Lenz Compost Facility, Stanwood WA
Plan of Operation

2019

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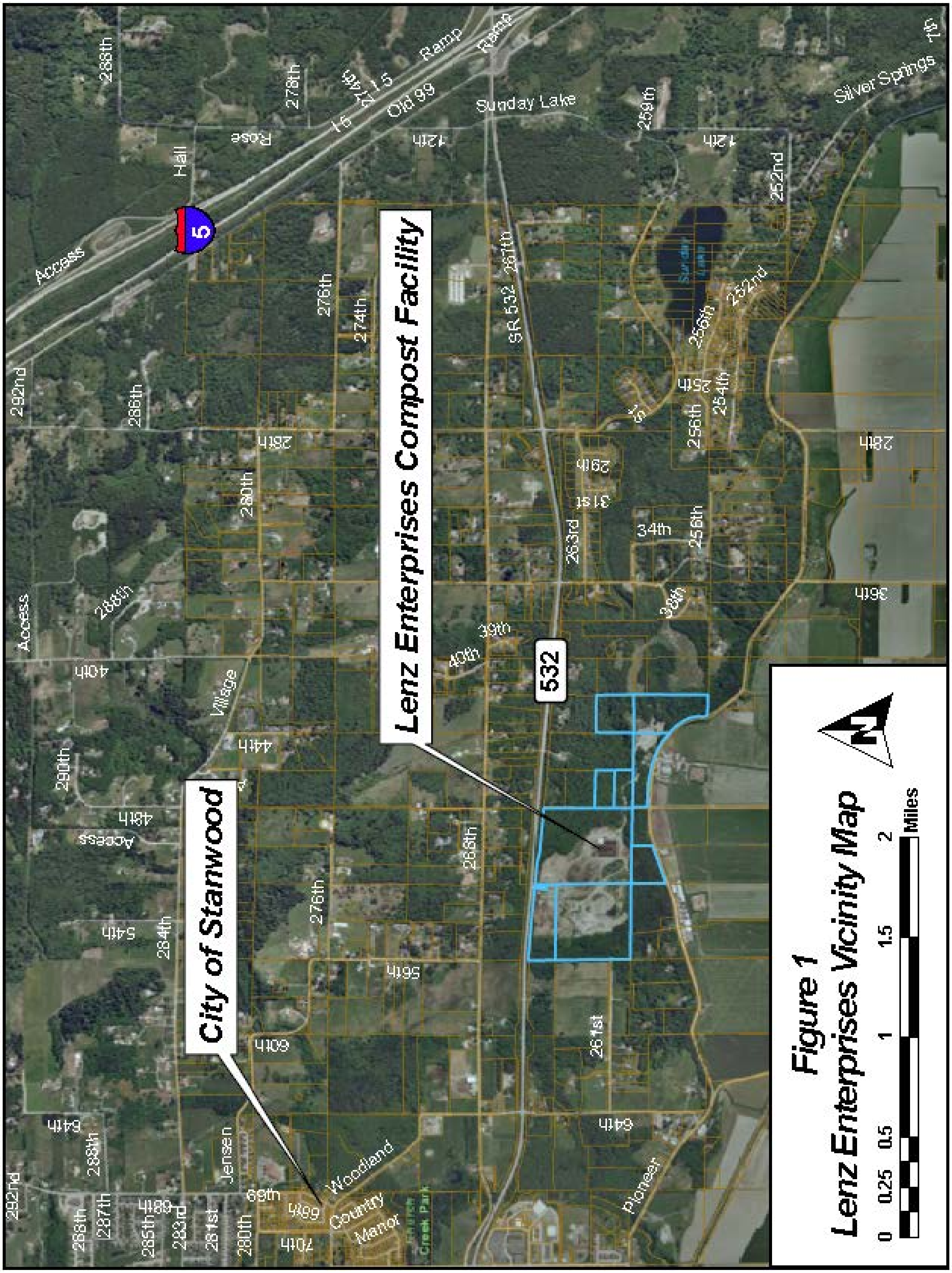


Figure 1. Location Map

I. Introduction

Overview

Lenz Enterprises, Inc. is a family-owned and operated earth materials and services company that has been serving Western Washington as a family-based operational facility since 1976 and as a Washington State corporation since 1985. The Lenz Enterprises facility is situated on approximately 160 acres in Snohomish County located just east of Stanwood. Lenz Enterprises has built a reputation for providing prompt, skilled service, and for stocking a full range of quality products from gravel to topsoil to mulch. The Lenz Compost Facility (LCF) began operations in 2008 and is permitted to process feedstocks as defined by Washington Administrative Code (WAC) 173-350-110 and site specific permits. Site operations are conducted in accordance with all rules, regulations, permit requirements, and the provisions of this Plan of Operation.

The mission of the LCF is to preserve and enhance the environment and create local sustainable environmental solutions by providing cost effective composting of organic materials from commercial, residential, industrial and municipal customers. The LCF strives to create a service beneficial the region by providing alternatives to landfilling. Quality soil amendments and landscaping products are the primary products derived from this process.

Purpose and Objectives

The purpose of this document is to describe acceptable methods of operation in compliance with all laws, rules and regulations; and to ensure a safe work place for site personnel. This document aligns with Chapter 70.95 Revised Code of Washington (RCW), WAC 173-350 requirements; and Snohomish County Code Title 7: Health and Sanitation.

Objectives include reducing impact to the environment through responsible recycling of organics; reduction of Greenhouse Gases (GHG); landfill diversion of solid waste, and production of a useful product. Regulatory objectives include:

- Develop, keep and abide by this plan of operation approved as part of the permitting process
- Convey to site personnel the concept of operation intended by the designer
- Make this plan available for inspection at the request of the jurisdictional health department
- Work with the jurisdictional health department to ensure the plan meets regulatory expectations

This Plan of Operation is a living document which requires review and update to ensure continual improvement of site activities.

Facility Description

The Lenz Compost Facility (LCF) is located within 108 permitted acres of land in Snohomish County, Washington designated as Mineral Resource Lands. Operations are accessed by an all-weather gravel road. Composting activities occur on approximately eight acres of land and all active composting occurs on a pad meeting the requirements of WAC 173-350.

Active composting includes:

<u>Phase 1 Composting</u>: High-Rate Phase, Aerated Static Pile (ASP) composting with controlled forced airflow plenum (negative airflow - top down; positive airflow - bottom up; or no airflow) with constant temperature monitoring;

<u>Phase 2 Composting</u>: Stabilization Phase, Windrow composting with manual temperature and gas production monitoring; and may include:

Phase 3 Composting: Curing Phase; Turned or Unturned composting. This material may be screened or unscreened. Curing occurs for some materials based on the maturity of the product after Phase 2 Composting and the ultimate use of the final product.

The LCF is designed to ensure that compost meets WAC 173-350-220 regulatory requirements before leaving Phase 2 composting. Compost may, or may not be cured on site depending upon product demand and the requested character of the final product.

The LCF system begins with on-time handling of received organics, and mixing and grinding of the material. The first stage of composting used on site is the Aerated Static Pile (ASP) method of composting. System controls for the LCF ASP were developed by Engineered Compost Systems (ECS). The ASP method uses aeration trenches installed in concrete beneath the compost pile; aeration trenches are connected to electric blowers that provide either positive or negative aeration. Positive aeration forces air into the compost pile and negative aeration draws air through the pile. Application of the ECS ASP methodology allows for precise temperature and moisture control during the initial phase of composting resulting in efficient destruction of pathogens, rapid stabilization of compost and reduced VOC generation. This high-rate process is characterized by high oxygen uptake rates, thermophilic temperatures, and high biodegradable volatile solids (BVS) reductions.

The next stage of composting is the Windrow Stabilization Phase. During the Windrow Stabilization Phase the compost continues to undergo biological stabilization. This process occurs under similar conditions to Phase 1 composting only compost conditions (i.e. temperature, moisture, aeration, etc.) are controlled by turning the compost rather than by forced aeration. This stage of composting is characterized by lower biological activity resulting in lower oxygen uptake rates than Phase 1 composting and lower temperatures.

The third stage of composting (Curing), when needed, is characterized by lower temperatures than the previous processes and reduced oxygen updated rates. The Curing Phase provides time for degradation of the more refractory organics and re-establishes lower temperature microbial populations, which are beneficial in creating mature compost.

The Lenz facility includes:

- Weigh Scales
- Organics Receiving Area
- Organics Pre-Processing And Post-Processing Equipment
- Contaminant Removal Picking Station (as needed)
- Contaminant Removal Equipment and Screens
- Material Grinding and Mixing Equipment
- Aerated Static Pile Equipment and Controls
- Leachate Collection, Treatment and Reuse Facilities
- Finished Product Screening and Storage Facilities

Lenz Enterprises compost facility meets all mandated local, state and federal operating requirements, some of which include time and temperature for providing pathogen control and stability of finished compost products.

The compost facility is permitted through the Snohomish County Health District (Permit No. SW-106) and the Puget Sound Clean Air Agency.

Site Access, Contact Information, Location and Typical Hours of Operation

Access

Site access is from SR 532 as shown on the Site Vicinity Map in Figure 2.

Site Contact

Lenz Enterprises Inc.

P.O. Box 868

Stanwood, WA 98292

Attn: Jason Lenz

Email: jason@lenz-enterprises.com

Phone: 360.629.2933

Hours of Operation

Typical hours of operation for receiving and processing feedstocks is 7:00 a.m. to 5:30 p.m., Monday through Saturday.

Figure 2. Lenz Enterprises Facility Overview

II. List of Feedstocks

The composting process at the LCF begins with proper identification and sourcing of feedstocks. Acceptable feedstock shall be limited to organic materials meaning any solid waste that is a biological substance of plant or animal origin capable of microbial degredation Organic materials include, but are not limited to manure, yard debris, food waste, food processing wastes, wood wastes, yard waste, yard waste mixed with food waste, pre-consumer food waste, post-consumer food waste, wood and paper fiber, untreated wood waste that is free of paint, agriculture crop waste, wax coated cardboard, animal manure and bedding, paunch waste and shell.

Feedstock Sources

Sources of feedstock for the Lenz Enterprises compost facility may include solid and semi-solid organic wastes generated by residential, commercial, municipal and industrial sources. Source examples include: home, lawn, landscaping and mowing services; municipal yard, garden and food-waste collection; construction and land clearing service companies; solid waste collection facilities; animal slaughterhouse facilities; cold storage facilities; pre-consumer food processing facilities; orchards, produce farms organic farms, and viniculture; home gardeners; and other residential, commercial, municipal and industrial sources that have similar organic feedstocks.

Unacceptable materials include feedstocks, not identified by site specific permits such as, liquid wastes, non-herbivorous animal manure, wood waste containing chemical preservatives of paint, biosolids and similar materials.

Feed Stock Acceptance Criteria

Once a potential feedstock is identified, a characterization assessment is conducted to ensure that the feedstock meets permit conditions. If the origin of the material is unambiguous and meets the feedstock criteria as defined by permits, then the material may be accepted. If the origin of the material is ambiguous or from a source that is not typical, additional assessment will be conducted. This may include a review of generators, handling, pre-sorting, trucking, and holding times at a minimum. Laboratory analyses may be performed on a representative sample if necessary to ensure that the feedstock meets acceptance criteria. If during any part of the feedstock assessment questions arise as to the acceptability of the material, a consultation and determination with the Snohomish County Health Department (SCHD) will be requested.

Table 1. Examples of organic materials accepted at Lenz Enterprises, contaminating materials, and prohibited materials.

Allowable Materials	
Compostable paper	Food waste
Cardboard	Manures (herbivore only)
ASTM compostable films and containers	Produce
Branches, leaves, grass, and brush	Bread
Non-painted wood, non-treated lumber	Animal bedding
Non-painted wallboard	Saw dust
Commercial food scraps	Stumps
Meat and dairy waste	Approved manufactured compostables
Contaminating Materials (removed or rejected)	
Textiles, carpet, upholstery	Shrink wrap and Styrofoam,
Diapers	Shoes, leather, non-compostable fibers
Plastic film and rigid plastics	Concrete
Tires/rubber	Brick
Ceramics	Tile
Glass	Metal

Asphalt and Asphalt roofing	Grease and other non-compostable materials
Prohibited Materials (not allowed at Lenz Enterprises)	
Hazardous waste	Household hazardous waste
Medical waste	Feces
Special/designated waste	Painted and treated wallboard
Painted and treated wood	Contaminated soils
Appliances: white, brown, grey goods	Universal waste and e-waste
Liquid waste	Biosolids

III. Description of Organics Handling

Entrance to the site occurs from State Route 532, approximately three miles west from Interstate-5. Scales are located at the site entrance. An all-weather gravel road leads from the scales to the compost site, approximately 500 feet from the site entrance. Incoming trucks carrying compost feedstock are received and weighed at the scale house. Daily weight records are maintained by the scale operator entering feedstock quantities. Haulers are directed to follow the signs to the processing area; for safety and efficiency during winter operations, directional signs are reflective. Incoming loads are weighed in, identified, and directed to the appropriate unloading area.

Materials are received and unloaded at the facility as quickly as possible. Lenz Enterprises strives to maintain streamlined conditions at its scale house to avoid potential delays and processes loads in a timely manner. After delivery of organic materials, trucks return to the scales following the route shown on Figure 3.

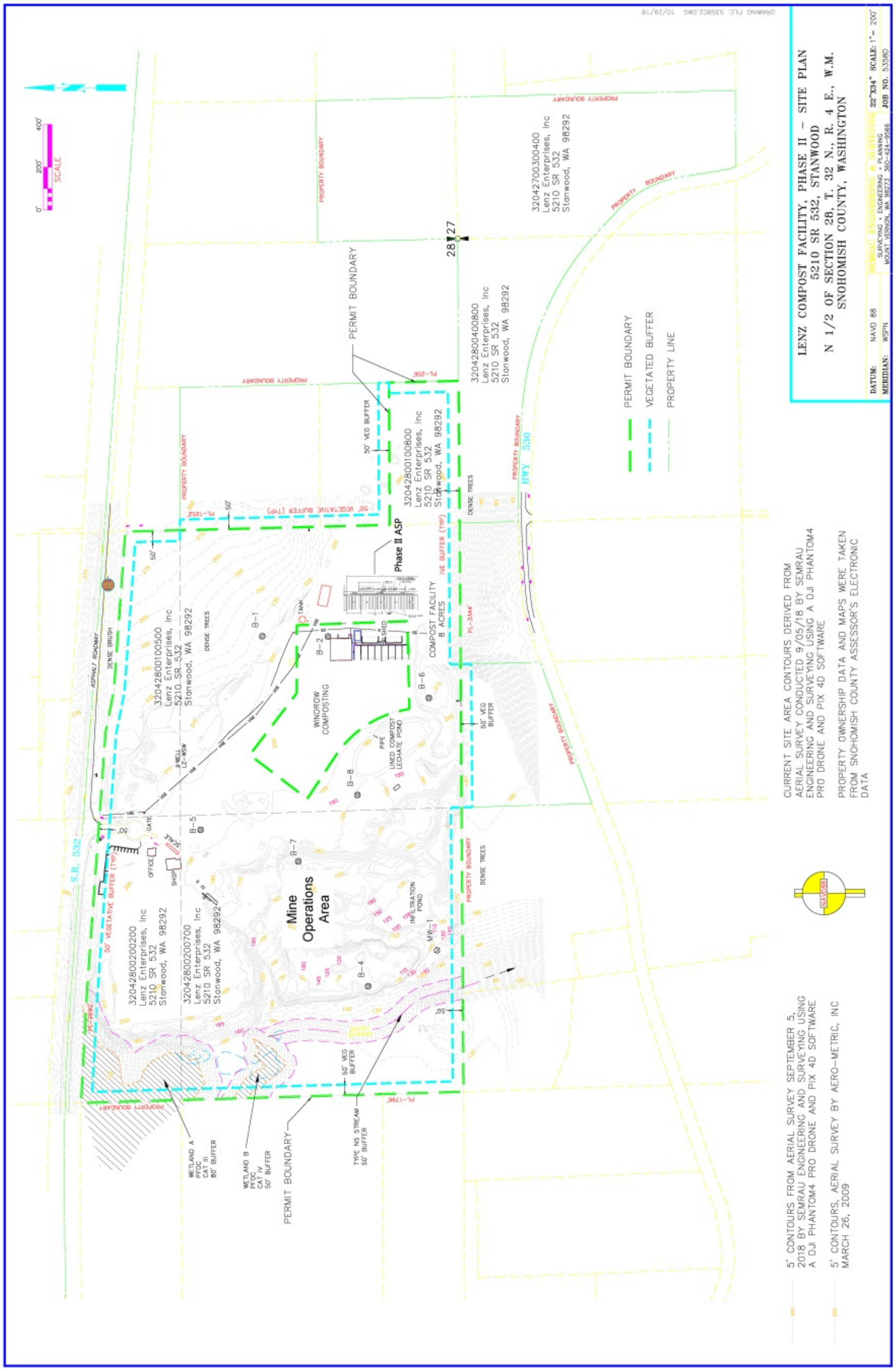


Figure 3. Lenz Compost Facility Overview

The organics receiving area includes a 180 foot by 103 foot open air concrete slab for receiving and storing feedstocks and a 10,000 square foot steel tipping and processing building (Building A) enclosed on three sides. Building A includes an air collection and handling system to capture potential odors from the processing of organics and routes this air through a biofiltration system for treatment prior to discharge to the environment.

Organic feedstocks primarily are unloaded in Building A. Material is then sorted and processed. Putrescible feedstock is always unloaded within Building A. Self-haul yard waste drop-off occurs adjacent to the processing building; if grass is included in the self-haul organics, it is immediately moved to the processing building. The self-haul delivery area is shown in Figure 4. Commercial, industrial and municipal organics and putrescible feedstocks are unloaded in the main receiving are of Building A and are inspected after unloading to ensure that loads meet site acceptance criteria.

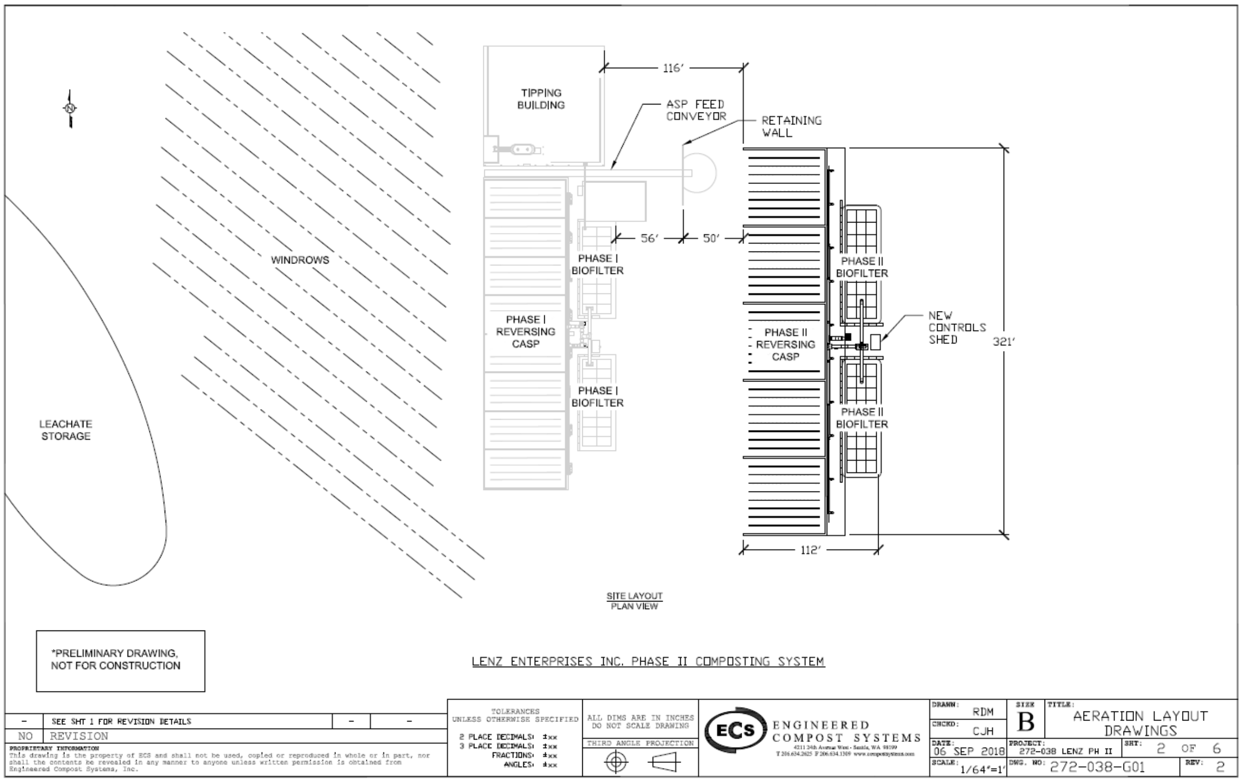


Figure 4. Lenz Compost Facility Detail

Organic material largely consisting of yard waste from commercial sources (e.g., landscapers) is also directed to Building A. Current practice dictates that grass and grass mixed loads be directed to slightly separate unloading area from the brush and wood. Wet organics such as paunch manure, food waste, and grass are also unloaded within Building A. Small quantity generators (e.g. local, residential self-haul customers) are directed to either the yard waste receiving pad located as shown on Figure 4 or to the small quantity generator sealed bins located near the site entrance.

Upon receipt of approved loads of organic materials, primary processing commences. If material is received bagged, the bags are broken open using a loader or equivalent mechanism. If the bags are Lenz-approved compostable bags, they will remain with the yard debris. Non-compostable bags are removed and disposed of at a licensed landfill or other approved disposal location with other non-compostable materials gleaned from the input stream. Brush and woody debris are separated and ground in the existing Lenz Enterprises wood waste processing area on the site.

Food waste, because of its potential putrescibility and vector attraction characteristics, is immediately incorporated with on-site yard debris (ground or unground) and other bulking agents as necessary. Other compostables are managed based on their putrescibility through grinding or bulking, as conditions dictate.

At a minimum, two employees are involved in the management, processing and handling of incoming and finished materials at this site. This is for operational and safety reasons and to ensure proper and efficient operations.

Organic residuals delivered to the site from curb-side recycling will be manually picked through, after grinding, but before delivery to an ASP bay for Phase I composting.

IV. Procedures for Handling Unacceptable Wastes

Prior to unloading, each load will be inspected to confirm contents and to observe levels of potential contaminants. If contaminants are as described in contractual agreements, as defined based on the current LCF operations plan, or are observed to be de minimis, the load may be discharged. The load will continue to be inspected during and after tipping to assess contaminants content; site personnel will also inspect the offloaded materials.

If contaminant content is observed by site personnel to be excessive, the load is not discharged and is turned away from the facility. Any load that is partially or fully discharged and determined to include excessive non-compostable contamination will require validation of the extent of contamination. Validation is conducted based on protocols mutually acceptable to Lenz and commercial customers if a contract is in place; and by regulatory requirements or restrictions.

For loads deemed to be unacceptable, Lenz Enterprises site equipment is used to re-load materials onto the transfer vehicle for return per contract specifications when applicable. If possible, and also based on a mutually agreed upon protocols, partial loads may be rejected and acceptable portions processed.

In the event that, at any point in the contaminant inspection process, the site operator is temporarily occupied with other activities and direct inspection is not possible, the daily records will be compared to loads received and any hauler responsible for delivering unacceptable loads will be notified to return to the site to retrieve the unacceptable materials; or the materials will be handled by LCF site personnel if other handling agreements are in place. A video camera located at the compost office is directed toward the unloading areas to assist in monitoring unloading activities.

Waste materials delivered to the site, classified as Municipal Solid Waste (MSW), and not suitable for composting, will be:

- Removed from the site within twenty-four hours or placed in an on-site covered dumpster.
- Storage of MSW will occur in such a manner as to prevent rodents, insects, and other animals from accessing the contents as a food source.
- Putrescible solid waste will be removed from the site to a permitted solid waste handling facility no less than once per week.
- All MSW will be disposed of at a permitted solid waste handling facility.

V. Mass balance calculations for feedstocks

Composition of the initial compost mix is one of the most critical factors in developing successful compost and reducing potential odors. Organic materials must be properly blended to provide the nutrients that support microbial activity and growth, including a balanced supply of carbon and nitrogen (C:N ratio); and proper physical characteristics.

Determining the appropriate mix ratio for feedstocks and bulking agents requires knowledge about the material properties and requirements of the composting process. Feedstock volume and character can vary by season. Green wastes from residential sources, for example, increase in the spring and continue through late fall. Commercial and industrial sources can also fluctuate based on seasonal or product demand. These types of variations require the operator to assess each feedstock to be mixed for each batch and make determinations based on experience and knowledge of the feedstock.

When prior knowledge of feedstocks is not available mass balance calculation can be useful in determining appropriate mix ratios. Mass balance calculation for feedstocks and amendments are dependent upon several factors including:

- Carbon to Nitrogen Ratio (Target range 20:1 – 40:1)
- Volatile solids (Target range is dependent upon other material composition)
- Moisture Content of Mix (Target range 40-65 Percent)
- Particle Size and Exposed Surface Area on Feedstocks (Dependent upon feedstock character and use for compost)
- Interstitial Space (Target 30%)
- Bulk Density (Target range 800 – 1,000 lbs/yd^3)

LCF personnel have several calculations available to them in an Excel spreadsheet format for ease of use and consistency in results.

An example of average carbon-to-nitrogen ratios, moistures and densities for types of feedstocks typically accepted at the LCF is shown below. Additional information on a wider variety of feedstocks is included in the LCF Feedstock Calculator.

Information on currently processed feedstocks is included in Table 2.

Ingredient	Season/Time Frame	Purpose
Paunch Manure	Year-Round	Nitrogen & Wetting Agent
Yard Debris Self Haulers	Year-Round but more in Spring and Fall	Porosity & Nutrients
Yard/food waste & curbside collected	Year round	Porosity & Nutrients
Land clearing, stumps, Brush & Hogged fuel	Year round	Porosity & Carbon
Paper Fiber, Wood fiber, wood shavings & Saw dust	Year round	Carbon and Drying Agent
Pre-consumer food Waste	Occasional	Porosity & Nutrients

The volume of incoming organic feedstocks currently varies by season. A quarterly characterization for different seasons, along with the general type of materials produced is provided below:

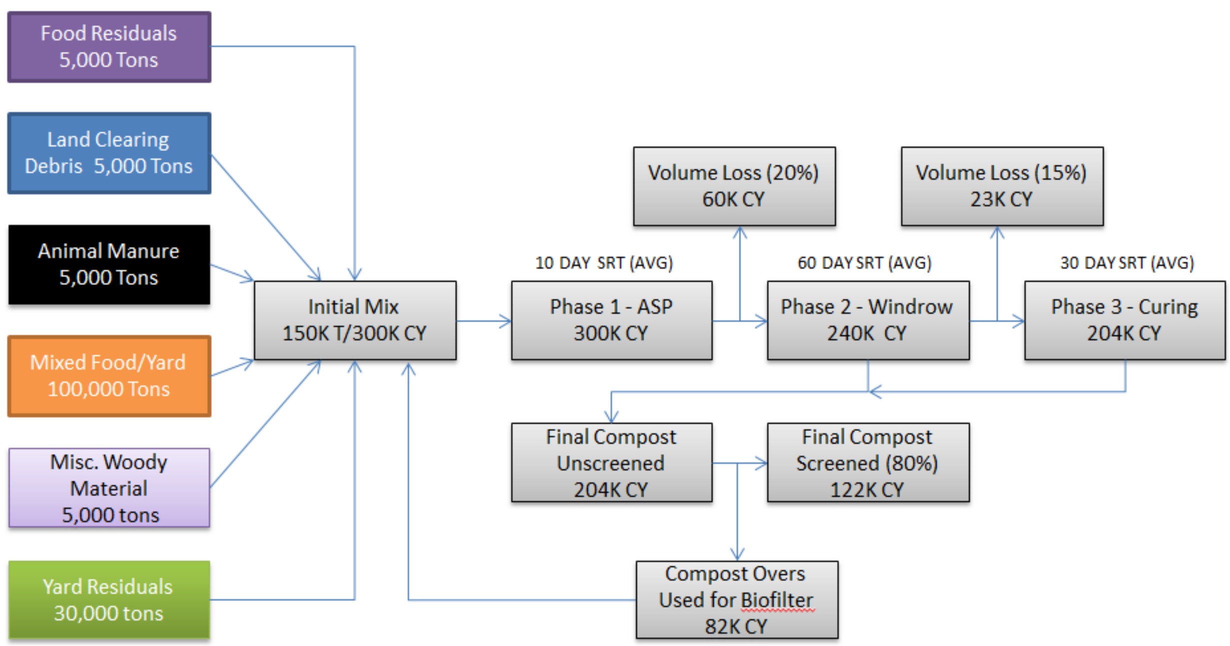
- First Calendar Year Quarter – Organic feedstocks consist primarily of brush and yard waste, lacking in nitrogen.
- Second Quarter – Organic feedstocks consist primarily of curb-side recycled organics that may contain up to 10 percent food waste.
- Third Quarter – similar to 2nd quarter but less quantity.
- Fourth quarter – Incoming organics consists of leaves, pumpkins, Christmas trees, corn stalks, and food waste.

Future feedstock source development will consider overall LCF mix requirements prior to acceptance or contractual agreements. This evaluation will consider feedstock character, volume/mass per unit time, seasonal variations and special considerations where applicable. This type of evaluation is required prior to acceptance of each new feedstock to ensure a proper balance of feedstocks are available in the correct quantities to maximize compliant and efficient compost operations.

Annual Mass Balance Flow Chart

The following Mass Balance Flow Chart illustrates approximate measurements of materials processed annually.

Lenz Compost Facility Mass Balance Flow Chart 150K Tons Organics



VI. Material flow plan

Material flow can generally be categorized into the following:

- Incoming Organics Handling (Feedstocks)
- Acceptance and stockpiling of bulking agents
- Feedstock Preparation (grinding, mixing, conditioning)
- Phase 1 ASP Composting (Pile Construction, Aeration, Monitoring)
- Phase 2 Windrow Compost Stabilization (turning and monitoring)
- Phase 3 Compost Curing
- Screening
- Material Return (Used as compost cover, used as part of bio-filter)
- Finished Compost Storage, Mixing and Sales

Material flow is illustrated in Figure 5.

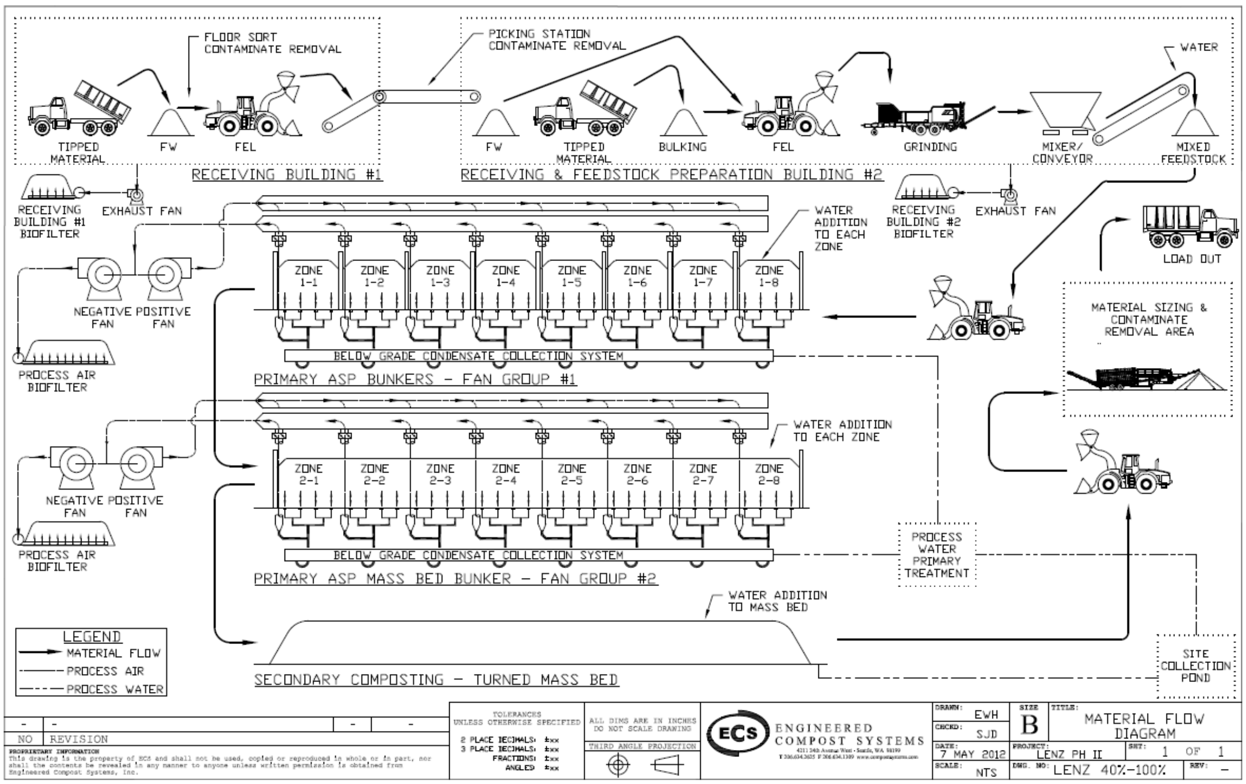


Figure 5. LCF Material Flow

Composting at Lenz Enterprises includes controlled biological stabilization of organic materials. The composting process is optimized to yield a desired and valuable end product. Biological processes are optimized by combining feedstock received in the correct proportions and maximizing site design conditions and then actively managing critical environmental parameters.

Lenz Enterprises accepts organic feedstocks that include yard debris and other vegetative waste from commercial and residential sources. Lenz Enterprises' compost permit, SW-106, issued by Snohomish Health District, allows for processing feedstocks defined in WAC173-350-220 and permit conditions.

Lenz Enterprises processes feedstock at the facility based on customer need and peak throughput capacity. The majority of the expected feedstock includes:

- yard debris;
- pre-consumer vegetative food waste;

- meats, dairy, and post-consumer food waste;
- agricultural residuals and paunch manure;
- wood waste;
- and approved compostable bags, packaging, and food service ware.

Feedstock sources include commercial and residential generators and mixtures of the above-listed feedstocks.

Compost is initially stabilized in “Phase 1 ASP Composting”. The LCF compost system employs the ECS aeration system for Aerated Static Pile (ASP) composting. The ECS ASP system uses a centralized aeration distribution system that provides metabolic oxygen and cooling for the aerobic composting process. Two variable-speed fans generate the necessary airflow through supply and exhaust plenums. Dampers at each zone modulate the airflow to the material. These dampers can supply negative airflow (top down), positive airflow (bottom up), or turn the airflow off. A variable portion of the exhaust air is re-circulated or exhausted. The make-up air and exhaust air volumes are controlled by motorized dampers with a feedback signal from the Control Node. The main goal of initial stabilization is to reach pathogen reduction time and temperature and to begin the aerobic composting process.

Once the goals of initial stabilization have been met, compost is moved to the pad directly west of the active ASP zones 1 - 8. This area is approximately five acres and is used to further stabilize compost using the Windrow composting method (Phase 2 Composting). The Windrows are turned to maintain the proper levels of porosity and oxygen content, mix in or remove moisture, redistribute cooler and hotter portions of the pile, and generally homogenize the material. The main goal of Phase 2 Composting is to reach a state of stabilization and material quality that allows for use of the product. Material is sampled and analyzed per WAC 173-350-220 requirements. If laboratory results meet regulatory standards the material may be sold, mixed with other products or move on to Phase 3 composting depending upon its determined use.

Phase 3 Composting is commonly referred to as a curing stage. Phase 3 Composting consists of turned or unturned composting. The goals of Phase 3 Composting are to further stabilize the material until such time that it meets the requirements for a designated use.

Supporting processes include a leachate collection and treatment system, which collects leachate from all active composting, stabilizing and curing areas; and a biofiltration system used to clean air from both the feedstock processing building and the ASP active compost zones.

Mixed Organic Material Pre-Processing

Once unloaded, facility staff separate incoming feedstocks into “wet” and “dry-bulky” material types through a combination of hand picking and use of site equipment. “Wet” feedstocks are materials such as grass clippings, food waste, paunch manure, and other agricultural waste. Bulky materials eventually become the necessary bulking agents for the composting process and typically include yard and land clearing waste with a high wood content.

Because the ratio of carbon to nitrogen in a compost feedstock is a critical parameter that dictates material decomposition rate, Lenz Enterprises balances yard and wood waste with other feedstocks that contain higher levels of nitrogen. Wood wastes can be stored on the site in unprocessed form due to biological stability.

Incoming Organics Handling

Upon receipt of approved loads of organic materials, primary processing commences. If material is received bagged, the bags will be broken open using a loader or equivalent mechanism. If the bags are LCF-approved compostable bags, they will remain with the incoming organics for processing. Non-compostable bags will be removed and disposed of at a licensed landfill or other approved disposal location with other non-compostable materials gleaned from the input stream. Brush and woody debris will be separated and ground in the existing Lenz Enterprises wood waste processing area on the site.

Food waste has a lower (C:N) ratio than green waste due to its higher nitrogen content. Food waste must be mixed with higher carbon materials in a specific recipe in order to compost optimally without development of odors and anaerobic conditions. Typically the C:N ratio for food wastes is 14-16:1. Food wastes generally do not store well as incoming material to the composting area because of their higher moisture content. LCF incorporates food wastes into a biologically active composting process with the shortest possible storage period prior to incorporation. Piles of food waste are surrounded with a perimeter of wood chips for absorption of any liquids that leach out; leachate is captured in the site leachate collection system, treated with the leachate treatment system and stored in the leachate storage lagoon. Food waste is at no time stored outside. Gross categorical separation and contaminant removal will occur in the tipping building, Building A.

Size reduction of bulky materials -yard debris and clean wood – is accomplished using an excavator, and a horizontal grinder. Materials will typically be reduced to a 6-inch minus size. In the ASP composting system, wood chips of both the smaller size and larger size are needed: smaller wood chips provide carbon to the process and break down completely; larger chips provide bulk to the pile, increasing structural porosity and air flow. Larger chips are screened out as “overs” and are re-used in the mixing and composting process until they break down completely.

The horizontal grinder will then be used to prepare the ultimate feedstock mix. An excavator adds appropriate volumes of wet and bulky material into the mixer. Loading and mixing take place in Building A. Compost “recipes” are based on character of incoming feedstocks and LCF professional knowledge in producing commercially viable end products. Water is typically added to obtain the proper moisture content. The LCF includes a 132,000 gallon fresh water tank that provides a fresh water source for compost. The tank consistently maintains a 90,000 gallon capacity for fire flow, but the remainder is available for site process usage. Alternatively, moisture is provided to the compost mix using recycled and treated leachate.

At the LCF, odors are controlled partially through moisture management and by optimizing C:N ratios through correct feedstock mixing. Excessive moisture in a compost pile restricts the flow of oxygen into the pile and may cause anaerobic conditions with resulting nuisance odors. An ideal C:N for a feedstock or feedstock mixture is approximately 30:1. Ratios of greater than 40:1 slow the composting process while ratios of less than 20:1 lead to nuisance odors as nitrogen converts to ammonia and gases off. When mixing and grinding are complete, materials are moved to the ASP. Lenz Enterprises strives to meet the feedstock mix parameters shown in Table 3.

The initial mixing at Lenz Enterprises is accomplished promptly to produce a homogeneous blend of materials as the first step to mitigate potential nuisance odors. If feedstock cannot be processed immediately upon delivery it will be covered with either a bulking agent or finished, un-screened compost to minimize odors (compost overs). These materials will be stockpiled behind the center drain of the receiving building to allow for leachate collection and maximize air handling.

Table 3. Lenz Enterprises feedstock mix parameters.

Parameter	Mix Goal
% Solids – by weight	40 – 45%
Moisture	60%
Density (lb/yd3)	850 – 950
Carbon:Nitrogen Ratio (Ideal)	30:1

ASP Composting Process

Lenz Enterprises uses the Aerated Static Pile (ASP) method of composting, combined with the window method. Control systems for the ASP were developed by Engineered Compost Systems (ECS). The ASP method uses aeration trenches in the concrete beneath each compost pile; aeration trenches are connected to electric blowers that can force air into the compost pile (positive aeration) or draw air through the pile (negative aeration). The Lenz Enterprises composting process includes phases for active composting, stabilization, and curing. Average timing associated with each phase of treatment is included in Table 4.

Table 4. Lenz Enterprises compost process performance standards

Compost Phase	Time (days)
Active Aeration	10 days average
Stabilization	60 days average
Curing	Dependent upon demand and quality of compost

Lenz Enterprises uses the following methodology for each material batch being prepared for active composting:

- Prior to placing material into one of the ASP airfloors the aeration setting is optimized to avoid drawing material into the aeration trenches.
- A layer of dry coarse material may be placed over the aeration trenches as a diffuser layer or the mixed material batch may be placed without the diffuser layer and aeration trenches are thoroughly cleaned between batches.
- The remainder of the batch is loaded onto the pile and temperature probes are added.
- A minimum 6-inch cover of finished compost, or other approved biofiltration media, is then added to the newly-created mixed feedstock materials. This covering serves three purposes:
    - Provides insulation to ensure that all of the materials reach desired temperatures for pathogen reduction, weed seed destruction, and vector attraction reduction
    - Acts as a biofilter to digest odor-causing compounds and VOCs before being emitted to the atmosphere
    - Aids in moisture maintenance.

The LCF employs computer controlled centralized aeration that provides metabolic oxygen and cooling for the aerobic composting process. Within this system, two variable-speed fans generate airflow through supply and exhaust plenums. Dampers at each compost pile location modulate airflow to each pile. These dampers can supply negative air flow (top down), positive air flow (bottom up), or no air flow. The computer continuously monitors the composting process, adjusts fan speeds and damper settings, and produces a process temperature compliance record for each batch.

The ASP piles are constructed on a concrete slab that drains by gravity to a leachate collection sump. A pump is used to transfer leachate to the auger mixer or grinder discharge belt to water the feedstocks during the initial days of composting. Individual pile sizes typically equate to either 800 or 1600 cubic yards in Phase I and Phase II ASP air floors respectively. Shrinkage through the curing process will result in material consolidation and decomposition, reducing overall pile size and yardage by the end of the active phase of composting.

During the active phase of composting, pathogen reduction will be met in accordance with WAC 173-350-220. To meet the requirement, temperatures within the pile are maintained above 55°C (131°F) for a minimum of 72 hours (3 days). If a particular compost batch falls below optimum moisture levels, the pile will be remixed and watered. Often, recycled leachate is used to provide required moisture to a batch; leachate that is added is treated with the on-site advanced leachate treatment system to ensure that bacterial re-growth does not occur.

In addition to temperature control, oxygen levels are maintained to enhance aerobic decomposition; an oxygen level of approximately 5 to 8 percent within the pile reduces the chance for odor production (lower levels of oxygen allow conversion of nitrogen to ammonia, resulting in odor).

Windrow Stabilization

After ASP composting, compost batch placed in a windrow (refer to Figure 4). A compost turner is used to add either fresh water or leachate, and to blend and re-homogenize materials. The turner allows porosity to be re-established and air to reach all parts of the compost pile. The turner discharges the mixed compost against the previously turned pile, creating an extended bed of turned compost. These windrows will, with the provision of adequate bulking agents in the mix, maintain aerobic conditions. Turning of the actively windrows occurs at least once every seven days. The primary goal of stabilization is to maintain at least 2% oxygen in the mass bed. Oxygen is checked regularly using an oxygen meter.

At the LCF, compost stability is measured as carbon dioxide evolution using the Solvita Maturity Test. This test indicates that compost is stable when carbon dioxide evolution rate and ammonia are at low.

Curing

Compost may be cured at Lenz Enterprises once the material meets all regulatory requirements for Final Compost. Not all material produced on site is cured, this process is driven by the requirements for ultimate use of the product and supply and demand. The curing phase may be accomplished either in the original compost pile or in a separate stockpile prior to sale to end users. If the finished product is to be screened, the screening process can take place either before or following product curing. The compost curing area is shown in Figure 4.

Final Screening

After curing, the compost is screened to specifications. The screening process separates the coarse fraction of the compost, typically comprised of coarse wood. The coarse fraction is cleaned to remove the remaining contamination (typically plastics) and sold as mulch or is re-introduced as cover in the ASPs for odor control. Screeners include a Komptech L3 Star Screen with wind screen plastics removal system for final contaminant removal prior to storage and ultimate sale or topsoil blending and trommel screens.

Pathogen Reduction

Washington State Solid Waste Regulations (WAC 173-350) govern pathogenicity of commercial compost. The criteria applicable to the LCF, as referenced in the Snohomish County issued solid waste permit, is that ASP temperatures shall be maintained at 55°C (131°F) or higher for a minimum of 3 days (i.e., piles must be covered to ensure minimum temperatures throughout the pile).

The LCF uses the ASP to meet the requirements listed above through maintenance of compost pile temperatures. Compost pile temperatures are continuously tracked in the ASP using computer-monitored temperature probes. Computer-monitored pile temperatures are taken from two locations in each batch at two different depths; the computer system monitors temperatures and controls air flow based on temperature feedback. All temperature readings are recorded as part of pathogen reduction requirements.

Finished Product

Finished product at the LCF may be created prior to or upon demand of a product. Seasonal and project specific demand is anticipated and therefore material may be made prior to shipment of final product. This can result in finished product being stored on site or at a satellite facility. The primary goal for finished product at the LCF is to minimize the amount of time it is stored on site. Typical storage locations have been approximately three months. Finished product is typically stored on site adjacent to the mass bed composting area.

VII. A description of equipment

Equipment at the LCF includes both permanently installed infrastructure and mobile equipment. Major equipment is listed below.

- Certified truck scale
- Site office
- Compost control building
- 132,000 gallon fresh water tank for fire protection and wash-downs
- Receiving pad for non-putrescible feedstock acceptance and traffic flow
- Receiving building for feedstock acceptance, storage and mixing with air collection and biofiltration system, fixed conveyors and fire alarm system.
- Tipping building with air handling and biofiltration system, material conveyors, and fire alarm system
- Concrete pad with reversing aerated static pile (ASP) bunker system for active composting
- Asphalt pad for turned mass bed, product curing, and screening
- Concrete pad with biofiltration, blowers, controls, aeration plenum, and leachate collection system
- Asphalt pad for product storage and handing
- Treated lined leachate pond with 2.5 million gallon capacity
- Composting Process Equipment
    - Aerated Static Pile aeration equipment including:
    - Aeration trenches for distribution of air
    - Aeration plenums for distribution of air
    - Biofilters
    - Blowers
    - Dampers
    - Electrical support equipment
    - Temperature probes (to maintain conditions in ASP)
    - Vertical auger Mixer
    - Picking Station
    - Grinder (for blending and reaching optimum compost particle size)
    - Cross belt magnet and roll head (removal of metal contaminants)
    - Compost Turner, side discharge (maintains conditions in mass bed)
    - Screens (for optimal sizing of finished product and plastics removal)
    - Leachate collection tank with aeration system
    - Leachate transfer and application pumps
    - 144,000 gallon leachate collection tank with aeration system
- Mobile Equipment
    - Grinders
    - Peterson 5710C horizontal grinder
    - Diamond Z tub grinder (back-up)
    - Loaders
    - Caterpillar 980F Series II
    - Caterpillar 980F Series II (1/2 time – seasonal)

- 980K or 966K Caterprillar Loader Tier IV
- 2008 Luck Now Mixer (electric)
- Screens
- Komptech L3 Star Screen with plastic removal
- CEC Roadrunner 6X16 Deck screen (back-up)
- Conveyors, Multiple
- Sweeper Truck

Moisture may be added to the process at several locations. Moisture may be added to the initial compost mix using pump and a distribution manifold at the exit location of the mix conveyor. Moisture may be added to the ASP during Phase I composting when needed using a pump and a sprinkler system location at the top of the ASP zone bunkers. Moisture may be added to the windrow compost using a pump and a series of sprinklers heads that are manually placed as needed.

Mobile equipment is also available in the form of irrigation distribution equipment that can be used to add water to any stage of the composting process.

VIII. Process monitoring plan

Composting is a controlled biological process to convert organics into useful end products typically used for landscaping and soil enrichment.

Monitoring of the composting process occurs at several stages using different methods.

Incoming Organics Storage (Tipping Building): Received organics are monitored visually for contamination and approximate moisture and porosity. Identified contamination is removed at this point of the process. Incoming organics are also monitored for nuisance odor potential. If nuisance odor potential is atypical steps are taken to mitigate odor (see Comprehensive Progressive Odor Mitigation Plan (CPOMP).

Incoming Bulking Agents: Received bulking agents are visually monitored for contamination and character. Identified contamination is removed at this point of the process.

Initial Compost Mix: The initial compost mix (organics and bulking agents) are visually monitored to determine approximate density, moisture content, C:N ratios, and porosity. The initial compost mix is also monitored for nuisance odor potential. If nuisance odor potential is atypical steps are taken to mitigate odor (see CPOMP). Target levels for each of these parameters is provided in Table 3.

Phase I ASP Composting: The ASP is continually monitored, using the automated ECS system for temperature, and visually monitored for bulk density, moisture content, porosity and maturity. Assessing the compost visually by smell and feel can provide valuable insight into the process for a trained compost technician. The ASP may also be monitoring manually for oxygen levels if primary visual indicators or temperature appear atypical. The ASP is also monitored for nuisance odor potential. If nuisance odor potential is atypical steps are taken to mitigate odor (see CPOMP).

Phase II Windrow Composting: The windows are visually monitored for bulk density, moisture content, porosity and maturity. Assessing the compost visually by smell and feel can provide valuable insight into the process for a trained compost technician. The mass bed may also be monitoring manually for oxygen levels if primary indicators are atypical. If primary indicators suggest that the compost is mature, the windows are sampled and monitored for Solvita maturity level. If the Solbita maturity level meets regulatory requirements (at a minimum), a representative sample of the windrow compost is obtained and analyzed for metals and other testing parameters listed in WAC 173-350-220 Table 220-B. The windrows are also monitored for nuisance odor potential. If nuisance odor potential is atypical steps are taken to mitigate odor (see CPOMP).

Phase III Curing: Curing compost is visually monitored for bulk density, moisture content, porosity and maturity. Assessing the compost visually by smell and feel can provide valuable insight into the process for a trained compost technician. Compost in the curing state is continually monitored for nuisance odor potential. If nuisance odor potential is atypical steps are taken to mitigate odor (see CPOMP).

Process Monitoring Frequency

Compost Parameter Testing Schedule for the LCF		
Test Parameters	Location	On-Going Operations
Phase I ASP		
Pile Temperature	Air floors 1-13	Continuous
Moisture Content	Air floors 1-13	As needed to maintain proper moisture levels
Bulk Density / Porosity	Air floors 1-13	On each cell as needed
Oxygen content	Air floors 1-8	On each cell as needed
Phase II Windrows		
Pile Temperature	Windrows in multiple representative location	As needed to maintain a good microbial environment
Moisture Content	Windrows in multiple representative location	As needed to maintain proper moisture levels and a good microbial environment
Bulk Density / Porosity	Windrows in multiple representative location	As needed to maintain a good microbial environment
Oxygen content	Windrows in multiple representative location	As needed to maintain a good microbial environment
Phase III Curing		
Pile Temperature	Representative location	As needed to ensure proper conditions

IX. Pathogen reduction plan

Initial Pathogen Reduction

Lenz Enterprises accepts organic feedstocks for processing as defined in this document and in site specific permit conditions. Pathogens are reduced in Phase I ASP composting at the site. Temperatures in the ASP are controlled by the proprietary ECS CompTroller™ system. The system is a closed loop aerobic compost batch controller. It relies on fans to cool the process temperature, supply oxygen, and to maintain a uniform operator-selected temperature throughout the composting mass. Turning dampers to positive or negative aeration, or off, controls the composting process. These adjustments are made based on automatically measured temperatures and user selected control parameters. The CompTroller™ is capable of controlling multiple batches through a sequence of up to three "control regimes". Multiple control regimes are useful when composting pathogenic materials that must be held at an elevated temperature for a short time, then returned to lower, more biologically active temperature for more rapid decomposition.

Per WAC 173-350-220, pathogen reduction criteria for the aerated static pile composting system on site includes:

"Aerated static pile must have a cover such as a synthetic material or a layer of finished compost to ensure that pathogen reduction temperatures are reached and vectors are controlled - The temperature of the active compost pile must be maintained at fifty-five degrees Celsius (one hundred thirty-one degrees Fahrenheit) or higher for three consecutive days (seventy-two hours)".

Required time and temperature for regulatory pathogen reduction as stated above is typically accomplished in the first 3-5 days in the LCF ASP. If a compost zone fails to meet pathogen reduction requirements the zone is remixed to enhance compost character and put back into the ASP for further treatment. Alternatively, the compost may be incorporated into the Mass Bed and manually monitored for time at temperature. If this occurs data is collected and logged manually.

The primary objective in setting up and managing the control variables in the CompTroller™ PC software is to maintain optimal conditions in the piles for pathogen kill (ASP Control Regime 1) followed by high rate aerobic decomposition (ASP Control Regime 2). Process conditions (temperature and moisture) are managed by controlling the:

- rate of airflow through the piles
- direction of airflow through the piles
- humidity and temperature of the supply air

Air is provided automatically to piles for three purposes:

- to cool temperatures when they rise above the operator input set points
- to provide uniform temperatures inside the piles for optimum biological activity
- to provide a minimum air flow (metabolic air) to ensure that aerobic conditions are maintained in the biomass even if the temperatures are not exceeding the set points.

Insufficient air supply, or supply air that is very warm (near the temperature set point) and saturated, will typically cause temperatures to exceed the set points. Excessive temperatures will slow decomposition and could potentially produce nuisance odors. On the other hand, excessive air flow can over- cool (making it difficult to achieve the minimum temperatures required for pathogen kill) and remove too much moisture, which is essential for microbial activity.

The target operating ranges are as follows:

Process Stage	Temperature C	Moisture %	Oxygen %
Pathogen Reduction	57°-65°	40-50%	>15%
High Rate Decomposition	50°-60°	40-50%	>15%

The control system operator manages key variables on an ongoing basis to achieve the best results from the system.

Managing a Low Energy Biomass

A low energy biomass poses a challenge for the operator since it is difficult to meet the process goal of pathogen reduction. Control settings become critical as a very small amount of extra air flow can overcool the biomass to below pathogen reduction temperatures (55°C) and cause the time/temperature counter to be reset to zero. This situation is avoided at the LCF in most cases by precisely constructing compost to identified ideal conditions. However, when a low-energy biomass is encountered, the settings that must be considered include:

- The differential pressure set point must be low (<2.0 inches w.c.) to avoid overcooling the biomass during minimum aeration cycles.
- The minimum aeration time in the duty cycle should also be reduced to provide the lowest aeration possible for maintaining aerobic conditions (3% is the minimum setting) – if necessary, increase the duty cycle time and reduce the minimum aeration time.
- Set the recirculation damper and the supply damper to promote increased re-circulation air and provide additional heat and moisture to the piles.
- Actively monitor and manage the system to keep variables optimized

If a low energy biomass cannot be mitigated as described above, the compost may need to be re-mixed and the process started again.

Additional Pathogen Control

Phase I ASP composting has been shown to reduce up to 99.9 percent of pathogens of concern. In subsequent phases of operation the re-growth of pathogens is a potential issue. To mitigate this issue, the LCF utilizes the following operational strategies:

- Windrow composting includes temperatures that inhibit the regrowth of pathogenic bacteria.
- Leachate that is collected and used in any part of the compost system for adding moisture is treated in an advanced leachate treatment system to minimize potential pathogen re-growth. Treatment includes solids maceration, solids separation, aerobic biological reduction of Biological Oxygen Demand (BOD), Total Suspended Solids (TSS) and clarification.

  To meet regulatory requirements, pathogens are sampled and analyzed during final compost characterization per WAC 17-350-220 requirements.

X. Sampling and analysis plan

Types of Samples

There are two basic types of sample collection, grab sampling and composite sampling. Grab sampling consists of site-specific sample collection and composite sampling consists of multiple grab samples taken from various locations within the compost pile. A composite sample, if taken correctly, should represents an average value of the properties for the general mass. Properly implemented composite sampling is desirable for most sampling plans because it provides a reliable estimate of the average conditions.

Representative Sampling / Collection Points

This sampling plan relies on composite sampling of representative sub-samples from the compost pile. The term "sample" will be used henceforth to mean a composited representative sample.

Sample collection points will be selected to represent the mass condition, and will generally be taken a minimum of 12-inches to 18-inches beneath the exposed pile surface. A total of six to eight sub-samples will be taken from each compost pile, with two taken from each of three or four vertical positions in the pile.

Sampling Equipment List

The following equipment and materials should be used for collecting, preparing, packaging and transporting compost samples:

- Sampling container – 20-L (5-gal) plastic, stainless steel, plastic, glass or Teflon.
- Sampling device – stainless steel, plastic, glass or Teflon spatula or spade, etc.
- Trowel – high-density polypropylene (HDPE)
- Plastic shipping container – minimum 20-L size cooler
- Plastic disposable gloves
- Tarp – clean, plastic, canvas, etc.
- Plastic bags – 1-gal "Ziploc" plastic freezer bags
- Cold packs – chemical ice packs
- Adhesive tape – duct tape, packing tape, etc.

Sample Collection

Technicians identify and collect an appropriate number of sub-samples needed to ensure a reliable analytical result, as described above. Each sub-sample is approximately the same volume. Technicians ensure the size of the sub-samples is adequate to produce at least the total sample volume needed by the laboratory for the analyses required. This is determined by conferring with the laboratory representative prior to sampling. Technicians place each sub-sample into the mixing surface (container) and proceed to the next selected sample point.

Technicians thoroughly mix the sub-samples using the trowel, moving the materials from the outside to the center, repeatedly.

Technicians split (i.e., subdivide) the sample into quarters, remove three quarters of the sample and remix as before. Again split the sample, and remix, and repeat to produce three samples approximately 4-L (1-gal) in volume.

If multiple samples are needed for confirmation testing, technicians remix and split the reserved portion to produce additional samples, each should be at least the volume required for the tests specified. Technicians confer with the laboratory representative to determine required sample volume.

Technicians place each sample in a 4-L (1-gal) Ziploc freezer bag, and remove most of the air prior to sealing. Label the bag as described below, and place the sample in a second, sealed Ziploc plastic bag.

At the conclusion of each sampling event, technicians thoroughly washed and three-times rinse equipment before initiating subsequent sampling efforts.

Proper Packaging and Delivery to Analytical Laboratory

Each sample is labeled to include the following information:

- Sample number
- Sampling date and time
- Cell/Pile number
- Age of compost sampled (time since pile formation)
- Person who obtained and processed the sample

Technicians place the plastic Ziploc freezer bags containing the samples in the cooler and inter-weave with cold packs for shipping. The cooler is sealed and the lid secured with adhesive tape. Custody seals are placed on at least two sides of the lid so that the cooler cannot be opened without breaking the custody seals. The cooler is labeled and sent by two-day express service to the selected laboratory for analysis. A completed chain of custody form along with detailed laboratory instructions (i.e. testing program) are included.

Sampling Log Book

Technicians record all sampling events in a Sampling Log Book. Each sampling event must include a brief discussion regarding the objectives of the sampling event along with the following information for each sample:

- Sample number
- Sampling date and time
- Date on which the cell was constructed
- Mix of materials (proportions biosolids / green waste / other bulking agents)
- Person who obtained and processed the sample
- General observations and comments

A Sample Tracking Form is provided in the “Inspection Plan and Forms” section of this Permit Application as a starting point for managing the sample documentation required.

Sample Chain-of-Custody

Chain-of-custody (COC) forms and procedures are used with all environmental or regulatory samples. A chain-of-custody form is used to track sample handling from the time of collection through laboratory analysis, and data reporting. Suggested information for the chain-of-custody record includes, at a minimum:

- Collectors name
- Signature of collector
- Date and time of collection
- Place and address of collection site
- Requested preprocessing
- Requested analyses
- Sample code number for each sample (if used)
- Signature of the persons involved in the chain of possession.

Chain of Custody forms are maintained along with the Sample Tracking Form, Sampling Log Book, Shipping paperwork, and Laboratory Reports.

Preparation of Samples for Analysis

Some laboratory tests require that the sample be prepared prior to testing. This may include further sub-sampling, compositing, particle size reduction, etc. The technician requesting the test procedure should specify this.

Analytical Detection Limits

The laboratory that provides the analytical services will provide the detection limits and regulatory limits as part of their analytical reports. WAC 173-350-220 Table A values will be used as the regulatory limits.

Pesticide and herbicide scans and bioassays will also be conducted during the first year of start-up. Periodic testing may also be conducted during standard operations, at the request of Snohomish Health District.

For stability testing, the Solvita™ Test Method will be used on a regular basis.

All analyses will be performed by a certified laboratory.

Analytical Methods and Procedures

The analytical methods used by the laboratories to evaluate the required parameters shall be in accordance with EPA and Ecology recommendations.

The US Composting Council (USCC) Test Methods for the Evaluation of Compost and Composting (TMECC) will be used to guide the laboratories on compost product specific procedures or adaptations needed for standard soil or microbiological methods.

Quality Control Procedures

Field QC Procedures

- Ensure all sampling equipment and containers are clean prior to use. Clean any equipment used between each sample:
    - Partially fill a five-gallon bucket with a 5% solution of household bleach or tri-sodium phosphate (TSP) and De-ionized (DI) water.
    - Lightly scrub with the bleach/TSP water. Double rinse by pouring DI water over item thoroughly directly from DI water container or use clean squirt bottle of DI water.
    - Commence sampling the next pile and repeat the decontamination procedure after sampling has been conducted.
    - The bleach/TSP water should be discarded and remade after 5 samples.
- Properly label all samples and keep accurate records.
- Store grab samples in a refrigerator before analysis when delays in shipment to the laboratory are anticipated. If delays exceed sample holding times given by the analytical laboratory, new samples should be collected and shipped to the laboratory in accordance with all described procedures.
- Ship samples in accordance with the analytical laboratory's sample handling criteria.
- Always use chain of custody forms and procedures with environmental samples.

Laboratory QC Procedures

The analytical laboratory that is used must provide their laboratory QA/QC procedures, as well as sample holding times and handling requirements for required analyses.

All final compost produced at the LCF will be analyzed for the following minimum constituents prior to characterizing the material as "Final Compost".

WAC 173-350-220 Table 220-B Testing Parameters

Metals and other testing parameters	Limit (mg/kg dry weight), unless otherwise specified
Arsenic	≤ 20 ppm
Cadmium	≤ 10 ppm
Copper	≤ 750 ppm
Lead	≤ 150 ppm
Mercury	≤ 8 ppm
Molybdenum	≤ 9 ppm
Nickel	≤ 210 ppm
Selenium	≤ 18 ppm
Zinc	≤ 1400 ppm
Physical contaminants[1]	≤ 1 percent by weight total, not to exceed .25 percent film plastic by weight
Sharps	0
pH	5 - 10 (range)
Biological stability[2]	Moderately unstable to very stable
Fecal coliform[3]	< 1,000 Most Probable Number per gram of total solids (dry weight)
OR	
Salmonella	< 3 Most Probable Number per 4 grams of total solids (dry weight)

Note: Other constituents may be required depending on the source of the material.

Laboratory Testing is conducted by the following laboratory:

Name: Frank Shields, or Assaf at Soil Control Lab

Address: 42 Hangar Way, Watsonville, CA 95076

Telephone / Fax: 831-724-5422/ 831-724-3188

Soil Control Lab receives and analyzes LCF samples for physical, chemical and biological properties in accordance with established Ecology and EPA protocol.

All samples will be collected, handled, and analyzed as described in certified laboratory methods. Compost samples will be tested for a variety of constituents and, depending upon the specifications of an individual analysis, may require special handling. All samples, however, will be handled in a similar manner to ensure sample integrity from collection to data reporting. This handling process includes the ability to trace possession and handling of the sample from the time of collection through analysis and final disposition, referred to as the "chain of custody" process. Chain of custody is important in the event litigation involving sample results is initiated and is useful for routine control of sample flow.

XI. Odor management

See Lenz Comprehensive Progressive Odor Management Plan (CPOMP)

XII. Leachate management

Introduction

Leachate management at the LCF is designed to fully utilize leachate as a resource for composting (for moisture management of the composting process) and to result in no excess water. The composting process, due to feedstock moisture requirements and process operating temperatures, can use and evaporate a significant amount of water. Annual precipitation and storm events also influence the overall site water balance. To ensure that leachate management goals are met at the LCF, this balance is carefully monitored and managed.

Leachate at the LCF is generated by two main sources: moisture collected from the composting process; and precipitation that collects on the compost, and compost area that contacts process materials. Leachate is used at the LCF to moisten feedstocks as they are mixed to create a proper moisture balance for the compost and is added to the composting process at different stages to maintain adequate moisture levels. Where possible, moisture for the compost process is derived from collected and treated leachate. Precipitation will occur at various levels from year to year. Precipitation, where possible, is prevented from contacting the Lenz feedstock and mixing areas, the ASP zones, the Mass Bed, and the Curing piles. This occurs through the use of slopes, berms and proper grading slopes. Slopes of no less than 1 percent are used in most areas to ensure that ponding does not occur.

Leachate that is collected on site is directed to an underground collection tank. The collection tank is aerated using a regenerative blower and coarse bubble diffusers to maintain aerobic conditions. Leachate is pumped from the collection tank by a chopper pump to create a uniform size of solids for removal. The leachate is then directed to a Rotary Drum Screen (RDS), using a wedgewire screen with an opening size of 0.02-inch to separate solids from the leachate. The operational parameters of the RDS can be adjusted to increase efficiency. Screen sizes can be changed if conditions dictate a smaller or larger screen size is optimal. It is expected that primary screening will separate approximately 75 percent of solids from the waste stream. An associated 27 percent of insoluble BOD related constituents associated with these solids is also expected to be reduced at this point in the treatment system. Separated solids from the RDS are collected and incorporated back into the compost process. Leachate from the RDS is directed to an above-ground 144,000 gallon treatment tank. This tank also serves as a surge collection tank for storm events. The treatment tank is operated cyclically and used for biological reduction of the leachate, along with nitrification/denitrification if necessary. It is estimated that this biological treatment can account for up to 90 percent reduction in BOD and TSS compounds and up to a 50% reduction of nitrogenous and phosphorus compounds. Under normal conditions, the treatment tank cycles through three phases of treatment:

1. Phase 1, Aeration. During the aeration phase the treatment tank is mixed and aerated using a blower and fine bubble diffusion system

2. Phase 2, Settle. During the settle phase the tank contents are quiescent. This allows for the biologically active solids to settle to the bottom of the tank.
3. Phase 3, Decant. During the decant phase treated and clarified leachate is pumped from the top of the tank and either used immediately in the compost process or delivered to the storage lagoon for use at a later time.

The treatment tank is checked regularly for the following parameters to ensure that proper treatment is occurring.

Table 5. Leachate Treatment Tank Operating Parameters

Parameter	Range	Comments
pH	6.0–8.5 Std. Units	This range should be maintained 24/7
Dissolved Oxygen	2.0–4.0 mg/L	Range for aeration phase. D.O. should reach 2.0 within ~30 min.
Temperature	5.0–35.0 C	As temperature rises so does activity
Nutrient balance		For every 100 mg/L of BOD_5, micro-organisms need: 5.0-10.0 mg/L of nitrogen 0.5-3.0 mg/L of phosphorus
Mixed Liquor Volatile Suspended Solids (MLSS)	2,000-8,500 mg/L	Determined by laboratory analysis
Food to Micro-organism ratio (F:M)	0.05-0.15	= Applied BOD, lb./day / MLVSS, lb.
Toxicity	See attached	Many toxics can disrupt biological activity. These must not be allowed in the system

Feedstock Development – Moisture Management

Proper moisture management of feedstocks and compost during the composting process is imperative to proper compost production. This moisture management process is carefully controlled and checks and balances are in place to ensure that excess moisture is not added (see process monitoring). Moisture is added to the compost process by adding leachate first, when possible, and then potable water when necessary. The use of potable water is carefully controlled to maintain the no-excess water balance management strategy in place at the LCF.

To minimize the generation of excess leachate and to avoid having too high of a moisture level in the feedstocks , target moisture levels for feedstocks are 50 to 60 percent moisture. These numbers can vary depending upon the absorbency of the feedstock.

Aerated Static Pile (ASP) Leachate Management

The LCF Aerated Static Pile (ASP) is designed so that collected precipitation is directed away from the active compost piles, the feedstock mixing and handling area, and the curing piles. Treated and stored leachate water is used to moisten the ASP compost to ensure a proper composting environment. Because the ASP composting process occurs in the thermophilic temperature range (between 45 and 122 °C - 113 and 252 °F) the amount of evaporation that occurs during this process is significant.

Windrow Composting Leachate Management

The LCF Windrow composting is designed so that collected precipitation is directed away from the active compost piles. Treated and stored leachate water is used to moisten the Windrow composting to ensure a proper composting environment. Because the Windrow composting process occurs in the mesophilic and thermophilic temperature ranges the amount of evaporation that occurs during this process is significant.

Water Balance

As stated, the LCF leachate management plan is designed to fully utilize leachate as a resource for composting and to result in no excess water. Due to the range of precipitation that may occur throughout the year at the LCF, the quantity of stored leachate is assessed each month to ensure that an adequate supply exists for the composting process and that excess leachate is not accumulating. Storm events and above-average precipitation that may occur each year are tracked to ensure that sufficient storage is available. Higher than normal ambient temperatures are also tracked and used to consider if potable water will be needed for the compost process.

Storm Event Leachate Management:

Impervious surface used for composting activities where precipitation may be collected is approximately 200,000 ft^2. However, only small portion of the surface area typically receives direct precipitation, the remainder of the surface area is covered with composting materials, final product and biofilters. The LCF leachate collection, treatment tank and storage lagoon system was designed and constructed to contain precipitation from a 100 yr 24 hr storm. The combined volume of the collection tank (6,000 gallons), the treatment tank (144,000 gallons) and the storage lagoon (2.5 million gallons) is more than adequate to contain this storm event. Transfer pumps between the three storage areas are capable of up to 150 gallons per minute (GPM), which is also more than adequate to handle these flows should transfer of storm flows be required during the event.

The leachate pond is lined with 60 mil high density polyethylene, welded and tested for leaks under pressure at each seam. The pond is designed with a 338,324 cubic feet of water storage capacity from a collection area of 200,000 square feet providing storage for over 20 inches of rainfall from the site.

Total Annual and Monthly Water Balance

The primary factors contributing to the water balance at the LCF include:

- Precipitation and the generation of leachate
- The amount of leachate used in the composting process
- Ambient environmental conditions
- Contingency plans for excess and lack of leachate

Annual precipitation for the region is reported as 36.44 inches (Soil Survey of Snohomish County Area, Washington, SCS 1983). Monthly average precipitation ranges from 1.07 in July to 5.21 in December.

Leachate is collected, treated, and used in the composting process to maintain moisture in the initial feedstock, ASP compost, Mass Bed Compost and the Biofilters. Using standard physical constants such as latent heat of vaporization, the fraction of biodegradability of the feedstock, etc,; and actual process and environmental conditions such as composting rates, composting temperatures, ambient temperatures, and precipitation rates, a water balance for the site has been calculated. This calculated water balance indicates that there will be no excess water from the process during years when average, and even above-average conditions are experienced. Actual experience at the site from 2008-2012 supports this hypothesis. Only one year during the history of operations has resulted in excess water being generated at the site.

Using the Practical Handbook of Compost Engineering, by Roger T. Haug as a guide, a water balance was developed to determine the compost site annual water balance. The primary factors used for this water balance calculation include the following:

- 60% moisture in feedstocks as received;
- 70% volatile solids of dry feedstock;
- 65% biological volatile solids reduction potential;
- 50% moisture content in final compost;
- 45,000 tons of feedstock annually;
- 2,142 kcal/gal required for evaporation of water;
- 4,700 cal/gram heat release of dry biodegrable volatile solids
- 65% of process energy is consumed by evaporation

Calculations indicate that with the exception of the months November, December and January, a water deficit will exist at the site which will require the use of potable water during years with average annual precipitation. Site storage volumes are more than adequate to handle water accumulation during these winter months.

XIII. Storm water management

The LCF does not discharge stormwater collected on the composting pad and comes in contact with organics, compost, final product or compost equipment. All stormwater is used in the composting process to moisten the compost feedstock and active compost piles (see Leachate Management Plan). Due to this condition, the LCF does not require a stormwater permit.

The LCF was designed to minimize stormwater run-on to the compost site. The LCF is part of a larger industrial site that is permitted for sand and gravel operations as its primary activity. Sand and Gravel operations operate under authority of the Sand and Gravel General Permit. Sand and gravel operations surrounding the LCF also operate as a zero-discharge facility and infiltrates all stormwater on site.

All stormwater that falls on the LCF acre site is collected. Stormwater that falls in the product storage area that does not come in contact with process material may be collected directly in the leachate lagoon. Leachate pond water is used to add moisture to the compost (see Leachate Management Plan for more information).

The perimeter of the LCF compost pad slopes inward to prevent run-off of surface water into the adjacent soils. Asphalt berms or slopes are constructed around the concrete/asphalt slab to prevent surface water run-on from the adjoining land. No upstream considerations are necessary. Downstream considerations are not a factor because there is no planned runoff. The collected stormwater and leachate is used in the composting process.

Stormwater flows, containment structures, and general site conditions are illustrated on the LCF Drainage Plan Appended to this document.

In the event of a drainage containment structure failure, or excessive precipitation in a short-period of time, there is potential for surface water or ground water contamination to occur as a result of spills from handling and using petroleum products, principally diesel fuel, hydraulic oil and similar materials associated with construction equipment. In the event of a petroleum product spill, contaminated soils will be excavated and disposed of in an acceptable manner (i.e., a permitted waste handling facility or as directed by the Snohomish Health District.

If a spill occurs on an impervious surface, the spilled materials will be contained and cleaned up using absorbent materials. These materials will then be contained in a safe manner and disposed of offsite in accordance with Snohomish County Health District regulations.

XIV. Inspections

LCF equipment, structures and other systems are inspected daily, at a minimum. Most equipment, structures and systems are inspected multiple times daily. Maintenance of equipment structures and system occur per manufacturers recommendations and include both regular and preventive maintenance. Frequency of maintenance for specific equipment, structures and systems are located in several site operation and maintenance manuals and plans.

A site inspection checklist is used at the LCF to ensure proper operation of equipment, structures and other systems. The inspection checklist is maintained in site offices and available for agency review. At a minimum, the following information is maintained:

- Date and time of inspection
- Names and signatures of person(s) conducting the inspection
- Notations of observations made during the inspection
- Dates and nature of any repairs or corrective actions taken

Records retention for maintenance is set at least three years from the date of inspection.

Inspection Schedule

Formal facility inspections are conducted weekly, at a minimum, by site management. Significant observations or maintenance requirements are relayed to LCF operations staff and noted in the site log.

XV. Staff training - odor management

Introduction

Training for LCF personnel is based on job description. Compost technicians receive initial Compost Facility Operator Training (CFOT) from the Washington Organics Recycling Council (WORC), regularly attend compost training seminars, take on-line training as appropriate, and maintain a regular self-study schedule to stay current with new information in the organics processing industry. Compost technicians from sites throughout Washington State also have regular meetings where they share best practices and new ideas on how best to facilitate successful operations.

All employees participate in an annual 8 hours of MSHA (Mine Safety and Health Administration), due to the adjacency of this activity. Employees participate in a four hour First Aid certification every other year.

Nuisance Odor Identification

The human nose's unique ability to smell, and the way the human brain processes this information, makes it the most sensitive detection tool available for odor detection in relation to nuisance odors. Sensitivity to odors is variable from one person to the next and is therefore subjective and personal. Each individuals physical ability to detect odors, an individual's history with different odors (did they grow up on a farm or in the city?), the type of odor being emitted, and many other factors contribute to the level required for each individual to detect an odor and whether or not they perceive the odor as offensive (nuisance or malodor). Quantifying the amount of odor that constitutes an objectionable amount to all individuals is impossible due to the wide variation in how people perceive odors as well as the transient nature of odors.

Given the unique nature of how humans detect and perceive odors, a "one-size fits all" approach to nuisance odors is difficult at best. At the LCF, odors are assessed by facility staff continually. This constant awareness acts as on-the-job training for site personnel and allows them a unique opportunity to compare odors from one day to the next. Unfortunately, this situation also offers employees the opportunity to become passive to common odors. To avoid this situation, the subject of odors is discussed at each staff meeting and new ideas to monitor and assess site odors are reviewed. In addition, appropriate facility staff is trained in the operation of field olfactory meters should the need arise for their use; and to provide a basic understanding of how odors are typically measured. This provides staff with an understanding of how to assess odor persistence, hedonic tone, odor character, and odor intensity. If classroom odor training becomes available in Washington state, a representative from the LCF will attend.

Nuisance Odor Corrective Action

Different types of emissions and odors can potentially occur at different stages of the LCF process. In general there are eight potential sources of different types of nuisance odors at the LCF:

1. Organics receiving, temporary storage
2. Feedstock mixing and grinding
3. Phase 1 ASP Composting
4. Phase 2 Mass Bed Composting
5. Compost Curing
6. Leachate collection and treatment
7. Leachate storage
8. General site conditions

Odor mitigation is built into the LCF process in the following manner:

- All putrescible feedstocks are tipped in the receiving building southeast corner of the building with air evacuation. The evacuated air is directed through a biofilter.
- Grass clippings and other nitrogen rich materials will be incorporated into a compost pile immediately (e.g., mixed with a bulking agent and placed in a new aerated static pile cell) to minimize odor generation.
- If processing cannot be accomplished the same day as delivery, all putrescible feedstocks are covered with a 6 inch layer of wood residuals, compost, or tarped for the evening.
- Putrescible yard debris and food waste are ground within the receiving building equipped with a biofilter to reduce the potential for odor releases.
- During active composting, each compost pile is covered by a 6 to 12-inch layer of ground wood residuals, finished compost or compost screen overs, or some mixture of these materials to mitigate odors and reduce vector attraction.
- During compost stabilization, moisture is managed to ensure proper stabilization and to prevent overwatering.
- Curing and finished compost is stored in appropriately sized stockpiles (no more than 18 feet high) to minimize odors and fire risk.
- All initial processing is conducted indoors with air handling and treatment with a biofilter.

Composting operations can result in odors when putrescible materials and wet manures are not properly managed and are allowed to become anaerobic. Lenz Enterprises has prepared and implemented a Comprehensive Progressive Odor Management Plan (CPOMP) that provides guidance for assuring proper operation of the facility odor control systems. In addition, the plan provides for accountability in a progressive manner for identifying, notifying, and responding to nuisance odors.

The LCF has not experienced an odor complaint. In the event of an odor complaint, the odor source will be investigated and measures to mitigate the odor source will be discussed. Specific material handling and process air control measures must be monitored, mitigated, and reported within the PSCAA permit conditions.

Additional information on corrective actions for nuisance odors are contained in the Comprehensive Progressive Odor Management Plan (CPOMP) included as an Appendix to this document.

XVI. Community relations

Introduction

This Community Relations Plan (CRP) is designed to provide guidance to establish and maintain effective community relations with any potentially interested parties (stakeholders) of the LCF. Effective community relations are built upon respect for all individuals and their rights; and effective and timely communications. This plan summarizes potential perceptions of stakeholders regarding past, present and future activities at the LCF.

Community Profile

The US Census Bureau for 2011indicates that approximately 717,000 people live in unincorporated Snohomish County, with approximately 7,000 living in or near Stanwood Washington. The Census also provides statistics on age, race, income, and many other parameters. Unfortunately, these statistics don't take into consideration the unique perspective of each individual and their situation. Management at the LCF will treat each individual uniquely as their conditions and perceptions are unique and require empathy to understand those unique conditions and perceptions.

Site Activities and Potential Stakeholder Interest

The general site where the LCF is located has been an active sand and gravel mine since the 1970's. Company officials have actively supported community activities and continue to participate in local government and business organizations.

The LCF began operation in 2008 and has received several letters of support from the community. Composting is perceived by most as a sustainable solution to otherwise wasteful activities such as landfilling of organics. Support has been voiced from the City of Stanwood Mayoral office, the Stanwood Chamber of Commerce, and the Washington State University Extension Office.

Stakeholder interest can also be negative in nature if site activities present themselves in an annoying fashion to immediately adjacent neighbors, for example. Issues that could potentially arise in relation to composting activities typically relate to noise, light and glare, vehicular traffic, product complaints, and odors.

Active Management

LCF owners take an active part in all community relations. Owners are typically on site and will often respond to stakeholder issues and concerns personally. The site Vice President and General Manager is the primary individual responsible for issues and concerns. In addition, LCF employees a Program Director, Fleet Manager, and Sales and Marketing Manager, all with secondary responsibility for community relations and complaint management.

Noise

Maximum permissible sound levels are described in Snohomish County Noise Ordinance Chapter 10.01, Noise Control. Measurements of sound levels from all sources except motor vehicles on public roads are made at or within the property boundary of the receiving property. Maximum permissible sound levels for districts within unincorporated Snohomish County, expressed in dB(A)'s are:

Type of Receiving Property	Type of Noise Source			
	Rural	Residential	Commercial	Industrial
Rural	49	52	55	57
Residential	52	55	57	60
Commercial	55	57	60	65
Industrial	57	60	65	70

If a complaint or issue is raised concerning noise from the LCF, an investigation will be conducted to determine the source, intensity, duration, and extent of the noise issue. Individuals raising the concern will be interviewed to ensure that the full extent of the issue is understood. At that initial point of contact, the LCF representative will ensure the complainant that all reasonable methods to control noise to legal limits will be initiated. Good communication throughout this process is paramount to its success.

Once the issue is well understood; and it has been determined that the issue is related to operations at the LCF, then an action plan will be developed to measure the noise intensity, duration and extent. If any noise source associated with the LCF is exceeding county limits, the offending source will be discontinued until a suitable mitigation plan can be implemented. If the offending noise is within county standards for the type of receiving source where the noise has been identified, the complainant will be educated on the status of the situation, including any readings or data obtained during the investigation. If the complainant is still dissatisfied after learning of the legal right for the LCF to create the perceived offending noise, other alternatives will be developed by site management to hopefully mitigate the issue.

Light or Glare

If a complaint or issue is raised concerning light or glare from the LCF, an investigation will be conducted to determine the source, intensity, duration, and extent of the illumination issue. Individuals raising the concern will be interviewed to ensure that the full extent of the issue is understood. At that initial point of contact, LCF representative will ensure the complainant that all reasonable methods to control light or glare to legal limits will be initiated. Good communication throughout this process is paramount to its success.

Once the issue is well understood; and it has been determined that the issue is related to operations at the LCF, an action plan will be developed to measure the light or glare intensity, duration and extent. If the levels of light and glare appear to be invasive a mitigation plan will be developed and implemented.

If the complainant is still dissatisfied after learning the LCF efforts, other alternatives will be developed by site management to hopefully mitigate the issue.

Vehicular Traffic

If a complaint or issue is raised concerning vehicular traffic from the LCF, an investigation will be conducted to determine the source, intensity, duration, and extent of the traffic issue. Individuals raising the concern will be interviewed to ensure that the full extent of the issue is understood. At that initial point of contact, LCF representative will ensure the complainant that all reasonable methods to control vehicular traffic to legal limits will be initiated. Good communication throughout this process is paramount to its success.

Once the issue is well understood; and it has been determined that the issue is related to operations at the LCF, an action plan will be developed to better understand the extent of the issue. If the vehicular traffic issue is beyound legal limits, a mitigation plan will be developed and implemented. If the complainant is still dissatisfied after learning the LCF efforts, other alternatives will be developed by site management to hopefully mitigate the issue.

Product Complaints

If a complaint or issue is raised concerning product quality from the LCF, an investigation will be conducted to determine the full extent of the issue. Individuals raising the concern will be interviewed to ensure that the full extent of the issue is understood. At that initial point of contact, LCF representative will ensure the complainant that all reasonable methods to solve the product issue be initiated; the LCF motto is the age old "The Customer is Always Right". Good communication throughout this process is paramount to its success.

Once the issue is well understood; and it has been determined that the issue is valid, an action plan will be developed to better understand the extent of the issue. Once understood, a mitigation plan will be developed and implemented to ensure customer satisfaction. If the complainant is still dissatisfied after initial LCF efforts, another alternative will be developed by site management to hopefully mitigate the issue.

Odors

Odors represent a growing concern for the organic waste industry. Improperly operated compost facilities can generate nuisance odors which can impact local receptors as these odors are the main perception of pollution (with dust and noise). Odors complaints due to compost facility operations can occur due to site and process conditions such as poor management of organics, exposing composting materials to improper conditions and poor housekeeping; or due to misconceptions or misinterpretations about a particular odor such as its originating source. While all compost facilities create emissions and odors due to the biological stabilization of organics, not all compost facilities produce nuisance, or malodors; nor do all emit odors beyond their site boundaries.

Potential odor emission sources at the LCF include:

- Transport to site (route to site, waiting queue to reception)
- Reception of organic material
- Pre-treatment of incoming organic material (mixing/homogenization)
- Movement of material on-site
- Treatment process releases (composting)
- Building envelope releases (fugitives)
- Waste material and by-products management
- Leachate collection, treatment and storage
- Screening and blending
- Finished products management

Due to the complex nature of odor generation, odor transport and odor perception, the LCF has developed a Comprehensive Progressive Odor Management Plan (CPOMP). This plan is designed to be proactive to potential odor issues, and proactively reactive to any actual odor complaints or issues that arise. The LCF CPOMP is included in this document as an Appendix, provides additional information to this section, and should be referenced to fully understand the LCF Community Relations plan with regard to odors.

In general, if a complaint or issue is raised concerning odor from the LCF, an immediate investigation will be conducted to determine the source, character, intensity, duration, and extent of the potential odor issue. Individuals raising the concern will be interviewed to ensure that the full extent of the issue is understood. At that initial point of contact, LCF representative will ensure the complainant that all reasonable methods to control odors to legal limits will be initiated. Common respect and good communication throughout this process is paramount to its success.

Once the issue is well understood; and it has been determined that the issue is related to operations at the LCF, an action plan will be developed to better understand the extent of the issue. If the odor issue appears to be above legal limits, a mitigation plan will be developed and implemented. If the complainant is still dissatisfied after learning the LCF efforts, other alternatives will be developed by site management to hopefully mitigate the issue. Additional information can be found in the LCF CPOMP. Safety, fire and emergency plans

The following actions will be employed if a fire, explosion, spill or other emergency occurs at the LCF

Emergency Response

In the event of a serious injury or other emergency, personnel will telephone 911 immediately. All personnel have cellular phones and a wired telephone is located in the compost office for use by any employee. Additionally, two-way radios are available and should be used in case of emergency if other sources are not available.

A first aid kit is kept on-site at all times and accessible to all personnel. All LCF personnel must pass a certified course in first aid and will be required to take refresher courses as required to maintain current certification.

Bodily Injury

In the event that anyone on-site is injured, for any reason, an appropriate level of first aid should be applied immediately. In the event of life threatening injury, the injured person shall be treated using appropriate first aid techniques, including treatment for shock, and the attending person should phone 911 immediately.

Each injury must be reported to the Lenz Enterprises Inc. owner or general manager. All work related injuries will be reported using appropriate forms and other methods of notification.

Fire and Alarm System and Fire Mitigation

A fire alarm system protects the organics receiving building. It uses a rate of rise temperature system. An above-ground water tank is installed for fire flow for the facility. An alarm engages if the water in the fire flow tank decreases below the required level. The fire alarm notifies an alarm company who contacts, according to a contact list, site personnel and notifies the fire department if no one is available to respond. There are three pull stations in the transfer station, a bell and a light alarm.

Access roads leading to the site are maintained in suitable conditions (width, surface, etc.) for fire department equipment.

All stockpiles, including unprocessed and processed wood materials, will have minimum 15-feet access on all sides.

Fire extinguishers will be kept on each piece of equipment, and each site vehicle. Non-wood fires will be put out immediately. Fire extinguishers are serviced by a contractor yearly and checked for fill level by site personnel each month.

In the event of a smoldering wood fire, the burning area will be separated from the main pile using heavy construction equipment such as a front-end loader. The materials are then spread in a thin layer to enable extinguishing fluids to contact burning materials. Once separated, the burning materials will be extinguished.

In the event of a fire that is beyond the capabilities of site personnel, the area will be cordoned off and the fire department will be notified by calling 911. Site personnel will move all equipment, fuel and other flammable materials away from the burning area if safe to do so. Site personnel with construction equipment will remain on-site to assist with extinguishing the fire, as directed by the fire department crew chief.

After the fire has been extinguished, the source or cause of the fire will be determined and appropriate action will be taken to prevent a repeat fire. The fire and actions to prevent future fires will be discussed at a minimum at the next Health and Safety meeting.

Emergency Contact Information:

Emergency Phone No: Call 911

Site Street Address: 5212 SR 532 Stanwood WA. Snohomish County

Site Mailing Address: Lenz Enterprise Inc. P.O. Box 868 Stanwood WA, 98292

Site Emergency Contact: Jason Lenz, Phone No. 360 629 2933, Cell 425 508 3197

Backup Contact: Edward Wheeler, Phone No. 360 629 2933, Cell 425 508 3180

Hospitals / Emergency Medical Center

The closest Hospital / Emergency Medical Centers to the Lenz Enterprises Inc. facility are: 9631 269th Street, Stanwood, WA 98292. Tel: 360-629-5800

Driving directions to Emergency Center: 9631 269th St NW, Stanwood, WA 98292

1. Head west on WA-532 W toward 64th Ave NW 3.0 mi
2. Turn right onto 270th St NW/Camano St.
3. Continue to follow 270th St NW 0.2 mi
4. Take the 2nd right onto 97th NW 253 ft
5. Slight right onto 269th St NW
6. Destination will be on the right 131 ft

Notify in case of fire, explosion, or oil or hazardous material release.

Contact:	Mr. Jason Lenz
Telephone:	360-629-2933
Cell:	425-508-3197
Fax:	360-629-6213

Safety Equipment

The following safety equipment is maintained and accessible on-site at all times:

- Site Safety Plan, read and signed by all site personnel.
- Telephone
- Hard hats, gloves, hearing protection, visibility vests, eye protection
- Fire extinguishers, one per piece of equipment plus one for the facility office
- First Aid Kit
- Spill Response Kit including oil absorbent products (i.e., booms and pads), drain plugs and catch basin inserts or covers.
- Steel toed protective Boots

Explosion

In the event of explosion, all site personnel will be removed from the area and first aid will be applied immediately, as necessary. Follow the directions under Bodily Injury.

Phone 911 immediately to notify the appropriate emergency response crew.

If possible, trained emergency personnel should determine the source and/or cause of the explosion, and appropriate action should then be taken to prevent further explosions.

a) Confined Spaces and Ponded Water Procedures

WAC 296-809-100 provides regulations to protect employees from the hazards associated with confined spaces. This chapter applies to all confined spaces and provides requirements to protect employees from the hazards of entering and working in confined spaces. This chapter applies in any of the following circumstances:

- Confined spaces in your workplace.
- Employees will enter another employer's confined spaces.
- A contractor will enter your confined spaces.
- You provide confined space rescue services

Tanks, storage bins, utility vaults, pits and many other commonly encountered work spaces are typically classified as confined spaces. These spaces are large enough to accommodate workers, but aren't primarily designed for continuous employee occupancy and offer limited means for entry or exit.

Any catch basin, water pipe, tank or pond that receives runoff water from composting operations can develop an anaerobic environment that and can form dangerous and hazardous gasses that can be injurious to human health. The primary gas of concern is in these situations is Hydrogen Sulfide (H^2S); however, methane, carbon monoxide and other oxygen depleting gases can also occur. Methane and Carbon Monoxide are odorless, and H^2S can easily overwhelm a human's sense of smell at dangerous levels. Any water collection feature at the compost site meeting the definition of a confined space will have entry requirements. Confined space entry requirements are clearly described in the site safety manual, and must be followed by any one removing pumps, repairing drainage fixtures when their faces go near or below grade or tank openings, or where a risk of falling into such spaces can occur. Requirements may include monitoring equipment, retrieval harnessing, air evacuation or fresh air replacement blowers, or use of OSHA approved SCUBA face mask and tanks by certified employees or contractors. To minimize risks and reduce odors, compost leachate contaminated water is treated in an aerated collection and aerated treatment tank. Sludge accumulations will be removed regularly, and aeration systems will be maintained in the storage tanks to maintain aerobic conditions and reduce the generation of dangerous gasses.

Personal Hygiene and Safety Training

All facility operators must follow proper standards for personal hygiene. Raw materials used for composting and compost products may contain a wide range of pathogens and contaminants, including plastic products; nails, bottles and other sharps; rusty yard tools; chemical garden products; and pet wastes. Agricultural waste can also contain some pathogens, which can impact human health.

Employees should wear eye protection for protection against dust, flying objects and gloves for protection against sharp objects. Employees should wash hands before using the restroom, and should always wash hands and face before eating or smoking.

Exposure to dust from compost can cause health problems, particularly if a person has a history of respiratory illness. Dust may contain fungi, bacteria and other irritants. The facility operator should use an approved dust mask and safety goggles for protection during dusty operations, such as grinding and soil screening.

Personal protective equipment will be used to ensure that staff and visitors will be protected from contaminants. Staff will also be trained on machine safety for heavy equipment they operate, material handling safety, personal protective equipment, and hearing protection.

LCF compost technicians and workers must pass a certified first aid course as a condition of employment. Staff will be required to attend at least one operations and safety training session each year, along with a first aid refresher course. Site safety meetings will be held on a regular basis.

Emergency Evacuation

The retail area behind the Lenz Enterprises main office will be used as the assembly point should a site emergency occur. Employees should remain in this assembly area until the emergency team lead has noted that you are present and safe and the emergency has ceased. The emergency team lead will provide additional information as it becomes available and instructions for further actions based on the nature of the emergency.

b) Site Personnel Signature Page

Written acknowledgment and agreement with this Plan of Operations is a condition of employment at the LCF. The following individuals indicate by signing below that they agree to comply with all of the procedures described herein.

Printed Name	Signature	Date
____________________	____________________	_______________

XVII. Forms

The LCF utilizes a Sequel Server based database for recoding daily weights of incoming feedstock. Each load delivered to the site is logged by source, and type. Likewise, records of finished product sales are also logged in this fashion. Apex is a Windows-based, fully integrated family of products using the flexible capabilities of a SQL database. The underlying architecture and connectivity between multiple locations provides for integration of diverse work groups at one central location and for managing the complete Quote to Cash process. General features include:

- User-friendly interface
- Advanced data management and retrieval
- Remote installation of ticketing software with integrated datareplication using WAN, LAN, remote access server, or modem
- Customizable menus and shortcuts
- User-modifiable screens and print templates
- Built-in document imaging
- Enhanced system security
- Readily interfaces with most models of digital scale indicators
- Operates on standard Windows hardware and with Windows compatible printers
- Powerful inquiry tools for viewing ticket, order, and invoice data
- Large variety of standard reports included
- Customized reports may be added to the Apex menu system using Crystal Reports®
- Apex database provides for access by outside ODBC compliant tools for additional reporting using tools such as Excel and Access

All data relating to weights of feedstock by type and finished compost products can be obtain from this database tool. Examples of forms used for recordkeeping of process monitoring results are included as an appendix to this document.

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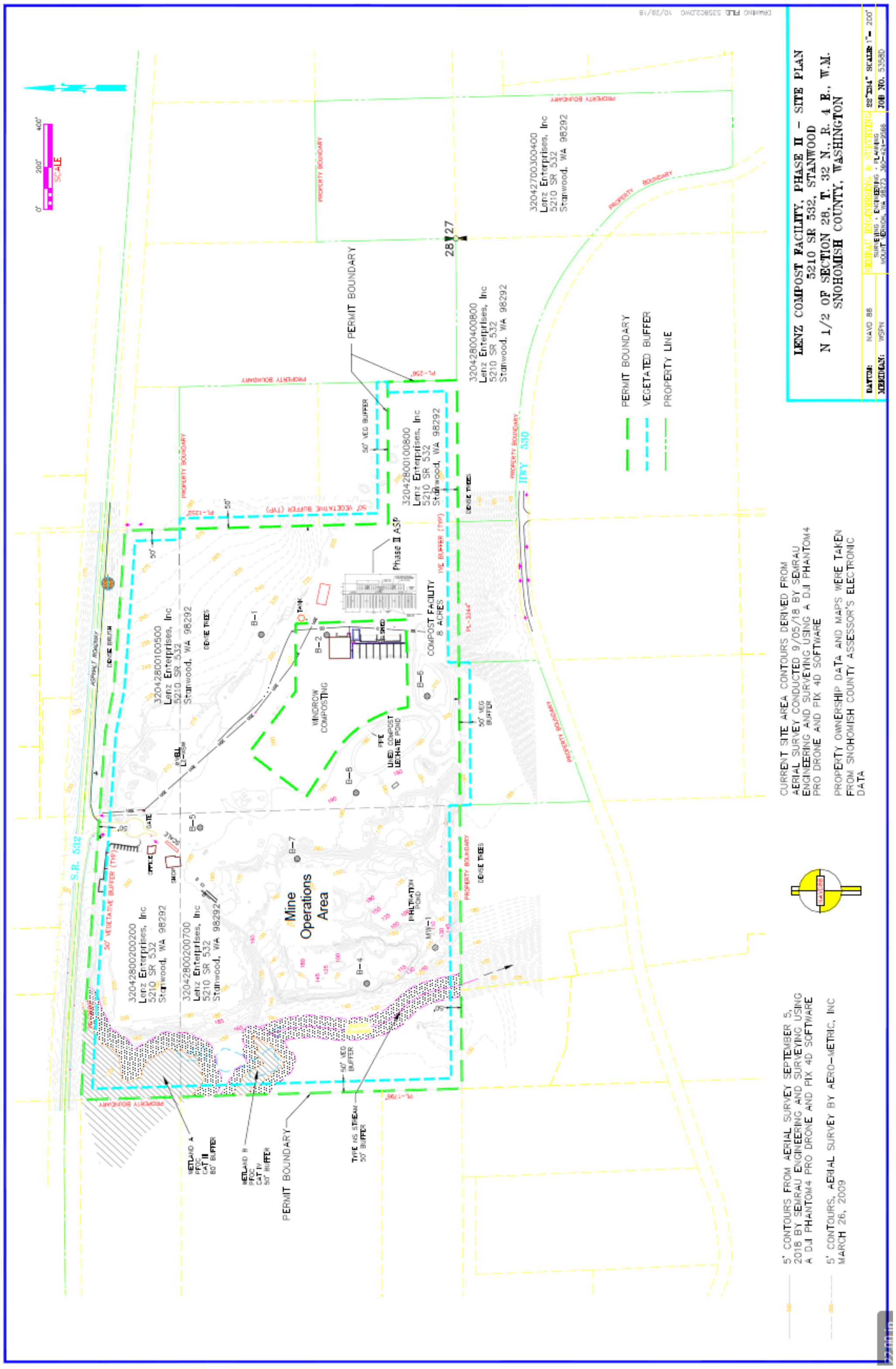
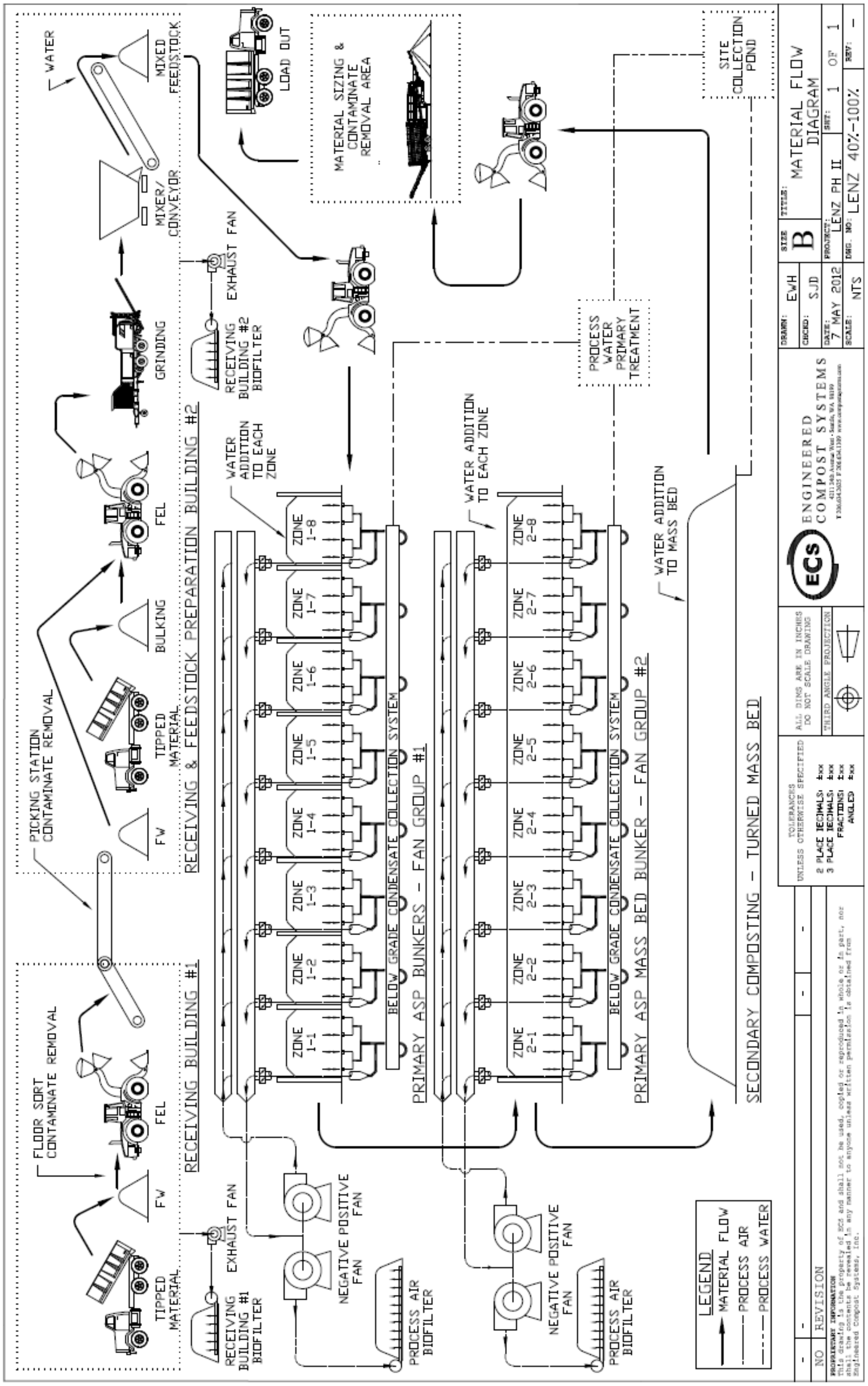
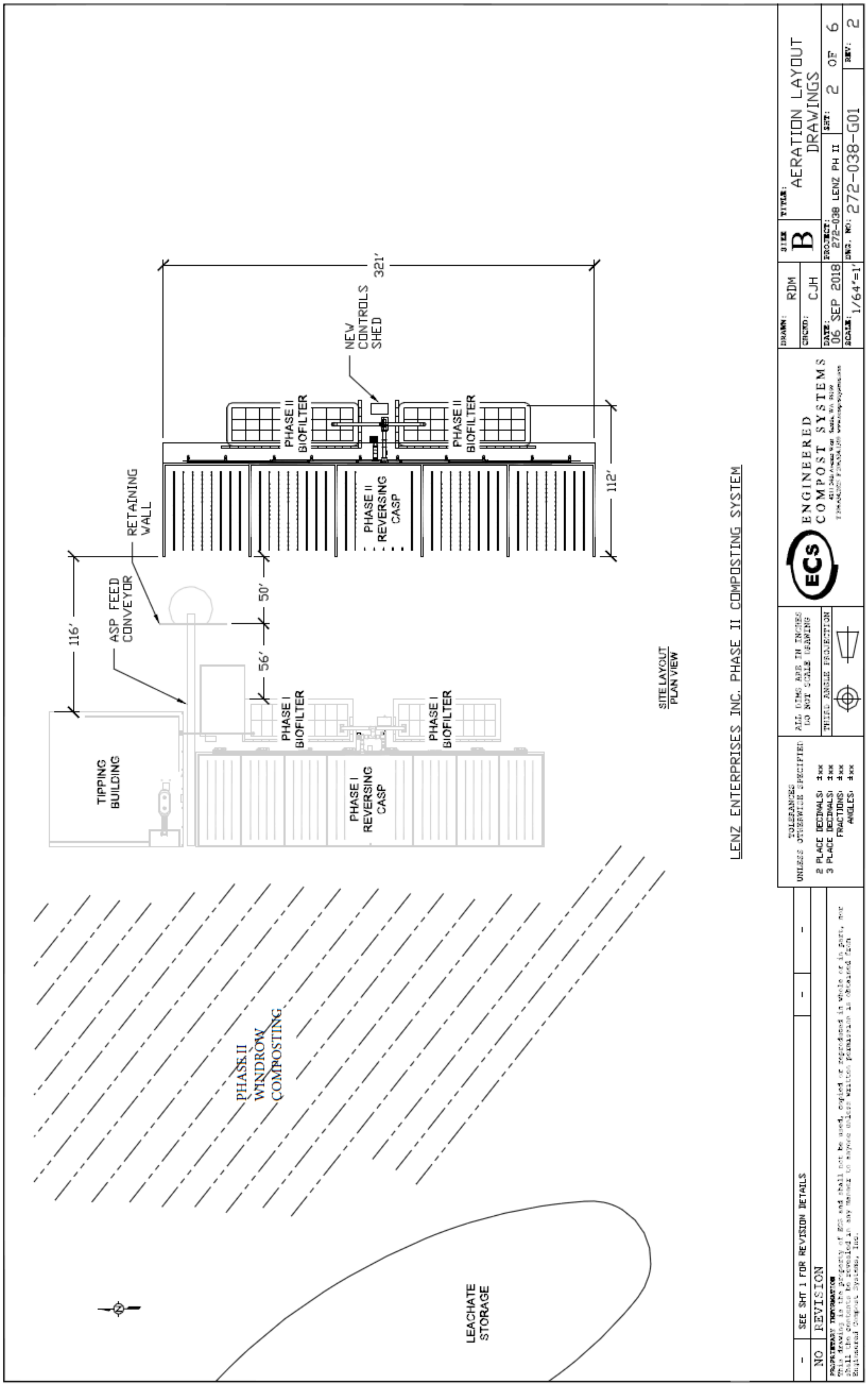
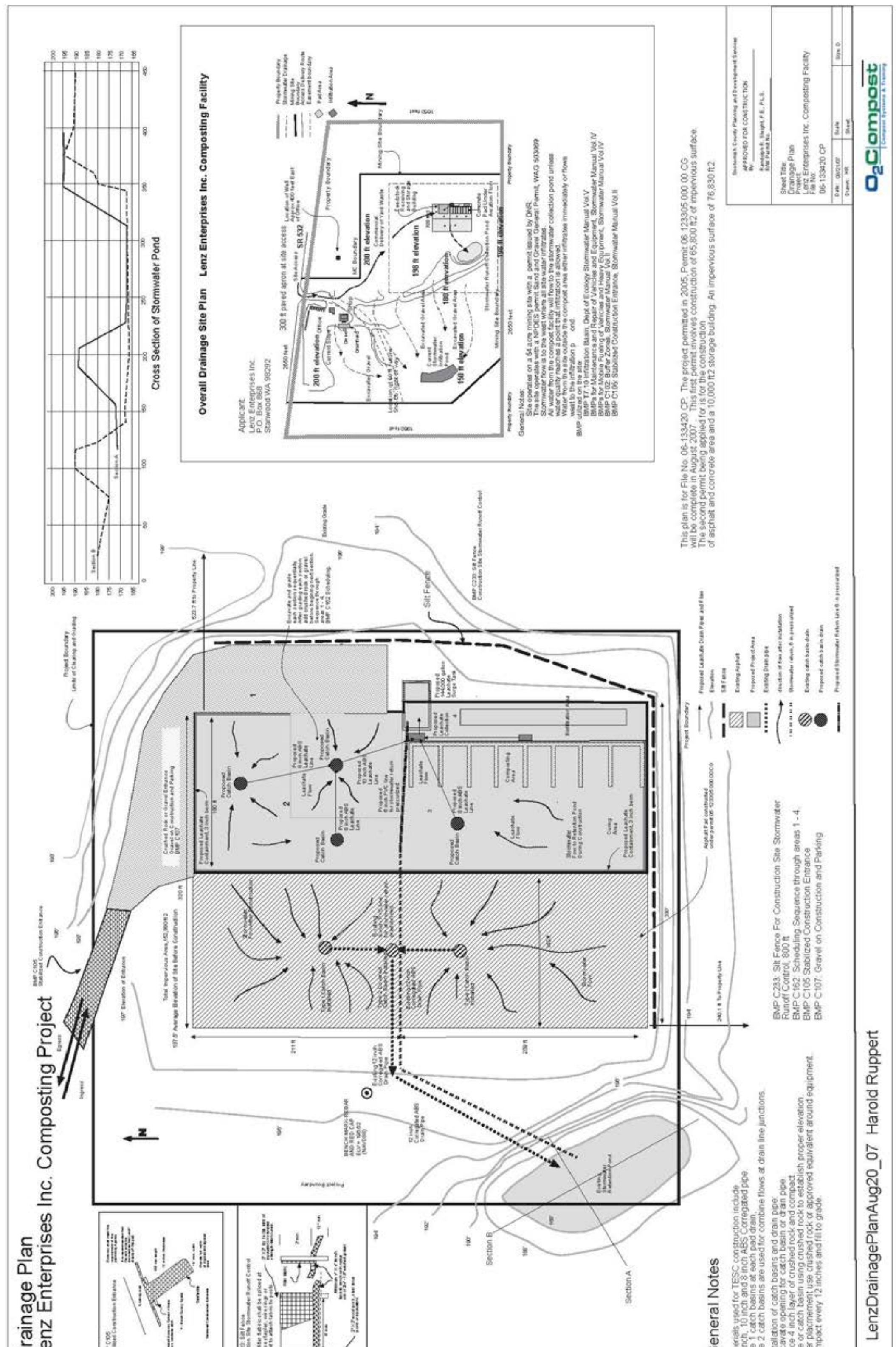
APPENDIX A. FIGURES AND MAPS




RECEIVING BUILDING #1
RECEIVING & FEEDSTOCK PREPARATION BUILDING #2
TIPPED MATERIAL
FW
FEL
FLOOR SORT CONTAMINATE REMOVAL
PICKING STATION CONTAMINATE REMOVAL
BULKING
GRINDING
MIXER/ CONVEYOR
WATER
MIXED FEEDSTOCK
EXHAUST FAN
RECEIVING BUILDING #1 BIOFILTER
RECEIVING BUILDING #2 BIOFILTER
LOAD OUT
MATERIAL SIZING & CONTAMINATE REMOVAL AREA
SITE COLLECTION POND
PROCESS WATER PRIMARY TREATMENT
WATER ADDITION TO EACH ZONE
WATER ADDITION TO MASS BED
ZONE 1-1
ZONE 1-2
ZONE 1-3
ZONE 1-4
ZONE 1-5
ZONE 1-6
ZONE 1-7
ZONE 1-8
ZONE 2-1
ZONE 2-2
ZONE 2-3
ZONE 2-4
ZONE 2-5
ZONE 2-6
ZONE 2-7
ZONE 2-8
BELOW GRADE CONDENSATE COLLECTION SYSTEM
PRIMARY ASP BUNKERS – FAN GROUP #1
PRIMARY ASP MASS BED BUNKER – FAN GROUP #2
SECONDARY COMPOSTING – TURNED MASS BED
NEGATIVE FAN
POSITIVE FAN
PROCESS AIR BIOFILTER
LEGEND
MATERIAL FLOW
PROCESS AIR
PROCESS WATER
ENGINEERED COMPOST SYSTEMS
TITLE: MATERIAL FLOW DIAGRAM
SIZE B
PROJECT: LENZ PH II
DWG. NO: LENZ 40%-100%
SHT: 1 OF 1
REV: -
DRAWN: EWH
CHKD: SJD
DATE: 7 MAY 2012
SCALE: NTS
NO
REVISION



TIPPING BUILDING
PHASE I REVERSING CASP
PHASE I BIOFILTER
PHASE I BIOFILTER
ASP FEED CONVEYOR
116'
56'
50'
RETAINING WALL
PHASE II REVERSING CASP
PHASE II BIOFILTER
PHASE II BIOFILTER
NEW CONTROLS SHED
321'
112'
PHASE II WINDROW COMPOSTING
LEACHATE STORAGE
SITE LAYOUT PLAN VIEW
LENZ ENTERPRISES INC. PHASE II COMPOSTING SYSTEM
TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE DECIMALS: ±xx
3 PLACE DECIMALS: ±xx
FRACTIONS: ±xx
ANGLES: ±xx
ALL DIMS ARE IN INCHES DO NOT SCALE DRAWING
THIRD ANGLE PROJECTION
ENGINEERED COMPOST SYSTEMS
DRAWN: RDM
CHCKD: CJH
DATE: 06 SEP 2018
SCALE: 1/64"=1'
SIZE B
TITLE: AERATION LAYOUT DRAWINGS
PROJECT: 272-038 LENZ PH II
SHT: 2 OF 6
DWG. NO: 272-038-G01
REV: 2
SEE SHT 1 FOR REVISION DETAILS
NO REVISION


Drainage Plan
Lenz Enterprises Inc. Composting Project
Cross Section of Stormwater Pond
Overall Drainage Site Plan Lenz Enterprises Inc. Composting Facility
Applicant:
Lenz Enterprises Inc.
P.O. Box 868
Stanwood WA 98292
This plan is for File No. 06-133420 CP. The project permitted in 2005, Permit 06-123305 000 00 CG will be complete in August 2007. This first permit involves construction of 65,800 ft2 of impervious surface.
The second permit being applied for is for the construction of asphalt and concrete area and a 10,000 ft2 storage building. An impervious surface of 76,830 ft2.
BMP C233: Silt Fence For Construction Site Stormwater Runoff Control, 800 ft
BMP C162: Scheduling Sequence through areas 1 - 4.
BMP C105 Stabilized Construction Entrance
BMP C107: Gravel on Construction and Parking
General Notes
Materials used for TESC construction include 12 inch, 10 inch and 8 inch ABS Corrugated pipe.
Type 1 catch basins at each pad drain.
Type 2 catch basins are used for combine flows at drain line junctions.
Installation of catch basins and drain pipe:
Excavate opening for catch basin or drain pipe.
Place 4 inch layer of crushed rock and compact.
Place catch basin using crushed rock to establish proper elevation.
After placement use crushed rock or approved equivalent around equipment.
Compact every 12 inches and fill to grade.
Silt Fence
Section A
Section B
LenzDrainagePlanAug20_07 Harold Ruppert
O2Compost

XVIII. APPENDIX B. ECS ASP OPERATING MANUAL

ECS

engineered COMPOST systems

Lenz Enterprises, Inc. CASP Composting System

Phase II Expansion

Operations and Maintenance Manual

Version 1.1

Prepared For:

Lenz Enterprises, Inc.

TABLE OF CONTENTS

Introduction

The following operation and maintenance manual is for the Covered Aerated Static Pile (CASP) composting system designed by Engineered Compost Systems (ECS). This manual is specifically written for the Lenz Composting Facility and is intended as a reference for the facility operators at this site only. It should be considered a supplement to, and not a replacement for, the on-site operator startup training. For additional technical assistance, e-mail **support@compostsystems.com**.

 It is not intended to be a comprehensive guide to the operation of a composting facility and the methodologies explained herein may not be applicable to every composting facility. Engineered Compost Systems, Inc. strongly advises all compost facility operators to become Certified Operators per the US Composting Council, and thereby be able to make informed process decisions.

This manual also includes the following Appendices; a list of ECS installation drawings, information on best management practices for composting, additional background information on biofilters, and manufacturer data sheets for some of the supplied composting equipment.

Figure 1: ECS CASP Bunker System

System Overview

The Lenz composting facility utilizes two covered aerated static pile (CASP) systems, both provided by Engineered Compost Systems, for primary composting. The first system, which was built in 2008, consists of eight (8) concrete bunkers that each process approximately 800 yd^3 of feedstock material at a time. The Phase I CASP uses reversing aeration and a low-friction trench (LFT) aeration floor. The Phase II CASP also uses reversing aeration and an LFT aeration floor, but utilizes larger bunkers. The Phase II CASP has five (5) bunkers that are each roughly twice as wide as the Phase I bunkers and can process approximately 1,250 yd^3 of mixed feedstocks.

Each multi-zone group of bunkers (Phase I and Phase II) uses two, speed-controlled fans and a centralized aeration system to provide metabolic oxygen and cooling air to the static compost piles. The fans either draw ambient air into the piles (negative aeration) and exhaust it to a common biofilter to remove odors, or force air up into the piles (positive aeration) and exhaust through the insulative bio-layer on the tops of the piles, which also removes odors. Dampers at each zone are automatically controlled by the CompTroller control system, and modulate the direction and amount of airflow to the composting material. Damper control is based on pile temperature feedback; comparing temperatures taken in the composting material to user defined temperature set points for different stages of the composting process.

The target duration for processing material under automatic control in a primary composting bunker is ten (10) days. During this time the system will begin the high aeration rate composting process and attempt to achieve time and temperature requirements of WAC 173-350-220. Upon completion, the material will be drier and significantly more dense, due to settling. If, at the completion of primary composting, the material is drier than desired for secondary composting (<50% moisture), it can be top watered for a period of 12 to 24 hours before being removed from the bunker using a front-end loader (FEL). The process of moving the material into secondary with a FEL will both re-incorporate the water into the mix and agitate the material to create a more porous (less dense) mix.

A typical ECS compost system is organized in groups of zones (a “zone” is a single area that represents an independently controlled and aerated volume of compost). A group of zones are all connected to a common aeration plenum and process air fans. Each group of zones is called a Fan Group (since each group of zones shares common process fans). There can be multiple Fan Groups at a site, which are all monitored and controlled via the CompTroller™ automated control system. This facility will have one Phase I fan group and one Phase II fan group.

The aeration rates in the CASP systems are widely variable and are controlled by setpoints according to the operator’s process goals. Typically, aeration rates are set just high enough to adequately control the temperatures within the composting material. Lower aeration rates can be used to reduce fan power requirements and to limit the amount of drying that occurs during the process. However, this may produce odorous conditions at the surfaces of the piles due to higher temperatures and possibly lower oxygen levels.

The major components of the CASP bunker composting system that are discussed in this manual include the following:

- Aeration System
- Zone Floor Trenches
- CompTroller™ and CompTroller™ GUI
- Biofilter

All the major components are intended to work together as a system, and need to be competently operated and well maintained to ensure successful facility operation.

Figure 2: A CASP Fan Group Aeration System

Safety Caution

Walking on a covered or uncovered pile, or the biofilter media, is a safety risk. Piles are often uneven and of varying density, and not stable like dirt or solid ground. Thus, they become a trip hazard. Operators rarely walk on these types of surfaces in day to day life, so caution is required every time work is conducted on the piles; such as inserting or removing temperature probes or moving the sprinklers on the biofilter media.

Basic Operating Instructions

Developing a BMP Mix

Successful composting relies largely on adhering to Best Management Practices (BMP) as set forth by the US Composting Council, the Compost Council of Canada, and others. Starting your composting process with the proper initial feedstock mix is the first, and often most important step. Guidelines for achieving a BMP feedstock mix are shown below.

Initial Mix BMP Guidelines

Parameter	Value
Density	750 – 900 lb/cy
% Water – by weight	55% - 61%
C/N Ratio	25 - 40
Organic Matter	>50%

For more detailed information on Best Management Practices see Appendix B.

Loading a Primary Compost Bunker

Active composting will begin with pre-processed, BMP feedstocks being stacked in the bunkers with a front-end loader (FEL) to a nominally level height of nine feet. Each discrete batch of material is loaded into a separate bunker, which eliminates the potential for cross-contamination from adjacent compost material that has not met pathogen reduction requirements. Material is loaded from the back of the bunker forward and as the pile is built, it will be covered by six to twelve inches of finished compost overs as an insulating layer. Care should be taken by the FEL operator not to overly compact the material by driving up on it or dropping in on to the floor from an excessive height. Continue filling the bunker until material extends all the way out to the ends of the sidewalls to ensure the aeration floor trenches are adequately covered (approximately 80' from the rear push wall). If a bunker is not filled completely and the trenches are not adequately covered, air will short-circuit the composting material. This prevents the rest of the material in the bunker from receiving adequate aeration, which will adversely affect the composting process and could lead to excess odor generation. When loading a bunker with less than the full amount (approximately 800 yds in Phase I and 1,250 yds in Phase II), lower the pile height so that the material still covers the entire aeration floor (68') and maintains a roughly uniform height.

Primary Composting

Once a bunker has been completely filled with feedstock material and the temperature probes put in place (see below), the "batch" can be created in the CompTroller user interface (see Section 3) and automatic control begun. For the duration of primary composting, the pile temperatures and system variables can be monitored in CompTroller, but direct operator intervention is not required for the batch. After the material has been in the bunker for the required time (typically a minimum of 10 days) of controlled aeration, the system control should be paused (using CompTroller) and the material physically moved into the secondary composting system.

When placing the temperature probes in a Phase I bunker pile, make sure they are approximately centered between the side walls and located roughly 1/3 and 2/3 the length of the pile. Each Phase I zone has one probe with a short cable and one probe with a long cable to assist in locating them properly. Phase II zones also have two temperature probes but they will both have the same length cables and should be equally spaced across the width of the bunker, near the center of the pile (front to back). Take care not to pull excessively against the cables when putting them in place (there should be slack in the cable after it is inserted into the pile), and never use the cable as a handle to pull a probe out of the material.

A note on the mix properties: Typically, after ten to fifteen days of aerated static composting, a batch of material will have undergone significant drying and densification. Therefore, in order to re-establish a BMP mix, the material will need to be re-wetted and agitated before starting the next stage of composting. Re-wetting the piles can be done using the bunker irrigation sprinklers and should be manually initiated by the operator at the end of the composting stage (prior to moving the material). The added moisture will be thoroughly incorporated into the mix when the FEL moves the material to the next stage. The amount/duration of watering that will be required will need to be determined by the operators through experience and observation. The target moisture content of the material at the beginning of secondary composting should be in the 55-60% range. Moving the material with the FEL will also adequately agitate the material and lower the mix density back into the BMP range.

Additionally, if less odor release is required during the break down and transfer of material from the bunkers, ECS recommends implementing a high aeration period (12-24 hours) just prior to moving any material. This can be done by manually overriding the damper to "open" (see Section **Error! Reference source not found.**). If using a high aeration period at the end of a stage, be sure to adjust the amount of re-wetting as necessary.

Process Control Equipment

Aeration Butterfly Dampers

A pair of butterfly aeration dampers at each zone/bunker controls the amount and direction of air flowing through the material in a zone. The dampers are controlled on a duty cycle basis, which means that the control system varies the amount of air to a zone by increasing or decreasing the time the zone's damper is open during a set duty cycle. CompTroller's control duty cycle is 10 minutes. So, for example, a 10% damper command would mean that the damper is open for 1 out of every 10 minutes. In addition, each damper actuator includes a feedback sensor that can detect a jammed or malfunctioning damper motor, which is then displayed as an error in the CompTroller interface.

Figure 3: Aeration butterfly damper

Temperature Probes

Two, dual-sensor, 60" long temperature probes are provided for each zone. Each probe has one temperature sensor located at the end of the probe shaft and one sensor located 18 inches from the handle top. The system also includes two, 30" long single-sensor probes for the biofilter media. All probes are designed to be inserted vertically into the material. When using either the zone probes or the biofilter probe, they must be inserted into the material to their full depth.

Figure 4: Temperature probes in storage racks on top of push wall

Pressure Sensors

Duct pressure sensors are located at each common aeration duct and at the biofilter plenum. The aeration duct sensors provide the feedback for controlling the aeration fan speeds, while the biofilter plenum sensors are used to monitor the resistance to flow in the biofilter media. Pressure sensors are mounted inside junction boxes located near each duct. Each junction box with a pressure transducer has a small heater that will automatically turn on to prevent freezing during colder weather. Pressure sensors are connected to the duct with a ¼" ID vacuum hose.

Figure 5: ECS Junction Box (mounted on wall) with pressure hose connected to aeration duct

Aeration Fans

Each fan group uses two fans to provide aeration to the composting zones. One for each direction of airflow, positive and negative. Fan speeds are controlled by variable frequency drives (VFDs). During normal operation, the speed of a fan is automatically adjusted by the system to maintain a set pressure in each aeration duct.

Figure 6

Biofilter

The composting areas both exhaust process from the negative aeration plenums to a biofilter. The biofilter, which consists of a 4' to 5' tall bed of ground wood media, is used to reduce the odor and VOCs of the process air before it is released to the atmosphere. A well maintained biofilter can reduce odors and VOCs by 90% or more. For detailed information on design, operation and maintenance of the biofilter, see the Biofilter Technical Bulletin attached in Appendix C.

Figure 7: Biofilter media being installed

Maintenance

The CASP system is designed to have minimal maintenance requirements. However, there are a few items that should be checked periodically. Below is a list of these items, including how often they should be checked.

Dampers and Actuators

Frequency: Every 12 months

Procedure: Test action of air dampers at each zone. Use manual overrides to force each zone into the CLOSED and OPEN positions. Observe the actuator position as well as the damper blade position.

- In the CLOSED position the damper should be completely closed (blade perpendicular to duct).
- In the OPEN position the damper should be completely open (blade parallel to duct).
- Damper blade position can be observed by looking at the score mark on the end of the damper blade shaft.

Figure 8: Damper & Actuator with score on end of shaft (closed position)

Fans – Lubricate Bearings

Frequency: Every 1 month

Procedure: Lubrication points are located on the frame; see the fan manufacturer's maintenance manual included in Appendix D for more details. See the motor nameplate for lubrication requirements of motor bearings.

VFDs

Frequency: ***Every 3 months or as needed.***

Procedure: Remove accumulated dust from the cooling fins of the VFDs on the ECS Controls Skid. This is best done using compressed air. These may require more frequent cleaning if VFD overheat faults occur.

Figure 9: VFDs on Controls Skid

Temperature Probes

Frequency: Every 12 months

Procedure: Place each temperature probe in a bucket of water along with a dial thermometer of known accuracy. Wait two full minutes and compare with the reported temperature displayed in CompTroller™. Variations of more than +/- 2 degrees Celsius may indicate a failed sensor or wiring issue. Consult ECS for troubleshooting.

Frequency: Monthly

Procedure: Inspect cables for integrity and physical damage. Repair minor coating damage with electrical tape. Ensure spare probe is ready for installation.

Pressure Sensor Calibration

Frequency: Every 6 months or as needed.

Procedure: Turn off fans and check pressure sensor readings. All pressure sensors should read 0.0 inches of water column. If sensor readings are off by more than +/- 0.2 inches, zero pressure sensors using the CompTroller™. See “Zeroing (Calibrating) Pressure Sensors Section 3.13.

Aeration Floor & Drain Cleaning

The compost bunkers use ECS's Low Friction Trench (LFT) air floor to provide aeration to the composting material.

Figure 10: LFT with one trench cover removed.

Trench Covers—Inspect & Clean as Necessary

Frequency: Inspect every month, clean as required

Procedure: Inspect the aeration trench covers for clogging. If more than 20% of the holes are found to be clogged, clear them manually with a stiff narrow brush, power washer, or an awl (nail in the end of dowel works well).

Aeration Trenches and Below Grade Pipe —Inspect & Clean as Necessary

Frequency: Inspect every 3 months, clean as required

Procedure: Override all of the zone dampers to closed (0%) and manually control the aeration fan to 0% speed. Override all drain valves to remain OPEN (See section 3.15). Remove the 6^{th} and 16^{th} covers of each trench, counting from the rear push wall, as well as the center cleanout cover (see Figure 6). Check for solids accumulation or standing water. Flush with water jet if clogged. Remove trench covers and clean trenches if solids depth is greater than ½ an inch along the length of the trench.

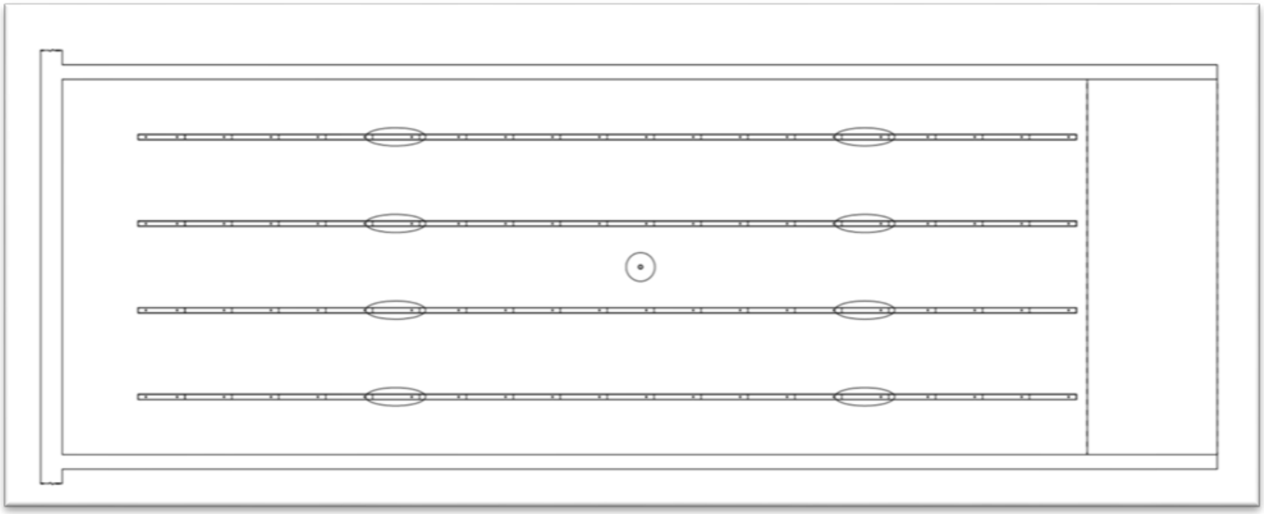


Figure 11: Aeration Floor Cleanout Locations

Level-Controlling Sump—Inspection and Solids Removal

Frequency: Inspect every 6 months, clean as required.

Procedure: Check level of solids accumulation and clean out with a Vacuum Truck to remove solids and as necessary to keep inlets clear. It is often necessary to pump the sump simultaneously while flushing the up-stream components.

Glossary

Actuator: See Damper Actuator

Aeration Duct Pressure: The pressure measurement in an aeration duct. Pressures typically range from 0 to 10 inches of water column.

Aeration Fan: A fan which provides negative pressure to the aeration plenum, drawing air from the zones and exhausting it to the biofilter.

Aeration Floor: The part of the aeration system responsible for supplying air to the bottom of a compost pile. For the AC Composter, SV Composter™ and Standard ASP systems, the aeration floor can be cast-in-slab aeration trenches, or the CompDog pipe-less aeration floor system. The CV Composter™ has its own built-in, low-friction aeration floor. Perforated plastic aeration pipe, although once very common, is not typically used on ECS systems.

Aeration Plenum: The ductwork that connects the zones to the aeration fan.

Aeration System: The system components responsible for supplying air to the compost zones. ECS aeration systems are tailored to our client's facility specifications and requirements. They provide either single direction, or reversing direction with re-circulating aeration. All aeration components exposed to the corrosive environment of composting are made of stainless steel or polymeric materials. Major components of an ECS aeration system are: the aeration floor, zone dampers, aeration plenum (ducting), fans, and system air dampers.

Ambient Temperature: The outdoor air temperature, typically measured at the controls shed.

Batch: The material being processed in a zone. A batch of material is tracked by the CompTroller even when moved from zone to zone. Recorded data is always associated with a particular batch. All ECS systems are batch and static. Depending on the facility throughput, one to several days incoming feedstocks are collected/processed until enough material is gathered to fill a zone/pile. Once the zone/pile is full and the aeration system is engaged, it is considered a batch. (Similar to making a batch of cookies.)

Biofilter: A biofilter is a pollution control technique that uses living microorganisms to capture and biologically degrade process pollutants. ECS systems use biofilter to scrub odor, VOCs and other pollutants from compost process air. Biofilters are made from ground wood and mature compost. They are a robust, efficient and cost-effective tool against odors.

Biofilter Media: The material used to make up the filter bed in a biofilter. Typically, this is made from a ground wood waste material mixed with a small amount of mature compost.

Biofilter Plenum: The part of the aeration ducting that distributes air to the biofilters. The biofilter plenum is just outside the media and is the ducting that connects to the sparger pipes buried under the media.

Biofilter Temperature: The temperature measured by a biofilter temperature probe inserted into the biofilter media.

Biofilter Temperature Probe: Probes that measure the temperature of the biofilter media at one or more points along the biofilter. They are physically inserted into the biofilter as part of the biofilter media building procedure.

Bus Voltage: Diagnostic detail for a fan VFD. Reports the voltage on the input bus of a VFD. This is rectified voltage from the incoming line. This information is typically only needed to diagnose over/under-voltage faults and normal values will depend on the specifics of the site.

Bus Current: Diagnostic detail for a fan VFD. It reports the line power current draw from a VFD. This is typically only used when diagnosing over-current faults.

Control Cycle: The time period used by the controls system for evaluating and readjusting the control parameters for each compost zone. For example, at the end of each control cycle the system will set the amount a zone damper is open based on the zone's pile temperatures over the last control cycle. A typical control cycle is 10 minutes.

CompTroller™: ECS Aeration Control and Monitoring System. The CompTroller automates the amount of aeration to each compost zone depending on its cooling requirements. It automatically guides each batch of compost through the time and temperature protocol of the US EPA PFRP and VAR regulations; records the time/temperature process; and keeps track of each batch of compost as it moves through the facility. The CompTroller constantly optimizes process control based on user input settings. It simplifies operations, conserves electricity, and reduces labor. It is the controls system found in all ECS In-vessel and ASP systems.

CompTroller™ GUI: A graphical user interface where you can control and view the settings of your fans, dampers, biofilters and composting batches.

Control Regime: The CompTroller is designed to hold/maintain multiple, different user input temperatures for a certain period of time. These time and temperature periods are called Control Regimes and are preset to follow the time/temperature protocols (regulations) for biosolids composting found in the US EPA 503 regulations. The first control regime is typically for the process to further reduce pathogens (PFRP), the second is for vector attraction reduction (VAR), and the third is optional and set by the user.

Damper: A mechanical device for regulating the flow of air. Dampers can be either butterfly or louvered-vane type. Typically, in an ASP system they are used to regulate the air flow through a compost pile (zone damper), or to prevent flow from going in an undesired direction (backdraft damper).

Damper Actuator: An electro-mechanical device (motor) for automatically controlling the position of an aeration damper.

Exhaust Pressure: The pressure measurement in the aeration plenum on the exhaust side of the aeration fan leading to the biofilter. Pressures typically range from 0 to 10 inches of water column.

Exhaust Plenum: A positively pressured plenum or duct on the exhaust side of a fan. Typically provides air to the biofilter.

Exhaust Temperature: The temperature of the air in the exhaust duct measured by a probe permanently mounted in duct between the aeration fan and the biofilters. This is the temperature of the air entering the biofilters.

Fan: See Aeration Fan.

In-Duct Temperature Probe: A permanently mounted probe in an aeration duct that measures air temperature.

Pile: A generic term referring directly to the compost media in a given zone or as any given batch. A pile is built in a zone.

Plenum: See Aeration Plenum or Biofilter Plenum

Pressure Sensors: The instrument used to measure the pressure inside an aeration duct. An ACC system typically has one suction side sensor (Aeration Duct Pressure) and one exhaust side sensor (Exhaust Duct Pressure). An ASP system typically has three pressure sensors, one supply plenum pressure, one for exhaust plenum pressure and a third for pressure in the biofilter line.

Probe: See Biofilter Temperature Probe or In-Duct Temperature probe or Zone Temperature Probe.

Sparger Pipe: A perforated pipe buried at the bottom of the biofilter media for distributing system exhaust air into the media.

Variable Frequency Drive (VFD): An electronic device for supplying variable frequency power to a fan motor to control fan speed.

Zone: A vessel or aeration floor area that contains and processes a single batch of composting material. Each zone can independently monitor and record pile temperatures in its contained batch and control airflow through the material. In-vessel systems typically refer to vessels or zones; ASP and ACC systems are typically referred to as zones or piles. A zone/pile is a volume of feedstocks prepared for composting and placed in the appropriate vessel or pile area of the composting system. The zone/pile has an independently controlled air supply based on temperatures. For example, in a typical ACC system, an aeration zone/pile has the following components: discreet pile of compost, one zone damper, zone temperature probes, and one AC cover.

Zone Junction Box: An electrical junction box enclosure located at each zone. The damper and temperature probes for each zone are connected to the controls system at each zone junction box. Each zone junction box also includes a selector switch for manually overriding the damper position.

Zone Temperature Probe: Probes that measure the temperature of composting material at one or more points along pile length. They are physically inserted into compost piles as part of the pile building procedure.

This section includes the following installation drawings for this system.

Drawing No.	Revision	# of Shts	Description
266-M01	1	21	Mechanical Installation Drawings
266-M02	-	5	Biofilter Irrigation Layout
266-P01	2	2	Process & Instrumentation Diagram
266-E01	1	2	Control System Diagram
266-E02	2	1	Field Connections Diagram
266-E03	1	1	One Line Power Diagram
266-E04	1	1	Cable Schedule
266-E05	1	1	AP1 Power & Control Diagram
266-E06	-	1	AP1 Enclosure Drawing
266-E07	1	1	MCP1 Power Diagram
266-E08	1	1	MCP1 Enclosure Drawing
266-E09	1	1	Junction Box Enclosure Drawing

The operator should choose feedstocks that result in a mix with the characteristics proscribed by the US Composting Council's best practices guidelines. The properties of the target mix are summarized in the Table B-1. Mixes with properties outside these ranges can still be composted but may stabilize more slowly, produce more odors, and produce a less desirable end product.

Table B-1: Properties of a Target Mix

Property	**Units**	**Range**
% Water – by weight	%	55-61
Density	lbs/yd^3	750–900
Density	lbs/gallon	3.7–4.5
Carbon/Nitrogen Ratio	ratio	25–40

A. What is Composting?

Composting is a managed process that controls the natural, biological process of decomposition and transformation of biodegradable material into a humus-like substance called compost. The primary organisms responsible for composting are bacteria and fungi that are naturally present on organic matter and soils. Many other microorganisms, insects, bugs, worms, and larger decomposers may also be involved in the later mesophilic curing phases of composting. Like all living systems, the composting process requires oxygen, water, an energy source (organic carbon), and essential nutrients (nitrogen predominantly).

The end product of an optimized compost process is a valuable soil amendment that helps to make low density and well-drained soil, provides plants with valuable nutrients, prevents soil erosion and compaction, and conserves water and other resources.

ECS Composting Systems are designed for high-rate, high-temperature composting that optimizes aerobic decomposition. The following discussions focus on creating optimal conditions for these organisms in ECS systems.

When the proper environmental conditions are provided the bacteria responsible for decomposing organic matter will grow and reproduce rapidly. This bacterial activity generates the heat associated with composting. Temperatures in excess of 170°F can be generated. As readily metabolized energy sources become depleted, temperatures decline and eventually return to ambient levels.

Many groups of bacteria help to decompose organic matter. Each group thrives in different conditions and consumes different components of organic materials. *Mesophilic* bacteria thrive at temperatures from 70° to 90°F, and survive between 40° and 110°F. Mesophiles are important at the beginning of the composting process in converting acidic feedstocks (SSO and leaf / yard waste) to neutral pH. Mesophiles can complete the pH adjustment over a 1-5 day period if the pile temperature is kept below 110°F. If heat generated is not removed through high rate aeration early in the process, the temperature of the pile can rise above the tolerance levels of the mesophiles and into the thermophilic zone. Thermophiles are inhibited by low pH conditions (<6) and the process will be much slower than if the proper conditions for mesophiles were maintained (with maximum aeration rates) until the pH rise past 6.5

With proper pH in the pile (6.5-8.5) *thermophilic* bacteria work rapidly within the temperature range of 100° to 150°F. Beyond 150°F the thermophilic process will become increasingly inhibited by temperature due to the difficulty dissolving oxygen in the pore air space into the biofilm (liquid) layer of the particles of decomposing organic matter. Other than the early mesophilic phase (<110°F) and PFRP phase (3 days >131°F to kill pathogens and inactivate weed seeds) the rest process should be maintained below 150°F for maximum decomposition and lowest odor generation.

The ECS ASP system automatically controls aeration to achieve temperatures sufficient to accomplish these steps, in a properly constructed BMP mix, through the input of temperature set points in the GUI.

B. Environmental and Feedstock Impacts on Composting

The rate of bacterial decomposition depends on five primary factors that can be manipulated by the facility operator:

B.1 The Carbon:Nitrogen Balance (C:N ratio) of Feedstocks

Bacteria (decomposers) require carbon for energy, and nitrogen to synthesize proteins to build their bodies. The optimal carbon to nitrogen ratio for aerobic composting is 25-40:1. When the ratio is much above 40:1, bacterial activity slows dramatically. When the ratio falls much below 20:1, nitrogenous compounds such as free ammonia build to levels toxic to beneficial decomposer bacteria, and unpleasant odors may result. As Table B-2 illustrates, most composting feedstocks do not have the ideal carbon-to-nitrogen ratio. Selection and mixing of nitrogen-rich feedstocks and carbon-rich bulking agents is discussed below.

B.2 Moisture Content of Feedstocks

The most efficient decomposers are *aerobic* bacteria, that thrive with an adequate supply of oxygen (discussed below), and at moisture levels of between 40 to 60 percent by weight. At moisture levels below this range, bacterial activity slows dramatically. At higher moisture levels, small pores between organic waste particles fill with water, diffusion of oxygen decreases and bacteria switch to anaerobic oxidation pathways which generate foul smelling by products. Moisture levels in compost feedstocks can be measured by laboratory tests, or by a trained individual based on a hand squeeze test which is typically taught at USCC Operator Training courses.

Moisture may be adjusted by wetting the mix prior to composting and at the end of each stage in the compost process:

1) Wet and dry feedstocks may be blended in proportions designed to achieve an optimal moisture level (Table B-2).
2) Water can be sprayed onto dry feedstocks to achieve optimum moisture levels near the end of the compost stage (immediately prior to unloading). Once the composting process is started, it is difficult to moisten dry feedstocks except by pulling apart the composting mass (or unloading a vessel), and spraying water on materials as they are re-mixed.

B.3 Adequate Aeration

In order to make use of *aerobic* bacteria, it is important to have an adequate supply of oxygen. Oxygen diffusion from the pore air between compost particles to the liquid biofilm of the decomposing waste is affected by temperature. The higher the temperature, the less oxygen can stay dissolved in the liquid (i.e. beer is fizzier when it's cold, cold liquids hold more gas than hot liquids). When oxygen concentrations fall below 4ppm (see table below), oxidation proceeds into *anaerobic* decay, and excess odor is generated and the process dramatically slows, especially at high temperature. The table below (excerpted from the UK Environment Agency) recommends keeping putrescible feedstocks above 3ppm, but ECS experience indicates that >4ppm is a much safer zone to be in, and with our aeration supply rates, this should be readily achievable through most of the 10-day aerated retention time.

Saturation O2 concentrations in water mg/l (ppm)

O2 partial pressures (%) vs temperature (C)

O2	20ºC (68F)	25ºC	30ºC (86F)	35ºC	40ºC (104F)	45ºC	50ºC (122F)	55ºC	60ºC (140F)	65ºC	70ºC (158F)	75ºC	80ºC (176F)
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

kH for O2 in H2O
0.0013
(l atm / mole)

van't Hoff constant
1700
(ºK)

- 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

Aeration is automatically managed during the 10 days primary composting process. Feedstocks may be blended in proportions designed to achieve a density that ensures adequate porosity to allow unrestricted airflow (Table B-3). The optimal initial density for composting is approximately 800 to 900 pounds per cubic yard. Denser materials are difficult for air to diffuse through evenly, and anaerobic pockets of materials can form. Lighter materials are likely to be too dry. Aeration can be managed by using the aeration control and monitoring systems found in all ECS systems.

B.4 Surface Area Exposed on Feedstocks

A rotting log provides a good illustration of how surface area affects the speed of decomposition. A large tree branch lying in the environment decomposes slowly, but when it is chipped into smaller pieces the surface area increases and it decomposes more quickly. With more surface area exposed, bacteria have greater access to easily available food. The desire to increase surface area must be balanced against the need to maintain porosity for adequate aeration of composting materials. Shredding (or grinding where contamination is not a concern) and blending feedstocks to produce a mix with a density of 750 to 900 pounds per cubic yard) is a common BMP procedure prior to aerated static pile composting.

B.5 Mass (Pile Size) or Insulation to Retain Heat

Generally, a few cubic yards of piled composting material will provide adequate mass to hold sufficient heat to maintain *thermophilic* composting conditions **in the middle of the pile**. However, when composting pathogenic materials such as biosolids or post-consumer food waste, (EPA Section 503 mandated) pathogen reduction requirements dictate that insulation must be provided to achieve high temperatures uniformly through the mass. This is achieved in the ASP by insulating the pile with a cover coat or insulating blanket. In static freestanding piles, insulation can be achieved by covering the entire pile with a 6- to 12-inch-layer of finished compost. Pile insulation is not necessary in ECS SV Composter™ in-vessel systems.

C. Selection of Feedstocks and Bulking Agents

Selection and preparation of feedstocks and bulking agents should be carefully managed to optimize the environmental factors affecting composting rates describe in the previous sections. Most compost feedstocks are commonly categorized as either nitrogen-rich feedstocks or carbon rich bulking agents. The major characteristics of each group relative to the factors affecting bacterial composting are defined below.

C.1 Nitrogen Rich Feedstocks

Green landscape waste, biosolids, food wastes, animal manure and other byproducts are typically relatively high in nitrogen and moisture content (Table B-2). In most cases it is desirable to dewater or dry out biosolids, food- and animal-wastes to approximately 18 percent solids prior to mixing for composting; in order to make material handling clean and efficient, and to minimize the amount of bulking agent and composting equipment capacity required. Several methods can be used for dewatering such as sand drying beds, belt filter presses, centrifuges, dewatering containers, vacuum filters, etc. The nitrogen-rich feedstocks should have a minimum volatile solids concentration of 40 percent.

C.2 Carbon Rich (Woody) Bulking Agents

Carbon rich materials such as wood chips are commonly used as “bulking agents” to provide porosity and energy for composting. They are also used to balance moisture if the organic feedstock is excessively moist. Woody materials such as wood chips and sawdust are the most common bulking agents, since they have the structural rigidity required to maintain porosity for adequate airflow. Fresh green wood chips have more energy than older recycled chips. Particle size also determines the energy available. Sawdust, for example, will generate more heat than chips if the other key BMP parameters are maintained (including density and moisture).

Shredded paper, pulp, or paper sludge may also be used as bulking agents, however they must be mixed with coarser, more rigid materials to ensure adequate porosity. Woody material can both be fresh or dry, and ideally have a minimum of 50 percent solids. Leaves and mixed yard waste can also be use as bulking agents if they have sufficient solids content. See Table B-2 below for physical properties.

Table B-2: Typical Properties of Compost Feedstocks and Bulking Agents

Material	**C:N**	**Moisture**	**Density lbs/yd^3**
Nitrogen-Rich Feedstocks			
Dewatered Biosolids			
+ Aerobically digested		85–90%	1500–1600
+ Anaerobically digested	7:1–15:1	76–83%	1800
+ Primary		76–85%	1900
Food scraps	7:1–15:1	70–90%	1200–1500
Green Landscape Wastes	10:1–20:1	70–90%	600-850
Carbon-Rich Bulking Agents			
Ground Wood Chips / Woody	100:1–200:1	20–40%	500–900

Pruning's			
Paper (dry, shredded)	200:1–300:1	5–10%	
Sawdust	200:1–500:1	10–40%	450–600

D. Calculating a Compost Mix

Composition of the initial compost mix is among the most critical aspects for successful composting. Determining the appropriate mix ratio for all the different ingredients first requires some basic knowledge about the material properties.

D.1 Moisture

The target moisture content of the initial composting mix is 60 percent (40 percent solids by weight). The percent solids of the nitrogen-rich feedstocks and bulking agents are used to determine the ratio of bulking agent to feedstock required in the batch mixer. Optimal moisture levels for composting occur when materials are about as moist as a wrung-out sponge. They should be obviously moist to touch, but yield little liquid when tightly squeezed by hand.

An optimal mix can be determined by trial and error; however, it is more efficient and accurate to determine the moisture content of each feedstock and bulking agent by laboratory methods in order to calculate mix rates, see Table B-3 *(Note: A spreadsheet for performing these calculations is available from ECS)*. Refer to Standard Methods for the appropriate lab method of determining percent solids. The percent solids of the compost mix should be checked prior to loading each vessel or zone. The percent solids of the bulking agent or other ingredients should be sampled weekly.

An example of calculating a bulking agent mix ratio and total mix volume for a two-feedstock mix is shown in Table B-3. In this case the dry tonnage of the wet (nitrogen-rich) feedstock is fixed. Also fixed, are the desired mix percent solids (combined mix at 40 percent) and the percent solids of the bulking agent (62 percent). The moisture content of the wet feedstock then varies from 12 to 20 percent. The model calculates the resulting raw mix and amendment volumes. Table B-3 clearly shows the effect of very wet feedstock to total volume.

D.2 Volatile Solids and Carbon/Nitrogen Ratio

Adjusting the ratio of the nitrogen-rich feedstock to the carbon-rich bulking agent typically controls the carbon/nitrogen (C/N) ratio of the compost mix. The volatile solids concentration is determined by the nature, pre-digestion or ages of the feedstocks. Generally, samples must be sent to a lab for total nitrogen (TKN) analysis, or refer to Standard Methods. The ideal C/N ratio is between 25:1 and 40:1. Controlling this ratio during mixing can be best done using the laboratory data and mixer scale weights, rather than on a volume basis.

Volatile solids represent the amount of carbon (potentially) available for degradation during composting. Burning a dry sample and weighing the difference between the ash and the original sample determines the volatile solids. (Refer to Standard Methods for the correct lab procedure). The amount burned off is assumed to be volatile carbon. Feedstocks such as foodwaste, poultry litter, fresh wood chips, and primary sludge have a high level of bio-available volatile solids. Feedstocks such as paper sludge, old wood chips, and secondary aerated biosolids tend to have low levels of bio-available volatile solids. Mixes from the former group will heat up quickly and require more fan power to control temperature. Mixes characterized by low levels of bio-available volatile solids heat-up slowly and can have trouble reaching and maintaining PFRP and VAR temperature levels.

Table B-3: Mix Volume Calculations

Dry tons wet feedstock	dry ton	1.00					
% Solids of feedstock	%	0.12	0.14	0.16	0.17	0.18	0.2
Wet weight tons	tons	8.33	7.14	6.25	5.88	5.56	5.00
Volume of feedstock	yd3	9.52	8.16	7.14	6.72	6.35	5.71
Mix % solids	%	0.40	0.40	0.40	0.40	0.40	0.40
% Solids wood waste	%	0.62	0.62	0.62	0.62	0.62	0.62
Mix ratio (wt chips/wt feedstock)		1.27	1.18	1.09	1.05	1.00	0.91
Volume ratio		4.05	3.45	3.18	3.05	2.92	2.65
Wet wt wood waste	tons	10.6	8.44	6.82	6.15	5.56	4.55
Density wood waste	lb/yd^3	550.0	550.0	550.0	550.0	550.0	550.0
Volume wood waste	yd^3	38.57	28.1	22.7	20.5	18.5	15.2
Total wet wt	tons	18.9	15.6	13.1	12.0	11.1	9.6
Total daily volume	yd^3	42.3	31.9	26.3	23.9	21.9	18.4
Bulk Density of Mix	(tons/ yd^3)	895.0	975.7	994.3	1004	1015	1039
For 2000 lb wet feedstock Weight of bulking agent (lb)		2545	2364	2182	2091	2000	1818

Biofilter Theory, Design and Operation

Design Theory and Operation

Biofilters are a common means (thousands of installations worldwide) of scrubbing odors associated with exhaust air from composting and other processes that generate volatile compounds. They work based on the concept of an active biological film supported by a substrate - the same principal as composting. The volatile compounds are absorbed on to the surface of the media and bio-oxidized by the microbes present. As long as the media is appropriate, installed in a manner that does not allow the air flow to channel or short- circuit, and the moisture and temperature levels are maintained, biofilters work very efficiently to oxidize a broad spectrum of volatile chemicals at low part-per-million concentrations. The rule-of-thumb for biofilter efficiency is that a well maintained biofilter will provide a one log (factor of 10) reduction of most bio-oxidizable compounds. Biofilters are resilient to varying environmental conditions such as snow and rain, hot and cold; under average to best management practices biofilters remain effective.

Design Specifications

The specifications for a biofilter design depend on the volume and contents of the exhaust air, the climate, and the site's sensitivity to odor generation. The following is a list of generalized design specifications.

Residence time	• 40 - 90 seconds
Media temperature	• 10° – 50° C
Active media depth	• 36" – 66"
Media components	• 95-97% screened coarse resilient wood (ideally shredded root wood) chips sized 1" to 2"plus (discard the fines) • 3-5% stable compost (preferably made from the feedstocks themselves)
Media moisture content	• >50%
Max pressure drop through media	• < 0.5" SP/foot of depth (once greater than this the media should be replaced)

When building the biofilter, the media choice is very important to performance efficiency and longevity. A bed of relatively coarse stable media will provide more uniform flow, lower friction loss, and a longer lifetime then a bed finer degradable media. Only a very small amount of more degradable material, such as compost, should be added to otherwise coarse (with the fines removed) clean stable shredded wood. The primary reason for adding the compost to the media is to shorten the biological conditioning period required for the effective microbes to become established. This period is thought to typically take 4-8 weeks.

A critical operational factor for a biofilter is maintaining the correct moisture content in the filter media. The media must be maintained at greater than 45 percent moisture, so a higher design setpoint of 50% is chosen. If the media becomes too dry, microbiological activity will be suppressed and odorous gases will not be fully oxidized. Eventually channeling will occur as air moves through drier passages causing further localized drying and shrinkage of the media. Once this occurs, the media should be changed.

The exhaust air from a composting process is generally saturated (100% RH). This humidity maintains the moisture content in the majority of the media. The upper layer will often still dry due to evaporation, but this generally does not impact the overall performance. Imbedding a soaker hose near the top of the pile is a good means to both insure uniform moisture throughout the pile, and to provide a means of occasionally washing out soluble nitrates that can build-up in the media (especially while composting biosolids). In hot and dry environments, adding surface irrigation is often required to keep the top layer moist.

Typical Biofilter with Above Grade Pipe and Coarse Media

Another important operational factor is the temperature of the biofilter media. An ideal range of media temperature between 10° and 45° C. Biofilter efficiency begins to decline above 45° C and falls off quickly above 50° C. The media also volatilizes quickly at temperatures above 50° C (a bed may lose feet of height in a matter of months if high temperatures are maintained). Short term excursions in the 50's° C range are generally acceptable so long as monthly average media temperatures are $\leq$ 45° C. The compost aeration and control system needs to monitor and control the temperatures of exhaust air and biofilter media. Ideally, the system will automatically control the exhaust air temperature to an operator chosen setpoint by adjusting the volume of dilution air. In some cases (especially when large volumes of pre-heated building air are mixed with process air) additional humidification is required to prevent dilution air from over-drying out the biofilter media.

The media bed and aeration floor must be constructed in manner that avoids short circuiting of the air. This is easily done with the correct density and particle size media built in a bed that extends past the edges of the aeration floor. Vertical walls tend to promote short circuiting; if they are necessary in the site design make sure that they are at least 2-4 feet back from the edges of the actively aerated floor (the higher the wall, the further the setback).

Biofilter with a Suspended Perforated Floor

Maintenance

Even though biofilters are quite resilient to varying environmental conditions there are few things an operator should periodically check.

Moisture

The operator should take grab samples from the media once every two weeks to test for moisture content. If the media appears to be over drying, increase the irrigation frequency with a soaker hose.

Temperature

The operator should monitor the biofilter media temperature weekly (this temperature will be displayed on the operator PC in the automated control and monitoring software). The operator can vary make-up and exhaust damper control setpoints, as well as the relative settings of the supply and exhaust blowers, to control the temperature of this exhaust air. These settings are typically adjusted seasonally.

Pressure Drop/Media Densification

The operator should record the static pressure drop through the biofilter at a standardized operating condition (compost aeration process supplier should specify system setting during start-up that identify such a condition) once every six months to track densification in the media.

General Inspection

The useful life of the biofilter media depends on the material used and the operating conditions. Different types of coarse ground wood have varying resistance to breaking down. Also, higher temperatures tend to degrade biofilters more quickly. Generally the media is expected to last 1-3 years. Spent biofilter media is characterized by:

- Cracking and channeling
- Breakthrough of contaminants (odors)
- Increased head loss (compaction and increased density)
- Shifts in media pH

Once the media is degraded, it should be removed and either added into the compost mix as an amendment or marketed as well-matured compost.