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Introduction

This paper addresses the economic feasibility of complying with the proposed rule of "a zero discharge requirement from the production area that does not allow for an overflow under any circumstances," presented as "Option 5" on page 3060 of the Federal Register (Vol. 66, No. 9, Friday, January 12, 2001). In the proposed rule, the EPA suggested the strategies of improved water management, covered storage or additional storage to meet the no discharge criteria. While improved water management and additional storage may aid in manure management, covered storage was viewed as the only way to guarantee compliance with the "no overflow under any circumstances" wording of the rule. EPA staff have repeatedly indicated that all swine manure storage structures would need to be covered in some way to meet the rule's requirements.

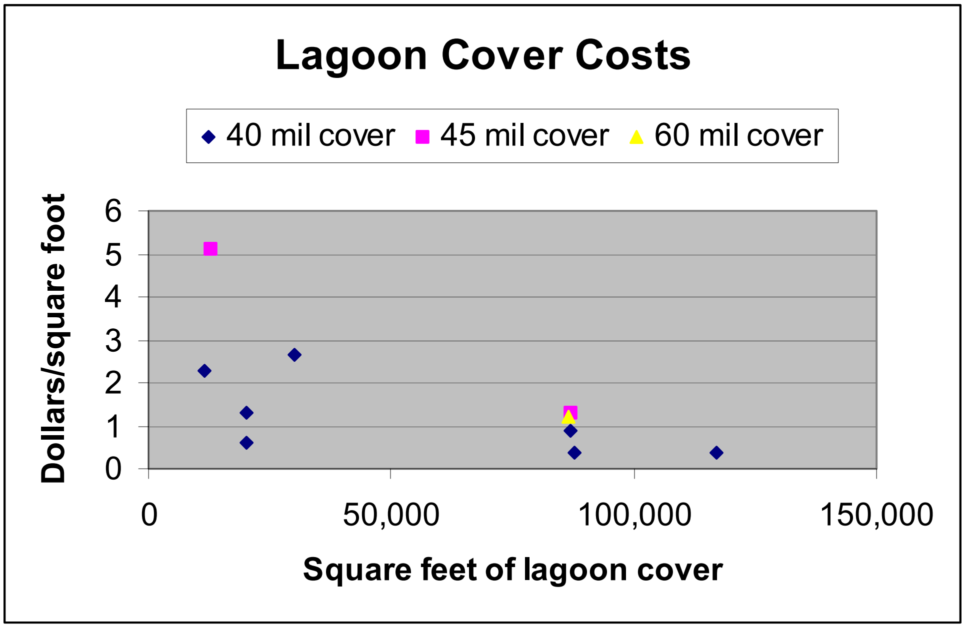
Initial Cover Costs

The number of manufacturers that make and install covers is unknown and experience with installation is small. The only data that are available to estimate the cost of covers is provided by the EPA Cost Methodology Report and a report from the AgStar Charter Farm Program. From the AgStar Charter Farm Program (Roos, et al.) lagoon cover summary data presented in figure 1 below, it appears that the EPA estimated cost of $4/square foot of cover is more than adequate.

The $4/square foot is for a complete system including design, mobilization, material and installation/attachment to the lagoon. Several system components are size independent so the cost/square foot decreases as size increases (see figure 1). It may be possible to acquire a cover for less than the $4/square foot used in the EPA assessment and in this report but uncertainties on warranty and additional retrofitting costs for covering existing lagoons argues for keeping the $4 estimate.

The initial cost of a cover would be a function of the size of the lagoon from berm midline to berm midline (as opposed to waterline). Factors that affect size include animal numbers and type, months of capacity, side slope and environmental factors such as rainfall and evaporation. To estimate the cost of lagoon covers the EPA listed the following assumptions: 1) 12 feet was the maximum depth, 2) side slopes for lagoons were 2:1 (horizontal to vertical), 3) the lagoon shape was square (EPA Cost Methodology Report for Swine and Poultry Sectors page 61)."

Figure 1. Lagoon cover costs as a function of size



The EPA assumptions estimate the lowest impact dimension and are likely to underestimate the cost of existing lagoons. The cost of covering existing lagoons will be greater than that for new construction to the extent that it requires additional engineering design to create the necessary support for the cover or the lagoon was larger than would have been designed if it were known from the beginning that it was to be covered.

A study of 19 lagoons in Missouri, North Carolina, Oklahoma and Pennsylvania indicated that only 2 (11%) had slopes of 2:1, as assumed by the EPA. A slope of 3:1 was most common and increases the size of the lagoon by moving the berm centerline away from the liquid line. Five (26%) of the 19 lagoons were square; the rest having length: width ratios closer to 2:1. While this does not increase the square foot of material needed it does increase the perimeter where anchoring occurs.

Other characteristics of existing lagoons that will potentially increase cover costs relative to new construction include: 1) irregular shapes that fit the topography, including berms on the upside to divert water from entering the lagoon, 2) larger designed sizes for greater storage (more than 12 month) or for evaporative purposes (arid regions).

Most lagoons in NC, MO and OK were designed for at least 12 months but the average monthly capacity of open storage structures in IA and PA is 7 months (Lory, et al.). The smaller size will require a smaller cover but any regulations against fall applied manure for spring planted crops will require larger (or second) structures to be built and covered. The impact on the capacity of lagoons in arid areas is unknown. Lagoons in arid areas use evaporation which would be prevented from occurring with an impermeable cover so the size may be insufficient to store the effluent for the designed storage period.

Assuming the EPA estimate of $4/square foot, the previously mentioned study of 19 swine facilities with lagoons finds that the cost of lagoon covers averages $539/AU with a range of $190 to $1,275/AU. This initial cost would be compared to a $50/AU rule of thumb for lagoon construction. Conversations with consultants indicate that this would be the maximum cost because the $4/square foot is generous. If the cost is estimated at $2/square foot, the average cost of lagoon covers is $269/AU.

For the EPA scenario of permitting operations as small as 300 AU, the smallest facility regulated could be expected to have an initial cost of $161,700. If this were 100% debt financed over 5 years at 8% interest, the annual principle and interest payment would be $40,500. The lagoon cover would generate no cash flow to put towards loan repayment. Increased expenses would need to come from existing revenue.

Fixed Costs

The annual fixed cost of depreciation (10 year life), interest (8%) and taxes and insurance (2%) of $539/AU would be $80.85/AU. Of the 19 operations with lagoons in the database, 5 were finishing facilities. Finishing facilities sell market hogs so the average lagoon cover cost can be reported as $6.05/cwt. of hog marketed. This can be compared to a historical 10-year (1990-1999) average live hog price of $42.57/cwt. Covers would constitute 14% of the cost (value) of production.

Uncertainties which exist regarding the annualized cost of a lagoon covers include:
1) the uncertain life of the lagoon cover, 2) repair and warranty costs, 3) the disposal cost of the lagoon cover and 4) any changes in liability insurance rates from having a lagoon cover.

The estimated life of the covers by the EPA is 10 years. Since 1996, 10 AgSTAR Charter Farms have been completed utilizing a variety of anaerobic digester systems. Insufficient time has elapsed to get an accurate estimate of the true life expectancy of the covers. Roos, et al. (1999) reports that 2 of the covers on 5 of these charter farms had problems of such extent that repair was not possible and replacement was required within the first year. The longest reported warranty included in the Roos et al. report for 40 to 60 mil HDPE covers is 2 years. The University of Missouri submitted comments to the EPA on January 15, 2002 detailing 12 lagoon cover failures in MO, OK, TX, NC, AR and VA. The covers were in place from several months to 4 years before they were destroyed or removed because of failure.

Conversations with 2 lagoon cover providers revealed that the cover failures in the Roos et al. report were due to using less than 40 to 60 mil covers. Their companies personally had installed covers on slaughter plant lagoons that have lasted over 10 years. One indicated that he would not be comfortable recommending less than a 60 mil HDPE cover for hog lagoons. Given additional time, a study of lagoon covers on processing plants might provide better cost information.

Given the possibility of cover failure, estimates of repair costs and length of warranties are critical. Again, given the limited experiences with covers, no repair cost coefficients are known. Roos et al. (1999) reports needed repairs to several covers but all were within the warranty period of the covers and no costs were reported. Roos, et al (1999) offers the following summary of warranty offerings from literature they have collected from manufacturers.

> "Warranties were offered for varying lengths of time. Warranties are generally limited to a per cent of the original cost, reduced by product age. Materials are warranted by their manufacturer for a period of 2 to 10 years, though some accompanying literature cited 20 year warranties. Fabrication was generally warranted 1 to 2 years. Several suppliers warranted cover design for a period of 1 year based on the recommended criteria for cover performance."

From a financial analysis perspective, the technology is untested enough that a less than 10 year life would be expected. The concern is not with the life of the material as much as with the durability of the fabrication given the winds and other vagaries that are expected to impact the cover. The annualized cost estimation would be higher than reported earlier for the cover.

The documented cases of lagoon cover failures list either allowing the failed covers to remained submerged in the lagoon or disposed of in a landfill. Submerged covers would eventually need to be removed when the sludge in the bottom of the lagoon is pumped. No costs were reported for the cost of landfilling the lagoon covers.

The last uncertain cost deals with potential increased liability insurance rates. Given the record of failures and the possibility of attempted repairs made on floating covers, liability insurance for employees involved in repairs needs to be investigated.

Operating Costs and System Changes

The EPA Cost Document estimates, without reference, 2% of the initial cost as annual operation and maintenance cost. Given our estimate of $539/AU for the cover, this would equal about $10.78/AU. Our estimates that follow concur with this cost estimate.

The addition of a cover to a lagoon affects the entire manure management system of the swine facility. It does not merely entail the addition of a cover with its attenuating fixed costs. Lagoon covers will affect the amount of effluent pumped, the nutrient content of the lagoon effluent, the type of machinery needed for application, the application rate and, potentially, the cropping system. This section outlines some of the potential cost increases and decreases associated with installing a lagoon cover.

Management and Training Expense

The documented experiences with lagoon covers indicate that they are not passive systems that can be installed and ignored. They will require careful attention to the integrity of the cover and its seals/anchors and to the collection of gases under the cover and water and sand on top of the cover.

Increased time associated with inspecting the cover, flaring off gases and pumping off precipitation from the surface would be expected to increase the annual management cost of a covered lagoon relative to an uncovered lagoon. In addition, the cover would increase other traditional management time spent on such activities as assuring that the effluent is leaving the production house and entering the lagoon (discharge pipe is not visible under cover) and measuring the depth of the lagoon (no depth marker).

No estimate is provided here for the cost/AU of increased management because no data on time differences was available.

Effluent Pumping Costs Differences

A cover prevents precipitation from entering the lagoon and water from leaving the lagoon through evaporation. Lagoons in rainfall abundant areas such as in Missouri and eastward would be expected to have less effluent to pump; lagoons in arid regions of the west would be expected to have more effluent to pump.

In the west, where additional effluent needs to be pumped and irrigation is the primary land application method, any additional expense would be associated with increased pumping time. If a center pivot is used, no additional pumping cost is expected because mixing effluent with fresh water is common. If a traveling gun is used, mixing is not common and additional pumping costs would be expected. The average variable cost of the additional pumping due to reduced evaporation for 2 farms, referenced in the Missouri study, using non-center pivot irrigation was $1.59/AU.

In some parts of the west, evaporative ponds are used that are never intended to be pumped. They exist were irrigation is not common and crop removal rates of nutrients is very low. Preventing evaporation and forcing land application of manure would create a need for these producers to find land that is productive enough to accept manure nutrients.

In rainfall abundant areas, less effluent will be pumped but the cost of land applying each gallon is expected to increase. Greater hauling distances and reduced application rates for the more concentrated effluent will likely require a switch from irrigation systems to tractor pulled tanker systems. Assuming a tractor pulled tanker and a custom application rate of $.011/gallon (with no charge for distance), the additional land application costs for 9 farms in the UM study database was $6.89/AU.

The above estimate of the changes in effluent pumping costs assumes that all precipitation caught on top of the impermeable cover is inexpensively pumped off the cover and allowed to run into a ditch or stream. Several comments by the EPA have indicated that they would like to insure that captured rainwater has not been contaminated by the lagoon. Any expense of testing captured precipitation, and possibly land applying it as manure due to contamination, would be additional to the estimate above. If the water captured on top of the lagoon would need to be treated as a waste product the cost of application would increase because more effluent will be pumped annually (due to no evaporation under the cover) and the expense per gallon would increase (due to the already mentioned distance and application rate changes).

Acreage and Application Time Changes

Uncovered lagoons typically can lose 80% or more of the nitrogen entering the lagoon through ammonia volatilization and other processes. Covered slurry storages typically experience 30% losses of nitrogen. Covering the lagoon with an impermeable cover will reduce gas exchange and likely increase the nitrogen retained by in the lagoon. Nitrogen losses in covered lagoons will likely be greater than slurry storages (30%) but less than existing uncovered lagoons (80%).

Increasing the nitrogen retention of the lagoon with a cover will necessitate additional land for manure application as the cover increases nitrogen content of the manure, regardless of whether a nitrogen limit or a phosphorus limit is imposed on the producer. The land requirements of lagoon systems are very sensitive to small changes in nitrogen retention by the lagoon. A 25% reduction in nitrogen loss from a lagoon (a decrease from 80 to 60% nitrogen loss) will double the land requirements for manure application. A reduction of nitrogen loss to 30% would require 3.5 times the land base needed with 80% loss.

To the degree that more acres must be accessed for land application of covered lagoon effluent, application costs are expected to rise due to increased transportation to reach more distant acres. Time to access these more distant acres could also increase the number of hours required to apply manure. Land availability and travel distance will probably impact eastern producers (NC and PA) most heavily because of their limited land base and the concentration of animals in their animal production regions.

Potential costs associated with increased acreage and time requirements include planting delays, compaction due to compaction associated with driving tractors or trucks on wet soils, planting less profitable crops in order to have adequate time to land apply effluent, increased permit nutrient plans costs for the additional acres receiving manure.

Accessing additional land associated with either the adoption of the phosphorus rule or covering lagoons can be very difficult for farmers with insufficient land. The worst case scenario is that no land would be available within an economical transportation distance – due either to other livestock operations competing for the land or neighbors who refuse to permit manure application on their land.

Financial and Business Considerations

The large expenditure for lagoon covers and the probable system changes they have on a farm creates several business and financial concerns. The first concern is whether or not an agricultural business would be willing to subsidize pork production from other enterprises. This concern, in its most basic form, is the assumption that the EPA made in the preamble to its proposed rule that both crop and livestock farm income would be available and usable to finance compliance with the rule. This is almost certainly not the case.

Large hog farms tend earn most of their income from pork production and will not have other income to assist with compliance costs. Small hog farms will not only be unwilling to subsidize pork production but will rather look at the increasing burden of environmental regulations as another reason to exit production altogether.

The changes in land application technology that might accompany lagoon covers will also fall heaviest on small to medium producers. Currently, irrigation technology for land application of effluent is inexpensive and fits in with other production systems. If covers increase the necessary transportation distance or change the consistency and nutrient concentration of the effluent away from irrigation technology, tractor and truck based systems will be necessary. Many small and medium sized producers do not have tractors large enough to pull either tankers or dragline injectors. Purchase of a large enough tractor would be prohibitive for their swine enterprise and unneeded by their cropping enterprises.

Custom application is a potential way that farmers will comply with switching from irrigation technologies. Custom application will be more expensive than irrigation technology but potentially less expensive than owning land application equipment. Custom application is most likely to increase in areas where a critical mass of producers exists in a geographic region to justify custom services. Farms isolated from other producers may have difficulty accessing custom services.

The EPA rule changes that would affect application for non-agronomic purposes, such as no fall application on spring planted crops, would affect the critical demand periods of custom applicators. If the custom manure application season is shortened, custom operators' fixed costs will increase as they are spread over fewer hours. Counteracting this is the potential to more fully use their fixed costs as demand increases.

The cash flow implications of the initial cost of lagoon covers have been mentioned earlier. The assumption was that financing would be available. Personal conversations with lenders in MO and OK indicate that they are reconsidering their lending policies to animal production facilities. Of particular concern is the idea of loaning money on a 10 year basis for facility construction (not just lagoon covers but all swine production buildings and equipment) given that the producer receives a 5-year permit. They are considering the wisdom of loan repayment periods longer than production permit lengths.

Government Assistance

The USDA has several assistance programs for livestock producers dealing with environmental issues. Their technical assistance in comprehensive nutrient management plans is growing but would likely be strained given the new rules. It is doubtful that the USDA would be able to meet the demand associated with covering lagoons in addition to the other assistance they would be giving to comply with the rule.

Federal cost share dollars dispersed by the USDA is a potential source of compliance cost assistance. Questions yet to be answered are: 1) what percentage would be cost shared? 2) what maximum dollar amount would be cost shared? 3) what size limitations would be set for eligibility for cost share dollars? and 4) how many cost share dollars is Congress and the President going to allocated to animal producers?

Other methods of Compliance

The USDA asked that other methods of compliance, aside from impermeable covers, be considered. While it appears that the EPA considers covers on all manure storage structures as the only viable way to comply, the following bulleted points are from Chapter 6 of the UM Commercial Ag Program comments to the EPA (Zulovich, et al. http://agebb.missouri.edu/commag/news/frindex.htm).

- The average incremental cost:sales ratio for obtaining 18-month storage capacity by adding a second storage cell is 7% for the farms using lagoon effluent storage in this study. Fifty percent of these farms would be in the EPA's Moderate to Financial Stress 3 categories.
- The average incremental cost:sales ratio for adding an emergency storage cell designed to contain a 10-year, 10-day frequency storm plus 30 days of manure and facility wastewater production is 1%. All of the lagoon system farms studied would be in the EPA's Affordable 1 category.

Economic Compliance of New vs. Existing Producers

There is little doubt that the zero discharge rule will be more difficult for existing operations than for new operations. Existing operations were designed as a system that considered expected nutrient concentration, effluent characteristics, land availability, cropping systems and financial constraints. An existing facility compelled to cover its lagoon would have higher costs for the cover since the original lagoon was not designed with a cover in mind and would have costs associated with changes to the land application system. An existing facility would have higher annual management and pumping costs because of changes to the system that were previously optimized for the nutrient content of uncovered lagoons.

If only new operations were expected to use impermeable lagoon covers, design of a total system would be easier. Producers would likely locate to areas where the cropping system and environment are more conducive to such a system and would start with the necessary equipment that is consistent with the size of the animal and cropping operation.

Economic Benefits to the Producer of Covered Lagoons

Covering a lagoon could provide economic benefit to producers by reducing fertilizer expenses (associated with increased nitrogen retention) and by capturing biogas that could be used as a fuel.

Necessary conditions that must exist for recognizing a fertilizer benefit from covered lagoons are 1) the producer has adequate land to receive the manure nutrients and 2) the manure is applied to crops needing nitrogen fertilizer. Few producers have been able to get neighbors to pay for manure nutrients and so they give them the manure as a way of getting rid of the manure. Farms in the Midwest that grow corn and soybeans in rotation may find that they are applying manure to soybean acres to have sufficient land to spread the increased nutrients. Manure spread on soybeans would experience no decreased fertilizer cost due to manure supplied nitrogen because soybeans require no nitrogen fertilizer.

The economics of biogas production and utilization are beyond the scope of this paper. An impermeable lagoon cover gives the ability to collect and utilize biogas which has the potential to reduce the producer's energy expense and possibly provide revenue from sell of electricity to utilities. Unfortunately, many of the potential biogas utilization are only partially realized with conversion of existing lagoons, which are oversized to provide storage of precipitation.

Environmental Benefits

Paul Shriner, EPA, sent the following response to a question regarding the calculation of environmental benefit of the zero discharge rule.

> "For proposal we did not calculate any *water benefits* of zero discharge, and only saw a small change [reduction] in air emissions because the form of N in the covered lagoon is generally volatile and some will be lost during lagoon pumpdown and land application. For final, we will use documented spills that occurred during heavy rainfall as a basis to generate water benefits. So far this appears to be a small number compared to the other benefits. (The no discharge standards are our current rule and thus are part of our baseline, so all benefits of a zero discharge standard are incremental benefits to no discharge standards)."

The question of environmental benefit is crucial to the zero discharge debate because it has the highest compliance cost associated with it and it has been deemed to provide little benefit, incremental to existing rules. The annualized compliance cost difference for all operations greater than 300 AU between option 2 and option 5 (assumed to be the cost estimated for zero discharge) reported in Table 10-5 of the Rule's Preamble is $1,038,000,000. It is amazing that a billion dollar compliance cost could be recommended with no estimated environmental benefit. The cost:benefit ratio is undefined as infinity.

It is beyond the scope of this paper but a theoretical model could be developed that looked at the risk of spills and the impact of a zero discharge rule on the environment. If, as seems to be the case, spills are more a factor of management than catastrophic weather events, a rule which increases managerial demands may actually decrease water quality by creating more management related spills while preventing few weather related spills.

Given the admittedly low incidence of documented spills, far less expensive methods of achieving environmental quality could be achieved. Possible solutions range from training on lagoon management to having producers purchase bonds/insurance to pay for cleanup from spills due to weather related events. Given the actuarial information such insurance should be inexpensive for most producers.

Static and Dynamic Analysis

Both the EPA estimation of costs and our estimation in this paper assumes a static system. Producers are assumed to continue seeking land application as the desired manure management scheme. Potential cost savings or realized economic benefits could be envisioned if whole system changes occurred. Were manure to be processed and markets developed many of the system costs mentioned above might not materialize. The cost of the cover, it appears, is not negotiable. It is the greatest cost to the system.

However, one dynamic scenario for the cost of applying covers actually increases their costs. If the zero discharge rule is achieved principally by impermeable lagoon covers, as many as 8,550 swine operations will be seeking covers (Table 10-6 of the Preamble) to be installed in a relatively short time period. Assuming that only ½ choose to install impermeable lagoon covers, the demand will surely cause many manufacturers to enter. In the absence of design standards (e.g. cover thickness) the experience of the AgStar program will be relived. Inappropriate covers will be installed that fail and, in the long run, end up costing more than if more expensive covers that had a higher probability of working were initially purchased.

Conclusion

We do not disagree with the EPA economic costs and benefit estimates. The economic costs will be very high. Additional costs of accessing land, increased management and system changes will be high. Benefits are likely to be low to zero (some estimate negative benefits due to increased spills from improper management).

We disagree that the costs are bearable by the industry. The EPA Notice of Data Availability reported that all farms with insufficient land base will experience financial stress complying with the zero discharge rule. Most existing facilities, regardless of land availability, when faced with putting on an impermeable lagoon cover will experience financial stress.

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