LENZ ENTERPRISES COMPOST FACILITY
PROPOSED FACILITY EXPANSION

Air Quality Technical Report

Prepared for
Lenz Enterprises
Stanwood, WA

Prepared by

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ACRONYMS AND ABBREVIATIONS

ASIL	Acceptable Source Impact Level
DEM	Digital Elevation Model
EnviroComp	EnviroComp Consulting, Inc.
EPA	U.S. Environmental Protection Agency
HAP	Hazardous Air Pollutant
PSCAA	Puget Sound Clean Air Agency
TAP	Toxic Air Pollutant
tpy	Tons per year
SQER	Small Quantity Emission Rate
WAC	Washington Administrative Code

1 Introduction and Overview

Lenz Enterprises, Inc.[1] ("Lenz") retained the services of EnviroComp Consulting, Inc.[2] ("EnviroComp") to assist in the process of obtaining an air quality permit from the Puget Sound Clean Air Agency (PSCAA) for the expansion of an existing composting facility near Stanwood Washington in Snohomish County. Currently Lenz processes 75,000 tons per year (tpy) of organic feedstock, and proposes to modify and expand their current compost facility to process 150,000 tpy.

Dr. Zannetti[3] is the principal author of this report. A summary of Dr. Zannetti's experience and qualifications is presented in Appendix A together with his CV.

This report presents the current results of our investigation and opinions, based upon the materials reviewed and the analyses performed to date. We reserve the right to supplement this report in the event new information is presented.

We are fully committed to the highest ethical standards of scientific and professional integrity - these standards are enforced through a rigorous internal and external peer-review of assumptions, calculations, opinions, and results.

[1] http://www.lenz-enterprises.com/
[2] https://www.envirocomp.com/
[3] http://envirocomp.com/people1/zannetti.html

2 Project description

(Most material in this Section is taken from "Lenz Enterprises Compost Facility. Air Quality Technical Report. ENVIRON International Corporation, August 2013. Project N. 29-31910A", hereafter referred to as "ENVIRON Report".)

Lenz Enterprises owns and operates a composting facility in Stanwood, Washington. Figure 1 shows the general location of the facility. Figure 2 is a close-up image depicting the various elements of the facility itself.

The facility receives organic feedstock via truck and processes the material in a tipping building location as marked in Figure 2. The organic feedstock consists predominantly of curbside collected yard debris. A small amount of direct food residuals is also included in the feed material. In addition, the facility has always composted a quantity of paunch manure and animal bedding. These animal by-products constitute approximately five weight-percent of the total input material.

A mass balance flow chart[4] of the organic feedstocks proposed for the facility is shown in Figure 3. Within the same day of receiving, the input material is ground and mixed with a bulking agent and then placed in one of eight aerated static piles (ASPs) termed Phase 1 composting (ASP zones in Figure 2). After a static pile has been filled, it is covered with a finished compost product approximately one foot in depth. The aeration for the piles comes from a bottom layer manifold that can either force air up through the material to be exhausted to the atmosphere through the compost biofilter cap (positive air), or draw air down through the pile from the atmosphere and route it to an engineered biofilter where it is then released to the atmosphere (negative air). The switching from positive air to negative air is computer-controlled and based on temperature differential between the top and bottom sections of the pile. Data collected by Lenz, along with many research projects and papers, indicate that reversing the flow in the ASPs maintains a more homogenous temperature profile throughout the bed and results in better overall aeration and a more time-efficient composting process. By avoiding hot spots, cold spots and anaerobic spots, the biogenic process in the ASP is more efficient, thus resulting in fewer VOC and odor emissions. On average the ASP is actively aerating the composting mass 80 percent of time. Positive flow occurs approximately 40 percent of the time, negative air occurs approximately 40% of the time, and the system is in a quiescent period approximately 20 percent of the time.

[4] The mass balance flow chart has been obtained from figure 7 of the Engineering Report dated February 2019 (Prepared by: O2 Compost, Engineered Compost Systems, Inc, and Lenz Enterprises Inc. - 312 Maple Ave, Snohomish, WA 98290).

The period of time material remains in the ASPs is variable. Data indicate the material can reach its desired degree of composting for Phase 1 of the process in a time as short as seven days. On average, Lenz currently keeps the material in the ASP for an average of 10 days because the throughput rate at the facility is low enough that the ASP capacity can accommodate a longer Phase I composting period.

After Phase 1 composting, the material is moved to the Phase 2 composting area, labelled "windrow" in Figure 2, which is a mechanically-aerated and homogenized process typically known as "windrow composting". Material is placed in windrows and mechanically turned at regular intervals. As with the ASP, the duration of the composting process in the windrows is variable depending upon composting goals. Currently the Phase 2 composting period averages 60 days. With the future expansion to 150,000 tpy the Phase 2 period is expected to average 60 days as well due to the expanded windrow composting area.

The final phase, Phase 3, is the curing process which may occur in an open unturned pile on the west side of the mass bed; or may not occur at all if the material is ready for use. The composting process is typically complete for the material prior to curing, but curing may occur to provide additional stabilization for certain uses.

The material is then screened (area labelled "screening" in Figure 2) and is sold as compost. The screening process separates the composted material into varying sizes. A portion of the larger woody material (compost overs) is then recycled back through the process and provides a bulking agent to the earlier phases, and is also used for biofilter material.

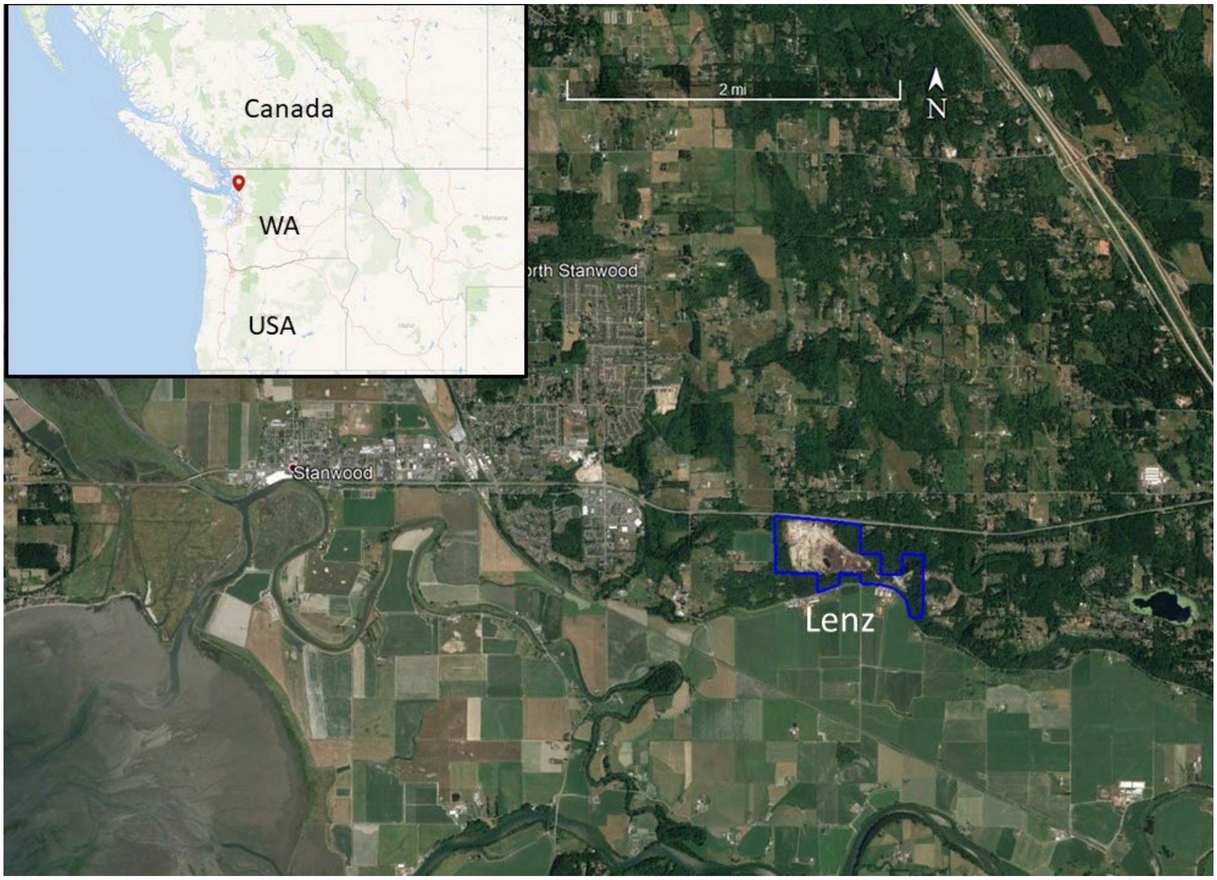

Figure 1. Location of the Lenz Composting Facility.

Figure 2. Oblique aerial view of the Lenz Composting Facility.

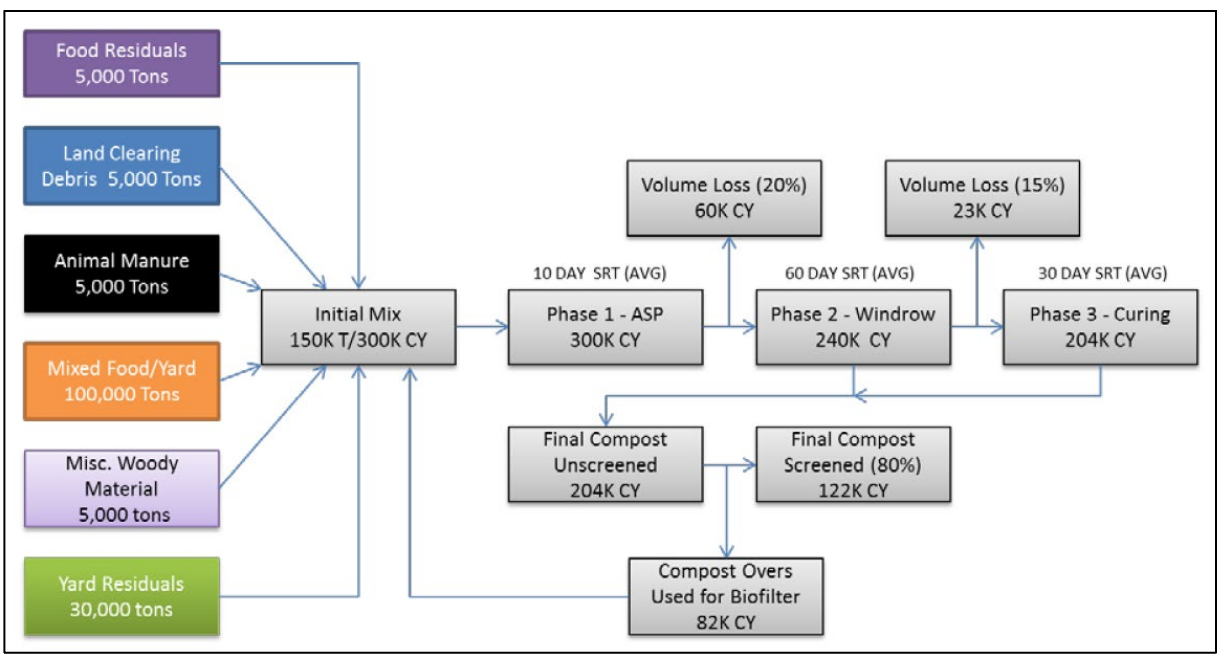

Figure 3. Lenz Composting Facility mass balance flow chart.

3 Emissions estimates

3.1 VOLATILE ORGANIC COMPOUNDS (VOC)

Volatile Organic Compounds (VOCs) are emitted by all composting operations, regardless of design and technology used. In 2013, the Washington Department of Ecology[5] ("Ecology") performed testing at various composting facilities in the state to better understand emissions of VOCs, odors, and Toxic Air Pollutants (TAPs). Ecology conducted emission testing at the Lenz facility on June 26th and 27th of 2013. The testing provides emission concentration measurements taken from various sources at the facility. Starting from the laboratory data and using additional assumptions, we estimated the VOC emission rates, using a methodology similar to the one described by the ENVIRON Report (our methodology is presented in Appendix B: VOC/TAP/HAP Emissions Factors Calculations).

Contrary to ENVIRON, we used the median in place of the average to get a representative concentration from the (maximum) five testing points over the mass bed, then we used the same volume flow to estimate the emission rate. The reason to use the median in place of the mean (average) for determining the windrow emission rate is that the first is a more robust estimator of the central value with respect to the second one[6]. Both mean and median are commonly used as estimators for the "true" value of a sampled quantity. The uncertainty of these estimators is given by their standard deviation (SD). For normal distributions the SD of the mean is lower than the SD of the median. This means that in this case the mean is a better estimator in terms of uncertainty. On the other hand, if outliers are present (as in the case of the mass bed testing), the SD of the mean may become very large, while the SD of the median remains more or less the same. In the case of an outlier the mean itself is potentially changed drastically, while the median remains close to the central value of the original statistical distribution. These are well-known properties of the mean and median, and it is said, that the median is a more robust estimator of the central value.

Another difference with respect to the ENVIRON methodology is that for the biofilter we used the median, not the maximum, to get the representative concentration from the (maximum) three testing points, then we used the same volume flow to estimate the emission rate. This choice is justified by the fact that the use of the maximum concentration is over conservative.

[5] https://ecology.wa.gov/

[6] See, for example, de Nijs R. and Klausen T.L. (2013) On the expected difference between mean and median. Electronic Journal of Applied Statistical Analysis, Vol.6, 1, 110-117. (https://core.ac.uk/download/pdf/41166695.pdf)

Finally, for the ASP and the biofilters we considered that 40% of the time there is positive air flow, 40% negative air flow, and 20% of the time there is no flow at all.

Our VOC emission estimate, based on Ecology's testing, is 10.9 tpy, using toluene as the base species. Since at the time of the Ecology's testing the amount of organics processed by Lenz was 38,000 tpy, the resulting VOC emission factor is about 0.57 pounds per ton of organics processed. In the ENVIRON Report, they determined a similar emission factor, but then decided to use an average more conservative, higher value found in the literature[7,8,9,10,11]. However, Lenz personnel reviewed the literature cited by ENVIRON and found that none of the sites evaluated had the same amount of environmental controls as Lenz Enterprises (including, for example, positive/negative aeration, properly engineered biofilters, the same quality control measures used in maintaining proper operating procedures, etc.). We therefore conclude that the value of 0.57 pounds per ton, derived from Ecology's testing, is the most appropriate for our current study.

Then, using a VOC emission factor of 0.57 lb/ton and considering the amount of organics processed in the current (75,000 tpy) and future (150,000 tpy) scenarios, we estimate a VOC emission of 21.5 tons and 43.0 tons, respectively.

It should be noted that, at the time of the Ecology sampling in 2013, neither the biofilters nor the secondary composting process were optimized. Lenz ceased moisturizing of these two processes during the week of sampling to help facilitate the process. Therefore, the above estimate is likely a worse-case scenario for emissions release.

3.2 TAPS AND HAPS

In Ecology's testing at the Lenz facility on June 26-27, 2013, the measured concentrations of various individual airborne gases were grouped into three categories:

- Individual VOCs
- Sulfur compounds

[7] Krzymien, M., M. Day, K. Shaw, and L. Zaremba (1999) An Investigation of Odors and Volatile Organic Compounds Released During Composting. J. of Air and waste Management.
[8] SCAQMD Emission Factor
https://www.valleyair.org/busind/pto/emission_factors/Criteria/Criteria/Composting/Compost%20EF.pdf
[9] Modesto Study for San Joaquin Valley.
https://www.arb.ca.gov/cc/compost/documents/modesto_source.pdf
[10] Air Emissions Source Test- Emissions Evaluation of Complete Compost Cycle VOC and Ammonia Emissions. Jepson Prairie Organics Compost Facility, Vacaville, CA
[11] Ammonia and Volatile Organic Compound (VOC) Emissions from a Greenwaste Composting Facility. Inland Empire Composting, Colton, CA.

- Aldehydes

Testing was conducted at 11 locations over the course of the two-day program. Measured concentrations above detection limits were found - for 24 different VOCs, 4 different sulfur compounds, and 10 different aldehydes - in at least one of the 11 locations. Of these 38 chemical species found at the Lenz facility, 16 are classified as TAPs under Ecology's regulation WAC 173-460-150[12], and 16 (with some overlap with the TAPs) are classified as Hazardous Air Pollutants (HAPs) by the EPA[13].

Using the same methodology previously applied for VOC, similarly to the work described in the ENVIRON Report, we calculated an emission factor (see Appendix B: VOC/TAP/HAP Emissions Factors Calculations) for each single species (TAPs and HAPs). Consequently, we estimated the total annual emission rates for the two scenarios (current and proposed), as reported in Table 1.

Table 1. Summary of calculated TAP and HAP emissions.

CAS No	**Name**	**TAP ?**	**HAP ?**	**Current (tpy)**	**Proposed (tpy)**
115-07-1	Propene	Yes	No	0.177	0.355
74-87-3	Chloromethane	Yes	Yes	0.053	0.106
106-99-0	1,3-Butadiene	Yes	Yes	0.004	0.008
75-05-8	Acetonitrile	Yes	Yes	0.043	0.085
75-09-2	Methylene Chloride	Yes	Yes	0.0002	0.0003
108-05-4	Vinyl Acetate	Yes	Yes	0.255	0.509
78-93-3	2-Butanone (MEK)	Yes	No	0.491	0.983
110-54-3	n-Hexane	Yes	Yes	0.027	0.053
71-43-2	Benzene	Yes	Yes	0.016	0.033
108-10-1	4-Methyl-2-pentanone	Yes	Yes	0.059	0.117
108-88-3	Toluene	Yes	Yes	0.040	0.080
100-41-4	Ethylbenzene	Yes	Yes	0.001	0.001
100-42-5	Styrene	Yes	Yes	0.073	0.147
463-58-1	Carbonyl Sulfide	No	Yes	0.022	0.044
75-15-0	Carbon Disulfide	Yes	Yes	0.038	0.075
50-00-0	Formaldehyde	Yes	Yes	0.038	0.075
75-07-0	Acetaldehyde	Yes	Yes	0.006	0.012
123-38-6	Propionaldehyde	No	Yes	0.228	0.457

[12] https://apps.leg.wa.gov/WAC/default.aspx?cite=173-460-150
[13] https://www.epa.gov/haps/initial-list-hazardous-air-pollutants-modifications

3.2 AMMONIA

Ammonia (NH3) is classified as a TAP under Ecology's regulation WAC 173-460-150 but, for its importance in composting facilities, is treated in a specific Section here.

We started the NH3 emission calculation by considering the uncontrolled emission factor (EF) of 0.78 lb/ton reported in the "ARB Emissions Inventory Methodology for Composting Facilities" (2015)[14]. However, we believe that the NH3 EF for the Lenz facility is smaller because:

1. The California ARB EF has been determined starting from the analysis of composting facilities processing feedstocks with up to 15% of food organics, while the content of food organics in the Lenz feedstock is within the range 5%-10%
2. Lenz does not use stockpiling
3. Lenz ASP has more efficient controls
4. Lenz C:N ratio[15] is optimized
5. Table II of the California ARB document only contains three relevant sources that are comparable with the processing carried out at the Lenz composting facility

In order to take into account the different content of food organics, we decreased the uncontrolled California ARB EF by 25%. Also, considering that when the ASP is in negative flow the air is emitted through the 5-foot biofilter, we applied a 95% reduction in such situation of negative flow (according to the scientific literature[16], this is a typical removal efficiency). On the contrary, when on positive flow, we applied a 90% reduction since the air exits from a 1-foot biofilter cover on the top of the ASP. Finally, we take into account the 20% of the time of the year when there is no flow in the ASP, and therefore de-minimis emissions, while the remaining 80% of the time is equally divided between positive and negative flow. By applying the above specified assumptions, we obtained an emission factor of 0.035 lb/ton from the system (ASP + biofilters). Also, assuming that 90% of the total NH3 emissions are from the ASP the emission factor of the windrow is 0.004 lb/ton.

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[14] https://www.arb.ca.gov/ei/areasrc/Composting%20Emissions%20Inventory%20Methodology%20Final%20Combined.pdf

[15] The carbon to nitrogen (C:N) ratio is an important factor affecting NH3 emissions. Too low a C:N ratio in the composting pile will lead to excessive N loss, while too high a C:N ratio will prevent the composting pile from heating up properly. A negative correlation between C:N ratio and NH3 loss has been observed. (http://www.globalsciencebooks.info/Online/GSBOnline/images/0812/DSDP_2(SI1)/DSDP_2(SI1)10-18o.pdf).

[16] For example: la Pagans E., Font X. and Sánchez A. (2005) Biofiltration for ammonia removal from composting exhaust gases. Chemical Engineering Journal, 113, 105–110

The ammonia emissions calculated for the Lenz facility are summarized in Table 2. Our calculation procedure is described in Appendix C: Ammonia (NH3) Emissions Calculations.

Table 2. Summary of calculated ammonia emissions.

CAS No	Name	TAP ?	HAP ?	Current (tpy)	Proposed (tpy)
7664-41-7	Ammonia	Yes	No	1.463	2.925

4 Analytical methods

The air quality impact analysis consisted in the dispersion modeling of the TAP species emitted in quantities greater than the SQER. The following sections discuss the methods employed and the critical assumptions involved in the analysis.

4.1 DISPERSION MODELING

We used air quality dispersion modeling simulations to estimate ambient concentrations of TAPs from the various emission sources at the Lenz facility for the proposed scenario, characterized by the processing of 150,000 tpy of organics. This section discusses the methods used to develop these simulations to assess potential future pollutant concentrations in the area surrounding the facility.

4.1.1 Model used

The air quality model used in this analysis is AERMOD (version 18081)[17]. AERMOD is the tool adopted by the US-EPA as the preferred model for near-field dispersion of emissions for distances up to 50 km, as indicated in Appendix W to 40 CFR Part 51[18].

4.2 MODEL SETUP AND APPLICATION

4.2.1 Receptors and elevation data

We used Cartesian receptors covering an area of 1.9 x 1.5 km^2 with origin at the point of UTM coordinates in zone 10 U: 551000, 5341600. The space resolution is 50 m, for a total number of receptors of 1,209, as shown in Figure 4. Moreover, we placed other 129 discrete receptors along the permit boundary, as shown in Figure 5.

Terrain elevations for each receptor and emission source were prepared using digital elevation models developed by the United States Geological Survey (USGS) and available on the USGS Seamless Server system[19]. These data have a horizontal spatial resolution of approximately 7 m along X and 10 m along Y. The base elevation and hill height scale for each receptor were determined using AERMAP (Version 18081). The output of AERMAP has been included in AERMOD.

[17] https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models#aermod
[18] https://www3.epa.gov/ttn/scram/guidance/guide/appw_17.pdf
[19] ftp://rockyftp.cr.usgs.gov/vdelivery/Datasets/Staged/NED/13/IMG/

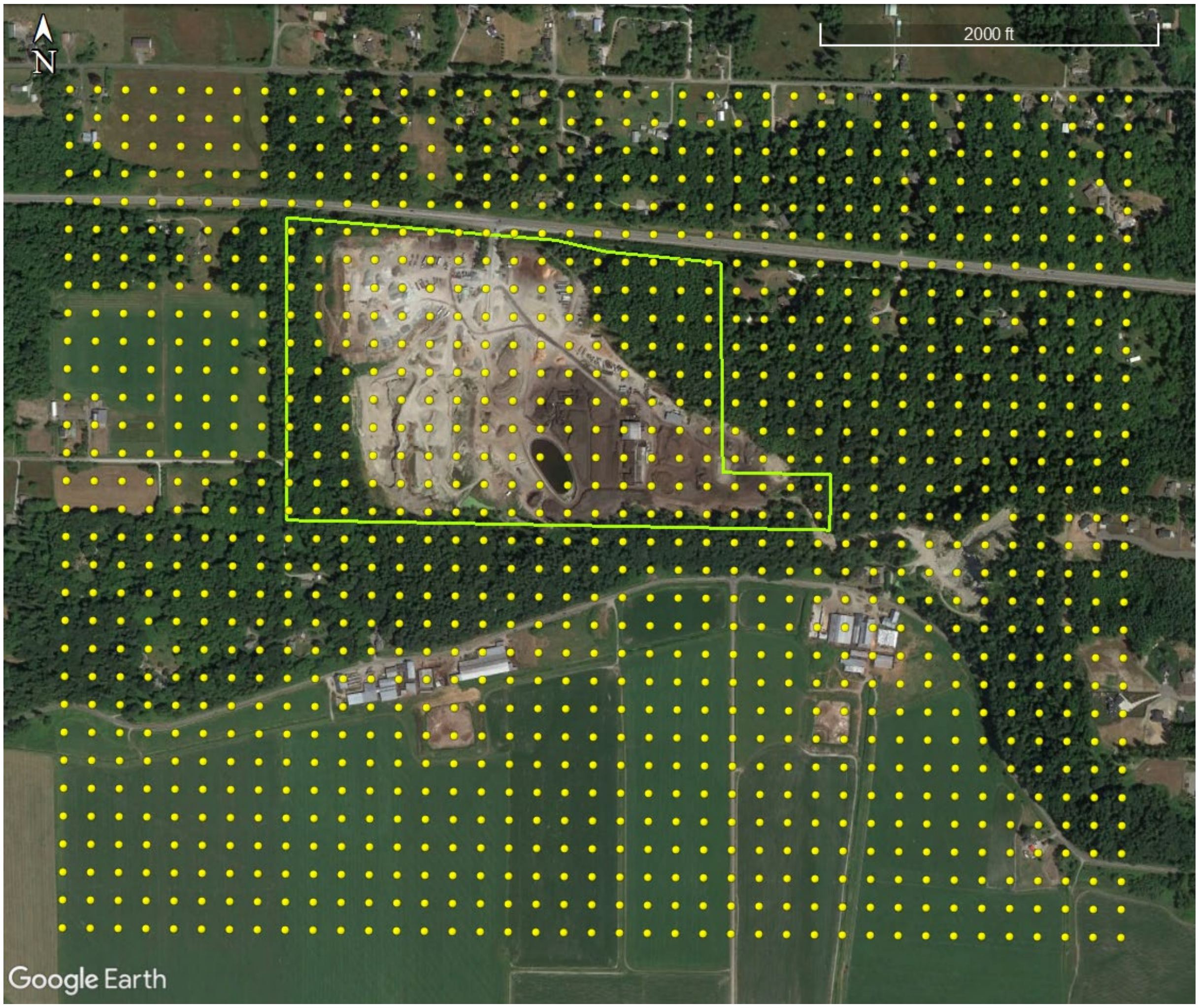

Figure 4. Gridded receptors used in AERMOD.

Figure 5. Receptors used in AERMOD over the permit boundary.

4.2.2 Meteorological data

We used the same 2008-2012 surface and upper air meteorological data used before in the ENVIRON Report.

In the ENVIRON Report, since there are no meteorological monitoring stations close to the Lenz facility, they investigated the possibility of using surface data from two nearby airport stations operated by the National Weather Service: the Arlington Airport, located about 14 kilometers to the southeast of the Lenz facility, and the Skagit County Regional Airport, located approximately 28 kilometers to the north of the Lenz facility.

After processing with AERMET and analysis, ENVIRON selected the Skagit County Regional Airport data, characterized by more data and a minor number of calms. Since the AERMOD model treats calm conditions the same as missing data, it was judged that the

Arlington Airport data, although collected closer to the Lenz facility, were not acceptable for the modeling analysis. We agree with this decision.

A wind rose obtained from the Skagit County Regional Airport data after their processing with AERMET is shown in Figure 6. The wind rose indicates that the winds are predominantly light and are from the northeast and south-southeast directions. The average wind speed during the 5-year meteorological period was 2.8 meters per second (m/s), while the maximum wind speed was 14.2 m/s.

For the upper air data ENVIRON used the measurements of Quillayute, compiled from the National Oceanic and Atmospheric Administration (NOAA) Forecast Systems Laboratory Radiosonde Database[20].

The surface parameters were determined by ENVIRON with the AERSURFACE processor.

[20] https://ruc.noaa.gov/raobs/

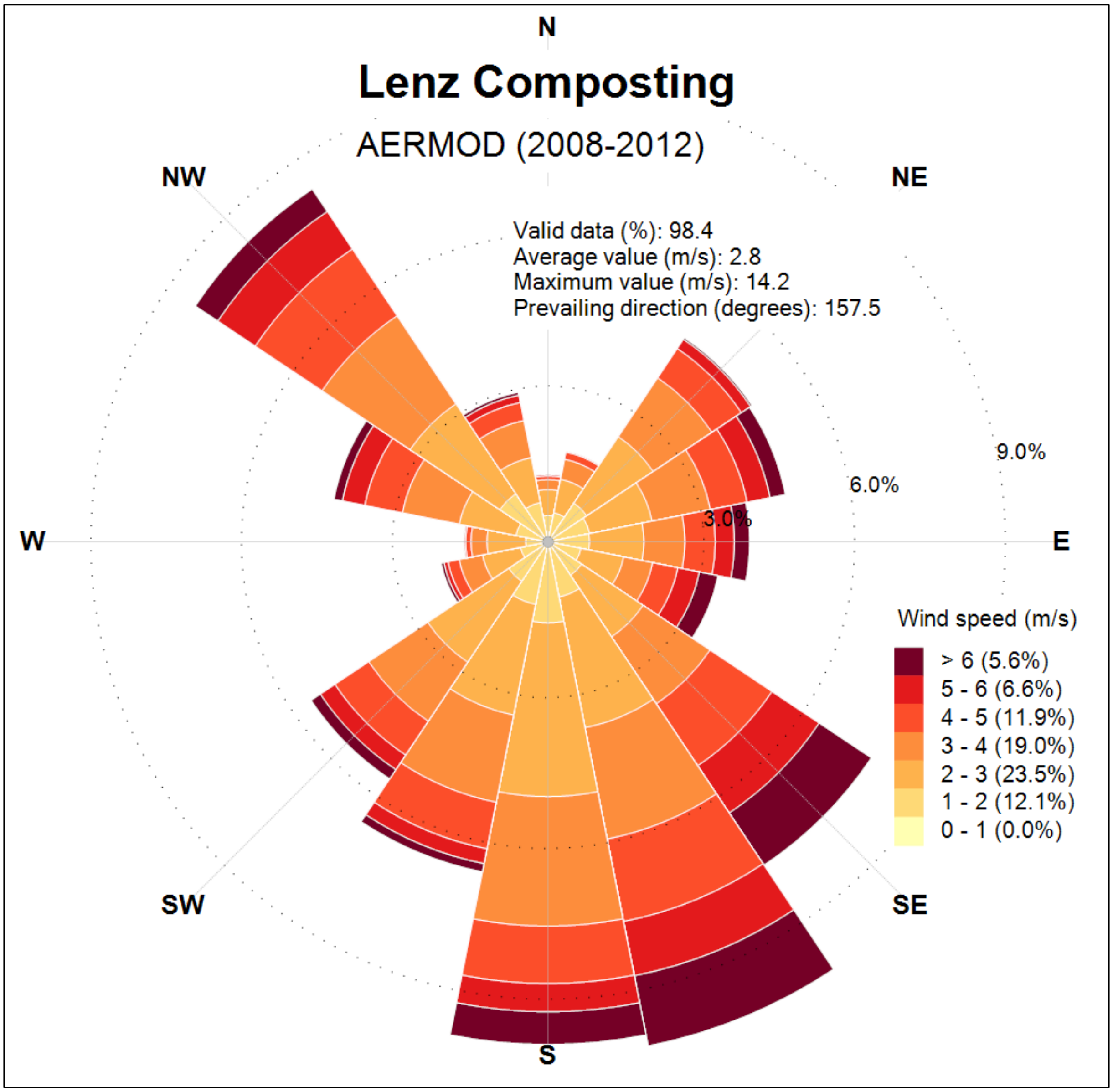

Figure 6. Wind rose from the surface data used in AERMOD.

4.2.3 Emissions

PSCAA asked Lenz to model any TAP emission value that exceeds the Small Quantity Emission Rate (SQER) defined in WAC 173-460-150. Starting from the total emissions of the proposed scenario summarized in Table 1 and Table 2, we determined the average emission over the period of interest for each TAP, and then compared it with the corresponding SQER, as shown in Table 3. The TAPs exceeding their SQER - marked in bold - for which modeling will be performed, are four: 1,3 butadiene, benzene, formaldehyde and ammonia.

The averaging time for the modeled concentrations of these four TAPs is 1-year, except for ammonia (maximum 24-hour). These concentrations have been compared with the ASIL (Acceptable Source Impact Levels) defined for each TAP by WAC 173-460-150. The ASILs of the four TAPs are summarized in Table 4.

Table 3. Comparison between TAPs emission rates and their SQERs.

CAS No	Name	SQER (lb/avg_period)	Averaging Period	Proposed scenario (lb/avg_period)
115-07-1	Propene	394	24-hr	1.9
74-87-3	Chloromethane	11.8	24-hr	0.6
106-99-0	**1,3-Butadiene**	**1.13**	**year**	**15.1**
75-05-8	Acetonitrile	11,500	year	170.3
75-09-2	Methylene Chloride	192	year	0.7
108-05-4	Vinyl Acetate	26.3	24-hr	2.8
78-93-3	2-Butanone (MEK)	657	24-hr	5.4
110-54-3	n-Hexane	92	24-hr	0.3
71-43-2	**Benzene**	**6.62**	**year**	**65.4**
108-10-1	4-Methyl-2-pentanone	394	24-hr	0.6
108-88-3	Toluene	657	24-hr	0.4
100-41-4	Ethylbenzene	76.8	year	2.6
100-42-5	Styrene	118	24-hr	0.8
75-15-0	Carbon Disulfide	105	24-hr	0.4
50-00-0	**Formaldehyde**	**32**	**year**	**150.1**
75-07-0	Acetaldehyde	71	year	24.9
7664-41-7	**Ammonia**	**9.31**	**24-hr**	**16.0**

Table 4. ASILs for the four modeled TAPs.

CAS No	Name	ASIL (μg/m^3)	Averaging Period
106-99-0	1,3-Butadiene	0.00588	year
71-43-2	Benzene	0.0345	year
50-00-0	Formaldehyde	0.167	year
7664-41-7	Ammonia	70.8	24-hr

We understand that the Department of Ecology is expected[21] to modify the values of SQER and ASIL for some TAPs before the end of year 2019. This modification aims at the use of the most recent, best available health effects information to update the list of toxic air

[21] https://ecology.wa.gov/Regulations-Permits/Laws-rules-rulemaking/Rulemaking/WAC173-460

pollutants and recalculate ASILs, SQERs, and de minimis emission values. According to a draft of the possible new values[22], the only ASIL that will remain unchanged in Table 4 is the one of formaldehyde, while the others will increase (0.033 μg/m^3 for 1,3 butadiene, 0.13 μg/m^3 for benzene and 500 μg/m^3 for ammonia). However, in this report, the current ASIL values will be used in evaluating the impact of the plant.

4.2.4 Sources

The Ecology air testing carried out in June 2013 at the Lenz Composting Facility showed that the four TAPs exceeding their SQER were emitted by one or more of the following sources: biofilters, ASP on positive air, mass bed and finished. We assumed that the emission rate estimated starting from the measurements on the mass bed remains valid for the windrows too.

The positions of the sources used in AERMOD are depicted in Figure 7. They have been described in the dispersion model with the AREAPOLY source type.

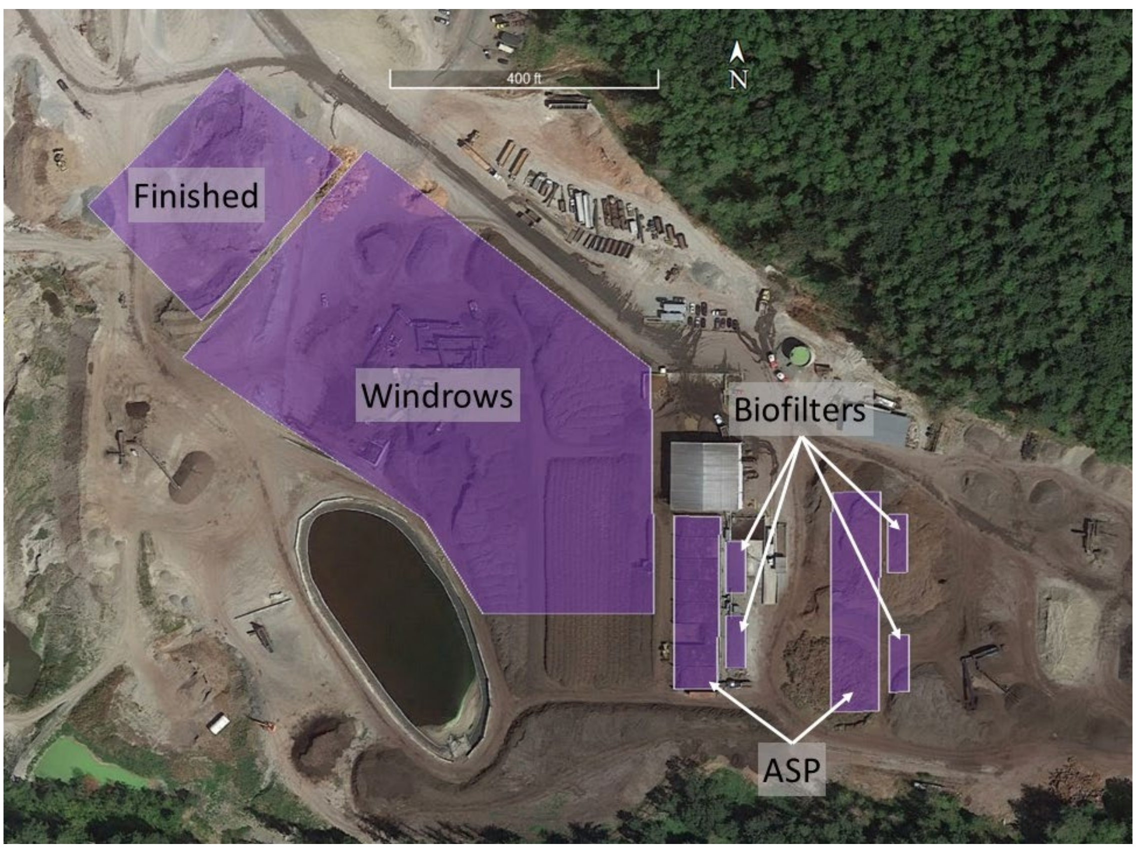

Figure 7. Location of the sources in the AERMOD simulation.

[22] https://ecology.wa.gov/DOE/files/65/651e0b34-2a86-4e3e-8f8f-011653306e0c.pdf

5 Air quality modeling results

The air quality impact analysis consisted in the dispersion modeling of the TAP species emitted in quantities greater than the SQER.

5.1 RESULTS

The simulation results are shown from Figure 8 to Figure 11, where the red contour represents the ASIL of each TAP. The ASIL values of the four TAPs are never exceeded outside the facility boundary.

Figure 8. Proposed scenario. Maximum 24-hr concentrations of ammonia (µg/m³).

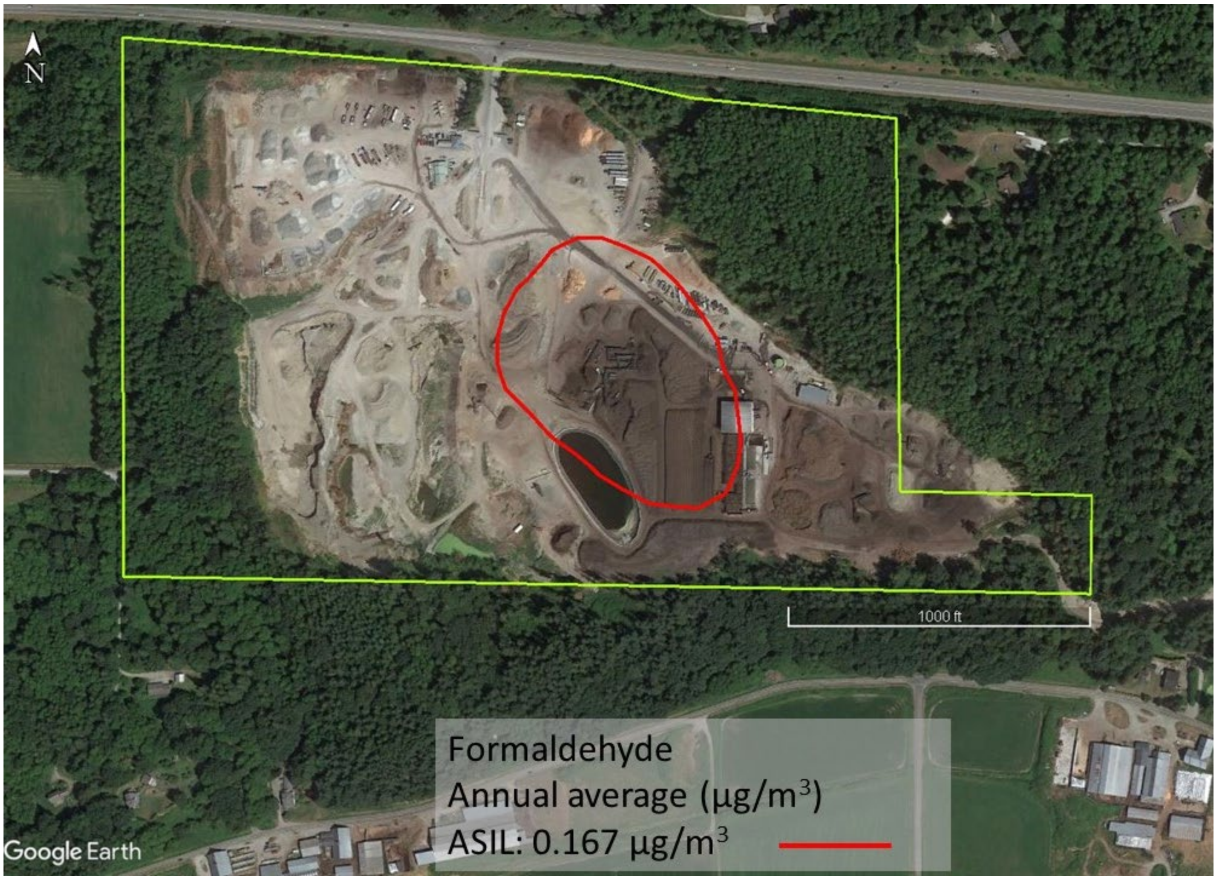

Figure 9. Proposed scenario. Annual average concentrations of formaldehyde (µg/m^3).

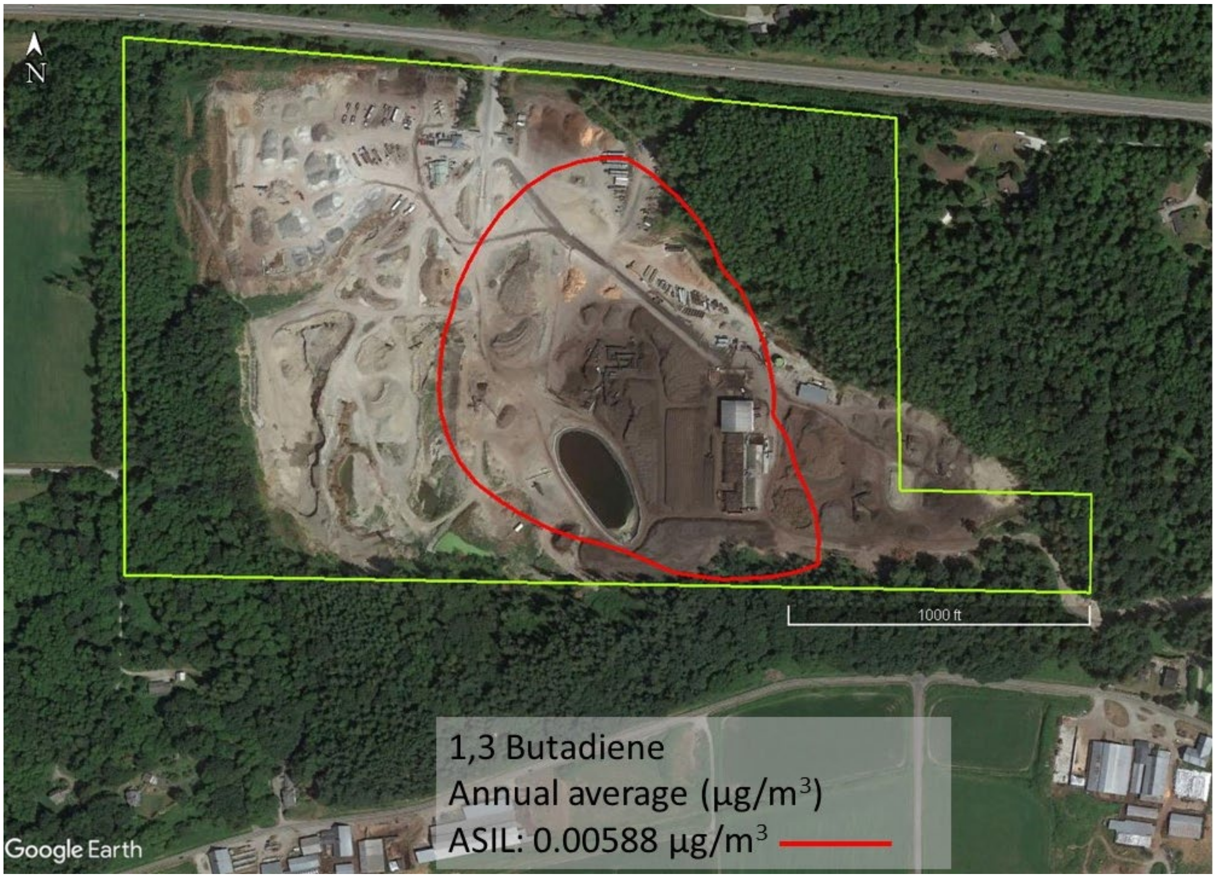

Figure 10. Proposed scenario. Annual average concentrations of 1,3 butadiene (µg/m³).

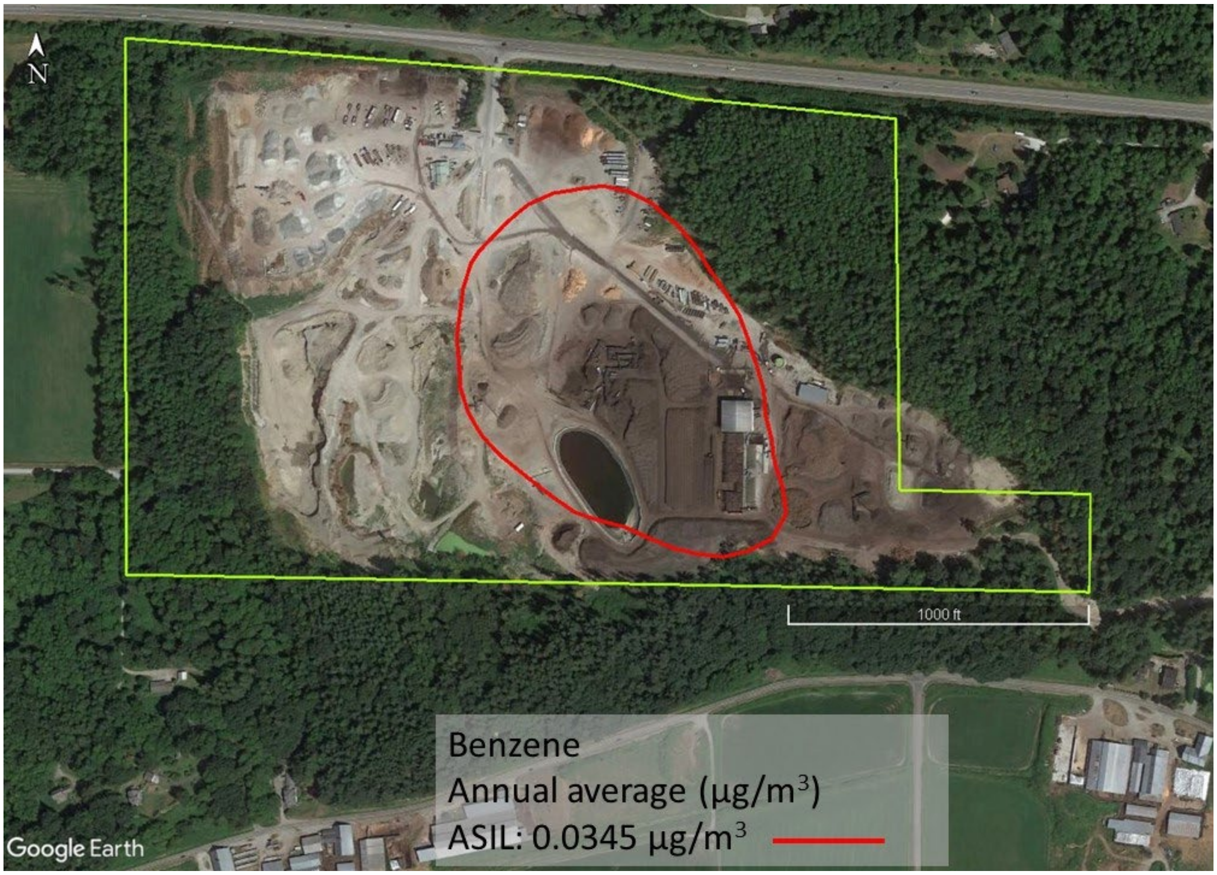

Figure 11. Proposed scenario. Annual average concentrations of benzene (µg/m^3).

6 Conclusions

This report presents an air quality study performed by EnviroComp for Lenz Enterprises, Inc. The study deals with the proposed expansion of an existing composting facility near Stanwood Washington in Snohomish County. The expansion is expected to change, from the current process of 75,000 tpy of organic feedstock, to 150,000 tpy.

We calculated an emission factor for each single species (TAPs and HAPs) emitted by the facility. Consequently, we estimated the total annual emission rates for the two scenarios (current and proposed). Afterwards, using dispersion modeling, we calculated the air quality impact of the four TAP species that emitted in quantities greater than the SQER. Our results show that the ASIL values of the simulated TAPs were never exceeded outside the facility boundary.

This report presents the current results of our investigation and opinions, based upon the materials reviewed and the analyses performed to date. We reserve the right to supplement this report in the event new information is presented.

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Appendix A: CV of Dr. Paolo Zannetti, QEP

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EDUCATION AND TITLES

- *Qualified Environmental Professional (QEP),* Institute of Professional Environmental Practice (IPEP) (www.ipep.org) (http://ipep.org/applications/qep-certification/)
  Certificate #029440029 (2/1994) – Recertified on 7/2007

- *Doctoral Degree in Physics*, University of Padua, Italy (12/1970) (www.unipd.it)

- *Diploma of Maturita' Scientifica* (Science Degree), Scientific Lyceum Ippolito Nievo, Padova, Italy (7/1965)
  (http://www.liceonievo.it/)

PROFESSIONAL EXPERIENCE

- ***President*, EnviroComp Consulting, Inc. (4/2001 – present)** (http://www.envirocomp.com)

  - *President and Founder*, EnviroComp Institute (10/1996 – present) (http://www.envirocomp.org)

  - *Project Leader,* Comprehensive Air Modeling/Optimization System (CAMOS) (Since 2013) (http://camos.co/)

  - *Regional Coordinator* for the Institute of Professional Environmental Practice (IPEP) in the San Francisco Bay Area (9/1997 – present) (http://www.ipep.org)

  - *Visiting Teacher,* Computational Mechanics and Wessex Institute of Technology, Southampton, UK (1980 – present) (http://www.wessex.ac.uk). Currently:

  - *Professor of Environmental Sciences* at Wessex Institute of Technology (WIT), Ashurst, UK (https://www.wessex.ac.uk/research/wit-staff/862-dr-paolo-zannetti)

  - *Visiting Professor*, Polytechnic University of Bari-Taranto, Italy (1999 – 2008) (http://www.uniba.it/ateneo/sede-di-taranto)

  - *Peer-Reviewer,* Kuwait Institute of Scientific Research, Kuwait, Wessex Institute of Technology, Southampton, UK (2002-2012) (http://www.kisr.edu.kw/)

- ***Principal Scientist,* Exponent, Inc., Menlo Park, CA (11/1991 – 4/2001)** (http://www.exponent.com)

  - *Instructor,* University Extension, University of California, Berkeley (10/1992 – 7/1997) (http://extension.berkeley.edu/)

- ***Department Manager*, AeroVironment, Inc., Pasadena/Monrovia, CA (10/1979 – 11/1991)** (http://www.aerovironment.com)

  - *Consultant*, IBM Semea, Milan, Italy (1/1991 – 10/1991; on leave of absence from AeroVironment) (http://www.ibm.com/planetwide/it/)

  - *Head, Environmental Sciences*, IBM Scientific Center, Bergen, Norway, and *Leader, Environmental Sciences Activities of IBM Europe* (3/1990 – 12/1990; on leave of absence from AeroVironment) (http://www.ibm.com/planetwide/no/)

  - *Consultant*, Research Center of the Italian National Electric Power Company (CRTN/ENEL), Milan, Italy (3/1984 – 10/1984; on leave of absence from AeroVironment) (http://www.enel.com/en-GB/)

  - *Project Manager*, Kuwait Institute for Scientific Research (KISR), Kuwait (2/1982 – 2/1984; on leave of absence from AeroVironment) (www.kisr.edu.kw)

- ***Researcher,* IBM Scientific Center, Venice, Italy (8/1971 – 10/1979)** (http://www.ibm.com/planetwide/it/)

  - *Visiting Scientist,* Department of Statistics, Stanford University, California (1/1978 – 3/1979; on assignment from IBM Italy) (http://www-stat.stanford.edu/)

  - *Visiting Scientist,* IBM Scientific Center, Palo Alto, CA (1/1978 – 3/1979; on assignment from IBM Italy) (http://www.ibm.com/contact/us/en/)

  - *Assistant Professor,* Department of Civil Engineering, University of Padua, Italy (1974 – 1977) (http://www.unipd.it/)

- ***Systems Analyst*, UNIVAC/Sperry Rand, Milano, Italy (3/1971 – 7/1971)** (http://en.wikipedia.org/wiki/UNIVAC)

EDITORIAL RESPONSIBILITY

- Member, Editorial Board, International Journal of Environmental Science and Technology. Springer International Publisher. 2013-present http://www.springer.com/environment/journal/13762?detailsPage=editorialBoard

- Member, Editorial Advisory Board (EAB) of Atmospheric Pollution Research (APR) Journal. 2011-present. http://www.atmospolres.com/editorial.html

- Editor, Book Series, “Environmental Sciences and Environmental Computing”. Three published volumes. http://www.envirocomp.org/esec

- Editor and Co-Author, Book Series, “Air Quality Modeling – Theories, Methodologies, Computational Techniques, and Available Databases and Software”. Four published volumes, 2003-2010 http://www.envirocomp.org/aqm

- Editor, Book Series, “Environmental Modeling”. Computational Mechanics Publications. Three published volumes. http://www.witpress.com/978-1-85312-281-1.html

- Founder and President, The EnviroComp Institute – The International Institute of Environmental Sciences and Environmental Computing (since 1996). http://www.envirocomp.org

- Founder and Editor-in-Chief (1986 – 1993), quarterly journal *Environmental Software*, Computational Mechanics Publications and (since September 1991) Elsevier Applied Science; currently Founding Editor (journal was renamed *Environmental Modelling and Software*) http://www.journals.elsevier.com/environmental-modelling-and-software/

- Founder and Co-Director (until 1998), biennial ENVIROSOFT Conference – Computer Techniques in Environmental Studies (conferences held every two years since 1986) http://www.wessex.ac.uk/

- Founder and Co-Director, first two AIR POLLUTION Conferences – Computer Techniques in Environmental Studies (1993 – 1994); currently Member, Advisory Committee http://www.wessex.ac.uk/15-conferences/air-pollution-2015.html

- Associate Editor/Member, Editorial Board, *Atmospheric Environment*, Pergamon Press (1987 – 1999), now Elsevier. http://www.journals.elsevier.com/atmospheric-environment/

- Member, Editorial Board, *Ecological Modeling*, Elsevier Applied Science (1992 – 2007) http://www.journals.elsevier.com/ecological-modelling/

- Member, Editorial Board, *ENVIRONews*, FiatLux Publications (1993 – 1998)

MEMBERSHIPS

- Faculty Member, International Institute for Computational Engineering Mathematics (since 2016) http://computationalengineeringmathematics.com/cem/

- Member, International Scientific Advisory Committee, AIR POLLUTION Conference Cycle, Wessex Institute of Technology, UK (since 2000) http://www.wessex.ac.uk/15-conferences/air-pollution-2015.html

- Member, “SATURN Specialist Group”, subproject of EUROTRAC-2 dealing with urban air pollution (1998-2000). http://www.gsf.de/eurotrac

- San Francisco Bay Area Regional Coordinator for the Institute of Professional Environmental Practice (IPEP) (since 1997). http://www.ipep.org

- Athens 2004 Committee (1997 – 2000). http://www.olympic.org/athens-2004-summer-olympics

- Reviewer Group, Center for Indoor Air Research (CIAR) (1995 – 1999)

- International Scientific Advisory Committee, Environmental Engineering and Management Conference, Barcelona, Spain (October 1998)

- International Scientific Advisory Committee, Environmental Engineering, Education and Training Conference (EEET96), Southampton, UK (April 1996)

- Scientific Advisory Board, International Congress on Modeling and Simulation (MODSIM 93 and MODSIM 95), Modeling and Simulation Society of Australia, Inc. http://www.modsimworldconference.com/

- International Federation for Information Processing (IFIP), Working Group WG 5.11 (Computers and Environment) (1992 – 1997). http://www.ifip.org/homeintro.html

- ISATA Programme Committee (1992 – 1994)

- Scientific Committee of the Technological Consortium THETIS (Venice, Italy) (1991) http://www.thetis.it/thetis/environmental-engineering.html

- Board of Directors, MONDOMETANO, RES Editrice srl (1989 – 1992)

- European Association for the Science of Air Pollution (EURASAP) (1987 – 1994) http://www.eurasap.org/AboutEURASAP.html

- EPA-ASRL pool for the review of U.S. Environmental Protection Agency publications (1987 – 1996) http://www.epa.gov/

- American Meteorological Society (AMS) (1978 – 1985) http://www.ametsoc.org/

- Air & Waste Management Association (A&WMA) (originally Air Pollution Control Association, APCA) (since 1978). Emeritus Member since 2013. http://www.awma.org/Public

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MISCELLANEA

- Member, Accademia Italiana della Cucina (since 2015) http://www.accademiaitalianacucina.it/

- Italian Citizen by birth; U.S. Citizen since 1989

- Languages: English, Italian, French (reading), plus understanding of Spanish

HONORS

- Award from the Royal Scientific Society of Jordan (1/2019)

- Medal Award "Awarded for Excellence", Department of Mathematical Sciences, The United States Military Academy, West Point, New York (4/2018)

- Medal award from Computational Mechanics, Ashurst, UK, in recognition of contribution to the development of Environmental Modeling (11/1994)

- Plaque award from the South Coast Air Quality Management District, in recognition of contribution to the Toxic Symposium at Caltech, Pasadena, CA (7/1986)

PUBLICATIONS (DL indicates downloadable publications[1])

Books

B.26 Zannetti, P. (ed) (2010) Air Quality Modeling – Theories, Methodologies, Computational Techniques, and Available Databases and Software, Vol. IV – Advances and Updates, Book Series, The EnviroComp Institute and the Air & Waste Management Association (http://www.envirocomp.org/aqm)

B.25 Zannetti, P. (ed) (2008) Air Quality Modeling – Theories, Methodologies, Computational Techniques, and Available Databases and Software, Vol. III – Special Issues, Book Series, The EnviroComp Institute and the Air & Waste Management Association (http://www.envirocomp.org/aqm)

B.24 Zannetti, P., S. Elliott, and D. Rouson (eds) (2007) Environmental Sciences and Environmental Computing, Vol. III, Electronic book (on CD-ROM), The EnviroComp Institute (http://envirocomp.org/books/esec.html)

B.23 Zannetti, P., D. Al-Ajmi, and S. Al-Rashied (eds) (2007) Ambient Air Pollution, The Arab School for Science and Technology (ASST) and The EnviroComp Institute (http://envirocomp.org/asst)

B.22 Zannetti, P. (ed) (2005) Air Quality Modeling – Theories, Methodologies, Computational Techniques, and Available Databases and Software, Vol. II – Advanced Topics, Book Series, The EnviroComp Institute and the Air & Waste Management Association (http://www.envirocomp.org/aqm)

B.21 Zannetti, P. (ed) (2004) Environmental Sciences and Environmental Computing, Vol. II, Electronic book (on CD-ROM), The EnviroComp Institute (http://envirocomp.org/books/esec.html)

B.20 Zannetti, P. (ed) (2003) Air Quality Modeling – Theories, Methodologies, Computational Techniques, and Available Databases and Software, Vol. I – Fundamentals, Book Series The EnviroComp Institute and the Air & Waste Management Association (http://www.envirocomp.org/aqm)

B.19 Brebbia, C.A. and P. Zannetti (eds) (2002) Development and Application of Computer Techniques to Environmental Studies IX, WIT Press (http://www.witpress.com/)

B.18 Ibarra-Berastegi, G., C.A. Brebbia, and P. Zannetti (eds) (2000) Development and Application of Computer Techniques to Environmental Studies VIII, WIT Press (http://www.witpress.com/)

B.17 Zannetti, P. and Y.Q. Zhang (eds) (1998) Environmental Sciences and Environmental Computing, Vol. I, Electronic book (on CD-ROM), FiatLux Publications and EnviroComp Institute (http://envirocomp.org/books/esec.html)

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[1] Downloadable online at http://www.envirocomp.com/zcv/zannetti.pdf

B.16 Pepper, D.W., C.A. Brebbia, and P. Zannetti (eds) (1998) Development and Application of Computer Techniques to Environmental Studies, Proceedings, ENVIROSOFT 98 Conference, Las Vegas, NV, November, WIT Press – Computational Mechanics Publications, Southampton (http://www.witpress.com/)

B.15 Zannetti, P. (ed) (1996) Environmental Modeling – Computer Methods and Software for Simulating Environmental Pollution and its Adverse Effects – Vol. III, Computational Mechanics Publications, Southampton (http://www.witpress.com/)

B.14 Zannetti, P. and C. Brebbia (eds) (1996) Development and Application of Computer Techniques to Environmental Studies VI, Proceedings, ENVIROSOFT 96 Conference, Como, Italy, September, Computational Mechanics Publications, Southampton (http://www.witpress.com/)

B.13 Zannetti, P. (ed) (1994) Pollution Modeling, Vol. I, Proceedings, ENVIROSOFT 94 Conference, San Francisco, CA, November, Computational Mechanics Publications, Southampton (http://www.witpress.com/)

B.12 Zannetti, P. (ed) (1994) Environmental Systems, Vol. II, Proceedings, ENVIROSOFT 94 Conference, San Francisco, CA, November, Computational Mechanics Publications, Southampton (http://www.witpress.com/)

B.11 Baldasano, J.M., C.A. Brebbia, H. Power, and P. Zannetti (eds) (1994) Computer Simulation, Vol. I, Proceedings, Second International AIR POLLUTION Conference, Barcelona, Spain, September 1994, Computational Mechanics Publications, Southampton (http://www.witpress.com/)

B.10 Baldasano, J.M., C.A. Brebbia, H. Power, and P. Zannetti (eds) (1994) Pollution Control and Monitoring, Vol. II, Proceedings, Second International AIR POLLUTION Conference, Barcelona, Spain, September 1994, Computational Mechanics Publications, Southampton (http://www.witpress.com/)

B.9 Zannetti, P. (ed) (1994) Environmental Modeling – Computer Methods and Software for Simulating Environmental Pollution and its Adverse Effects – Vol. II, Computational Mechanics Publications, Southampton (http://www.witpress.com/)

B.8 Zannetti, P., C.A. Brebbia, J.E. Garcia Gardea, and G. Ayala Milian (eds) (1993) Air Pollution, First International Conference on Air Pollution, Monterrey, Mexico, February, Computational Mechanics Publications, Southampton, and Elsevier Science Publishers, London (http://www.witpress.com/)

B.7 Zannetti, P. (ed) (1993) Environmental Modeling – Computer Methods and Software for Simulating Environmental Pollution and its Adverse Effects – Vol. I, Computational Mechanics Publications, Southampton, and Elsevier Science Publishers, London (http://www.witpress.com/)

B.6 Zannetti, P. (ed) (1992) Computer Techniques in Environmental Studies IV, Proceedings, Fourth International Conference ENVIROSOFT 92, Computational

Mechanics Publications, Southampton, and Elsevier Applied Science, London (http://www.witpress.com/)

B.5 Melli, P. and P. Zannetti (eds) (1992) Environmental Modeling, Computational Mechanics Publications, Southampton, and Elsevier Applied Science, London (http://www.witpress.com/)

B.4 Zannetti, P. (1990) Air Pollution Modeling – Theories, Computational Methods and Available Software, Computational Mechanics Publications, Southampton, and Van Nostrand Reinhold, New York, 450 pp (http://link.springer.com/book/10.1007%2F978-1-4757-4465-1) **DL**

B.3 Zannetti, P. (ed) (1990) Computer Techniques in Environmental Studies III, Proceedings, Third International Conference ENVIROSOFT 90, Computational Mechanics Publications, Southampton, UK (http://www.witpress.com/)

B.2 Zannetti, P. (ed) (1988) Computer Techniques in Environmental Studies, ENVIROSOFT 88, Second International Conference, Porto Carras, Greece, September, Ashurst, UK, Computational Mechanics Publications (http://www.witpress.com/)

B.1 Zannetti, P. (ed) (1986) ENVIROSOFT 86, Proceedings, International Conference on Development and Application of Computer Techniques to Environmental Studies, Los Angeles, CA, USA, November 1986, Ashurst, UK, Computational Mechanics Publications (http://www.witpress.com/)

Book Chapters

BC.16 Zannetti, P. (2010) Air Quality Modeling Resources on the Web – An Update, Chapter 27, Air Quality Modeling – Theories, Methodologies, Computational Techniques, and Available Databases and Software, Vol. IV – Advances and Updates, P. Zannetti (ed), The EnviroComp Institute and the Air & Waste Management Association (http://www.envirocomp.org/aqm) **DL**

BC.15 Zannetti, P. (2008) Air Quality Modeling Resources on the Web, Chapter 27, Air Quality Modeling – Theories, Methodologies, Computational Techniques, and Available Databases and Software, Vol. III – Special Issues, P. Zannetti (ed), The EnviroComp Institute and the Air & Waste Management Association (http://www.envirocomp.org/aqm) **DL**

BC.14 Freedman, F. and P. Zannetti (2007) Global Warming and Climate Change: State of the Science, Chapter 5, Ambient Air Pollution, P. Zannetti, D. Al-Ajmi, and S. Al-Rashied (eds), The Arab School for Science and Technology (ASST) and The EnviroComp Institute (http://www.envirocomp.org/); also Chapter 10, Environmental Sciences and Environmental Computing, Vol. III, P. Zannetti, S. Elliott, and D. Rouson (eds), The EnviroComp Institute (http://www.envirocomp.org/) **DL**

BC.13 Daly, A. and P. Zannetti (2007) Air Pollution Modeling – An Overview, Chapter 2, Ambient Air Pollution, P. Zannetti, D. Al-Ajmi, and S. Al-Rashied (eds), The Arab School for Science and Technology (ASST) and The EnviroComp Institute (http://www.envirocomp.org/asst) **DL**

BC.12 Daly, A. and P. Zannetti (2007) An Introduction to Air Pollution – Definitions, Classifications, and History, Chapter 1, Ambient Air Pollution, P. Zannetti, D. Al-Ajmi, and S. Al-Rashied (eds), The Arab School for Science and Technology (ASST) and The EnviroComp Institute (http://www.envirocomp.org/asst) **DL**

BC.11 Byun, D.W., A. Lacser, R. Yamartino, and P. Zannetti (2005) Eulerian Dispersion Models, Chapter 10, Air Quality Modeling – Theories, Methodologies, Computational Techniques, and Available Databases and Software, Vol. I – Fundamentals, P. Zannetti (ed), The EnviroComp Institute and the Air & Waste Management Association (http://www.envirocomp.org/aqm) **DL**

BC.10 Zannetti, P. (2004) Air Pollution Dispersion Modeling, Section 16.6, The CRC Handbook of Mechanical Engineering, Second Edition, F. Kreith and D.Y. Goswami (eds), CRC Press (http://www.crcpress.com/product/isbn/9780849308666) **DL**

BC.9 Calamari, D., K. Jones, K Kannan, A. Lecloux, M. Olsson, M. Thurman, and P. Zannetti (2000) Monitoring as an Indicator of Persistence and Long-Range Transport, Chapter 6, Evaluation of Persistence and Long-Range Transport of Organic Chemicals in the Environment, G. Klecka, et al. (eds), SETAC Press (http://www.setac.org/) **DL**

BC.8A Zannetti, P. (1998) Today's Debate on Global Climate Change: Searching for the Scientific Truth. Chapter 5 of Environmental Sciences and Environmental Computing, Vol I, Edited by P. Zannetti and Y. Q. Zhang, EnviroComp Institute (http://www.envirocomp.org/) **DL**

BC.8 Zannetti, P. (1998) Air Pollution Dispersion Modeling, Section 16.6, The CRC Handbook of Mechanical Engineering, F. Kreith (ed), CRC Press (http://www.crcpress.com/) **DL**

BC.7 Zannetti, P. (1996) Environmental Modeling: Today and Tomorrow, Chapter 1, Environmental Modeling – Computer Methods and Software for Simulating Environmental Pollution and its Adverse Effects – Vol. III, P. Zannetti (ed), Computational Mechanics Publications, Southampton (http://www.witpress.com/) **DL**

BC.6 Zannetti, P. (1994) Introduction to Environmental Modeling, Chapter 1, Environmental Modeling – Computer Methods and Software for Simulating Environmental Pollution and its Adverse Effects – Vol. II, P. Zannetti (ed), Computational Mechanics Publications, Southampton (http://www.witpress.com/) **DL**

BC.5 Zannetti, P. (1993) Introduction and Overview, Chapter 1, Environmental Modeling – Computer Methods and Software for Simulating Environmental Pollution and its Adverse Effects – Vol. I, P. Zannetti (ed), Computational Mechanics Publications, Southampton, and Elsevier Science Publishers, London (http://www.witpress.com/) **DL**

BC.4 Zannetti, P. (1993) Numerical Simulation Modeling of Air Pollution: An Overview, Section of Ecological Physical Chemistry, L. Bonati, U. Cosentino, M. Lasagni, G. Moro, D. Pitea, and A. Schiraldi (eds), Elsevier Science Publishers, London; also Air Pollution, P. Zannetti, C.A. Brebbia, J.E. Garcia Gardea, and G. Ayala Milian (eds), First International Conference on Air Pollution, Monterrey, Mexico, February, Computational

Mechanics Publications, Southampton, and Elsevier Science Publishers, London (http://www.witpress.com/) **DL**

BC.3 Zannetti, P. (1992) Particle Modeling and its Application for Simulating Air Pollution Phenomena, Chapter 11, Environmental Modeling, P. Melli and P. Zannetti (eds) Computational Mechanics Publications, Southampton, and Elsevier Applied Science, London (http://www.witpress.com/) **DL**

BC.2 Zannetti, P. (1989) Simulating Short-Term, Short-Range Air Quality Dispersion Phenomena, Chapter V, Library of Environmental Control Technology, Vol. 2, Air Pollution Control, P.N. Cheremisinoff (ed), Gulf Publishing, Houston, TX **DL**

BC.1 Zannetti, P., G. Carboni, and A. Ceriani (1986) AVACTA II model simulations of worst-case air pollution scenarios in Northern Italy, Section of Air Pollution Modeling and Its Application, C. De Wispelaere, F.A. Schiermeider, and N.V. Gillani (eds), Plenum Press, New York, NY **DL**

Journal Articles

JA.28 Bellasio, R., R. Bianconi, S. Mosca, and P. Zannetti (2018) Incorporation of Numerical Plume Rise Algorithms in the Lagrangian Particle Model LAPMOD and Validation against the Indianapolis and Kincaid Datasets. Atmosphere **9**(10), 404. doi:10.3390/atmos9100404. **DL**

JA.27 Bellasio, R., R. Bianconi, S. Mosca, and P. Zannetti (2017) Formulation of the Lagrangian particle model LAPMOD and its evaluation against Kincaid SF_6 and SO_2 datasets. Atmospheric Environment **163** (2017) 87-98, Elsevier Ltd. **DL**

JA.26 Zannetti, P., A. D. Daly, and F. R. Freedman (2015) Dispersion Modeling of Particulate Matter Containing Hexavalent Chromium during High Winds in Southern Iraq. Journal of the Air & Waste Management Association, **65**(2):171–185. **DL**

JA.25 Daly, A., P. Zannetti, and T. Echekki (2013) A Combination of Fire and Dispersion Modeling Techniques for Simulating A Warehouse Fire. Int. J. of Safety and Security Eng., Vol. 2, No. 4 (2012) 368–380. **DL**

JA.24 Liberti, L., M. Notarnicola, R. Primerano, and P. Zannetti (2006) Air Pollution from a Large Steel Factory: Polycyclic Aromatic Hydrocarbon Emissions from Coke-Oven Batteries, ISSN 1047-3289, Journal of the Air & Waste Management Association, **56**:255–260 **DL**

JA.23 Zannetti, P. (1996) Modeling Danger – Computer Simulations Analyze Pollution Effects, Forecast Problems, Contingency Magazine, (March/April):73-75 **DL**

JA.22 Boybeyi Z., S. Raman, and P. Zannetti (1995) Numerical Investigation of Possible Role of Local Meteorology in Bhopal Gas Accident, Atmospheric Environment (Urban Atmosphere), **29**(4):479-496 **DL**

JA.21 Zannetti, P., I. Tombach, S. Cvencek, and W. Balson (1993) Calculation of visual range improvements from SO_2 emission controls – II: An application to the Eastern United States, Atmospheric Environment, **27A**:1479-1490 **DL**

JA.20 Zannetti, P., I. Tombach, and W. Balson (1990) Calculation of visual range improvements from SO_2 emission controls – I: Semi-empirical methodology, Atmospheric Environment, **24A**:2361-2368 **DL**

JA.19 Zannetti, P., I.H. Tombach, and S. Cvencek (1989) An analysis of visual range in the Eastern United States under different meteorological regimes, Journal of the Air & Waste Management Association, **39**:200-203 **DL**

JA.18 Brusasca, G., G. Tinarelli, D. Anfossi, and P. Zannetti (1987) Particle modeling simulation of atmospheric dispersion using the MC-LAGPAR package, Environmental Software, **2**(3):15l-158 **DL**

JA.17 Zannetti, P. (1986b) A new mixed segment-puff approach for dispersion modeling, Atmospheric Environment, **20**(6):1121-1130 **DL**

JA.16 Zannetti, P. (1986a) Monte-Carlo simulation of auto- and cross-correlated turbulent velocity fluctuations (MC-LAGPAR II model), Environmental Software, **1**(1):26-30 **DL**

JA.15 Tirabassi, T., M. Tagliazucca, and P. Zannetti (1986) KAPPA-G, a non-Gaussian plume dispersion model: description and evaluation against tracer measurements, Journal of the Air Pollution Control Association, **36**:592-596 **DL**

JA.14 Zannetti, P. (1984) New Monte Carlo scheme for simulating Lagrangian particle diffusion with wind shear effects, Applied Mathematical Modeling, **8**:188-192 **DL**

JA.13 Zannetti, P. (1982b) Il "Controlled Trading" negli Stati Uniti [Controlled Trading of pollution emissions in the US], Note di Inforrnatica, **1**:71-83, IBM Italia; also in Inquinamento, **25**(7/8):61-64, Etas Kompass, 1983 **DL**

JA.12 Zannetti, P. (1981b) Scommessa con il sole [Solar Challenger], Scienza e Vita Nuova, **3**(7):16-21, Rusconi Editore **DL**

JA.11 Zannetti, P. (1982a) E' la anidride carbonica nella atmosfera uno dei futuri maggiori pericoli per l' umanita'? [Is the increase of atmospheric CO_2 one of the most serious future problems for the human beings?], Inquinamento, **24**(3):59-62, Etas Kompass **DL**

JA.10 Zannetti, P. (1981a) An improved puff algorithm for plume dispersion simulation, J Applied Meteorology, **20**(10):1203-1211. **DL**

JA.9 Zannetti, P. (1980-81) Problemi energetici ed ambientali negli USA [Energy and environmental problems in the US], Inquinamento, **22**(12):65-69 and **23**(1):63-66, Etas Kompass **DL**

JA.8 Finzi, G., P. Zannetti, G. Fronza, and S. Rinaldi (1979) Real time prediction of SO_2 concentration in the Venetian Lagoon area, Atmospheric Environment, **13**:1249-1255 **DL**

JA.7 Runca, E., P. Zannetti, and P. Melli (1978) A computer-oriented emissions inventory procedure for urban and industrial sources, Journal of the Air Pollution Control Association, **28**(6):584-588 **DL**

JA.6 Zannetti, P. (1977) Metodiche adottate nell'analisi dei dati misurati nelle reti di monitoraggio dell'area veneziana [Analysis of atmospheric monitored data in the Venitian region], Tavola Rotonda su "La gestione operativa di una rete di monitoraggio dell'inquinamento atmosferico," Venice, Italy, June 1976; Annex to Inquinamento, **19**(6), Etas Kompass **DL**

JA.5 Zannetti, P., P. Melli, and E. Runca (1977) Meteorological factors affecting SO_2-pollution level in Venice, Atmospheric Environment, **11**:605-616 **DL**

JA.4 Zannetti, P. (1977) Stabilita' atmosferica e livelli di SO_2 in Venezia: limiti del modello gaussiano [Atmospheric stability and SO_2 levels in Venice: the limitations of the Gaussian model], Inquinamento, **19**(3):49-53, Etas Kompass **DL**

JA.3 Runca, E. and P. Zannetti (1976) Applicazione di un metodo per il censimento degli scarichi gassosi di origine industriale nell'area Veneziana [A method based on optical reading for the inventory of air pollution emissions in the Venetian area], Inquinamento, **18**(11):13-17, Etas Kompass **DL**

JA.2 Runca, E., P. Melli, and P. Zannetti (1976) Computation of long-term average SO_2 concentration in the Venetian area, Applied Mathematical Modeling, **1**:9-15 **DL**

JA.1 Zannetti, P. and E. Runca (1975) Validita' della applicazione di un modello gaussiano di tipo climatologico nell'area veneziana [Validity of the climatological Gaussian model in the Venetian area], Inquinamento, **17**(5):9-13, Etas Kompass **DL**

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P.51 Daly, A., P. Zannetti, and M. Jennings (2013) Accident Reconstruction and Plume Modeling of an Unplanned Ammonia Release. AIR POLLUTION XXI, Siena, Italy. WIT Transactions on Ecology and The Environment, Vol 174, WIT Press. **DL**

P.50 Mongia, R., W. Qin, J. Belanger, A. Reza, and P. Zannetti (2002) Effect of exhaust stack geometry on the amount of liquid condensate during plant start-up, Paper 453000, Proceedings, Air & Waste Management Association, (A&WMA), 95th Annual Conference, Baltimore, MD, June 23-27, 2002 **DL**

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P.44 Jackson, J. and P. Zannetti (1997) Design and Implementation of a Supplemental Control Program for SO_2 Episodes in the Region of Ilo, Peru, Proceedings, AIR POLLUTION 97, Bologna, Italy, September, Computational Mechanics Publications, Southampton, UK **DL**

P.43 Fox, D., K. McDonald, P. Zannetti, and Z. Nejedley (1997) Impact of north-western emission changes on visibility in the Rocky Mountains parks, Air & Waste Management Association, 90th Annual Meeting & Exhibition, Toronto, Canada, June

P.42 Zannetti, P. (1996) Environmental Modeling – The Next Generation, Keynote Address, Proceedings, ENVIROSOFT 96 – Development and Application of Computer Techniques to Environmental Studies VI, Como, Italy, September **DL**

P.41 Zannetti, P. (1995) Environmental Modeling – Past, Present and Future, Keynote Address, Proceedings, MODSIM 95 – International Congress on Modelling and Simulation 1995, University of Newcastle, Newcastle, New South Wales, Australia, November

P.40 Hansen, D.A., P. Zannetti, and J.M. Hales (1995) Design of a Framework for the Next Generation of Air Quality Modeling System, Proceedings, AIR POLLUTION 95, Porto Carras, Greece, Computational Mechanics Publications, Southampton, UK, September

P.39 Zannetti, P. (1995) Is Virtual Reality the Future of Air Pollution Modeling?, Keynote Address, Proceedings, AIR POLLUTION 95, Porto Carras, Greece, Computational Mechanics Publications, Southampton, UK, September

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P.37 Boybeyi, Z., S. Raman, and P. Zannetti (1993) A coupled model applied to the Bhopal gas accident, International Conference on Sustainable Development Strategies and Global/Regional/Local Impacts on Atmospheric Composition and Climate, Indian Institute of Technology, New Delhi, India, January **DL**

P.36 Zannetti, P., and I. Tombach (1989) Intercomparison of numerical techniques for the simulation of visibility improvements from SO_2 emission controls in the eastern United States, A&WMA/EPA International Specialty Conference on Visibility and Fine Particles, Estes Park, CO, October **DL**

P.35 Zannetti, P. (1989) Can we continue to apply dispersion models without a proper linkage with meteorological models?, Paper 89-43.1, 82nd Annual A&WMA Meeting, Anaheim, CA, June **DL**

P.34 Brusasca, G., G. Tinarelli, J. Moussafir, P. Biscay, P. Zannetti, and D. Anfossi (1988) Development of a portable FORTRAN 77 code for Monte Carlo particle modeling of atmospheric diffusion (MC-LAGPAR II) – Validation against analytical solutions and tracer experiments, ENVIROSOFT 88 – Computer techniques in environmental studies, 2nd International Conference Porto Carras, Greece, September, Computational Mechanics Publications, Southampton **DL**

P.33 Zannetti, P., I. Tombach, and S. Cvencek (1988) Semi-empirical analysis of the potential visibility improvements from SO_2 emission controls in the eastern United States, Proceedings, 81st Annual Air Pollution Control Association Meeting, Dallas, TX, June 19-24, 1988 **DL**

P.32 Brusasca, G., G. Tinarelli, P. Zannetti, and D. Anfossi (1986) Monte-Carlo simulation of plume dispersion in homogeneous and non-homogeneous turbulence, ENVIROSOFT 86, Newport Beach, CA, November **DL**

P.31 Tirabassi, T., M. Tagliazucca, and P. Zannetti (1986b) A non-Gaussian climatological model for air quality simulations, ENVIROSOFT 86, Newport Beach, CA, November **DL**

P.30 Tirabassi, T., M. Tagliazucca, and P. Zannetti (1986a) Evaluation and sensitivity of a model of dispersion in turbulent shear flow, WMO Conference on Air Pollution Modeling and its Application, Leningrad, USSR, May

P.29 Zannetti, P. (1985) Air pollution modeling R&D in Italy and Kuwait, Air Pollution Control Association 78th Annual Meeting and Exhibition, Detroit, MI, June **DL**

P.28 Zannetti, P., G. Carboni, and A. Ceriani (1985) AVACTA II model simulations of worst-case air pollution scenarios in Northern Italy, 15th International Technical Meeting on Air Pollution Modeling and Its Application, NATO/CCMS, St. Louis, MO, April **DL**

P.27 Tirabassi, T., M. Tagliazucca, and P. Zannetti (1984) Evaluation of a dispersion model based on a non-Gaussian analytical solution in turbulent shear flow, DOE/AMS Model Evaluation Workshop, Kiawah Island, SC, October **DL**

P.26 Zannetti, P. and N. Al-Madani (1983b) Simulation of transformation, buoyancy and removal processes by Lagrangian particle methods, 14th International Technical Meeting on Air Pollution Modeling and Its Application, NATO/CCMS, Copenhagen, Denmark, September **DL**

P.25 Zannetti, P. and N. Al-Madani (1983a) Numerical simulations of Lagrangian particle diffusion by Monte-Carlo techniques, Sixth World Congress on Air Quality (IUAPPA), Paris, May **DL**

P.24 Wilbur, D.W. and P. Zannetti (1983) Field measurements and model validation of dispersion over water and at land/sea interface, Sixth Symposium on turbulence and Diffusion, Boston, MA, March **DL**

P.23 Zannetti, P. (1982) A new Monte-Carlo scheme for simulating Lagrangian particle diffusion with wind shear effects, 13th International Technical meeting on Air Pollution Modeling and Its Application, NATO/CCMS, Ile Des Embiez, France, September **DL**

P.22 Zannetti, P., D. Wilbur, and G. Schacher (1982) Coastal atmospheric diffusion characterization from three-dimensional monitoring of SF_6 releases, First International Conference on Meteorology and Air/Sea Interaction in the Coastal Zone, The Hague, The Netherlands, May **DL**

P.21 Schacher, G., C. Fairall, and P. Zannetti (1982) Comparison of stability classification methods for parameterizing coastal over-water dispersion, First International Conference on Meteorology and Air/Sea Interaction in the Coastal Zone, The Hague, The Netherlands, May **DL**

P.20 Zannetti, P. (1981) Some aspects of Monte Carlo type modeling of atmospheric turbulent diffusion, 7th Conference on Probability and Statistics in Atmospheric Sciences, American Meteorological Society, Monterey, CA, November **DL**

P.19 Zannetti, P. (1980c) A new puff algorithm for non-stationary dispersion on complex terrain, 5th Symposium on Turbulence, Diffusion and Air Pollution, American Meteorological Society, Atlanta, GA, March **DL**

P.18 Zannetti, P. (1980b) A new Gaussian puff algorithm for nonhomogeneous nonstationary dispersion in complex terrain, 11th International Technical Meeting on Air Pollution Modeling and Its Application, NATO/CCMS, Amsterdam, The Netherlands, November **DL**

P.17 Zannetti, P. (1980a) A new puff model for an accurate nonstationary plume description in both transport and calm conditions, Symposium on Intermediate Range Atmospheric Transport Processes and Technology Assessment, Gatlinburg, TN, October **DL**

P.16 Zannetti, P. and P. Switzer (1979b) The Kalman filtering method and its application to air pollution episode forecasting, Air Pollution Control Association Specialty Conference "Quality Assurance in Air Pollution Measurement," New Orleans, LA, March; also IBM Palo Alto Technical Report G320-3381 and Department of Statistics, Stanford University, Technical Report 22 **DL**

P.15 Zannetti, P. and P. Switzer (1979a) Some problems of validation and testing of numerical air pollution models, 4th Symposium on Turbulence, Diffusion and Air Pollution, American Meteorological Society, Reno, NV, January; also Department of Statistics, Stanford University, Technical Report 21 **DL**

P.14 Zannetti, P. (1978) Short-term, real-lime control of air pollution episodes in Venice, 71st Air Pollution Control Association Annual Meeting, Houston, TX, June; also Technical Report G320-3371, IBM Scientific Center, Palo Alto, CA **DL**

P.13 Runca, E., P. Zannetti, and P. Melli (1978) Air quality management: Proposal for a computer oriented approach, International Symposium "Simulation '77," Montreux, Switzerland, June 1977 **DL**

P.12 Finzi, G., G. Fronza, S. Rinaldi, and P. Zannetti (1978) Modeling and forecast of the Dosage Population Product in Venice, IFAC Symposium on Environmental System Planning, Design and Control, Kyoto, Japan, August 1977 **DL**

P.11 Zannetti, P., G. Finzi, G. Fronza, and S. Rinaldi (1978) Time series analysis of Venice air quality data, IFAC Symposium on Environmental System Planning, Design and Control, Kyoto, Japan, August 1977 **DL**

P.10 Zannetti, P. (1977b) Modeling and forecasting SO_2 air pollution levels: a statistical approach, Applied Numerical Modeling, International Conference, Southampton, England, July (presented by P. Melli) **DL**

P.9 Zannetti, P. (1977a) Modelli statistici e loro possibilita' applicative per lo studio delle serie di misure meteorologiche e di SO_2 nell'area veneziana [Statistical models and their application to meteorological and air quality time series in the Venetian area], Ambiente e Risorse, 4th Meeting, Bressanone, Italy, September 1976

P.8 Gambolati, G., P. Zannetti, and P. Gatto (1977) A mixed finite difference-finite element approach to simulate unconfined flow in the Crescentino area, Regional Groundwater Hydrology and Modeling Seminar, IBM Scientific Center, Venice, Italy, May 1976 **DL**

P.7 Runca, E., P. Melli, and P. Zannetti (1976) Computation of SO_2-1ong term concentration in the Venetian area, Mathematical Models for Environmental Problems, International Conference, Southampton, England, September 1975 **DL**

P.6 Zannetti, P., P. Melli, and E. Runca (1976) SO_2 in Venezia: analisi e prospettive [SO_2 in Venice: analyses and future perspectives], Ambiente e Risorse, 3rd Meeting, Bressanone, Italy, September 1975

P.5 Zannetti, P. (1976) Analisi delle serie temporali di misure della qualita dell'aria in Venezia: uno studio preliminare [A preliminary study of meteorological and air quality time series in Venice], XIV Convegno Internazionale di Automazione e Strumentazione, Automazione e Utilizzazione delle Risorse, FAST, Milano, Italy, November **DL**

P.4 Runca, E., P. Melli, and P. Zannetti (1976b) An application of air pollution models to the Venetian area, Air Pollution Modeling Seminar, IBM Scientific Center, Venice, Italy, November 1975 **DL**

P.3 Runca, E., P. Melli, and P. Zannetti (1976a) Simulation of SO_2 dispersion in the Venetian area, 6th International Technical Meeting, NATO/CCMS Expert Panel on Air Pollution Modeling, Frankfurt, West Germany, September 1975 **DL**

P.2 Zannetti, P. and E. Runca (1975) Studio dell'inquinamento atmosferico nell'area veneziana mediante l'uso di un modello di diffusione gaussiano [Study of air quality in Venice using a Gaussian model], Ambiente e Risorse, 2nd Meeting, Bressanone, Italy, September 1974 **DL**

P.1 Zannetti, P. and E. Runca (1974) Meteorologia ed inquinamento nell'area veneziana. [Meteorology and air pollution in Venice], Sep/Pollution 74, Padova, Italy, June **DL**

Technical Reports

Dr. Zannetti has authored and co-authored hundreds of internally peer-reviewed technical reports while working for IBM Scientific Centers, AeroVironment, Inc., the Kuwait Institute of Scientific Research, CRTN/ENEL, Exponent, Inc., and EnviroComp Consulting, Inc. Many of these reports remained confidential or were prepared for litigation cases and have not been published. A few key reports are listed below:

- Zannetti, P. (2011): Atmospheric Deposition Modeling of Oust®-Contaminated Dust in Southern Idaho during 1999-2001. Analyses Related to: Adams, et al., v the United States of America, Case No.: CIV 03-0049-E-BLW, United States District Court, District of Idaho. Project: EC-11-001, Report: 11-03-25. **DL**

- EnviroComp Consulting, Inc (2006) Air Quality Issues in the Beverly Hills High School Area, Beverly Hills, CA. Project: EC-04-004, Report: 06-03-10. **DL**

- Zannetti, P., B. Bruegge, D.A. Hansen, N. Lincoln, W.A. Lyons, D.A. Moon, R.E. Morris, A.G. Russell (1996) Framework Design - Design and Development of a Comprehensive Modeling System (CMS) for Air Pollution. FaAA Report SF-R-96-02-21 prepared for the Electric Power Research Institute. [Also published as Zannetti et al. (1996): Design of a Framework for the Development of a Comprehensive Modeling System for Air Pollution. EPRI TR-106852, WO4311-02, Final Report, September 1996]. **DL**

- Zannetti, P. (1987): Diffusion and transport model enhancement. AeroVironment Report AV-R-87/714 prepared for the U.S. Army. **DL**

- Zannetti, P., and L. Matamala (1986): Lagrangian modeling of tracer experiments in the Los Angeles basin. Prepared for the Southern California Edison Company. AeroVironment Report AV-R-86/533. **DL**

- Zannetti, P., G. Carboni, R. Lewis and L. Matamala (1986): AVACTA II - User's guide, Release 3.1. AeroVironment Report AV-R-86/530. **DL**

- Zannetti, P., M. Sudairawi, N. Al-Madani and N. El-Karmi (1983): Air Pollution Dispersion and Prediction Model for Shuaiba Industrial Area. Prepared for the Shuaiba Area Authority, Kuwait. Kuwait Institute for Scientific Research, Document KISR 1090A, 5 Volumes:

    - Volume I – Executive Summary **DL**
    - Volume II – Technical Report **DL**
    - Volume III – Special Studies and Appendices **DL**
    - Volume IV – Software User's Manuals **DL**
    - Volume V – Data and Program Listings **DL**

Short Communications

Dr. Zannetti has published dozens of short communications including the most recent:

- Zannetti, P. (2012) Preface to "Venice Shall Rise Again" by G. Gambolati and P. Teatini, The EnviroComp Institute (http://www.envirocomp.org/Venice) **DL**
- Zannetti, P. (2007) Preface to "Environmental Modeling Using MATLAB" by E. Holzbecher, Springer, 2007 **DL**

Other Publishing/Editorial Activities

- Since the mid-1990s, most of Dr. Zannetti's editorial/publishing work has been performed as part of the activities of his non-profit EnviroComp Institute (http://envirocomp.org/activities.html). In particular, he promoted and directed the publication a unique, new-generation series of environmental book in electronic format:
  - Venice Shall Rise Again - Engineered Uplift of Venice through Seawater Injection
  - Air Quality Modeling book series
  - Environmental Sciences and Environmental Computing book series
  - Ambient Air Pollution
  - Groundwater Modeling: Computer Simulation of Groundwater Flow and Pollution
  - Urban Air Pollution: Athens 2004 Air Quality
- EnviroNews, a bimonthly environmental newsletter, FiatLux Publications (1993 – 2000)

UNPUBLISHED WORKS

Doctoral Degree Thesis

- Zannetti, P. (1970) Riconoscimento a mezzo di elaboratore elettronico di caratteri numerici manoscritti [Computer pattern recognition of handwritten digits], Relatori: Profs. L. Mezzetti and D. Toniolo, University of Padua, Faculty of Science (Physics)

Poster Paper

- Zannetti, P. (1986) AVACTA II: a new Gaussian dynamic model for the simulation of atmospheric dispersion, transformation and deposition phenomena, Poster paper, WMO Conference on Air Pollution Modeling and Its Application, Leningrad, USSR, May 1986

Course Materials

C.37 Zannetti, P. (2013) Fundamentals of Air Quality Modeling. 1-Day Course given at A&WMA Annual Meeting, Chicago, IL, 23 June 2013. Outline **DL**

C.36 Zannetti, P. and L. Delle Monache (2012) AIR QUALITY - Management, Modeling, and Forecast. September 25-27, 2012, Wessex Institute of Technology, Ashurst, UK

C.35 Zannetti, P. (2011) Air Quality Management - Goals, Regulations, Implementations, and Available Software Tools, May 4-5, 2011, Wessex Institute of Technology, Ashurst, UK. Lessons: Introduction to Air Pollution Issues, Scientific Understanding of Air Pollution Phenomena, Air Quality Management in the US, Air Quality Management in Europe, Health Risks and Other Adverse Effects of Air Pollution, Emergency Preparedness and Response - Case Studies, Air Quality Modeling and Software, Air Quality Management Tools and Software

C.34 Zannetti (2006) Introduction to Air Pollution Modeling, Organized by Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton, UK, Topics: Air Pollution Problems and Phenomena, Air Pollution Meteorology, The Gaussian Plume Model, Segmented and Puff Model, Eulerian Models, Lagrangian Particle Models, Atmospheric Chemistry and Deposition, Long-range and Global Modeling, 25-26 May 2006

C.33 Zannetti (2005) Workshops on Ambient Air Pollution: 1) Introduction to Air Pollution, 2) Introduction to Air Pollution Modeling, 3A) Air Pollution Case Studies, and 3B) Global Issues, The Kuwait Foundation for the Advancement of Science (KFAS), Kuwait, 5-9 February 2005

C.32 Zannetti, P. (2004) Fluid Pollution Modeling, Engineering Faculty, Taranto, Italy, October 2004

C.31 Zannetti, P. (2003) Fluid Pollution Modeling, Engineering Faculty, Taranto, Italy, May 2003

C.30 Zannetti, P. (2002) Fluid Pollution Modeling, Engineering Faculty, Taranto, Italy, September 2002

C.29 Zannetti, P. (2001) Fluid Pollution Modeling, Engineering Faculty, Taranto, Italy, September 2001

C.28 Zannetti, P. (2001) Accidental Chemical Releases – Accident Reconstruction, Air Dispersion Modeling, Source Identification, and Allocation of Responsibility, Environmental Litigation: Advanced Forensics and Legal Strategies, San Francisco, CA, April 4-5, 2001

C.27 Zannetti, P. (2000) Fluid Pollution Modeling, Engineering Faculty, Taranto, Italy, October 9-12, 2000

C.26 Zannetti, P. (1999) Fluid Pollution Modeling, Engineering Faculty, Taranto, Italy, June 2-5, 1999

C.25 Zannetti, P. (1998) Air Pollution Modeling, Wessex Institute of Technology, Southampton, UK, April 1998

C.24 Zannetti, P. (1997) Air Dispersion Modeling and Meteorology, University of California, Berkeley Extension, July 1997

C.23 Zannetti, P. (1997) Air Pollution Modeling, Wessex Institute of Technology, Southampton, UK, May 1997

C.22 Zannetti, P. (1997) Air Pollution, Wessex Institute of Technology, Southampton, UK, May 1997

C.21 Zannetti, P. (1996) Air Dispersion Modeling and Meteorology, University of California, Berkeley Extension, April/May 1996

C.20 Zannetti, P. (1995) Air Dispersion Modeling and Meteorology, University of California, Berkeley Extension, March/April 1995

C.19 Zannetti, P. (1994) Air Dispersion Modeling and Meteorology, University of California, Berkeley Extension, March 1994

C.18 Zannetti, P. (1993) Air Dispersion Modeling and Meteorology, University of California, Berkeley Extension, March 1993

C.17 Zannetti, P. (1993) Introduction to Air Pollution Modeling, Instituto Tecnologico y de Estudios Superiores de Monterrey, Mexico, 15 February 1993

C.16 Zannetti, P. (1992) Air Pollution Modeling and Software, Computational Mechanics Institute, Ashurst, Southampton, UK, September 1992

C.15 Zannetti, P. (1990) Air Pollution Modeling and Software, Computational Mechanics Institute, Ashurst, Southampton, UK, November 1990

C.14 Zannetti, P. (1990) Computer Simulation using Particle Modeling, Computational Mechanics Institute, Ashurst, Southampton, UK, November 1990

C.13 Zannetti, P. (1990) Air Pollution Modeling, Department of Meteorology, University of Bergen, Norway, Fall 1990

C.12 Zannetti, P. (1989) Air Quality Modeling and Software, Computational Mechanics Institute, Ashurst, Southampton, UK, April 1989

C.11 Zannetti, P. (1989) Computer Simulation Using Particle Modeling, Computational Mechanics Institute, Ashurst, Southampton, UK, April 1989

C.10 Pielke, R., J. Seinfeld, I. Tombach, and P. Zannetti (1988) A Short Course on Air Pollution: Simulation Modeling and Measurement Strategies, Monrovia, CA, March 1988

C.9 Pielke, R., J. Seinfeld, I. Tombach, and P. Zannetti (1987) Air Pollution – Simulation Modeling and Measurement Strategies, AeroVironment, February 1987

C.8 Zannetti, P. (1986) Air quality modeling and software, Computational Mechanics Institute, Ashurst, Southampton, UK, June 1986

C.7 Zannetti, P., J.C.R. Hunt, and A.G. Robins (1985) Air Pollution Modeling Course, Computational Mechanics Centre, Ashurst, Southampton, UK, September 1985

C.6 Gopalakrishnan, T.C. and P. Zannetti (1983) Numerical Modeling Course, Kuwait Institute for Scientific Research, Kuwait, December 1983

C.5 Zannetti, P. and J.C.R. Hunt (1983) Air Pollution Modeling Course, Computational Mechanics Centre, Ashurst, Southampton, UK, May 1983

C.4 Zannetti, P. and I. Tombach (1983) Air Pollution Course, Kuwait Institute for Scientific Research, Kuwait, January 1983; also Tombach, I. and P. Zannetti (1984) Air Pollution – Part 1: Introduction to Air Pollution and Dispersion Modeling, prepared for Kuwait Institute of Scientific Research, Kuwait, May 1984, AeroVironment Memorandum AV-M-84/533

C.3 Zannetti, P., G.I. Jenkins, and D.J. Moore (1982) Air pollution modeling course, Computational Mechanics Centre, Southampton, UK, May 1982

C.2 Zannetti, P. (1980) A short course on air pollution modeling, Computational Mechanics Centre, Southampton, UK, December 1980

C.1 Zannetti, P. (1977) EURATOM CCM Courses, Modeling and Simulation of Ecological Processes: 1) Statistical models and their application to data collected in Venice, and 2) Statistical programs application to meteorological and air quality data (Computer practical exercise), Ispra, Italy, October 1977

Invited Lectures/Seminars

Dr. Zannetti has presented more than a hundred invited lectures and seminars throughout the world, including the most recent ones listed below:

- Recent Air Quality Developments: Management, Assessment, and Modeling. Water and Environment Center (WEC) of the Royal Scientific Society (RSS) and UN ESCWA Technology Centre (ETC), Amman, Jordan, January 6, 2019 **DL**

- Air Pollution Litigation in the US and the Role of Computer Modeling, The Voeikov Main Geophysical Observatory, St. Petersburg, Russia, 22 June 2018 **DL**

- Dynamic Simulations Using Particle Models, 2nd Annual Distinguished Symposium in Computational Engineering Mathematics, United States Military Academy, West Point, April 3rd, 2018 **DL**

- Mathematical Methods in Air Pollution Studies, Distinguished Colloquia in Computational Engineering Mathematics, U.S. Army Department of Mathematical Sciences, West Point, NY, 4 October 2016 **DL**

- Air Pollution. Hazardous Materials Class, San Jose State University, California, 28 April 2015

- Cost-Benefit Optimization Approach to Air Pollution Management. Keynote Address, UPWIND-DOWNWIND CONFERENCE 2014: Built Environment – Foundation for Cleaner Air Sheraton Hotel, HAMILTON, Ontario, CANADA, 24 February 2014 **DL**

- Air Quality Modeling and Cost-Benefit Optimization - Design of a Software Prototype for Managing Urban and Industrial Development, Keynote Address, AIR POLLUTION XXI, Siena, Italy, 4 June 2013 **DL**

- Computer Simulation of Air Pollution - Methodologies and Case Studies, San Jose State University, California, 23 April 2013

- Environmental Crises: Accident Reconstruction and Plume Modeling, 2012 International Student Conference on Environment and Sustainability, Tongji University, Shanghai, China, 6 June 2012 **DL**

- Atmospheric Issues - Chemical Releases, 2012 Asia-Pacific Leadership Programme on Environment for Sustainable Development, Tongji University, Shanghai, China, 5 June 2012 **DL**

- Computer Modeling of Air Pollution Phenomena, San Jose State University, California, 22 March 2011

- Applications of Dispersion Modeling in the Atmosphere, San Jose State University, California, Chemical Engineering Department, 27 April 2009

- Modellistica di Rilasci Accidentali di Inquinanti in Atmosfera. ARPA Puglia, Bari, Italy, 18 April 2009

- Guest Lecturer, 1) Introduction to Air Pollution; 2) Introduction to Air Pollution Modeling; 3) Litigation case studies for accidental releases of chemicals in the atmosphere, 22 October 2008, Environmental Science for Lawyers, Tulane Law School, Louisiana

- Business-Oriented Environmental Applications – Case Studies and ICT Tools, April 20, 2008, University of Damascus, Syria; April 21, 2008, University of Homs, Syria; April 22, 2008, University of Lattakia, Syria; April 23, 2008, University of Aleppo, Syria

- Computer Modeling of Accidental Releases of Air Pollutants – University of PADOVA, Department of Mathematical Methods and Models for Applied Sciences (DMMMSA), 26 March 2008; and University of VENEZIA, Italy, Faculty of Science, 27 March 2008

- 1) Introduction to Air Pollution Modeling; and 2) Accidental Releases in the Atmosphere. Presentations at Yunnan Environmental Science Society (YESS), Kunming Region, China. October, 2007. Member of the A&WMA Delegation to China under the banner of the People-to-People Citizen Ambassador programs. Full report of the Mission.

- Air Pollution Modeling of Accidental Releases – Science and Litigation, Universidade Federal de Santa Maria, Brazil, 15 September 2005

- Workshop on Ambient Air Pollution, February 5 - 9, 2005, Kuwait Foundation for the Advancement of Sciences, Kuwait. Seminars: Introduction to Air Pollution, Introduction to Air Pollution Modeling, Air Pollution Case Studies

Appendix B: VOC/TAP/HAP Emissions Factors Calculations

The emission factors of total VOC, TAPs, and HAPs have been determined starting from the testing carried out by Ecology in June 2013. The details about the calculations are reported in the following tables.

Ecology Testing at the Lenz Facility for VOCs.					# days	# days	
				Assume>	1	13	
		ASP Biofilter	Tipping & ASP Biofilter	Tipping & ASP Biofilter Dup	Fresh ASP	7-Day ASP	Finished
CAS No		ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
115-07-1	Propene	54	56	53	370	3.3	14
75-71-8	Dichlorodifluoromethane					1.6	1.1
74-87-3	Chloromethane					1.1	
106-99-0	1,3-Butadiene						
64-17-5	Ethanol						
75-05-8	Acetonitrile			14		24	6.7
67-64-1	Acetone					13	16
75-69-4	Trichlorofluoromethane						2
75-09-2	Methylene Chloride					1.1	
108-05-4	Vinyl Acetate						
78-93-3	2-Butanone (MEK)						
141-78-6	Ethyl Acetate				580	130	
110-54-3	n-Hexane						1.3
71-43-2	Benzene						1.5
142-82-5	n-Heptane					1.4	
108-10-1	4-Methyl-2-pentanone						
108-88-3	Toluene	12	6.6		370	8.6	
111-63-9	n-Octane						
100-41-4	Ethylbenzene						
179601-23-1	m,p-Xylenes						
100-42-5	Styrene						
111-84-2	n-Nonane						
80-56-8	alpha-Pinene	1100	800	900	45000	75	1.7
5989-27-5	d-Limonene	670	600	630	34000	160	0.9
	TVOC as Toluene	10000	5200	5000	130000	930	200

Ecology Testing at the Lenz Facility for VOCs.						
		Mas Bed NE Corner	Mas Bed NW Corner	Mass Bed Middle W	Mass Bed Middle S	Mass Bed Middle E
CAS No		ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
115-07-1	Propene	72	49	5000	1700	160
75-71-8	Dichlorodifluoromethane		1.5			
74-87-3	Chloromethane	10		87	53	
106-99-0	1,3-Butadiene		3.8			
64-17-5	Ethanol	36				580
75-05-8	Acetonitrile	11	23	46	110	
67-64-1	Acetone	38	9.1		1000	1100
75-69-4	Trichlorofluoromethane		0.78			
75-09-2	Methylene Chloride					
108-05-4	Vinyl Acetate	33				480
78-93-3	2-Butanone (MEK)				340	650
141-78-6	Ethyl Acetate					
110-54-3	n-Hexane		2	51		
71-43-2	Benzene	7.9	2.3	41	24	
142-82-5	n-Heptane	5.9	2.3	83	37	
108-10-1	4-Methyl-2-pentanone				59	
108-88-3	Toluene	11	4.2	75	55	
111-63-9	n-Octane	6.4		77	23	
100-41-4	Ethylbenzene		0.65			
179601-23-1	m,p-Xylenes		2.1			
100-42-5	Styrene	5.6		83	74	
111-84-2	n-Nonane				18	62
80-56-8	alpha-Pinene	620	13	4000	3500	6600
5989-27-5	d-Limonene	360	7.9	1600	18000	5000
	TVOC as Toluene	3000	440	19000	19000	31000

Ecology Testing for Sulfur compounds							
		ASP Biofilter	Tipping & ASP Biofilter	Tipping & ASP Biofilter Dup	Fresh ASP	7-Day ASP	Finished
CAS No		ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
463-58-1	Carbonyl Sulfide				100		
74-93-1	Methyl Mercaptan						
75-18-3	Dimethyl Sulfide				16000	34	
75-15-0	Carbon Disulfide				28		
Ecology Testing for Aldehydes							
		ASP Biofilter	Tipping & ASP Biofilter	Tipping & ASP Biofilter Dup	Fresh ASP	7-Day ASP	Finished
CAS No		ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
50-00-0	Formaldehyde						
75-07-0	Acetaldehyde			4	21		
123-38-6	Propionaldehyde						
123-72-8	Butyraldehyde						
100-52-7	Benzaldehyde						
590-86-3	Isovaleraldehyde						
110-62-3	Valeraldehyde						
529-20-4	o-Tolualdehyde						
66-25-1	n-Hexaldehyde						
5779-94-2	2,5-Dimethylbenzaldehyde						

Ecology Testing for Sulfur compounds						
		Mas Bed NE Corner	Mas Bed NW Corner	Mass Bed Middle W	Mass Bed Middle S	Mass Bed Middle E
CAS No		ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
463-58-1	Carbonyl Sulfide					21
74-93-1	Methyl Mercaptan				22	51
75-18-3	Dimethyl Sulfide	390		850	1300	720
75-15-0	Carbon Disulfide			41	34	
Ecology Testing for Aldehydes						
		Mas Bed NE Corner	Mas Bed NW Corner	Mass Bed Middle W	Mass Bed Middle S	Mass Bed Middle E
CAS No		ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
50-00-0	Formaldehyde	9.6				66
75-07-0	Acetaldehyde	6.1		3.8	4.6	1100
123-38-6	Propionaldehyde					230
123-72-8	Butyraldehyde					220
100-52-7	Benzaldehyde	4.8				250
590-86-3	Isovaleraldehyde					260
110-62-3	Valeraldehyde					6.6
529-20-4	o-Tolualdehyde					13
66-25-1	n-Hexaldehyde					23
5779-94-2	2,5-Dimethylbenzaldehyde				3.8	

Ecology Testing at the Lenz Facility for Vocs.						
		TAP?	**HAP?**	**VOC?**	**SQER**	**Avg period**
CAS No					lb/av period	
115-07-1	Propene	Yes	Not Found	Not Found	394	24-hr
75-71-8	Dichlorodifluoromethane	Not Found	No	No	Not Found	Not Found
74-87-3	Chloromethane	Yes	Yes	Yes	11.8	24-hr
106-99-0	1,3-Butadiene	Yes	Yes	Yes	1.13	year
64-17-5	Ethanol	Not Found	No	Yes	Not Found	Not Found
75-05-8	Acetonitrile	Yes	Yes	Yes	11500	year
67-64-1	Acetone	Not Found	No	No	Not Found	Not Found
75-69-4	Trichlorofluoromethane	Not Found	No	No	Not Found	Not Found
75-09-2	Methylene Chloride	Yes	Yes	No	192	year
108-05-4	Vinyl Acetate	Yes	Yes	Yes	26.3	24-hr
78-93-3	2-Butanone (MEK)	Yes	No	Yes	657	24-hr
141-78-6	Ethyl Acetate	Not Found	No	Yes	Not Found	Not Found
110-54-3	n-Hexane	Yes	Yes	Yes	92	24-hr
71-43-2	Benzene	Yes	Yes	Yes	6.62	year
142-82-5	n-Heptane	Not Found	No	Yes	Not Found	Not Found
108-10-1	4-Methyl-2-pentanone	Yes	Yes	Yes	394	24-hr
108-88-3	Toluene	Yes	Yes	Yes	657	24-hr
111-63-9	n-Octane	Not Found	Not Found	Not Found	Not Found	Not Found
100-41-4	Ethylbenzene	Yes	Yes	Yes	76.8	year
179601-23-1	m,p-Xylenes	Not Found	Not Found	Not Found	Not Found	Not Found
100-42-5	Styrene	Yes	Yes	Yes	118	24-hr
111-84-2	n-Nonane	Not Found	No	Yes	Not Found	Not Found
80-56-8	alpha-Pinene	Not Found	Not Found	Not Found	Not Found	Not Found
5989-27-5	d-Limonene	Not Found	Not Found	Not Found	Not Found	Not Found
	TVOC as Toluene					

Ecology Testing at the Lenz Facility for VOCs.		Emissions			
		Biofilter	ASP on positive Air	Mass Bed	Finished
CAS No		tpy	tpy	tpy	tpy
115-07-1	Propene	0.00456	0.002491	0.080485	0.002396
75-71-8	Dichlorodifluoromethane	0	0.000125	0.000755	0.000188
74-87-3	Chloromethane	0	8.63E-05	0.026661	0
106-99-0	1,3-Butadiene	0	0	0.001912	0
64-17-5	Ethanol	0	0	0.154935	0
75-05-8	Acetonitrile	0.001182	0.001882	0.017355	0.001147
67-64-1	Acetone	0	0.001019	0.261075	0.002738
75-69-4	Trichlorofluoromethane	0	0	0.000392	0.000342
75-09-2	Methylene Chloride	0	8.63E-05	0	0
108-05-4	Vinyl Acetate	0	0	0.129028	0
78-93-3	2-Butanone (MEK)	0	0	0.249002	0
141-78-6	Ethyl Acetate	0	0.013692	0	0
110-54-3	n-Hexane	0	0	0.01333	0.000222
71-43-2	Benzene	0	0	0.008023	0.000257
142-82-5	n-Heptane	0	0.00011	0.01079	0
108-10-1	4-Methyl-2-pentanone	0	0	0.029679	0
108-88-3	Toluene	0.000785	0.002906	0.0166	0
111-63-9	n-Octane	0	0	0.01157	0
100-41-4	Ethylbenzene	0	0	0.000327	0
179601-23-1	m,p-Xylenes	0	0	0.001056	0
100-42-5	Styrene	0	0	0.037225	0
111-84-2	n-Nonane	0	0	0.020121	0
80-56-8	alpha-Pinene	0.076001	0.277313	1.76062	0.000291
5989-27-5	d-Limonene	0.053201	0.217628	0.804855	0.000154
	TVOC as Toluene	0.439116	0.85706	9.557649	0.034228

Ecology Testing for Sulfur compounds						
		TAP?	**HAP?**	**VOC?**	**SQER**	**Avg period**
CAS No					lb/av period	
463-58-1	Carbonyl Sulfide	Not Found	Yes	Yes	Not Found	Not Found
74-93-1	Methyl Mercaptan	Not Found	No	Yes	Not Found	Not Found
75-18-3	Dimethyl Sulfide	Not Found	Not Found	Not Found	Not Found	Not Found
75-15-0	Carbon Disulfide	Yes	Yes	No	105	24-hr
Ecology Testing for Aldehydes						
		TAP?	**HAP?**	**VOC?**	**SQER**	**Avg period**
CAS No					lb/av period	
50-00-0	Formaldehyde	Yes	Yes	Yes	32	year
75-07-0	Acetaldehyde	Yes	Yes	Yes	71	year
123-38-6	Propionaldehyde	Not Found	Yes	Yes	Not Found	Not Found
123-72-8	Butyraldehyde	Not Found	Not Found	Not Found	Not Found	Not Found
100-52-7	Benzaldehyde	Not Found	Not Found	Not Found	Not Found	Not Found
590-86-3	Isovaleraldehyde	Not Found	Not Found	Not Found	Not Found	Not Found
110-62-3	Valeraldehyde	Not Found	No	Yes	Not Found	Not Found
529-20-4	o-Tolualdehyde	Not Found	Not Found	Not Found	Not Found	Not Found
66-25-1	n-Hexaldehyde	Not Found	Not Found	Not Found	Not Found	Not Found
5779-94-2	2,5-Dimethylbenzaldehyde	Not Found	Not Found	Not Found	Not Found	Not Found

Ecology Testing for Sulfur compounds		**Emissions**			
		Biofilter	ASP on Positive Air	Mass Bed	Finished
CAS No		tpy	tpy	tpy	tpy
463-58-1	Carbonyl Sulfide	0	0.000603	0.010564	0
74-93-1	Methyl Mercaptan	0	0	0.018361	0
75-18-3	Dimethyl Sulfide	0	0.099175	0.394882	0
75-15-0	Carbon Disulfide	0	0.000169	0.018864	0
Ecology Testing for Aldehydes		**Emissions**			
		Biofilter	ASP on Positive Air	Mass Bed	Finished
CAS No		tpy	tpy	tpy	tpy
50-00-0	Formaldehyde	0	0	0.019015	0
75-07-0	Acetaldehyde	0.000338	0.000127	0.002691	0
123-38-6	Propionaldehyde	0	0	0.115698	0
123-72-8	Butyraldehyde	0	0	0.110668	0
100-52-7	Benzaldehyde	0	0	0.064087	0
590-86-3	Isovaleraldehyde	0	0	0.130789	0
110-62-3	Valeraldehyde	0	0	0.00332	0
529-20-4	o-Tolualdehyde	0	0	0.006539	0
66-25-1	n-Hexaldehyde	0	0	0.01157	0
5779-94-2	2,5-Dimethylbenzaldehyde	0	0	0.001912	0

Appendix C: Ammonia (NH3) Emissions Calculations

The following table summarizes our emission calculations for ammonia. Assumptions and input values are reported in the yellow area. The SQER of ammonia is 9.31 lb/24-hr. The annual NH3 emissions in the future scenario are 5,850 lb, and dividing by 365 we get 16.0 lb/24-hr, which exceeds the SQER.

Species	Ammonia				
CAS	7664-41-7				
Input values					
Assumptions	**Value**	**Units**			
Uncontrolled NH3 EF	0.78	lb/wet ton			
Possible reduction due to difference in food organics	25	%			
Control efficiency negative flow (biofilter 5-foot)	95	%			
Control efficiency positive flow (biofilter cover 1-foot)	90	%			
Fraction of time with negative flow	0.4				
Fraction of time with positive flow	0.4				
Amount of NH3 emission in the CASP (remaining in windrows)	90	%			
Output					
Calculations	**Value**	**Units**			
Reduced NH3 EF due to difference in food organics	0.585	lb/wet ton			
CASP NH3 EF after control	0.059	lb/wet ton			
Biofilter NH3 EF after control	0.029	lb/wet ton			
CASP+Biofilter NH3 EF after control	0.035	lb/wet ton			
Windrow NH3 EF	0.004	lb/wet ton			
1 ton =	2000	lb			
		CASP+Biofilter	**Windrow**	**Total**	
	tpy organics	**lb/y NH3**	**lb/y NH3**	**lb/y NH3**	**tpy NH3**
Current scenario	75000	2633	293	2925	1.5
Future scenario	150000	5265	585	5850	2.9