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# Facilitating Use of the Odor Footprint Tool by Nebraska Pork Producers

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# RESEARCH REPORT

ENVIRONMENT

Title: Facilitating Use of the Odor Footprint Tool by Nebraska Pork Producers – **NPB #06-141**


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**Institution:** University of Nebraska



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**Industry Summary:**

The goal of this project was to make Odor Footprint Tool (OFT) resources readily usable by pork producers and their technical advisors as a planning and screening tool when siting swine facilities. The project had the following objectives:

1) Produce odor footprints for 'Nebraska Model'-sized finishing and sow units for six geographic regions in NE and develop footprints for the same-sized production units using 'localized' [AWDN] weather data for 2-3 selected counties within each region;

2) Compare 'regional' footprints to the 'localized' footprints within each region and describe implications of using one versus the other;

3) Compare the separation distances as illustrated with regional and localized odor footprints to existing zoning requirements for the selected counties;

4) Illustrate expected reductions in odor impacts on neighbors that are achievable by implementing suggested odor control technologies for each production scenario;

5) Provide information, training and assistance in the use of Odor Footprint Tool resources to key individuals in Nebraska who advise producers in planning new facilities.

Detailed odor footprints for the specified sizes of swine facilities were developed for twenty-four locations throughout Nebraska: six regional sites and three "localized" sites within each region. Each odor footprint shows the predicted odor annoyance-free frequency as a function of the distance from the facility.

Footprints developed using localized weather data differed only slightly from footprints produced using weather data from a regional site when the general topography of the sites was similar. However, when the general topography of sites was noticeably different, such as was the case for locations selected in the NE Panhandle, the footprints differed considerably. The detailed footprints for the lower odor annoyance-free frequencies were more consistent in size and shape than were the footprints for the higher odor annoyance-free frequencies. Simplified regional odor footprints generally missed 10-15% of the risk-based odor impact area for localized sites in this study, while being 75% too large overall on an area basis. A balanced perspective should be maintained between trying to capture all of the area impacted by odor and being overly conservative in designating the area off limits to building a swine facility.

A graphical approach was developed to illustrate how a county's setback requirements compared to science-based estimates of frequency of exposure to annoying odor levels. As expected, there were differences in how restrictive counties were of livestock facilities. Plans are to use this approach to equip rural communities with more reliable information upon which to make decisions.

The effect of reduced odor emissions from implementing odor control was illustrated using odor footprints. The footprints showed reductions in areas that were generally similar to the reductions in emissions when using odor control. More effective odor control technologies, like biofilters, had much less risk-based area of odor impact compared to less effective odor control practices, like oil sprinkling.

Pork producers in Nebraska were informed about the Odor Footprint Tool via presentations made at the 2008 Nebraska Pork Industry Day. Training workshops on use of the OFT were provided to key industry representatives to expand utilization of the OFT resources.

Implications for the industry:

- Odor footprint materials are now available specifically for pork production facilities, making it easier to communicate with producers and to work with conventional sizes of swine production facilities;
- Now that 'localized' graphical resources and 'regional' resources have been compared, use of regional resources, which are relatively simple to use and require no additional modeling, can be recommended with more confidence for several regions.
- An approach has been developed by which producers and rural communities can assess how setback requirements from local zoning ordinances compare to science-based frequencies of exposure to annoying odor levels.
- As producers look to utilize the Odor Footprint Tool in planning facilities, there are now industry representatives trained and ready to assist producers.

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III. Scientific Abstract:

The goal of this project was to make Odor Footprint Tool (OFT) resources readily usable by pork producers and their technical advisors as a planning and screening tool when siting swine facilities. Detailed odor footprints for five specified sizes of swine facilities were developed for twenty-four locations throughout Nebraska: six regional sites and three "localized" sites within each region. Each odor footprint shows the predicted odor annoyance-free frequency as a function of the distance from the facility. Footprints developed using localized weather data differed only slightly from footprints produced using weather data from a regional site when the general topography of the sites was similar. However, when the general topography of sites was noticeably different, the footprints differed considerably. Simplified regional odor footprints generally missed 10-15% of the risk-based odor impact area for localized sites in this study, while being 75% too large overall on an area basis. A graphical approach was developed to illustrate how a county's setback requirements compared to science-based estimates of frequency of exposure to annoying odor levels. The effect of reduced odor emissions from implementing odor control was illustrated using odor footprints. The footprints showed reductions in areas that were generally similar to the reductions in emissions when using odor control. Pork producers in Nebraska were informed about the Odor Footprint Tool via presentations made at the 2008 Nebraska Pork Industry Day. Training workshops on use of the OFT were provided to key industry representatives to expand utilization of the OFT resources.

IV. Introduction

Concern about odor is a limiting factor for growth in the pork production industry in Nebraska (and elsewhere). The Odor Footprint Tool (OFT) has been developed by the air quality workgroup within Biological Systems Engineering to assess odor impacts and address setback distances for livestock facilities. The tool utilizes historical weather data and representative odor emission rates for livestock and manure storage facilities to illustrate the extent of areas impacted by odors emitted from such facilities. The Odor Footprint Tool allows visualization of both the projected impact of odors on the area surrounding a [proposed] livestock facility and the reduction in odor impact that can be achieved by implementing a proven odor control technology.

Early needs for the OFT involved calibrating the modeling of odor transport from various types of sources and verifying performance of the model in field applications. A subsequent, but important need emerged to prepare to work with producers in using the OFT when planning facilities and with county officials in evaluating proposed facilities.

V. Project Objectives:

The goal of this project was to make Odor Footprint Tool (OFT) resources readily usable by pork producers and their technical advisors as a planning and screening tool when siting swine facilities. The project had the following objectives:

1) Produce odor footprints for 'Nebraska Model'-sized finishing and sow units for six geographic regions in NE and develop footprints for the same-sized production units using 'localized' [AWDN] weather data for 2-3 selected counties within each region;
2) Compare 'regional' footprints to the 'localized' footprints within each region and describe implications of using one versus the other;
3) Compare the separation distances as illustrated with regional and localized odor footprints to existing zoning requirements for the selected counties;
4) Illustrate expected reductions in odor impacts on neighbors that are achievable by implementing suggested odor control technologies for each production scenario;

5) Provide information, training and assistance in the use of Odor Footprint Tool resources to key individuals in Nebraska who advise producers in planning new facilities.

## VI. Materials and Methods:

Objective #1: Produce regional and localized odor footprints:

Odor concentrations around the five specified types and sizes of swine facilities were modeled using AERMOD, the US EPA Air Dispersion Model (Cimorelli et al., 2004), for twenty-four locations throughout Nebraska. The locations included six regional sites and three "localized" sites within each region, as shown in Table 1. National Weather Service (NWS) weather data was used to perform the necessary dispersion modeling and to create the footprints for all of the regional sites except for the North-Central Region, where NWS weather data was not available. The rest of the sites were modeled using a combination of Automated Weather Data Network (AWDN) and Automated Surface Observing Systems (ASOS) weather data. Localized sites were chosen to represent the breadth of each respective region based upon the available AWDN and ASOS weather stations in the region.

**Table 1. Nebraska regions and weather station locations for modeling odor footprints.**

| Region | Regional site | Localized sites |
|---|---|---|
| Southeast NE | Lincoln | Mead, Beatrice, York |
| Northeast NE | Norfolk | Concord, Westpoint, O'Neill |
| South-central NE | Grand Island | Red Cloud, Holdrege, Central City |
| North-central NE | Ainsworth | Valentine, Ord, Gudmundson's Ranch* |
| Southwest NE | North Platte | McCook, Champion, Lexington |
| NE Panhandle | Scottsbluff | Gordon, Sidney, Alliance |

* Located in northeast Grant County

For each of the sites, modeling was completed for 'Nebraska Model' sized facilities, plus additional common sizes within the current range of family-operated facilities. Deep-pit, swine finishing facilities with capacities of 1000, 2400, and 4800 head, and sow operations with shallow-pit farrowing and deep-pit gestation facilities with total capacities for 600 and 2400 sows were modeled. Odor concentrations for a grid of receptor locations were modeled on an hourly basis using weather data from April 15$^{th}$ through October 15$^{th}$ of each year, over a 5- or 10-year period, depending on the amount of weather data that was available.

Once the dispersion modeling was completed for a site, computer subroutines were employed to calculate the frequencies with which modeled odor concentrations exceeded the assigned annoyance threshold of 75 OU/s at the receptor locations around the modeled swine facility. The desired output was the corresponding 'odor annoyance-free frequency' at each receptor location. Lastly, a commercial graphics package was utilized to plot out detailed odor footprints – graphical representations of those locations having odor annoyance-free frequencies of 90%, 94%, 96%, 98% and 99%.

Objective #2: Compare regional and localized odor footprints:

A few different comparisons were made between the regional and localized footprints for each facility type/size within each of the six regions. First, a qualitative comparison was made of the size and shape of the detailed footprints for the regional vs. the corresponding localized footprints for each region. The general idea is illustrated in Figure 1a.

Next, within each region, the maximum extent of the detailed regional footprint in each of four primary directions was compared to the maximum extents of the detailed localized footprints in the same four directions. The maximum extent of a detailed regional footprint in a given primary direction corresponds to the 'directional setback distance' that would be output by the Odor Footprint Tool for a given type and size of facility within the region. Users of the Odor Footprint Tool obtain four minimum recommended separation distances (corresponding to these directional setback distances) for a specified odor annoyance-free frequency, from which a simplified odor footprint can be constructed. Figure 1b illustrates the relationship between a detailed odor footprint (for only one odor annoyance-free frequency) and the corresponding simplified odor footprint. This comparison of extents is equivalent to a comparison of directional setback distances for the regional site vs. those for localized footprints in the same primary directions for the same type and size of facility. For practical reasons, results for only the 2400-head finishing are highlighted in this report, with comparisons being made at two odor annoyance-free frequencies, 94% and 98%.

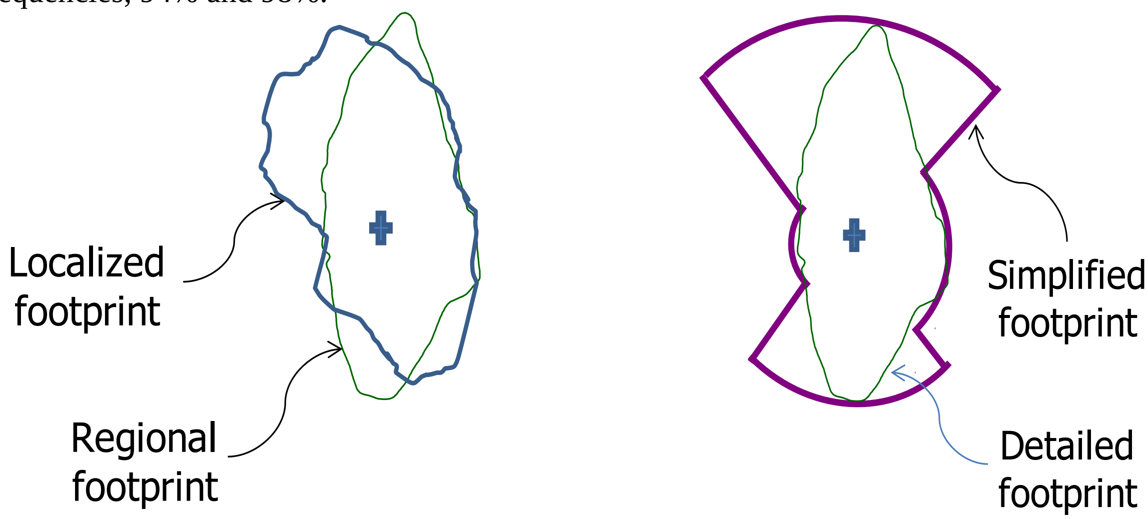



**Figure 1. Generic illustrations of footprints: a) at left, modeled footprints shown in detail for a regional site and a localized site within the region; and b) at right, a simplified footprint - as described using OFT directional setback distances - in relation to a detailed footprint produced using dispersion modeling.**

Lastly, the area of odor impact outlined by the simplified footprint for a regional site (as would be determined by using the Odor Footprint Tool), was compared to the areas of impact enclosed within the detailed footprints for the four sites within the region (Figure 2a). The area of the simplified regional odor footprint was simply the sum of the four quarter circles defined by the four directional setback distances. The area of the detailed footprints was determined manually using large, scaled plots of the footprints and planimetry. In these comparisons, information was sought to address the following two questions:

1) How much of the modeled area of odor impact for a given site would be "missed" (or not captured) if the simplified footprint for the regional site (based on OFT setbacks) was used to describe the area of odor impact for the site? Refer to Figure 2b.

2) How conservative is the Odor Footprint Tool in terms of the area of odor impact defined by the simplified footprint for the regional site (based on OFT setbacks) compared to the modeled area of odor impact for a given site? Refer to Figure 2c.

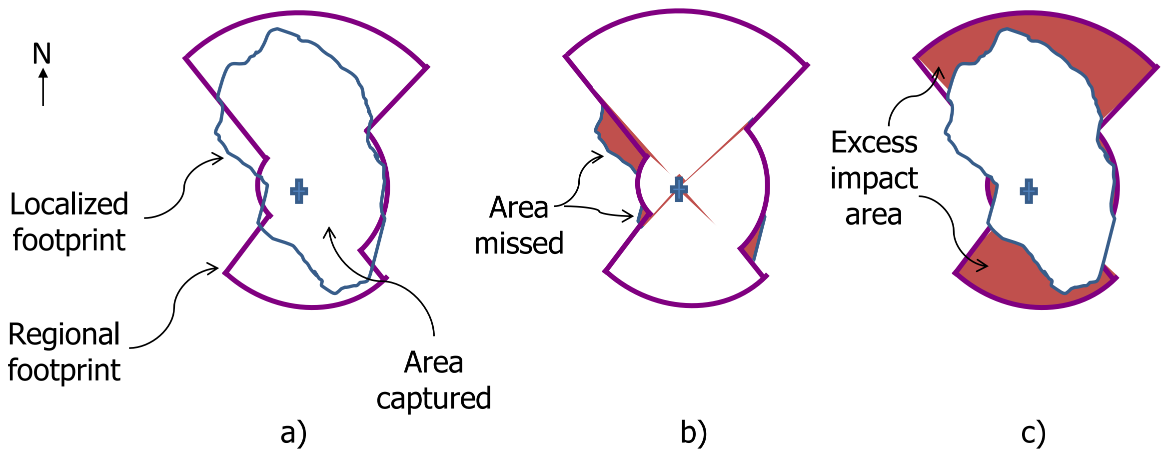



**Figure 2.** **Generic illustrations of footprint area comparisons: a) modeled local footprint shown with simplified footprint for the regional site; b) areas of modeled local footprint that are not captured ('missed') by the simplified footprint; and c) conservativeness of the simplified footprint in capturing the modeled local footprint.**

<u>Objective #3: Compare OFT setback results with zoning setbacks:</u>

Once the extents of the regional and localized odor footprints were determined, graphical comparisons were made between these distances and setbacks established by corresponding county zoning commissions, whenever the zoning ordinances were available on the Web. The facility sizes considered in this study were converted to Animal Units (A.U.) using the standard equivalents of 2.5 finishing pigs or sows = 1 A.U., which resulted in the following sizes:

1000-head finisher = 400 A.U.     600 sows = 240 A.U.

2400-head finisher = 960 A.U.     2,400 sows = 960 A.U.

4800-head finisher = 1,920 A.U.

The county setback requirements were shown on graphs along with the setback curves for the 94% and 98% odor annoyance-free frequencies for the best- and worst-case directions. County setback requirements generally followed a "sliding scale", meaning the setback distance stair-steps upward whenever specified animal unit thresholds are exceeded. Separation distances derived from odor footprints were shown as smooth curves connecting model-derived separation distances for the studied sizes. Since these setback distance curves existed already for the regional footprints, the curves were extrapolated out well beyond the 2,000 A.U.

Objective #4:  Illustrate the effects of implementing odor control:

Modeling was repeated for each regional site to assess the effect of implementing odor control practices on the resulting footprints and minimum separation distances.  Two odor control practices were considered:

i) Directing airflow from all cool-season fans (lower-stage fans for cold and mild weather) through a biofilter; and

ii) Using oil spray/sprinkling within the building.

The effect of the odor control was accounted for by entering a reduced odor emission rate into the model.  The net overall reductions in odor emissions from the housing facilities were 60% and 20% for the biofilter and for oil spraying, respectively.  Since this objective was primarily illustrative, modeling was performed for only the 2400-hog finisher and 2400-sow facilities.

Objective #5:  Provide information, training and assistance on the OFT:

Training was conducted via Extension presentations and workshops that were targeted for pork producers and pork industry service representatives.

VII.  Results:

Objective #1:  Produce regional and localized odor footprints:

Figure 3 shows the footprints for a 2400-hog, deep-pit swine finishing facility for the four selected sites within Northeast Nebraska.  Footprints for the remaining five regions for this size and type of finishing facility are provided in the appendix.  Footprints for sow facilities and for the other two sizes of finishing facilities have been developed, for a total of 120 odor footprints.  The full set of footprints will be made available to interested pork producers and industry representatives in Nebraska via web access.

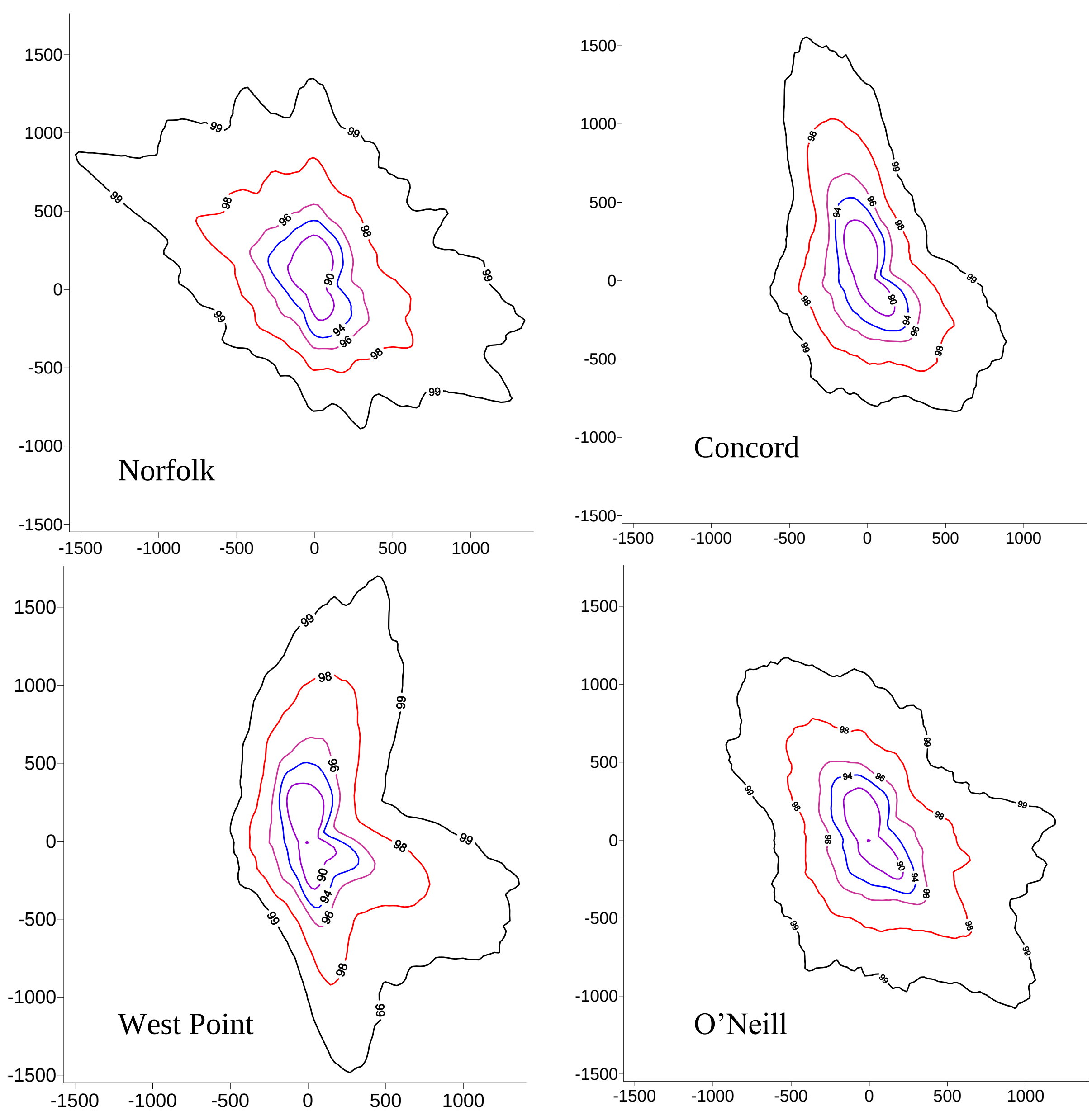



**Figure 3. Modeled odor footprints for a 2,400-hog, deep-pit swine finisher for selected sites within the Northeast NE region.** An odor footprint shows the predicted odor annoyance-free frequency as a function of the distance from the facility (all distances are shown in meters). Norfolk currently represents this region within the Odor Footprint Tool.

<u>Objective #2: Compare regional and localized odor footprints:</u>

General comparisons of odor footprint size and shape can be made by examining the sets of graphs provided for each region (Figure 3 and Appendix A). For Northeast Nebraska (Figure 3), for example, the footprints for O'Neill appear quite similar in size and shape to those for Norfolk, the regional site. By contrast, the odor footprints for Concord and West Point have a more elongated shape and more of a north-south orientation. Variations between the detailed/modeled footprints within a region are most evident for the Panhandle and North-central regions of Nebraska (Figures A4 and A5). It also appears that the detailed footprints for the lower odor annoyance-free frequencies (interior curves representing 90% and 94% annoyance-free frequencies) are more consistent in size and shape than are the footprints for the higher odor annoyance-free frequencies.

Numerical comparisons were also made of the separation distances recommended through use of the Odor Footprint Tool (via simplified regional footprints) and modeling of localized sites within the given regions. In some regions, there was little difference between separation distances given by regional and localized footprints. Table 2 shows, for example, that the setbacks for a 2400-head, deep-pit finisher using Norfolk weather data (that is, using the Odor Footprint Tool for Northeast NE) were within 0.05 miles of the setbacks based upon modeling using weather data from a weather station in Concord, NE, for three of the four primary directions and differed by at most 0.11 miles (or 21%) to the northwest. In other scenarios, differences were greater. Table 3 shows that, for the 94% odor annoyance-free criterion, the setbacks for a 2400-head, deep-pit finisher using Lincoln NWS weather data (that is using the Odor Footprint Tool for Southeast NE) were near to or less than 0.05 miles of setbacks based upon modeling using weather data from Beatrice, NE. However, for the lower odor risk level of 98%, the setbacks differed by 0.10 miles to close to 0.25 miles.

**Table 2. Minimum separation distances for deep-pit swine finishing facilities in four primary directions as recommended for Northeast Nebraska using the Odor Footprint Tool (using Norfolk as the regional site) and by modeling for Concord, NE (a localized site).**

| # of head | Site | Setback distance (miles) for given direction, annoyance-free frequency | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Northeast | | Southeast | | Southwest | | Northwest | |
| | | 94% | 98% | 94% | 98% | 94% | 98% | 94% | 98% |
| 1000 | Norfolk | 0.17 | 0.31 | 0.13 | 0.29 | 0.12 | 0.20 | 0.17 | 0.34 |
| | Concord | 0.17 | 0.31 | 0.15 | 0.26 | 0.11 | 0.20 | 0.21 | 0.39 |
| | Diff (mi.) | 0.01 | 0.00 | 0.02 | -0.02 | -0.01 | 0.00 | 0.04 | 0.06 |
| | % Diff | 3.3% | -0.1% | 17.7% | -7.9% | -5.5% | 0.7% | 22.9% | 16.4% |
| 2400 | Norfolk | 0.27 | 0.51 | 0.20 | 0.45 | 0.18 | 0.32 | 0.27 | 0.55 |
| | Concord | 0.28 | 0.52 | 0.24 | 0.43 | 0.17 | 0.33 | 0.34 | 0.66 |
| | Diff (mi.) | 0.01 | 0.00 | 0.04 | -0.02 | -0.02 | 0.01 | 0.06 | 0.11 |
| | % Diff | 2.7% | 0.5% | 20.9% | -4.3% | -8.4% | 2.4% | 23.6% | 20.9% |
| 4800 | Norfolk | 0.39 | 0.78 | 0.27 | 0.64 | 0.25 | 0.46 | 0.40 | 0.80 |
| | Concord | 0.37 | 0.78 | 0.34 | 0.63 | 0.22 | 0.48 | 0.49 | 1.00 |
| | Diff (mi.) | -0.02 | 0.00 | 0.06 | -0.01 | -0.03 | 0.01 | 0.09 | 0.19 |
| | % Diff | -4.4% | 0.0% | 23.3% | -0.9% | -12.8% | 2.4% | 23.5% | 23.9% |

The last comparison was of footprint areas. The localized footprint areas for a 2400-head, deep-pit swine finishing facility averaged 66.6 acres and 303.2 acres for odor annoyance-free frequencies of 94% and 98%, respectively (Table 4). York, NE, had the smallest footprint (39 acres) for 94%, but its footprint at 98% was larger than average. Grand Island had the smallest footprint (191 acres) at 98%. Red Cloud, NE, had the largest footprint (100 acres) for 94%, but the four sites in North-central Nebraska had the largest footprints at 98% (Ord's covered 612 acres).

**Table 3. Minimum separation distances for deep-pit swine finishing facilities in four primary directions as recommended for Southeast Nebraska using the Odor Footprint Tool (using Lincoln as the regional site) and by modeling for Beatrice, NE (a localized site).**

| # of head | Site | Setback distance (miles) for given direction, annoyance-free frequency | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | North | | East | | South | | West | |
| | | 94% | 98% | 94% | 98% | 94% | 98% | 94% | 98% |
| 1000 | Lincoln | 0.20 | 0.47 | 0.09 | 0.19 | 0.17 | 0.39 | 0.12 | 0.22 |
| | Beatrice | 0.20 | 0.41 | 0.12 | 0.27 | 0.13 | 0.27 | 0.17 | 0.34 |
| | Diff (mi.) | 0.01 | -0.07 | 0.02 | 0.08 | -0.04 | -0.13 | 0.04 | 0.13 |
| | % Diff | 3.2% | -14.3% | 22.9% | 45.2% | -25.3% | -31.9% | 34.4% | 57.8% |
| 2400 | Lincoln | 0.31 | 0.77 | 0.13 | 0.29 | 0.27 | 0.65 | 0.20 | 0.36 |
| | Beatrice | 0.32 | 0.67 | 0.17 | 0.41 | 0.19 | 0.41 | 0.26 | 0.55 |
| | Diff (mi.) | 0.01 | -0.10 | 0.03 | 0.12 | -0.07 | -0.24 | 0.06 | 0.19 |
| | % Diff | 3.8% | -12.5% | 25.0% | 40.3% | -28.3% | -36.6% | 30.6% | 54.5% |
| 4800 | Lincoln | 0.44 | 1.10 | 0.17 | 0.41 | 0.37 | 0.97 | 0.27 | 0.51 |
| | Beatrice | 0.46 | 1.01 | 0.22 | 0.58 | 0.26 | 0.58 | 0.36 | 0.81 |
| | Diff (mi.) | 0.02 | -0.09 | 0.05 | 0.17 | -0.12 | -0.39 | 0.08 | 0.30 |
| | % Diff | 3.8% | -8.1% | 28.8% | 40.7% | -30.9% | -40.6% | 30.9% | 59.2% |

On average, the simplified regional footprints would not include 6.6% and 9.4% of the localized footprint areas within the respective regions for the 94% and 98% odor annoyance-free frequencies, respectively (Table 4). The simplified footprint for North Platte (Southwest NE region) covered the entire footprint for McCook at both annoyance-free frequencies. On the other hand, the simplified footprint for Scottsbluff (NE Panhandle region) left over 40% of the footprint for Gordon uncovered at 98%. Missed area for a localized site was generally focused in one direction.

The simplified regional footprints were quite conservative in terms of the total areas included compared to the areas of the localized footprints within the corresponding regions, averaging about 75% more area than in the localized footprints (Table 4). Using the Odor Footprint Tool would only be unconservative on an area basis for one location - Red Cloud, NE – for both annoyance-free frequencies, with the represented area being about 10% less than that in the localized footprint.

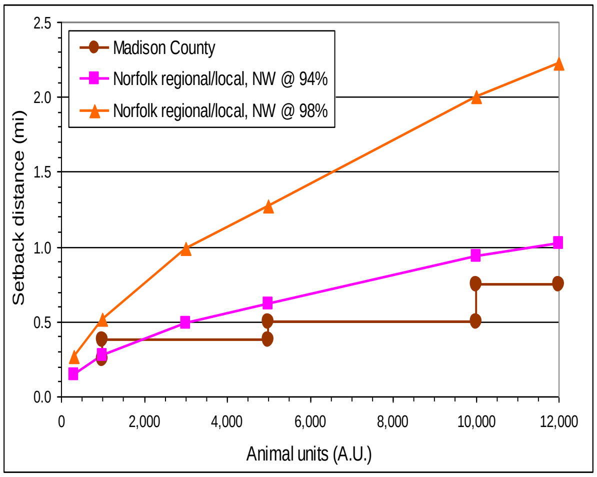
**Table 4. Comparison of odor footprint areas for a 2400-head, deep-pit swine finishing facility as recommended for Nebraska regions using the Odor Footprint Tool and by modeling using weather data from a local site (for two annoyance-free frequencies).**

| Region | Site | Localized footprint area (Acres) | | Area missed by OFT (% of acres) | | Max. area missed within a sector (%, direction) | | Ratio of OFT to localized footprint | |
|---|---|---|---|---|---|---|---|---|---|
| | | 94% | 98% | 94% | 98% | 94% | 98% | 94% | 98% |
| Northeast NE | Norfolk* | 62 | 262 | 0 | 0 | 0 | 0 | 1.77 | 1.66 |
| | Concord | 57 | 219 | 11 | 5 | 16, NW | 11, NW | 1.93 | 1.99 |
| | West Point | 70 | 281 | 15 | 15 | 28, SE | 22, NE | 1.57 | 1.55 |
| | O'Neill | 67 | 263 | 12 | 3 | 34, SE | 8, SE | 1.65 | 1.65 |
| Southeast NE | Lincoln* | 56 | 286 | 0 | 0 | 0 | 0 | 1.98 | 2.17 |
| | Beatrice | 76 | 306 | 10 | 9 | 32, E | 24, W | 1.49 | 2.02 |
| | Mead | 56 | 317 | 4 | 13 | 20, E | 35, W | 2.00 | 1.95 |
| | York | 39 | 325 | 5 | 17 | 12, W | 48, E | 2.85 | 1.90 |
| South-central NE | Gr. Island* | 53 | 191 | 0 | 0 | 0 | 0 | 1.70 | 1.56 |
| | Central City | 79 | 312 | 7 | 15 | 17, E | 24, E | 1.15 | 0.95 |
| | Holdrege | 65 | 252 | 6 | 14 | 13, W | 27, N | 1.39 | 1.18 |
| | Red Cloud | 100 | 320 | 20 | 23 | 31, W | 45, W | 0.91 | 0.93 |
| Southwest NE | North Platte* | 57 | 225 | 0 | 0 | 0 | 0 | 1.89 | 1.90 |
| | Lexington | 72 | 313 | 5 | 9 | 13, E | 20, E | 1.49 | 1.37 |
| | McCook | 61 | 262 | 0 | 0 | 2, SE | 2, NE | 1.75 | 1.63 |
| | Champion | 66 | 259 | 11 | 12 | 22, NW | 23, NW | 1.61 | 1.65 |
| Nebraska Panhandle | Scottsbluff* | 67 | 252 | 0 | 0 | 0 | 0 | 1.83 | 1.99 |
| | Alliance | 62 | 231 | 9 | 15 | 34, NE | 53, NE | 1.96 | 2.18 |
| | Gordon | 62 | 305 | 23 | 41 | 61, NE | 81, NE | 1.96 | 1.65 |
| | Sidney | 61 | 217 | 10 | 16 | 40, NE | 52, NE | 2.02 | 2.32 |
| North-central NE | Ainsworth* | 73 | 403 | 0 | 0 | 0 | 0 | 2.03 | 2.28 |
| | Gudmundsons | 82 | 402 | 0 | 0 | 0 | 0 | 1.81 | 2.28 |
| | Ord | 80 | 612 | 10 | 14 | 15, NW | 19, NW | 1.86 | 1.50 |
| | Valentine | 75 | 462 | 0 | 4 | 0 | 14, SE | 1.98 | 1.99 |
| Average for all sites | | 66.6 | 303.2 | 6.6 | 9.4 | --- | --- | 1.77 | 1.77 |

* Site is basis for Odor Footprint Tool's regional setback distances and resulting simplified footprint.

<u>Objective #3: Compare OFT setback results with zoning setbacks:</u>

Eight counties had zoning regulations easily accessible on the Web. Norfolk, NE, is in one of these counties, Madison County, and is the regional OFT site for the Northeast NE region. Figure 4 shows setback information for Madison County for the worst- and best-case directions for odor. Beyond 2,000 A.U., Madison County's setback requirements are less than the setback provided by odor footprint modeling for 94% and 98% odor annoyance-free frequencies in the worst-case direction, to the northwest. For the best-case direction, to the southwest, the county's setback requirements lie in between the setbacks for 94% and 98%.



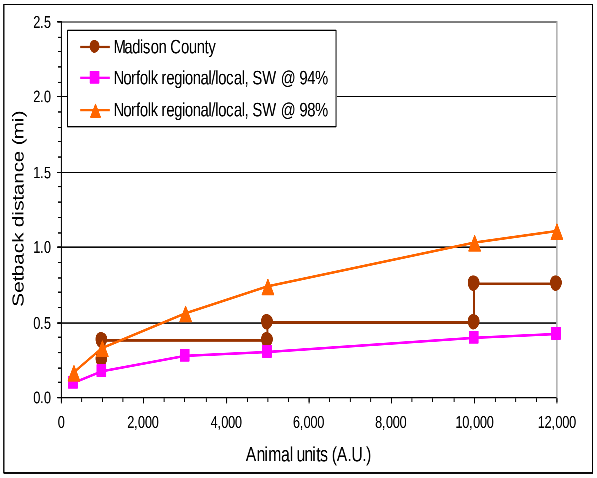
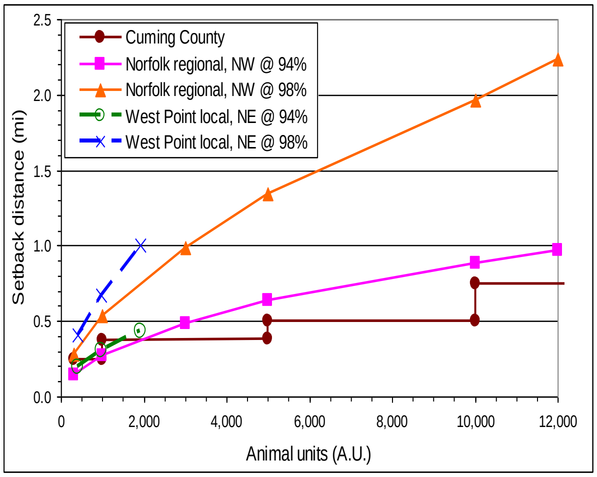




**Figure 4. Setback distances as specified in Madison County zoning ordinances and as given by the Odor Footprint Tool for various sizes of deep-pit swine finishing facilities for the a) worst-case, northwest direction (left) and b) best-case, southwest direction (right).**

Figure 5 shows similar setback information for Cuming County, showing setback distances for both the regional footprint (Norfolk) and the localized footprint (West Point). Both graphs show that the localized setbacks (for West Point) are greater than the regional setbacks (for Norfolk). In the worst-case directions, Cuming County's setback requirements begin between the 94% and 98% odor annoyance-free curves, but beyond about 2,000 A.U. are less than the setback provided by odor footprint modeling for 94%. For the best-case direction, to the southwest, the county's setback requirements lie in between the localized setbacks for 94% and 98% with less than 2,000 A.U. and between the regional setbacks for 94% and 98% with more than 2,000 A.U.



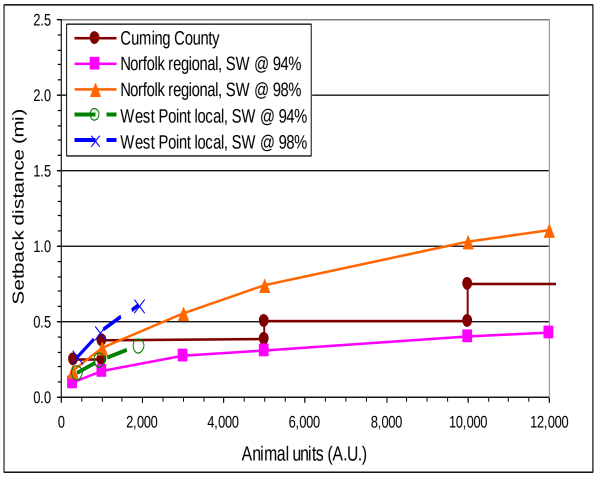




**Figure 5. Setback distances as specified in Cuming County zoning ordinances and as given by the odor footprint modeling for various sizes of deep-pit swine finishing facilities for the a) worst-case, NW/NE direction (left) and b) best-case, southwest direction (right).**

Appendix B includes comparisons for three other Nebraska counties in different regions.

Objective #4: Illustrate the effects of implementing odor control:

The effect of implementing odor control on the risk-based odor impact is illustrated in Figure 6 for the Northeast NE region and a 2400-hog finishing facility. The risk-based impact area is less than half as large with the biofilter in place to treat exhaust air from early-stage fans, while the effect of oil sprinkling is less noticeable. The shape of the footprints is essentially unchanged.

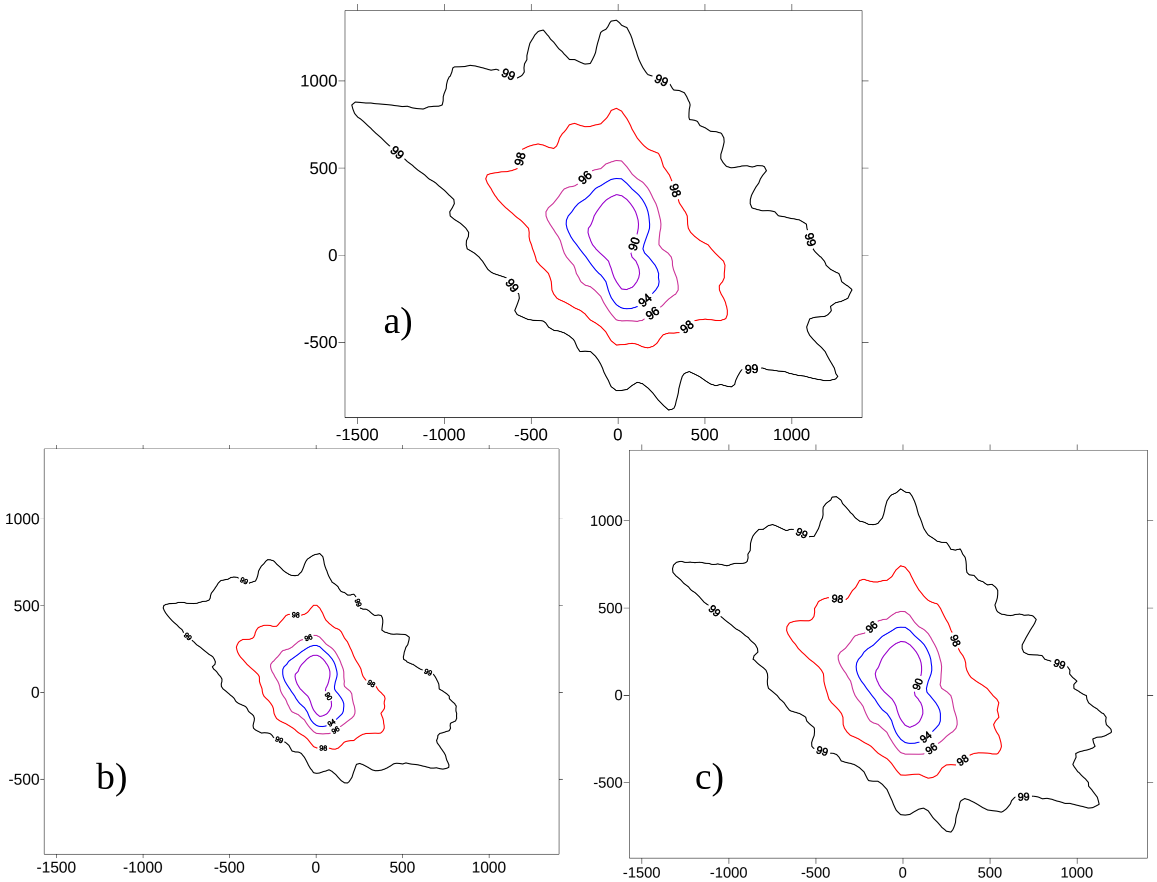



**Figure 6. Modeled odor footprints for a 2,400-hog, deep-pit swine finisher within the Northeast NE region with a) no odor control; b) a biofilter treating exhaust from all cool-weather fans; and c) oil sprinkling within the pig space.**

Objective #5: Provide information, training and assistance on the OFT:

General information on the Odor Footprint Tool and how this resource could be utilized for an expanding pork operation was conveyed to about 50 producers and industry representatives at the 2008 Nebraska Pork Industry Day, which was held in February, 2008. Individuals who were interested in learning more about the Odor Footprint Tool and how to use OFT resources were invited to attend a training workshop in March of 2008. Three people were trained to use the OFT will their clientele, and another 3-4 expressed interest in receiving training, but were unable to participate in the first round of training.

VIII. Discussion:

The detailed footprints developed in this project allow pork producers to quickly visualize the risk-based odor impacts of common sizes of finishing and sow facilities, using a choice of weather stations for representing their location within the state. In several cases, the regional location was fairly to quite representative of the other locations within the region. In other cases, such as was observed for the NE Panhandle region, there was a noticeable difference in the shape of footprint that resulted in separation distances differing by more than a tenth of a mile in some directions. [Note that users of the Odor Footprint Tool are discouraged from interpreting OFT results more precisely than to the nearest 1/20 (0.05) of a mile.] One likely explanation for the differences that were observed between locations within some regions is differing topography. For example, Scottsbluff, NE, is located within the river valley of the North Platte River, which flows from WNW to SSE through western Nebraska (NE Panhandle region). Gordon, by contrast is located near the Pine Ridge, which runs from WSW to ENE. The expected result would be a difference in the orientation of the footprints for these two locations that aligns odor movement with the natural topography, and this difference in orientation was evident in our results. The other two locations in this region were not as strongly influenced by terrain and have more of a round footprint. When using the Odor Footprint Tool, we recommend that users consider differences in topography between their location and the regional site. Some of this effect can be countered by using a topography correction factor. Discussions are also underway within the development team for the OFT as to how to enhance the information provided to OFT users to best fit their respective situations.

Differences between footprints in a region also tended to be more pronounced at lower odor-risk levels (higher odor annoyance-free frequencies). Odor footprints for 98% odor annoyance-free frequencies typically were also 3-5 times larger than at 94%. At very low frequencies of occurrence, we are essentially talking about rare/extreme weather conditions. Rare weather conditions are likely to be localized, not widespread, events. Consideration of the size and shape of a facility's odor footprint at a low odor-risk level is recommended, but the user of this information needs to keep in mind that odor footprints become less precise as the odor-risk level is made very small.

It appears that using simplified odor footprints based upon weather data from regional weather stations is likely to "miss" 10-15% of impacted areas at a localized site within a region. If one or both locations have unique terrain that affects local weather patterns, the amount of missed odor impact area will likely be greater than this. Odor impact area was generally missed due to differences in directionality of weather patterns between two sites. Thus, there would be little or no reduction in missed area obtained by increasing the maximum separation distance for the regional site. This is especially important, considering that the simplified odor footprints typically identified odor impact areas that were already about 75% larger than the localized footprints. Methods that use ovals or other continuous shapes to represent the impact area defined by the four directional setback distances given by the OFT show promise to reduce this "over-sizing" of odor impact areas. These methods are not as simple to outline, though, and need to be evaluated to see if they effectively reduce the amount of missed impact area and/or make footprint areas less overly conservative.

The approach developed in this study to assess local zoning setbacks for animal facilities appears to hold significant promise for showing local communities how their zoning requirements compare to science-based information for odor annoyance. Since Nebraska counties may adopt [legally defensible] setback ordinances to meet local needs, the intent is to inform communities about their ordinances. Some counties openly want to appear 'livestock friendly', while others prefer to be more restrictive of new and expanding agricultural developments. Also, some counties appeared to be more or less restrictive for facilities having capacities for less than about 2,000 A.U. than they were for larger facilities. By comparing the requirements against a science-based reference, counties can assess for themselves whether their requirements serve the intended purpose.

Voluntary implementation of odor control technologies will likely be a key to facilitating growth of pork production into the future. There are significant differences in the costs and effectiveness of various technologies, so it is important to have a frame of reference by which to evaluate technologies. The size of the odor footprint appears to have merit as the practical measure of benefit derived for odor control. Odor control technologies that can reduce odor emissions noticeably (such as a biofilter) result in noticeably smaller odor footprints. From initial calculations, the reduction in odor footprint area due to implementing odor control appears to be closely related to the % reduction in odor emissions, while the setback distances are related by some smaller factor.

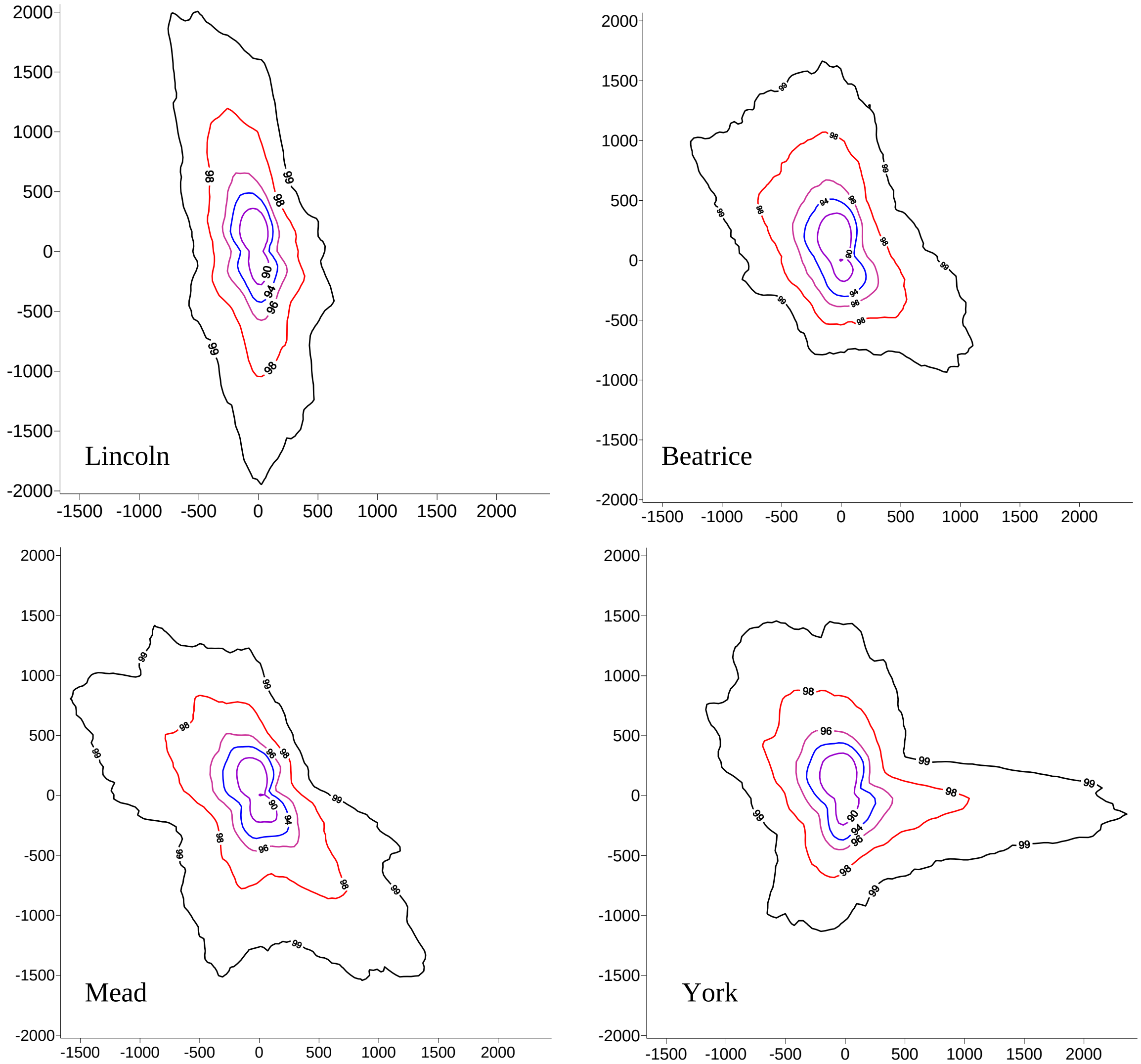
Lastly, the feedback from producers was positive concerning the utility of the Odor Footprint Tool as a planning aid. With some key industry representatives trained to use the OFT, producers should have greater access to good information concerning siting of new facilities in Nebraska for minimal odor impact.

**References:**

Cimorelli, A. J., S. G. Perry, A. Venkatram, J. C. Weil, R. J. Paine, R. B. Wilson, R. F. Lee, W. D. Peters, R. W. Brode, and J. O. Paumier. 2004. AERMOD: description of model formulation. U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Emissions Monitoring and Analysis Division. EPA-454/R-03-004. Research Triangle Park, NC: U.S. EPA.

## Appendix A – Modeled Odor Footprints for Remaining Five Nebraska Regions.

**Figure A1.**




**Modeled odor footprints for a 2,400-hog, deep-pit swine finisher for selected sites within the Southeast NE region.** An odor footprint shows the predicted odor annoyance-free frequency as a function of the distance from the facility (all distances are shown in meters). Lincoln currently represents this region within the Odor Footprint Tool.

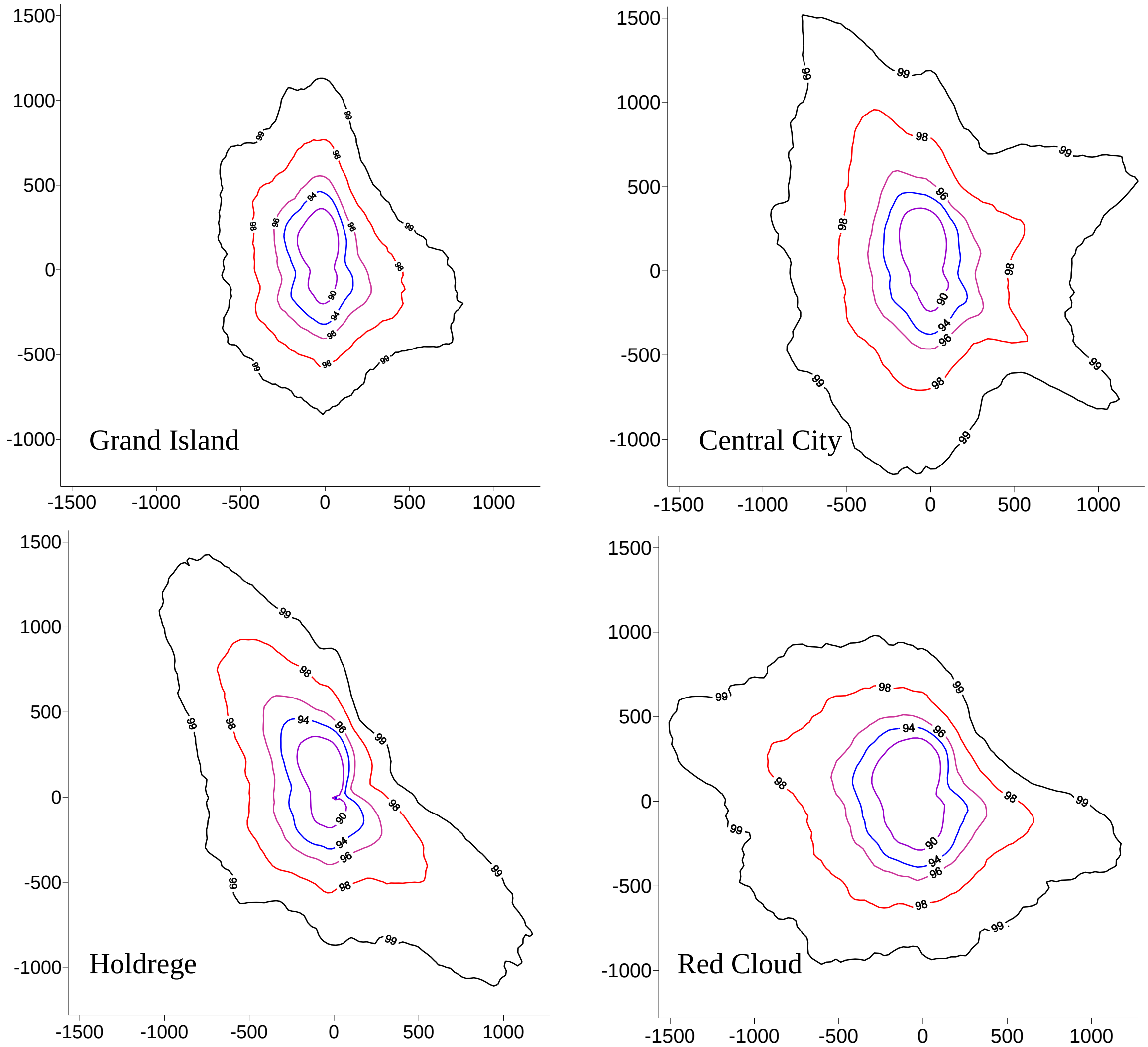



**Figure A2. Modeled odor footprints for a 2,400-hog, deep-pit swine finisher for selected sites within the South-Central NE region.** An odor footprint shows the predicted odor annoyance-free frequency as a function of the distance from the facility (all distances are shown in meters). Grand Island currently represents this region within the Odor Footprint Tool.

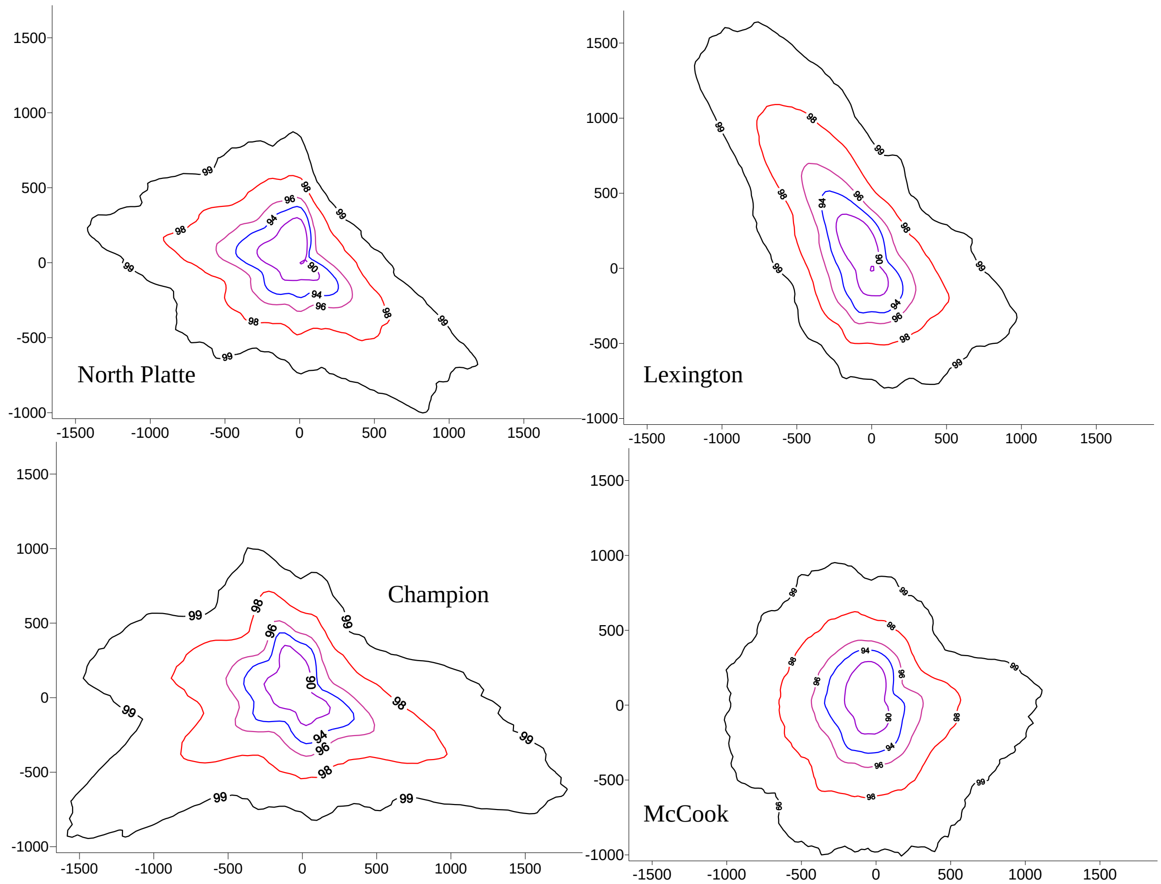



**Figure A3. Modeled odor footprints for a 2,400-hog, deep-pit swine finisher for selected sites within the Southwest NE region.** An odor footprint shows the predicted odor annoyance-free frequency as a function of the distance from the facility (all distances are shown in meters). North Platte currently represents this region within the Odor Footprint Tool.

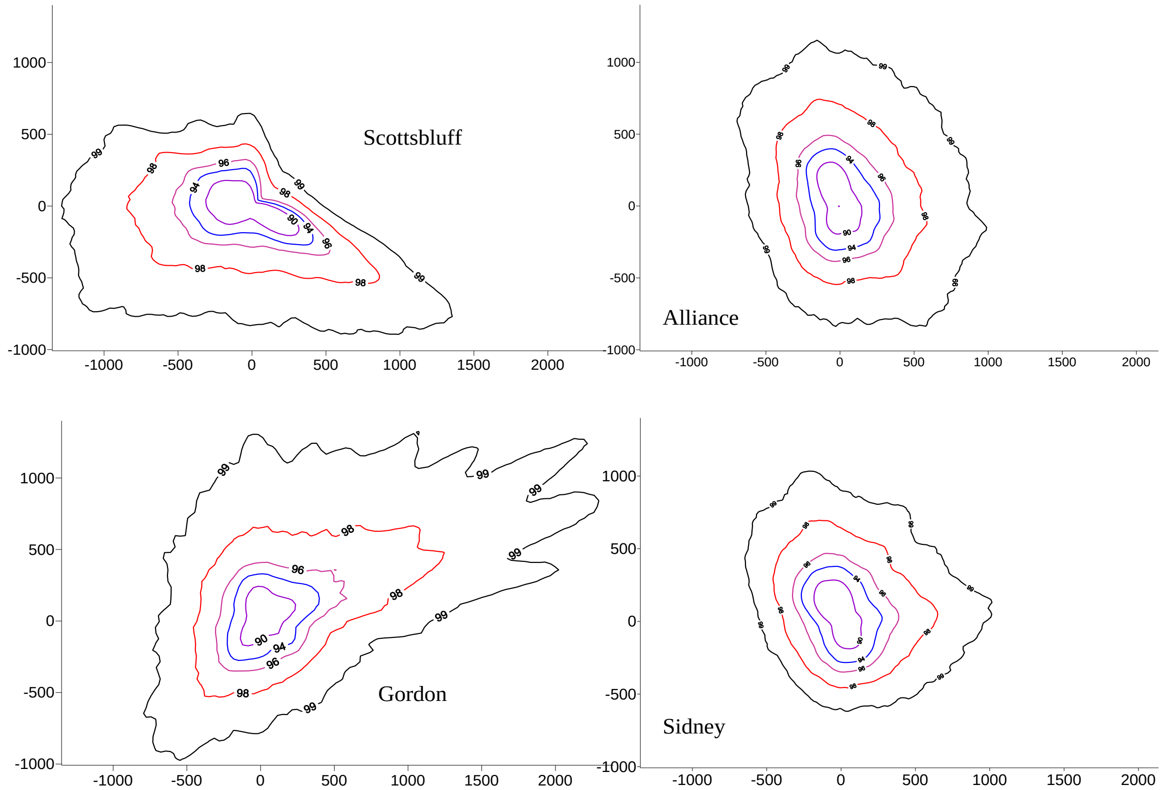



**Figure A4. Modeled odor footprints for a 2,400-hog, deep-pit swine finisher for selected sites within the NE Panhandle region.** An odor footprint shows the predicted odor annoyance-free frequency as a function of the distance from the facility (all distances are shown in meters). Scottsbluff currently represents this region within the Odor Footprint Tool.

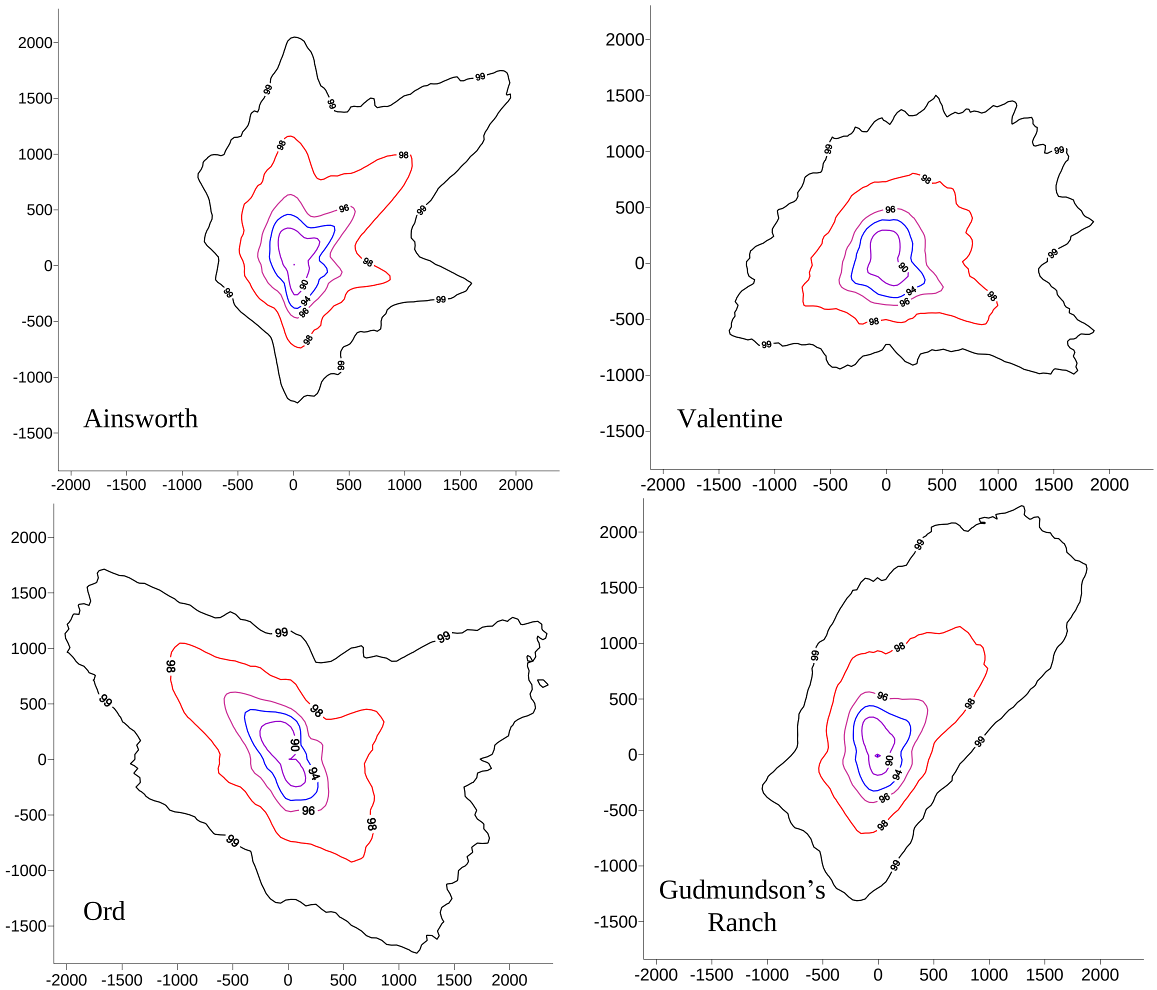
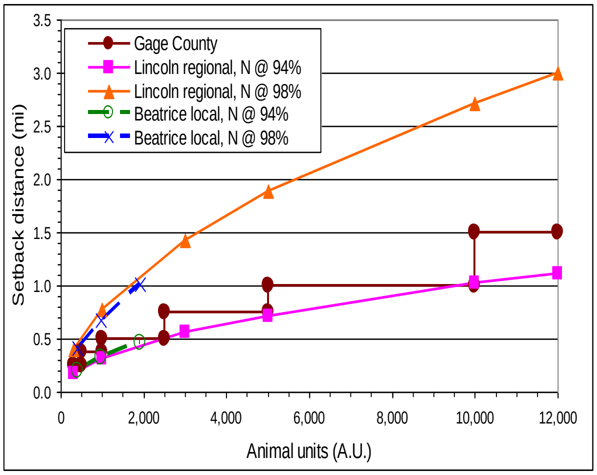



**Figure A5. Modeled odor footprints for a 2,400-hog, deep-pit swine finisher for selected sites within the North-Central NE region.** An odor footprint shows the predicted odor annoyance-free frequency as a function of the distance from the facility (all distances are shown in meters). Ainsworth currently represents this region within the Odor Footprint Tool.

**Appendix B – Modeled Setback Distances vs. Zoning Setbacks for Selected Counties**.



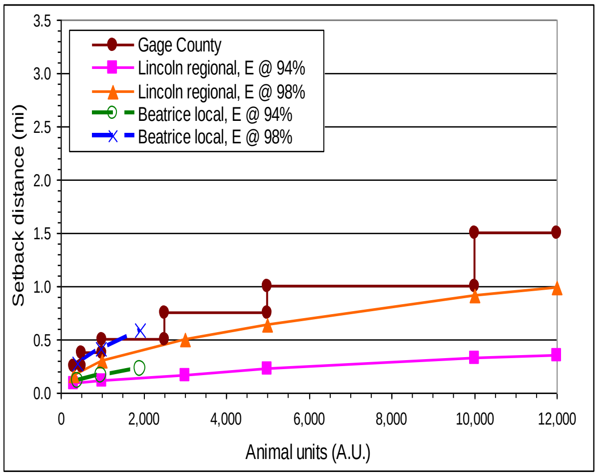
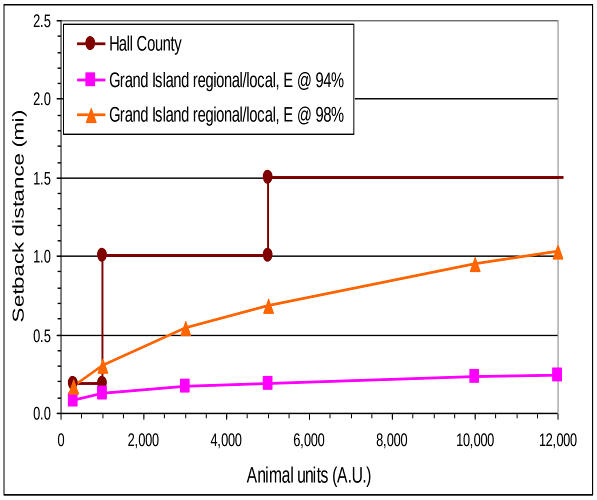




**Figure B1. Setback distances as specified in Gage County zoning ordinances and as given by odor footprint modeling for various sizes of deep-pit swine finishing facilities for the a) worst-case, north direction (left) and b) best-case, east direction (right).**



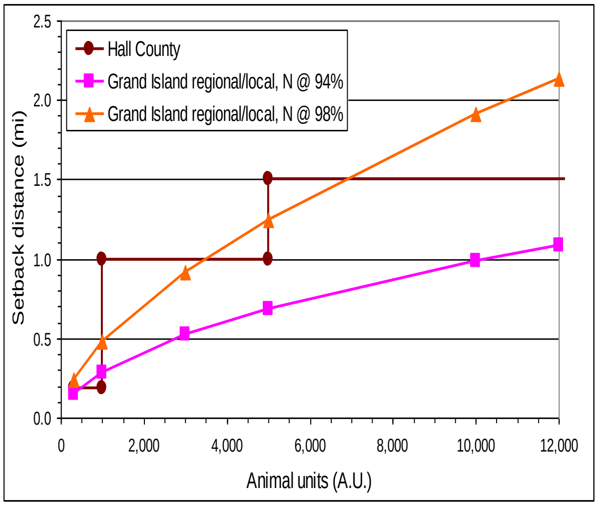




**Figure B2. Setback distances as specified in Hall County zoning ordinances and as given by odor footprint modeling for various sizes of deep-pit swine finishing facilities for the a) worst-case, north direction (left) and b) best-case, east direction (right).**

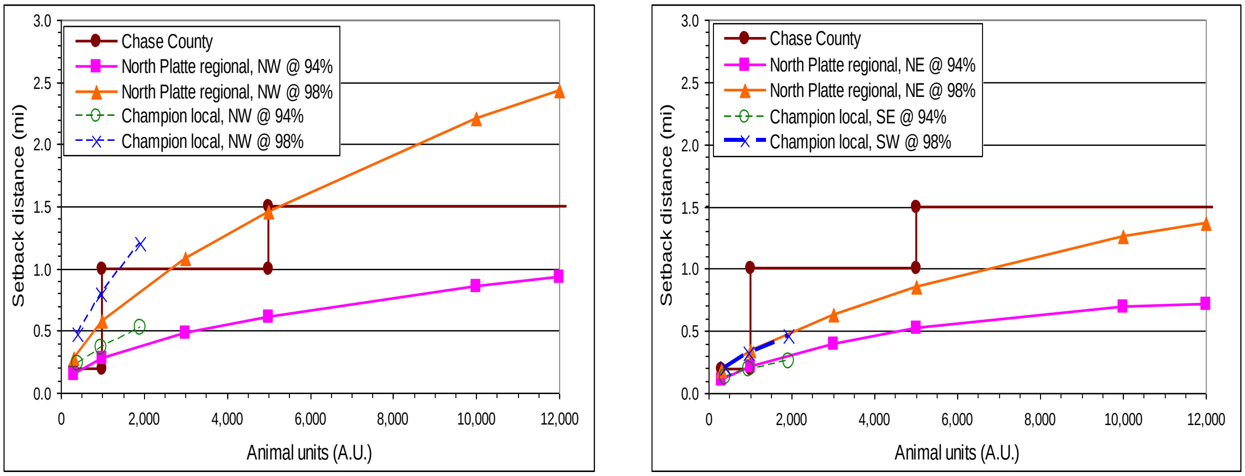



**Figure B3. Setback distances as specified in Chase County zoning ordinances and as given by odor footprint modeling for various sizes of deep-pit swine finishing facilities for the a) worst-case, northwest direction (left) and b) best-case, NE/SE/SW direction (right).**