



Livestock Odor Modeling

Dr. Bob Thaler, Extension Swine Specialist South Dakota State University

What Are Typically the Main Reasons People Object to CAFOs?

- Water contamination
 - Manure storage designs approved by SD DANR
 - Manure application approved by SD DANR
- ■Odor
 - Focus of presentation
- ■Local impact roads, labor, water availability
- ■Fear of the Unknown/Something Different

Primary Sources of Odor

Animal housing facilities



■ Manure storages



Land application of manure



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Odor

- Caused by odorous chemicals in gases and particulate matter
- No specific composition
- Humans can detect over 1 billion different odors
- Difficult to measure
 - There is *NO* instrument that accurately measures odor!!!
 - How can you regulate what you can't measure??
 - MN uses hydrogen sulfide levels at property line
- No correlation between individual gas levels (like ammonia) and odor

Olfactometer for Lab Testing

- Dynamic, triangular, forced choice
- Trained panelists



Health Impacts of Odors

- Physiological and psychological symptoms have been reported in various studies
- Systematic study of available literature by O'Connor et al. (2010):
 - A weak and inconsistent association between <u>self-reported</u> disease in people with allergies or familial history of allergies
 - No consistent dose-response relationship between exposure and disease



How do I assess air quality?

Assessment Tools

South Dakota Odor Footprint Tool

• https://www.sdstate.edu/abe/research/structures/odor-modeling.cfm

National Air Quality Site Assessment Tool

• http://nagsat.tamu.edu/

Air Management Practices Assessment Tool

• http://www.agronext.iastate.edu/ampat/

National Air Quality Site Assessment Tool

- Qualitative assessment
- Site-specific analysis
- Multiple air pollutants considered
- Survey format
- Adopted by the NRCS

National Air Quality Site Assessment Tool

Select a species to begin:

Swin

Beef National Air Quality Site Assessment Tool

Dairy

Note: Do not use your browser's back button to navigate this form.

Save often using the Sa

X

tool only

wer will nt practice

Beef

Hors

Animals and Housing

Note to User: Many farms may one of the choices can be select affect their results. See user's rewill accomplish that result.

Housing type:

- O Under roof Enclosed pe
- O Under roof Enclosed pa
- O Dry lot
- O Concrete lots



Save Progress

Housing type:

- O Under roof Enclosed pens
- Under roof Enclosed pack

Bedding conditions: (Click on an image below; your selection will highlight in green.)



No bedding visible, deep manure accumulation, wet, matted manure on hides



<25% bedding visible, moderate manure accumulation, animal hides dirty



25-75% bedding visible, little manure accumulation, mostly clean hides



>75% bedding visible, little manure accumulation, clean hides



Air Management Practices Assessment Tool

- Qualitative assessment
- Conservative estimate of the range in effectiveness for ammonia, hydrogen sulfide, dust, odor, volatile organic compounds, and greenhouse gases
- ■Relative cost

Animal Housing

	<u>Ammonia</u>	<u>H₂S</u>	<u>Odor</u>	Dust & Particulates	<u>voc</u>	<u>GHG</u>	Cost
<u>Barriers</u>							\$
<u>Biofilters</u>							\$\$
Chimneys							\$
Diet Manipulation							\$
Electrostatic Precipitation							\$\$
Landscaping							\$
Oil Sprinkling							\$
Pit Ventilation							\$\$
Scrubbers							\$\$\$
Siting							\$
Urine/Feces Segregation							\$\$-\$\$\$
<u>UV Light</u>							\$\$

H₂S = Hydrogen Sulfide; VOC = Volatile Organic Compounds; GHG = Greenhouse Gases

red - low impact; yellow - medium impact; green - high impact; blank - insufficient data

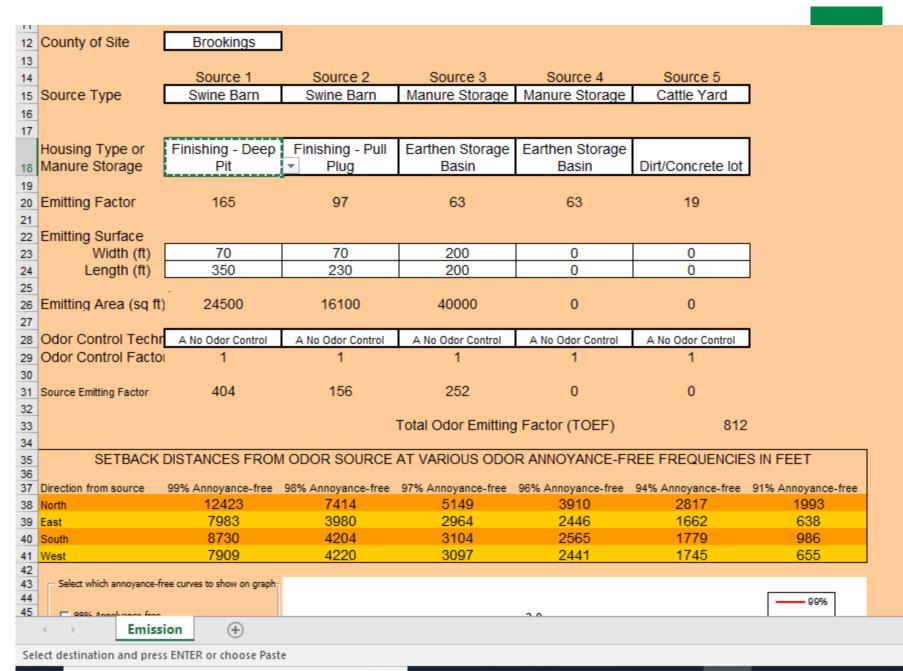
The table is laid out as a score card. Each technology within the tool is laid out on the vertical axis on the left. The pollutants are laid out on the horizontal axis at the top. A green color indicates a particular technology has a high impact on that particular pollutant. Likewise, yellow and red indicate medium and low impact respectively. As an example, if a person were concerned about a potential odor problem from animal housing, you would scan down the list under the "odor" column at the top. You would find that "Siting", "Scrubbers" and "Biofilters" have green bars, meaning they have high impact on odors. You could then investigate them further or check out some of the yellow bars that have a medium impact. Consequently red bars, would have low impact or would not be suitable for addressing that pollutant.

Source: http://www.agronext.iastate.edu/ampat/animalhousing/homepage.html

South Dakota Odor Footprint Tool

- Estimate odor impacts (setback distances needed)
- Assumes flat terrain
 - Odor "flows" like a liquid
- Starting point for discussion

- Factors:
 - Animal Species
 - Manure Storage
 - Housing Type
 - Size of OdorEmitting Surface
 - Historical Weather
 - Mitigation
 Methods



Type here to search













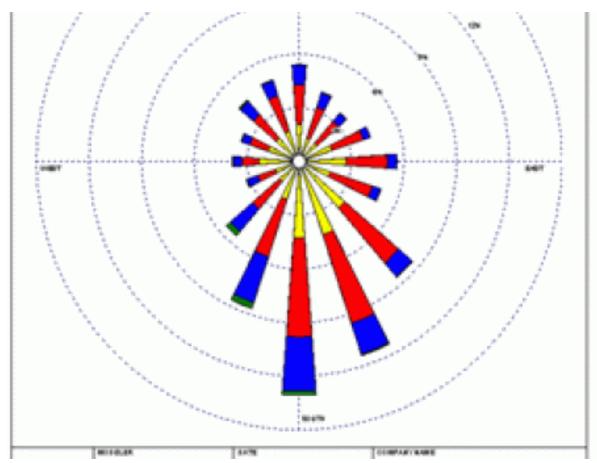






SD Odor Footprint Tool (SDOFT)

Select a county



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Weather/Terrain Impact Odor Plumes



South wind at 10 mph, Summer day With a few broken clouds,
Open flat terrain



South wind at 10 mph, Clear summer night, Open flat terrain



5+ odor units

2-4 odor units

1 odor unit



South wind at 2 mph, Summer day with a few broken clouds, Open flat terrain

South wind at 10 mph, Clear summer night, Trees down-wind of odor source

SD Odor Footprint Tool (SDOFT)

- Select a county
- Select an Odor Source
 - Cattle yard
 - Dairy Barn
 - Swine Barn
 - Manure Storage
 - Poultry Barns

SD Odor Footprint Tool (SDOFT)

- Select a county
- Select an Odor Source
- Housing Type or Manure Storage



Housing Type or Manure Storage

- Cattle Yard
 - Dirt/concrete lot
 - Free stall/scrape
- ■Dairy Barn
 - Free stall
 - Loose housing
 - Tie Stalls
- Manure Storage
 - Earthen basin
 - Steel/concrete tank
 - Crusted stockpile

- ■Swine Barn
 - Gestation deep pit
 - Gestation pull-plug
 - Farrowing
 - Finishing deep pit
 - Finishing hoop barn
 - Finishing pull-plug

SD Odor Footprint Tool (SDOFT)

- Select a county
- Select an Odor Source
- Housing Type or Manure Storage
- **■**Emitting Surface (dimensions)
 - Length & width
 - For swine barns with deep pits, only use building dimensions since research was done with them as one unit

SD Odor Footprint Tool (SDOFT)

- Select a county
- Select an Odor Source
- Housing Type or Manure Storage
- **■**Emitting Surface (dimensions)

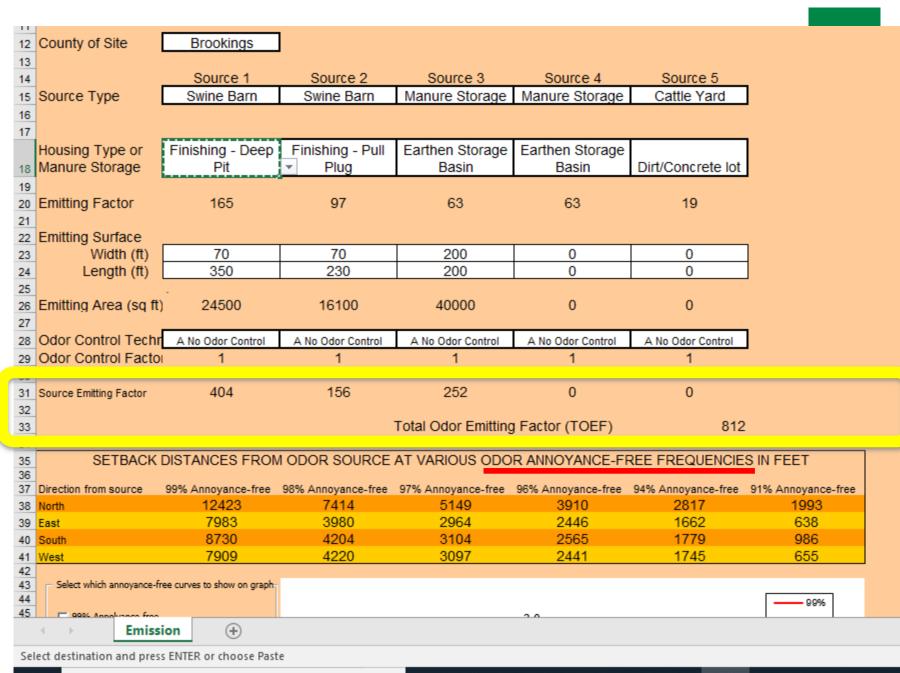
Odor Control

Biofilter
Geotextile cover

Impermeable cover
Oil sprinkling

Straw cover at either 2", 4", 6", or 8"





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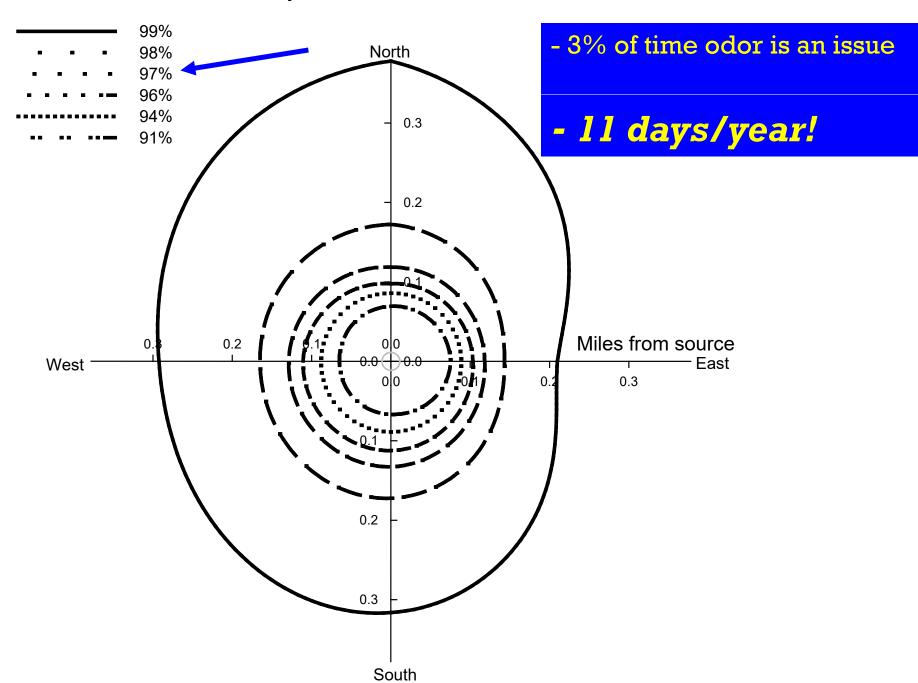


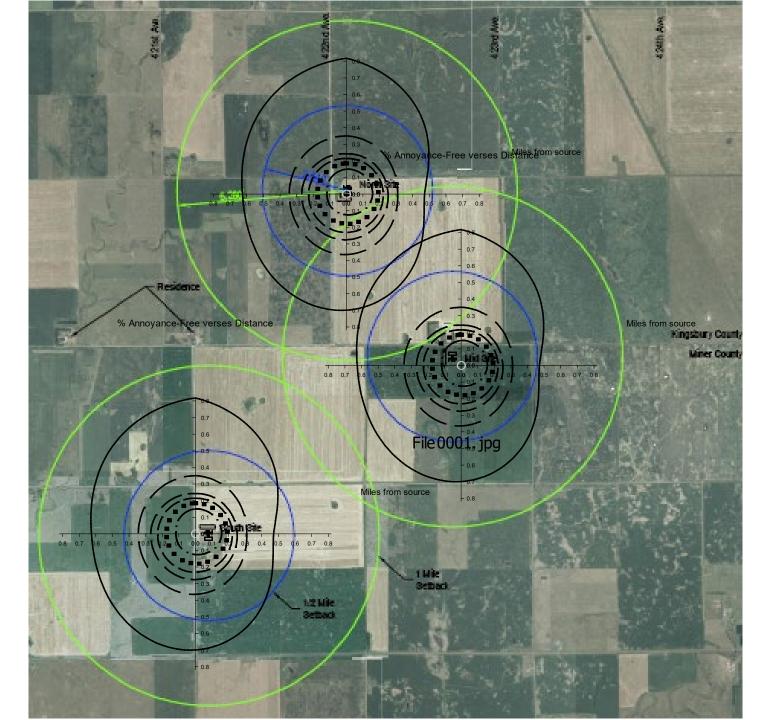






% Annoyance-Free verses Distance





Version 4.1

SOUTH DAKOTA ODOR FOOTPRINT TOOL

Procedure to use SDOFT:

- 1 Select South Dakota County from drop down list where site is located.
- 2 Select Odor Source Type from drop down list for each odor source at the site.
- 3 Select housing or manure storage type from drop down list for each odor source at the site.
- 4 Enter size (width and length) of emitting surface for each odor source at the site.
- 5 Enter odor control technology if any from drop down list for each odor source at the site.
- 6 View annoyance-free distances at bottom of page (scroll down).
- 7 Select the annoyance-free curves to be graphed by checking the square on the left bottom of this page.

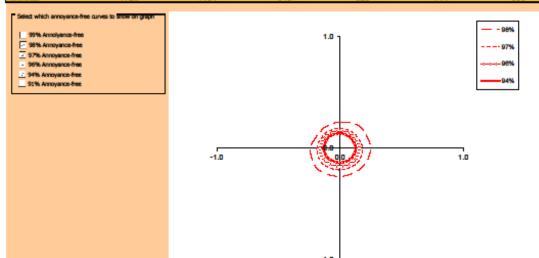
County of Site

Yankton

	Source 1	Source 2	Source 3	Source 4	Source 5
Source Type	Swine Barn	Swine Barn	Manure Storage	Manure Storage	Cattle Yard

Housing Type or	Finishing - Deep	Finishing - Pull	Earthen Storage	Earthen Storage			
Manure Storage	Pit	Plug	Basin	Basin	Dirt/Concrete lot		
Emitting Factor	165	97	63	63	19		
Emitting Surface							
Width (ft)	61	0	0	0	0		
Length (ft)	140	0	0	0	0		
Emitting Area (sq ft)	8540	0	0	0	0		
Odor Control Technol	A No Odor Control	A No Odor Control	A No Odor Control	A No Odor Control	A No Odor Control		
Odor Control Factor	1	1	1	1	1		
Source Emitting Factor	141	0	0	0	0		
	Total Odor Emitting Factor (TOEF) 141						

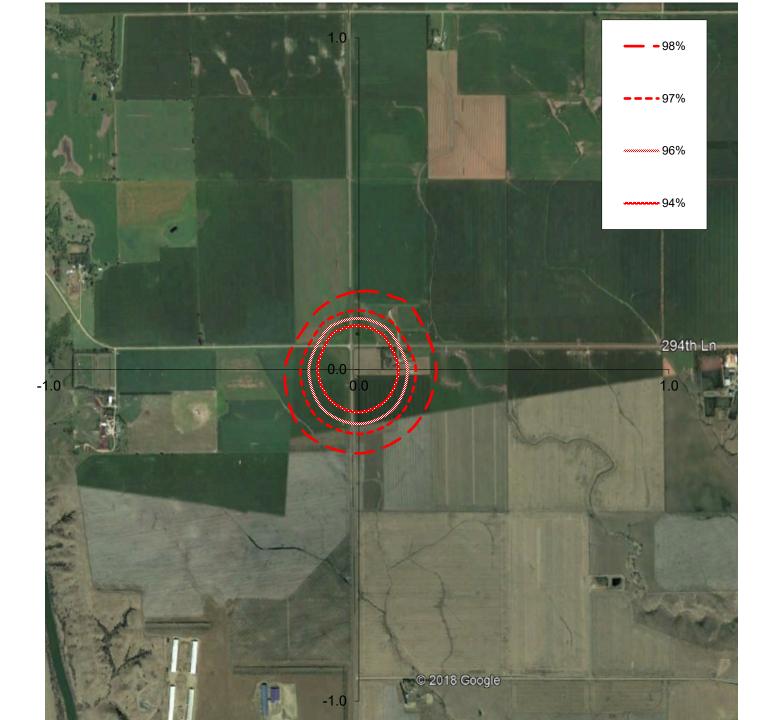
SETBA	SETBACK DISTANCES FROM ODOR SOURCE AT VARIOUS ODOR ANNOYANCE-FREE FREQUENCIES IN FEET									
Direction from source	99% Annoyance-free	98% Annoyance-free	97% Annoyance-free	96% Annoyance-free	94% Annoyance-free	91% Annoyance-free				
Northeast	3072	1331	928	796	672	553				
Southeast	2330	1306	1008	857	673	471				
Southwest	2587	1367	1044	878	690	499				
Northwest	1728	1154	948	829	714	598				



2,400 head Nursery



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Version 4.1

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County of Site

McPherson

	Source 1	Source 2
Source Type	Swine Barn	Swine Barn

Source I	Source 2	Source 3	Source 4	Source 5
Swine Barn	Swine Barn	Manure Storage	Manure Storage	Cattle Yard

Housing Type or Manure Storage	Finishing - Deep Pit	Finishing - Deep Pit	Earthen Storage Basin	Earthen Storage Basin	Dirt/Concrete lot
Emitting Factor	165	165	63	63	19
Emitting Surface					
Width (ft)	101.83	101.83	0	0	0
Length (ft)	193	193	0	0	0
Emitting Area (sq ft)	19653.19	19653.19	0	0	0

Odor Control Technol	A No Odor Control				
Odor Control Factor	1	1	1	1	1
Source Emitting Factor	324	324	0	0	0

Total Odor Emitting Factor (TOEF)

-2 n J

649

SETBA	SETBACK DISTANCES FROM ODOR SOURCE AT VARIOUS ODOR ANNOYANCE-FREE FREQUENCIES IN FEET							
Direction from source	99% Annoyance-free	98% Annoyance-free	97% Annoyance-free	96% Annoyance-free	94% Annoyance-free	91% Annoyance-free		
North	11069	6465	4554	3496	2531	1800		
East	7135	3623	2646	2195	1488	627		
South	7753	3811	2783	2315	1605	893		
West	7155	3685	2745	2123	1542	655		

Select which annoyance-free curves to snow on graph		
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94% Annoyance-free	96%	
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Two 2,400 head Finishing Barns



Version 4

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Procedure to use SDOFT:

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County of Site

Faulk

Source Type

Source 1	Source 2	Source 3	Source 4	Source 5
Swine Barn	Swine Barn	Swine Barn	Manure Storage	Cattle Yard

Housing Type or Manure Storage	Farrowing	Gestation - Deep Pit	Finishing - Deep Pit	Earthen Storage Basin	Dirt/Concrete lot		
Emitting Factor	68	243	165	63	19		
Emitting Surface							
Width (ft)	185	171.83	98	0	0		
Length (ft)	466	642	313.33	0	0		
Emitting Area (sq ft)	86210	110314.86	30706.34	0	0		
Odor Control Technol	A No Odor Control	A No Odor Control	A No Odor Control	A No Odor Control	A No Odor Control		

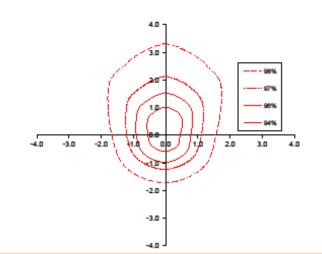
Odor Control Technol	A No Odor Control				
Odor Control Factor	1	1	1	1	1
Source Emitting Factor	586	2681	507	0	0

Total Odor Emitting Factor (TOEF)

3774

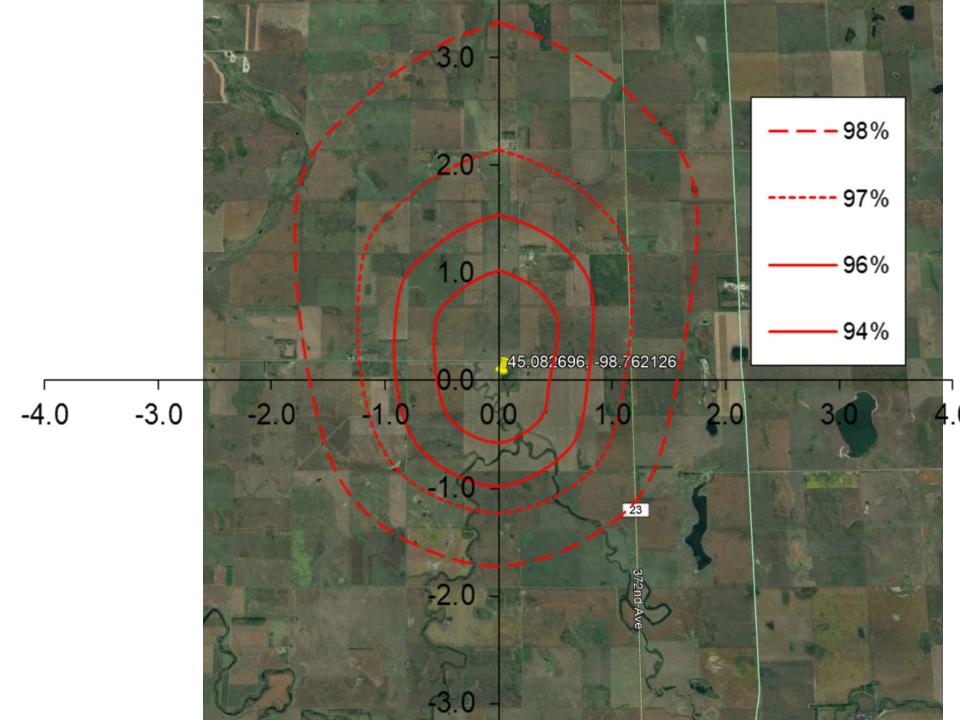
SETBACK DISTANCES FROM ODOR SOURCE AT VARIOUS ODOR ANNOYANCE-FREE FREQUENCIES IN FEET						
Direction from source	99% Annoyance-free	98% Annoyance-free	97% Annoyance-free	96% Annoyance-free	94% Annoyance-free	91% Annoyance-free
North	30402	17603	11315	8124	5407	3543
East	17541	8277	5864	4135	2357	814
South	19577	9068	6502	5145	3063	1093
West	16879	8801	6373	4790	2882	889

Select which annoyance-free curves to snow on graph
99% Annolyance-free
98% Annoyance-free
✓ 97% Annoyance-free
- 96% Annoyance-free
2 94% Annoyance-free
91% Annoyance-free



5,400 Sow Complex





SOUTH DAKOTA ODOR FOOTPRINT TOOL

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County of Site

Faulk

59

Source Type

Source Emitting Factor

Source 1	Source 2	Source 3	Source 4	Source 5
Swine Bam	Swine Bam	Swine Barn	Manure Storage	Cattle Yard

Gestation - Deep Earthen Storage Housing Type or Finishing - Deep Basin Dirt/Concrete lot Manure Storage Farrowing 68 **Emitting Factor** 243 165 63 19 **Emitting Surface** Width (ft) 185 171.83 98 Length (ft) 466 642 313.33 0 Emitting Area (sq ft) 86210 110314.86 30706.34 0 0 Odor Control Techno Biofilter Biofilter Biofilter A No Odor Control A No Odor Control Odor Control Factor

268

Total Odor Emitting Factor (TOEF)

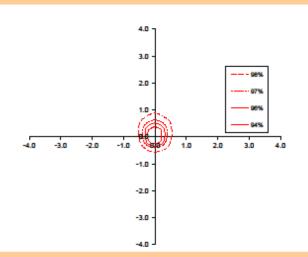
377

SETBACK DISTANCES FROM ODOR SOURCE AT VARIOUS ODOR ANNOYANCE-FREE FREQUENCIES IN FEI
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Direction from source	99% Annoyance-free	98% Annoyance-free	97% Annoyance-free	96% Annoyance-free	94% Annoyance-free	91% Annoyance-free
North	8479	4703	3412	2718	1989	1477
East	5346	2788	2030	1649	1125	550
South	5789	2956	2135	1816	1340	753
West	5586	2667	2085	1603	1210	611

Select which annoyance-free curves to answ on graph

| 99% Annoyance-free
| 98% Annoyance-free
| 99% Annoyance-free



5,400 Sow Complex with **Biofilters**



Biofilter **Mechanically Ventilated Building Exhaust Fan Odorous Air Dust Impactor Biofilter** Reduced Odor Air Media **Media Support Air Plenum** Pit Beneath Barn **Air Duct**

Biofilter on MN 1500 Sow Unit



Vertical Biofilter



Biofilter Performance

- **■**Odor reduction = 80% 90%
- ■**H**₂**S** reduction = 80% 90%
- ■NH₃ reduction = 50% 60%
- ■Different designs & <u>effectiveness</u>
- ■They are a tool that should be used when appropriate
- **Only on cold weather fans**

SOUTH DAKOTA ODOR FOOTPRINT TOOL

Procedure to use SDOFT:

- 1 Select South Dakota County from drop down list where site is located.
- 2 Select Odor Source Type from drop down list for each odor source at the site.
- 3 Select housing or manure storage type from drop down list for each odor source at the site.
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County of Site Lincoln

Source 1	Source 2	Source 3	Source 4	Source 5
Source Type Cattle Yard	Cattle Yard	Manure Storage	Manure Storage	Cattle Yard

Housing Type or Manure Storage	Dirt/Concrete lot	Dirt/Concrete lot	Crusted Stockpile	Earthen Storage Basin	Dirt/Concrete lot
Emitting Factor	19	19	9	63	19
Emitting Surface					
Width (ft)	400	150	75	0	0
Length (ft)	200	50	75	0	0
Emitting Area (sq ft)	80000	7500	5625	0	0
Odor Control Technol	A No Odor Control	A No Odor Control			

Odor Control Technol	A No Odor Control				
Odor Control Factor	1	1	1	1	1
Source Emitting Factor	152	14	5	0	0

Total Odor Emitting Factor (TOEF)

171

Version 4.1

SETBACK DISTANCES FROM ODOR SOURCE AT VARIOUS ODOR ANNOYANCE-FREE FREQUENCIES IN FEET								
rection from source	99% Annoyance-free	98% Annoyance-free	97% Annoyance-free	96% Annoyance-free	94% Annoyance-free	91% Annoyance-free		
ortheast	3418	1472	1027	893	756	620		
outheast	2600	1449	1123	957	748	522		
outhwest	2908	1526	1160	974	763	544		
orthwest	1939	1286	1056	925	795	662		

Northwest	1939	1286	1056	925	795
Select which annoyance-free 99% Annoyance-free 96% Annoyance-free 96% Annoyance-free 94% Annoyance-free	ie auves to Snow on graph			97%	
		-1.0	(0.0	

Beef Feedlot

- 400' x 200'
- 150' x 50'
- Stockpile manure



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SOUTH DAKOTA ODOR FOOTPRINT TOOL

Procedure to use SDOFT:

- 1 Select South Dakota County from drop down list where site is located.
- 2 Select Odor Source Type from drop down list for each odor source at the site. that enables TOEF values greater than 4000
- located. using a non-public version of the SDOFT
 unce at the site that enables TOFF values are sterified 4000

NOTE: Worksheet was modified by E. Cortus

- 3 Select housing or manure storage type from drop down list for each odor source at the site.
- 4 Enter size (width and length) of emitting surface for each odor source at the site.
- 5 Enter odor control technology if any from drop down list for each odor source at the site.
- 6 View annoyance-free distances at bottom of page (scroll down).
- 7 Select the annoyance-free curves to be graphed by checking the square on the left bottom of this page.

County of Site

Lincoln

Source Type

Source 1	Source 2	Source 3	Source 4	Source 5
Cattle Yard	Manure Storage	Manure Storage	Cattle Yard	Manure Storage

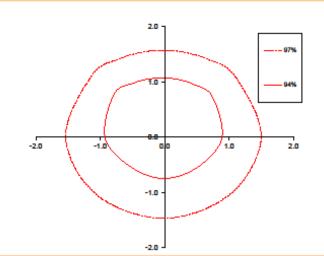
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Housing Type or Manure Storage	Dirt/Concrete lot	Earthen Storage Basin	Earthen Storage Basin	Dirt/Concrete lot	Earthen Storage Basin
Emitting Factor	19	63	63	19	63
Emitting Surface					
Width (ft)	1000	375	90	800	300
Length (ft)	2250	350	515	1000	600
Emitting Area (sq ft)	2250000	131250	46350	800000	180000
Odor Control Technol	A No Odor Control	A No Odor Control	A No Odor Control	A No Odor Control	A No Odor Control
Odor Control Factor	1	1	1	1	1
Source Emitting Factor	4275	827	292	1520	1134

Total Odor Emitting Factor (TOEF)

8048

SETBA	SETBACK DISTANCES FROM ODOR SOURCE AT VARIOUS ODOR ANNOYANCE-FREE FREQUENCIES IN FEET							
Direction from source	99% Annoyance-free	98% Annoyance-free	97% Annoyance-free	96% Annoyance-free	94% Annoyance-free	91% Annoyance-free		
Northeast	25100	9397	8198	7116	5496	3391		
Southeast	21283	10632	7646	6186	3916	1797		
Southwest	23370	11118	7824	6174	3942	1433		
Northwest	17427	10159	8393	7351	5825	4118		

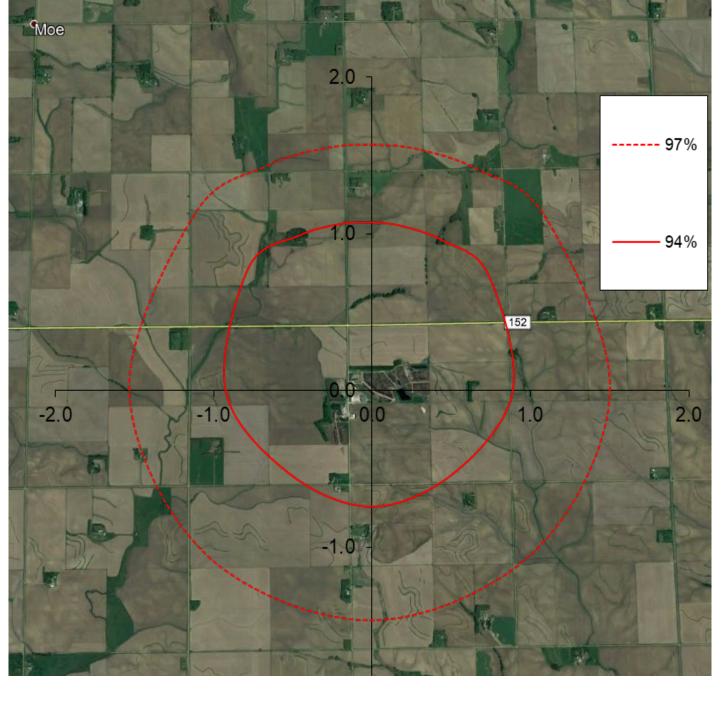
Select which annoyance-free curves to show on gr	apri
99% Annolyance-free	
98% Annoyance-free	
✓ 97% Annoyance-free	
96% Annoyance-free	
≤ 94% Annoyance-free	
91% Annoyance-free	



2 Beef Feedlots



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Summary

- SD Odor Footprint Tool is a science-based program
- Provides a solid starting point for discussion
- Not perfect
- **■**Common sense!





Natural Windbreaks

- Take some time to establish
- Odor reduction not well researched, but thought to be beneficial
 - Mixing
 - Dispersion
 - Absorption
- Esthetically pleasing

