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TO: **Co-chairpersons Senator Frank B. Wood and Representative Wes Whitead, and Members of the Livestock Odor Study Committee**

FROM: **Doug Adkisson, Senior Legal Counsel, Legal Services Division, Legislative Services Agency**

RE: **Background Memorandum on Livestock Odor Study Committee**

I. Introduction

A. Purpose. Part of the Committee charge of the Livestock Odor Study Committee is to consider "additional state funding for research into cost-effective management practices, facilities, equipment, and practices to mitigate odor from livestock production facilities." The purpose of this memorandum is to summarize a number of studies conducted by or in association with the Department of Natural Resources (DNR) or Iowa State University which have monitored and attempted to measure odors emitted from livestock operations or fields where livestock manure has been applied. A primary goal of these studies is to evaluate odor mitigation strategies which may measurably reduce the presence of odors at a given time (i.e., an "odor event"). Note, the studies consider two major sources of odor emitted from livestock operations: (1) livestock facilities including (a) structures used in production such as confinement buildings and (b) structures used to store or treat manure which are commonly under-building pits or anaerobic lagoons, and (2) the application of manure on land to provide nutrients to planted crops.

B. Full Reports. The full reports of the studies are located on the space reserved for the Livestock Odor Study Committee on the General Assembly's Website:

http://www.legis.state.ia.us/aspx/Committees/Committee.aspx?id=213

II. Summary of Studies

A. DNR Odor Study. The DNR completed a study in January 2006.[1] Departmental staff took measurements from production facilities or fields where manure from animal feeding operations were applied, and from statutorily benefited locations which are public use areas, educational institutions, religious institutions, residences, and commercial enterprises (so-called "PERRC's").[2] Measurements of odor emitted from facilities and manure applications were conducted at the fence line of the property where the odor source was located. Measurement for PERRCs was conducted at the benefited location in response to a complaint. The results of the measurements are recorded in the following table from the study:[3]

Measurement Results

Measurement Type	Exceedances	Measurements	Exceedance Rate
Facility	71	1066	7%
Manure Application	36	338	11%
PERRC	11	304	4%
Total	118	1708	7%

B. Swine Production Facility Study. Staff from Iowa State University issued a study in 2002 evaluating air quality downwind from swine production facilities.[4] The study focused upon local weather patterns affecting gasses, including odor, emitted from livestock operations, and considered the impact of clear sunny days on odor migration. The study found that during times when there are clear skies and the sun is shining, the atmosphere tends to be unstable, with a greater degree of turbulence, which consequently dilutes gases close to their source. Alternatively, during cloudy days when the sun is not present, the atmosphere is less turbulent and correspondingly there is less probability of gases mixing with the surrounding air.

C. Odor Dispersion Study. Staff from Iowa State University, in conducting a study of new livestock operations issued in 2003, including poultry operations, found that when deciding to site a livestock operation, the distance between a proposed livestock operation and neighboring property is one of several factors to consider.[5] The study recommended the use of a model that accounts for a community's "odor load," which also considers historical local weather patterns, the size of the proposed livestock operation, the presence of other livestock operations, and the planned implementation of odor control measures.

D. Biofiltration Study. Staff from a number of universities collaborated to investigate methods to reduce odor emission from deep-pit swine finishing operations. Specifically the study issued in 2007 considered biofiltration which uses a system of activated carbon, water, and oxidation to

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[1] Iowa DNR Ambient Air Monitoring Group, Department of Natural Resources, *Results of the Iowa DNR Animal Feeding Operations Odor Study, p. 5-6, (January 2006).* Website: http://www.iowadnr.gov/air/afo/files/Odor.pdf, accessed October 22, 2007.

[2] Code sections 459.202 and 459.204.

[3] Iowa DNR study, p. 6.

[4] Dwaine S. Bundy, Ph.D., P.E., and Steven J. Hoff, Ph.D., P.E., Department of Agricultural and Biosystems Engineering, Iowa State University, *Air Quality Evaluation Downwind from Swine Facilities*, presentation at the 2002 American Society of Agricultural and Biological Engineers (A.S.A.E.) Mid-Central Meeting, Paper No. MC02-402, Ramada Inn, St. Joseph, MI, p. 5, (April 12–13, 2002).

[5] Steven J. Hoff, Ph.D., P.E., Department of Agricultural and Biosystems Engineering, Iowa State University, and Dwaine S. Bundy, Ph.D., P.E., Department of Agricultural and Biosystems Engineering, Iowa State University, *Model Odor Dispersion From Multiple Sources to Multiple Receptors*, 2003.

"wash" out odor-charged air.[6] According to the report, a biofiltration system may remove up to 90 percent of odor, and is simple and economical to install and maintain. The results of the study indicate that the technology could be cost effectively used during evening hours when the atmosphere tends to be more stable and there is less potential for the mixing of ventilated and natural air (i.e., when odor plumes are more likely to be transported greater distances). However, the report also states that several preconditions must exist in order to effectively operate a biofiltration system, including a large land area and high capacity fans to properly ventilate the air as it is treated during the biofiltration process.

E. Shelterbelt Study. Staff from Iowa State University considered the use of vegetation (i.e., shelterbelts) planted near livestock operations.[7] According to the report published in 2007, there is little empirical evidence to assess the effectiveness of shelterbelts, but initial research indicates that it may significantly reduce odor concentrations. The study emphasizes the need for appropriate design within the "airshed" in order to maximize the effectiveness of shelterbelts, especially when combined with other odor mitigation strategies (e.g., separation distances). The study also noted that shelterbelts are comparatively inexpensive to establish and maintain (costs include site preparation, the purchase of plant stock, and planting).

F. Odor Classification Analysis. The following table is from an analysis prepared by Iowa State University which summarizes information regarding various methods of odor control which are considered effective, while understanding that there is no "one-size-fits-all" approach.[8]

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[6] Steven J. Hoff, Ph.D., P.E., Department of Agricultural and Biosystems Engineering, Iowa State University; K.A. Janni, University of Minnesota; D.R. Schmidt, University of Minnesota; and R.E. Nicolai, South Dakota State University, White Paper, Paper No. MC02-402, *Partial Biofiltration from a Curtain-Sided Deep-Pit Swine Finisher* (Final Report Submitted to the Iowa Pork Producers Association), presentation at the American Society of Agricultural and Biological Engineers (ASAE) Meeting Presentation, September 28, 2007, p. 1-2.

[7] John Tyndall, Department of Natural Resource Ecology & Management, Iowa State University, and Joe Colletti, Department of Natural Resource Ecology & Management, Iowa State University, *Mitigating Swine Odor With Stragegically Designed Shelterbelt Systems: A Review*, Agroforestry Systems 69:45–65, Springer Science+Business Media B.V., p. 58 and 60 (2007).
Website: http://www.nrem.iastate.edu/research/veb/pub.swinesb.pdf.

[8] College of Agriculture and Life Sciences Air Quality Team, Iowa State University, *Classification of Effective Odor Mitigation Techniques*, prepared October 4, 2007.

ODORS ORIGINATING FROM HOUSING				
Method	Description	Limitations	Primary Benefits	Relative Costs
Siting	• Selection of the proper site before construction, considering winds and neighbor locations.	• Terrain effects are difficult to model.	• Difficult to quantify but viewed as the most effective strategy.	• Cost effective • May lead to some sites being unusable
Biofiltration	• Biomaterials used to filter ventilation air. • Filtration of air during stable conditions is most effective.	• Only effective for fan ventilation. • Must be designed to minimize impact on ventilation. • Moisture maintenance very important. • Can have a large footprint.	• 60% odor reduction • 60% NH_3 reduction • 60% H_2S reduction • PM reduction	• Installation on existing fans: $9 per pig space • Operational cost: $0.45/pig produced
Vegetative Environmental Buffer	• Rows of trees and shrubs • Filters, disrupts air patterns and acts as a visual barrier	• Time to become fully effective. • Must be placed to minimize impact on natural ventilation. • Can use a large amount of land. • Effectiveness is very site-specific, yet could increase with time as vegetation grows	• 6 to 13% odor reduction (poultry) • Up to 15% (swine) • Visual barrier • PM reduction • NH_3 reduction	• Large range – $0.03 to $0.33 per pig produced over 20 years
Diet Manipulation (swine)	Various approaches for swine including: • Crystalline amino acids used with a reduction in the dietary crude protein; • Minimizing feed wastage; • Reduction of bloodmeal use in excess of animal need.	• Varies with cost of feedstuffs • Limited research is available	• Up to 30% reduction in odors when methods used in combination. • May improve hedonic tone of odors. • 30 – 50% NH_3 & H_2S reduction	• Varies with feed ingredient costs. May be no added cost with some strategies.

ODORS ORIGINATING FROM STORAGE				
Method	Description	Limitations	Primary Benefits	Relative Costs
Permeable Covers	• Manure storage surface is covered with material that lets some air exchange but prevents wind from blowing across the surface • Material forms a biofilter on the surface to reduce odor • Materials include: straw, floating LECA rock, and geotextile fabric and geotextile fabric covered with straw	• Biological materials sink eventually and need to be replenished. Straw covers are effective for 2 – 6 months. • May cause some pumping problems • Materials that must be distributed across a surface (straw and LECA) impractical on very large storage (> 5 acres).	• 4" straw - 40%, 6" Straw - 60%, 12 inch straw 90% odor reduction respectively. • LECA Rock – 90% odor reduction • Geotextile – 50% odor reduction • Geotextile w/straw – 60% odor reduction • NH_3 reduction • H_2S reduction	• Straw – $0.10/ft^2$ (< 1 year) • LECA – $1.5/ ft^2 (10 + years) • Geotextile – $0.25/ ft^2 (3 to 5 years) • Geotextile w/Straw – $0.35/$ft^2$
Impermeable covers	• High density polyethylene (HDPE), ethylene propylene diene monomer rubber (EPDM) materials traps gases, odors and dusts.	• Snow, wind effects • Life up to 20 years • Manure agitation and removal is more difficult.	• Depends on leakage from cover. With proper installation 90 + % odor reduction. Odor reduction will be much less if cover has significant leakage.	• $2.50 / ft^2 for HDPE * Cost per ft^2 will be higher for small area installations and lower for very large area installations.
Vegetative Environmental Buffer	• See building section			

ODORS ORIGINATING FROM LAND APPLICATION				
Method	Description	Limitations	Primary Benefits	Relative Costs
Injection	• Injection of manure during application either with an umbilical system or tanker with injectors	• The use of no-till injection tool-bars may be advisable on highly erodible land to reduce residue disturbance. • Requires more tractor horsepower compared to broadcasting manure.	• Odor reduction may be > 90% • Injection tool-bars can be retrofitted to existing manure tanks.	• Capital investment of injection equipment (injection toolbar and hose reel). • While most custom manure applicators are currently charging the same price for injection and manure broadcast, producers who move from broadcast to injection systems can expect additional operating costs of ~$0.004/gal applied.
Timing	• Avoiding holidays, weekends and neighbors events	• Not always able to plan ahead	• Maintenance of neighbor relations	• NA

G. Odor Mitigation Techniques Recommended For Additional Research. The following table is from of an analysis conducted by Iowa State University which provides information regarding various methods of odor control which require further research to determine their effectiveness.[9]

GAPS IN TECHNOLOGIES NEEDING FURTHER RESEARCH			
Method	Description	Known	Unknown
Barriers	Sometimes called a "windwall". This is a wall of plastic or other material that forces the air leaving fans vertically.	• Removes particulate matter • Localized dispersion	• Impact further downwind where receptors are located • Quantification of PM removal
Biocurtain	Barrier with electrostatic precipitator	• Removes particulate matter • Antidotal information	• Quantification of PM removal • Impact on downwind receptors
Diet Manipulation (poultry)	Reduced crude protein level of nutritionally balanced diet; incorporation of certain feed additives into diet	• 10 to 40% ammonia reduction	• Quantification of odor reduction • Complete economic analysis
Manure Belt (layers)	Use of a manure belt to remove manure to a storage shed on a frequent basis vs. the more common practice of manure storage in a high-rise house and removed once a year.	• 80% ammonia reduction • 50% more expensive to build (MB houses)	• Quantification of odor reduction • Quantification of PM reduction
Manure separator scraper (swine)	Separates liquid and solid manure immediately after excretion.	• Reduces NH_3 • Reduces H_2S • Limited manufacturers currently	• Quantification of odor reduction
UV degradation	Use of UV light to degrade odorous compounds	• Strong odor reduction	• Tested on lab. Scale-up and pilot study needed.
Bio-scrubbers	Single or multiple stage filtration or treatment of odor/gases/PM-laden exhaust air	• Appreciable odor and gaseous reductions based on ongoing field evaluations in Europe	• On-farm evaluation under US/Iowa production conditions • Evaluation of system longevity, operational costs under US production conditions • Complete economic analysis
Topical application of certain treatment agents to manure storage	Application of certain chemical or natural treatment agents to manure storage (e.g., manure storage associated with the manure belt system, zeolite)	• Lab-testing has shown appreciable reduction in odor and gases of (laying hen) manure storage	• On-farm verification of efficacy and determination of application frequency • Design and testing of a mechanical system to apply the treatment agents • Complete economic analysis
Dietary Manipulation	Including: Manipulation of gut micro flora, addition of low levels of fermentable nonstarch polysaccharides, pH and buffering feed additives.	• Preliminary work shows ammonia reductions are typical.	• Odor documentation related to intensity and hedonic tone are not widely reported. • Evaluation of performance must be a part of a study.

[9] *Classification of Effective Odor Mitigation Techniques*, supra.

III. Conclusion

This memorandum is only a summary of a few of multiple studies regarding odor emitted from livestock operations. An interested reader is encouraged to consider the full studies for more information and further elaboration of the points presented here.

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