

Animal Husbandry (Swine, Poultry, Cattle) Area Source Category Calculation Methodology Sheet

I. Source Category:

Animal Husbandry – Cattle
Animal Husbandry – Swine
Animal Husbandry – Poultry

II. Pollutants: NH₃

III. SCC: Many more SCC codes have been created for this category. See Appendix E in *National Emissions Inventory - Ammonia from Animal Husbandry been Operations Report* <http://www.epa.gov/ttn/chief/net/2002inventory.html>.

2805020000 - Animal Husbandry – Cattle
2805025000 - Animal Husbandry – Swine
2805030000 - Animal Husbandry – Poultry

IV. Description:

This document describes the methodology to be used to calculate emissions of ammonia (NH₃) from animal husbandry activities.

V. Current Methodology:

EPA has developed a new methodology for estimating ammonia emissions from animal husbandry operations. This methodology is described in the *EPA National Emission Inventory Ammonia Emissions from Animal Husbandry Operations Report*. Estimated average annual animal populations, manure management trains (MMTs) and corresponding emission factors are used in calculating ammonia emissions from this source category. The method is based on a mass balance equation, which ensures that the nitrogen coming out of the process does not exceed nitrogen going in. EPA has created a national ammonia emissions inventory for animal husbandry operations based on this methodology (EPA 2004).

Ammonia (NH₃) emissions for animal husbandry are estimated using activity data published by the Census of Agriculture. The Census of Agriculture publishes county-level estimates of number of head. The 2002 Census of Agriculture data is not yet available, and therefore EPA used 1997 county level distributions applied to USDA NASS reports (state level) to estimate animal populations in the *National Emissions Inventory - Ammonia from Animal Husbandry Operations Report*.

VI. Emission Calculation:

One sample calculation will be carried through steps A – E. The example will calculate ammonia emissions from swine managed in houses with lagoons, in Beaufort County, NC.

A. Estimate average annual animal populations by animal group, state and county.

1. Sample Calculation

Swine Subgroup	Annual Average Population (head)
Swine <60 lbs.	33,857
Swine 60-119 lbs.	20,410
Swine 120-179 lbs.	16,929
Swine >180 lbs.	14,287
Swine Breed	18,991
Total	104,474

B. Identify MMTs used by each animal group and then estimate the distribution of the animal population using each MMT.

1. Equation:

$$\text{Pop}_{\text{county,MMT}} = \% \text{MMT} \times \text{Avg Annual Pop}_{\text{county}}$$

2. Variables:

- a. $\text{Pop}_{\text{county,MMT}}$ = 2002 population that use specific MMT
- b. $\% \text{MMT}$ = Percent of population in specific MMT
- c. $\text{Avg Annual Pop}_{\text{county}}$ = Average Annual County Population

MMT Component for Each Animal Type

Animal Type	MMT	Component of System
Swine	Swine Houses with Lagoon Systems	Swine House with Flush, Pit Recharge, or Pull Plug pit, Solids Separator*, Solid Storage, Lagoon and Land Application
	Swine Houses with Deep Pit Systems	Swine house with deep pit and land application
	Outdoor Confinement Area	Outdoor Confinement Area
Dairy	Flush Barn	Milking center, flush barn, solids separator*, lagoon, dry storage of solids, and land application
	Scrape Barn	Milking center, scrape barn, drylot, solids separator*, lagoon, dry storage of solids, and land application
	Outdoor Confinement Area	Milking center, outdoor confinement area, manure storage tank, and land application

	Daily Spread (Scrape Barn)	Milking center, scrape barn, drylot, manure storage tank, land application
	Barn with Deep Pit	Milking center, barn with deep pit, drylot, manure storage tank, and land application
	Drylot	Drylot, storage pond, and land application
	Dairy Barns with Slurry Systems	Scrape Barn with Milking, Slurry tank/ basin, and land application
	Dairy Barn with Solid Storage Systems	Barn with Milking, Slurry tank/ basin, and land application
Poultry	Dry Layers	Dry layer House and land application
	Wet Layers	Wet layer house, lagoon and land application
	Broiler House	Broiler house, cake storage, and land application
	Turkey House	Turkey house, cake storage and land application
	Broiler/ Turkey Outdoor Confinement Area	Outdoor Confinement Area
Beef	Feedlot	Drylot, Settling Basin *, Storage Pond *, Solid Storage and land application
	Outdoor Confinement Area	Outdoor Confinement Area

* These components are not present at all applications

3. Sample Calculation

$$\text{Pop}_{\text{county,MMT}} = \% \text{MMT} \times \text{Avg Annual Pop}_{\text{county}}$$

Swine Subgroup	Annual Average Population (head) {Avg Annual Pop _{county} }	Distribution of Swine Managed in House with Lagoon Systems ¹ {%MMT }	Population Managed in Houses with Lagoon Systems (head) {Pop _{county,MMT} }
Swine <60	33,857	89%	30,133
Swine 60-119	20,410	89%	18,165

¹ Data Resource: U.S. EPA National Emissions Inventory Ammonia Emissions from Animal Husbandry Operations Report, 2003. Table C-3.

Swine 120-179	16,929	89%	15,067
Swine >180	14,287	89%	12,715
Swine Breed	18,991	89%	16,902
Total	104,474	89%	92,982

C. Estimate the amount of nitrogen excreted from the animals using each type of MMT, using general manure characteristics data.

1. Equation:

$$N_{\text{excreted MMT}} = \text{Pop}_{\text{county,MMT}} \times \text{ALW} \times N_{\text{rate}}$$

2. Variables

- a. $N_{\text{excreted MMT}}$ = Nitrogen excreted in a particular MMT (lbs/day)
- b. $\text{Pop}_{\text{county,MMT}}$ = 2002 animal population associated with specific MMT (animals/yr)
- c. ALW = Average live weight (lb animal mass/head)
- d. N_{rate} = Nitrogen excretion rate (lb N/1000 lb animal mass/day)

3. Sample Calculation

$$N_{\text{excreted MMT}} = \text{Pop}_{\text{county,MMT}} \times \text{ALW} \times N_{\text{rate}} \times 365$$

	Pop (head)	N_{rate} (lb N/ lb animal mass/ day)	ALW (lb/ head)	Conversion factor (days /yr)	N_{excreted} (lb N/yr)
$N_{\text{excreted Swine}<60}$	= 30,133 x	0.60 /1000 x	35 x	365	= 230,969
$N_{\text{excreted swine 60-119}}$	= 18,165 x	0.42/1000 x	90 x	365	= 250,622
$N_{\text{excreted swine 120-179}}$	= 15,067 x	0.42/1000 x	149 x	365	= 344,156
$N_{\text{excreted swine >180}}$	= 12,715 x	0.42/1000 x	200 x	365	= 389,842
$N_{\text{excreted swine breed}}$	= 16,902 x	0.24/1000 x	437 x	365	= 647,029
$N_{\text{excreted, Swine House with Lagoon System (total)}}$					= 1,862,618

D. Calculate Ammonia Emissions

1. Equation

- a. For Emission Factor expressed as a fixed amount

$$\text{NH}_3 \text{ MMT component A} = \text{Pop}_{\text{county, MMT}} \times \text{EF}_{\text{MMT component A}^*}$$

- b. For EF expressed as a percent of nitrogen lost as ammonia

$$\text{NH}_3 \text{ MMT component B} = N_{\text{MMT}} \times \text{EF}_{\text{MMT component B}^*} \times 17 \text{ NH}_3 / 14\text{N}$$

c. When a component follows another component

$$\text{NH}_3 \text{ MMT component B} = \left[\text{N}_{\text{MMT}} - (\text{NH}_3 \text{ MMT component A} \times 14/17) \right] \times \text{EF}_{\text{MMT component B}} \times 17/14$$

* REPEAT FOR EACH COMPONENT OF THE MMT

d. Emissions from all MMTs components

$$\text{NH}_3 \text{ Total MMT} = \sum \text{NH}_3 \text{ MMT components}$$

2. Variables

a. $\text{NH}_3 \text{ MMT component A-B}$ = NH_3 emissions from a particular MMT component (lbs/yr)

b. $\text{Pop}_{\text{county, MMT}}$ = Animal population in particular MMT

c. $\text{EF}_{\text{MMT component A-B}}$ = The emission factor (lbs NH_3 /head/yr or %) of the MMT component (see table below)

d. N_{MMT} = Nitrogen managed in a particular MMT component

e. 14/17 = Conversion factor (N/ NH_3)

f. 17/14 = Conversion factor (NH_3 /N)

g. $\text{NH}_3 \text{ Total MMT}$ = Total Ammonia lost throughout MMT

Ammonia Emission Factors by Animal Type and MMT Component (EPA 2004)

Animal Type	Operations	Ammonia Emission Factor	
		lb NH_3 /head/year	Percent N loss*
Swine	Houses with Lagoons	6.0	NA
	Houses with Deep Pits	7.3	NA
	Outdoor Confinement Area	MA	16.6%
	Lagoons	NA	71%
	Stockpile	NA	20%
	Liquid Land Application (>2,000 head)	NA	20%
	Liquid Land Application (<2,000 head)	NA	23%
	Solid Land Application (>2,000 head)	NA	19%
	Solid Land Application (<2,000 head)	NA	17%
Dairy	Flush Barn	NA	23.5%

	Scrape Barn	18.5	NA
	Outdoor Confinement Areas	NA	8%
	Drylots	18.58	NA
	Deep Pits	NA	28.5%
	Lagoons	NA	71%
	Tanks	NA	6.6%
	Stockpile	NA	20%
	Liquid Land Application (>200 head)	NA	20%
	Solid Land Application (> 200 head)	NA	17%
	Liquid Land Application (100-200 head)	NA	22%
	Solid Land Application (100-200 head)	NA	18%
	Liquid Land Application (<100 head)	NA	24%
	Solid Land Application (<100 head)	NA	19%
Poultry	Dry Layer Houses	0.89	NA
	Wet Layer Houses	0.25	NA
	Broiler Houses	0.22	NA
	Turkey Houses	1.12	NA
	Outdoor Confinement Areas	NA	8%
	Lagoon	NA	71%
	Cake storage	NA	20%
	Wet Layer Land Application	NA	41.5%
	Dry Layer Land Application	NA	7%
	Broiler Land Application	NA	25%
	Turkey Land Application	NA	25%
	Beef and Heifers	Drylots	25.2
Outdoor Confinement Are		NA	8%

	Stockpile	NA	20%
	Storage Pond	NA	71%
	Liquid Land Application	NA	20%
	Solid land Application	NA	17%

3. Sample Calculation

a. Ammonia Emissions from Housing Area

$$\begin{aligned}
 \text{NH}_3 \text{ House} &= \text{Pop Swine house with lagoon} \times \text{EF Swine house with lagoon} \\
 &= 92,982 \text{ head} \times 6 \text{ lbs ammonia/hd/yr} \\
 &= 557,892 \text{ lbs NH}_3/\text{yr}
 \end{aligned}$$

b. Nitrogen emitted from house area

$$\begin{aligned}
 \text{N}_{\text{house loss}} &= \text{NH}_3 \text{ House} \times 14 \text{ N} / 17 \text{ NH}_3 \\
 &= 557,892 \text{ lbs NH}_3/\text{yr} \times 14 \text{ N} / 17 \text{ NH}_3 \\
 &= 459,440 \text{ lbs N/ yr}
 \end{aligned}$$

c. Amount of N managed in the lagoon

$$\begin{aligned}
 \text{N}_{\text{lagoon}} &= \text{N}_{\text{excreted, swine house with lagoon}} - \text{N}_{\text{house loss}} \\
 &= 1,862,618 \text{ lbs N/yr} - 459,440 \text{ lbs N/yr} \\
 &= 1,403,178 \text{ lbs N/ yr}
 \end{aligned}$$

d. Ammonia emissions from lagoons

$$\begin{aligned}
 \text{NH}_3 \text{ lagoon} &= \text{N}_{\text{lagoon}} \times \text{EF}_{\text{swine lagoons}} \times 17 \text{ NH}_3 / 14 \text{ N} \\
 &= 1,403,178 \text{ lbs N/ yr} \times 71\% \times 17/14 \\
 &= 1,209,740 \text{ lbs NH}_3/\text{yr}
 \end{aligned}$$

e. Amount of N lost in the house and lagoon

$$\begin{aligned}
 \text{N}_{\text{house + lagoon loss}} &= (\text{NH}_3 \text{ house} + \text{NH}_3 \text{ lagoon}) \times 14 \text{ N} / 17 \text{ NH}_3 \\
 &= (557,892 + 1,209,740) \times 14/17 \\
 &= 1,455,697 \text{ lbs N / yr}
 \end{aligned}$$

f. Amount of N available for land application

$$\begin{aligned}
 \text{N}_{\text{Land App}} &= \text{N}_{\text{excreted, Swine House with lagoon}} - \text{N}_{\text{house+lagoon loss}} \\
 &= 1,862,618 - 1,455,697 \\
 &= 406,921 \text{ lbs N /yr}
 \end{aligned}$$

g. Amount of NH3 emissions from Land Application

$$\begin{aligned}
 \text{NH}_3 \text{ Land} &= (\text{N}_{\text{land App}} \times \text{EF}_{\text{swine land ap liquid large}} \times \text{SD}_{>2000} \times 17 \text{ NH}_3/14 \text{ N}) \\
 &+ (\text{N}_{\text{land App}} \times \text{EF}_{\text{swine land ap liquid small}} \times \text{SD}_{<2000} \times 17 \text{ NH}_3/14 \text{ N}) \\
 &= (406,921 \text{ lbs N/yr} \times 20\% \times 94.9\% \times 17/14) + \\
 &\quad (406,921 \text{ lbs N/yr} \times 23\% \times 5.09\% \times 17/14) \\
 &= 99,569 \text{ lbs NH}_3/\text{yr}
 \end{aligned}$$

h. Total Ammonia emissions lost from Swine Houses with Lagoon Systems

$$\begin{aligned}\text{NH}_3 \text{ MMT Total} &= \sum \text{NH}_3 \text{ MMT components} \\ &= 557,892 \text{ lbs NH}_3/\text{yr} + 1,209,740 \text{ lbs NH}_3/\text{yr} \\ &\quad + 99,569 \text{ lbs NH}_3/\text{yr} \\ &= 1,867,201 \text{ lbs NH}_3/\text{yr}\end{aligned}$$

VII. Point Source Adjustments:

It is unlikely that animal husbandry activities would be included in a point source inventory, so no adjustments need to be made.

VIII. Adjustments for Controls:

It is unlikely that controls would affect this source.

IX. Spatial Adjustments:

Activity information provided by the Census of Agriculture provides population estimates by county, so spatial adjustments are not necessary. If Census of Agriculture data is not available, use of USDA NASS, or FAO data require county spatial allocation. EPA applied 1997 Census of Ag county level distribution of animal populations to the 2002 state-level populations. For more information on this method see *National Emissions Inventory - Ammonia from Animal Husbandry Operations* <http://www.epa.gov/ttn/chief/net/2002inventory.html>.

X. Temporal Adjustments:

Emissions from animal husbandry may be assumed to be constant through the year.

XI. Uncertainties/Shortcomings:

A. The animal counts reported to Census of Agriculture may undercount nonproduction animals. USDA NASS data is the only available 2002 data at this point.

XII. Assumptions:

- A. Total animal population / distribution by county
- B. Emission factor

XIII. Rule Effectiveness:

Not applicable.

XIV. Recommendations to Improve Methods/Data

- A. Obtain local data on the total herd size for dairies including calves, bulls, and replacement stock
- B. For Hogs, obtain local data on the total number of animals including breeding, and replacement stock.
- C. For Poultry, obtain local data on the total number of layers, pullets, broilers, and turkeys, etc. including any breeding, and replacement stock.
- D. Estimate the typical practices for feeding, waste treatment, and waste disposal practices in the area.

- E. Obtain local data on the total number of beef cattle on the range and in feedlots.
- F. Adjust emission factors to represent the local conditions as appropriate.

XV. Additional Information/Guidance:

EPA Contact: Mr. Dallas Safriet, MD-14
Emission Factor and Inventory Group
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National Emissions Inventory - Ammonia from Animal Husbandry Operations
<http://www.epa.gov/ttn/chief/net/2002inventory.html>

NH₃ Emission Factors Report
www.epa.gov/ttn/chief/efdocs/ammonia.pdf

NEI Methodology Description
www.epa.gov/ttn/chief/publications.html#reports

CMU NH₃ Emissions Inventory
www.cmu.edu/ammonia/

1997 Census of Agriculture
www.nass.usda.gov/census/

XVI. References:

Emission Inventory Improvement Program, EIIP Document Series - Volume IX,
Particulate Emissions, Animal Husbandry - Cattle
<http://www.epa.gov/ttn/chief/eiip/techreport/volume09/cattle.pdf>

Emission Inventory Improvement Program, EIIP Document Series - Volume IX,
Particulate Emissions, Animal Husbandry - Hogs
<http://www.epa.gov/ttn/chief/eiip/techreport/volume09/hogs.pdf>

Emission Inventory Improvement Program, EIIP Document Series - Volume IX,
Particulate Emissions, Animal Husbandry - Poultry
<http://www.epa.gov/ttn/chief/eiip/techreport/volume09/poultry.pdf>

Lake Michigan Air Directors Consortium (LADCO), *Recommended Improvements to the CMU Ammonia Emission Inventory Model for Use by LADCO*, prepared by Sonoma Technology, Inc., March, 2003.

U.S. Environmental Protection Agency, *Documentation for the Draft 1999 National Emissions Inventory (Version 3.0) for Criteria Air Pollutants and Ammonia, Area Sources*, March 2003.

U.S. Environmental Protection Agency, *National Emissions Inventory – Ammonia Emissions from Animal Husbandry Operations, Draft*, January 2004.

<http://www.epa.gov/ttn/chief/net/2002inventory.html>