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Cost and Returns Analysis of Manure Management Systems Evaluated in 2004 under the North Carolina Attorney General Agreements with Smithfield Foods, Premium Standard Farms, and Front Line Farmers

TECHNOLOGY REPORT: EKOKAN

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: $342.26
Standardized Feeder-to-Finish Farm with 4,320 head (Tables EK.19- EK.29)
10-Year Amortization, Pit Recharge, N limited Irrigation onto Forages

Includes:	Modifications to Barn Flushing System:	$ 1.86 / 1,000 lbs. SSLW / Yr
	Lift Station:	$ 5.43 / 1,000 lbs. SSLW / Yr.
	Solids Separator:	$ 20.40 / 1,000 lbs. SSLW / Yr.
	Equalization Tank:	$ 8.59 / 1,000 lbs. SSLW / Yr.
	Biofilters:	$ 269.25 / 1,000 lbs. SSLW / Yr.
	Electrical Installation:	$ 23.39 / 1,000 lbs. SSLW / Yr.
	Technology Start-up Fees:	$ 3.83 / 1,000 lbs. SSLW / Yr.
	Increased Land Application Cost:	$ 9.51 / 1,000 lbs. SSLW / Yr.

Range:	Across Farm Sizes and Types (Pit-Recharge): / 1,000 lbs. SSLW / Yr.	$117.42 To $1,395.06
	Across Farm Sizes and Types (Flush): / 1,000 lbs. SSLW / Yr.	$118.55 To $1,433.44

Confidence in Estimates:

Medium to Medium-Low

Based on 10.5 months evaluation, real commercial setting data for solids separation, biofilter performance, electricity use and price, construction and operating performance and expense. Separated solids and backwash solids returned to lagoon which also received effluent from other barns.

Costs by Category:

Direct Construction:	$140.90 / 1,000 lbs. SSLW / Yr.
Contractor Overhead	$ 42.41 / 1,000 lbs. SSLW / Yr.
Total Operating:	$145.61 / 1,000 lbs. SSLW / Yr.
Technology Start-up Fees:	$ 3.83 / 1,000 lbs. SSLW / Yr.
Increased Land Application Cost:	$ 9.51 / 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	$114.14	$132.18
Baseline Cost Projection (10-year economic life, 8 % interest rate)	0.1490	$157.20	**$183.31***
High-Cost Projection (7-year economic life, 10 % interest rate)	0.2054	$209.72	$245.70

* 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)	$114.41
Baseline Cost of Electricity ($0.08 / kWh)	**$145.61***
High-Cost Electricity ($0.10 / kWh)	$176.80

* 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 $183.31 is the actual predicted 2004 construction and overhead cost for the EKOKAN system 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 value of annual construction and overhead costs.

Similarly, predicted **annual operating costs** of the EKOKAN system are recalculated using higher and lower prices for electricity. The 25% increase or decrease in electricity price has a significant effect on the predicted annual operating cost per unit reflecting significant use of electricity by the biofilter system.

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. The EKOKAN system produces separated solids, biofilter backwash, and liquid effluent. While systems for de-watering the biofilter backwash have been proposed, none was demonstrated so separation performance and cost data are not available. Breakeven analysis is conducted for the separated solids.

Break-even Analysis on Separated Solids: 4,320-Head Feeder to Finish Farm

Cost to be Recovered	**($ / 1,000 lbs. SSLW / Year)**	**Breakeven Price @ 448 lbs. / 1,000 lbs. SSLW per Year***
		($ / ton)
Cost of solids separator only	$20.40	$91
Cost EKOKAN system retrofit	$342.26	$1528

* Calculated as 261,578 wet pounds per year containing 85% moisture.

The table above presents partial and total breakeven prices. The first row of numbers in the table presents the breakeven price of the additional technology necessary to produce the by-product (e.g. the separator to produce separated solids). The bottom line in each table is the price necessary to offset the cost of the entire retrofitted manure management system.

To be economically viable, by-product prices must at least exceed their cost of production. Solids separation is required for the biofilters to function properly so separation will occur in this system whether or not the solids can generate savings or revenue sufficient to offset the cost of separation.

If more than one by-product is produced and they each generate revenue or savings greater than their cost, a set of breakeven prices for the total system can be calculated by assigning a fraction of the remaining cost to each by-product. For example, if separated solids and biofilter backwash both generate revenue higher than their costs, then the remaining costs of the system could be assigned in some proportion (e.g. 10% to solids and 90% to backwash) and breakeven prices for each could be calculated.

1. Overview of the EKOKAN Technology

1.1 Farm Overview

The EKOKAN system was evaluated on the Brown's of Carolina #93 farm near Bladenboro, NC in Bladen County. This is a finishing farm containing a total of twenty houses that are separated into four groups of five houses. The EKOKAN system treats effluent from one of these five-house groups. The farm has a total capacity of 16,000 head, divided equally among the four five-house groups (4,000 head capacity per group). In total, the EKOKAN system treats five barns, with a 4,000 head capacity or 540,000 lbs. SSLW.[1]

Prior to the construction of the EKOKAN technology, all of Farm #93's swine manure was treated with two single-stage lagoons, each being 634' x 344' at the bank top. The lagoons have one five-house group on either length side, so one lagoon served a total of ten houses. The total lagoon volume reported is 1,582,724 ft^3 (Worley-Davis).

All Farm #93 barns use pit-recharge systems containing one pit per house (Worley-Davis). Each pit is emptied once a week, and the volume required to recharge the pits is approximately 23,000 gallons (Worley-Davis). Thus, it is estimated that the daily barn effluent flow is 35,890 gallons per weekday,[2] assuming pits are emptied and recharged only on weekdays.

1.2 Technology Overview

The EKOKAN system provides mechanical solids separation and nitrification/denitrification via up-flow biofilters. The system is designed based on farm type and size and the chemical oxygen demand contained in the barn effluent flow, among other manure characteristics. At the evaluation site, the frequency of pit-recharges was modified and placed on automatic control, but in the future the flushing schedule will not be altered. This is because the evaluation site was operated 24 hours a day, whereas most farms will not want any machinery running during non-working hours. Two baffles were placed to separate the lagoon into three partitions. The third partition receives barn effluent from the five barns not being treated by the EKOKAN technology.

Piping is placed in front of the buildings to divert barn effluent away from the lagoon to the EKOKAN treatment center. In emergencies, the barn effluent can overflow into the lagoon. After flowing by gravity from the barns, the effluent first undergoes solids separation. In practice, the solids will be land applied. At the site, however, they are pumped into the second section of the partitioned lagoon. After the solid separation, the

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[1] Using 135 lbs. SSLW / head

[2] [23,000 gallons / week / pit * 5 Pits + 7*[2.3 gallons manure, urine, and excess wash water / head / day (NRCSa) * 4,000 head capacity]] = 179,400 gallons / week. Assuming the pits are emptied one at a time Monday-Friday, this implies an average daily flow of 179,400 /5 = 35,890 gallons / work day.

supernatant (liquid) is pumped by a lift station up to an equalization tank. The supernatant then flows from the equalization tank to two sets of biofilters.

Each set of biofilters is identical. Liquid flows by gravity from the equalization tank to the first biofilter of the set. The first biofilter performs digestion that breaks down volatile and carbon compounds, a necessary step before nitrification. The second biofilter performs nitrification where bacteria convert ammonium to nitrate. The first and second biofilters contain different bacteria colonies. The biofilters are filled with media to increase surface area to which bacteria cling. Air is pumped in from below, providing all necessary ingredients for nitrification (transformation of ammonia nitrogen to nitrate). As the first biofilter fills, it empties into the second biofilter where the same treatment takes place. Finally, the liquid from both biofilter sets is emptied into the first section of the partitioned lagoon. Some denitrification may occur in this partition, depending on how much carbon remains after the first biofilter treatment.(Kantardjieff)

Periodically, sludge accumulates in the biofilters and is washed out. This 'backwash' material was proposed to be treated with a sludge drying bed, but at the evaluation site it is pumped into the second section of the partitioned lagoon. As a default, it is assumed in our model that the backwash is mixed with the treated effluent and land applied at a later time.

The EKOKAN system became operational on August 14, 2002, when it was acclimated with diluted lagoon liquid. From that date until June 30, 2003, when the system was terminated due to lack of operational funding, the EKOKAN technology was operating continuously.

2. EKOKAN System Design and Mass Balance

2.1 Solids Separator

Effluent drained from barns is first sent to a TR mechanical solids separator. Separated solids are pumped to the second section of the partitioned lagoon where they are stored to be land applied at a later date. In the model it is assumed that the solids are stored short term in a temporary storage. The cost of the storage is estimated at $10,000 and does not vary with the size of the farm. Design, cost, operation, and environmental effects of a separated solids storage remain to be specified and evaluated. The separator contains a concrete basin that must be large enough to hold a single weekday volume of barn effluent. Because the solids were conveyed directly from the separator to the lagoon via an auger, there was no measurement of the total amount of solids that were separated from the flushed manure. However, batch tests were performed on six separate flushes to provide some sample data. For the first four of these grab samples, there was a press section (weighted plate over the solids outlet at the top of the inclined screen/conveyor) on the solids separator. For the final two readings, the press section had been removed.

For the four grab samples in which the press was present on the solids separator, the average amount of solids collected by the EKOKAN separator was 43.0 lbs. (wet basis) per pit release from the barn. On average, 78.7 % of this weight was moisture which resulted in 9.16 lbs. of separated dry solids and 33.84 lbs. of water. The total amount of solids contained in the flushed manure on those dates averaged 944.6 lbs. With the press section of the separator attached, 0.97 % of flushed solids were being separated. When the press section was removed, the EKOKAN separator collected an average of 153.2 lbs. of solids (wet basis) per pit release from the barn. Without the press, a higher percentage of the solids were moisture (85.0 %). On average, 23.0 lbs. of solids (dry matter basis) per pit release from the barn were collected in the two samples without the press section. The total amount of dry solids in the flushed manure for these dates averaged 926.9 lbs., resulting in a separation efficiency of 2.48 % without the press section. To avoid overstating the cost of separation, it is assumed in the model that the separator is able to separate 3 % of total solids. Based on the averages of the six grab samples, the nutrient content of the solids separated by the EKOKAN system was 0.80 % nitrogen, 0.33 % phosphorus, and 0.87 % potassium (percentages are for wet basis separated solids including an average of 81.26 % water). For the readings taken without the press section attached, the content of nitrogen and phosphorus dropped slightly, while the content of potassium increased (Westerman).

The solids separator is designed such that separated liquid (supernatant) flows via gravity to the separator concrete basin. This basin is designed to hold one weekday volume of barn effluent. A lift station then pumps supernatant from the separator to the equalization tank. From the equalization tank, the supernatant gravity flowed through the biofilters. Some of the treated effluent from the biofilters gravity flowed to a storage cell where it was used for recharging the pits. Approximately half of the treated effluent was returned to the equalization tank. pH level was monitored in the equalization tank and was generally between 8 and 9. The purpose of the equalization tank is to ensure that the appropriate amount of supernatant will flow to the biofilters regardless of flow from the barns or the separator.

2.2 Upflow Biofilters

EKOKAN's mass balance studies suggested that 25.46 % of the total nitrogen in the supernatant (separated liquid leaving solid separator and entering biofilters) is retained in backwash from the two filters. The first filter's backwash contains 20.72 % of total nitrogen, while the backwash from the second filter contains an additional 4.74 %. Of the remaining nitrogen in the supernatant, 13.85 % is unaccounted for and likely volatilized as elemental nitrogen or ammonia. The remaining 60.69 % of the total nitrogen was contained in the biofilter liquid effluent. Of total phosphorus, 29.00 % was captured by backwashing the first filter. An additional 6.79 % was retained by the second filter's backwash, for a total of 35.79 % of phosphorus contained in the backwash. 23.96 % of the total phosphorus was unaccounted for, with the final 40.25 % of phosphorus residing in the biofilter liquid effluent. Of the 0.63 % (6,317 mg / L) of total solids in liquid entering the biofilters, 25.62 % was captured by backwashing the first biofilter. 6.00 %

of total solids were retained by backwashing the second biofilter, summing to 31.62 % of total solids contained in the backwash. All total solids were accounted for, with the remaining 68.38 % exiting in the biofilter effluent. In total, the backwash volume was 24.97 % of total separator supernatant volume. The backwash also contained 25.46 % of total nitrogen, 35.79 % of total phosphorus, and 31.62 % of total solids contained in the separator supernatant. The average of samples taken from section L1 of the lagoon (the section that received biofilter effluent) from 12/01/02 to 6/03/03 contained 0.0526 % nitrogen (20 samples), 0.0077 % phosphorus (12 samples), and 0.146 % potassium (12 samples) (Westerman).

3. EKOKAN Technology Invoiced Construction Costs (Tables EK.1-EK.5)

3.1 Modifications to Flushing System

At the evaluation site, automatic flushers were installed in each of five barns so that the pits could be recharged frequently and at any time of day. These automatic flushers allow the EKOKAN system to run 24 hours / day. Originally, pipes extended straight out of each barn into the lagoon. These pipes were intersected, diverting barn effluent away from the pipes toward the solids separator. Barn effluent can flow into the lagoon should the system malfunction.

Table EK.1 shows the costs incurred for these inputs. It was decided that, should EKOKAN be used on an alternative site, automatic flushers would not be installed. This is because most farms do not want systems running except during working hours when people are present, just as a precaution. Thus, the only modifications to the flushing system would be the piping diverting barn effluent away from the lagoon to the solids separator. The only inputs in Table 1 that would be used are the manholes, riser, and 8'' PVC pipe to the solids separator. For this 4,000-head finishing farm, the cost of these components would be $4,555.26 (includes labor).

Farms with more or fewer barns will incur greater or lesser costs. The evaluation site suggests an average cost of $911 / barn. This is the charge that was used on this farm and it was applied to all technologies that modified barn effluent evacuation systems. This charge is doubled where flush systems are used to account for the extra pipes.

3.2 Solids Separator and Lift Station

The separator is Model Max 1024-24 and is manufactured by Blossom Agritec Limited and utilizes 0.62 mm screens. This separator can handle an average flow rate of 200 gallons per minute or 12,000 gallons per hour (Blossom Agritec Limited). Smithfield Foods and Premium Standard Farms prefer not to run equipment when farms are unattended. Thus, it is assumed that the separator does not run more than ten hours per day, which means the number of separators needed per farm equals:

(1) Number of Separators = Daily Discharge / (10 hours * 12,000 Gal. / Hour)

Table EK.2 shows the solids separator construction and lift station costs. The lift-station was actually a demonstrational version and was obtained at a substantially reduced price of $10,000. The normal purchase price is actually $26,630 (Brock Equipment). Therefore, the invoiced $12,700 separator cost (purchase price and labor) was adjusted to reflect purchase of new equipment ($26,630 + $2,700 = $29,330). The cost of a lift station will not change because its size does not vary with effluent flow. The concrete basin in the separator is designed to accommodate the daily effluent flow and the lift station pumps. Nothing on the separator changes with effluent flow either except the size of the concrete basin. The concrete basin(s) for the separator must be able to hold the equivalent of one day's discharge. If two basins are used, each must hold one-half of the total daily output. The cost of purchasing and installing the concrete basin at the evaluation site (which is 30,000-40,000 gallons) was $10,737. NRCSb suggests these same costs for a 1,000-1,500 gallon tank are $486-$599. By interpolating between these two costs, we can derive a linear cost function for concrete basins of:

(2) Concrete Basin Costs = $263 + $233(Gallon Capacity / 1,000)

See Appendix F for more on costing lift stations and concrete basins.

The other cost (excluding separator purchase price and concrete basin purchase and installation) involved with the separator installation is estimated to be $2,303. Considering all costs, the mechanical solids separator construction costs are estimated as:

(a) Number of Separators = Daily Effluent Flow / (10 hours * 12,000 Gal. / Hour)

(b) Concrete Basin Volume = (Daily Effluent Flow in Gallons) / (Number of Separators)

(c) Total Mechanical Solids Separator Construction Costs =
Number of Separators*(Separator Purchase and Installation Costs
+ Concrete Basin Cost)

3.3 EKOKAN Biofilters

The EKOKAN biofilter system consists of an equalization tank(s) and sets of biofilters. The equalization tank ensures the appropriate flow of effluent into the biofilters, regardless of the flow from the barn or separators.

EKOKAN biofilters are designed to be used in sets. Effluent is gravity fed from the equalization tank top to the bottom of the first biofilter (if more than one set of biofilters are used, as on the evaluation site, effluent is distributed evenly between the first biofilters of each set). As the first biofilter fills up, it overflows to the bottom of the second biofilter. As the second biofilter fills up, biofilter effluent drains to the original lagoon for storage before land application. Periodically, the biofilters are backwashed, removing a significant portion of the nutrients in film, suspended solids, and bacteria biomass.

The equalization tank and biofilter costs are estimated as follows. First, the size of equalization tanks and number of biofilter sets is calculated (see Appendix E). The costs recorded at the EKOKAN evaluation site are shown in Table EK.3.

The equalization tank's volume must be sufficiently large to store the daily barn effluent flow.[3] The equalization tank on the evaluation site is a Slurrystore 2020 steel tank, which is 19.58 feet in diameter and 18.81 feet high (liquid is only 17.64 feet high). The four biofilter tanks also are Slurrystore 2020's. This implies a storage volume equal to:

(3) Tank Volume= $\pi(19.58/2)^2(17.64)(7.48 \text{ gallons} / \text{ft}^3) = 40{,}000$ gallons.

The purchase price of this tank was \$6,000. As indicated by the tank manufacturer (ESPCb) this price represents a significant markdown from the normal market price. The market price for an installed Slurrystore 2020 tank which included material, labor, freight and overhead was estimated by the manufacturer to equal \$20,125. In the standardized model the size of the homogenization tank varies with the amount of effluent flow. The required volume is calculated first and then the least expensive tank providing the volume is selected from a spreadsheet provided by the tank manufacturer[4]

Concrete pads and rebar for concrete totaled \$3,764, or \$753 for each five tanks at the evaluation site. The charge of \$903.4 was applied to each tank to estimate the cost of concrete pads (includes labor, excavation, gravel and sand , equipment required for construction).

While the size of equalization tanks varies as required, the biofilter tank sizes are assumed constant by design: only the number of biofilter sets used can change.[5] The number of biofilter sets depends upon the chemical oxygen demand (COD) discharge from the barn. As Tables EK.A.1-EK.A.3 (Appendix EK.A) indicate, this farm has a discharge of (0.746 lbs. COD / head capacity / day)(4,000 head) = 2,986 lbs. COD / day. According to the technology provider, each biofilter can handle 2,000 lbs. of COD / day. The number of sets needed is calculated by the following formula:

(4) Number of Biofilters = COD (lbs. / day / farm) / Biofilter Loading Rate

The number of biofilters calculated is rounded to the nearest whole number.

[3] Volume of barn effluent removed by the separator is minor and is therefore not included.
[4] For more information on tank sizes and prices see Appendix E.
[5] If the biofilter volumes are changed, the technology performance cannot be guaranteed.

The filter media costs (media provided by EKOKAN) were $13,494, or $6,747.38 per biofilter set (materials and labor). A support structure for the two biofilter sets were $11,684 or $5,842 / set, which includes materials and labor. Additional media and support totaled $73,238.49 or $36,619 / set. Additional biofilter tank accessories were ($27,600 / 2) = $13,800 / biofilter set. The concrete pad charge (including rebar) was $1,506 / biofilter set. Biofilter covers were $1,167 / biofilter set. These suggest a materials and labor charge equal to:

(5) Material and Labor = ($14,570 + $1,800 + $6,747.38 + $5,842 + $36,619 + $1,506 + $1,166) = $68,252 / biofilter set.

These are referred to as the "direct biofilter materials costs." Additional piping, valves, site preparation, interceptor boxes, and other accessory charges were $79,620.

Finally, a 60-HP Kaiser Omega 63 blower injects air into the biofilters and can serve one biofilter set. The blower purchase price was $13,856 / blower. The two blowers, the concrete pad under them, and materials and labor charges were $35,234 or ($35,234) / (2 biofilter sets) = $17,617 / biofilter set.

3.4 Electrical Installation Cost (Table EK.4)

Substantial electrical work is needed to make the biofilters operational. Table EK.4 shows the total electrical cost to be $59,569. This includes office building installations, control cabinets, wiring, and programming of the system. It is assumed that this cost does not change with the farm type and size in the model. These electrical costs are included in Table EK.5's summary of invoiced costs for the EKOKAN technology as it was originally constructed.

4. Invoiced Operating Costs (Table EK.6)

Table EK.6 summarizes EKOKAN's monthly invoiced electrical bills for the period when the system was fully operational (8/02-3/03). The EKOKAN technology accrued a monthly average of $3,794.73 in power bills over the 8 months for which invoiced costs are available.

5. Cost Modeling

Invoiced costs were reported in detail for the construction of the EKOKAN technology as it was built on Brown's of Carolina #93 farm. These costs are reported by unit process in Tables EK.1-EK.4 and in total in Table EK.5. The EKOKAN technology costs summed to $499,635.42. In the next step of the economic analysis, the data reported in Tables EK.1-EK.5 was adjusted for missing components and outdated prices. The technology provider did not report any unnecessary expenses that occurred at the experimental site and could be excluded from invoices.

Tables EK.7-EK.18 represent complete construction and operating cost incurred at the experimental site. In the next step, estimates of costs that would occur on standard (representative) North Carolina farms were calculated. These costs are presented in Tables EK.19-EK.29 for a 4,320-head feeder-to-finish facility using a pit-recharge system of manure removal. Tables EK.30-EK.40 present the costs associated with a standard North Carolina feeder-to-finish operation with a capacity of 4,320 head using a flush system of manure removal. A representative NC 8,800-head feeder-to-finish facility with a pit-recharge manure removal system is detailed in Tables EK.41-EK.51. is a 4,000-sow. Tables EK.52-EK.62 provide the estimated costs associated with using the EKOKAN technology on a 4,000 sow farrow-to-wean operation using a pit-recharge system of manure removal. Tables EK.63 and EK.64 extrapolate predicted costs to other representative farm sizes and types for all DWQ permitted farms and for Smithfield Foods/Premium Standard Farms owned operations only, respectively.

5.1 Actual Cost for EKOKAN Technology at Farm #93 (Tables EK.7-EK.18)

Table EK.7 provides the assumptions for the cost estimate calculation and 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).[6] Annualized cost for the whole farm and per 1,000 lbs. of SSLW (incremental cost) is also reported. In Table EK.7, incremental costs of the retrofit for each of the four land application scenarios equal about $385-$390 per 1,000 pounds SSLW per year. Tables EK.8-EK.15 summarize costs associated with individual unit processes of the EKOKAN technology. Specifically, the costs of the following unit processes are detailed: modifications to barn flushing system (EK.8), lift station (EK.9), solids separator (EK.10), equalization tank (EK.11), biofilters (EK.12), lagoon partitions (EK.13), electrical installation (EK.14), and technology start-up fees (EK.15). Table EK.15 also reports the total costs associated with the unit processes listed above. Total construction costs are reported as $723,711.94, while operating costs are estimated as $88,520.75. The total annualized cost of the EKOKAN technology before land application is estimated to be $205,201.36 for the 4,000-head feeder-to-finish facility at Farm #93. Tables EK.16 (lagoon effluent) and EK.17 (solids) report land application costs associated with the EKOKAN technology. Table EK.18 provides the mass balance of nutrients associated with the EKOKAN technology. This table is necessary to derive the numbers found in Tables EK.16 and EK.17.

5.2 Standardized Costs for EKOKAN Technology at a 4,320-Head Feeder-to-Finish Farm (Pit-Recharge System) (Tables EK.19-EK.29)

[6] For more on land application, see Appendix B of the Summary report for 2004 technologies.

Tables EK.19- EK.29 provide estimates of the standardized cost of constructing and operating the EKOKAN technology on a representative North Carolina farm. The representative farm modeled is a 4,320-head feeder-to-finish facility using a pit-recharge system for manure removal. Table EK.19 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs for the standardized retrofit with EKOKAN technology. The standardized incremental costs are around $340/1000 pounds SSLW per year for each of the four land application scenarios: about 12 % less than the cost estimate based on actual Farm #93 prices and performance data. Tables EK.20-EK.26 report standardized costs for the same unit processes as listed in the previous section (in the same order), with the notable exception of lagoon partitions. This particular component was deemed site-specific to the Farm #93 EKOKAN construction and would not be necessary at a standard NC farm. Within certain unit processes (e.g., modifications to barn flushing system), there might be differences in individual components between the actual and standardized models. Table EK.26 also sums the total costs of the standardized EKOKAN technology for a 4,320-head finishing facility with a pit-recharge system. Total construction costs are estimated at $671,118.09, while total annual operating costs are reported as $84,917.00. Total annualized costs before land application are estimated at $194,057.63 for this representative farm size and type. Tables EK.27 (lagoon effluent) and EK.28 (solids) summarize predicted land application costs associated with the standardized model for each of four scenarios. Table EK.29 provides an estimated mass balance of nutrients for this representative NC farm.

5.3 Standardized Costs for EKOKAN Technology at a 4,320-Head Feeder-to-Finish Farm (Flush System) (Tables EK.30-EK.40)

Tables EK.30- EK.40 provide estimates of the standardized cost of constructing and operating the EKOKAN technology on a representative 4,320-head feeder-to-finish farm in North Carolina with a flush system for manure removal. The type of manure removal system used is the only difference between the farm modeled in Tables EK.30-EK.40 versus the one in Tables EK.19-EK.29. Table EK.30 provides total annualized and per unit ($ / 1,000 lbs. SSLW) costs for the standardized EKOKAN technology. The standardized costs are around $345 / 1000 pounds SSLW per year for each of the four land application scenarios—about 2 % higher than the estimated cost for a similar farm with a pit-recharge system. Tables EK.31-EK.37 report the predicted costs of individual unit processes in this standardized model. Changes in recycled liquid volume in the flush system versus the pit recharge system cause some cost estimates to change between the two models. Total construction costs are estimated at $685,404.11(Table EK.37), while total annual operating costs are predicted at $85,306.66. Total annualized costs before land application are estimated at $196,278.28 for this representative farm size and type. Tables EK.38 (lagoon effluent) and EK.39 (solids) summarize the land application costs associated with this standardized model for each of four scenarios. Table EK.40 provides an estimated mass balance of nutrients for this representative farm.

5.4 Standardized Costs for EKOKAN Technology at an 8,800-Head Feeder-to-Finish Farm (Tables EK.41-EK.51)

Tables EK.41- EK.51 provide estimates of the cost of constructing and operating the EKOKAN technology on a standard (representative) 8,800-head feeder-to-finish farm in North Carolina with a pit-recharge system for manure removal. The standardized costs (Table EK.41) for the 8,800-head finishing facility are around $300 / 1,000 lbs. SSLW per year for each of the four land application scenarios—about 12 % less than the predicted cost for a similar type of operation with only 4,320-head finishing capacity. This result illustrates that economies of scale are present in the economic model of the EKOKAN technology. Specifically, the lift station and solids separator demonstrated significant economies of scale. The equalization tank also exhibited economies of scale, but to a lesser degree than the previously listed unit processes. Tables EK.42-EK.48 report the costs of individual unit processes in this standardized model. Total construction costs are estimated at $1,162,584.68 for the 8,800 head finishing farm and total annual operating costs are $165,885.14 (Table EK.48). Total annualized costs before land application are estimated at $356,382.44 for this representative farm size and type. While these total construction costs are higher than in the standardized 4,320-head model, the per unit capacity costs 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. Tables EK.49 (lagoon effluent) and EK.50 (solids) summarize the land application costs associated with this standardized model for each of four scenarios. Table EK.51 provides an estimated mass balance of nutrients for this representative farm.

5.5 Standardized Costs for EKOKAN Technology at a 4,000-Sow Farrow-to-Wean Farm (Tables EK.52-EK.62)

Tables EK.52- EK.62 provide standardized cost and returns estimates of construction and operating costs of retrofitting the EKOKAN technology onto a representative North Carolina 4,000-sow farrow-to-wean operation with a pit-recharge waste removal system. This representative farm contains 1,732,000 pounds of SSLW—the largest of any standard farm modeled for the EKOKAN technology. The standardized costs are around $125 / 1,000 lbs. SSLW / year (Table EK.52) for each of the four land application scenarios. These estimated costs are about 63 % less than predicted costs for the standardized 4,320-head finishing facility and 58 % less than costs of the 8,800-head finishing facility. The unit processes that contribute most significantly to these economies of scale are the equalization tank and the biofilters. Biofilter costs are reduced because 4,000 sows, though having a higher SSLW than 8,800 head of finishing pigs (1,732,000 lbs. vs. 1,188,000 lbs.), produce only about half as many pounds / day of COD (3,508 lbs. / day vs. 6,665 lbs. / day—see Appendix EK.A). Tables EK.53-EK.59 report the costs of individual unit processes in this standardized model. Total construction costs for the EKOKAN technology on a 4,000-sow farrow-to-wean operation are estimated at $784,452.55, while total annual operating costs are estimated at $91,210.82 (Table EK.59). Total annualized costs before land application are estimated at $217,358.06 for this representative farm size and type. Tables EK.60 (lagoon effluent) and EK.61 (solids) summarize the land application costs associated with this standardized model for each of four scenarios. Table EK.62 provides an estimated mass balance of nutrients for the 4,000-sow farrow-to-wean operation with the EKOKAN technology.

5.6 Extrapolation to Other Farm Types and Sizes (Tables EK.63-EK.64)

Table EK.63 presents the predicted per unit costs ($ / 1,000 lbs. SSLW/year) of the EKOKAN technology for each of the 25 size of farm / type of operation combinations. This table uses the representative farm size for permitted North Carolina farms within a size / type combination. Incremental costs are shown for both pit-recharge and flush systems and assume nitrogen-based land application to forages. Table EK.64 is similar to Table EK.63, but uses representative farm sizes for only those farms owned by Smithfield Foods or Premium Standard Farms. Tables EK.63 and EK.64 reveal that predicted costs decrease as the size of the farm increases. For the EKOKAN technology, farrow-to-wean operations are generally the least expensive within a given size category while wean-to-feeder operations are clearly the most expensive. The electrical installation cost (not dependent on size or type of operation), lift station, and solids separator contribute significantly to the diseconomies of size while daily COD production per 1000 pounds SSLW contributes to differences between types of farms.

6. Summary and Conclusions

The EKOKAN system was installed on an existing feeder to finish farm (Brown's of Carolina #93) and treated effluent from 5 pit recharge barns with capacity for 4,000 feeder-to-finish pigs. It was evaluated over a 10.5-month period. A solid separator removed less than 3 percent of the solids in the barn effluent. The separated liquid was treated in biofilters that were aerated by one 60-HP blower per biofilter set. The biofilters separated 25.46 % of the nitrogen as backwash (solids/sludge that accumulates in the biofilters) and 13.85% of nitrogen is unaccounted for in the biofilters and likely volatilized. Due to funding limitations, separated solids and backwash were returned to sections of the partitioned existing lagoon. That lagoon also received untreated effluent from five other barns at the site. It seems that little can be predicted from this evaluation about the level of nutrients in a lagoon that received only biofilter treated liquid.

The cost of installing the EKOKAN system at the experimental site was approximated at $499,635.42. Annualized costs of the actual system were approximated at $210,811.36 or $390.39 per 1,000 pounds SSLW per year for the 4,000-head feeder-to-finish farm. Observed operating costs included electricity bills of $3,794.73 per month.

Standardized cost of the EKOKAN system was approximated at $342.26 per 1,000 pounds SSLW per year for a 4,320-head feeder-to-finish farm with pit recharge and nitrogen-based land application onto forage. Significant economies of scale are generated by the model with costs ranging from $117.42 (for the largest farrow-to-wean farm) to $1,395.06 (for the smallest wean-to-feeder farm) per 1,000 pounds SSLW per year. The cost and returns models of EKOKAN assumes that only one size of biofilter set is used and that additional sets are added as needed to meet design capacity. This assumption leads to considerable overcapacity and excess cost per SSLW on smaller farms. Another assumption is that biofilter sets have capacity for a given amount (2,000 pounds) of COD loading per day. This assumption results in no increase in predicted biofilter cost despite adding 39% to the COD load. Specifically, the predicted biofilter cost for 4,000 sows farrow to wean (3,900 pounds of COD per day) is the same as the predicted biofilter cost for 4,320 feeder to finish pigs (2,800 pounds COD per day). It remains to be demonstrated whether the biofilters could achieve the same degree of treatment at the same cost if loaded with 39% more COD and other manure constituents. Finally, the standardized models assume that all solid and liquid effluents are land applied.

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Tables EK.1 through EK.6: Invoiced Construction Costs and Electricity Costs for EKOKAN

Table EK.1. Invoiced Construction Costs of EKOKAN Flush System

Component	Cost
Flush valve—automatic flusher	$1,778.00
Additional valve—automatic flusher	$1,365.25
Manhole	$1,905.00
Riser	$1,320.80
8” PVC to solids separator	$1,329.46
2” PVC for recycled water	$840.11
Control cabinets	$3,542.00
Total Cost of Flush System	**$12,080.62**

Table EK.2. Invoiced Construction Costs of EKOKAN Solids Separator

Component	Cost
Separator	$12,700.00
Concrete basin	$10,736.58
Concrete pad for auger	$314.96
Additional concrete inside separator	$1,988.19
Concrete lift station	$604.90
Float switch	$103.50
Float bracket	$23.00
V3WHV30 pump	$1,734.20
8” PVC	$145.67
Additional lift station accessories	$7,715.73
Total Cost of Solids Separator	**$36,066.73**

Table EK.3. Invoiced Construction Costs of EKOKAN Biofilters

Component	Cost
Slurrystore tanks	$34,500.00
Support structure	$11,684.00
Filter media	$13,494.76
Additional media and support	$73,238.49
Additional equalization tank accessories	$6,900.00
Additional biofilter tank accessories	$27,600.00
Concrete pads	$2,438.43
Rebar for concrete	$1,365.25
Galvanized steel piping	$21,414.74
6” PVC	$682.93
8” PVC	$1,784.76
Miscellaneous PVC accessories	$3,299.40
C92 actuator	$5,603.24
AVMA actuator	$9,626.60
B92 actuator	$8,756.65
AUMA actuator	$4,559.30
Pratt ballcentric plug valve	$1,924.05
Solenoid valve	$1,365.25
Additional valves and accessories	$6,852.92
Blowers	$35,194.82
Site preparation	$8,064.70
Restoring site	$2,810.00
Interceptor boxes	$2,875.00
Biofilter covers	$2,333.65
Total Cost of Biofilters	**$288,368.94**

Table EK.4. Additional Invoiced Construction Costs for the EKOKAN Technology

Component	Cost
Lagoon baffles	$31,050.00
Electrical costs	$59,569.13
Miscellaneous expenses	
EKOKAN supervision	$15,000.00
Shop drawings	$11,500.00
Additional site expenses	$11,000.00
Project management	$20,000.00
Dry and wet tests	$5,000.00
Process start-up	$5,000.00
Operation and maintenance manual	$5,000.00
Subtotal	**$72,500.00**
Total Cost of Additional Expenses	**$163,119.13**

Table EK.5. Summary of Invoiced Construction Costs for EKOKAN Technology

Project Component	Cost	% of Total Cost
Flush system	$12,080.62	2.42 %
Solids separator	$36,066.73	7.22 %
Biofilters	$288,368.94	57.72 %
Lagoon baffles	$31,050.00	6.21 %
Electrical costs	$59,569.13	11.92 %
Miscellaneous expenses	$72,500.00	14.51 %
Total Cost of EKOKAN Technology	**$499,635.42**	**100.00 %**

Table EK.6. Monthly Operating Costs (Power Usage) for the EKOKAN Technology

Month	Operating Cost
August '02	$3,693.78
September '02	$3,642.35
October '02	$3,992.28
November '02	$3,914.91
December '02	$4,163.33
January '03	$3,619.48
February '03	$3,653.28
March '03	$3,678.40
Total Operating Cost	**$30,357.81**
Average Monthly Operating Cost	**$3,794.73**

Tables EK.7 through EK.18: Predicted Costs and Returns and Mass Balance for the EKOKAN System Based on Actual Cost and Performance Data-- 4,000-Head Feeder to Finish Farm

Table EK.7. EKOKAN Technology Assumptions and Total Annualized Costs—Actual Costs and Performance Data

Number of Animals	**4,000**				
Type of Operation	**Feeder-Finish**				
Barn Cleaning System	**Pit-Recharge System**				
Annualized Cost ($ / Year)					
Total Annualized Cost			Forages		Row Crops
	If Nitrogen-Based Application	**$**	**210,811.36**	**$**	**208,726.62**
	If Phosphorus-Based Application	**$**	**210,431.65**	**$**	**207,709.75**
Incremental Cost ($ / 1,000 Lbs of SSLW)					
Total Annualized Cost per Unit			Forages		Row Crops
	If Nitrogen-Based Application	**$**	**390.39**	**$**	**386.53**
	If Phosphorus-Based Application	**$**	**389.69**	**$**	**384.65**

Note: Daily volume discharged from barns is 120,000 gallons / day including recharge liquid.
SSLW equals 540,000 lbs.

Table EK.8. EKOKAN Technology Modifications to Barn Flushing System—Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Automatic Flushers	$ 3,143.25	$ 468.44
Manhole	$ 3,225.80	$ 480.74
Piping	$ 2,169.57	$ 323.33
Control Cabinets	$ 3,542.00	$ 527.86
Contractor & Engineering Services & Overhead	$ 5,206.75	$ 775.96
Total Construction Cost	$ 17,287.36	$ 2,576.33
Maintenance Cost		$ 241.61
Property Taxes		$ 61.37
Total Operating Cost		$ 302.98
TOTAL ANNUALIZED COST OF MODIFICATIONS TO BARN FLUSHING SYSTEM		**$ 2,879.31**

Table EK.9. EKOKAN Technology Lift Station Costs—Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Concrete Lift Station	$ 604.90	$ 90.15
Switches and Brackets	$ 126.50	$ 18.85
Pump	$ 1,734.20	$ 672.93
Piping	$ 145.67	$ 21.71
Lift Station Accessories	$ 7,715.73	$ 1,149.87
Contractor & Engineering Services & Overhead	$ 4,450.94	$ 663.32
Total Construction Cost	$ 14,777.94	$ 2,616.83
Maintenance Cost		$ 258.57
Electric Power Cost		$ 1,075.94
Property Taxes		$ 52.46
Total Operating Cost		$ 1,386.97
TOTAL ANNUALIZED COST OF LIFT STATION		**$ 4,003.80**

Table EK.10. EKOKAN Technology Solids Separator Costs—Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Storage for Separated Solids	$ 10,000.00	$ 1,490.29
Separator	$ 29,330.00	$ 4,371.03
Concrete Basin	$ 10,736.58	$ 1,600.07
Concrete Pad for Auger	$ 314.96	$ 46.94
Additional Concrete	$ 1,988.19	$ 296.30
Contractor & Engineering Services & Overhead	$ 18,261.35	$ 2,721.48
Total Construction Cost	$ 70,631.08	$ 10,526.11
Electric Power Cost		$ 2,498.31
Maintenance Cost		$ 1,927.29
Property Taxes		$ 250.74
Total Operating Cost		$ 4,676.34
TOTAL ANNUALIZED COST OF SOLIDS SEPARATOR		**$ 15,202.46**

Table EK.11. EKOKAN Technology Equalization Tank Costs—Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Equalization Tank	$ 20,125.00	$ 2,999.22
Concrete Pads and Rebars	$ 752.86	$ 112.20
Equalization Tank Accessories	$ 6,900.00	$ 1,028.30
Support Structure for Tanks	$ 2,336.80	$ 348.25
Contractor & Engineering Services & Overhead	$ 4,305.54	$ 641.65
Total Construction Cost	$ 34,420.20	$ 5,129.62
Maintenance Cost		$ 602.29
Property Taxes		$ 122.19
Total Operating Cost		$ 724.48
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 5,854.11**

Table EK.12. EKOKAN Technology Biofilters Costs—Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Biofilter Tanks	$ 80,500.00	$ 11,996.87
Support Structure for Tanks	$ 11,684.00	$ 1,741.26
Filter Media	$ 13,494.77	$ 2,011.12
Additional Filter Media and Support Structure	$ 73,238.49	$ 10,914.69
Biofilter Tank Accessories	$ 27,600.00	$ 4,113.21
Piping, Piping Accessories, and Valves	$ 65,869.83	$ 9,816.55
Blowers	$ 35,194.85	$ 13,656.78
Site Preparation	$ 8,064.70	$ 1,201.88
Restoring Site	$ 2,810.00	$ 418.77
Interceptor Box	$ 2,875.00	$ 428.46
Concrete Pads and Rebars	$ 3,011.42	$ 448.79
Biofilter Covers	$ 2,333.65	$ 347.78
Contractor & Engineering Services & Overhead	$ 140,797.37	$ 20,983.00
Total Construction Cost	$ 467,474.37	$ 78,079.18
Maintenance Cost		$ 5,994.26
Electric Power Cost		$ 71,951.33
Property Taxes		$ 1,659.53
Total Operating Cost		$ 79,605.12
TOTAL ANNUALIZED COST OF BIOFILTERS		**$ 157,684.30**

Table EK.13. EKOKAN Technology Lagoon Partitions Costs—Actual Costs and Performance Data

Component	Total Cost	Annualized Cost
Baffle Curtain	$ 15,525.00	$ 2,313.68
Contractor & Engineering Services & Overhead	$ 6,691.28	$ 997.20
Total Construction Cost	$ 22,216.28	$ 3,310.88
Maintenance Cost		$ 310.50
Property Taxes		$ 78.87
Total Operating Cost		$ 389.37
TOTAL ANNUALIZED COST OF LAGOON PARTITIONS		**$ 3,700.25**

Table EK.14. EKOKAN Technology Electrical Installation Costs—Actual Costs and Performance Data

Component		Total Cost		Annualized Cost
Electrical-Material	$	35,551.00	$	5,298.15
Electrical-Labor	$	21,685.00	$	3,231.70
Contractor & Engineering Services & Overhead	$	24,668.72	$	3,676.37
Total Construction Cost	$	81,904.72	$	12,206.22
Maintenance Cost			$	1,144.72
Property Taxes			$	290.76
Total Operating Cost			$	1,435.48
TOTAL ANNUALIZED COST OF ELECTRICAL INSTALLATION			**$**	**13,641.70**

Table EK.15. EKOKAN Technology Start-up Fees—Actual Costs and Performance Data

Component		Total Cost		Annualized Cost
Dry and Wet Tests	$	5,000.00	$	745.15
Process Start-up	$	5,000.00	$	745.15
Operation and Maintenance Manual	$	5,000.00	$	745.15
TOTAL COST OF START-UP FEES	**$**	**15,000.00**	**$**	**2,235.44**

TOTAL CONSTRUCTION COST OF EKOKAN TECHNOLOGY INCLUDING START-UP	**$**	**723,711.94**
TOTAL OPERATING COST OF EKOKAN TECHNOLOGY INCLUDING ROYALTIES (IF ANY)	**$**	**88,520.75**
TOTAL ANNUALIZED COSTS OF EKOKAN TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**205,201.36**

Table EK.16. EKOKAN Technology Predicted Liquid Land Application Costs for Four Scenarios — Based on Actual Costs and Performance Data

Annual Cost of Applying Lagoon Effluent		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	11,285.77	$	7,038.99
If Phosphorus-Based Application	$	10,871.94	$	7,040.07
Acres Needed For Assimilation		**Forages**		**Row Crops**
If Nitrogen-Based Application		14.17		45.91
If Phosphorus-Based Application		24.46		66.87
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	849.95		-
If Phosphorus-Based Application	$	1,467.65		-
Irrigation Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	10,435.82	$	8,017.69
If Phosphorus-Based Application	$	8,537.60	$	8,459.45
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application		-	$	(978.70)
If Phosphorus-Based Application		-	$	(1,419.39)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application		-		-
If Phosphorus-Based Application	$	866.69		-

Note: 4,125,688 gallons / year of effluent land applied at Farm # 93.

Table EK.17. EKOKAN Technology Solids Application Costs for Four Land Application Scenarios—Actual Costs and Performance Data

Annual Cost of Applying Solids	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 4,516.76	$ 4,162.02
If Phosphorus-Based Application	$ 7,757.60	$ 4,187.59
Acres Needed For Application	**Forages**	**Row Crops**
If Nitrogen-Based Application	4.02	13.04
If Phosphorus-Based Application	18.68	49.91
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 241.48	-
If Phosphorus-Based Application	$ 1,120.85	-
Application Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 4,275.27	$ 4,448.60
If Phosphorus-Based Application	$ 4,556.20	$ 5,142.32
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	$ (286.58)
If Phosphorus-Based Application	-	$ (828.28)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	-
If Phosphorus-Based Application	$ 2,080.54	-

Note: 242,202 lbs. / year of solids land applied at Farm #93.

Table EK.18. Summary and Mass Balance of Generated and Land Applied Nutrients for EKOKAN Technology—Actual Costs and Performance Data

Nutrient Balance	**Nitrogen (lbs / year)**	**Phosphorus (lbs / year)**	**Potassium (lbs / year)**
Generated At Barn	80,960	23,200	39,800
Removed in Separated Solids	1,947	791	2,096
Land Applied in Lagoon Effluent	8,225	1,211	22,751
Removed in Biofilters and Unaccounted For	70,788	21,198	14,953

Tables EK.19 through EK.29: Predicted Costs and Returns and Mass Balance for The EKOKAN System Based on Standardized Cost and Performance Data-- 4,320-Head Representative Feeder to Finish Farm with Pit-Recharge

Table EK.19. EKOKAN 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	**$**	**199,604.57**	**$**	**197,520.57**
	If Phosphorus-Based Application	**$**	**199,300.57**	**$**	**196,442.17**
Incremental Cost ($ / 1,000 Lbs of SSLW)					
Total Annualized Cost per Unit			Forages		Row Crops
	If Nitrogen-Based Application	**$**	**342.26**	**$**	**338.68**
	If Phosphorus-Based Application	**$**	**341.74**	**$**	**336.84**

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

Table EK.20. EKOKAN Technology Modifications to Barn Flushing System—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Waste Evacuation/Plumbing Charge	$ 4,555.00	$ 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 Cost		$ 114.24
TOTAL ANNUALIZED COST OF MODIFICATIONS TO BARN FLUSHING SYSTEM		**$ 1,085.64**

Table EK.21. EKOKAN Technology Lift Station Costs—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Concrete Lift Station	$ 604.90	$ 90.15
Switches and Brackets	$ 126.50	$ 18.85
Pump	$ 1,734.20	$ 672.93
Piping	$ 145.67	$ 21.71
Lift Station Accessories	$ 7,715.73	$ 1,149.87
Contractor & Engineering Services & Overhead	$ 4,450.94	$ 663.32
Total Construction Cost	$ 14,777.94	$ 2,616.83
Maintenance Cost		$ 258.57
Electric Power Cost		$ 236.18
Property Taxes		$ 52.46
Total Operating Cost		$ 547.21
TOTAL ANNUALIZED COST OF LIFT STATION		**$ 3,164.04**

Table EK.22. EKOKAN Technology Solids Separator Costs—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Storage for Separated Solids	$ 10,000.00	$ 1,490.29
Separator	$ 29,330.00	$ 4,371.03
Concrete Basin	$ 6,871.12	$ 1,024.00
Concrete Pad for Auger	$ 314.96	$ 46.94
Contractor & Engineering Services & Overhead	$ 15,738.43	$ 2,345.49
Total Construction Cost	$ 62,254.51	$ 9,277.76
Electric Power Cost		$ 590.46
Maintenance Cost		$ 1,810.22
Property Taxes		$ 221.00
Total Operating Cost		$ 2,621.68
TOTAL ANNUALIZED COST OF SOLIDS SEPARATOR		**$ 11,899.44**

Table EK.23. EKOKAN Technology Equalization Tank Costs—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Equalization Tank	$ 15,202.50	$ 2,265.62
Concrete Pads and Rebars	$ 752.86	$ 112.20
Equalization Tank Accessories	$ 6,900.00	$ 1,028.30
Support Structure for Tanks	$ 2,336.80	$ 348.25
Contractor & Engineering Services & Overhead	$ 4,305.54	$ 641.65
Total Construction Cost	$ 29,497.70	$ 4,396.03
Maintenance Cost		$ 503.84
Property Taxes		$ 104.72
Total Operating Cost		$ 608.56
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 5,004.59**

Table EK.24. EKOKAN Technology Biofilters Costs—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Biofilter Tanks	$ 80,500.00	$ 11,996.87
Support Structure for Tanks	$ 11,684.00	$ 1,741.26
Filter Media	$ 13,494.77	$ 2,011.12
Additional Filter Media and Support Structure	$ 73,238.49	$ 10,914.69
Biofilter Tank Accessories	$ 27,600.00	$ 4,113.21
Piping, Piping Accessories, and Valves	$ 65,869.83	$ 9,816.55
Blowers	$ 35,194.85	$ 13,656.78
Site Preparation	$ 8,064.70	$ 1,201.88
Restoring Site	$ 2,810.00	$ 418.77
Interceptor Box	$ 2,875.00	$ 428.46
Biofilter Covers	$ 2,333.65	$ 347.78
Contractor & Engineering Services & Overhead	$ 139,499.74	$ 20,789.57
Total Construction Cost	$ 463,165.02	$ 77,436.96
Maintenance Cost		$ 5,994.26
Electric Power Cost		$ 71,951.33
Property Taxes		$ 1,644.24
Total Operating Cost		$ 79,589.82
TOTAL ANNUALIZED COST OF BIOFILTERS		**$ 157,026.78**

Table EK.25. EKOKAN Technology Electrical Installation Costs—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component	Total Cost	Annualized Cost
Electrical-Material	$ 35,551.00	$ 5,298.15
Electrical-Labor	$ 21,685.00	$ 3,231.70
Contractor & Engineering Services & Overhead	$ 24,668.72	$ 3,676.37
Total Construction Cost	$ 81,904.72	$ 12,206.22
Maintenance Cost		$ 1,144.72
Property Taxes		$ 290.76
Total Operating Cost		$ 1,435.48
TOTAL ANNUALIZED COST OF ELECTRICAL INSTALLATION		**$ 13,641.70**

Table EK.26. EKOKAN Technology Start-up Fees—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Component		Total Cost		Annualized Cost
Dry and Wet Tests	$	5,000.00	$	745.15
Process Start-up	$	5,000.00	$	745.15
Operation and Maintenance Manual	$	5,000.00	$	745.15
TOTAL COST OF START-UP FEES	**$**	**15,000.00**	**$**	**2,235.44**

TOTAL CONSTRUCTION COST OF EKOKAN TECHNOLOGY INCLUDING START-UP	**$**	**671,118.09**
TOTAL OPERATING COST OF EKOKAN TECHNOLOGY INCLUDING ROYALTIES (IF ANY)	**$**	**84,917.00**
TOTAL ANNUALIZED COSTS OF EKOKAN TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**194,057.63**

Table EK.27. EKOKAN Technology Liquid Land Application Costs for Four 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	$	11,404.06	$	7,131.63
If Phosphorus-Based Application	$	11,143.70	$	7,175.45
Acres Needed For Assimilation		**Forages**		**Row Crops**
If Nitrogen-Based Application		15.27		49.49
If Phosphorus-Based Application		26.37		72.07
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	916.15		-
If Phosphorus-Based Application	$	1,581.95		-
Irrigation Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	10,487.92	$	8,186.55
If Phosphorus-Based Application	$	8,627.56	$	8,705.38
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application		-	$	(1,054.92)
If Phosphorus-Based Application		-	$	(1,529.93)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application		-		-
If Phosphorus-Based Application	$	934.19		-

Note: 4,446,995 gallons / year of effluent modeled to be land applied

Table EK.28. EKOKAN Technology Solids Application Costs for Four Land Application Scenarios—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Pit-Recharge System)

Annual Cost of Applying Solids	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 4,607.50	$ 4,223.27
If Phosphorus-Based Application	$ 8,105.77	$ 4,245.50
Acres Needed For Application	**Forages**	**Row Crops**
If Nitrogen-Based Application	4.35	14.09
If Phosphorus-Based Application	20.18	53.90
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 260.80	-
If Phosphorus-Based Application	$ 1,210.52	-
Application Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 4,346.69	$ 4,532.78
If Phosphorus-Based Application	$ 4,648.26	$ 5,276.11
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	$ (309.51)
If Phosphorus-Based Application	-	$ (1,031.11)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	-
If Phosphorus-Based Application	$ 2,246.99	-

Note: 261,578 lbs. / year of solids modeled to be land applied

Table EK.29. Summary and Mass Balance of Generated and Land Applied Nutrients for EKOKAN Technology—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	87,437	25,056	42,984
Removed in Separated Solids	2,103	854	2,264
Land Applied in Lagoon Effluent	8,865	1,306	24,523
Removed in Biofilters and Unaccounted For	76,468	22,896	16,197

Tables EK.30 through EK.40: Predicted Costs and Returns and Mass Balance for the EKOKAN System Based on Standardized Cost and Performance Data-- 4,320-Head Representative Feeder to Finish Farm with Flush System

Table EK.30. EKOKAN 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	**$**	**201,825.22**	**$**	**199,741.22**
	If Phosphorus-Based Application	**$**	**201,521.21**	**$**	**198,662.82**
Incremental Cost ($ / 1,000 Lbs of SSLW)					
Total Annualized Cost per Unit			Forages		Row Crops
	If Nitrogen-Based Application	**$**	**346.07**	**$**	**342.49**
	If Phosphorus-Based Application	**$**	**345.54**	**$**	**340.64**

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

Table EK.31. EKOKAN Technology Modifications to Barn Flushing System—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Waste Evacuation/Plumbing Charge	$ 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 Cost		$ 228.48
TOTAL ANNUALIZED COST OF MODIFICATIONS TO BARN FLUSHING SYSTEM		**$ 2,171.29**

Table EK.32. EKOKAN Technology Lift Station Costs—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Concrete Lift Station	$ 604.90	$ 90.15
Switches and Brackets	$ 126.50	$ 18.85
Pump	$ 1,734.20	$ 672.93
Piping	$ 145.67	$ 21.71
Lift Station Accessories	$ 7,715.73	$ 1,149.87
Contractor & Engineering Services & Overhead	$ 4,450.94	$ 663.32
Total Construction Cost	$ 14,777.94	$ 2,616.83
Maintenance Cost		$ 258.57
Electric Power Cost		$ 279.02
Property Taxes		$ 52.46
Total Operating Cost		$ 590.05
TOTAL ANNUALIZED COST OF LIFT STATION		**$ 3,206.88**

Table EK.33. EKOKAN Technology Solids Separator Costs—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Storage for Separated Solids	$ 10,000.00	$ 1,490.29
Separator	$ 29,330.00	$ 4,371.03
Concrete Basin	$ 8,069.63	$ 1,202.61
Concrete Pad for Auger	$ 314.96	$ 46.94
Contractor & Engineering Services & Overhead	$ 16,254.99	$ 2,422.47
Total Construction Cost	$ 63,969.58	$ 9,533.35
Maintenance Cost		$ 1,834.19
Electric Power Cost		$ 697.55
Property Taxes		$ 227.09
Total Operating Cost		$ 2,758.83
TOTAL ANNUALIZED COST OF SOLIDS SEPARATOR		**$ 12,292.18**

Table EK.34. EKOKAN Technology Equalization Tank Costs—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Equalization Tank	$ 19,255.25	$ 2,869.60
Concrete Pads and Rebars	$ 752.86	$ 112.20
Equalization Tank Accessories	$ 6,900.00	$ 1,028.30
Support Structure for Tanks	$ 2,336.80	$ 348.25
Contractor & Engineering Services & Overhead	$ 4,305.54	$ 641.65
Total Construction Cost	$ 33,550.45	$ 5,000.01
Maintenance Cost		$ 584.90
Property Taxes		$ 119.10
Total Operating Cost		$ 704.00
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 5,704.01**

Table EK.35. EKOKAN Technology Biofilters Costs—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Biofilter Tanks	$ 80,500.00	$ 11,996.87
Support Structure for Tanks	$ 11,684.00	$ 1,741.26
Filter Media	$ 13,494.77	$ 2,011.12
Additional Filter Media and Support Structure	$ 73,238.49	$ 10,914.69
Biofilter Tank Accessories	$ 27,600.00	$ 4,113.21
Piping, Piping Accessories, and Valves	$ 65,869.83	$ 9,816.55
Blowers	$ 35,194.85	$ 13,656.78
Site Preparation	$ 8,064.70	$ 1,201.88
Restoring Site	$ 2,810.00	$ 418.77
Interceptor Box	$ 2,875.00	$ 428.46
Biofilter Covers	$ 2,333.65	$ 347.78
Contractor & Engineering Services & Overhead	$ 139,499.74	$ 20,789.57
Total Construction Cost	$ 463,165.02	$ 77,436.96
Maintenance Cost		$ 5,994.26
Electric Power Cost		$ 71,951.33
Property Taxes		$ 1,644.24
Total Operating Cost		$ 79,589.82
TOTAL ANNUALIZED COST OF BIOFILTERS		**$ 157,026.78**

Table EK.36. EKOKAN Technology Electrical Installation Costs—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Electrical-Material	$ 35,551.00	$ 5,298.15
Electrical-Labor	$ 21,685.00	$ 3,231.70
Contractor & Engineering Services & Overhead	$ 24,668.72	$ 3,676.37
Total Construction Cost	$ 81,904.72	$ 12,206.22
Maintenance Cost		$ 1,144.72
Property Taxes		$ 290.76
Total Operating Cost		$ 1,435.48
TOTAL ANNUALIZED COST OF ELECTRICAL INSTALLATION		**$ 13,641.70**

Table EK.37. EKOKAN Technology Start-up Fees—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Component	Total Cost	Annualized Cost
Dry and Wet Tests	$ 5,000.00	$ 745.15
Process Start-up	$ 5,000.00	$ 745.15
Operation and Maintenance Manual	$ 5,000.00	$ 745.15
TOTAL COST OF START-UP FEES	**$ 15,000.00**	**$ 2,235.44**

TOTAL CONSTRUCTION COST OF EKOKAN TECHNOLOGY INCLUDING START-UP	**$ 685,404.11**
TOTAL OPERATING COST OF EKOKAN TECHNOLOGY INCLUDING ROYALTIES (IF ANY)	**$ 85,306.66**
TOTAL ANNUALIZED COSTS OF EKOKAN TECHNOLOGY WITHOUT LAND APPLICATION	**$ 196,278.28**

Table EK.38. EKOKAN Technology Liquid Land Application Costs for Four 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	$ 11,404.06	$ 7,131.63
If Phosphorus-Based Application	$ 11,143.70	$ 7,175.45
Acres Needed For Assimilation	**Forages**	**Row Crops**
If Nitrogen-Based Application	15.27	49.49
If Phosphorus-Based Application	26.37	72.07
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 916.15	-
If Phosphorus-Based Application	$ 1,581.95	-
Irrigation Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 10,487.92	$ 8,186.55
If Phosphorus-Based Application	$ 8,627.56	$ 8,705.38
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	$ (1,054.92)
If Phosphorus-Based Application	-	$ (1,529.93)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	-
If Phosphorus-Based Application	$ 934.19	-

Note: 4,446,995 gallons / year of effluent modeled to be land applied

Table EK.39. EKOKAN Technology Solids Application Costs for Four Land Application Scenarios—Standardized Quantities and Prices (4,320-Head Feeder-Finish with Flush System)

Annual Cost of Applying Solids	Forages	Row Crops
If Nitrogen-Based Application	$ 4,607.50	$ 4,223.27
If Phosphorus-Based Application	$ 8,105.77	$ 4,245.50
Acres Needed For Application	**Forages**	**Row Crops**
If Nitrogen-Based Application	4.35	14.09
If Phosphorus-Based Application	20.18	53.90
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 260.80	-
If Phosphorus-Based Application	$ 1,210.52	-
Application Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 4,346.69	$ 4,532.78
If Phosphorus-Based Application	$ 4,648.26	$ 5,276.11
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	$ (309.51)
If Phosphorus-Based Application	-	$ (1,031.11)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	-
If Phosphorus-Based Application	$ 2,246.99	-

Note: 261,578 lbs. / year of solids modeled to be land applied

Table EK.40. Summary and Mass Balance of Generated and Land Applied Nutrients for EKOKAN Technology—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	87,437	25,056	42,984
Removed in Separated Solids	2,103	854	2,264
Land Applied in Lagoon Effluent	8,865	1,306	24,523
Removed in Biofilters and Unaccounted For	76,468	22,896	16,197

Tables EK.41 through EK.51: Predicted Costs and Returns and Mass Balance for the EKOKAN System Based on Standardized Cost and Performance Data-- 8,800-Head Representative Feeder to Finish Farm with Pit-Recharge

Table EK.41. EKOKAN Technology Assumptions and Total Annualized Costs—Standardized Quantities and Prices (8,800-Head Feeder-Finish)

Number of Animals	**8,800**				
Type of Operation	**Feeder-Finish**				
Barn Cleaning System	**Pit-Recharge System**				
Annualized Cost ($ / Year)					
Total Annualized Cost			Forages		Row Crops
	If Nitrogen-Based Application	**$**	**360,981.84**	**$**	**358,898.22**
	If Phosphorus-Based Application	**$**	**361,698.61**	**$**	**356,896.47**
Incremental Cost ($ / 1,000 Lbs of SSLW)					
Total Annualized Cost per Unit			Forages		Row Crops
	If Nitrogen-Based Application	**$**	**303.86**	**$**	**302.10**
	If Phosphorus-Based Application	**$**	**304.46**	**$**	**300.42**

Note: Daily volume discharged from barns is 57,772 gallons / day including recharge liquid.
SSLW equals 1,188,000 lbs.

Table EK.42. EKOKAN Technology Modifications to Barn Flushing System—Standardized Quantities and Prices (8,800-Head Feeder-Finish)

Component	Total Cost	Annualized Cost
Waste Evacuation/Plumbing Charge	$ 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 Cost		$ 228.48
TOTAL ANNUALIZED COST OF MODIFICATIONS TO BARN FLUSHING SYSTEM		**$ 2,171.29**

Table EK.43. EKOKAN Technology Lift Station Costs—Standardized Quantities and Prices (8,800-Head Feeder-Finish)

Component	Total Cost	Annualized Cost
Concrete Lift Station	$ 604.90	$ 90.15
Switches and Brackets	$ 126.50	$ 18.85
Pump	$ 1,734.20	$ 672.93
Piping	$ 145.67	$ 21.71
Lift Station Accessories	$ 7,715.73	$ 1,149.87
Contractor & Engineering Services & Overhead	$ 4,450.94	$ 663.32
Total Construction Cost	$ 14,777.94	$ 2,616.83
Maintenance Cost		$ 258.57
Electric Power Cost		$ 481.11
Property Taxes		$ 52.46
Total Operating Cost		$ 792.14
TOTAL ANNUALIZED COST OF LIFT STATION		**$ 3,408.97**

Table EK.44. EKOKAN Technology Solids Separator Costs—Standardized Quantities and Prices (8,800-Head Feeder-Finish)

Component	Total Cost	Annualized Cost
Storage for Separated Solids	$ 10,000.00	$ 1,490.29
Separator	$ 29,330.00	$ 4,371.03
Concrete Basin	$ 13,723.98	$ 2,045.28
Concrete Pad for Auger	$ 314.96	$ 46.94
Contractor & Engineering Services & Overhead	$ 18,692.01	$ 2,785.66
Total Construction Cost	$ 72,060.95	$ 10,739.21
Electric Power Cost		$ 1,202.78
Maintenance Cost		$ 1,947.28
Property Taxes		$ 255.82
Total Operating Cost		$ 3,405.87
TOTAL ANNUALIZED COST OF SOLIDS SEPARATOR		**$ 14,145.08**

Table EK.45. EKOKAN Technology Equalization Tank Costs—Standardized Quantities and Prices (8,800-Head Feeder-Finish)

Component	Total Cost	Annualized Cost
Equalization Tank	$ 25,179.42	$ 3,752.48
Concrete Pads and Rebars	$ 752.86	$ 112.20
Equalization Tank Accessories	$ 6,900.00	$ 1,028.30
Support Structure for Tanks	$ 2,336.80	$ 348.25
Contractor & Engineering Services & Overhead	$ 4,305.54	$ 641.65
Total Construction Cost	$ 39,474.62	$ 5,882.88
Maintenance Cost		$ 703.38
Property Taxes		$ 140.13
Total Operating Cost		$ 843.52
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 6,726.40**

Table EK.46. EKOKAN Technology Biofilters Costs—Standardized Quantities and Prices (8,800-Head Feeder-Finish)

Component	Total Cost	Annualized Cost
Biofilter Tanks	$ 161,000.00	$ 23,993.75
Support Structure for Tanks	$ 23,368.00	$ 3,482.52
Filter Media	$ 26,989.53	$ 4,026.24
Additional Filter Media and Support Structure	$ 146,476.97	$ 21,829.39
Biofilter Tank Accessories	$ 55,200.00	$ 8,226.43
Piping, Piping Accessories, and Valves	$ 131,739.67	$ 19,633.09
Blowers	$ 70,389.70	$ 27,313.56
Site Preparation	$ 16,129.40	$ 2,403.76
Restoring Site	$ 5,620.00	$ 837.55
Interceptor Box	$ 5,750.00	$ 856.92
Biofilter Covers	$ 4,667.30	$ 695.57
Contractor & Engineering Services & Overhead	$ 278,999.48	$ 41,579.15
Total Construction Cost	$ 926,330.05	$ 154,873.91
Maintenance Cost		$ 11,988.52
Electric Power Cost		$ 143,902.66
Property Taxes		$ 3,288.47
Total Operating Cost		$ 159,179.65
TOTAL ANNUALIZED COST OF BIOFILTERS		**$ 314,053.56**

Table EK.47. EKOKAN Technology Electrical Installation Costs—Standardized Quantities and Prices (8,800-Head Feeder-Finish)

Component	Total Cost	Annualized Cost
Electrical-Material	$ 35,551.00	$ 5,298.15
Electrical-Labor	$ 21,685.00	$ 3,231.70
Contractor & Engineering Services & Overhead	$ 24,668.72	$ 3,676.37
Total Construction Cost	$ 81,904.72	$ 12,206.22
Maintenance Cost		$ 1,144.72
Property Taxes		$ 290.76
Total Operating Cost		$ 1,435.48
TOTAL ANNUALIZED COST OF ELECTRICAL INSTALLATION		**$ 13,641.70**

Table EK.48. EKOKAN Technology Start-up Fees—Standardized Quantities and Prices (8,800-Head Feeder-Finish)

Component		Total Cost		Annualized Cost
Dry and Wet Tests	$	5,000.00	$	745.15
Process Start-up	$	5,000.00	$	745.15
Operation and Maintenance Manual	$	5,000.00	$	745.15
TOTAL COST OF START-UP FEES	**$**	**15,000.00**	**$**	**2,235.44**

TOTAL CONSTRUCTION COST OF EKOKAN TECHNOLOGY INCLUDING START-UP	**$**	**1,162,584.68**
TOTAL OPERATING COST OF EKOKAN TECHNOLOGY INCLUDING ROYALTIES (IF ANY)	**$**	**165,885.14**
TOTAL ANNUALIZED COSTS OF EKOKAN TECHNOLOGY WITHOUT LAND APPLICATION	**$**	**356,382.44**

Table EK.49. EKOKAN Technology Liquid Land Application Costs for Four Scenarios—Standardized Quantities and Prices (8,800-Head Feeder-Finish)

Annual Cost of Applying Lagoon Effluent		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	13,071.85	$	8,437.71
If Phosphorus-Based Application	$	14,975.13	$	9,084.16
Acres Needed For Assimilation		**Forages**		**Row Crops**
If Nitrogen-Based Application		30.82		99.90
If Phosphorus-Based Application		53.22		145.49
Opportunity Cost of Land		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	1,849.39		-
If Phosphorus-Based Application	$	3,193.40		-
Irrigation Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application	$	11,222.46	$	10,567.23
If Phosphorus-Based Application	$	9,895.92	$	12,172.55
Savings From Not Having To Buy Fertilizer		**Forages**		**Row Crops**
If Nitrogen-Based Application		-	$	(2,129.53)
If Phosphorus-Based Application		-	$	(3,088.39)
Extra Fertilizer Purchase Costs		**Forages**		**Row Crops**
If Nitrogen-Based Application		-		-
If Phosphorus-Based Application	$	1,885.81		-

Note: 8,976,943 gallons / year of effluent modeled to be land applied

Table EK.50. EKOKAN Technology Solids Application Costs for Four Land Application Scenarios—Standardized Quantities and Prices (8,800-Head Feeder-Finish)

Annual Cost of Applying Solids	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 5,826.77	$ 5,016.96
If Phosphorus-Based Application	$ 12,907.93	$ 4,936.08
Acres Needed For Application	**Forages**	**Row Crops**
If Nitrogen-Based Application	8.85	28.70
If Phosphorus-Based Application	41.10	109.80
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 531.27	-
If Phosphorus-Based Application	$ 2,465.88	-
Application Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 5,295.50	$ 5,647.43
If Phosphorus-Based Application	$ 5,864.86	$ 7,036.49
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	$ (630.48)
If Phosphorus-Based Application	-	$ (2,100.41)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	-
If Phosphorus-Based Application	$ 4,577.20	-

Note: 532,844 lbs. / year of solids modeled to be land applied

Table EK.51. Summary and Mass Balance of Generated and Land Applied Nutrients for EKOKAN Technology—Standardized Quantities and Prices (8,800-Head Feeder-Finish)

Nutrient Balance	**Nitrogen (lbs / year)**	**Phosphorus (lbs / year)**	**Potassium (lbs / year)**
Generated At Barn	178,112	51,040	87,560
Removed in Separated Solids	4,284	1,740	4,612
Land Applied in Lagoon Effluent	17,896	2,635	49,503
Removed in Biofilters and Unaccounted For	155,932	46,664	33,445

Tables EK.52 through EK.62: Predicted Costs and Returns and Mass Balance for the EKOKAN System Based on Standardized Cost and Performance Data-- 4,000-Sow Representative Farrow to Wean Farm with Pit-Recharge

Table EK.52. EKOKAN Technology Assumptions and Total Annualized Costs—Standardized Quantities and Prices (4,000-Sow Farrow-Wean)

Number of Animals	**4,000**				
Type of Operation	**Farrow-Wean**				
Barn Cleaning System	**Pit-Recharge System**				
Annualized Cost ($ / Year)					
Total Annualized Cost			Forages		Row Crops
	If Nitrogen-Based Application	**$**	**220,129.23**	**$**	**218,751.57**
	If Phosphorus-Based Application	**$**	**212,711.60**	**$**	**215,232.71**
Incremental Cost ($ / 1,000 Lbs of SSLW)					
Total Annualized Cost per Unit			Forages		Row Crops
	If Nitrogen-Based Application	**$**	**127.10**	**$**	**126.30**
	If Phosphorus-Based Application	**$**	**122.81**	**$**	**124.27**

Note: Daily volume discharged from barns is 142,682 gallons / day including recharge liquid.
SSLW equals 1,732,000 lbs.

Table EK.53. EKOKAN Technology Modifications to Barn Flushing System—Standardized Quantities and Prices (4,000-Sow Farrow-Wean)

Component	Total Cost	Annualized Cost
Waste Evacuation/Plumbing Charge	$ 6,377.00	$ 950.36
Contractor & Engineering Services & Overhead	$ 2,748.49	$ 409.61
Total Construction Cost	$ 9,125.49	$ 1,359.97
Maintenance Cost		$ 127.54
Property Taxes		$ 32.40
Total Operating Cost		$ 159.94
TOTAL ANNUALIZED COST OF MODIFICATIONS TO BARN FLUSHING SYSTEM		**$ 1,519.90**

Table EK.54. EKOKAN Technology Lift Station Costs—Standardized Quantities and Prices (4,000-Sow Farrow-Wean)

Component	Total Cost	Annualized Cost
Concrete Lift Station	$ 1,209.80	$ 180.30
Switches and Brackets	$ 253.00	$ 37.70
Pump	$ 3,468.40	$ 1,345.86
Piping	$ 291.34	$ 43.42
Lift Station Accessories	$ 15,431.46	$ 2,299.74
Contractor & Engineering Services & Overhead	$ 8,901.87	$ 1,326.64
Total Construction Cost	$ 29,555.87	$ 5,233.66
Maintenance Cost		$ 517.13
Electric Power Cost		$ 1,188.21
Property Taxes		$ 104.92
Total Operating Cost		$ 1,810.27
TOTAL ANNUALIZED COST OF LIFT STATION		**$ 7,043.93**

Table EK.55. EKOKAN Technology Solids Separator Costs—Standardized Quantities and Prices (4,000-Sow Farrow-Wean)

Component	Total Cost	Annualized Cost
Storage for Separated Solids	$ 10,000.00	$ 1,490.29
Separator	$ 58,660.00	$ 8,742.07
Concrete Basin	$ 33,770.94	$ 5,032.87
Concrete Pad for Auger	$ 629.92	$ 93.88
Contractor & Engineering Services & Overhead	$ 40,109.23	$ 5,977.46
Total Construction Cost	$ 143,170.10	$ 21,336.57
Electric Power Cost		$ 2,970.54
Maintenance Cost		$ 3,821.02
Property Taxes		$ 508.25
Total Operating Cost		$ 7,299.81
TOTAL ANNUALIZED COST OF SOLIDS SEPARATOR		**$ 28,636.37**

Table EK.56. EKOKAN Technology Equalization Tank Costs—Standardized Quantities and Prices (4,000-Sow Farrow-Wean)

Component	Total Cost	Annualized Cost
Equalization Tank	$ 28,236.16	$ 4,208.02
Concrete Pads and Rebars	$ 752.86	$ 112.20
Equalization Tank Accessories	$ 6,900.00	$ 1,028.30
Support Structure for Tanks	$ 2,336.80	$ 348.25
Contractor & Engineering Services & Overhead	$ 4,305.54	$ 641.65
Total Construction Cost	$ 42,531.35	$ 6,338.43
Maintenance Cost		$ 764.52
Property Taxes		$ 150.99
Total Operating Cost		$ 915.50
TOTAL ANNUALIZED COST OF EQUALIZATION TANK		**$ 7,253.93**

Table EK.57. EKOKAN Technology Biofilters Costs—Standardized Quantities and Prices (4,000-Sow Farrow-Wean)

Component	Total Cost	Annualized Cost
Biofilter Tanks	$ 80,500.00	$ 11,996.87
Support Structure for Tanks	$ 11,684.00	$ 1,741.26
Filter Media	$ 13,494.77	$ 2,011.12
Additional Filter Media and Support Structure	$ 73,238.49	$ 10,914.69
Biofilter Tank Accessories	$ 27,600.00	$ 4,113.21
Piping, Piping Accessories, and Valves	$ 65,869.83	$ 9,816.55
Blowers	$ 35,194.85	$ 13,656.78
Site Preparation	$ 8,064.70	$ 1,201.88
Restoring Site	$ 2,810.00	$ 418.77
Interceptor Box	$ 2,875.00	$ 428.46
Biofilter Covers	$ 2,333.65	$ 347.78
Contractor & Engineering Services & Overhead	$ 139,499.74	$ 20,789.57
Total Construction Cost	$ 463,165.02	$ 77,436.96
Maintenance Cost		$ 5,994.26
Electric Power Cost		$ 71,951.33
Property Taxes		$ 1,644.24
Total Operating Cost		$ 79,589.82
TOTAL ANNUALIZED COST OF BIOFILTERS		**$ 157,026.78**

Table EK.58. EKOKAN Technology Electrical Installation Costs—Standardized Quantities and Prices (4,000-Sow Farrow-Wean)

Component	Total Cost	Annualized Cost
Electrical-Material	$ 35,551.00	$ 5,298.15
Electrical-Labor	$ 21,685.00	$ 3,231.70
Contractor & Engineering Services & Overhead	$ 24,668.72	$ 3,676.37
Total Construction Cost	$ 81,904.72	$ 12,206.22
Maintenance Cost		$ 1,144.72
Property Taxes		$ 290.76
Total Operating Cost		$ 1,435.48
TOTAL ANNUALIZED COST OF ELECTRICAL INSTALLATION		**$ 13,641.70**

Table EK.59. EKOKAN Technology Start-up Fees—Standardized Quantities and Prices (4,000-Sow Farrow-Wean)

Component	Total Cost	Annualized Cost
Dry and Wet Tests	$ 5,000.00	$ 745.15
Process Start-up	$ 5,000.00	$ 745.15
Operation and Maintenance Manual	$ 5,000.00	$ 745.15
TOTAL COST OF START-UP FEES	**$ 15,000.00**	**$ 2,235.44**

TOTAL CONSTRUCTION COST OF EKOKAN TECHNOLOGY INCLUDING START-UP	**$ 784,452.55**
TOTAL OPERATING COST OF EKOKAN TECHNOLOGY INCLUDING ROYALTIES (IF ANY)	**$ 91,210.82**
TOTAL ANNUALIZED COSTS OF EKOKAN TECHNOLOGY WITHOUT LAND APPLICATION	**$ 217,358.06**

Table EK.60. EKOKAN Technology Liquid Land Application Costs for Four Scenarios —Standardized Quantities and Prices (4,000-Sow Farrow-Wean)

Annual Cost of Applying Lagoon Effluent	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 14,257.06	$ 9,365.88
If Phosphorus-Based Application	$ 17,697.96	$ 10,440.59
Acres Needed For Assimilation	**Forages**	**Row Crops**
If Nitrogen-Based Application	41.88	135.72
If Phosphorus-Based Application	72.31	197.66
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 2,512.60	-
If Phosphorus-Based Application	$ 4,338.59	-
Irrigation Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 11,744.47	$ 12,259.07
If Phosphorus-Based Application	$ 10,797.29	$ 14,636.51
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	$ (2,893.20)
If Phosphorus-Based Application	-	$ (4,195.92)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	-
If Phosphorus-Based Application	$ 2,562.08	-

Note: 12,196,173 gallons / year of effluent modeled to be land applied

Table EK.61. EKOKAN Technology Solids Application Costs for Four Land Application Scenarios—Standardized Quantities and Prices (4,000-Sow Farrow-Wean)

Annual Cost of Applying Solids	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 4,806.39	$ 4,356.45
If Phosphorus-Based Application	$ 5,873.38	$ 4,369.05
Acres Needed For Application	**Forages**	**Row Crops**
If Nitrogen-Based Application	5.06	16.40
If Phosphorus-Based Application	23.48	62.73
Opportunity Cost of Land	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 303.54	-
If Phosphorus-Based Application	$ 1,408.91	-
Application Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	$ 4,502.84	$ 4,716.68
If Phosphorus-Based Application	$ 4,849.25	$ 5,569.14
Savings From Not Having To Buy Fertilizer	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	$ (360.23)
If Phosphorus-Based Application	-	$ (1,200.09)
Extra Fertilizer Purchase Costs	**Forages**	**Row Crops**
If Nitrogen-Based Application	-	-
If Phosphorus-Based Application	$ 2,615.23	-

Note: 304,446 lbs. / year of solids modeled to be land applied

Table EK.62. Summary and Mass Balance of Generated and Land Applied Nutrients for EKOKAN Technology—Standardized Quantities and Prices (4,000-Sow Farrow-Wean)

Nutrient Balance	**Nitrogen (lbs / year)**	**Phosphorus (lbs / year)**	**Potassium (lbs / year)**
Generated At Barn	117,000	37,040	77,000
Removed in Separated Solids	2,448	994	2,635
Land Applied in Lagoon Effluent	24,314	3,580	67,255
Removed in Biofilters and Unaccounted For	90,239	32,465	7,110

Tables EK.63 and EK.64: Predicted Costs and Returns ($ / 1,000 lbs. SSLW / year) for the EKOKAN System Based on Standardized Cost and Performance Data for Various Representative Farm Sizes, Farm Types, and with Pit Recharge or Flush Systems

Table EK.63. $ / 1,000 Pounds of Steady-State Live Weight (SSLW) for DWQ Permitted Representative Farm Type / Farm Size Combinations—EKOKAN Technology

	Size of Farm (1,000 pounds SSLW)				
Type of Operation	**0-500**	**500-1000**	**1000-1500**	**1500-2000**	**> 2000**
Farrow-wean					
Rep. # of sows	752	1,540	2,400	4,000	6,000
Pit-recharge system	$369.21	$185.80	$197.80	$127.10	$117.42
Flush system	$372.75	$187.92	$199.06	$128.84	$118.55
Farrow-feeder					
Rep. # of sows	500	1,200	2,000	3,600	5,500
Pit-recharge system	$458.16	$198.61	$198.16	$161.04	$162.76
Flush system	$466.20	$204.55	$213.01	$166.34	$171.65
Farrow-finish					
Rep. # of sows	150	500	1,000	1,200	2,000
Pit-recharge system	$558.34	$285.25	$202.03	$216.04	$190.82
Flush system	$565.97	$289.75	$206.44	$225.44	$194.91
Wean-feeder					
Rep. head capacity	3,840	20,000	N/A	N/A	N/A
Pit-recharge system	$1,025.30	$467.16	N/A	N/A	N/A
Flush system	$1,059.59	$509.06	N/A	N/A	N/A
Feeder-finish					
Rep. head capacity	2,448	5,280	8,800	12,240	17,136
Pit-recharge system	$361.97	$281.79	$303.86	$267.59	$260.70
Flush system	$364.69	$285.07	$306.88	$270.18	$267.35

Table EK.64. $ / 1,000 Pounds of Steady-State Live Weight (SSLW) for Smithfield Foods/Premium Standard Farms Representative Farm Type / Farm Size Combinations—EKOKAN Technology

	Size of Farm (1,000 pounds SSLW)				
Type of Operation	0-500	500-1000	1000-1500	1500-2000	> 2000
Farrow-wean					
Rep. # of sows	650	1,700	2,400	4,000	7,000
Pit-recharge system	$425.82	$169.13	$197.80	$127.10	$130.72
Flush system	$428.67	$171.17	$199.06	$128.84	$132.23
Farrow-feeder					
Rep. # of sows	675	1,200	2,000	3,419	5,500
Pit-recharge system	$342.65	$198.61	$198.16	$169.23	$162.76
Flush system	$350.45	$204.55	$213.01	$174.65	$171.65
Farrow-finish					
Rep. # of sows	N/A	500	1,000	1,200	2,000
Pit-recharge system	N/A	$285.25	$202.03	$216.04	$190.82
Flush system	N/A	$289.75	$206.44	$225.44	$194.91
Wean-feeder					
Rep. head capacity	2,808	N/A	N/A	N/A	N/A
Pit-recharge system	$1,395.06	N/A	N/A	N/A	N/A
Flush system	$1,433.44	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	$706.92	$291.64	$303.86	$267.46	$260.70
Flush system	$710.26	$294.52	$306.88	$270.05	$267.35

Appendix EK.A Chemical Oxygen Demand (COD) for Representative NC Farms

Table EK.A.1. COD Assumptions for Type of Operation

Type of Operation	Production Unit (PU)	Chemical Oxygen Demand (lbs / PU / year)
Farrow-Wean	sow	320.30
Farrow-Feeder	sow	594.17
Farrow-Finish	sow	2,034.31
Wean-Feeder	head capacity	94.44
Feeder-Finish	head capacity	276.63

Table EK.A.2. COD (lbs. / day) for DWQ Permitted Representative Farm Type / Farm Size Combinations—EKOKAN Technology

	Size of Farm (1,000 lbs. SSLW)				
Type of Operation	0-500	500-1000	1000-1500	1500-2000	> 2000
Farrow-wean					
Rep. # of sows	752	1,540	2,400	4,000	6,000
COD (lbs. / day)	659	1,350	2,105	3,508	5,261
Farrow-feeder					
Rep. # of sows	500	1,200	2,000	3,600	5,500
COD (lbs. / day)	759	1,820	3,034	5,461	8,344
Farrow-finish					
Rep. # of sows	150	500	1,000	1,200	2,000
COD (lbs. / day)	836	2,785	5,570	6,684	11,140
Wean-feeder					
Rep. head capacity	3,840	20,000	N/A	N/A	N/A
COD (lbs. / day)	993	5,172	N/A	N/A	N/A
Feeder-finish					
Rep. head capacity	2,448	5,280	8,800	12,240	17,136
COD (lbs. / day)	1,854	3,999	6,665	9,271	12,979

Table EK.A.3. COD (lbs. / day) for Smithfield Foods/Premium Standard Farms Representative Farm Type / Farm Size Combinations—EKOKAN Technology

	Size of Farm (1,000 lbs. SSLW)				
Type of Operation	0-500	500-1000	1000-1500	1500-2000	> 2000
Farrow-wean					
Rep. # of sows	650	1,700	2,400	4,000	7,000
COD (lbs. / day)	570	1,491	2,105	3,508	6,138
Farrow-feeder					
Rep. # of sows	675	1,200	2,000	3,419	5,500
COD (lbs. / day)	1,024	1,820	3,034	5,187	9,288
Farrow-finish					
Rep. # of sows	N/A	500	1,000	1,200	2,000
COD (lbs. / day)	N/A	2,785	5,570	6,684	11,140
Wean-feeder					
Rep. head capacity	2,808	N/A	N/A	N/A	N/A
COD (lbs. / day)	726	N/A	N/A	N/A	N/A
Feeder-finish					
Rep. head capacity	1,240	5,100	8,800	12,246	17,136
COD (lbs. / day)	939	3,863	6,665	9,275	12,979