Agroforestry Comes of Age:
Putting Science into Practice

Proceedings of the 11th North American Agroforestry Conference

May 31-June 3, 2009

Columbia, Missouri

Michael A. Gold & Michelle M. Hall, Eds.

CONTROLLING SWINE ODOR WITH WINDBREAKS

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Abstract: Emissions of malodor from swine facilities are an increasing environmental concern for the swine producers and nearby local communities. Use of natural windbreaks for odor abatement is recent and the science in support of using windbreaks for this purpose is limited. To provide sound science to the study of windbreaks and odor control, the University of Missouri Center for Agroforestry initiated a study in 2007 to evaluate the effects of windbreaks on transport of odors. A 3-row windbreak configuration was implemented consisting of pitch-loblolly pine (*Pinus rigida×P. taeda*), a conifer, on the inside row closest to the farrowing house; red maple (*Acer rubrum*) alternating with pin oak (*Quercus palustris*) a deciduous hardwood species that retains many of its leaves throughout much of the winter, as the middle row and; Viburnum 'Allegheny' (*Viburnum rhytidophyllum* X V. lantana), a semi-evergreen shrub that quickly reaches heights of 10 to 15 feet, as the outside row. Before the windbreak takes effect, air samples are being taken at varying distances from the facility (up to a mile radius) to monitor the baseline background concentrations of odorous gasses including ammonia (NH_3), hydrogen sulfide (H_2S), major volatile organic compounds (VOCs) and particulates. The spatial distribution and temporal variation in concentrations of these malodorous compounds have been characterized and mapped. This baseline information will be used for evaluating the impact of the windbreak on odor concentrations and movement over time.

INTRODUCTION

Use of windbreaks for odor abatement is recent and the science in support of using windbreaks for this purpose is still being developed. Reports on the use of windbreak technologies adjacent to poultry house ventilatyion fans strongly suggest that significant quantities of compounds known to correlate highly with odor can be removed from the air (e.g., ammonia 46%; dust emissions 49%). However, the overall effect on reducing odor, based upon the literature, appears to be low (6%) (Malone et al., 2006). Variability in windbreak effectiveness is known to be related to its physical location, species composition, density, and geometric configuration. Additional studies have shown windbreaks to have an impact on odor plume dispersal (Lin et al., 2006).

The purpose of this project was to develop a windbreak design that has the highest probability for maximizing odor abatement by effectively using the limited science available in the literature and, Center for Agroforestry knowledge of windbreak technology for crop protection.

MATERIAL AND METHODS

In late October, 2007 after visiting and evaluating many sites, the principal investigator visited and came to an agreement with Newport Farms, LLC to conduct the odor abatement research on one of their farms. The facility chosen is located approximately 7 miles west of Novelty, MO on highway 156 on the Macon and Knox County line but in Macon County. The facility is now just over two-years-old and has minimal grade changes that resulted from construction. The "foot-print" (approximately 18 acres) is considerably larger than required, but other than this, the facility is ideal for the project. There are 5 buildings (see aerial view, Figure 1) ranging from 100 to 900 feet in length. The owners of the actual facility and land are Gary Chinn and Bill Roewe (Newport Farm, LLC). Management of the facility, however, is under the authority of Professional Swine Management, LLC, Carthage, IL.

A 3-row windbreak configuration was implemented consisting of a pitch/loblolly pine hybrid (Pinus rigida x P. taeda), a conifer, on the inside row closest to the farrowing house; pin oak (Quercus palustris), a deciduous hardwood species that retains many of its leaves throughout much of the winter alternated with red maple (Acer rubrum), as the middle row and, Viburnum 'Allegheny' (Viburnum rhytidophyllum X V. lantana), a semi-evergreen shrub that quickly reaches heights of 10 to 15 feet, as the outside row. Effectiveness of a windbreak is strongly correlated with height and density. Therefore, the largest plants available were used in establishing the windbreak. Since sufficiently large containerized pine, oak and maple were unavailable, the principal investigator located six to nine-foot trees (balled and burlapped - - see Figure 2). RPM (Root Production Method) 'Allegheny' viburnum were purchased and planted due to the fast growth of RPM containerized plants.

The inside pine row was positioned a minimum of 60 feet from the building. The row of pin oak/red maple was located 20 feet from the pine and the viburnum 20 feet to the outside of the pin oak/maple. Spacing between trees within a row was 15 feet, while shrubs (viburnum) were spaced at 8-foot intervals. With these species and spacing, a density of approximately 60% (40% optical porosity) will be maintained through proper pruning (i.e., 60% of wind striking the "break" will pass up and over; 40% will be allowed to pass through). In summarizing many studies, Tyndall and Colletti (2007) have suggested that windbreaks with an optical porosity of 40-50% are most effective at limiting dust and odor movement.

The 3-row configuration was placed parallel to and along all four sides of the farrowing house complex. Where necessary, a trip row (a row of pine and shrubs placed on the windward side to "trip" snow before it reaches the main windbreak), was positioned to avoid potential snow build-up problems. To maximize the growth response and create a state-of-the-art design, an automated drip irrigation system was installed.

Even though all trees were staked and tied to support them against wind and ice damage, a severe ice storm was experienced and a great deal of tree damage occurred during the winter of 2007-2008. Moreover, due to the unusually superficial root system of the pine (in retrospect believed to be the result of the soil characteristics on the site where they were grown), pine mortality during the winter months was high and it was decided that all pine would be replaced. Replacement occured November 2008 using RPM-grown, pitch/loblolly pine.

The measurements of emitted ammonia (NH_3) from swine facilities were made by a continuous flow NH_3 analyzer (Pranalytica Nitrolux 200). The concentrations of hydrogen sulfide (H_2S) were measured with a Jerome® 631-X Hydrogen Sulfide Analyzer (Arizona Instrument). Other major odorous volatile organic compounds (VOCs) emitted from the swine production facilities were sampled by passing 4 L of air through the conditioned thermal desorption tubes containing many layers of sorbent material (Anasorb CMS and Tenax GR, SKC Inc.). Analytes captured on the adsorbent tubes was desorbed from the sorbent at 300^oC and analyzed by gas chromatography and mass spectrometry (GC-MS, Varian 3400x). Ventilation rates, air flow, and wind velocity were recorded during the sampling period to calculate the emission rates and flux of these odorous compounds. A Fluke 983 Particle Counter was acquired to determine both the concentration of particles (particles/m^3) and the size distribution of the particulates (0.3 μM to 10 μm) under field conditions.

RESULTS AND DISCUSSION

Air sampling was performed in 2008 to monitor the effects of the windbreak on odor abatement. Sampling consisted of 4 to 6 visits each season (spring, summer, fall and winter), with samples collected at (1) a location just outside the exhaust fans, (2) between the exhaust fans and the inside row of the windbreak and, (3) at intervals of distances downwind from the windbreak (see Figure 3). Distances will vary based upon topography, presence of native forest stands, etc. Since it was impossible to find two matching sites to compare, it is necessary that comparisons in levels of odor-causing compounds be made between years, beginning with the year of establishment (i.e., 2008). This provides a quantitative assessment of changes occurring with the growth of the trees and developmental dynamics of the windbreak. We envision monitoring the site for a minimum of five years. To guarantee access to the site for this period of time, a formal agreement has been made between the University of Missouri and Professional Swine Management, LLC.

Table 1 identifies the concentration of NH_3 and H_2S expressed in parts per billion (ppb) measured on 9/19/2008 (15 sampling points plus 4 exhaust fan readings). All data collected to date is obviously preliminary in nature but is important in that it will be used to establish baselines to which future data sets will be compared. Without a baseline (i.e., concentrations without a significant effect from a windbreak), it would be impossible to establish an odor abatement effect as the windbreak grows and develops.

While it is clear from the literature that wind velocity and direction have significant effects on odor concentrations, no discernable trends are visible in our limited data set. However, it is obvious that at wind speeds of less than 10 miles per hour (we had winds of 5.3 and 8 mph) concentrations of NH_3 and H_2S are significantly reduced over a distance of only 0.5 miles at this site (Figure 3, Table 1).

In addition to NH_3 and H_2S, it was our goal to identify and quantify more than 20 odorous volatile organic compounds (VOC's) believed to be present in emissions from swine production facilities. The identification and quantification of the VOC's (accomplished using Thermal Desorption GC-MS) is underway (Figure 4). However, to achieve our goal, we must first create a tentative identification of each compound by comparing their mass spectra and retention times (Figure 4). To secure a positive (100%) identification of each compound we must purchase "commercial standards" of each VOC that we tentatively identify using GC-MS and compare them to the standard. Based upon the detections and quantifications shown in Figure 4, it appears as though we will monitor more than 20 VOC's during this study. Moreover, based upon our findings in Figure 5, it appears that most of the VOC's drop out or, are significantly reduced in concentration, over very short distances. The concentration levels shown in red (i.e., highest concentrations) were measured at the exhaust fan. Concentrations shown in blue (Figure 5) were measured approximately 100 feet away just inside the wind break.

CONCLUSIONS

Before the windbreak takes effect, air samples are being taken at varying distances from facility (up to a mile radius) with our developed analytical methods to monitor the baseline concentrations of odorous gasses including ammonia (NH_3), hydrogen sulfide (H_2S), major volatile organic compounds (VOCs) and particulates. The spatial distribution and temporal variation in concentrations of these malodorous compounds have been successfully characterized and mapped. This baseline monitoring information will be used for evaluating the effect of the windbreak on odor concentrations and movement over time.

LITERATURE CITED

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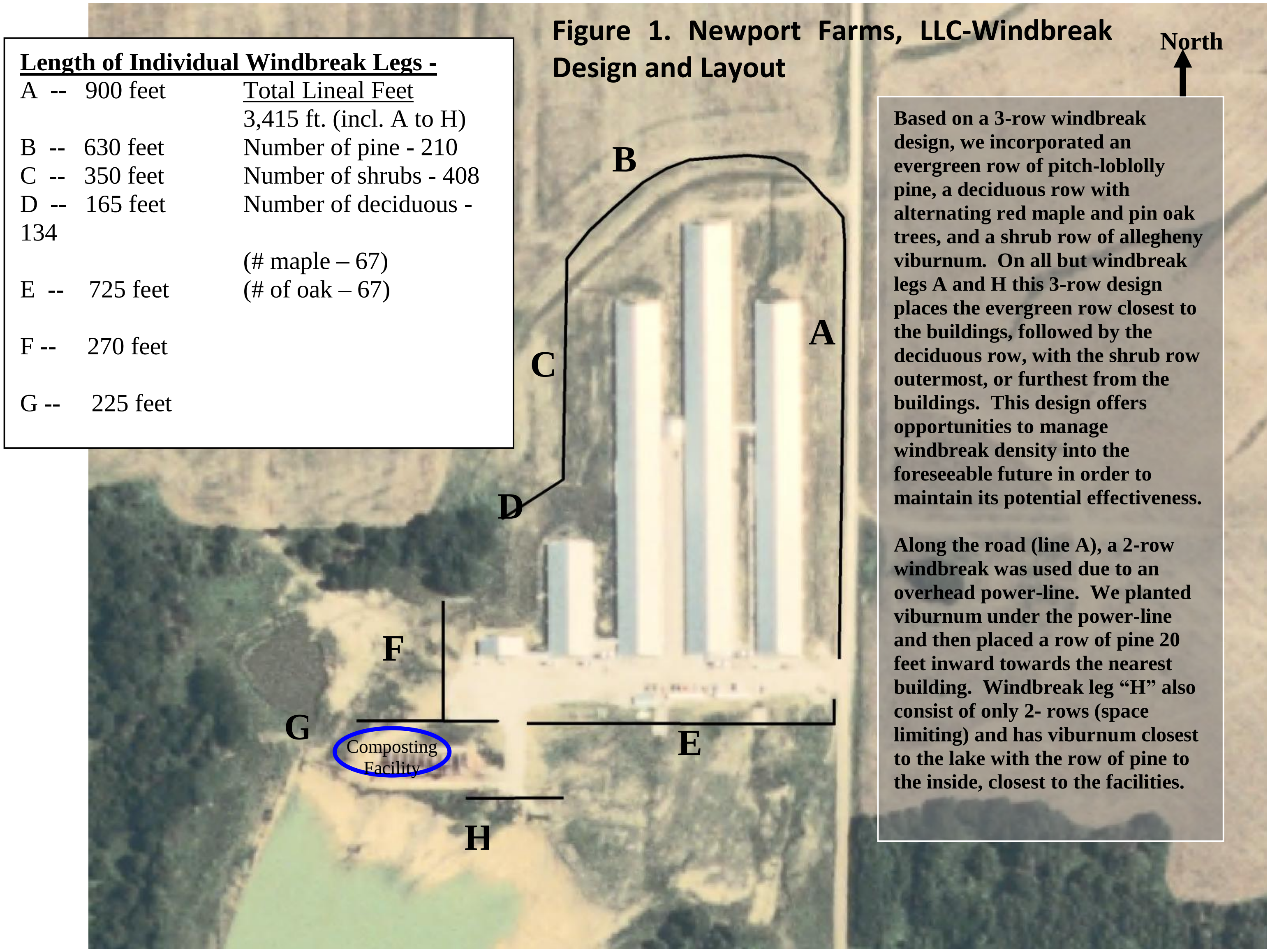

Figure 1. Newport Farms, LLC-Windbreak Design and Layout

Figure 2. Attached Photos of the Newport Farms LLC Windbreak Project following tree establishment (4-Images)

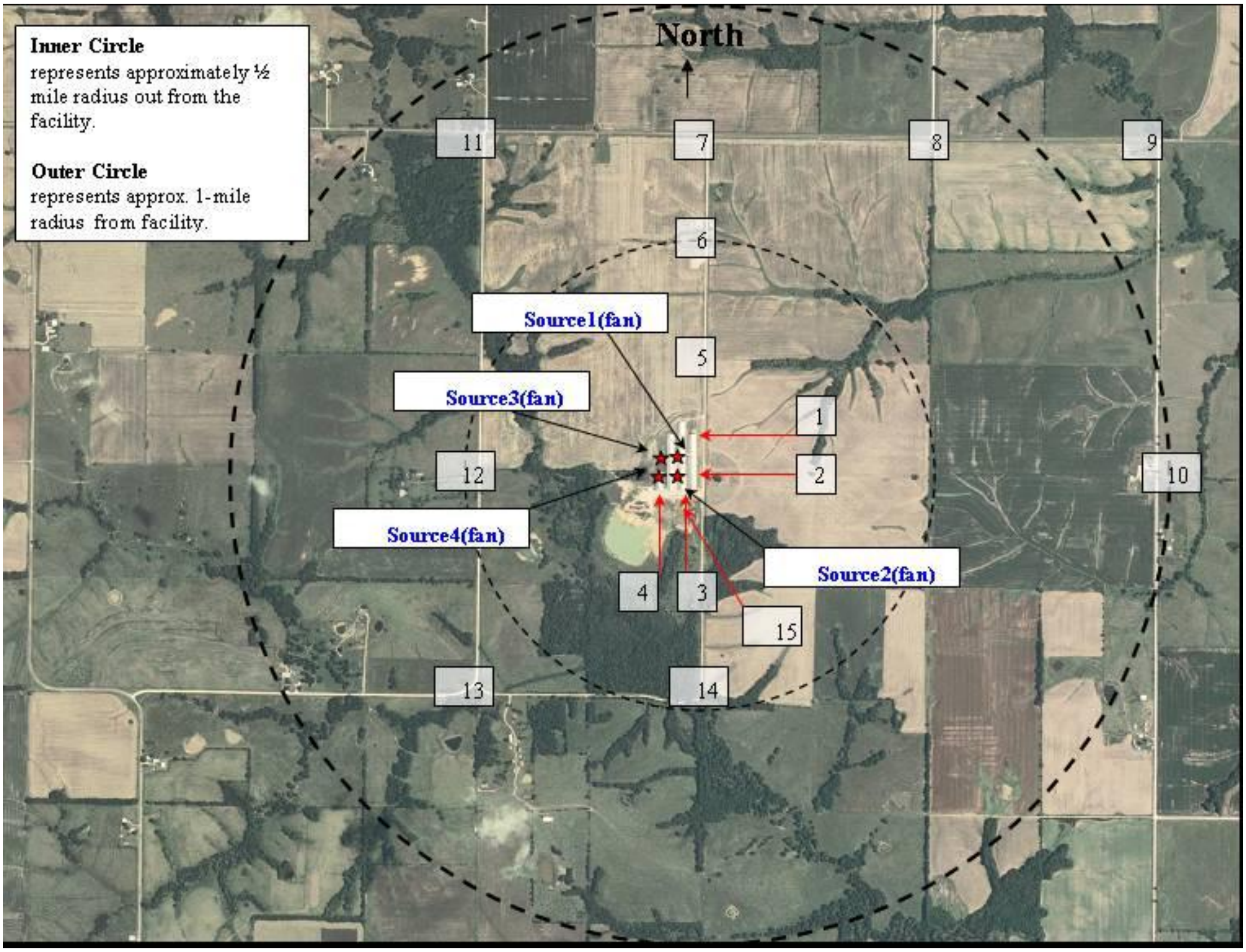

Figure 3. Identification of locations at which air samples were taken for determining NH_3 and H_2S concentrations.

Table 1 - - Ammonia (NH_3) and hydrogen sulfide concentrations (H_2S), in parts per billion (ppb) and their standard deviations (SD) at various distances from a swine CAFO located in northeast Missouri. Data was collected 9/19/2008, wind speed was 5.3 mph with wind direction from the south.

Sampling Point	**NH_3(ppb)**	**SD (n=5)**	**H_2S(ppb)**	**SD (n=5)**
1	136.20	16.00	0.20	0.03
2	363.00	45.21	115.00	7.07
3	75.94	13.16	0.12	0.01
4	33.28	4.60	0.03	0.01
5	24.38	1.30	0.07	0.02
6	15.46	0.61	0.01	0.01
7	8.85	0.17	0.02	0.01
8	22.58	1.09	0.02	0.00
9	14.12	0.59	0.02	0.01
10	15.13	0.42	0.02	0.00
11	5.26	0.57	0.02	0.01
12	4.49	0.18	0.02	0.01
13	6.02	0.09	0.01	0.01
14	9.44	0.50	0.01	0.01
15	20.48	1.77	0.02	0.00
Source1(Fan)	750.00	0.00	36.33	13.65
Source2(Fan)	1000.00	0.00	123.33	15.28
Source3(Fan)	3500.00	0.00	123.33	15.28
Source4(Fan)	500.00	0.00	35.33	3.21

Figure 4. Detection and quantification of swine, CAFO odorous volatile organic compounds (VOC) with Thermal Desorption GC-MS. Samples were collected near ventilation fan (Source Fan #3 - - Figure3) on 9/19/2008. Our current efforts are focused on validation and quantification of VOCs by comparing their mass spectra and retention times with commercial standards and NIST National Mass Spectral Library.

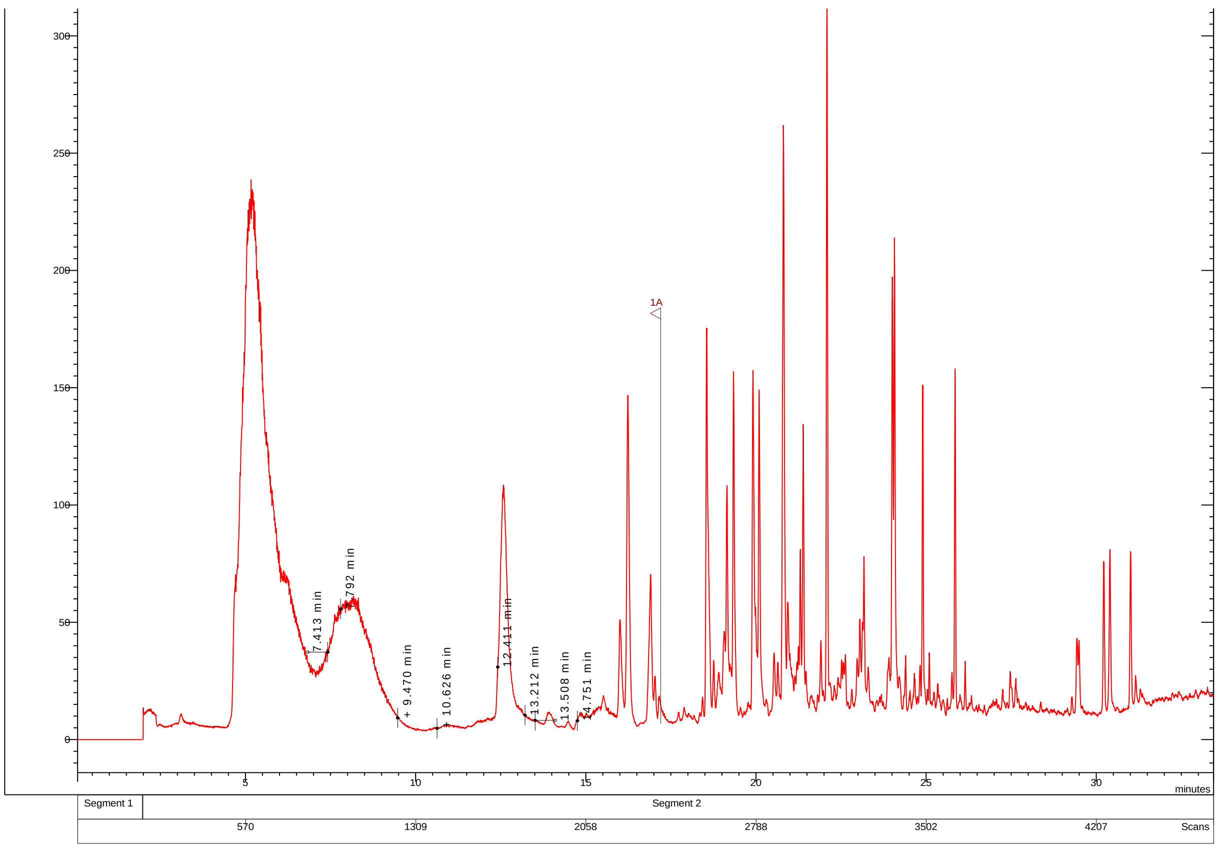

Figure 5. Detection and quantification of swine, CAFO odorous volatile organic compounds (VOC) with Thermal Desorption GC-MS. Readings represent concentrations of VOC's taken at an exhaust fan (shown in red) and at a distance of approximately 100 feet away (shown in blue) from the exhaust fan on 8-5-08.