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Cost and Returns Analysis of Manure Management Systems Evaluated in 2005 under the North Carolina Attorney General Agreements with Smithfield Foods, Premium Standard Farms, and Front Line Farmers

TECHNOLOGY REPORT: ISSUES AEROBIC BLANKET SYSTEM (ABS) (ISSUES CARROLL'S)

Prepared as Part of the Full Economic Assessment of Alternative Swine Waste Management Systems Under the Agreement Between the North Carolina Attorney General and Smithfield Foods

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Summary of Results

Retrofit Cost per 1,000 pounds Steady State Live Weight per year: $95.02
Standardized Feeder-to-Finish Farm with 4,320 head (Tables ABS.29- ABS.37)
10-Year Amortization, Pit-Recharge, N limited Irrigation onto Forage

Includes:	Manure Evacuation:	$ 1.86 / 1,000 lbs. SSLW / Yr.
	Aeration (IESS) Cell:	$ 74.67 / 1,000 lbs. SSLW / Yr.
	Aerobic Blanket System:	$ 20.87 / 1,000 lbs. SSLW / Yr.
	Equalization Tank:	$ 0.61 / 1,000 lbs. SSLW / Yr.
	Control System:	$ 0.89 / 1,000 lbs. SSLW / Yr.
	Return to Barns:	$ 1.43 / 1,000 lbs. SSLW / Yr.
	Decreased Land Application Cost:	$ -5.31 / 1,000 lbs. SSLW / Yr.

Range:	Across Farm Sizes and Types (Pit-Recharge):	$38.79 To 597.29 / 1,000 lbs. SSLW / Yr.
	Across Farm Sizes and Types (Flush):	$42.77 To 675.03 / 1,000 lbs. SSLW / Yr.

Confidence in Estimates:

Low-Medium to Medium

Based on data collected during 9 months evaluation, real commercial setting data for treatment effects and construction expense. Limited or no data available for electricity use and cumulative effects on nutrient concentration in existing lagoon over time.

Costs by Category:

Direct Construction:	$ 52.42 / 1,000 lbs. SSLW / Yr.
Contractor Overhead	$ 21.58 / 1,000 lbs. SSLW / Yr.
Total Operating:	$ 26.33 / 1,000 lbs. SSLW / Yr.
Decreased Land Application Cost:	$ -5.31 / 1,000 lbs. SSLW / Yr.

Sensitivity Analysis

Effect of Expected Economic Life, Interest Rate, and Overhead Rate on Predicted Annualized Construction and Overhead Cost ($ / 1,000 lbs. SSLW)

		Overhead Rate	
Capital Recovery Factor (CRF)		20 %	43.1 %
Low-Cost Projection (15-year economic life, 6 % interest rate)	0.1030	$44.19	$52.18
Baseline Cost Projection (10-year economic life, 8 % interest rate)	0.1490	$62.43	**$74.00***
High-Cost Projection (7-year economic life, 10 % interest rate)	0.2054	$84.73	$100.67

* This predicted cost was estimated using the assumptions that are applied throughout the report—10-year economic life, 8 % interest rate, and 43.1 % overhead rate.

Effect of Electricity Price on Predicted Annual Operating Cost ($ / 1,000 lbs. SSLW)

Electricity Price ($ / kWh)	Predicted Annual Operating Cost ($ / 1,000 lbs. SSLW)
Low-Cost Electricity ($0.06 / kWh)	$22.14
Baseline Cost of Electricity ($0.08 / kWh)	**$26.33***
High-Cost Electricity ($0.10 / kWh)	$30.52

* This predicted cost was estimated using the assumption that is applied throughout the report--$0.08 / kWh.

The sensitivity of predicted costs and returns to a few critical assumptions is illustrated above by recalculating **annualized construction and overhead cost** with lower and higher values for amortization rate (cost recovery factor) and for overhead rate. The number in bold face, $74.00, is the predicted 2004 annual construction and overhead cost for the ISSUES aerobic blanket system technology on a 4,320-head feeder to finish farm with pit-recharge and nitrogen-limited land application to forage. Numbers are recalculated using two overhead rates: 20% and 43.1%, and three combinations of interest rate and maximum expected economic life: 15 year life and 6% interest rate, 10 year life and 8% interest rate, and 7 year life and 10% interest rate. The range of selected parameter values has a significant effect on the predicted annual construction and overhead costs.

Similarly, predicted **annual operating costs** of the ISSUES aerobic blanket system technology are recalculated using higher and lower prices for electricity. The 25% increase or decrease in electricity price has a significant effect (plus or minus $4.19 per 1,000 pounds SSLW per year or about 16%) on the predicted annual cost reflecting significant electricity use by the blower in the aerobic cell.

Note that the sensitivity analysis is not intended to propose alternative costs and returns estimates. It is solely intended to illustrate the sensitivity of the results to changes in parameter values.

Break-even Analysis on By-product Prices

Breakeven analysis is conducted for systems that produce potentially marketable by-products in order to determine the by-product price required to cover the cost of the system. As constructed and demonstrated at Carroll's Farm #2529, the ISSSUES aerobic blanket system technology has no marketable by-products.

1. Introduction and Farm Description

The Innovative Sustainable Systems Utilizing Economical Solutions (ISSUES) technology was a three-component program in which separate systems were constructed and tested at each of three farm sites. The economic analyses for the ISSUES systems will be reported in three separate documents. The following economic analysis is for the aerobic blanket system (ABS) component of the ISSUES technology.

The aerobic blanket system was constructed on Carroll's Farm #2529 in Duplin County, North Carolina. Carroll's Farm was originally constructed as 1,000-sow farrow-to-finish operation with a total finishing space of 6,480 head (9 houses of 720 head each). The farm was later converted to all finishing houses. The ABS technology handled the flushed manure from 9 finishing houses, or 6,480 head (874,800 pounds of SSLW). The finishing houses at Carroll's Farm #2529 were mechanically ventilated and used a flush system of manure removal.

2. Technology Description

Approximately 50,000 gallons per day of flush water was pumped from the finishing barns to the first-stage lagoon at Carroll's Farm #2529. The flushed wastewater underwent anaerobic digestion while in the first-stage lagoon. The same volume was subsequently fed into a 4.8-million gallon aeration (IESS) pond for additional reduction in oxygen demand. The aeration pond constructed and operated at Carroll's Farm #2529 was designed and installed by International Ecological Systems and Services (IESS) in Hilton Head, South Carolina. This aeration pond was divided into two cells by an impermeable membrane baffle curtain that has a flow-through section. Submerged biofilters were constructed on either side of the curtain for attached growth of nitrifying bacteria. Each biofilter was constructed of plastic sheet media with a specific surface area of 48 $ft.^2$ / $ft.^3$ and a total volume of 288 $ft.^3$. Aeration was provided by a 30-HP blower. Each cell of the aeration pond was equipped with fine bubble diffusion aeration tubing that lay on the bottom of the pond. Cell #1 had 12 air lines, while Cell #2 had 4 air lines to provide aeration. In total, about 3,500 feet of fine bubble diffuser line was installed in the aeration pond at Carroll's Farm #2529. Submersible sewage pumps were used to pump liquid from the first-stage lagoon to the aeration pond (1-HP) and from the aeration pond to the flush tanks (2-HP) (Westerman, et al.). A portion of the treated water (3,000 gallons per day) was sent to a 3,000-gallon conditioning/equalization tank and subsequently fed into the aerobic blanket system. The aerobic blanket system was proposed to include 32 nozzles, but only 24 nozzles were operable at Carroll's Farm #2529. Treated wastewater, along with pressurized air, was pumped daily to each nozzle to form a mist cover on top of the existing first-stage lagoon. A 7.5-hp compressor was used to pressurize air and store it in a 660-gallon buffer tank. A 1.5-HP liquid pump was used to feed the nozzles at 25 gallons per minutes (about 2 hours of pumping time per day) (Dugba(a)). Of the 50,000 gallons that were pumped into the aeration pond every day, approximately 35,000 gallons were returned to the flush tank, 3,000 gallons were

sent to the aerobic blanket system, and 12,000 gallons were land applied (or sent to the first-stage lagoon for eventual land application). The entire system was controlled automatically using a WinPLC-based automation unit.

The unit processes associated with the aerobic blanket system as constructed and operated at Carroll's Farm #2529 are:

1.) manure evacuation modifications
2.) aeration cell
3.) equalization tank
4.) aerobic blanket system
5.) return to barns
6.) control system
7.) land application of liquid effluent

3. Mass Balances and Performance Data (Tables ABS.1-ABS.2)

Evaluation and performance verification of the aerobic blanket system began in February, 2004 and concluded in October, 2004. A total of 9 sampling events occurred during this time period. Table ABS.1 reports the nutrient and dry matter content of the wastewater stream at different stages of the aerobic blanket system technology. Lagoon and lagoon ABS sampling points were from two areas within the first-stage lagoon: one sampling point from the side of the lagoon containing the aerobic blanket system and one sampling point from the side of the first-stage lagoon without the aerobic blanket. The data in Table ABS.1 indicates that the nutrient content of the wastewater in the two first-stage lagoon sampling points is very similar (the addition of 3,000 gallons of ABS mist does not have a significant effect on the relative composition of the misted part of the lagoon). Table ABS.1 also reports the nutrient concentration in both the aeration pond and the ABS mist. The samples for these streams are also very similar in nutrient content (as the ABS mist is pumped from the aeration cell before being briefly retained in an equalization tank). Table ABS.2 reports the mass balance of nutrients for the aerobic blanket system technology. TKN was reduced by 33% and P was reduced by 50% by the aerobic blanket system at Carroll's Farm as measured by comparing the mass balance of nutrients exiting the barns to the mass balance of nutrients entering the barns in flush water (Bull, Worley-Davis).

4. Costs of the ISSUES Aerobic Blanket System Technology as Constructed at Carroll's Farm #2529

4.1. Invoiced Construction Costs at Carroll's Farm #2529 (Tables ABS.3-ABS.7)

Reported cost estimates (Tables ABS.3-ABS.7) were based on cost invoices provided by Cavanaugh and Associates. The invoiced costs for the ISSUES aerobic blanket system

technology as constructed at Carroll's Farm #2529 were separated into unit processes by Cavanaugh. Because some components were already in place at Carroll's Farm #2529 (e.g., aeration cell excavation and liner), the costs invoices provided by Cavanaugh do not represent the total cost of the ISSUES aerobic blanket system technology.

Table ABS.3 reports the costs associated with manure evacuation/lift station modifications. Aeration pond construction costs are reported in Table ABS.4. Table ABS.5 reports the costs associated with the aerobic blanket system. Table ABS.6 lists the invoiced costs of the control system, along with miscellaneous costs (e.g., return to barns and consulting fees) of the aerobic blanket system technology Table ABS.7 summarizes the invoiced construction costs of the ISSUE aerobic blanket system technology as demonstrated at Carroll's Farm #2529. Total invoiced cost of the ISSUES aerobic blanket system technology was $205,018 (Table ABS.7). The aeration/IESS pond accounted for the largest percentage of this total invoiced cost, with a unit process cost of $140,979 (see Table ABS.4), or 68.8% of the ISSUE aerobic blanket system technology's total invoiced construction cost.

4.2. Modified Construction Costs at Carroll's Farm #2529 (Tables ABS.8-ABS.9)

Tables ABS.8 and ABS.9 describe cost modifications that were made to the invoiced costs listed in Tables ABS.3-ABS.7. These modifications were made in order to remove research-related or unnecessary expenses from the technology's invoiced costs. Determining which, if any, costs to modify was based on the discretion of the economics team after meetings with the technology providers and examination of the cost invoices received from Cavanaugh. Table ABS.8 lists the costs that were modified as well as the reason for the change. In Table ABS.9, a revised invoiced cost summary is shown. The total modified invoiced costs for the ISSUES aerobic blanket system technology decreased to $199,691; a $5,327 reduction (~ 2.5%) from the total reported in Table ABS.7.

5. Cost Modeling (Tables ABS.10-ABS.57)

5.1. Introduction

Original invoice costs were reported detailing the construction costs of the ISSUES aerobic blanket system technology as it was built on Carroll's Farm #2529. These costs are reported by unit process in Tables ABS.3-ABS.7 and summarized in total in Table ABS.8. Modified construction costs were also determined based on meetings between the technology providers and the economic modeling team. The modified costs are reported in Table ABS.8 and total modified construction costs are summarized in Table ABS.9. In the next step, the economic modeling team examined the data reported in Tables ABS.3-ABS.7 for missing components and outdated prices. Specifically, for the ISSUES aerobic blanket system technology, excavation and liner costs were added for

the aeration cell. The resulting complete estimate of construction cost is intended to approximate adjusted invoiced cost that can be compared to those for other technologies analyzed under the Agreement. These approximated invoiced costs are summarized in Tables ABS.11-ABS.19. In the next step, estimates of costs that would occur on standard (representative) North Carolina farms were calculated. Necessary modeling assumptions used in the cost standardization process are described in Section 5.2 and in Table ABS.10. These costs are presented in Tables ABS.20-ABS.28 for a 4,320-head feeder-to-finish facility using a flush system of manure removal. Tables ABS.29-ABS.37 present the costs associated with a standard North Carolina feeder-to-finish operation with a head capacity of 4,320 using a pit-recharge system of manure removal. A representative NC 8,800-head feeder-to-finish facility with a flush system for manure removal is reported in Tables ABS.38-ABS.46. The final standard NC farm described in these cost tables is a 4,000-sow farrow-to-wean operation using a flush system of manure removal. Tables ABS.47-ABS.55 list the costs associated with using the ISSUES aerobic blanket system technology at this representative facility.

5.2. Standardized Modeling Assumptions (Table ABS.10)

Table ABS.15 lists some assumptions that were used in constructing the cost models for the ISSUES aerobic blanket system technology. These assumptions were based on design equations found in the permit application and obtained in meetings that the economics team had with the principal investigators and technology providers.

The aeration cell was sized using a 30-day hydraulic retention time. It was assumed that 100% of the manure flushed from the houses would enter the aeration cell (after first entering the first-stage lagoon). The aeration cell had a total depth of 12 feet, including 11 feet of treatment depth and a 1-foot freeboard. The HDPE liner cost for the aeration cell was modeled using a function used in other standardized models for technologies with HDPE liners. The calculated liner cost was a function of liner surface area and the number of penetrations made to the liner. Fine bubble diffuser lines were assumed to be placed every 13 feet along the bottom the aeration cell. This was determined based on the number of diffuser lines used in the Carroll's Farm #2529 aeration pond and the amount of wastewater/COD that was being treated in that pond. The number of Bactivators (water treatment system) was also determined based on conditions at the Carroll's Farm #2529 aeration pond. A 30-HP blower was used at the Carroll's Farm aeration pond. Based on design equations in the permit application, it was shown that a 16.4-HP blower would have been sufficient to aerate the amount of wastewater/COD entering this cell. Using the design equation (and the 16.4-HP estimate), the amount of HP for a given-sized aeration cell was modeled based on COD production levels at the barns. Blowers were added to the aeration cell in multiples of 15-HP. The aerobic blanket system was not scaled. Regardless of the size or type of farm, it was assumed that 3,034 gallons of aeration pond effluent were diverted to the equalization tank and ABS. Because of this assumption, the cost of the aerobic blanket system (and equalization tank) is fixed across sizes and types of farms.

There are no costs associated with the first-stage lagoon in either the actual or standardized costs and returns models. All permitted North Carolina hog farms will have an existing lagoon, so no incremental costs will be incurred for this unit process

5.3. Estimated Adjusted Invoice Costs for ISSUES Aerobic Blanket System Technology at Carroll's Farm #2529 (Tables ABS.11-ABS.19)

Table ABS.11 lists the assumptions (6,480-head finishing facility with flush system) for the cost estimate calculation and also summarizes annualized costs by land application scenario (nitrogen-based application to forages, nitrogen-based application to row crops, phosphorus-based application to forages, and phosphorus-based application to row crops).[1] Annualized costs for the whole farm and per 1,000 lbs. of SSLW (incremental cost) are reported. Table ABS.11 presents annualized incremental costs for each of the four land application scenarios that range from $92.29 (phosphorus-based application to row crops) to $103.36 (nitrogen-based application to forages). Nitrogen-based land application is more costly than phosphorus-based application and application to forages is more costly than application to row crops with the ISSUES aerobic blanket system technology as modeled at Carroll's Farm #2529. Tables ABS.12-ABS.17 summarize costs associated with individual unit processes of the ISSUES aerobic blanket system technology. Costs are reported for the following unit processes: manure evacuation and lift station (ABS.12), aeration (IESS) cell (ABS.13), aerobic blanket system (ABS.14), equalization tank (ABS.15), control system (ABS.16), and return to barns (ABS.17). Table ABS.17 also reports the total costs associated with the unit processes listed above. Total construction costs are predicted as $422,117, while annual operating costs are estimated as $26,031. The total annualized cost of the ISSUES aerobic blanket technology before land application is estimated to be $91,308 for the 6,480-head feeder-to-finish facility at Carroll's Farm #2529. Table ABS.18 (lagoon effluent) reports land application costs associated with the ISSUES aerobic blanket system technology. Used in conjunction with the numbers reported at the end of Table ABS.17, the total annualized and incremental cost estimates are calculated and reported in Table ABS.11 for each of the four scenarios of land application. Table ABS.19 details the mass balance of nutrients associated with the ISSUES aerobic blanket system technology. The mass balance estimates are used to derive additional land application costs in Table ABS.18.

5.4. Standardized Costs for ISSUES Aerobic Blanket System Technology at a 4,320-Head Feeder-to-Finish Farm with Flush System (Tables ABS.20-ABS.28)

Tables ABS.20 to ABS.28 provide estimates of the cost of constructing and operating the ISSUES aerobic blanket system technology on a standard (representative) North Carolina farm. The representative farm reported in this section is a 4,320-head feeder-to-finish facility using a flush system for manure removal. Table ABS.20 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs for retrofitting the farm with standardized ISSUES aerobic blanket system technology. The standardized incremental

[1] For more on land application, see Appendix B in the Combined Appendices Report.

costs range from $90.26 (phosphorus-based application to row crops) to $99.90 (nitrogen-based application to forages), with an average incremental cost of $95.35 per 1,000 lbs. SSLW per year across the four land application scenarios. In the standardized ISSUES aerobic blanket system model, forages are more costly than row crops to land apply and nitrogen-based land application is more costly than phosphorus-based land application. Tables ABS.21-ABS.26 report standardized costs for the same unit processes (in the same order) as seen in Tables ABS.12-ABS.17. Within certain unit processes, there are differences in individual components between the actual and standardized models. In these cases, the technology as it was constructed at Carroll's Farm #2529 was not indicative of how it would be constructed on a representative NC farm. Table ABS.26 also summarizes the predicted total costs associated with the standardized ISSUES aerobic blanket system technology for a 4,320-head finishing facility with a flush system. Total construction costs are estimated at $297,374, while total annual operating costs are predicted as $15,671. Total annualized costs before land application are estimated at $61,356 for this representative farm size and type. Table ABS.27 (lagoon effluent) summarizes the land application costs predicted for this model for each of four scenarios. Table ABS.28 provides an estimated mass balance of nutrients for this representative NC farm size and type.

5.5. Standardized Costs for ISSUES Aerobic Blanket System Technology at a 4,320-Head Feeder-to-Finish Farm with Pit-Recharge System (Tables ABS.29-ABS.37)

Tables ABS.29- ABS.37 provide estimates of the cost of constructing and operating the ISSUES aerobic blanket system technology on a standard (representative) North Carolina 4,320-head feeder-to-finish facility using a pit-recharge system for manure removal. The only difference between the standard farm chosen to calculate the numbers in Tables ABS.29-ABS.37 versus the one chosen to estimate the numbers in Tables ABS.20-ABS.28 is the type of manure removal system used. Table ABS.29 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs for the standardized ISSUES aerobic blanket system technology. The standardized incremental costs of retrofitting the farm with the ISSUES aerobic blanket system technology range from $85.38 (phosphorus-based application to row crops) to $95.02 (nitrogen-based application to forages), with an average incremental cost across the four scenarios of $90.47 per 1,000 lbs. SSLW per year. Forages are more costly than row crops for land application and nitrogen-based applications are more costly than phosphorus-based applications. The use of the pit-recharge system of manure removal decreases average incremental cost estimates by about 5.1% for a 4,320-head finishing facility as compared to using a flush system on the same facility. Tables ABS.30-ABS.35 list the costs of individual unit processes in this standardized model. The set of unit processes and components are identical to those in Tables ABS.21-ABS.26, while some of the costs change between the two sets of tables. Table ABS.35 also summarizes the total costs associated with the standardized ISSUES aerobic blanket system technology for a 4,320-head finishing facility with a pit-recharge system. Total construction costs are estimated at $280,407, while total annual operating costs are reported as $15,355. Total annualized costs before land application are estimated at $58,512 for this representative farm size and type. Table ABS.36 (lagoon

effluent) summarizes the land application costs associated with this standardized model for each of four scenarios. Table ABS.37 provides an estimated mass balance of nutrients for the representative farm modeled in these tables.

5.6. Standardized Costs for ISSUES Aerobic Blanket System Technology at an 8,800-Head Feeder-to-Finish Farm (Tables ABS.38-ABS.46)

Tables ABS.38- ABS.46 provide estimates of the cost of constructing and operating the ISSUES aerobic blanket system technology on a standard (representative) North Carolina 8,800-head feeder-to-finish facility using a flush system for manure removal. Table ABS.38 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs for retrofitting a farm with the standardized ISSUES aerobic blanket system technology. The standardized incremental costs for the 8,800-head finishing facility range from $56.82 (phosphorus-based application to row crops) to $65.81 (nitrogen-based application to forages), with an average incremental cost of $62.05 per 1,000 lbs. SSLW per year across the four scenarios. This average incremental cost is about 35% less than that of a standardized 4,320-head finishing facility with a flush system. Based on this finding, the model suggests that economies of scale are present for the ISSUES aerobic blanket system technology when moving from one medium-sized farm to another. The next sections show that more significant economies of scale are predicted when moving from small farms to large farms (or, to a lesser degree, small farms to medium farms). The 36% cost reduction is overstated because the aerobic blanket system is not scaled (modeled to treat 3,034 gallons per day on both the 4,320-head and 8,800-head standard farms). However, the aeration pond does exhibit economies of scale when moving to the larger farm. Tables ABS.39-ABS.44 list the costs of individual unit processes in this standardized model. The set of unit processes and components are identical to those in Tables ABS.21-ABS.26 and ABS.30-ABS.35 although some of the costs change between the sets of tables. Table ABS.44 also summarizes the total costs associated with the standardized ISSUES aerobic blanket system technology for an 8,800-head finishing facility. Total construction costs are estimated at $390,081, while total operating costs are reported as $26,478. Total annualized costs before land application are estimated at $86,391 for this representative farm size and type. While these total construction costs are higher than in the standardized 4,320-head model, the costs per unit are lower. That is because the 8,800-head facility contains 1,188,000 pounds of steady-state live weight (SSLW) as compared to the 583,200 pounds of SSLW housed in the 4,320-head facility. Table ABS.45 (lagoon effluent) summarizes the land application costs associated with this standardized model for each of four scenarios. Table ABS.46 provides predicted mass balance of nutrients for the representative farm modeled here.

5.7. Standardized Costs for ISSUES Aerobic Blanket System Technology at a 4,000-Sow Farrow-to-Wean Farm (Tables ABS.47-ABS.55)

Tables ABS.47- ABS.55 provide estimates of the cost of constructing and operating the ISSUES aerobic blanket system technology on a standard (representative) North Carolina

4,000-sow farrow-to-wean operation using a flush system for manure removal. This representative farm contains 1,732,000 pounds of SSLW: the largest of any standard farm modeled for the ISSUES aerobic blanket system technology. Table ABS.47 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs for the standardized ISSUES aerobic blanket system technology. The standardized incremental costs range from $42.98 (phosphorus-based application to row crops) to $51.79 (nitrogen-based application to forages), with an average incremental cost of $47.85 per 1,000 lbs. SSLW per year across the four scenarios of land application. Nitrogen-based applications were modeled to be more costly than phosphorus-based applications and application to forages was modeled to be more costly than application to row crops. Tables ABS.48-ABS.53 provide details of the costs of individual unit processes in this standardized model. Table ABS.53 also summarizes the total costs of the standardized ISSUES aerobic blanket system technology for a 4,000-sow farrow-to-wean operation. Total construction costs are estimated at $524,226, while total annual operating costs are reported as $20,290. Total annualized costs before land application are estimated at $100,499 for this representative farm size and type. Although SSLW increases nearly 50% (from 1,188,000 pounds to 1,732,000 pounds), annualized costs (before land application) increase by only 14%. Part of this is due to economies of scale, while part is due to different COD production and manure production rates between types of farms. Lower COD and manure production rates (per / 1,000 lbs. SSLW) will result in lower construction (and operating) costs for the ISSUES aerobic blanket system technology. These variables (which differ between types of farms) will determine the number of blowers (COD rate) and size of aeration cell (manure production rate) for the ISSUES aerobic blanket system technology. Table ABS.54 (lagoon effluent) summarizes the land application costs associated with this standardized model for each of four scenarios. Table ABS.55 provides an estimated mass balance of nutrients for the 4,000-sow farrow-to-wean operation modeled for the ISSUES aerobic blanket system technology.

5.8. Extrapolation to Other Farm Types and Sizes (Tables ABS.56-ABS.57)

Table ABS.56 summarizes the per unit incremental costs ($ / 1,000 lbs. SSLW) of retrofitting the ISSUES aerobic blanket system technology onto each of the 25 size of farm / type of operation combinations. This table uses the representative farm size for a permitted North Carolina farm within a size / type combination. Incremental costs are shown for both pit-recharge and flush systems and Table ABS.56's costs assume nitrogen-based land application to forages. Table ABS.57 is analogous to Table ABS.56, but uses representative farm sizes for Smithfield Foods/Premium Standard Farms (SF/PSF) owned farms only. Incremental costs are again shown for both pit-recharge and flush systems. As in Table ABS.56, the costs in Table ABS.57 assume that a nitrogen-based land application to forages is chosen. Tables ABS.56 and ABS.57 illustrate that predicted incremental costs decrease as the size of the farm increases. These economies of scale are present across all five types of operations, and are the most significant when moving from the smallest size category (0-500,000 lbs. SSLW) to the next smallest size category (500,000-1,000,000 lbs. SSLW). It is also apparent in Tables ABS.56 and ABS.57 that retrofits of farms with flush systems of manure removal are predicted to be

more costly than those with pit-recharge systems for any size of farm/type of operation category (due to a higher daily volume of wastewater leaving the barns).

6. Summary

The ISSUES aerobic blanket system (ABS) technology was installed on Carroll's Farm #2529. It was operated to treat 50,000 gallons per day of lagoon effluent from nine flush type finishing barns each with 720-head capacity. Performance evaluation occurred between February, 2004 and October, 2004. The system includes an aeration pond and a misting system to create an aerobic blanket over a portion of the existing anaerobic lagoon. The design prescribed that of the 50,000 gallons that were pumped into the aeration pond every day, approximately 35,000 gallons were returned to the flush tank, 3,000 gallons were sent to the aerobic blanket system, and 12,000 gallons were returned to the lagoon for eventual land application. Nine sampling events occurred during the evaluation period. Sample averages were used in this report to characterize the performance of the system. Principal investigators indicated that the flush liquid returned to the barns (the effluent from the aeration pond) had 33% less TKN and 50% less P than the barn effluent (Table ABS.2.). Invoices provided to the costs and returns team were fairly complete and excluded the excavation and liner costs of the aeration pond (which had been built prior to the project). The initial investment predicted for installation of the ISSUES aerobic blanket system on a standardized 4,320-head flush type finishing farm is $297,374. The annual operating costs for the system are predicted at $15,671 and total annualized cost of the system is predicted at $99.90 per 1,000 pounds Steady State Live Weight per year over a 10-year amortization period. A considerable range of predicted costs ($39 to $675 per 1,000 pounds SSLW per year) occurs across different sizes and types of farms reflecting predicted economies of size and scale in construction of the system and reflecting differences in COD loading per 1,000 pounds SSLW across different types of farms.

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Worley-Davis, Lynn. North Carolina State University. Animal and Poultry Waste Management Center. Data provided and/or personal communication. March-October, 2005.

Tables ABS.1 through ABS.2: Performance Data and Mass Balance Tables for the ISSUES Aerobic Blanket System Technology as Constructed and Demonstrated at Carroll's Farm #2529

Table ABS.1. Nutrient Content of the Wastewater Stream at Various Sampling Points for the ISSUES Aerobic Blanket System Technology (Bull, Worley-Davis)

Sampling Point	TKN (ppm)	P (ppm)	K (ppm)	DM %
House effluent	707	132	1,172	0.45%
Lagoon	579	85	1,149	0.32%
Lagoon (ABS)	587	79	1,093	0.32%
Aeration cell	274	38	1,020	0.20%
ABS mist	279	37	1,008	0.18%

Note: These nutrient analyses are based on the average of 9 sampling events taken between the dates of 2/04 and 10/04 at Carroll's Farm #2529.

Table ABS.2. Mass Balance of Nutrients for the ISSUES Aerobic Blanket System Technology (Bull, Worley-Davis)

Sampling Point	TKN (lbs. / day)	P (lbs. / day)
House effluent	1,115.8	208.4
Lagoon influent	1,122.2	209.1
Lagoon effluent	904.4	127.1
Aeration cell influent	246.4	34.7
Aeration cell effluent	96.4	13.1
House influent	748.4	104.9
% total reduction for technology	**32.9%**	**49.7%**

Tables ABS.3 through ABS.7: Invoiced Cost Tables for the ISSUES Aerobic Blanket System Technology as Constructed at Carroll's Farm #2529

Table ABS.3. Invoiced Manure Evacuation/Lift Station Costs for the Aerobic Blanket System Technology (Cavanaugh)

Component	Invoiced Cost
Manure evacuation and lift station modifications (electrical, labor)	$7,810.81
Total Invoiced Cost of Manure Evacuation/Lift Station	**$7,810.81**

Table ABS.4. Invoiced Aeration (IESS) Cell Costs for the Aerobic Blanket System Technology (Cavanaugh)

Component	Invoiced Cost
Baffle curtain	$9,394.00
Prefabricated building	$847.70
Blower package	$8,780.00
Blower	$3,444,08
Regenerative blower	$468.90
Blower repair	$2,041.40
Blower silencer	$800.00
Change of blower shieves	$300.00
LDPE aeration tubing	$5,697.31
LDPE air feeding tubing	$3,852.69
HDPE header pipe	$2,260.00
Transfer pump and wiring	$3,000.00
Bactivators (water treatment system)	$10,000.00
Installation of IESS component	$3,106.00
Backhoe rental	$4,000.00
Boom truck rental	$400.00
Bio-filter (construction and installation)	$65,000.00
Plumbing and fabrication	$14,277.96
Electrical	$3,309.10
Total Invoiced Cost of Aeration Cell	**$140,979.14**

Table ABS.5. Invoiced Aerobic Blanket System Costs for the Aerobic Blanket System Technology (Cavanaugh)

Component	Invoiced Cost
Nozzle system (labor and materials)	$12,710.00
Pump, compressor, air tank, and control panel	$27,300.00
Plumbing and fabrication	$4,648.29
Electrical	$1,077.30
Total Invoiced Cost of Aerobic Blanket System	**$45,735.59**

Table ABS.6. Invoiced Control System and Miscellaneous Costs for the Aerobic Blanket System Technology (Cavanaugh)

Component	Invoiced Cost
Automated control system components	$1,684.35
Electrical supplies (control system)	$481.53
Transfer pump to flush tanks (return to barns)	$3,000.00
Elmer Environmental (consulting fees)	$5,326.76
Total Invoiced Cost of Control System and Miscellaneous Expenses	**$10,492.64**

Table ABS.7. Summary of Invoiced Costs for the ISSUES Aerobic Blanket System Technology

Unit Process	Invoiced Cost	% of Total Invoiced Cost
Manure evacuation/lift station	$7,810.81	3.81%
Aeration (IESS) cell	$140,979.14	68.76%
Aerobic blanket system	$45,735.59	22.31%
Control system	$2,165.88	1.06%
Return to barns	$3,000.00	1.46%
Consulting fees	$5,326.76	2.60%
Total Invoiced Costs	**$205,018.18**	**100.00%**

Table ABS.8 through ABS.9: Modified Invoiced Construction Costs for the ISSUES Aerobic Blanket System Technology as Constructed at Carroll's Farm #2529

Table ABS.8. Summary of Modified Costs for the ISSUES Aerobic Blanket System Technology

Unit Process	System Component	Invoiced Cost	Modified Cost	Reason for Modification
Miscellaneous	Consulting fees (Elmer Environmental)	$5,326.76	$0.00	Replaced by overhead/engineering services in the model

Table ABS.9. Summary of Modified Invoiced Costs for the ISSUES Aerobic Blanket System Technology

Unit Process	Invoiced Cost	% of Total Invoiced Cost
Manure evacuation/lift station	$7,810.81	3.91%
Aeration (IESS) cell	$140,979.14	70.60%
Aerobic blanket system	$45,735.59	22.91%
Control system	$2,165.88	1.08%
Return to barns	$3,000.00	1.50%
Total Modified Invoiced Costs	**$199,691.42**	**100.00%**

Tables ABS.10: Modeling Assumptions for Standardized Cost Models

Table ABS.10. Modeling and Operating Assumptions for Standardized Cost Models

Aeration cell hydraulic retention time*	30 days of flush volume
Aeration cell depth	12 feet (including 1-foot freeboard)
Aeration cell HDPE liner cost	modeled using liner surface area and number of penetrations
Number of lines of air tubing**	aeration cell length (in feet) divided by 13
Number of Bactivators**	1 for every 400,000 gallons of aeration cell volume
Blower operating time per day	24 hours
Blower HP***	modeled using COD production rates and loading rates into the aeration cell
Compressor HP for the aerobic blanket system	7.5-HP
Pumping time from equalization tank to nozzle system****	2 hours / day

* Dugba(b)

** Based on aeration cell design at Carroll's Farm #2529

*** A 30-HP blower was used in the aeration cell at Carroll's Farm #2529 and sufficiently aerated the wastewater stream produced by 6,480 finishing head.

**** Assuming that 3,034 gallons / day are pumped to the aerobic blanket system

Tables ABS.11 through ABS.19: Costs and Returns Estimates Based on Actual Cost and Performance Data for ISSUES Aerobic Blanket System On-Farm Technology: 6,480-Head Feeder to Finish Operation with Flush System

Table ABS.11. ISSUES Aerobic Blanket System Technology Assumptions and Predicted Total Annualized Costs: Actual Costs and Performance Data

Number of Animals	**6,480**		
Type of Operation	**Feeder-Finish**		
Barn Cleaning System	**Flush System**		
Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 90,415.27**	**$ 85,118.63**
	If Phosphorus-Based Application	**$ 82,122.78**	**$ 80,731.35**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 103.36**	**$ 97.30**
	If Phosphorus-Based Application	**$ 93.88**	**$ 92.29**

Note: Daily volume discharged from barns is 49,896 gallons / day including recharge liquid.
SSLW equals 874,800 pounds.

Table ABS.12. ISSUES Aerobic Blanket System Technology Manure Evacuation and Lift Station Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Manure Evacuation and Lift Station Modifications	$ 7,810.81	$ 1,164.01
Contractor & Engineering Services & Overhead	$ 3,366.46	$ 501.70
Total Construction Cost	$ 11,177.27	$ 1,665.74
Maintenance Cost		$ 156.22
Property Taxes		$ 39.68
Total Operating Costs		$ 195.90
TOTAL ANNUALIZED COST OF MANURE EVACUATION AND LIFT STATION		**$ 1,861.64**

Table ABS.13. ISSUES Aerobic Blanket System Technology Aeration (IESS) Cell Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Excavation	$ 51,366.15	$ 7,655.07
Liner Cost (40-mil. HDPE)	$ 42,422.98	$ 6,322.28
Baffle Curtain	$ 9,394.00	$ 1,399.98
Prefabricated Building	$ 847.70	$ 126.33
Blower Package and Installation	$ 9,880.00	$ 1,472.41
Blower (65 URI)	$ 3,444.08	$ 1,336.42
Regenerative Blower	$ 468.90	$ 181.95
LDPE Aeration Tubing	$ 5,697.31	$ 849.07
LDPE Air Feeder Tubing	$ 3,852.69	$ 574.16
HDPE Header Pipe	$ 2,260.00	$ 336.81
Transfer pump and wiring	$ 3,000.00	$ 1,164.10
Bactivators	$ 10,000.00	$ 1,490.29
IESS Installation	$ 3,106.00	$ 462.89
Plumbing and Fabrication	$ 14,277.96	$ 2,127.84
Electrical	$ 3,309.10	$ 493.15
Backhoe Rental	$ 4,000.00	$ 596.12
Construction and Installation of Biofilter	$ 65,400.00	$ 9,746.53
Blower Repair	$ 2,041.40	$ 304.23
Contractor & Engineering Services & Overhead	$ 101,185.13	$ 15,079.57
Total Construction Cost	$ 335,953.41	$ 51,719.19
Electric Power Cost		$ 18,154.04
Maintenance Cost		$ 3,482.86
Property Taxes		$ 1,192.63
Total Operating Cost		$ 22,829.54
TOTAL ANNUALIZED COST OF AERATION (IESS) CELL		**$ 74,548.73**

Table ABS.14. ISSUES Aerobic Blanket System Technology Aerobic Blanket System Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Nozzle labor and materials (design, fabricate, install)	$ 12,710.00	$ 1,894.16
Plumbing and fabrication	$ 4,648.29	$ 692.73
Electrical	$ 1,077.30	$ 160.55
Pump, compressor, air tank, and control panel	$ 27,300.00	$ 4,068.51
Contractor & Engineering Services & Overhead	$ 19,712.04	$ 2,937.67
Total Construction Cost	$ 65,447.62	$ 9,753.63
Electric Power Cost		$ 449.75
Maintenance Cost		$ 1,733.71
Property Taxes		$ 232.34
Total Operating Cost		$ 2,415.80
TOTAL ANNUALIZED COST OF AEROBIC BLANKET SYSTEM		**$ 12,169.42**

Table ABS.15. ISSUES Aerobic Blanket System Technology Equalization Tank Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Equalization/Conditioning Tank	$ 1,500.00	$ 223.54
Contractor & Engineering Services & Overhead	$ 646.50	$ 96.35
Total Construction Cost	$ 2,146.50	$ 319.89
Maintenance Cost		$ 30.00
Property Taxes		$ 7.62
Total Operating Cost		$ 37.62
TOTAL ANNUALIZED COST OF EQUALIZATON TANK		**$ 357.51**

Table ABS.16. ISSUES Aerobic Blanket System Technology Control System Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Control System	$ 1,684.35	$ 251.02
Electrical Supplies	$ 481.53	$ 71.76
Contractor & Engineering Services & Overhead	$ 933.49	$ 139.12
Total Construction Cost	$ 3,099.37	$ 461.90
Maintenance Cost		$ 43.32
Property Taxes		$ 11.00
Total Operating Cost		$ 54.32
TOTAL ANNUALIZED COST OF CONTROL SYSTEM		**$ 516.22**

Table ABS.17. ISSUES Aerobic Blanket System Return to Barns Costs: Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Pump and Wiring	$ 3,000.00	$ 1,164.10
Contractor & Engineering Services & Overhead	$ 1,293.00	$ 192.70
Total Construction Cost	$ 4,293.00	$ 1,356.80
Electric Power Cost		$ 332.42
Maintenance Cost		$ 150.00
Property Taxes		$ 15.24
Total Operating Cost		$ 497.66
TOTAL ANNUALIZED COST OF RETURN TO BARNS		**$ 1,854.45**

TOTAL CONSTRUCTION COST OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY	**$**	**422,117.18**
TOTAL OPERATING COST OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY	**$**	**26,030.83**
TOTAL ANNUALIZED COSTS OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**91,307.98**

Table ABS.18. ISSUES Aerobic Blanket System Technology Predicted Liquid Application Costs for Four Land Application Scenarios: Actual Costs and Performance Data

Annual Cost of Applying Lagoon Effluent	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 16,035.86	$ 7,787.38
If Phosphorus-Based Application	$ 13,560.24	$ 5,229.51
Acres Needed For Assimilation	**Forages**	**Row Crops**
If Nitrogen-Based Application	9.87	32.00
If Phosphorus-Based Application	15.99	42.73
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 592.33	-
If Phosphorus-Based Application	$ 959.63	-
Irrigation Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 15,443.53	$ 8,968.16
If Phosphorus-Based Application	$ 11,569.87	$ 8,632.12
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	$ (1,180.78)
If Phosphorus-Based Application	-	$ (3,402.61)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	-
If Phosphorus-Based Application	$ 1,030.74	-

Note: 5,519,516 gallons / year of effluent land applied at Carroll's Farm #2529.

Table ABS.19. Summary and Mass Balance of Generated and Land Applied Nutrients: Actual Costs and Performance Data

Nutrient Balance	Nitrogen (lbs / year)	Phosphorus (lbs / year)	Potassium* (lbs / year)
Generated At Barn	131,155.20	37,584.00	64,476.00
Removed in Lagoon/Storage Basin	25,457.22	14,736.69	8,362.54
Entering Aeration cell	105,697.98	22,847.31	56,113.46
Removed in Aeration Cell	55,681.69	12,632.28	-
Removed in ABS Mist	2,581.64	342.37	9,331.86
Remaining in Aeration Cell	47,434.64	9,872.67	46,781.60
Land Applied in Liquid Effluent	5,731.80	774.00	10,459.48

Tables ABS.20 through ABS.28: Costs and Returns Estimates Based on Standardized Cost and Performance Data for ISSUES Aerobic Blanket System Technology: 4,320-Head Feeder to Finish Operation with Flush System

Table ABS.20. ISSUES Aerobic Blanket System Technology Assumptions and Total Annualized Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Number of Animals	**4,320**		
Type of Operation	**Feeder-Finish**		
Barn Cleaning System	**Flush System**		
Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 58,261.66**	**$ 56,450.34**
	If Phosphorus-Based Application	**$ 55,078.79**	**$ 52,637.76**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 99.90**	**$ 96.79**
	If Phosphorus-Based Application	**$ 94.44**	**$ 90.26**

Note: Daily volume discharged from barns is 33,505 gallons / day including recharge liquid.
SSLW equals 583,200 pounds.

Table ABS.21. ISSUES Aerobic Blanket System Technology Manure Evacuation and Lift Station Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Manure Evacuation Modifications	$ 9,110.00	$ 1,357.66
Contractor & Engineering Services & Overhead	$ 3,926.41	$ 585.15
Total Construction Cost	$ 13,036.41	$ 1,942.81
Maintenance Cost		$ 182.20
Property Taxes		$ 46.28
Total Operating Costs		$ 228.48
TOTAL ANNUALIZED COST OF MANURE EVACUATION AND LIFT STATION		**$ 2,171.29**

Table ABS.22. ISSUES Aerobic Blanket System Technology Aeration (IESS) Cell Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Excavation	$ 12,906.11	$ 1,923.39
Liner Cost (40-mil. HDPE)	$ 21,096.54	$ 3,144.01
Baffle Curtain	$ 5,438.21	$ 810.45
Prefabricated Building	$ 847.70	$ 126.33
Blower Package and Installation	$ 4,940.00	$ 736.21
Blower (65 URI)	$ 1,722.04	$ 668.21
Regenerative Blower	$ 468.90	$ 181.95
LDPE Aeration Tubing	$ 1,828.77	$ 272.54
LDPE Air Feeder Tubing	$ 2,704.62	$ 403.07
HDPE Header Pipe	$ 2,260.00	$ 336.81
Transfer Pump and Wiring	$ 3,000.00	$ 1,164.10
Bactivators	$ 7,500.00	$ 1,117.72
IESS Installation	$ 1,474.42	$ 219.73
Backhoe Rental	$ 4,000.00	$ 596.12
Construction and Installation of Biofilter	$ 65,400.00	$ 9,746.53
Plumbing and Fabrication	$ 9,587.56	$ 1,428.83
Electrical	$ 2,222.04	$ 331.15
Contractor & Engineering Services & Overhead	$ 63,258.07	$ 9,467.56
Total Construction Cost	$ 210,924.98	$ 32,674.70
Electric Power Cost		$ 9,105.52
Maintenance Cost		$ 2,736.06
Property Taxes		$ 748.78
Total Operating Cost		$ 12,590.36
TOTAL ANNUALIZED COST OF AERATION (IESS) CELL		**$ 45,265.06**

Table ABS.23. ISSUES Aerobic Blanket System Technology Aerobic Blanket System Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Nozzle labor and materials (design, fabricate, install)	$ 12,710.00	$ 1,894.16
Plumbing and fabrication	$ 4,648.29	$ 692.73
Electrical	$ 1,077.30	$ 160.55
Pump, compressor, air tank, and control panel	$ 27,300.00	$ 4,068.51
Contractor & Engineering Services & Overhead	$ 19,712.04	$ 2,937.67
Total Construction Cost	$ 65,447.62	$ 9,753.63
Electric Power Cost		$ 449.75
Maintenance Cost		$ 1,733.71
Property Taxes		$ 232.34
Total Operating Cost		$ 2,415.80
TOTAL ANNUALIZED COST OF AEROBIC BLANKET SYSTEM		**$ 12,169.42**

Table ABS.24. ISSUES Aerobic Blanket System Technology Equalization Tank Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Equalization/Conditioning Tank	$ 1,500.00	$ 223.54
Contractor & Engineering Services & Overhead	$ 646.50	$ 96.35
Total Construction Cost	$ 2,146.50	$ 319.89
Maintenance Cost		$ 30.00
Property Taxes		$ 7.62
Total Operating Cost		$ 37.62
TOTAL ANNUALIZED COST OF EQUALIZATON TANK		**$ 357.51**

Table ABS.25. ISSUES Aerobic Blanket System Technology Control System Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Control System	$ 1,684.35	$ 251.02
Electrical Supplies	$ 481.53	$ 71.76
Contractor & Engineering Services & Overhead	$ 933.49	$ 139.12
Total Construction Cost	$ 3,099.37	$ 461.90
Maintenance Cost		$ 43.32
Property Taxes		$ 11.00
Total Operating Cost		$ 54.32
TOTAL ANNUALIZED COST OF CONTROL SYSTEM		**$ 516.22**

Table ABS.26. ISSUES Aerobic Blanket System Return to Barns Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Plumbing/Piping	$ 1,300.00	$ 193.74
Pumps	$ 600.00	$ 216.21
Contractor & Engineering Services & Overhead	$ 818.90	$ 122.04
Total Construction Cost	$ 2,718.90	$ 531.99
Electric Power Cost		$ 279.02
Maintenance Cost		$ 56.00
Property Taxes		$ 9.65
Total Operating Cost		$ 344.67
TOTAL ANNUALIZED COST OF RETURN TO BARNS		**$ 876.66**

TOTAL CONSTRUCTION COST OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY	**$**	**297,373.79**
TOTAL OPERATING COST OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY	**$**	**15,671.25**
TOTAL ANNUALIZED COSTS OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**61,356.16**

Table ABS.27. ISSUES Aerobic Blanket System Technology Predicted Liquid Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Annual Cost of Applying Lagoon Effluent		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	10,448.68	$	6,064.70
If Phosphorus-Based Application	$	10,807.72	$	3,396.57
Acres Needed For Assimilation		**Forages**		**Row Crops**
If Nitrogen-Based Application		13.16		42.64
If Phosphorus-Based Application		21.32		56.95
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	789.41		-
If Phosphorus-Based Application	$	1,278.93		-
Irrigation Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	9,659.26	$	7,638.36
If Phosphorus-Based Application	$	8,155.11	$	7,931.31
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application		-	$	(1,573.66)
If Phosphorus-Based Application		-	$	(4,534.74)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application		-		-
If Phosphorus-Based Application	$	1,373.69		-

Note: 3,338,827 gallons / year of effluent modeled to be land applied.

Table ABS.28. Summary and Mass Balance of Generated and Land Applied Nutrients: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Nutrient Balance	Nitrogen (lbs / year)	Phosphorus (lbs / year)	Potassium (lbs / year)
Generated At Barn	87,436.80	25,056.00	42,984.00
Removed in Lagoon/Storage Basin	16,971.48	9,824.46	5,575.02
Entering Aeration cell	70,465.32	15,231.54	37,408.98
Removed in Aeration Cell	37,121.13	8,421.52	-
Removed in ABS Mist	2,581.64	342.37	9,331.86
Remaining in Aeration Cell	30,762.54	6,467.65	28,077.12
Land Applied in Liquid Effluent	7,638.90	1,031.53	13,939.60

Tables ABS.29 through ABS.37: Costs and Returns Estimates Based on Standardized Cost and Performance Data for ISSUES Aerobic Blanket System Technology: 4,320-Head Feeder to Finish Operation with Pit-Recharge System

Table ABS.29. ISSUES Aerobic Blanket System Technology Assumptions and Total Annualized Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Number of Animals	**4,320**		
Type of Operation	**Feeder-Finish**		
Barn Cleaning System	**Pit-Recharge System**		
Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 55,417.10**	**$ 53,605.78**
	If Phosphorus-Based Application	**$ 52,234.24**	**$ 49,793.20**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 95.02**	**$ 91.92**
	If Phosphorus-Based Application	**$ 89.57**	**$ 85.38**

Note: Daily volume discharged from barns is 28,361 gallons / day including recharge liquid.
SSLW equals 583,200 pounds.

Table ABS.30. ISSUES Aerobic Blanket System Technology Manure Evacuation and Lift Station Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Manure Evacuation Modifications	$ 4,550.00	$ 678.83
Contractor & Engineering Services & Overhead	$ 1,963.21	$ 292.58
Total Construction Cost	$ 6,518.21	$ 971.40
Maintenance Cost		$ 91.10
Property Taxes		$ 23.14
Total Operating Costs		$ 114.24
TOTAL ANNUALIZED COST OF MANURE EVACUATION AND LIFT STATION		**$ 1,085.64**

Table ABS.31. ISSUES Aerobic Blanket System Technology Aeration (IESS) Cell Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Excavation	$ 11,020.41	$ 1,642.37
Liner Cost (40-mil. HDPE)	$ 18,509.15	$ 2,758.41
Baffle Curtain	$ 5,148.91	$ 767.34
Prefabricated Building	$ 847.70	$ 126.33
Blower Package and Installation	$ 4,940.00	$ 736.21
Blower (65 URI)	$ 1,722.04	$ 668.21
Regenerative Blower	$ 468.90	$ 181.95
LDPE Aeration Tubing	$ 1,607.81	$ 239.61
LDPE Air Feeder Tubing	$ 2,377.83	$ 354.37
HDPE Header Pipe	$ 2,260.00	$ 336.81
Transfer Pump and Wiring	$ 3,000.00	$ 1,164.10
Bactivators	$ 7,500.00	$ 1,117.72
IESS Installation	$ 1,296.27	$ 193.18
Backhoe Rental	$ 4,000.00	$ 596.12
Construction and Installation of Biofilter	$ 65,400.00	$ 9,746.53
Plumbing and Fabrication	$ 8,115.63	$ 1,209.47
Electrical	$ 1,880.90	$ 280.31
Contractor & Engineering Services & Overhead	$ 60,381.18	$ 8,998.58
Total Construction Cost	**$ 200,476.72**	**$ 31,117.60**
Electric Power Cost		$ 9,088.39
Maintenance Cost		$ 2,631.31
Property Taxes		$ 711.69
Total Operating Cost		$ 12,431.39
TOTAL ANNUALIZED COST OF AERATION (IESS) CELL		**$ 43,548.99**

Table ABS.32. ISSUES Aerobic Blanket System Technology Aerobic Blanket System Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Nozzle labor and materials (design, fabricate, install)	$ 12,710.00	$ 1,894.16
Plumbing and fabrication	$ 4,648.29	$ 692.73
Electrical	$ 1,077.30	$ 160.55
Pump, compressor, air tank, and control panel	$ 27,300.00	$ 4,068.51
Contractor & Engineering Services & Overhead	$ 19,712.04	$ 2,937.67
Total Construction Cost	$ 65,447.62	$ 9,753.63
Electric Power Cost		$ 449.75
Maintenance Cost		$ 1,733.71
Property Taxes		$ 232.34
Total Operating Cost		$ 2,415.80
TOTAL ANNUALIZED COST OF AEROBIC BLANKET SYSTEM		**$ 12,169.42**

Table ABS.33. ISSUES Aerobic Blanket System Technology Equalization Tank Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Equalization/Conditioning Tank	$ 1,500.00	$ 223.54
Contractor & Engineering Services & Overhead	$ 646.50	$ 96.35
Total Construction Cost	$ 2,146.50	$ 319.89
Maintenance Cost		$ 30.00
Property Taxes		$ 7.62
Total Operating Cost		$ 37.62
TOTAL ANNUALIZED COST OF EQUALIZATON TANK		**$ 357.51**

Table ABS.34. ISSUES Aerobic Blanket System Technology Control System Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Control System	$ 1,684.35	$ 251.02
Electrical Supplies	$ 481.53	$ 71.76
Contractor & Engineering Services & Overhead	$ 933.49	$ 139.12
Total Construction Cost	$ 3,099.37	$ 461.90
Maintenance Cost		$ 43.32
Property Taxes		$ 11.00
Total Operating Cost		$ 54.32
TOTAL ANNUALIZED COST OF CONTROL SYSTEM		**$ 516.22**

Table ABS.35. ISSUES Aerobic Blanket System Return to Barns Costs: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Plumbing/Piping	$ 1,300.00	$ 193.74
Pumps	$ 600.00	$ 216.21
Contractor & Engineering Services & Overhead	$ 818.90	$ 122.04
Total Construction Cost	$ 2,718.90	$ 531.99
Electric Power Cost		$ 236.18
Maintenance Cost		$ 56.00
Property Taxes		$ 9.65
Total Operating Cost		$ 301.83
TOTAL ANNUALIZED COST OF RETURN TO BARNS		**$ 833.82**

TOTAL CONSTRUCTION COST OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY	**$**	**280,407.33**
TOTAL OPERATING COST OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY	**$**	**15,355.20**
TOTAL ANNUALIZED COSTS OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**58,511.61**

Table ABS.36. ISSUES Aerobic Blanket System Technology Predicted Liquid Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Annual Cost of Applying Lagoon Effluent	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 10,448.68	$ 6,064.70
If Phosphorus-Based Application	$ 10,807.72	$ 3,396.57
Acres Needed For Assimilation	**Forages**	**Row Crops**
If Nitrogen-Based Application	13.16	42.64
If Phosphorus-Based Application	21.32	56.95
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 789.41	-
If Phosphorus-Based Application	$ 1,278.93	-
Irrigation Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 9,659.26	$ 7,638.36
If Phosphorus-Based Application	$ 8,155.11	$ 7,931.31
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	$ (1,573.66)
If Phosphorus-Based Application	-	$ (4,534.74)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	-
If Phosphorus-Based Application	$ 1,373.69	-

Note: 3,338,827 gallons / year of effluent modeled to be land applied.

Table ABS.37. Summary and Mass Balance of Generated and Land Applied Nutrients: Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Nutrient Balance	Nitrogen (lbs / year)	Phosphorus (lbs / year)	Potassium* (lbs / year)
Generated At Barn	87,436.80	25,056.00	42,984.00
Removed in Lagoon/Storage Basin	16,971.48	9,824.46	5,575.02
Entering Aeration cell	70,465.32	15,231.54	37,408.98
Removed in Aeration Cell	37,121.13	8,421.52	-
Removed in ABS Mist	2,581.64	342.37	9,331.86
Remaining in Aeration Cell	30,762.54	6,467.65	28,077.12
Land Applied in Liquid Effluent	7,638.90	1,031.53	13,939.60

Tables ABS.38 through ABS.46: Costs and Returns Estimates Based on Standardized Cost and Performance Data for ISSUES Aerobic Blanket System Technology: 8,800-Head Feeder to Finish Operation with Flush System

Table ABS.38. ISSUES Aerobic Blanket System Technology Assumptions and Total Annualized Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Number of Animals	**8,800**		
Type of Operation	**Feeder-Finish**		
Barn Cleaning System	**Flush System**		
Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 78,183.34**	**$ 75,842.81**
	If Phosphorus-Based Application	**$ 73,325.34**	**$ 67,506.47**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 65.81**	**$ 63.84**
	If Phosphorus-Based Application	**$ 61.72**	**$ 56.82**

Note: Daily volume discharged from barns is 68,251 gallons / day including recharge liquid.
SSLW equals 1,188,000 pounds.

Table ABS.39. ISSUES Aerobic Blanket System Technology Manure Evacuation and Lift Station Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Manure Evacuation Modifications	$ 18,220.00	$ 2,715.32
Contractor & Engineering Services & Overhead	$ 7,852.82	$ 1,170.30
Total Construction Cost	$ 26,072.82	$ 3,885.62
Maintenance Cost		$ 364.40
Property Taxes		$ 92.56
Total Operating Costs		$ 456.96
TOTAL ANNUALIZED COST OF MANURE EVACUATION AND LIFT STATION		**$ 4,342.58**

Table ABS.40. ISSUES Aerobic Blanket System Technology Aeration (IESS) Cell Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Excavation	$ 25,228.89	$ 3,759.85
Liner Cost (40-mil. HDPE)	$ 30,744.53	$ 4,581.84
Baffle Curtain	$ 6,978.40	$ 1,039.99
Prefabricated Building	$ 847.70	$ 126.33
Blower Package and Installation	$ 9,880.00	$ 1,472.41
Blower (65 URI)	$ 3,444.08	$ 1,336.42
Regenerative Blower	$ 468.90	$ 181.95
LDPE Aeration Tubing	$ 3,184.81	$ 474.63
LDPE Air Feeder Tubing	$ 4,710.11	$ 701.95
HDPE Header Pipe	$ 2,260.00	$ 336.81
Transfer Pump and Wiring	$ 3,000.00	$ 1,164.10
Bactivators	$ 15,000.00	$ 2,235.44
IESS Installation	$ 2,567.71	$ 382.66
Backhoe Rental	$ 4,000.00	$ 596.12
Construction and Installation of Biofilter	$ 65,400.00	$ 9,746.53
Plumbing and Fabrication	$ 19,530.21	$ 2,910.58
Electrical	$ 4,526.38	$ 674.56
Contractor & Engineering Services & Overhead	$ 86,963.62	$ 12,960.14
Total Construction Cost	$ 288,735.36	$ 44,682.31
Electric Power Cost		$ 18,215.18
Maintenance Cost		$ 3,606.89
Property Taxes		$ 1,025.01
Total Operating Cost		$ 22,847.08
TOTAL ANNUALIZED COST OF AERATION (IESS) CELL		**$ 67,529.40**

Table ABS.41. ISSUES Aerobic Blanket System Technology Aerobic Blanket System Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Nozzle labor and materials (design, fabricate, install)	$ 12,710.00	$ 1,894.16
Plumbing and fabrication	$ 4,648.29	$ 692.73
Electrical	$ 1,077.30	$ 160.55
Pump, compressor, air tank, and control panel	$ 27,300.00	$ 4,068.51
Contractor & Engineering Services & Overhead	$ 19,712.04	$ 2,937.67
Total Construction Cost	$ 65,447.62	$ 9,753.63
Electric Power Cost		$ 449.75
Maintenance Cost		$ 1,733.71
Property Taxes		$ 232.34
Total Operating Cost		$ 2,415.80
TOTAL ANNUALIZED COST OF AEROBIC BLANKET SYSTEM		**$ 12,169.42**

Table ABS.42. ISSUES Aerobic Blanket System Technology Equalization Tank Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Equalization/Conditioning Tank	$ 1,500.00	$ 223.54
Contractor & Engineering Services & Overhead	$ 646.50	$ 96.35
Total Construction Cost	$ 2,146.50	$ 319.89
Maintenance Cost		$ 30.00
Property Taxes		$ 7.62
Total Operating Cost		$ 37.62
TOTAL ANNUALIZED COST OF EQUALIZATON TANK		**$ 357.51**

Table ABS.43. ISSUES Aerobic Blanket System Technology Control System Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Control System	$ 1,684.35	$ 251.02
Electrical Supplies	$ 481.53	$ 71.76
Contractor & Engineering Services & Overhead	$ 933.49	$ 139.12
Total Construction Cost	$ 3,099.37	$ 461.90
Maintenance Cost		$ 43.32
Property Taxes		$ 11.00
Total Operating Cost		$ 54.32
TOTAL ANNUALIZED COST OF CONTROL SYSTEM		**$ 516.22**

Table ABS.44. ISSUES Aerobic Blanket System Return to Barns Costs: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Plumbing/Piping	$ 2,600.00	$ 387.48
Pumps	$ 600.00	$ 216.21
Contractor & Engineering Services & Overhead	$ 1,379.20	$ 205.54
Total Construction Cost	$ 4,579.20	$ 809.23
Electric Power Cost		$ 568.37
Maintenance Cost		$ 82.00
Property Taxes		$ 16.26
Total Operating Cost		$ 666.63
TOTAL ANNUALIZED COST OF RETURN TO BARNS		**$ 1,475.85**

TOTAL CONSTRUCTION COST OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY	**$**	**390,080.88**
TOTAL OPERATING COST OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY	**$**	**26,478.41**
TOTAL ANNUALIZED COSTS OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**86,390.98**

Table ABS.45. ISSUES Aerobic Blanket System Technology Predicted Liquid Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Annual Cost of Applying Lagoon Effluent	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 12,362.72	$ 6,661.85
If Phosphorus-Based Application	$ 15,772.39	$ 892.84
Acres Needed For Assimilation	**Forages**	**Row Crops**
If Nitrogen-Based Application	31.01	100.50
If Phosphorus-Based Application	50.24	134.21
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 1,860.45	-
If Phosphorus-Based Application	$ 3,014.11	-
Irrigation Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 10,502.27	$ 10,370.56
If Phosphorus-Based Application	$ 9,520.86	$ 11,580.08
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	$ (3,708.71)
If Phosphorus-Based Application	-	$ (10,687.25)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	-
If Phosphorus-Based Application	$ 3,237.43	-

Note: 7,868,774 gallons / year of effluent modeled to be land applied.

Table ABS.46. Summary and Mass Balance of Generated and Land Applied Nutrients: Standardized Quantities and Prices (8,800-Head Feeder-Finish with Flush System)

Nutrient Balance	Nitrogen (lbs / year)	Phosphorus (lbs / year)	Potassium* (lbs / year)
Generated At Barn	178,112.00	51,040.00	87,560.00
Removed in Lagoon/Storage Basin	34,571.54	20,012.78	11,356.53
Entering Aeration cell	143,540.46	31,027.22	76,203.47
Removed in Aeration Cell	75,617.11	17,154.95	-
Removed in ABS Mist	2,581.64	342.37	9,331.86
Remaining in Aeration Cell	65,341.70	13,529.90	66,871.61
Land Applied in Liquid Effluent	18,002.97	2,431.06	32,852.13

Tables ABS.47 through ABS.55: Costs and Returns Estimates Based on Standardized Cost and Performance Data for ISSUES Aerobic Blanket System Technology: 4,000-Sow Farrow to Wean Operation with Flush System

Table ABS.47. ISSUES Aerobic Blanket System Technology Assumptions and Total Annualized Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Number of Animals	**4,000**		
Type of Operation	**Farrow-Wean**		
Barn Cleaning System	**Flush System**		
Annualized Cost ($ / Year)			
Total Annualized Cost		Forages	Row Crops
	If Nitrogen-Based Application	**$ 89,695.31**	**$ 87,022.05**
	If Phosphorus-Based Application	**$ 80,347.41**	**$ 74,443.20**
Per Unit Cost ($ / 1,000 lbs. of SSLW)			
Total Annualized Cost per Unit		Forages	Row Crops
	If Nitrogen-Based Application	**$ 51.79**	**$ 50.24**
	If Phosphorus-Based Application	**$ 46.39**	**$ 42.98**

Note: Daily volume discharged from barns is 158,852 gallons / day including recharge liquid.
SSLW equals 1,732,000 pounds.

Table ABS.48. ISSUES Aerobic Blanket System Technology Manure Evacuation and Lift Station Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Manure Evacuation Modifications	$ 12,754.00	$ 1,900.72
Contractor & Engineering Services & Overhead	$ 5,496.97	$ 819.21
Total Construction Cost	$ 18,250.97	$ 2,719.93
Maintenance Cost		$ 255.08
Property Taxes		$ 64.79
Total Operating Costs		$ 319.87
TOTAL ANNUALIZED COST OF MANURE EVACUATION AND LIFT STATION		**$ 3,039.80**

Table ABS.49. ISSUES Aerobic Blanket System Technology Aeration (IESS) Cell Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Excavation	$ 54,409.36	$ 8,108.60
Liner Cost (40-mil. HDPE)	$ 44,011.25	$ 6,558.97
Baffle Curtain	$ 9,666.47	$ 1,440.59
Prefabricated Building	$ 847.70	$ 126.33
Blower Package and Installation	$ 4,940.00	$ 736.21
Blower (65 URI)	$ 1,722.04	$ 668.21
Regenerative Blower	$ 468.90	$ 181.95
LDPE Aeration Tubing	$ 6,501.31	$ 968.89
LDPE Air Feeder Tubing	$ 9,614.97	$ 1,432.91
HDPE Header Pipe	$ 2,260.00	$ 336.81
Transfer Pump and Wiring	$ 6,000.00	$ 2,328.20
Bactivators	$ 30,000.00	$ 4,470.88
IESS Installation	$ 5,241.59	$ 781.15
Backhoe Rental	$ 4,000.00	$ 596.12
Construction and Installation of Biofilter	$ 65,400.00	$ 9,746.53
Plumbing and Fabrication	$ 45,378.92	$ 6,762.80
Electrical	$ 10,517.14	$ 1,567.36
Contractor & Engineering Services & Overhead	$ 129,722.23	$ 19,332.44
Total Construction Cost	$ 430,701.88	$ 66,144.95
Electric Power Cost		$ 9,522.17
Maintenance Cost		$ 4,992.30
Property Taxes		$ 1,528.99
Total Operating Cost		$ 16,043.46
TOTAL ANNUALIZED COST OF AERATION (IESS) CELL		**$ 82,188.41**

Table ABS.50. ISSUES Aerobic Blanket System Technology Aerobic Blanket System Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Nozzle labor and materials (design, fabricate, install)	$ 12,710.00	$ 1,894.16
Plumbing and fabrication	$ 4,648.29	$ 692.73
Electrical	$ 1,077.30	$ 160.55
Pump, compressor, air tank, and control panel	$ 27,300.00	$ 4,068.51
Contractor & Engineering Services & Overhead	$ 19,712.04	$ 2,937.67
Total Construction Cost	$ 65,447.62	$ 9,753.63
Electric Power Cost		$ 449.75
Maintenance Cost		$ 1,733.71
Property Taxes		$ 232.34
Total Operating Cost		$ 2,415.80
TOTAL ANNUALIZED COST OF AEROBIC BLANKET SYSTEM		**$ 12,169.42**

Table ABS.51. ISSUES Aerobic Blanket System Technology Equalization Tank Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Equalization/Conditioning Tank	$ 1,500.00	$ 223.54
Contractor & Engineering Services & Overhead	$ 646.50	$ 96.35
Total Construction Cost	$ 2,146.50	$ 319.89
Maintenance Cost		$ 30.00
Property Taxes		$ 7.62
Total Operating Cost		$ 37.62
TOTAL ANNUALIZED COST OF EQUALIZATON TANK		**$ 357.51**

Table ABS.52. ISSUES Aerobic Blanket System Technology Control System Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Control System	$ 1,684.35	$ 251.02
Electrical Supplies	$ 481.53	$ 71.76
Contractor & Engineering Services & Overhead	$ 933.49	$ 139.12
Total Construction Cost	$ 3,099.37	$ 461.90
Maintenance Cost		$ 43.32
Property Taxes		$ 11.00
Total Operating Cost		$ 54.32
TOTAL ANNUALIZED COST OF CONTROL SYSTEM		**$ 516.22**

Table ABS.53. ISSUES Aerobic Blanket System Return to Barns Costs: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Component	Total Cost	Annualized Cost
Plumbing/Piping	$ 2,600.00	$ 387.48
Pumps	$ 600.00	$ 216.21
Contractor & Engineering Services & Overhead	$ 1,379.20	$ 205.54
Total Construction Cost	$ 2,718.90	$ 531.99
Electric Power Cost		$ 1,320.62
Maintenance Cost		$ 82.00
Property Taxes		$ 16.26
Total Operating Cost		$ 1,418.88
TOTAL ANNUALIZED COST OF RETURN TO BARNS		**$ 2,228.11**

TOTAL CONSTRUCTION COST OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY	**$**	**524,225.55**
TOTAL OPERATING COST OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY	**$**	**20,289.95**
TOTAL ANNUALIZED COSTS OF ISSUES AEROBIC BLANKET SYSTEM TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**100,499.47**

Table ABS.54. ISSUES Aerobic Blanket System Technology Predicted Liquid Application Costs for Four Land Application Scenarios: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Annual Cost of Applying Lagoon Effluent	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 13,722.94	$ 7,086.21
If Phosphorus-Based Application	$ 19,300.56	$ (886.45)
Acres Needed For Assimilation	**Forages**	**Row Crops**
If Nitrogen-Based Application	43.69	141.61
If Phosphorus-Based Application	70.79	189.12
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 2,621.59	-
If Phosphorus-Based Application	$ 4,247.22	-
Irrigation Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 11,101.35	$ 12,312.21
If Phosphorus-Based Application	$ 10,491.43	$ 14,173.10
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	$ (5,226.00)
If Phosphorus-Based Application	-	$ (15,059.55)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	-
If Phosphorus-Based Application	$ 4,561.91	-

Note: 11,088,005 gallons / year of effluent modeled to be land applied.

Table ABS.55. Summary and Mass Balance of Generated and Land Applied Nutrients: Standardized Quantities and Prices (4,000-Sow Farrow-Wean with Flush System)

Nutrient Balance	Nitrogen (lbs / year)	Phosphorus (lbs / year)	Potassium* (lbs / year)
Generated At Barn	117,000.00	37,040.00	77,000.00
Removed in Lagoon/Storage Basin	22,709.70	14,523.38	9,986.90
Entering Aeration cell	94,290.30	22,516.62	67,013.10
Removed in Aeration Cell	49,672.13	12,449.44	-
Removed in ABS Mist	2,581.64	342.37	9,331.86
Remaining in Aeration Cell	42,036.53	9,724.81	57,681.24
Land Applied in Liquid Effluent	25,368.25	3,425.64	46,292.42

Tables ABS.56 and ABS.57: Predicted Costs of Retrofitting Various Representative Farm Sizes and Farm Types with the ISSUES Aerobic Blanket System Technology: DWQ Permitted Farms and SF/PSF Owned Farms

Table ABS.56. Predicted Costs ($ / 1,000 Pounds of Steady-State Live Weight (SSLW) per Year) of Retrofitting DWQ Permitted Representative Farm Type / Farm Size Combinations: ISSUES Aerobic Blanket System Technology

	Farm Size (1,000 pounds SSLW)				
	0-500	**500-1000**	**1000-1500**	**1500-2000**	**> 2000**
Farm Type					
Farrow-wean					
Rep. # of sows	752	1,540	2,400	4,000	6,000
Pit-recharge system	$173.14	$94.33	$66.85	$48.16	$42.66
Flush system	$177.55	$98.01	$72.25	$51.79	$46.07
Farrow-feeder					
Rep. # of sows	500	1,200	2,000	3,600	5,500
Pit-recharge system	$209.05	$99.82	$68.56	$53.38	$45.81
Flush system	$223.73	$113.40	$82.90	$66.31	$57.93
Farrow-finish					
Rep. # of sows	150	500	1,000	1,200	2,000
Pit-recharge system	$246.29	$85.00	$57.24	$50.71	$39.48
Flush system	$258.78	$93.68	$66.70	$59.24	$48.17
Wean-feeder					
Rep. head capacity	3,840	20,000	N/A	N/A	N/A
Pit-recharge system	$440.02	$115.32	N/A	N/A	N/A
Flush system	$516.84	$183.73	N/A	N/A	N/A
Feeder-finish					
Rep. head capacity	2,448	5,280	8,800	12,240	17,136
Pit-recharge system	$160.06	$78.99	$60.58	$52.92	$40.75
Flush system	$165.30	$84.59	$65.81	$58.85	$45.49

Table ABS.57. Predicted Costs ($ / 1,000 Pounds of Steady-State Live Weight (SSLW) per Year) of Retrofitting Smithfield Foods/Premium Standard Farms Representative Farm Type / Farm Size Combinations: ISSUES Aerobic Blanket System Technology

	Farm Size (1,000 pounds SSLW)				
	0-500	**500-1000**	**1000-1500**	**1500-2000**	**> 2000**
Farm Type					
Farrow-wean					
Rep. # of sows	650	1,700	2,400	4,000	7,000
Pit-recharge system	$195.97	$86.80	$66.85	$48.16	$38.79
Flush system	$200.40	$91.14	$72.25	$51.79	$42.77
Farrow-feeder					
Rep. # of sows	675	1,200	2,000	3,419	5,500
Pit-recharge system	$161.81	$99.82	$68.56	$55.47	$45.81
Flush system	$175.76	$113.40	$82.90	$68.71	$57.93
Farrow-finish					
Rep. # of sows	N/A	500	1,000	1,200	2,000
Pit-recharge system	N/A	$85.00	$57.24	$50.71	$39.48
Flush system	N/A	$93.68	$66.70	$59.24	$48.17
Wean-feeder					
Rep. head capacity	2,808	N/A	N/A	N/A	N/A
Pit-recharge system	$597.29	N/A	N/A	N/A	N/A
Flush system	$675.03	N/A	N/A	N/A	N/A
Feeder-finish					
Rep. head capacity	1,240	5,100	8,800	12,246	17,136
Pit-recharge system	$304.34	$81.64	$60.58	$52.89	$40.75
Flush system	$310.76	$86.51	$65.81	$58.83	$45.49