Lenz Enterprises Inc.

Review to PSCAA comments on compost expansion application

1. Responses to "A. Approach using modified CARB Method for VOC"

Our statement that no agency has defined emission factors (EF) was based on the fact that no EF have been promulgated (established as rules, regulations, or ordinances) that relate to the Lenz compost facility (LCF). PSCAA's publication is an internal document that did not receive public comment or peer review. Additionally the document is based on data that is not representative of the LCF.

PSCAA's review of composting emissions and the majority of documents referenced by it are based on simple windrow composting. There is a significant difference between windrow composting and the LCF that uses Aerated Static Pile (ASP) for initial composting with regard to uncontrolled emissions. Emission production in composting processes can vary significantly depending upon the technology used for the composting process. The primary source of emission from composting is due to the microbial population that performs this process and/or potential anoxic conditions in a compost pile if not managed well. If the environment for compost microorganisms is optimized, the rate and character of emissions is significantly different than an environment which is not optimized.

In PSCAA's own guidance document, "A guide to completing your annual air pollution emission report", the agency specifically states that "…if a method for calculating actual emission has not been specified in an Order of Approval, please keep the following in mind when selecting the method: The method used must reflect the best available methods and data, and must produce an accurate representation of the types and quantities of air pollutants released at the facility." That is what we are trying to accomplish with this analysis.

In an effort to follow the above-mentioned PSCAA guidance, and to use published and widely accepted emission factors, Lenz relied on the "ARB Emission Inventory Methodology for Composting Facilities 3/2/2015. This document was developed and reviewed by a multitude of agencies in California and is recognized as a guidance document for the purpose of estimating emissions from composting facilities. Washington State has no such document on file. The CARB methodology addressed greenwaste mixed with foodwaste up to 15%, and specifically includes enhanced aerations systems such as ASP technology like that used at the LCF in the review. The document recognizes the advantages of controlled aeration and specifically states "... any measure that would promote active biological processes will decrease their emissions". Other examples of well-respected published literature that also describe this condition include:

1. VOC emissions from the composting of the organic fraction of municipal solid waste using standard and advanced aeration strategies[1]. Caterina Maulini-Duran, Belen Puyuelo, Adriana Artola, Xavier Font, Antoni Sánchez and Teresa Gea.

[1] https://www.onlinelibrary.wiley.com/doi/abs/10.1002/jctb.4160

2. Greenwaste Compost Site Emissions Reductions from Solar-powered Aeration and Biofilter Layer[2]. Report from the contract team 5/14/2013.
3. Air Emissions Assessment Summary of VOC and Greenhouse Gas Air Emissions with Comparison to Windrow Composting Emissions. Charles E. Schmidt, PhD and Thomas R. Card, 2012.
4. ARB Emissions Inventory Methodology for Composting Facilities 3/2/2015 Comparison of Air Emissions from a Negatively Aerated CASP and Turned Windrow During Composting of a Food Waste and Green Waste Mix. Charlie Krauter, ECS Project Engineer, January 5, 2014

Additionally, PSCAA's emission factor document states, "*After examining these (CARB) documents further, it was found that the majority of the papers identified by this project were also used as the basis for another agency's development of emission factors, which included factors for stockpiling feed stocks prior to composting, and emission factors for composting in windrows. This was documented in San Joaquin Valley Air Pollution Control District's (SJVAPC) paper, Compost VOC emission factors. Because it included the majority of papers identified during this project, it was decided, after reviewing the data for accuracy, <u>to use this single document as the basis for developing emission factors for the project</u>.*" Unfortunately, as previously described, this document did not look at aspects of operations such as differing compost processes and feedstocks, C:N ratio variability, moisture variability, and other important factors that relate to emission profiles. Studies referenced by this document primarily include operations with low C:N ratios and moisture contents using the windrow composting method. All of these factors can significantly affect emissions.

Other studies that take into consideration differing technologies and operating strategies include:

5. Emissions Testing of Volatile Organic Compounds from Greenwaste Composting at the Modesto Compost Facility in the San Joaquin Valley[3]. Revised May 2008.
6. Air Emissions Assessment Summary of VOC and Greenhouse Gas Air Emissions with Comparison to Windrow Composting Emissions. Charles E. Schmidt, PhD and Thomas R. Card, 2012.
7. ARB Emissions Inventory Methodology for Composting Facilities 3/2/2015

Composting occurs because of microorganisms. The primary goal of commercial composting is enhancing the environment where these microorganisms exist so that the process occurs more quickly and efficiently. This includes creating a microbial population that reduces emissions as well. Conditions that enhance this process include supplying adequate aeration to the pile as well as optimizing moisture content, C:N ratio, pH, and other factors. Data reviewed by PSCAA is based on windrow composting and does not include the optimization that occurs in a well-designed forced-air system such as the LCF. This comparison is analogous to comparing the emissions from a 1960's internal combustion engine with a simple air and fuel supply system (carburetor) and a modern combustion engine with enhanced controls to maximize the use of fuel and includes emission control devices.

The uncontrolled emission factors from the 2015 ARB document in Table III-1 are applicable, in conjunction realistic environmental controls, for the LCF in this permitting process to factor in the enhancements that have been designed into the system. Based on site testing at the LCF, and research

[2] https://www.o2compost.com/Userfiles/PDF/VOC-Emissions-Report.pdf
[3] https://ww3.arb.ca.gov/cc/compost/documents/modesto_source.pdf

of other ASP systems (see references given herein), these represent a worse-case scenario for VOC, NH3 and other emission production at the site.

A current permitting example of the use of these emission factors for an advance composting system is for the Waste Management of Alameda County facility that was permitted in 2017. This facility is engineered and operated in a similar fashion to the LCF. Lenz staff spoke with the engineer from the Bay Area Air Quality Management District (BAAQMD) in California, Mr. Stanley Tom ([mailto:stom@baaqmd.gov]) who permitted this facility and he confirmed these emission factors were used for the Waste Management facility which was permitted in 2017. Other facilities in California have been recently permitted using these EF as well.

An example of a more recently permitted facility in Washington State that uses advanced composting technology is the Silver Springs Organics (SSO) site regulated by the Olympic Region Clean Air Agency (ORCAA). Although the SSO facility also uses enhanced aeration technology it is not as efficient as that used at the LCF. The final Notice of Construction published for the site set emission factors at 1.20 lbs/ton of greenwaste process for VOC production, and 0.20 lbs/ton of greenwaste processed for NH3 production. The main differences between the SSO site and the LCF are that higher food waste (25%) is processed at the SSO site which can increase emissions and Lenz has a more efficient and configurable aeration system. This example is given to illustrate lower applicable emission factors use at Washington Composting site.

Lenz did not include an EF for stockpiling. This is because Lenz processes compost as it arrives. To incorporate this factor Lenz will now included an EF in the calculation per PSCAA's request. The factor used will be based on the fraction of the day when stockpiling could occur and the fact that emissions from this process are treated through the engineered biofiltration system.

The process for measuring and recording the quantity of food waste in our feedstock is part of our total feedstock analysis that initially occurred each quarter of the year and has now been reduced to twice a year based on statistical similarity between samples. To measure food waste in feedstocks, Lenz selects at random a delivery (typically 28-30 tons) of feedstock. The entire load is deposited into the tipping building where it is segregated into food waste (both pre- and post-consumer), green waste (grass, leaves, branches, etc.), and contaminants (non-compostables). The food waste and non-compostables are weighed separately. Since the entire load is weighed at our site scale the green waste mass can be calculated. This method has resulted in average food concentrations of five percent since 2014.

Modifications to Emission Factor

Calculations - General

We apologize for the errors found in the spreadsheet and the embedded comments. An earlier version of the spreadsheet was attached with calculations in mid-evaluation and contained comments that were part of an earlier conversation and do not reflect the final judgment of the team. These issues will be resolved in an updated EF spreadsheet.

The use of zero emissions during quiescent periods is based on actual measurements at the facility indicating emissions are de-minimus during these periods. This was confirmed by Ecology during their testing.

However, rather than debate this issue Lenz will move forward in this application with the following operational change. The site will be operated with 100 percent negative aeration. This will simplify the application process and any emission analysis. If in the future Lenz performs on site emission testing that is acceptable to PSCAA, or otherwise proves an alternate operational method is acceptable, operations may change back to reversing aeration.

Biofiltration Efficiency:

Efficient biofiltration of emissions is a function of biofilter engineering, media selection, maintenance and operation. Many research and testing projects have failed to include all of these factors in their baseline selection and review of biofilters and have instead taken the approach that all biofilter efficiency is the same and depth is the only parameter that affects operation. This not correct.

Lenz biofiltration starts with an engineering design that creates even and optimum surface loading, and retention time. Airflow to the biofilters is optimized to have a design flow of 8,640 CFM from the system with a loading area of 4,800 ft^2, average final bed depth of 4.0 feet and an empty bed retention time of 90 seconds. These are industry standards for enhanced biofiltration and result in superior emission control performance.

Media at the site is selected to create an environment for the microorganisms to perform optimally. Biofilter operation is monitored and assessed daily, with monthly flow reviews and third-party assessments conducted annually. An integral part of the ECS system is biofilter temperature monitoring to ensure optimum conditions.

Operation and maintenance is critical to a well performing biofilter. Sufficient water content is one of the most important parameters for an effective biofilter, because microorganisms responsible for the degradation of odorous compounds and other emissions require water to perform their normal metabolic reactions. In addition, appropriate moisture content is required for gas-water phase transition and movement of odorous molecules into the biofilm. Lenz biofilters are moisturized daily when sufficient rainfall does not occur. Enough moisture is applied to the biofilters to saturate the top of the biofilter which is a common industry standard (i.e. “Bioreactors for treatment of VOCs and odours – A review” Mudliar et al., 2010[4]; and “Biofiltration of Volatile Organic Compounds (VOCs) – An Overview” Thakur Prabhat Kumar et. al. 2011[5]). The documents “SAN JOAQUIN VALLEY UNIFIED AIR POLLUTION CONTROL DISTRICT FINAL DRAFT STAFF REPORT, Proposed New Rule 4566” and the subsequently published Rule 4566, describe the use of watering for emissions reduction. Lenz uses moisture in this way to control emission from the biofilter, the CASP and the Windrows. An emission control value of 19 percent is given as a reduction in the 4566 Rule. Lenz should be able to use this same reduction in estimating emission control efficiencies.

---

[4] https://www.sciencedirect.com/science/article/pii/S0301479710000071
[5] https://www.researchgate.net/publication/266352315_Biofiltration_of_Volatile_Organic_Compounds_VOCs_-_An_Overview

Examples of other highly efficiency biofilters include: 1) In the Silver Springs Organics (SSO) final Notice of Construction, control efficiencies of 100 percent were used for both Negative Aeration VOC Capture and Negative Aeration NH3 Capture. 2) In the document entitled "Greenwaste Compost Site Emissions Reductions from Solar-powered Aeration and Biofilter Layer Report from the contract team 5/14/2013." reductions of 97% for VOC and 99% for NH3 were measured using a simple constructed biofilter. 3) In the document "Air Emissions Assessment Summary of VOC and Greenhouse Gas Air Emissions with Comparison to Windrow Composting Emissions. Charles E. Schmidt, PhD and Thomas R. Card, 2012" similar reductions were measured at the 60-day cycle length of 98.9% reduction for VOCs and 94% reduction for NH3.

Additional references are numerous to support these control efficiencies. Examples include:

8. Biofiltration for ammonia removal from composting exhaust gases[6]. Estel.la Pagans, Xavier Font, Antoni Sánchez; 2005
9. Source Test for Measurement of Total Hydrocarbon and Ammonia Emission of a Biofilter Serving Compost Operations at Robert A. Nelson Material Recovery Facility, CA. (Note non-optimized biofiltration system)
10. Comparison of Air Emissions from a Negatively Aerated CASP and Turned Windrow During Composting of a Food Waste and Green Waste Mix. By Charlie Krauter, ECS Project Engineer, January 5, 2014

Data referenced is from enhanced aeration systems using optimized biofiltration, the LCF biofilters can reduce emission as well as or better than those identified in research documents reviewed by PSCAA. However, to estimate a worse-case scenario Lenz proposes the following engineered biofilter emission control factors based on the research provided herein:

Constituent	Percent control efficiency
VOC	95 percent
NH3	80 percent

Proposed operational alternative:

As mentioned previously, Lenz is proposing to change operations to include negative only aeration. Lenz will include this approach in an updated EF calculations. This will be the method used for future operations until such time that site specific testing data becomes. This operational change will simplify the application process by reducing the points of review for the agency.

[6] https://www.sciencedirect.com/science/article/pii/S1385894705001002

B. Approach using modified CARB method for ammonia

The Washington State Department of Ecology's emission factor for NH3 is, once again, not appropriate for an advance composting system. As described above, enhancing the environment for the microorganisms reduces all emissions including ammonia. Ammonia is produced during the composting process due to different reasons than some other emissions such as VOCs. These differences start with the type of feedstock used and are also significantly influenced by the rate of aeration, temperature profile of the composting process over time and pH. Ammonia release is favored by low C:N ratios (Zang et al., 2016[7]; Jiang et al., 2011[8]) and is strongly dependent on the pH and temperature of the composting pile (Pagans et al., 2005). Lenz optimizes all of these conditions which provide for lower ammonia emissions releases than less advanced composting systems such as windrow only composting.

The 25% reduction applied to the Lenz process was an estimate based on documented differences seen at other facilities, and in research papers, due of optimized aeration, C:N ratio, pH and temperature control of the ASP at the LCF. Examples of documented differences include:

11. Greenwaste Compost Site Emissions Reductions from Solar - powered Aeration and Biofilter Layer 5/14/2013
12. ECS Project Memo 6 South Coast Source Test, 2019.
13. Composting of food wastes: Cerda et. al. 2017[9].
14. And others readily available on the internet.

Again, using the updated "ARB Emissions Inventory Methodology for Composting Facilities 3/2/2015", along with reasonable environmental control efficiencies, is suitable for the LCF to estimate a worse-case scenario for the site. The ARB document uses a factor of 0.78 lbs/ton processed for an uncontrolled NH3 factor. Applying a control efficiency of 80 percent (again a worse-case scenario for NH3 control) provides an adequate safety factors for this analysis. Previously referenced documentation supports this approach.

C. Similar system test data for VOC (ECS) (Appendix A) / D. 2018 WSU sampling / E. Approach using 2013 Ecology VOC testing.

The ECS document referenced describes a CARB approved sampling event. Sampling was conducted to capture emissions from seven zones each at different stages of the composting cycle. This capture of emission provides the same type of average that individual grab sampling would provide only instead of averaging results of individual grab samples the "actual samples" are average by collecting them in one composite sample. Statistically this reduces the opportunity for error in collection and laboratory analysis and provides a representative sample of compost emissions from a facility operating in a similar

[7] https://www.sciencedirect.com/science/article/pii/S0956053X16303312
[8] https://www.sciencedirect.com/science/article/pii/S1001074210605918?via%3Dihub
[9] https://ddd.uab.cat/pub/artpub/2018/196243/biotec_a2018m1v248Ap57.pdf

fashion to the LCF. Additional information from the sampling is provided in the “ECS Project Memo 6 South Coast Test” document. A redacted version of the West Valley Emission report can be provided and can be verified by contacting the regulatory agency.

It is unfortunate that the Ecology data collected at the site cannot be used. However, in reviewing the Ecology data, the Lenz team also reviewed the previously submitted Air Quality Report submitted to PSCAA in 2014. In doing so the team found significant errors in the assumptions used by Environ to develop that report. The Environ report states “It is possible to estimate emission rates from these concentration measurements using additional assumptions and indeed, Environ has made such estimates and used them elsewhere in this document.” This statement refers to using the concentration data collected by Ecology and then assuming flow rates from each of the processes. Lenz never had reason to doubt these assumptions before (and did not review them) but careful review shows that they are incorrect.

To estimate flow rates for the biofilter (negative air) and CASP (positive air) Environ used a single reference study for flows. The study identified a flow rate of (6.1 m^3/s) reported by Gilley et al. (North Carolina Study). The cited study was for an in-vessel composting system with a completely different engineering design and operational method. This flow rate is approximately 1.5 times greater than the maximum flow rate possible from the LCF per engineering of the system. Flow rates from the Lenz system are well known and could have been provided during this previous study if they would have been requested. Additionally, the Environ study used a flow rate of 14.5 m^3/s for Massbed emission rate calculations which is significantly higher than the forced-air CASP; again which is impossible at the LCF. A paper which more accurately represents airflow from a Massbed or Windrow system is "Airflow measurement in passively aerated compost" by Yu et al (2005)[10]. This is a time variable air flow study, with a maximum value of about 19 l/min and a minimum value at the end of the experiment of about 9 l/min.

Moving forward with this application the actual engineered flow rate will be used for emission calculations from the CASP and the biofilter, and the flow rates outlined on by the Yu et. al, 2005 paper will be used for the Windrow emission calculations.

To facilitate a greater understanding of the Lenz approach to emission factor development, Lenz has provided adequate information to support the emission factors used, and included a sufficient safety factor built into those emission factors to result in a worse-case scenario for which to move forward. This method and applicable resources should be used for this analysis

Because this information is varied and complex, and requires a complete understanding of the LCF composting process, Lenz suggests an in-person meeting, with industry experts, to help PSCAA understand any of these conditions or data that are unclear. Please let us know when you have evaluated this additional information and when a meeting can be scheduled to facilitate this review.

[10] https://www.csbe-scgab.ca/docs/journal/47/c0502.pdf

F. Toxic Air Pollutant emissions (based on Ecology)

As described previously, Lenz will move forward in this application with negative only air operations. This negates the need for further discussion and debate on reversing air percentages to be used.

The idea that maximum values should be used instead of the median values has no scientific basis. A worse-case scenario has already been established by using maximum emission flow rates. By using both maximum flow rates and maximum concentrations, an unrealistic scenario is developed; not a worse-case scenario. All data has statistical outliers which are not valid even in the best of scenarios. Due to the number of variables associated with this type of testing the median values should be used; or this data should not be used at all. PSCAA has determined that Ecology data is not valid for VOC's. Since the same methods, techniques, samples, etc. were used to determine TAPs as well, perhaps this data should not be used for TAPs either?

Many other compost facilities have performed Toxic Air Pollutant analyses using published data (See referenced Silver Springs Organics (SSO), Waste Management Altamont Draft Engineering Evaluation Report, etc.) A published example is the work of Kumar et al. (2011)[11], whose results are also used by the EPA SPECIATE software[12]. If PSCAA is not comfortable using the Ecology derived data along with well-established data analysis methods then Lenz will propose to use a different source for this analysis. Either of the above-mentioned references may be valid.

Again, an earlier in-process emission inventory was supplied and contained incorrect data and assumptions. Concentration data should be taken from the Air Quality Report to ensure that the correct data is being referenced if on-site testing is to be used.

G. Air dispersion model review

1. Lenz's modeling team reviewed the receptor grid according to the Ecology's first tier review guidance[13]. Moreover, a receptor spacing of 12.5 m has been used over the whole fenceline. The base height of each receptor will be determined with AERMAP (version 18081)[14].

2. The air dispersion simulation model will be updated using the latest version of AERMOD (currently version 19191)[15]. Moreover, AERMET[16] version 19191, will be used to prepare the meteorological input

[11] Kumar, A., Alaimo, C.P., Horowitz, R., Mitloehner, F.M., Kleeman, M.J. and Green, P.G., 2011. Volatile organic compound emissions from green waste composting: Characterization and ozone formation. Atmospheric Environment, 45(10), pp.1841-1848. DOI: 10.101

[12] https://www.epa.gov/air-emissions-modeling/speciate
[13] https://fortress.wa.gov/ecy/publications/documents/0802025.pdf
[14] https://www.epa.gov/scram/air-quality-dispersion-modeling-related-model-support-programs#aermap
[15] https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models#aermod
[16] https://www.epa.gov/scram/meteorological-processors-and-accessory-programs#aermet

to AERMOD, starting from a whole year of on-site observations (at Lenz facility), and National Weather Station (NWS) observations for surface and upper-air data.

3. There are a multitude of methods used to restrict general public access from the LCF site. These include:

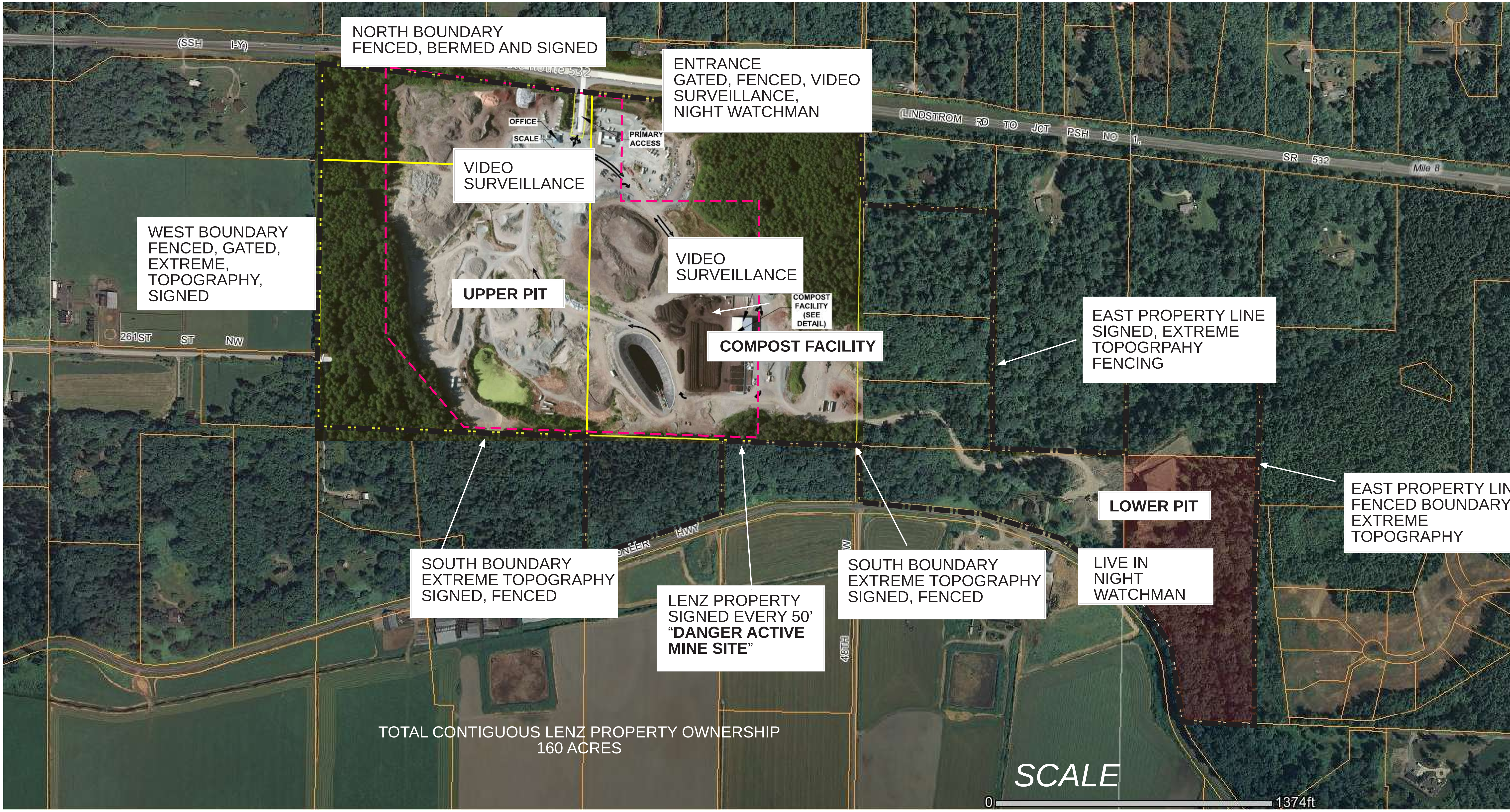
- Fences in some locations
- Entry gates
- Video surveillance
- Extreme topography
- Warning signs surrounding the entire permitted boundary of the site
- Site watchmen

These methods are illustrated on Figure 15, Site Access Restriction (see attached). During the previous compost upgrade these methods were acceptable to PSCAA; and according to PSCAA no changes to applicable regulations or rules have been instituted. So there is no reason why these methods should not be acceptable now as well.

4. Calm hours are outside of our control. Skagit airport weather data was used for the previously submitted Air Quality Report for the Lenz site without comment. There is no reason this previously submitted and accepted data should not be used again. However, the Lenz modeling team, working with Ecology experts, has determined an acceptable path forward. This includes (as anticipated), the use of one year of meteorological data measured within the LCF. The use of on-site data together to the Skagit data reduces the number of calm hours.

5. Biofilters subside over time. This is a function of a multimedia biofilter. Biofilters at the Lenz site begin their existence at approximately six feet in depth and subside to approximately four feet in depth during their useful operating life. The difference in this height is negligible to the air modeling output. However, we can use the height of four feet if PSCAA prefers.

6. All data should be taken from the updated Air Quality Modeling report that will be supplied to PSCAA. Any files supplied beyond this report were simply to make PSCAA's review more convenient. If there were errors we apologize.



SITE COORDINATES:
LATITUDE: 48° 27' 13.21"
LONGITUDE: -122° 18' 14.11"

LEGEND

LENZ CONTIGUOUSLY OWNED PROPERTY BOUNDARY

LENZ ENTERPRISES
5210 SR 532 STANWOOD WA 98292

DATE: 100419
DWN: EW
PROJ: LRP2019
APPR: JL

FIGURE 15

SITE ACCESS RESTRICTION