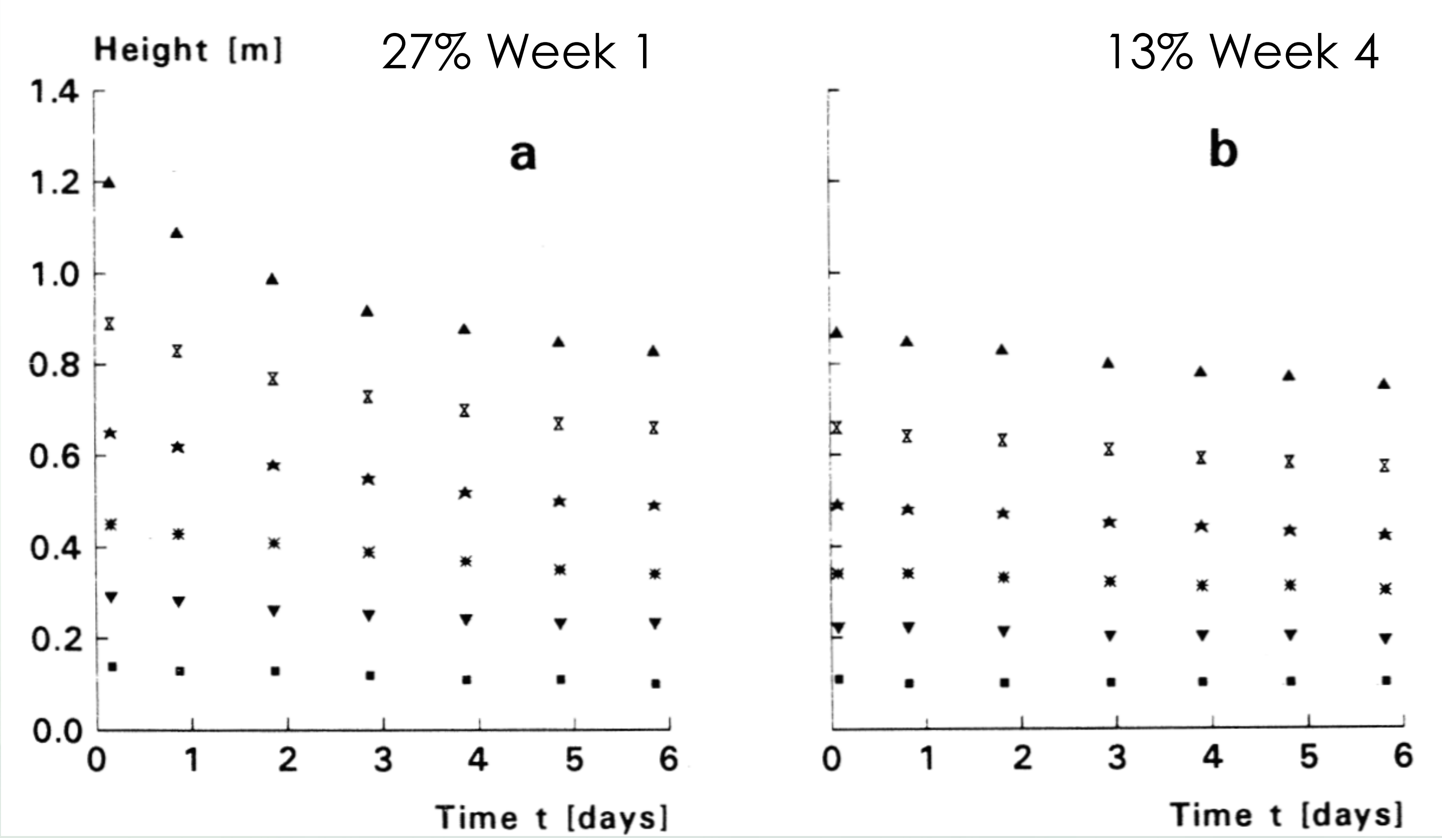
4.3

Pop Quiz: What kind of aeration is used on this pile?

Affects of Settling and Age



1. Average of 20% settling per week
   1. 4% mass loss
   2. 16% subsidence
2. Hay chicken manure pile mix
3. Settling decreases over time
4. Settling increases with pile height

1. J.T Van Ginkel

Affects of Settling and Age

Burke-Plummer Equation for Turbulent Flow

$$\Delta P = \frac{1.75\rho_f L V_\infty^2 (1-\emptyset)}{D_P \emptyset^3}$$

$$\frac{\Delta P_1}{\Delta P_2} = \frac{\dfrac{1.75\rho_f L V_\infty^2 (1-\emptyset_1)}{D_P \emptyset_1^3}}{\dfrac{1.75\rho_f L V_\infty^2 (1-\emptyset_2)}{D_P \emptyset_2^3}}$$

$$\frac{\Delta P_1}{\Delta P_2} = \frac{\emptyset_2^3 (1-\emptyset_1)}{\emptyset_1^3 (1-\emptyset_2)}$$

$$\frac{\Delta P_1}{\Delta P_2} = \frac{0.4^3 (1-0.5)}{0.5^3 (1-0.4)} = \mathbf{0.43}$$

ΔP = *Change in Pressure*
ρ_f = *Fluid Density*
L = *Pile Depth*
V_∞^2 = *Flow Velocity*
$\emptyset$ = *Porosity*
D_P = *Particle Diameter*

** Assume nothing but porosity changes over the course of a week and that the initial porosity is 50%

The pressure drop through the media is **2.3x** greater when porosity decreases by 10% !!

Affects of Pile Depth

Burke-Plummer Equation for Turbulent Flow

$$\Delta P = \frac{1.75\rho_f L V_\infty^2 (1-\emptyset)}{D_P \emptyset^3}$$

$$\frac{\Delta P_1}{\Delta P_2} = \frac{\frac{1.75\rho_f L V_\infty^2 (1-\emptyset_1)}{D_P \emptyset_1^3}}{\frac{1.75\rho_f L V_\infty^2 (1-\emptyset_2)}{D_P \emptyset_2^3}}$$

$$\frac{\Delta P_1}{\Delta P_2} = \frac{L_1}{L_2}$$

$$\frac{\Delta P_1}{\Delta P_2} = \frac{13}{14} = \mathbf{0.93}$$

ΔP $= Change\ in\ Pressure$
ρ_f $= Fluid\ Density$
L $= Pile\ Depth$
$V_\infty^2 = Flow\ Velocity$
$\emptyset$ $= Porosity$
D_P $= Particle\ Diameter$

** Assume nothing but depth changes

The pressure drop through the media is **7%** greater when the depth is increased by 1 foot

Pile depth and porosity are linked – so this is **not one to one** ! Recall more depth more settling.

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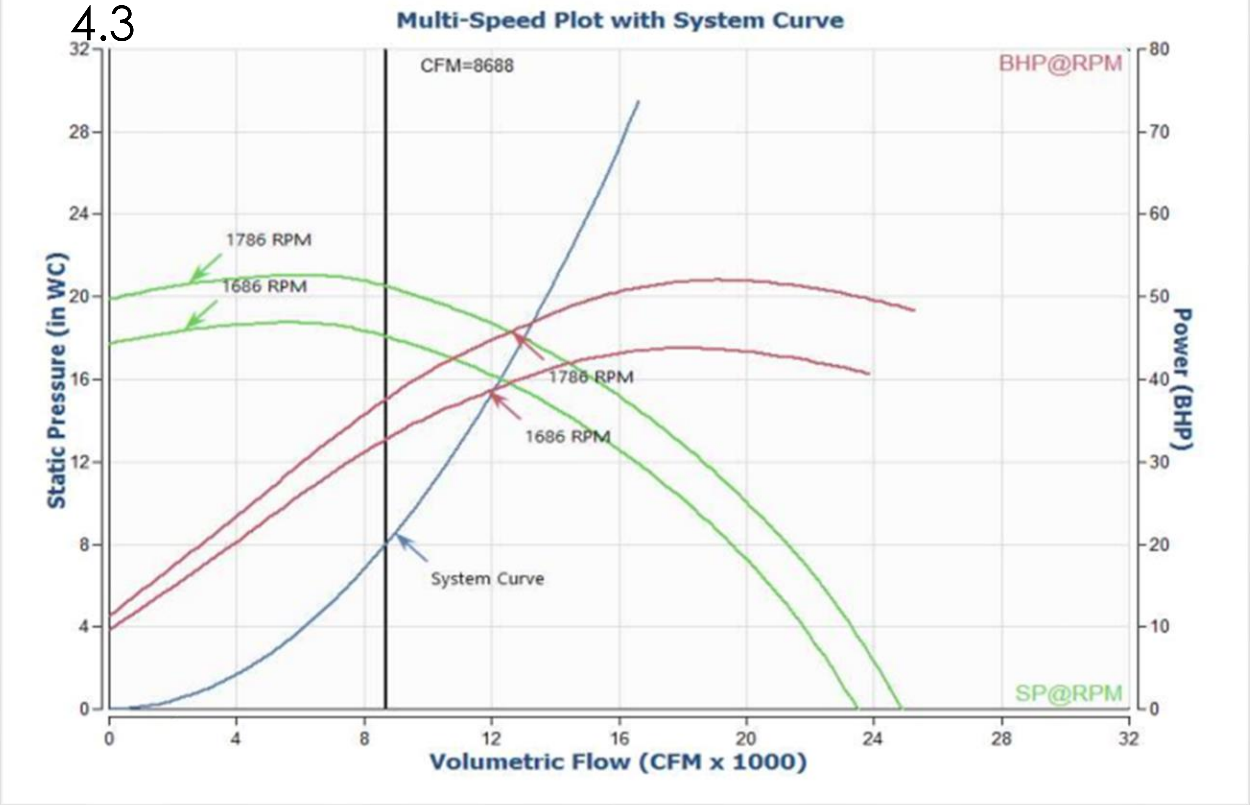
4.3



Lower, Faster, Better

- What is better? A pile that is 20' deep or one that is 10'?
  - Roughly **2x** more pressure to aerate 20' pile at start
  - Roughly **4x** more pressure to aerate 20' pile one week in
  - Roughly **7x** more pressure to aerate 20' pile four weeks in
- Deep piles lose aeration control
  - Greater blower and electrical cost
  - Longer retention times
  - Lower product quality
  - Less control
- Sweet spot for FW **7' to 12'** deep

4.4 Aurel Lubke

Turning Equipment

Working Surfaces – Orion Black Brown

- Types of working surfaces
  - Aggregate, CTB, Asphalt, Concrete
  - Slope for drainage for each
- Environmental considerations
  - Groundwater
  - Permitting limitations
- Geotechnical considerations
  - Pit Testing
  - Geo-Synthetics
- Structural considerations
  - Equipment Point Loading
  - Rebar vs mesh

Types of Working Surfaces

- Types of working surfaces (worst to best)
  - Soil
  - Bio-mat
  - Aggregate
  - Crushed Concrete
  - Cement Treated Base (CTB)
  - Asphalt
  - Concrete
    - Mesh (not recommended)
    - Rebar reinforced

Environmental Considerations: Groundwater

- If you are handling food waste site will be regulated like solid waste
- Regulations are constantly evolving, better to play it safe
- Keep contaminates such as nitrates, chemicals, PFOS, etc.. out of groundwater
  - May need a monitoring well
  - If impermeable surface your runoff will be monitored
- Groundwater depth changes seasonally, especially on ag land
- If groundwater is too close to surface design is constrained
  - Floating pipes, pressure trap insertion, compromises structural integrity of soils, pond depth
- **Key Question**: What is the depth of your groundwater? Does it change seasonally?
- **Key Question**: How will you keep contact water from infiltrating groundwater?

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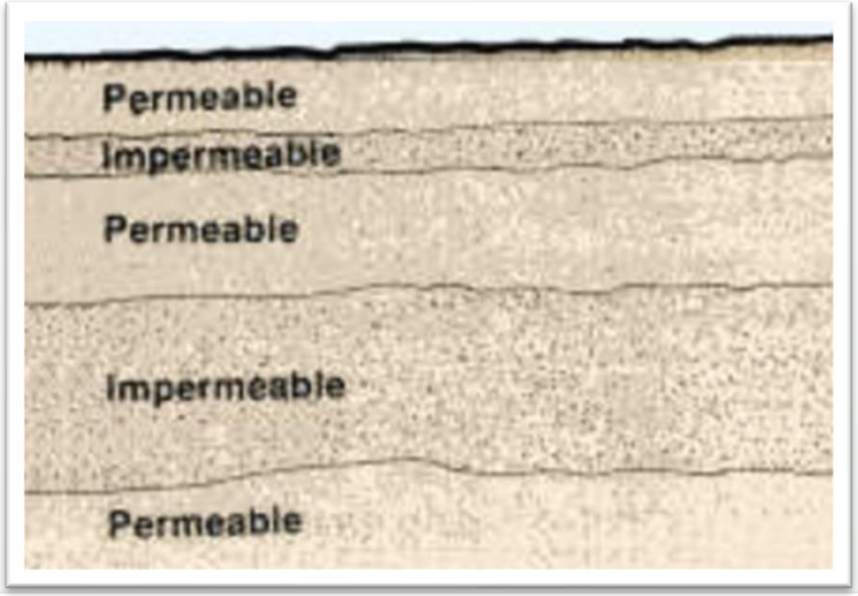
4.5



Soil Type	Description	Permeability (k) (equivalent rainfall rate)	Suitability
Cobbles and boulders	Permeability may be greater as flow may be turbulent	1 m/s	Excellent
Gravels	Uniformly graded coarse aggregate with zero fines and minimal sand	10^{-1} to 10^{-2} m/s (>3600 mm/hr)	Very Good
Gravel sand mixtures	Clean, well graded, with minimal fines (e.g. crushed stone or 'Type 3' road aggregate)	10^{-3} to 10^{-4} m/s (3600 to 360 mm/hr)	Good
Clean Sands	Sands with low silt or clay content	10^{-4} to 10^{-6} m/s (360 to 3.6 mm/hr)	Good to moderate
Silt mixtures	Mixtures of sand, silt and clay (topsoil is typically in this category)	10^{-6} to 10^{-10} m/s (<3.6 mm/hr)	Moderate to poor
Clays	Pure clays	10^{-10} to 10^{-12}	Practically Impermeable
Artificial	Bituminous mixtures, cement stabilised soil, geosynthetic liners	$<10^{-12}$	

Environmental Considerations: Permeability

- Permeability: The rate a fluid (liquid or gas) moves through a material
  - Permeability of the layers combined unless using an impermeable surface
  - Most regs require coefficient of permeability of 10^-10 m/s or better until "**stabilized**"
- **Challenge**: working surfaces must bear weight, be impermeable, and function when wet
- **Advantage**: Organic fines are like clay, clog up pores decreasing permeability

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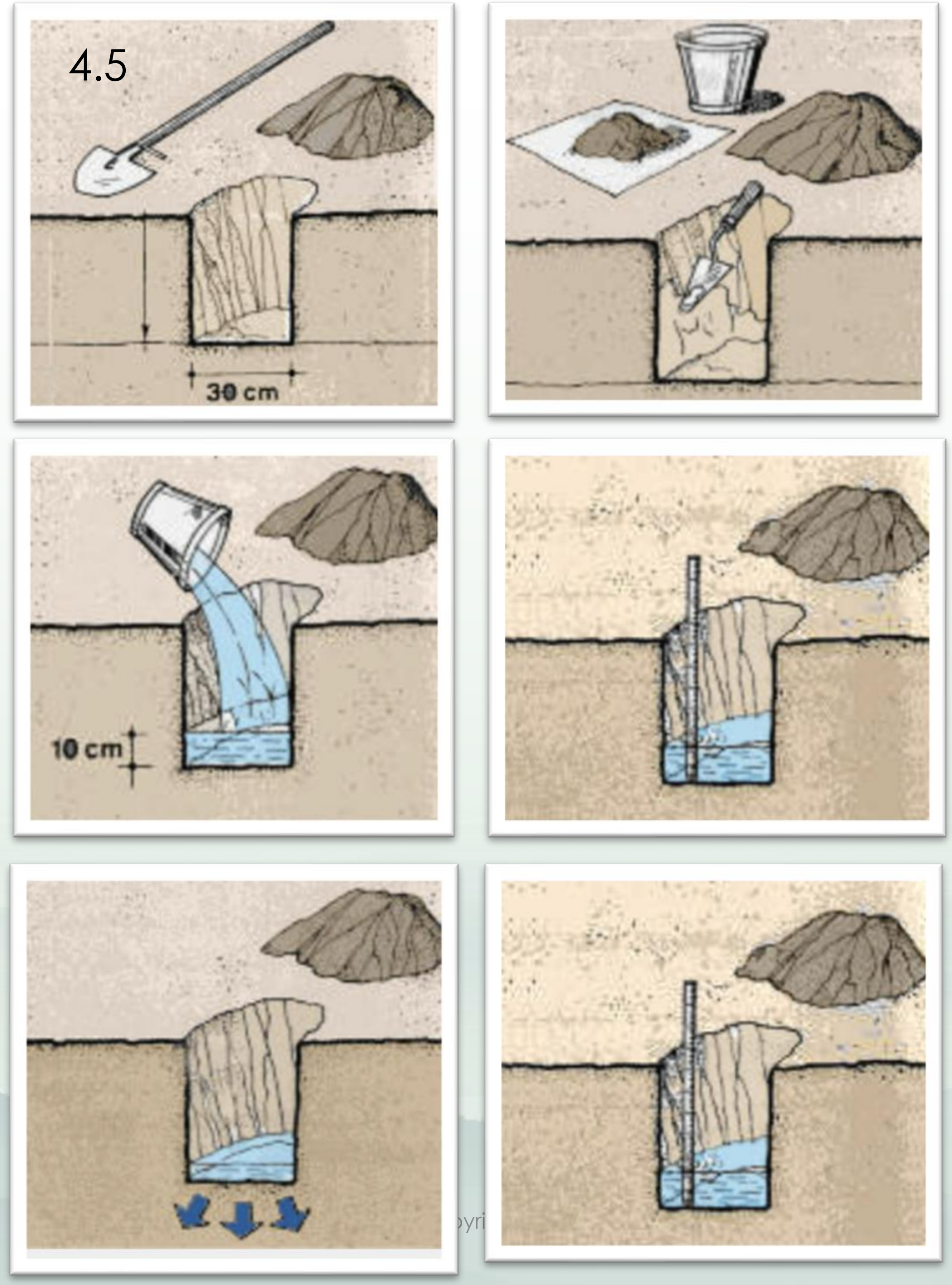

Environmental Considerations: Permeability Test

- Dig hole 30 cm diameter hole to horizon of interest
- Smear clay or place plastic on side walls
- Fill with 10 cm of water
- At first it will drain quickly, once this slows and area is saturated you are ready to test
- Measure water depth
- Cover to prevent evaporation
- Turn timer on
- Return every hour and measure depth for several hours
- **Note**: Different horizons will have different permeabilities. Running test at multiple locations and horizons will give you best information.

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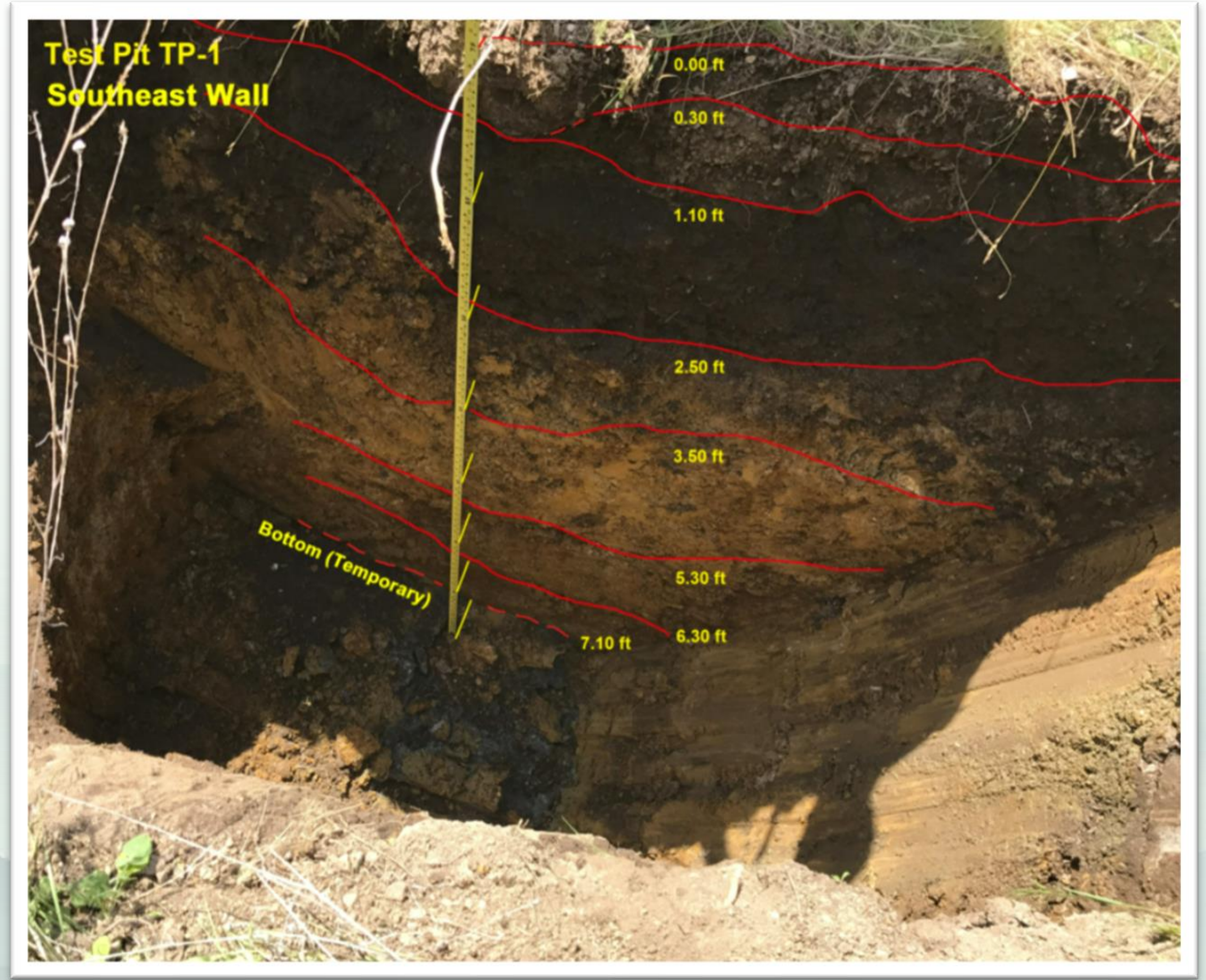
Geotechnical Considerations: Pit Testing



- Holes are dug at several random locations across the site
  - Make sure not to hit utilities
- Observations about the horizons of soil are made
- Need large, uniform bearing surfaces for slab on grade to function without cracking
- Will notify you of contamination on site
- **Challenge**: Soils perform very different when they are wet

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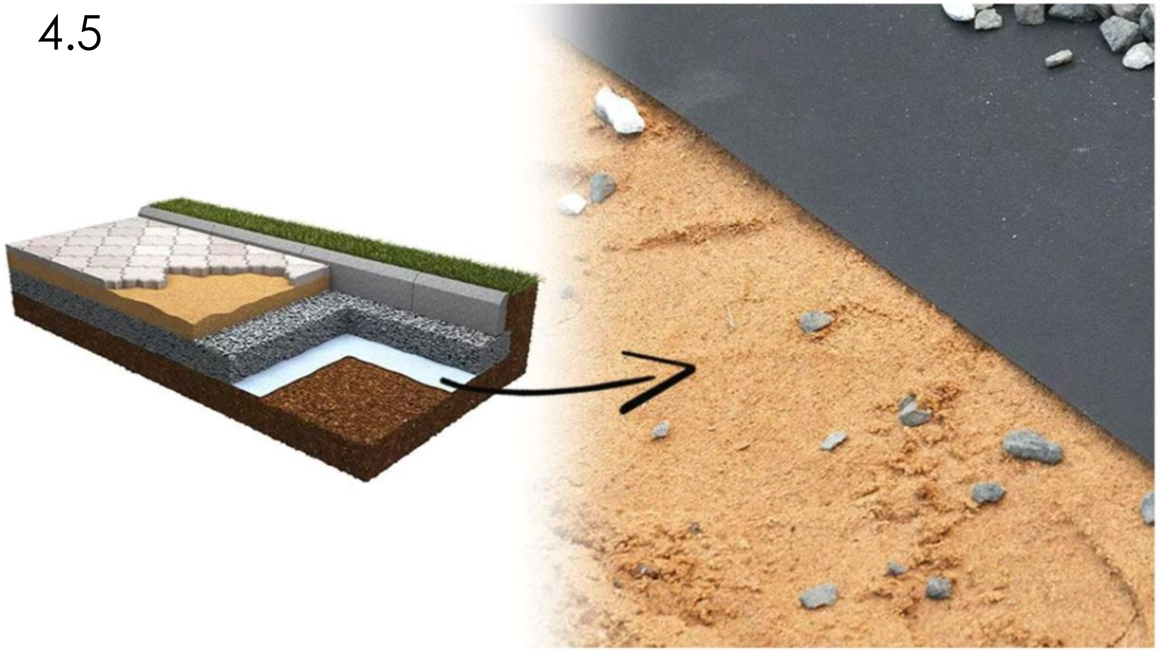
4.5



Geotechnical Considerations: Geo-synthetics

- Soil has very little shear strength especially when wet
- Geotextile
  - Holds aggregate in place
  - prevents intrusion of fines into the drainage layer
- Geogrid
  - Creates shear strength for soil

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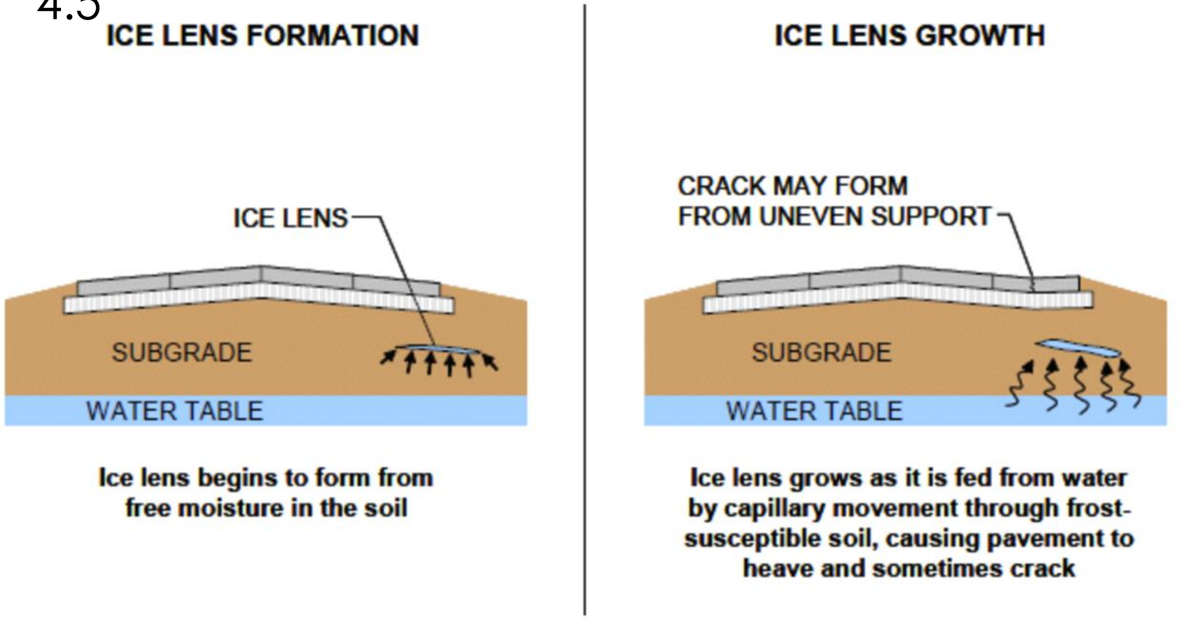
4.5



Geotechnical Considerations: Frost Depth

- Moisture in soil will freeze when its cold which can cause frost heaving or frost action
- Water freezes expanding and thaws contracting. This action works the surface often leading to failure.
- Make sure you have free draining soil or aggregate to frost depth to prevent frosting heaving

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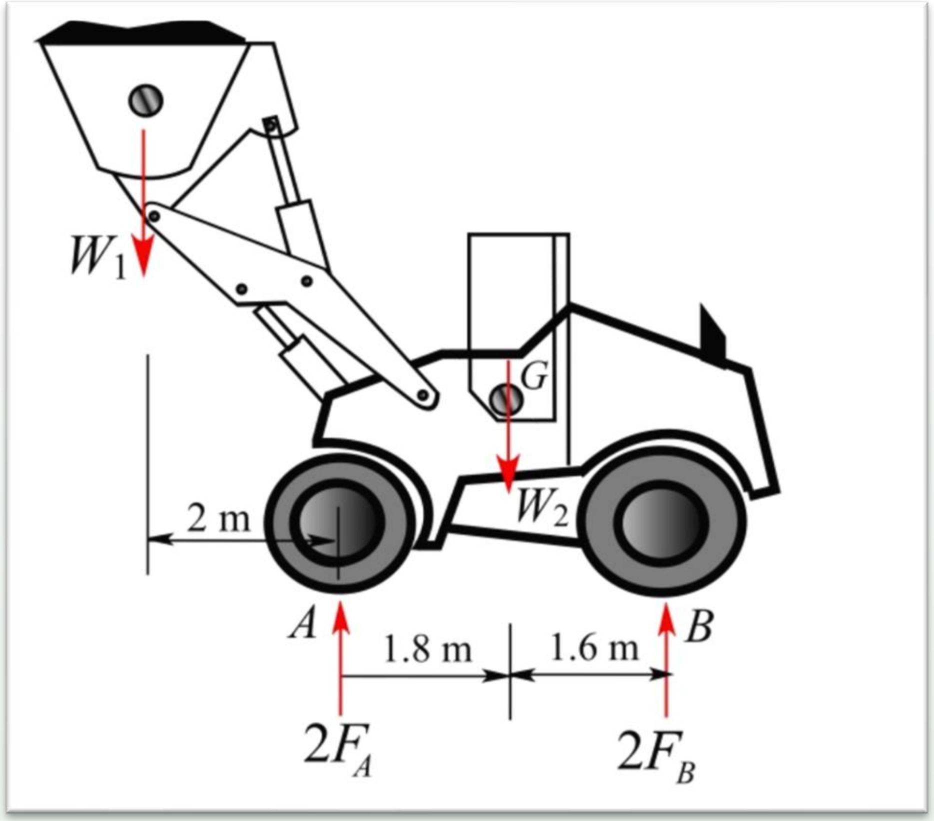
4.5



Structural Considerations: Point Loading

- Heavy machinery generates points loads from wheels on working surface
- Highest load is when digging into pile
  - All weight shifts to the two front wheels
  - Added force down from material
- Not going to go into details about calculations, just flag your structural engineer.

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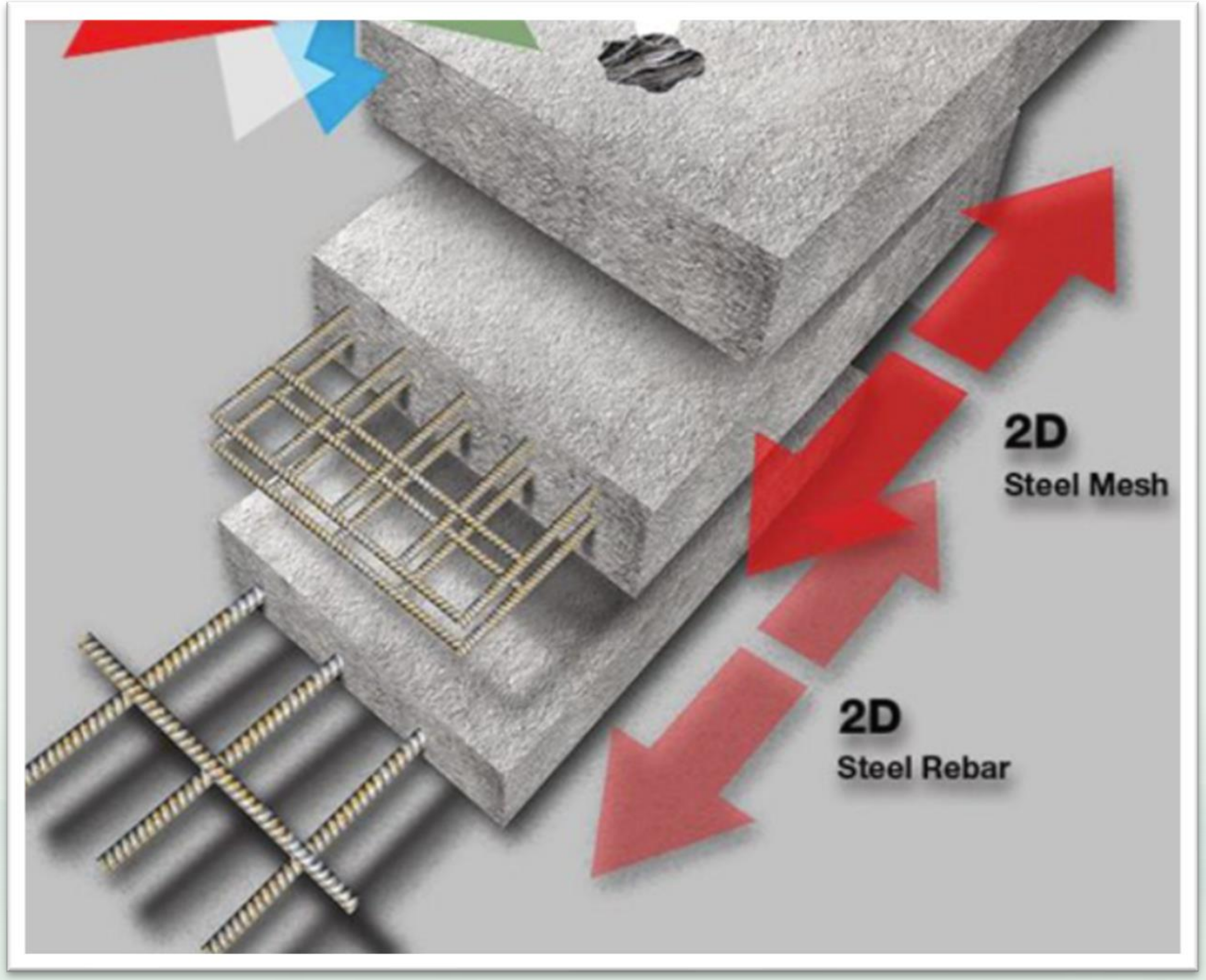

Structural Considerations: Reinforced Concrete

- Below grade pipes must be encased in concrete or will be crushed
- Concrete has 1/10 the tensile strength as compressive
  - Correct addition of fiber and or rebar can bring tensile strength to compressive strength
- Addition of fiber is much less labor intensive then rebar
- Rebar has a better lifespan, especially for large pads – 5 to 15 years fiber, 15 to 25 years rebar.
  - Make sure whatever you add is corrosion resistant

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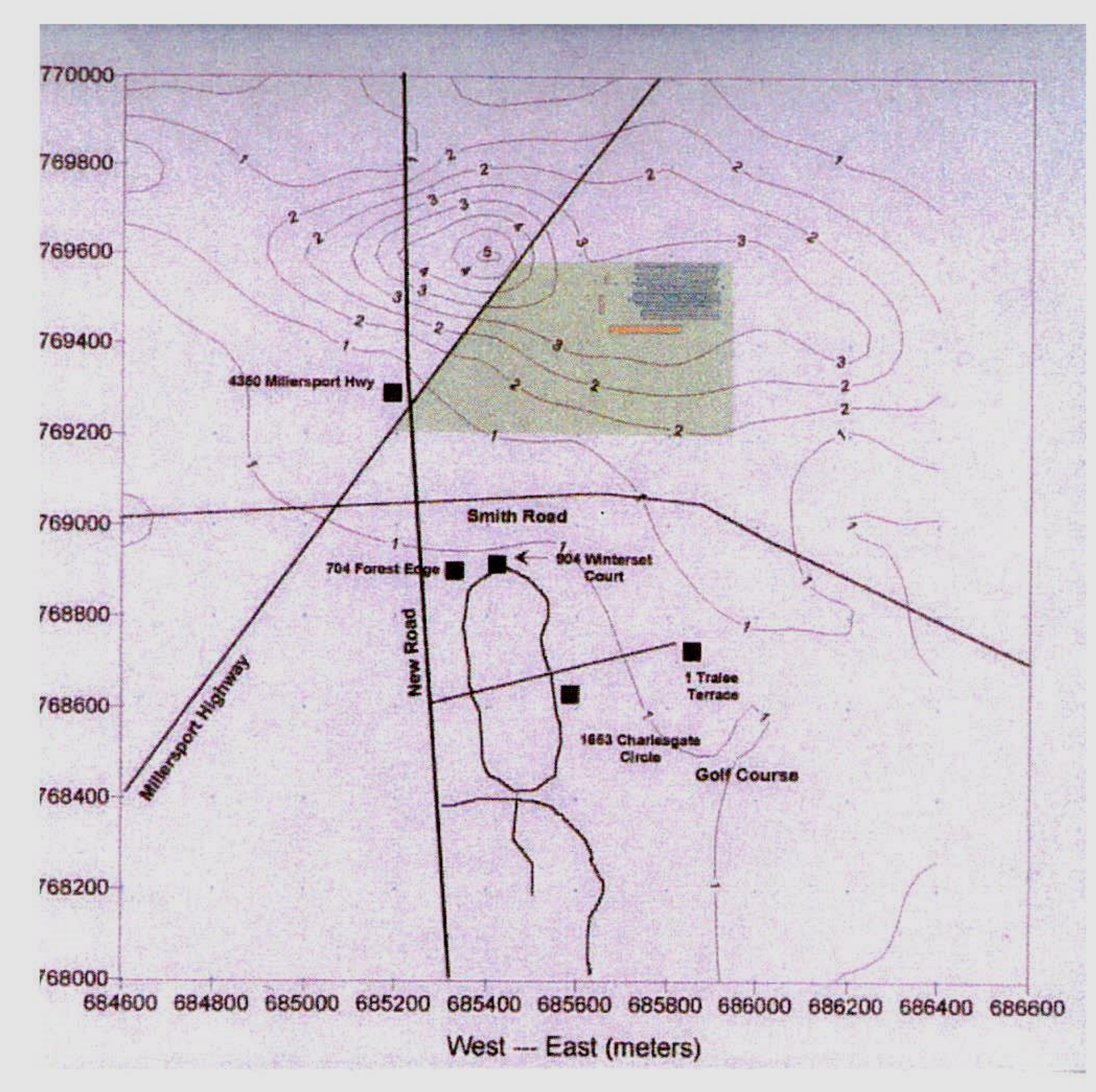
Working Surface Permitting

- Most states will require a stamp for:
  - Stormwater management plan
  - Grading plan
  - Working surface structural calculations
- It is recommended to have a geotechnical assessment !
- It is helpful when one engineering firm handles all stamping needs

Odor Control Design Modeling DT



Source Todd Williams CH2MHill

- Modeling can evaluate different composting technologies, different layouts, different odor removal system performance
- Concept layouts can be developed and evaluated for economics and odor control performance before significant engineering effort is expended
- Odor models are predictors of impacts under varying conditions. They are not real-time monitors

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Emissions Calculations from San Joaquin

Table III-3: Control Techniques for Composting Operations

Control Type	Aeration	VOC Control Efficiency	NH3 Control Efficiency
Windrow			
Static Pile – No Biofilter	Passive	0%	0%
Managed Windrow – No Biofilter	Passive	0%	0%
Water Management Requirements[1]	Passive	19%	19%
Static Pile/Passively Aerated Windrow covered 15 days with a biofilter[2]	Passive	40%	20%
Static Pile/Passively Aerated Windrow covered 22 days with a biofilter[1]	Passive	60%	20%
Aerated Static Pile (ASP)			
Negative ASP with Biofilter (classic)	Forced, Negative Air	26%	23%
Positive ASP with Biofilter Cover	Forced, Positive Air	80%-98%	53%
Enclosed Aerated Static Pile			
Enclosed, Negative ASP with Biofilter (e.g., ECS)	Forced, Negative Air	80%-98%	70%-78%
Negative ASP with Biofilter (indoor)	Forced, Negative Air	80%-98%	80%-99%
Enclosed, Positive ASP (e.g., GORE Cover)	Forced, Positive Air	80%	70%
Ag Bag	Forced, Positive Air	80%	70%
General Enclosed Pile vented through a Biofilter	Forced	80%	70%

[1]Requires compliance with pile management and/or watering requirements in SJVAPCD's rule 4566.
[2]Requires compliance with pile management and/or watering requirements in SCAQMD's rule 1133.3.

https://ww3.arb.ca.gov/cc/arcdsc/composting_emissions_inventory_methodology_final_combined.pdf

Systems for Odor Management

- Acid and chemical scrubbers
- Biofilters with pressure blowers
- Up draft blowers with stack dispersion
- Composting inside a building requires large energy inputs for ventilation blowers and biofilters

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Biofilter Treatment Systems

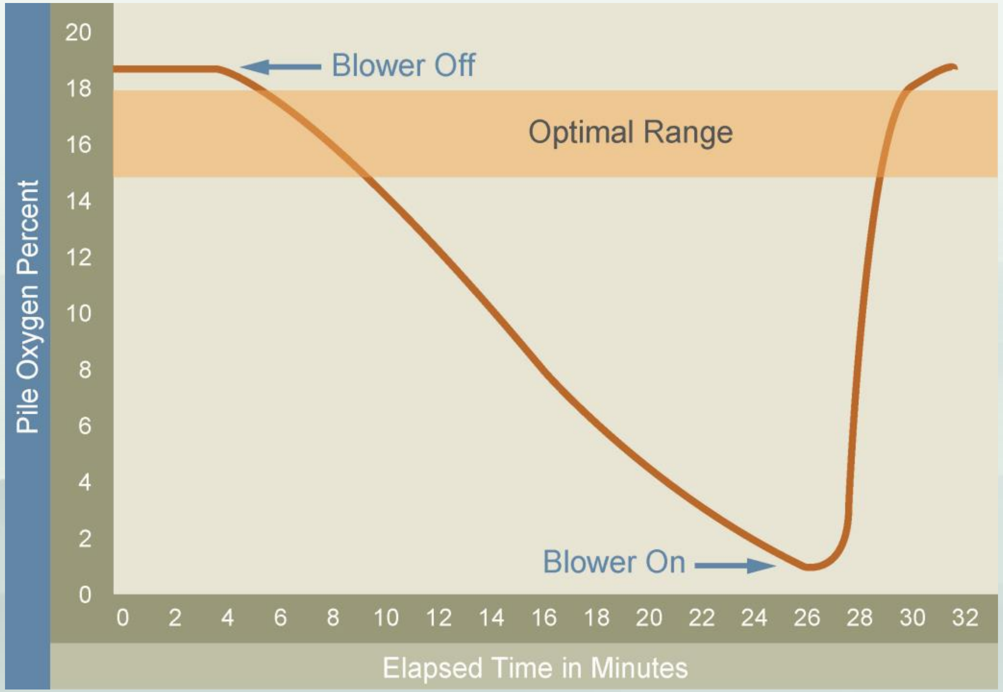
- Biofilters range from 1 to 1.5 meters deep
- Media typically ground wood waste ideally stumps
- Screen out fines before building biofilter
- Maybe up to ½ the footprint of building
- Require irrigation systems
- shallow beds subject to short-circuiting
- Typical back pressure of 1.5-7" w.c.

Compost Factory, Puyallup, WA

Initial VOC Control in the cooling pile

- Aerate to keep initial pile temperature between 90- and 100-degrees Fahrenheit for 8 to 24 hours or until pH is above 6.5
- This aeration rate may be more than 10 cfm/cubic yard. Pile height is a variable you can adjust to use the regular composting bays aeration system
- If using Positive aeration use biocovers or micro-porous covers – VOC emission control > 90%
- If using Negative aeration carry the air to a biofilter designed for that airflow

Source of picture Excellent article https://www.biocycle.net/managing-odors-in-organics-recycling/



4.6

Maintain Sufficient Oxygen Levels

- Oxygen travels via passive aeration (chimney effect) or forced aeration (fans).
- The oxygen introduced into a composting pile through mechanical agitation (e.g. windrow turning) or short bursts of air from fans can be consumed in as little as 30 minutes.

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Collect air from fresh piles and put through a biofilter

- Collect air by pulling air from the bottom of the pile (negative Aeration)
- Collect air from under a tarp placed over the pile (positive aeration)
- Collect air from an enclosure for fresh piles – Keep the air space as small as possible
- Biofilter collected air, 4-6' deep, residence time > 30 sec., moisture > 55%
- Design Criteria of less than 5 cfm per square foot of odorous air into a biofilter distribution floor

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Odor Mitigation - Planning for Challenges

Comprehensive Compost Odor Response Project

Produced under contract by:

SAN DIEGO STATE UNIVERSITY

March 2007

The Odor Mitigation Strategy Menu (OMSM) is a comprehensive listing of possible design and operating techniques that can be used to prevent and minimize odors from composting facilities.

- Odor Impact Management Plans provide a map of actions if odors increase or change significantly to a level which creates a nuisance.
- Use the C-CORP OMSM for ideas for ramping up your game
- Model the potential effect and cost of major changes using Odor Modeling

Source https://www.calrecycle.ca.gov/swfacilities/compostables/bmp/ccorp

Building Systems for Composting

- Fully enclosed vs open sided structures

Building Systems

- Tensile fabric buildings
- Steel building systems
- Wood frame structures

Austrian Composting Council Show 2019

4.7

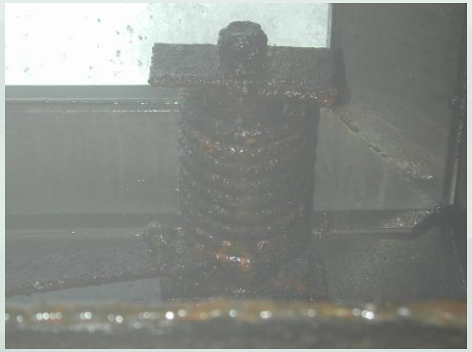
Corrosion is Real!

- Corrosion is the single biggest factor in building selection
- Iron rust is an energy source for bacteria
- Moisture laden vapor can penetrate coatings

Edmonton's composting facility, built in 2000, has been permanently shut down after failing a recent inspection. (Travis McEwan/CBC)

Edmonton's troubled composting facility, which is less than 20 years old, is being shut down and decommissioned after failing a recent safety inspection, city officials say.

The composter, built in 2000 at a cost of $97 million, was closed over the winter after structural problems with the roof were found.



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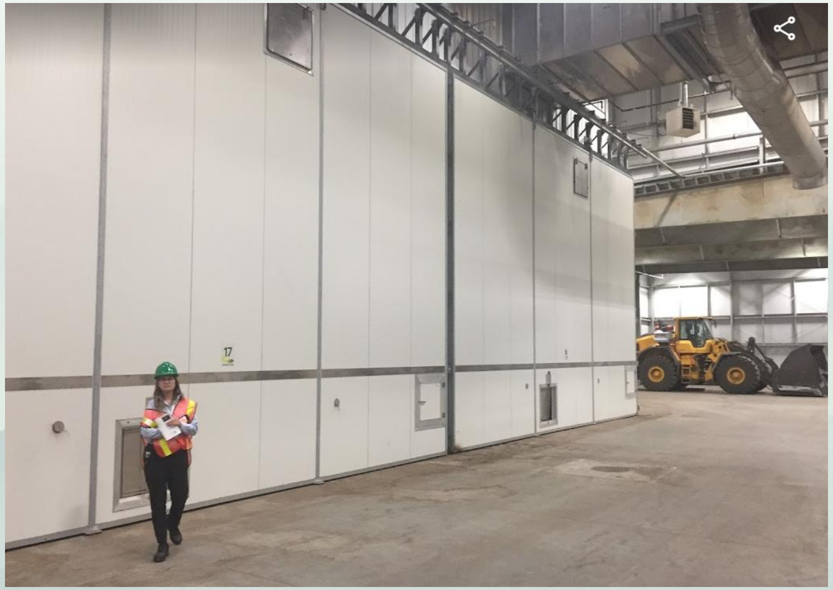
How to mitigate Condensing Conditions

- Dewpoint is the critical measure
- Process air typically 99-100% saturated
- Avoid mixing cold air with warm saturated process air
- Ventilate building at 10 air changes per hour

4.7

Tunnel Systems

- Reduces Headspace
- Reduces worker exposure
- Allows process air recirculatoin
- Batch processing only
- Typically 2-3 weeks in tunnel



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Compost Control Systems

- Temperature Feedback
- PID vs ON/OFF Controls
- VFD's to control flow incrementally

Temperature Data Collection

- How can you collect temperature data?
  - Wireless vs wired probes
- Data logging vs data acquisition and temperature feedback

Copyright Green Mountain Technologies, 2016

Types of Control Systems for Composting

- Basic timer system with on/off cycle
- ON/OFF vs PID logic
- Reversing aeration logic
- PLCs vs PC or cloud hosted platforms

Variable Frequency Drives (VFD's)

Variable Frequency Drive Energy Savings Calculator

The most common applications of using variable frequency drives are pumps and fans, suppose a 24/7 operate constant pressure water supply system's pump controlled by VFD may save as high as 30% electricity cost bills.

% Speed	% Hour
100%	30
90%	10
80%	20
70%	20
60%	10
50%	5
40%	5
30%	0
20%	0
10%	0
	100 %

Hours / Day 24
Days / Week 7
Hours / Week 168
Hours / Year 8,760

Motor size (HP):	75	Efficiency (%):	90
Input voltage (V):	480	Frequency (Hz):	60
Full load current (A):	56	Speed (RPM):	1800

Full load input power (kW): 41.9 kW

VFD Cost ($): 10000
Electricity rate ($/kWh): 0.15

Estimate annual operation cost without VFD: 54,994 $
Estimate annual operation cost with VFD: 33,200 $

Your Annual savings: 21,794 $
Payback time: 5.51 Months.

Calculate

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Case Studies

EnviroSmart Project Overview

In the spring of 2013 GMT was contracted by EnviroSmart to design a 100, 000 ton per year Turned Aerated Pad TAP) system for composting green waste and food waste from metro Vancouver, BC. GMT developed a 200x 200 aerated pad under roof using sparger nozzles to deliver high pressure air to a 10’ deep turned aerated mass bed. The system delivers reversing aeration based on temperature feedback with a biofilter for odor control. Based on the success of the sparger floor, GMT was hired to redesign the aeration trenches in the original ASP building and replace them with sparger nozzles due to clogging of the trenches.

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Food Waste Receiving with Depackaging

- Receives Curbside FW/GW
- Packaged expired ICI feedstocks
- Liquid waste from pumper trucks

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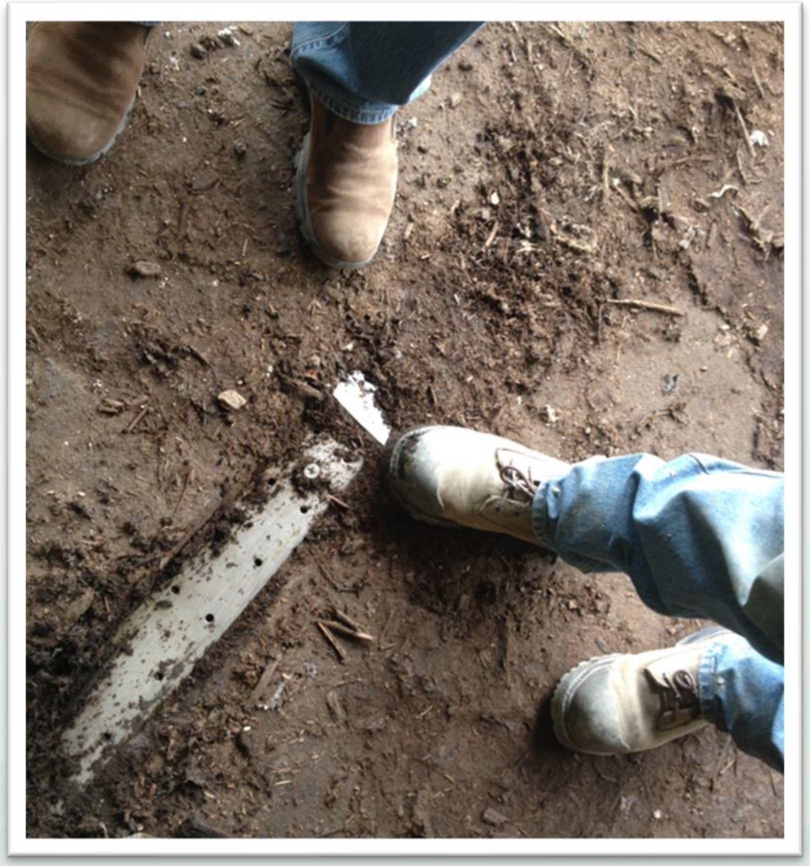
Building Retrofit to Replace Trenches

- Trench covers were crushing and then getting torn up by loader
- Required cleaning with every load
- One failed section would block the whole trench



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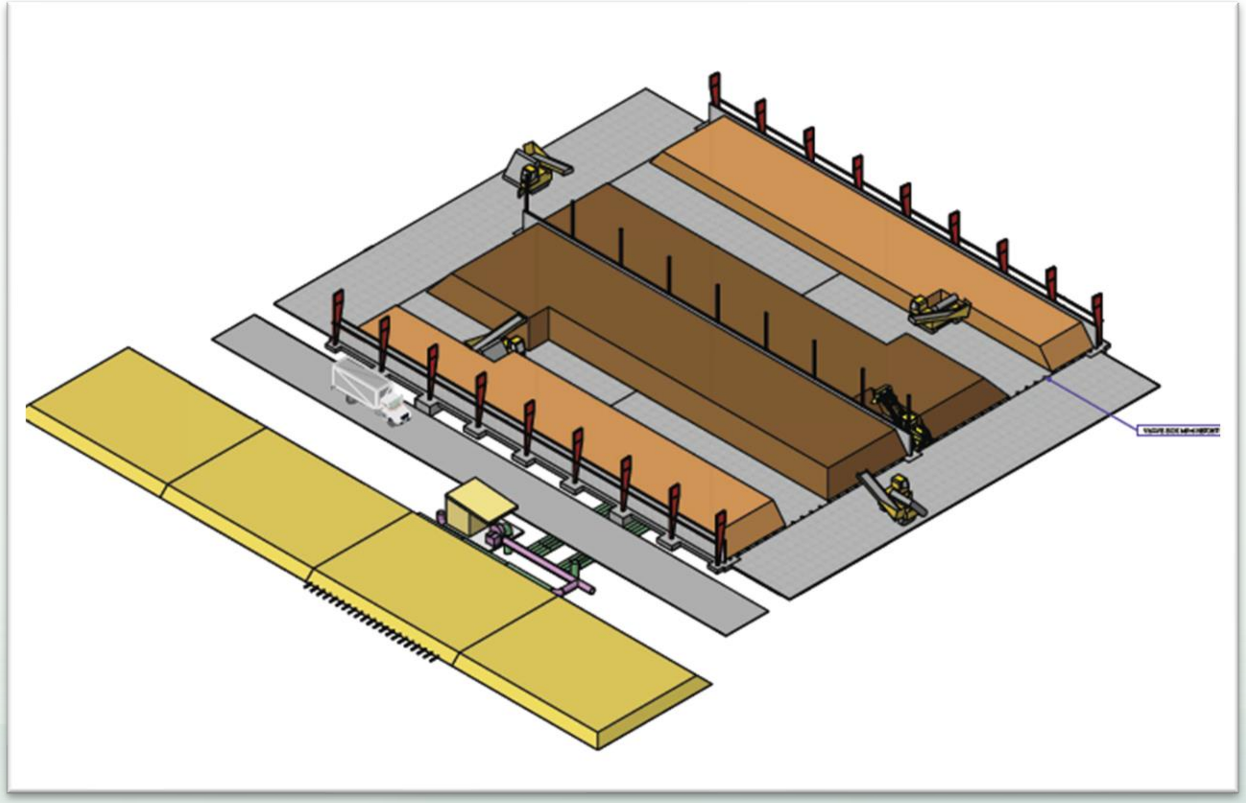
Turned Mass Bed Operation



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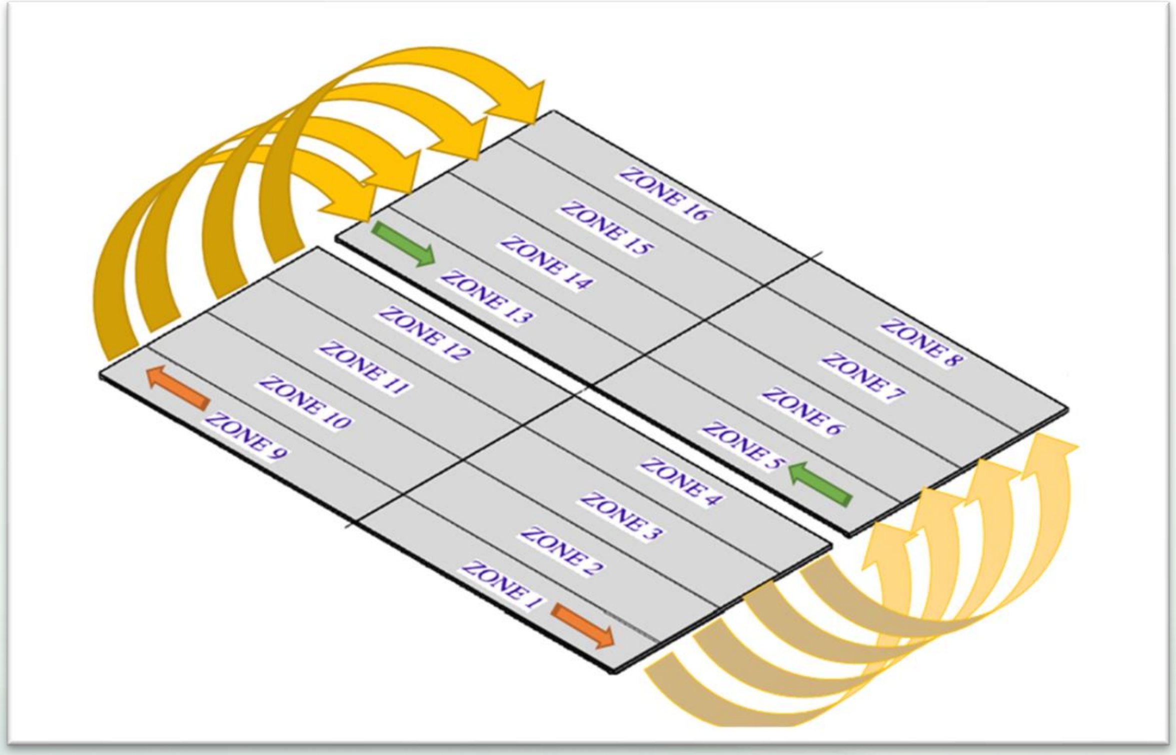
Aerated Static Pile Operation



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4.3.6

Case Study: Sun Peaks

- Containerized Compost System
  - 6 Containers
- Handled biosolids from the town of sun peaks (ski resort)
  - Mixed with woodchips
- Had lots of issues meeting PFRP and VAR
- In 2021 Thompson-Nicola District decided to compost their FW
- Asked GMT to help integrate it into existing CCS system
- 45% Wood, 45% Biosolids, 10% FW
- More FW to be added in future

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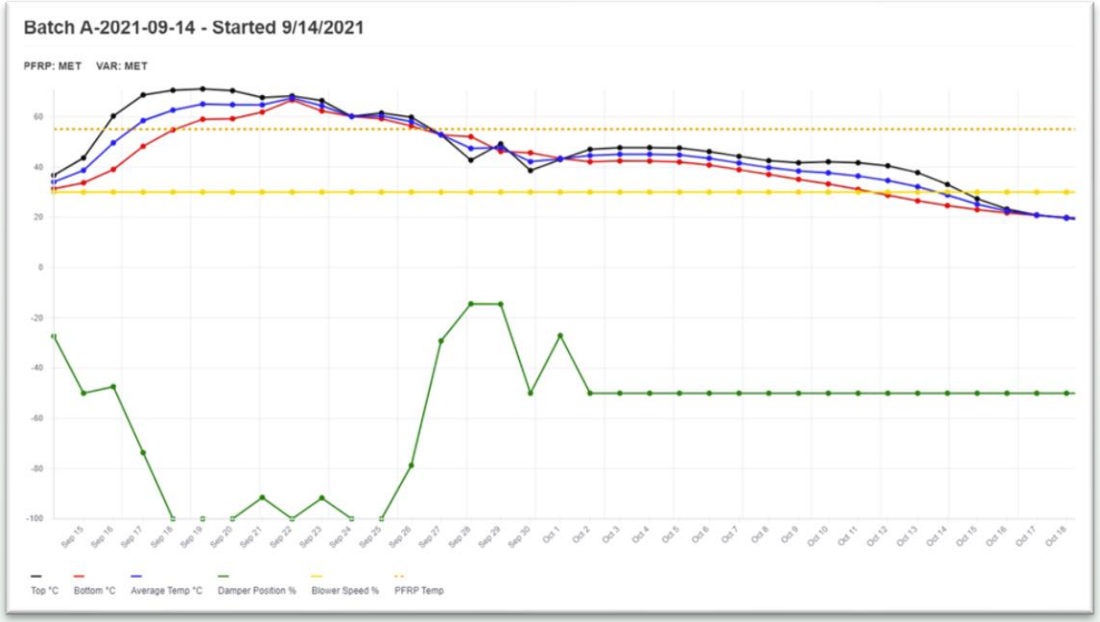
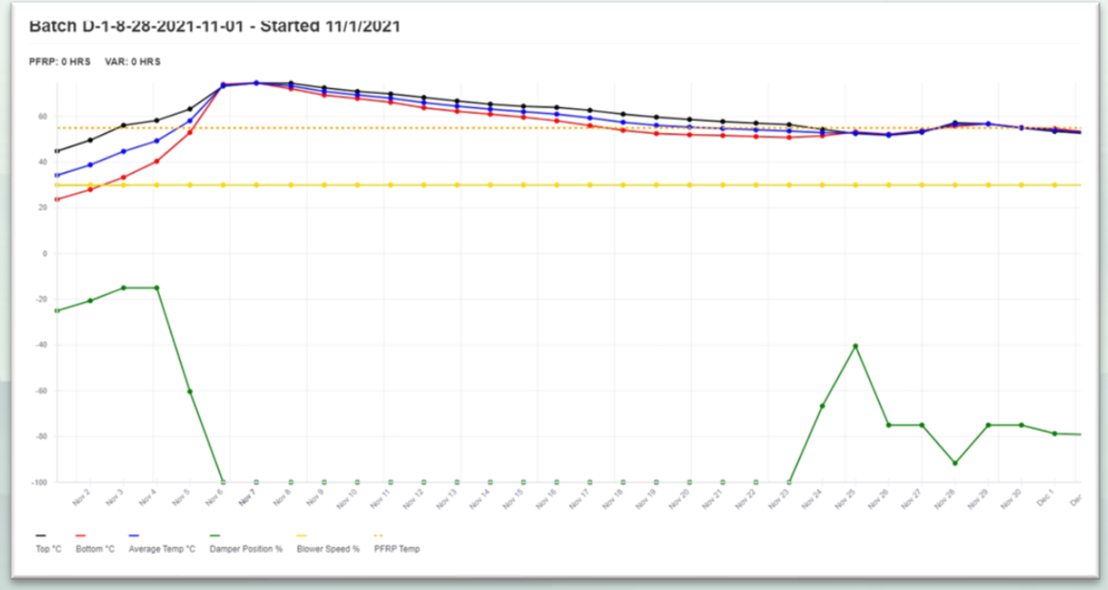
Case Study: Sun Peaks





- FW has energy !
- Biosolids have low energy !
- Woodchips have low energy !
- Mixer worked to homogenize material
- Hauling only from a few commercial sources.
  - They educated well, no contamination
- Sometimes the answer is right in front of you !

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Q & A

Pros and Cons of Adding FW to your Facility

Pros

- Adds Nutrients and Energy
- Adds Slow-Release Moisture
- Continuous Feedstock Source
- Higher Tipping Fees
- Meet Waste Diversion Goals

Cons

- Higher Odor Potential
- Adds Plastic Contaminants
- Higher Regulatory Standards
- Stinky leachate
- Vectors Such as Birds and Rats

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