Chapter 6
AGRONOMIC AND ECONOMIC IMPACTS OF CONVERTING MANURE SYSTEMS

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6.2 EXECUTIVE SUMMARY

The USEPA proposed in December 2000 that swine facilities be subject to a zero discharge rule. The zero discharge rule would mandate that all open manure storage structures not be allowed, under any circumstances, to discharge manure from the structure. Specific assumptions and results of the zero discharge study are presented below.

- Annual agitation of covered lagoons was assumed rather than tri-annual agitation as mentioned in the EPA preamble, because 3-year accumulations of phosphorus make land application difficult to attain. Agitated covered lagoons were assumed to have the same total nutrient content as slurry manure.

- Land requirements for agitated, covered lagoon effluent applied according to a nitrogen rule increase 6 to 12 times over that of open, unagitated lagoons.

- Land requirements for agitated, covered lagoon effluent applied according to a phosphorus rule increase 25 to 53 times over than of open, unagitated lagoon effluent applied according to a nitrogen rule.

- Land application of agitated, covered lagoon effluent usually cannot be accomplished with irrigation systems because the elevated phosphorous content of the effluent requires an application rate that is lower than can be applied with most irrigation systems (average cost of $.006/gallon). A tanker or dragline application system will often be needed to achieve the low application rate (average cost of $.011/gallon).

- The average cost:sales ratio, for the farms in this part of the study, increased from 2% for open, unagitated lagoons to 32% for covered, agitated lagoons. Sixty seven percent of these farms are in the EPA Financial Stress 3 category; 33% would be in the EPA Moderate to Financial Stress 2 categories (depending on their cash flow and debt to asset ratio).

- 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.

- In this study, the average incremental cost:sales ratio for converting from lagoons to slurry storage tanks is 30%. Fifty percent of the farms are in the EPA Financial Stress 3 category; 33% would be in the EPA Affordable 2 to Financial Stress 2 categories (depending on their cash flow and debt to asset ratio).

6.3 INTRODUCTION

The USEPA proposed in December 2000 that swine facilities be subject to a zero discharge rule. The zero discharge rule would mandate that all open manure storage structures not be allowed, under any circumstances, to discharge manure from the structure.

Currently, lagoons are designed to store a specified amount of water. When these structures are permitted, they are afforded the opportunity of overflowing if a storm event larger than its design storm occurs. This opportunity is defined in the permit as an “upset and bypass” provision.

The USEPA does not mandate any particular technology to achieve the “zero discharge” rule but indicates that it believes that impermeable covers on lagoons would be the most cost effective manner to achieve the standard. This chapter evaluates the economic impact of various technologies to reduce the probability of an overflow. The technologies analyzed are: 1) using impermeable covers on agitated lagoons (see Section 5.4.2), 2) expanding storage capacity to 18 months, 3) building emergency storage, and 4) conversion to a slurry tank system. All analyses assumed application of effluent according to a rotational phosphorus rule (see Section 3.4).

6.4 PHYSICAL CHARACTERISTICS OF LAGOON EFFLUENT UNDER AN IMPERMEABLE COVER

Open lagoon cells volatilize nitrogen into the atmosphere and precipitate P_2O_5 into the sludge that collects at the bottom of the lagoon. The effluent that is pumped onto fields is nutrient dilute. The N: P_2O_5 ratio of lagoon effluent is also relatively balanced for use as a fertilizer on many crops (see Section 2.5.1).

Covering the lagoon with an impermeable cover prevents the volatilization of nitrogen into the air. The resulting nitrogen load in the lagoon then becomes very much like that of a slurry pit, which does not volatilize as much nitrogen as an open lagoon.

An impermeable lagoon cover prevents both evaporation of influent water from the lagoon and collection of rainwater into the lagoon. The volume of water in a lagoon with an impermeable cover will differ from an uncovered lagoon depending on the rainfall-evaporation factor for that geographic location. Covered lagoons in areas where rainfall exceeds evaporation will have less liquid volume than uncovered lagoons in the same area. Conversely, covered lagoons in areas where evaporation exceeds rainfall will have more liquid volume than uncovered lagoons.

Lagoon agitation is a recommended practice of the USEPA. In their economic analysis, they assume agitation every third year. Agitation every third year poses two problems. The first is that nutrient concentrations in the lagoon effluent vary greatly in the year of agitation and manure application equipment must be recalibrated. The second problem is that accumulating three years of phosphorus prior to agitation creates an effluent that has a higher phosphorus concentration. This concentrated effluent may not be able to be applied using equipment currently on the market.

An engineering manure storage design computer program was used to estimate the annual number of gallons and nutrient quantities in effluent that would be pumped from a covered lagoon. Table 6-1 presents the six farms modeled and provides a brief description of the swine production operation and the number of pounds of plant available nitrogen and phosphate expected from both the existing lagoon effluent and an agitated, covered lagoon effluent each year. The current management practice of these farms is not to agitate lagoons prior to pumping. The existing anaerobic lagoon effluent nutrient quantities listed in Table 6-1 assume no agitation of the lagoon effluent.

The quantity of nitrogen in the covered lagoon effluent increases due to the cover capturing nitrogen. The EPA recommends that agitation of the lagoon every three years accompany the installation of an impervious lagoon cover (Federal Register 3061). This study assumes annual agitation where the EPA assumed a 3-year interval. Annual agitation already produces a concentrated effluent that may be too phosphorous rich to be applied using irrigation equipment. Accumulating three years of phosphorus in the lagoon before agitating would make the concentration difficult to apply with typical manure application equipment.

Table 6-1. Estimated nutrient content of existing lagoons and covered lagoons for select farms.

Presentation Code	Production Type	Number of Animal Units	Existing Anaerobic Lagoon Plant Available N (lb/yr)	Existing Anaerobic Lagoon Plant Available P_2O_5 (lb/yr)	Covered Lagoon Plant Available N (lb/yr)	Covered Lagoon Plant Available P_2O_5 (lb/yr)
MO-4	Farrow to wean	818	6645	2355	39280	58879
MO-6	Feeder to finish	3200	31686	7752	194,517	175,830
NC-1	Nursery	304	2410	648	29212	25042
NC-4	Farrow to feeder	844	6227	2169	38719	51489
OK-1	Farrow to wean	200	1350	565	8,868	14,122
OK-8	Nursery	600	6521	1697	76611	90780

Notes: PAN_{lagoon} = (TKN*0.8) + (TKN*0.2*0.62)
PAN_{slurry} = (TKN*0.65) + (TKN*0.35*0.62)
Covered lagoon nutrients were estimated as identical to covered slurry storage.
Number of Animal Units calculated based on the EPA's proposed methodology.

Table 6-2 presents the nutrient concentration in lbs/1000 gallons for the existing open lagoons studied. Table 6-3 presents the nutrient concentration in lbs/1000 gallons for the modeled, agitated covered lagoon. Nutrient concentrations for the effluent from a covered lagoon were assumed to be the same as swine manure pit slurry. Values for covered lagoon were developed using the design model as if the operation was collecting and storing manure slurry in covered tanks. Both nitrogen and phosphorus concentrations were increased over a range of several magnitudes. The range of nitrogen and phosphorus in the open, unagitated lagoon is 0.5 to 16.6 lb/1000 gallons and 0.2 to 3.2 lbs/1000 gallons, respectively. The range of nitrogen and phosphorus in the covered, agitated lagoon is 4.0 to 224.0 lb./1000 gallons and 5.0 to 287.0 lbs./1000 gallons, respectively.

Table 6-2 and Table 6-3 also presents the estimated volume of effluent that would require application from each lagoon system. The volume in the covered lagoons, modeled as manure slurry, was less than that in all but one of the open lagoons. The one covered lagoon with greater effluent volume (OK-8) is located in western Oklahoma where evaporation far exceeds rainfall. The covered lagoon prevents both evaporation from leaving and rainfall from entering the lagoon.

Table 6-2. Average annual pumpdown and nutrient concentration of current lagoons.

Presentation Code	Current Lagoons		
	Annual Volume (gallons)	N Conc. (lbs/1000 gal)	P_2O_5 Conc. (lbs/1000 gal)
MO-4	1,787,886	4.0	1.3
MO-6	3,564,137	9.6	3.2
NC-1	851,444	1.5	0.6
NC-4	3,076,788	1.0	0.6
OK-1	2,988,239	0.5	0.2
OK-8	604,033	16.6	1.9

Table 6-3. Average annual pumpdown and nutrient concentration of covered lagoons.

Presentation Code	Covered Lagoons		
	Annual Volume (gallons)	N Conc. (lbs/1000 gal)	P_2O_5 Conc. (lbs/1000 gal)
MO-4	1,538,569	28.0	38.0
MO-6	2,790,224	80.0	63.0
NC-1	547,607	162.0	127.0
NC-4	1,159,365	39.0	44.0
OK-1	2,804,112	4.0	5.0
OK-8	1,635,433	224.0	287.0

Note: Estimated values above were modeled as if operation was using a manure slurry system.

6.5 LAND REQUIREMENTS

The average crop removal per acre of nitrogen and phosphorus for the 31 farms listed in Chapter 4, Appendix A is summarized in Table 6-4. These crop removal estimates assume that manure would be applied to a "composite" crop rather than an actual crop. For example, an acre of land in Missouri would consist of ½ corn and ½ soybean rather than just corn or just soybean.

Using the nutrient removal per acre for each respective state and the quantity of nutrients in each farm's lagoon (open and covered), the number of acres needed to land apply the manure was estimated. Covering the lagoon increased the average number of acres needed to land apply manure effluent based on a nitrogen rule from of 59 to 413 acres. The average additional land required is about 6 times for each farm; however, two farms (NC-1 and OK-8) needed 12 times as much land for land application of manure. Both of the swine operations needing 12 times as much land are nursery units.

Covering the lagoon increased the average number of acres needed to land apply manure based on a phosphorus rule from of 61 to 1829 acres. On average, each farm would need about 25 times more land but the two farms (NC-1 and OK-8) required 39 and 53 times as much land as was needed under a nitrogen rule, respectively.

Table 6-4. Crop nutrient requirements for application of lagoon effluent and slurry to land in a corn-soybean rotation.

			Existing Anaerobic Lagoon		Covered Lagoon	
Presentation Code	N Removal for respective state (lb/ac)	P removal rate for respective state (lb/ac)	Acres needed for N removal	Acres needed for P removal	Acres needed for N removal	Acres needed for P removal
MO-4	147	45	45	52	267	1308
MO-6	147	45	216	172	1,323	3907
NC-1	240	64	10	10	122	391
NC-4	240	64	26	34	161	805
OK-1	142	23	10	25	62	614
OK-8	142	23	46	74	540	3947

Note: Covered lagoon nutrients were estimated as identical to the nutrient content of covered slurry storage.

Applying manure to land controlled (owned or rented) by the CAFO is better than applying to non-controlled land. First, the CAFO realizes the fertilizer value of manure applied to controlled land. Second, the availability of the land for applying manure is more certain. Applying manure to land not controlled by the swine operation requires getting permission to apply manure and delivering the manure within the time constraints mandated by the receiving farmer.

Table 6-5 provides the current spreadable acres and the number of additional acres that would be needed for each of the modeled farms under both a nitrogen application limit and a rotational phosphorus application limit. The number of acres needed for land application increases due to the high nutrient concentrations in the covered lagoons Two farms have adequate acreage to land apply covered lagoon effluent according to a plant available nitrogen limit (MO-4 and OK-1). The other farms would need increased land area for manure application varying from 47% to 836% of the present land area used for manure application.

When covered lagoon effluent is applied according to a rotational phosphorus limit, none of the farms currently have enough controlled acres. They would need access to an average of ten times more land for manure application. The additional land needed had a range of 407% to 2910%.

Table 6-5. Controlled land vs. needed land for land application of covered lagoon effluent applied according to a rotational phosphorus limit.

Presentation Code	Spreadable Acres on Farm	N limit acres needed	Percentage increase	P limit acres needed	Percentage increase
MO-4	252	267	6%	1308	419%
MO-6	437	1,323	203%	3907	794%
NC-1	13	122	836%	391	2910%
NC-4	87	161	85%	805	825%
OK-1	121	62	0%	614	407%
OK-8	368	540	47%	3947	973%

6.6 MANAGERIAL AND ECONOMIC CONSIDERATIONS

Covering a lagoon affects the entire manure management system. In addition to land access, the producer must determine appropriate land application technology. Of the farms used in the zero discharge portion of this study, only MO-6 currently uses dragline technology. The other five farms currently use irrigation systems to land apply effluent.

MO-6 could continue to use dragline technology to land apply manure assuming that the necessary acres could be accessed by pipes and hoses. Applying effluent according to a rotational phosphorus rule, this operation would require eight times more land than is currently receiving lagoon effluent. All of the additional acres probably cannot be accessed with above ground pipe/hoses. Burying sufficient pipe would probably be cost prohibitive. If the additional land could not be accessed using pipes, a tanker transport system would need to be adapted to land apply the manure.

The concentration of N and P in the effluent requires application rates below what can practically be achieved using a typical effluent irrigation system. While irrigation equipment is sold that can pump at very low rates, the low pumping rate systems have a small swath width and would require more hours for setup and actual land application. The number of dedicated labor hours required for irrigation application of effluent with elevated nutrient concentrations is usually not practical. Farms using covered lagoons would probably convert to tanker technology in order to be able to apply at an appropriate rate and to access the additional acres needed to apply the effluent. The average custom application cost per gallon for operating a tanker according to the analysis in Chapter 4 was used to estimate the cost of effluent application from covered lagoons. The average custom application cost was $.011/gallon applied.

The cost of covering a lagoon considers the cost of buying the cover and the cost of land applying the manure. This will give an estimate of the incremental annual cost associated with the management practice. The cash flow implications of the initial investments for a lagoon cover and necessary additional equipment are discussed. The annualized cost of owning and operating the equipment overlooks the first year cash outlay that must be made in the form of a down payment and the subsequent years' payments being more accelerated than that shown in a 10-year annualized cost.

6.6.1 Initial Investment

The square foot of material needed to cover a lagoon was estimated as the area from berm midline to berm midline. The berm midline to berm midline area was used to provide an estimate of the largest potential cover size. If final economic analysis shows the largest potential cover size to be feasible, then a slightly smaller cover, depending upon installation, would be feasible. The EPA estimate of $4/square foot for impermeable covers (Cost Methodology Report for Swine and Poultry Sectors, p 61) was used to calculate the cover cost. Table 6-6 presents the initial cost and the annualized costs of impermeable lagoon covers for the six farms modeled. The annualized cost assumes a 10-year loan at 10% interest with a zero down payment and zero salvage value. It also includes 2% for taxes and insurance. No estimate of repair costs has been developed because of the geographic and structural variables affecting the technical feasibility of covers (Chapter 5).

Table 6-6. Cost for impermeable lagoon covers

Presentation Code	Cover Size (ft^2)	Initial Cost for Cover	Annualized Cost
MO-4	86,933	$347,732	$60,069
MO-6	319,790	$1,279,160	$220,969
NC-1	39,933	$159,732	$27,593
NC-4	186,624	$746,496	$128,954
OK-1	45,579	$182,316	$31,494
OK-8	76,388	$305,552	$52,783

Note: Cover size was assumed to be the area from berm centerline to berm centerline as given in Table 5-2.

Most farms using covered lagoons would need to purchase new application equipment because the application rate is lower than can reasonably be attained using present irrigation system technology and access to more acres is required for nutrient distribution. Table 6-7 indicates the initial investment necessary for purchasing a tanker system or a dragline system.

Table 6-7. Costs for application equipment components.

Equipment	Description (Size)	Dollar investment	Annual Ownership Cost
Tanker Technology			
Tractor	160 horsepower	$60,000	$10,365
Tanker	4250 gallon	$29,000	$5,010
Total		**$89,000**	**$15,374**
Dragline Technology			
Tractor	225 horsepower	$92,000	$15,893
Toolbar	15 foot	$11,000	$1,900
Drag hose	660 feet	$4,000	$691
Delivery Hose	660 feet	$2,200	$380
Total		**$109,200**	**$18,864**

Note: At least 2 draghoses will need to be purchased. The number of delivery hoses purchased will depend on the distance to the fields from the manure source.

Some CAFO operators may own tractors large enough to pull a tanker; while others will need to purchase a larger tractor. All operations will need to purchase either the tank or the dragline system components. Table 6-7 covers the cost of purchasing one tank or individual components of a dragline system. Most dragline systems require at least two drag hoses and two delivery hoses. The number of delivery hoses depends on the distance from manure storage to the application fields. The operations modeled needed from 391 to 3,947 acres (see Table 6-5) to apply effluent. The operations will probably require two to ten hoses for access to sufficient acres for spreading effluent. A booster pump is usually required for each mile increment greater than one mile when pumping effluent to draghose application systems. Booster pump investments and their associated operation costs are not included in this analysis. A second smaller tractor is often used to help manage the movement of hoses and this additional investment was not included in the analysis.

It is uncertain how farmers would finance these initial investments. Most equipment loans require a down payment and have a repayment schedule of three to seven years.

The lagoon systems used in this study show that farm NC-1 would have the smallest investment of $248,732 for an impermeable cover and tractor-pulled tanker. Farm MO-6 would have the largest investment of $1,368,160 for a cover and tractor pulled tanker.

A down payment of 30% would require farm NC-1 to have liquid cash assets of $104,620 in the year the change was implemented. This required liquid cash asset exceeds the $67,075 annual revenue from livestock production. This operation probably cannot finance the needed changes.

In the section estimating the annual cost of managing a covered lagoon, estimates did *not* include a down payment requirement or a loan repayment period of less than ten years. The USEPA Economic Analysis methodology of estimating annual ownership costs as the principle (or depreciation) and interest payments over a 10-year period at a 10% interest rate was used in the analysis.

The difference between evaluating true cash needs due to a down payment and an accelerated payment schedule as opposed to an annualized expense is that the annualized expense estimates profitability but not cash flow feasibility. An investment that is feasible from an annualized cost perspective may not be feasible from a cash flow perspective.

6.6.2 Nutrient Value

Table 6-8 presents the fertilizer value of the nitrogen and phosphorus contained in the lagoon effluents of both the existing open lagoon and the proposed covered lagoon. Potential nutrient values increased an average of 45 times by covering and agitating lagoons. The increased potential nutrient value comes from increased nitrogen quantity and part from recovering phosphorus from the sludge. The phosphorus value in the existing open lagoon has the same potential value as the phosphorous in the covered lagoon; however, the current management practice on the farms is to not agitate to recover the phosphorus in the sludge.

The realized value of the additional nutrients would benefit the producer if application is on land he owns or rents. Covering and agitating a lagoon increases the value of effluent on controlled acres by an average of 4.6 times. The value on controlled acres equaled the potential value for the existing lagoons because all manure was applied to controlled acres. Covering the lagoon forced most producers to apply most of the manure nutrients on non-controlled land and the increased value of the manure is not economically recovered.

Table 6-8. Nutrient value of open lagoons and covered lagoons for 6 US farms.

	Existing Anaerobic Lagoon		Covered Lagoon	
Presentation Code	Controlled Acres only	Potential value	Controlled Acres only	Potential Value
MO-4	$3,131	$3,131	$8,820	$45,795
MO-6	$8,723	$8,723	$15,295	$136,757
NC-1	$324	$324	$841	$25,324
NC-4	$1,204	$1,204	$5,631	$52,068
OK-1	$529	$529	$4,216	$21,392
OK-8	$1,600	$1,600	$12,821	$137,512

6.6.3 Annual Cost of Covered Lagoons

Table 6-9 presents the application and PNP costs of the current open lagoons for the farms detailed in Chapter 4. Chapter 4 used a comprehensive simulation model to estimate manure application and regulatory compliance costs.

The application costs for effluent from the covered lagoons is estimated using a custom rate of $.011/gallon of effluent pumped (see Table 6-3 for effluent volumes). This is the average tractor pulled tanker rate estimated in Chapter 4. The annual PNP costs are estimated based on the number of acres needed to apply the effluent. For the covered lagoon, the annualized cost of the lagoon cover is added to the application and PNP costs to arrive at the Total Annual Cost. The annual incremental cost is the difference between the current lagoon total annual cost and the covered lagoon estimated total annual cost.

Table 6-10 presents the estimated gross livestock revenue, total cost of manure management and the cost:sales ratio for the six modeled farms. The gross revenue was estimated by taking into account the number and type of animals raised and whether the producer was an independent producer or contract producer. Independent producers sold their animals at a 10-year market price. Contract producers received a premium for each animal raised based on contract specifications.

The average cost:sales ratio for the existing, open lagoon is 2%. The average cost:sales ratio increases to 32% for the same farms using a covered, agitated lagoon.

The EPA uses the incremental cost:sales as a criterion for determining the financial feasibility of the proposed regulations. The incremental cost:sales ratio averages 30% with a range of 7% to 78%. All but two of the farms used in this study would be in the EPA category of Financial Stress 3 by having a cost:sales ratio greater than 10%.

While an exact cash flow estimate was not made for each farm, the section above dealing with cash outlay in the initial year of compliance makes it clear that all farms would have difficulty with cash flow. The two Missouri farms not in the Financial Stress 3 category would probably be in Financial Stress 1 category.

This analysis shows that covering a lagoon presents a financial hardship to all operations currently using open lagoons. Most operations using lagoons would exit production because of an inability to comply with a “zero discharge” rule.

A “zero discharge” rule is also likely to have regional implications. Lagoons are more common in the southern US productions regions. Requiring lagoon covers will affect producers in these states more than producers in northern states.

A “zero discharge” rule will probably affect contract producers more than independent producers. Contract producers have smaller annual gross revenue because they are being paid for services and facility rent. Contract producers do not get paid the market value of the livestock they raise.

Table 6-9. Annual costs of application, permit nutrient plans and covering lagoons for 6 US swine farms.

	Existing Anaerobic Lagoon			Covered Lagoon				
Presentation Code	Application costs ($/year)	Annual PNP costs ($/year)	Total Annual Cost	Annualized Cover Cost ($/year)	Application Cost ($/yr)	Annual PNP Costs ($/year)	Total Annual Cost	Annual Incremental Cost ($/year)
MO-4	$10,123	$477	$10,600	$60,069	$16,924	$11,891	$88,884	$78,284
MO-6	$12,774	$525	$13,299	$220,969	$30,692	$35,162	$286,823	$273,524
NC-1	$2,439	$414	$2,853	$27,593	$6,024	$4,117	$37,734	$34,881
NC-4	$7,355	$434	$7,789	$128,954	$12,753	$8,237	$149,944	$142,155
OK-1	$5,426	$432	$5,858	$31,494	$30,845	$5,836	$68,175	$62,317
OK-8	$3,624	$417	$4,041	$52,783	$17,990	$36,540	$107,312	$103,271

PNP = permit nutrient plan and includes the cost of plan writing, soil sampling and record-keeping.

Table 6-10. Financial analysis of covering lagoons for 6 US swine farms.

		Existing Anaerobic Lagoon		Covered Lagoon		
Presentation Code	Gross Sales	Total Cost	Cost:Sales	Total Cost	Cost:Sales	Incremental Cost:Sales
MO-4	$1,110,689	$10,600	1.0%	$88,884	8.0%	7.1%
MO-6	$2,786,611	$13,299	0.5%	$286,823	10.3%	9.8%
NC-1	$67,075	$2,853	4.3%	$37,734	56.3%	52.0%
NC-4	$1,019,564	$7,789	0.8%	$149,944	14.7%	13.9%
OK-1	$337,201	$5,858	1.7%	$68,175	20.2%	18.5%
OK-8	$131,745	$4,041	3.1%	$107,312	81.5%	78.4%

6.7 ALTERNATIVE METHODS OF COMPLYING WITH THE ZERO DISCHARGE RULE

Lagoon covers were deemed to be the most economically feasible method by the EPA (Federal Register, p. 3060). Other ways of complying with the "zero discharge" rule include building second storage cells, building emergency storage cells or closing lagoons and building covered slurry storages. Each of these alternatives has an initial investment cost of constructing the modification and then distributing an increased volume or a more concentrated manure effluent. The construction costs, land application and PNP costs were estimated for the six operations used in the cover analysis. The financial cost:sales ratio analysis done for the cover analysis was completed for the three alternative options listed above.

6.7.1 Second Storage Cells

The technical information about second storage cells was presented in Section 5.4.3.1. The size of potential second storage cells necessary to expand storage capability to either 12 or 18 months is presented in Table 5-7. Since the EPA desires lagoons to overflow less often, the 18-month option presented in Section 5.4.3.1 was selected for the economic analysis presented below.

Table 6-11 gives the various costs for both the existing anaerobic lagoon system and the additional second storage cell. The annualized storage cost is estimated as the principle (or depreciation) and interest payments over a 10-year period at a 10% interest rate for the second storage cell construction costs given in Table 5-8. The annual application cost for the second storage cell was estimated as the existing application cost plus cost of pumping and irrigating the additional pumpdown volume presented in Table 5-8. The irrigation cost was estimated at $0.006 per gallon based on the average irrigation spreading cost from Chapter 4. The annual PNP costs were kept constant between the two scenarios because the total available manure nutrients were assumed to be constant. The cost of the effluent volume pumped was changed between the two scenarios.

The financial analysis of 18-month second storage cells is presented in Table 6-12. The EPA uses the incremental cost:sales ratio as a criterion for determining the financial feasibility of an option. The incremental cost:sales ratio averages 7% with a range of 1% to 27%. Results of the six operations studied are that three operations would be in the Affordable 1 category. One operation would be in the Moderate category and one in the Affordable 2 to Moderate category (depending on cash flow and debt to asset ratio). One operation would be in the Financial Stress 3 category.

Table 6-11. Annual costs of application, permit nutrient plans and building second storage cells for 6 US swine farms.

Presentation Code	Existing Anaerobic Lagoon			Second Storage Cell				
	Application costs ($/year)	Annual PNP costs ($/year)	Total Annual Cost	Annualized Cell Cost ($/year)	Application Cost ($/yr)	Annual PNP Costs ($/year)	Total Annual Cost	Annual Incremental Cost ($/year)
MO-4	$10,123	$477	$10,600	$6,319	$11,581	$477	$18,377	$7,777
MO-6	$12,774	$525	$13,299	$14,155	$15,611	$525	$30,291	$16,992
NC-1	$2,439	$414	$2,853	$8,975	$6,796	$414	$16,185	$13,332
NC-4	$7,355	$434	$7,789	$34,716	$25,796	$434	$60,946	$53,157
OK-1	$5,426	$432	$5,858	$14,591	$6,003	$432	$21,026	$15,168
OK-8	$3,624	$417	$4,041	$2,368	$3,624	$417	$6,409	$2,368

PNP = permit nutrient plan and includes the cost of plan writing, soil sampling and record-keeping.

Table 6-12. Financial analysis of constructing second storage cells for 6 US swine farms.

		Existing Anaerobic Lagoon		Second Storage Cell		
Presentation Code	Gross Sales	Total Cost	Cost:Sales	Total Cost	Cost:Sales	Incremental Cost:Sales
MO-4	$1,110,689	$10,600	1.0%	$18,377	1.7%	0.8%
MO-6	$2,786,611	$13,299	0.5%	$30,291	1.1%	0.6%
NC-1	$67,075	$2,853	4.3%	$16,185	30.8%	26.5%
NC-4	$1,019,564	$7,789	0.8%	$60,946	3.3%	2.5%
OK-1	$337,201	$5,858	1.7%	$21,026	7.9%	6.2%
OK-8	$131,745	$4,041	3.1%	$6,409	7.0%	3.9%

6.7.2 Emergency Storage Cells

The technical information about emergency storage cells was presented in Section 5.4.3.2. The size of the potential emergency storage cells for the six operations used in this portion of this study is presented in Table 5-9. Since the EPA desires lagoons to overflow less often, the emergency storage cell option presented in Section 5.4.3.2 can reduce the frequency of lagoon storage overflow. The economic analyses for emergency storage cells are presented below.

Table 6-13 gives the various costs for both the existing anaerobic lagoon system and the emergency storage cell. The annualized emergency storage cell cost is estimated as the principle (or depreciation) and interest payments over a 10-year period at a 10% interest rate for the emergency storage cell construction costs given in Table 5-9. The annual effluent application cost for the emergency storage cell was estimated as the existing application cost plus the cost of pumping and irrigating one tenth (10%) of the total liquid volume presented in Table 5-9. Ten percent of the volume was used to calculate the added annual effluent volume because the 10-year design frequency predicts that the emergency cell will fill one year of every ten years. Irrigation cost was estimated at $0.006 per gallon based on the average irrigation spreading cost from Chapter 4. The annual PNP costs were kept constant between the two scenarios because the total available manure nutrients were assumed to be constant. The effluent volume pumped was changed between the two scenarios.

The financial analysis of emergency storage cells is presented in Table 6-14. The EPA uses the incremental cost:sales ratio as a criterion for determining the financial feasibility of an option. The incremental cost:sales ratio averages 1% with a range of 1% to 2%. All lagoon operations in this portion of the study would be in the Affordable 1 category. Emergency storage cells, if approved as a method to improve environmental protection, should be financially feasible for most swine operations currently using anaerobic lagoons.

Table 6-13. Annual costs of application, permit nutrient plans and building emergency storage cells for 6 US swine farms.

	Existing Anaerobic Lagoon			Emergency Storage Cell				
Presentation Code	Application costs ($/year)	Annual PNP costs ($/year)	Total Annual Cost	Annualized Cell Cost ($/year)	Application Cost ($/yr)	Annual PNP Costs ($/year)	Total Annual Cost	Annual Incremental Cost ($/year)
MO-4	$10,123	$477	$10,600	$1,969	$10,918	$477	$13,365	$2,765
MO-6	$12,774	$525	$13,299	$5,800	$15,169	$525	$21,494	$8,195
NC-1	$2,439	$414	$2,853	$1,067	$2,861	$414	$4,342	$1,489
NC-4	$7,355	$434	$7,789	$4,062	$9,023	$434	$13,519	$5,730
OK-1	$5,426	$432	$5,858	$1,567	$6,055	$432	$8,054	$2,196
OK-8	$3,624	$417	$4,041	$1,642	$4,392	$417	$6,451	$2,410

PNP = permit nutrient plan and includes the cost of plan writing, soil sampling and record-keeping.

Table 6-14. Financial analysis of constructing emergency storage cells for 6 US swine farms.

		Existing Anaerobic Lagoon		Emergency Storage Cell		
Presentation Code	Gross Sales	Total Cost	Cost:Sales	Total Cost	Cost:Sales	Incremental Cost:Sales
MO-4	$1,110,689	$10,600	1.0%	$13,365	1.2%	0.2%
MO-6	$2,786,611	$13,299	0.5%	$21,494	0.7%	0.3%
NC-1	$67,075	$2,853	4.3%	$4,342	6.2%	2.0%
NC-4	$1,019,564	$7,789	0.8%	$13,519	1.3%	0.5%
OK-1	$337,201	$5,858	1.7%	$8,054	2.3%	0.6%
OK-8	$131,745	$4,041	3.1%	$6,451	4.9%	1.8%

6.7.3 Converting to Slurry Storage Tanks

The last option evaluated to comply with the proposed "zero discharge" rule was to convert the operation to a slurry manure system from the current anaerobic lagoon system. The size and estimated costs of a covered, circular slurry manure storage tank for the operations used in this analysis are presented in Table 6-15. The tanks were assumed to provide 12 months of storage capacity. The annualized cost is estimated as the principle (or depreciation) and interest payments over a 10-year period at a 10% interest rate for the initial costs of implementing the slurry tank system.

Table 6-15. Cost for covered circular slurry storage tanks.

Presentation Code	Storage Diameter (ft^2)	Initial Cost for Storage	Annualized Cost
MO-4	120	$214,433	$37,042
MO-6	160	$381,213	$65,853
NC-1	108	$173,690	$30,004
NC-4	72	$77,196	$13,335
OK-1	164	$400,512	$69,187
OK-8	128	$243,977	$42,146

Notes: Storages were assumed to be 20' deep and provided 12 months of storage for operation. Total initial cost of storages included actual total storage and cover costs. Storage cost was estimated as $0.10 per gallon of storage, and cover cost was estimated as $4.00 per ft^2 of tank surface.

Table 6-16 gives various costs for both the existing anaerobic lagoon system and the covered slurry storage tank. The annual application cost for the covered slurry storage system was estimated using the volumes presented in Table 6-3 and an average of $0.011 per gallon to apply manure slurry (Chapter 4). The PNP costs for the covered slurry storage were estimated based on the land area required for phosphorus removal of manure applied as slurry (Table 6-4). The required acres, as shown in Table 6-4, are based on a composite crop rotation use on the farms modeled in Chapter 4. The composite crop rotation concept is further discussed in Chapter 3.

The financial analysis of converting to a slurry manure system using a covered slurry storage tank is presented in Table 6-17. The EPA uses the incremental cost:sales ratio as a criterion for determining the financial feasibility of an option. The incremental cost:sales ratio averages 30% with a range of 3% to 70%. Based on the costs included in Table 6-17, one operation would be in the Affordable 1 category; two operations would be in the Affordable 2 to Financial Stress 2 category (depending on their cash flow and debt to asset ratios); and three operations would be in the Financial Stress 3 category. There are however, other costs and issues that will affect the feasibility of converting to a slurry manure system.

All costs to convert the operations to a slurry based manure system are not included in the analyses presented in Table 6-16 and Table 6-17. Other costs, not currently considered, include swine production facility conversion costs, manure transfer costs, and current lagoon closure costs. Swine production facility conversion costs would include costs to convert the current manure collection and handling system to slurry based system. Depending upon the current manure collection and handling system in the production buildings, converting to a slurry system could range from $0 to $10,000 per building. Each operation studied has multiple buildings; so building conversion costs could be a minimum of $40,000 per operation.

Added manure transfer costs include any costs for pumping manure into the slurry storage tank. If the site topography does not allow manure to gravity flow from the buildings into the top of the 20-foot tall tank, a pumping system will be required to transfer the manure from the buildings into the storage tank. Manure pumping systems can range from $25,000 to $35,000 per installation.

Lagoon closure costs must also be added to the analysis. Lagoon closure costs data is very limited. The EPA reported a cost of $42,000 lagoon closure cost based on very limited data (Federal Register, p. 3014). If the sludge removed from a lagoon must be land applied on an annual crop removal basis, the phosphorus concentration will require a large land area for spreading. Lagoon closure costs could become very expensive. Chapter 3 provides more information about the difficulties of applying large amounts of phosphorus at low application rates. Adding the costs not included in the current economic analysis might add $100,000 to the cost of converting from the current anaerobic lagoon system to a slurry storage system. This additional cost would probably relegate those swine manure lagoon system operations not already in the Financial Stress 3 category to the Financial Stress 3 category.

Another issue related to converting the current manure system to a slurry-based system includes land available for spreading manure nutrients. The increase in required acres from the current lagoon system to a slurry system can be seen in Table 6-4. The conversion will require a substantial increase in the number of required acres. The increased acres needed to apply slurry may not be readily available to a particular operation. If the land is not available, the operation is placed in a situation of not being able to comply with the proposed regulation change. Chapter 4 presents additional information about access to additional land areas for manure application.

Table 6-16. Annual costs of application, permit nutrient plans and converting to slurry storage tanks for 6 US swine farms.

	Existing Anaerobic Lagoon			Covered Slurry Storage Tank				
Presentation Code	Application costs ($/year)	Annual PNP costs ($/year)	Total Annual Cost	Annualized Tank Cost ($/year)	Application Cost ($/yr)	Annual PNP Costs ($/year)	Total Annual Cost	Annual Incremental Cost ($/year)
MO-4	$10,123	$477	$10,600	$37,042	$16,924	$11,891	$65,857	$55,257
MO-6	$12,774	$525	$13,299	$65,853	$30,692	$35,162	$131,707	$118,408
NC-1	$2,439	$414	$2,853	$30,004	$6,024	$4,117	$40,145	$37,292
NC-4	$7,355	$434	$7,789	$13,335	$12,753	$8,237	$34,325	$26,536
OK-1	$5,426	$432	$5,858	$69,187	$30,845	$5,836	$105,868	$100,010
OK-8	$3,624	$417	$4,041	$42,146	$17,990	$36,540	$96,676	$92,634

PNP = permit nutrient plan and includes the cost of plan writing, soil sampling and record-keeping.

Table 6-17. Financial analysis of converting to slurry storages for 6 US swine farms.

		Existing Anaerobic Lagoon		Covered Slurry Storage		
Presentation Code	Gross Sales	Total Cost	Cost:Sales	Total Cost	Cost:Sales	Incremental Cost:Sales
MO-4	$1,110,689	$10,600	1.0%	$65,857	5.9%	5.0%
MO-6	$2,786,611	$13,299	0.5%	$131,707	4.7%	4.2%
NC-1	$67,075	$2,853	4.3%	$40,145	59.9%	55.6%
NC-4	$1,019,564	$7,789	0.8%	$34,325	3.4%	2.6%
OK-1	$337,201	$5,858	1.7%	$105,868	31.4%	29.7%
OK-8	$131,745	$4,041	3.1%	$96,676	73.4%	70.3%