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Liquid Dairy Waste Transport and Land Application Cost Comparisons Considering Herd Size, Transport Distance, and Nitrogen versus Phosphorus Application Rates

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Abstract. *This study provides cost comparisons for the transport and application of dairy waste slurries based on both phosphorus and nitrogen application rates. Estimated cost comparisons are made for several commonly used systems for dairy waste transport and application. Five dairy sizes ranging from 50 to 2,000 cows using 13 transport and application systems were evaluated. For each dairy size, the costs associated with the transport and application system combinations were determined for transport distances of 0.5, 1.5, and 4.5 miles for both nitrogen and phosphorus-based application rates. Total annual system cost, cost per acre, cost* *per cow, and manure value as fertilizer per acre based on nutrient requirements for a 20-ton per acre corn silage crop were calculated. Results indicate that depending on transport and application system choice, transport distance, and operation herd size, phosphorus-based applications caused cost increases of 5 to 60% over nitrogen-based application rates, an amount that could be significant to dairy producers.*

Keywords. Animal wastes, application equipment, cost analysis, economics, nitrogen, phosphorus

Introduction

Land application is the most prevalent method of utilizing animal manures. Manure applications increase soil organic matter, improve soil tilth, and increase water holding capacity and solar heat absorption capacity (Roka et al., 1995). More importantly, manure contains significant amounts of plant nutrients and can therefore substitute for commercial fertilizers. If the utilization of manure, in lieu of commercial fertilizer, increases farm profits, manure is an economic resource; where as if the costs outweigh the benefits, it is a waste. Determining whether manure nutrients are an economic resource or waste has environmental implications. If manure proves to be a waste, a producer's economic incentives are to minimize costs of manure disposal. This encourages over application and increases the potential for water quality problems from surface runoff or leaching. On the other hand, if manure nutrients are a resource, economic incentives would encourage nutrient conservation and efficient application rates. An efficient application rate matches crop nutrient requirements, and as a result, decreases the likelihood that nutrients would move into either ground or surface waters (Roka et al., 1995).

Dairy producers in the United States are subject to concentrated animal feeding operation (CAFO) regulations. To remain in compliance with CAFO regulations, producers must make decisions concerning the transport and application of wastes at their operation. It is essential that these systems be designed to operate in a cost effective manner for dairy producers to remain economically viable. Most animal waste applications are currently based on crop nitrogen requirements. When applications are based solely on nitrogen, phosphorus is applied in excess. Phosphorus, an essential nutrient for crop and animal production, can accelerate fresh water eutrophication (Carpenter et al., 1998). In 1996, the US Environmental Protection Agency identified eutrophication as the main problem in waters of impaired quality in the United States (Weld et al., 2001). Accelerated eutrophication restricts water use for fisheries, recreation, industry, and drinking due to the increased growth of undesirable algae and aquatic weeds and shortages of oxygen caused by algal death and decomposition (Carpenter et al., 1998). To reduce environmental impacts, it has been suggested that comprehensive nutrient management plans be developed based on phosphorus rather than nitrogen standards (Sharpley et al., 1996; US Department of Agriculture and Environmental Protection Agency, 1999).

It is well accepted that animal manures can substitute for commercial fertilizers. An additional benefit of manure is that long-term soil productivity can be enhanced because manure is a rich source of organic material (Cassman et al., 1995). Many argue that an integrated crop and livestock system is the best example of an economically and environmentally sustainable farming system (Fleming et al., 1998). However, delivering manure to a field at the right time and in the right amount can be costly. If delivery and application costs are low enough, then substituting manure for fertilizer can increase profits from crop production. If the delivery costs are too high, then only a portion of the delivery cost can be recovered by reduced fertilizer cost, and farmers will not have a strong incentive to adopt technologies that match manure application rates to crop nutrient requirements. While other investigations have examined the economics of animal waste management in general (Taraba et al., 1996; Grusenmeyer et al., 1997; Matulich et al., 1979; Badger, 1981), little research exists concerning the costs of specific manure transport and application systems. This study presents cost estimates for the transport and application of liquid dairy waste for a wide variety of systems considering dairy herd size, distance to application site, and manure application rates.

Materials and Methods

Transport and Application Systems Evaluated

There are many different equipment choices for the transport and application of animal manures. Each system combination is best suited for certain operational parameters. In this study, five common liquid transport and application systems were evaluated for use with dairy waste. Table 1 lists the systems with all their components that were analyzed in this study. A brief description of each system type considered for this study follows.

Liquid Slurry Tanks (LST)

Liquid slurry tanks (LST) range in size from 2,300 gallons to 12,000 gallons, and are classified as liquid hauling systems. Liquid waste from the storage area must be loaded into the tank. Commonly, a PTO agitation and loading pump attached to a tractor is used to load the tank. A PTO agitator-loading pump consists of a bladed propeller connected to a drive shaft which is rotated by the tractor's PTO. The rotating propeller agitates the storage area. The PTO agitator-loading pump also contains a PTO driven pump, which transfers the liquid waste through pipe mounted to the frame of the device which can be used to load the tank. A tractor is used to pull the tank to the application site and then through the application field. Tanks can be used to broadcast the liquid waste or can be equipped with an injection toolbar to directly inject the liquid waste beneath the soil surface.

Drag Hose Systems (DHS)

Drag hose systems (DHS) are classified as pumping systems. The manure slurry is agitated and a high-volume high-pressure pump is used to transport the liquid through pipe to the application site. At the application site, the pipe is attached to an umbilical application hose, which is attached to an injection toolbar mounted to the rear of a tractor. The hose is commonly 660 ft long and is pulled by the tractor through the application field where the liquid waste is directly injected under the soil's surface.

Big Gun Hard Hose Traveler (BGHH)

Big gun hard hose travelers (BGHH) are classified as pumping systems. The manure slurry is agitated and a high-pressure high-volume pump is used to transport the liquid through pipe to the application site. At the application site the pipe is attached to a hard hose reel. The vertical reel houses a flexible hose, which is usually 1,100 ft to 1,300 ft long. The hose is attached to a big gun irrigation sprinkler that is mounted on a retractable-wheeled cart. The hose is unwound by pulling the cart along a desired application towpath perpendicular to the reel. This can be done using a truck, tractor, ATV, etc. Once the hose has been unwound, liquid is pumped to the big gun sprinkler, where it is sprayed onto the application site. The cart is pulled along the towpath by a motor which turns the reel and rewinds the hose. Some reels are driven by an internal hydraulic turbine, but for animal waste slurries, engine driven reels are preferred to accommodate the faster tow speeds needed to apply at lesser rates.

Table 1. Transport and application systems evaluated

System Type	System Components
5000 Gallon Liquid Slurry Tank (LST5)	125 HP 4WD Transport and Application Tractor 100 HP 4WD Incorporation and Loading Tractor 32' PTO Agitator Loading Pump 20' Incorporation Disk 14' Injection Toolbar
10000 Gallon Liquid Slurry Tank (LST10)	250 HP 4WD Transport and Application Tractor 100 HP 4WD Incorporation and Loading Tractor 32' PTO Agitator Loading Pump 20' Incorporation Disk 24' Injection Toolbar
Drag Hose System (DHS)	225 HP 4WD Application Tractor 6" Aluminum Transport Pipe 18' Injection Toolbar 157 HP @ 2400 rpm Pumping Unit & Engine Driven Pump **
Big Gun Hard Hose Traveler (BGHH)	4.5" X 1310' Hard Hose Traveler 100 HP 4WD Agitation, Pumping, & Incorporation Tractor 124 HP @ 2200 rpm Pumping Unit & Engine Driven Pump ** 32' PTO Agitator Loading Pump 6" Aluminum Transport Pipe 20' Incorporation Disk
Big Gun Soft Hose Traveler (BGSH)	4.0" X 1310' Soft Hose Reel 100 HP 4WD Agitation, Pumping, & Incorporation Tractor 124 HP @ 2200 rpm Pumping Unit & Engine Driven Pump ** 32' PTO Agitator Loading Pump 6" Aluminum Transport Pipe 20' Incorporation Disk 80 HP 4WD Reel Tractor
Center-Pivot System (CPS)	124 HP @ 2200 rpm Pumping Unit & Engine Driven Pump ** 100 HP 4WD Agitation, Pumping, & Incorporation Tractor 6" Aluminum Transport Pipe
** For transport distances of 4.5 miles two pumping units were used	

Big Gun Soft Hose Traveler (BGSH)

Transport of waste to the application site is identical for both big gun hard hose (BGHH) and big gun soft hose (BGSH) systems. The transport pipe is attached to a soft flexible hose that is usually 660 ft long. This hose is wound on a horizontal reel and must be completely unwound for any pull. The reel is only used to transport the hose. A big gun irrigation sprinkler mounted to a retractable-wheeled cart is connected to the drag hose. The cart is then hooked to a cable, which is mounted to a PTO driven reel. The cable is usually 1,300 feet long. The cart is pulled along the towpath by the cable as it is wound around the reel.

Center-Pivot Systems (CPS)

Center-pivot systems (CPS) are classified as pumping systems. The storage area is agitated and a high-volume high-pressure pump is used to transport the liquid through pipe to the application site. The pipe is connected to a long boom which rotates around a fixed center point. The boom is comprised of individual spans. The individual spans can range in length from 109 ft to 205 ft. Center-pivot systems may include from one individual span up to many spans. The maximum length of a pivot which can be pulled and relocated without complete disassembly is ¼ mile. Table 2 presents the initial investment for each system.

Table 2 Total capital investment costs for each system

System Type and Application Method	Distance		
	0.5	1.5	4.5
LST5 No Inc	$156,845	$156,845	$156,845
LST5 Inc	$171,845	$171,845	$171,845
LST5 Inj	$164,545	$164,545	$164,545
LST10 No Inc	$250,845	$250,845	$250,845
LST10 Inc	$265,845	$265,845	$265,845
LST10 Inj	$275,845	$275,845	$275,845
DHS	$233,955	$248,739	$313,436
BGHH No Inc	$132,582	$147,366	$212,063
BGHH Inc	$147,582	$162,366	$227,063
BGSH No Inc	$147,032	$161,816	$226,513
BGSH Inc	$162,032	$176,816	$241,513
CPS No Inc	$128,404	$143,188	$207,885
CPS Inc	$143,404	$158,188	$222,885

Note: No Inc (no incorporation system), Inc (incorporation system), Inj (injection system)

Calculating Costs

A total operational cost per hour for individual pieces of equipment is estimated by the model. These costs were calculated from equipment capital cost, useful life, salvage value, annual hours of use, depreciation, interest, insurance, repairs and maintenance, fuel, and labor.

User input facilitated spreadsheets were developed to estimate costs for animal waste transport and application equipment. The user must enter the annual hours of use and age for the equipment to be considered. Annual hours of use are determined from another set of user input facilitated spreadsheets designed to estimate total loading, transport, application, and incorporation time for the system type selected. Five spreadsheets were designed to determine annual hours of use based on the transport and application system chosen. The user has the choice of solid manure hauling systems, liquid manure hauling systems, big gun pumping systems, drag hose direct injection systems, and center-pivot pumping systems. Users must input a manure volume, manure nutrient content, crop requirement application rate (N or P), and transport distance. Depending on the system choice, the user will input other variables including loading rate, discharge rate, pumping rate, transport speed, tank capacity, application width, incorporation width, incorporation speed, and gun throw diameter.

Machinery cost calculation methods followed methods and parameters used in estimating machinery costs for enterprise budgets constructed by the University of Tennessee Agricultural Extension Service (Cross et al., 1999). Whenever possible, American Society of Agricultural Engineers (ASAE) standards were followed. All costs were estimated for a dollars-per-hour basis. The equations used for calculations for this study are presented in the Appendix. Equipment depreciation costs were estimated based on straight-line depreciation methods. Fuel cost was calculated based on the price of fuel and estimated fuel consumption rates of tractors and self-propelled machinery. Fuel consumption rates were approximated from Nebraska Tractor Test Data, as reported in ASAE Agricultural Machinery Management Standard 6.3.2.1. The costs incurred in keeping a machine operable from normal wear, parts failure, accidents, and natural deterioration are calculated as repair and maintenance expenses. Annual repair costs are calculated based on annual and accumulated hours of use, following ASAE Agricultural Machinery Management Standard 6.3.1. Labor costs were determined by using a set labor rate of $10 per hour. Equipment salvage value was estimated using a salvage value of 10% of the equipment's capital cost. Insurance provides protection from risks associated with theft, fire, flood, or other natural disasters. The cost of insurance is based on the initial cost of machinery and an insurance rate. Insurance rates were determined based on for every $1,000 of investment; annually $10 must be spent to insure that piece of equipment. Interest is calculated as an opportunity cost using the remaining value of the machinery at the end of its useful life. For this study all equipment was assumed to have a useful life of ten years. The interest rate for all equipment was assumed to be 10%.

The model calculates the total annual system cost, system cost per acre, and system cost per gallon or cubic foot depending on system choice. This study only considers liquid dairy waste systems; so standard liquid volumetric units will be used. Other information calculated by the model includes application rate per acre, acreage required, acres per hour application rate, equipment speeds, and incorporation rate. In addition to producing a total annual system cost, the model presents the individual loading, transport, application, and incorporation cost to estimate the total annual system cost.

Operation Description

For this study, five lactating dairy herd sizes were considered; 50, 200, 400, 800, and 2,000 cow operations. All cows were assumed lactating, average cow weight was assumed to be 1,400 pounds, and cows were assumed to be continuously confined in freestall barns with open loafing lots. Sawdust was assumed as the bedding material. All excreted waste, parlor cleaning water, flush water, and lot runoff was assumed to be stored for 365 days in a 16-foot deep holding pond. Flush water was assumed to be recycled from the holding pond. All runoff from roofed structures was to be collected by gutters and diverted away from the operation and storage area. Uncovered loafing lot area considered to receive rainfall that would be handled as waste was based on 20 square feet of loafing lot per cow. Annual rainfall for the study was set at 50 inches. Net annual rainfall (precipitation – evaporation) for the study was set at 20 inches. The 24-hour/25 year storm for the study was 6 inches.

Determining Manure Volumes

Waste volumes from the Natural Resource Conservation Service (NRCS) part 651 Agricultural Waste Management Field Handbook were used for the study (NRCS, 1992). Bedding, excreted waste, and milking center clean-up water were combined to produce a total waste volume excluding rainwater for each cow per day. This volume was multiplied for the number of cows and for the desired storage period. Lot runoff was then added to this volume. This total volume was then used to estimate the waste volume to be applied from each size dairy. A holding pond area was calculated and used to determine additional storage volume needed to store net annual rainfall plus a 24-hour/25 year storm event. Table 3 presents the variables used for these calculations and the annual amount of waste produced from each operation.

Determining Nutrient Contents

The nutrient content of the liquid waste was estimated based on pounds of nutrients excreted per pound of live weight per day (Burns et al., 1998). For this study it was estimated that a 1,400-pound dairy cow excreted 0.63, 0.224, and 0.434 pounds per day N, P_2O_5, and K_2O respectively. These values were used to determine the mass of nutrients per year to be land applied considering handling, storage, and application nutrient losses associated with each system type. This information is presented in Table 4. These nutrient masses and estimated manure volumes were used to determine the pounds of nutrients per 1,000 gallons of waste for each nutrient and each application method and to determine the application rate per acre as shown in Table 5. Application rates for this study were based on a 20-ton per acre corn silage crop. This yield was assumed to require 150 pounds of N, 60 pounds of P_2O_5, and 120 pounds of K_2O per year (Savoy and Hamilton, 1994).

Determining Costs

For each dairy size, the total annual costs associated with the transport and application system combinations were determined for transport distances of 0.5, 1.5, and 4.5 miles for both nitrogen and phosphorus based applications. Using the total annual system cost, a cost per acre was determined based on the acreage required for that system. In addition, a cost per cow was determined based on the number of cows in that operation.

Table 3. Variables used for manure volume calculations and total manure volumes for each operation

Sawdust Bedding 12 lb/ft^3	0.18 ft^3/day/1400lb cow
Lactating Cow as Excreted Manure	1.82 ft^3/day/1400lb cow
Milking Center Waste	1.96 ft^3/day/1400lb cow
Total Volume Excluding Rainwater	3.96 ft^3/day/1400lb cow
	29.6 gallons/day/1400lb cow
	10,800 gallons/year/1400lb cow
Uncovered Loafing Lot Area per Cow	20 square feet
Annual Rainfall	50 inches
Annual Evaporation	30 inches
Net Annual Rainfall	20 inches
24-hour/25 year storm	6 inches
Holding Pond Depth	16 feet (plus 1 ft freeboard)
Number of Cows	Annual Amount of Waste Produced (gallons)
50	650,00
200	2,600,000
400	5,200,000
800	10,450,000
2000	26,000,000

Using the cost per acre value for each system and each dairy size, a manure value as fertilizer per acre was determined based on crop requirements. Current prices (at the time of this writing) for N, P, and K were used to determine the value of the manure nutrients per acre. For this study N, P_2O_5, and K_2O values of $0.30, $0.25, and $0.15 per pound respectively were used. No monetary credit was given to P and K when these nutrients were applied at rates greater than those needed to meet crop uptakes. Table 6 presents the manure nutrient value per acre for phosphorus and nitrogen based applications for a 20-ton per acre corn silage crop.

Table 4. Pounds of nutrients available per year following handling, storage, and application losses

Number of Cows		PAN Broadcast w/ No Incorporation	PAN Broadcast w/ Incorporation	PAN Injected	P_2O_5 all applications	K_2O all applications
50		4,599	5,749	6,899	4,088	7,921
200		18,396	22,995	27,594	16,352	31,682
400		36,792	45,990	55,188	32,704	63,364
800		73,584	91,980	110,376	65,408	126,728
2000		183,960	229,950	275,940	163,520	316,820

Note: PAN (plant available nitrogen)

Table 5. Pounds of nutrients per 1,000 gallons of waste following handling, storage, and application losses and corresponding application rates

	PAN Broadcast w/ No Incorporation	PAN Broadcast w/ Incorporation	PAN Injected	P_2O_5 all applications	K_2O all applications
Pounds of Nutrients per 1000 Gallons of Waste	7.0	8.8	10.6	6.3	12.1
Application Rate Gallons/Acre	21,000	17,000	14,000	9,600	9,900

Note: PAN (plant available nitrogen)

Table 6. Manure nutrient value per acre for a 20-ton corn silage crop

Standard	Application Method	Manure Nutrient Value per Acre
Phosphorus	Broadcast w/ No Incorporation	$53
Phosphorus	Broadcast w/ Incorporation	$58
Phosphorus	Injected	$63
Nitrogen	All	$78

Results and Discussion

Impact of Application Based on Nitrogen or Phosphorus Application Rates

One of the main concerns of basing applications on phosphorus is land availability. For this study there were assumed to be no land limitations. Land requirements for each operation are presented in Table 7. When land is not a limiting factor, the transport and application total annual system costs based on phosphorus and nitrogen application costs are similar. These cost estimates are presented in Appendix Table 8. Results for each system are summarized below.

Table 7. Land requirements (acres) for each operation, for each nutrient, and each application method

Number of Cows	Application Method			
	Phosphorus All	Nitrogen BWNI	Nitrogen BWI	Nitrogen I
50	68	31	38	46
200	270	120	150	180
400	550	250	300	360
800	1,100	500	600	740
2,000	2,700	1,200	1,500	1,800

Note: BWNI (broadcast w/ no incorporation), BWI (broadcast w/ incorporation), I (injected)

The slurry tank systems produced identical cost estimates for both nitrogen and phosphorus applications. Their costs only differed when the nutrients were incorporated into the soil. This cost difference was due to the increased cost associated with incorporation over a larger land area for the phosphorus-based application. When these systems were used to either broadcast the waste without any incorporation or to directly inject the waste into the soil they produced identical cost estimates. These costs were identical due to the fact that these systems were able to operate within a speed range that effectively allowed them to apply the waste at a desired application rate for both nitrogen and phosphorus-based applications. For phosphorus applications where the waste was broadcast onto the application site the slurry tanks could travel at 2.5 mph and this produced the desired application rate of 9,600 gallons/acre. When basing the application on phosphorus and the waste was to be injected into the soil the tanks could travel at 4.4 mph and meet the desired application rate of 9,600 gallons/acre. For nitrogen-based applications with desired application rates of 21,00, 17, 000, and 14,000 gallons/acre the tanks could travel at 1.1, 1.4, and 3.0 mph respectively to meet these application rates. For broadcast applications the broadcast width for these systems was assumed to be 25 feet. For injection applications the widths were assumed to be 14 feet and 24 feet for the 5,000 gallon and 10,000 gallon slurry tanks respectively.

Drag hose systems produced identical costs for both phosphorus and nitrogen-based applications. These systems were assumed to have an application width of 18 feet. For phosphorus-based applications they traveled at 2.6 mph and for nitrogen-based applications they traveled at 1.7 mph to meet the desired application rates of 9,600 and 14,000 gallons/acre for phosphorus and nitrogen respectively.

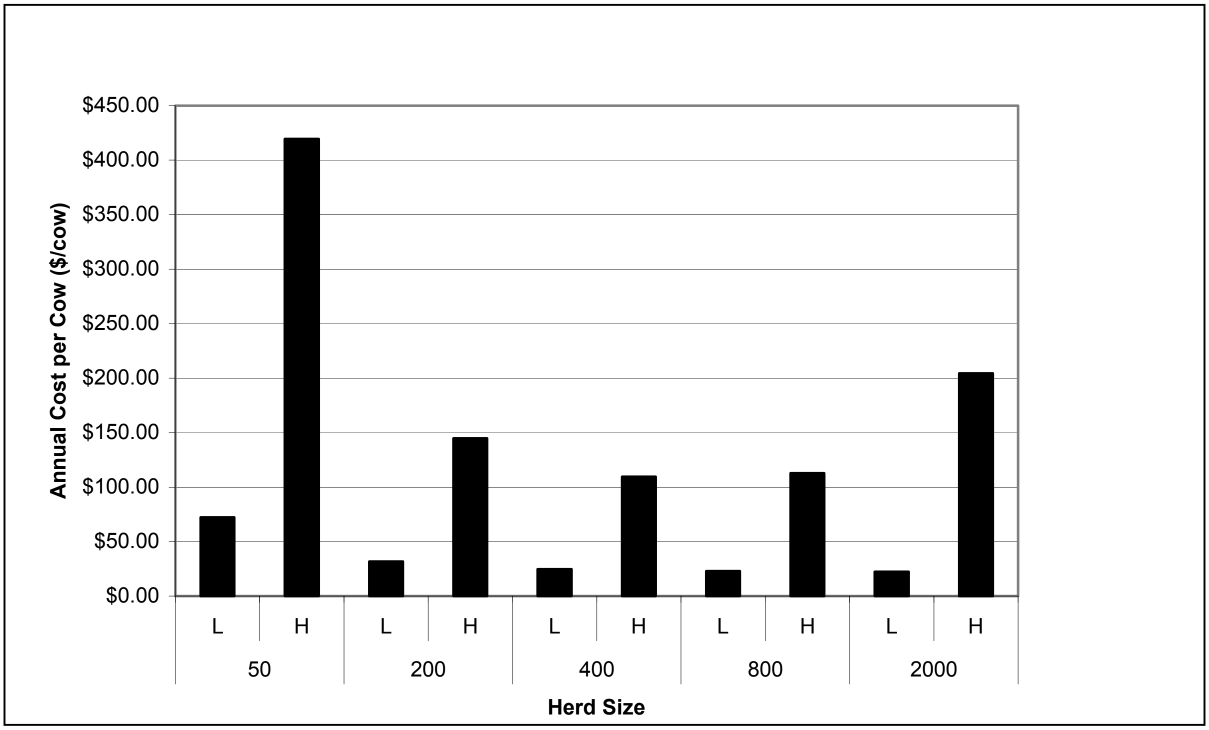
Big gun hard hose (BGHH) and big gun soft hose (BGSH) costs differed because of equipment limitations. In order to apply phosphorus at the lower 9,600 gallon/acre rate, gun flow rate had to be decreased to keep gun tow speed within an operation range below 7.0 feet/minute. For phosphorus applications gun flow rate for both the BGHH and BGSH systems had to be set to 550 gallons/minute to achieve a gun tow speed of 6.9 feet/minute. When applying based on nitrogen and using a BGHH system, the maximum operation gun flow rate of 600 gallons/minute could be used and gun tow speed remained within its operational range while still applying at the desired application rates. When using the BGSH system gun flow rate could be set at the maximum operational rate of 800 gallons/minute for nitrogen based applications and gun tow speed stayed in its operational range. Phosphorus-based application costs were slightly higher than nitrogen based applications for both the BGHH and BGSH systems. This cost difference was due to the increase amount of labor needed for additional set ups that were required to cover the additional land area needed for the phosphorus-based applications.

Costs of center-pivot systems differed for reasons similar to the big gun systems. The 50-cow operations did not require enough application land to house a ¼ mile pivot. For phosphorus-based applications 68 acres of land was required which would accommodate a pivot 972 ft long. For nitrogen-based applications, 30 acres of land was required if the waste was not incorporated and 38 acres was required if the waste was to be incorporated. These land areas required pivots of 652 ft and 729 ft long respectively. These center-pivot systems required that flow rate be decreased in order to apply at the desired application rates. Phosphorus applications required a flow rate of 500 gallons/minute and nitrogen applications required a flow rate of 320 gallons/minute to acquire the desired application rates. All other operations required enough application land to house a ¼ mile pivot and flow rate for these systems was set at 1000 gallons/minute. Phosphorus-based applications were higher for center-pivot systems compared to nitrogen-based applications for center-pivot systems. These cost differences were due to the increased amount of labor needed for additional set ups required to cover the additional land area needed for the phosphorus-based applications. For this study a ¼ mile pivot was assumed to apply liquid waste on 129 acres for each set up.

Cost per Cow Evaluation

From the estimated total annual system cost for each system an annual cost per cow for each system was determined. This value was obtained by simply dividing the total annual system cost for that system by the number of cows in the operation. For a 0.5 mile transport distance the 5,000 gallon liquid slurry tank with waste broadcast with no incorporation showed to have the lowest cost per cow for operations ranging from 50 to 800 cows. Applying on phosphorus or nitrogen showed no cost differences. For an operation with 2,000 cows a center-pivot system with nitrogen broadcast with no incorporation had the lowest cost per cow. When transport distance increased to 1.5 miles the 5,000 gallon liquid slurry tank with waste broadcast with no incorporation produced the lowest cost per cow for operations up to 400 cows. For operations larger than 400 cows, a center-pivot system with nitrogen broadcast with no incorporation produced the lowest cost per cow. Where distances to the application site were 4.5 miles, a 5,000 gallon slurry tank with waste broadcast with no incorporation produced optimum cost per cow for operations ranging from 50 to 200 cows. At this distance, for operations between 400 and 2,000 cows a center-pivot system with nitrogen broadcast with no incorporation produced the lowest cost per cow. Annual cost per cow for each system are presented in Appendix Table 9. Cost per cow values ranged from $78.23 to $192.72 for a 50-cow operation and a 0.5 mile transport distance. When this distance increased to 4.5 miles for a 50-cow operation cost per cow values ranged from $112.93 to $419.43. This substantial difference is due to the variance in initial capital cost for these systems and the annual hours of use that each receives. For small operations, the amount of hours that some systems are used annually does not justify their costs. The larger operations, which must apply more waste annually, are able to justify the higher initial cost because of the increased amount of time that these systems are used annually. As herd size increases the range of cost per cow differences decreases. The lowest and highest cost per cow for each operation is presented in Figure 1.

Figure 1. Lowest and highest cost per cow for each operation



For operations ranging from 50 to 200 cows the hauling tank systems had lower cost per cow even as transport distance increased to 4.5 miles. As herd size increased to 400 cows the pumping systems showed to be beneficial as transport distance increased. Table 10 shows what system produced the lowest and highest cost per cow for each sized operation at each transport distance.

Comparing nitrogen versus phosphorus application cost per cow differences shows that for the hauling systems the costs differed only when liquid wastes were incorporated into the soil. These differences were not large enough to be considered significant, with the phosphorus applications only increasing the cost per cow value by $1.83 per cow. Drag hose systems had the same cost per cow value for both nitrogen and phosphorus based applications. The big gun systems did show significant differences depending on whether applications were based on nitrogen or phosphorus. The largest difference was for a 2,000-cow operation using a BGSH system. Cost increased by $39.69 per cow when this system was used for a 4.5 mile transport

Table 10. Lowest and highest cost per cow values for each operation and each transport distance (rounded to the nearest dollar)

Number of Cows	0.5 Mile		1.5 Mile		4.5 Mile	
	Lowest	Highest	Lowest	Highest	Lowest	Highest
50	$78 LST5 (BWNI)	$193 BGHH (BWIP)	$86 LST5 (BWNI)	$237 BGHH (BWIP)	$113 LST5 (BWNI)	$419 BGHH (BWIP)
200	$32 LST5 (BWNI)	$75 BGHH (BWIP)	$41 LST5 (BWNI)	$89 BGHH (BWIP)	$77 LST5 (BWNI)	$145 BGHH (BWIP)
400	$25 LST5 (BWNI)	$60 BGSH (BWIP	$36 LST5 (BWNI)	$70 BGSH (BWIP)	$69 CPS (BWNIN)	$110 BGSH (BWIP)
800	$23 LST5 (BWNI)	$57 BGSH (BWIP)	$30 CPS (BWNIN)	$66 BGSH (BWIP)	$50 CPS (BWNIN)	$113 LST5 (I)
2,000	$22 CPS (BWNIN)	$56 BGSH (BWIP)	$27 CPS (BWNIN)	$66 BGSH (BWIP)	$44 CPS (BWNIN)	$205 LST5 (I)

Note: Broadcasted with no incorporation (BWNI), Broadcasted with incorporation (BWI), Injected (I), Nitrogen based application (N), Phosphorus based application (P)

distance and the waste was broadcasted with no incorporation with the application being based on phosphorus instead of nitrogen. BGHH systems differed less than the BGSH systems when comparing cost per cow differences between phosphorus and nitrogen-based applications. The largest difference was $18.52 per cow for a 2,000-cow dairy where liquid waste was broadcasted with no incorporation with the application being based on phosphorus. These differences in cost can be attributed to the increased labor cost which is associated with the number of set ups which are required to satisfy the land requirements for the phosphorus-based applications. The BGSH systems had larger differences in costs due to the additional labor which is required for their set ups as compared to the BGHH systems. Center-pivot systems also had differences in phosphorus versus nitrogen application costs. These differences were less than both the BGHH and BGSH systems and were due to the center-pivot systems requiring less set up labor than the big gun systems.

Manure Value as Fertilizer Evaluation

The results showed that just because one system has a low cost per cow value, that doesn't necessarily mean the system will optimize manure value as fertilizer. If a producer's main incentive is to land apply by the cheapest means possible, the cost per cow values should be considered in equipment selection. However, if a producer is interested in receiving maximum returns from land applied nutrients, then the manure value as fertilizer for various system combinations should be investigated. Appendix Table 11 presents the application cost per acre, manure value as fertilizer per acre, and the net value per acre for each system for each size dairy, each transport distance, and for phosphorus or nitrogen-based applications.

For a herd size of 50 cows, none of the systems evaluated showed positive net values for the manure as fertilizer. Only part of the delivery costs for these systems were recovered by lower commercial fertilizer costs needed to match crop requirements. For a transport distance of 0.5 miles a 5,000 gallon liquid slurry tank with application based on phosphorus standards and injected into the soil had the lowest negative value. This system came within $2.71/acre of a break-even point. The cost per acre to apply for this system was $65.52, and the manure value as fertilizer for this system was $62.81/acre. As transport distance for the 50-cow operation increased to 1.5 miles, applying based on phosphorus broadcasted with no incorporation using a 5,000 gallon liquid slurry tank produced the highest net value at -$10.78/acre. For this operation at a 4.5 mile transport distance the optimum system was the 5,000 gallon liquid slurry tank with a phosphorus-based application that was incorporated. This system produced a net value of -$28.19/acre.

As herd size increased to 200 cows, many of the systems produced positive net values for transport distances of 0.5 and 1.5 miles. A 5,000 gallon slurry tank with nitrogen-based application injected into the soil produced a positive value of $38.86/acre for a 200-cow operation and a 0.5 mile transport distance. For a 200-cow operation with a transport distance of 1.5 miles, injecting phosphorus using a 5,000 gallon slurry tank produced a net value of $28.69/acre. For this operation at a 4.5 mile transport distance, injecting based on phosphorus using a 5,000 gallon slurry tank also showed to produce the best net value at $0.06. This system was the only system for a 200-cow dairy with a transport distance of 4.5 miles that did not produce a negative net value for manure transport, application, and nutrient utilization.

For a herd size of 400 cows, all 0.5-mile transport distances produced positive net values. Injecting based on nitrogen using a 5,000 gallon liquid slurry tank produced the best net value at $48.15/acre. When transport distance for a 400-cow operation increased to 1.5 miles using a 5,000 gallon liquid slurry tank to inject on a nitrogen based application produced the highest net value at $34.42/acre. For a 400-cow operation with a transport distance of 4.5 miles the drag hose system with a phosphorus-based application produced a net value of $6.54/acre. This was the only system to produce a positive net value for a 400-cow operation at this transport distance.

As herd size increased to 800 cows all systems produced positive net values for transport distances of 0.5 and 1.5 miles. For a transport distance of 0.5 miles using a 5,000 gallon slurry tank to inject manure on a nitrogen-based application produced a net value manure value of $51.07/acre. For this same operation at a transport distance of 1.5 miles, using a drag hose system with an application based on nitrogen produced a net value of $37.37/acre. As transport distance increased to 4.5 miles for an 800 cow operation using a drag hose system with an application based on phosphorus produced the optimum net value at $21.17/acre.

With an operation consisting of 2,000 cows, at a transport distance of 0.5 miles the optimum manure value as fertilizer net value was produced using a 5,000 gallon liquid slurry tank with the application being based on nitrogen injected into the soil. This system produced a net value of $48.72/acre. For a 2,000-cow operation with a 1.5 mile transport distance, a drag hose system with a nitrogen-based application produced the best net value at $40.87/acre. For this operation, when transport distance increased to 4.5 miles using a center-pivot system with a no incorporation nitrogen-based application a manure value as fertilizer net value of $37.32/acre was produced.

For a given operation size and a given transport distance there was considerable variation in the fertilizer value of the manure between the transport and application systems. As with the cost per cow values this variation generally decreased as herd size increased. Table 12 presents the lowest and highest returns for each operation and for each transport distance.

Table 12. Lowest and highest net values for each operation and each transport distance (rounded to the nearest dollar)

Number of Cows	0.5 Mile		1.5 Mile		4.5 Mile	
	Lowest	Highest	Lowest	Highest	Lowest	Highest
50	$-221 BGHH (BWNIN)	$-3 LST5 (IP)	$-294 BGHH (BWNIN)	$-11 LST5 (BWNIP)	$-585 BGHH (BWNIN)	$-28 LST5 (BWIP)
200	$-27 BGHH (BWNIN)	$39 LST5 (IN)	$-49 BGHH (BWNIN)	$29 LST5 (IP)	$-136 BGHH (BWNIN)	$0 LST5 (IP)
400	$2 BGHH (BWNIN)	$48 LST5 (IN)	$-13 BGHH (BWNIN)	$34 LST5 (IN)	$-69 BGHH (BWNIN)	$7 DHS (IP)
800	$12 BGHH (BWNIN)	$51 LST5 (IN)	$1 BGHH (BWNIN)	$37 DHS (IN)	$-91 LST5 (BWNIN)	$21 DHS (IP)
2,000	$12 BGHH (BWNIN)	$49 LST5 (IN)	$-3 LST10 (BWNIN)	$41 DHS (IN)	$-235 LST5 (BWNIN)	$37 CPS (BWNIN)

Note: Broadcasted with no incorporation (BWNI), Broadcasted with incorporation (BWI), Injected (I), Nitrogen based application (N), Phosphorus based application (P)

These differences are due to the variation in the application costs per acre associated with each system. As operation size increased the application cost per acre generally decreased. This is attributed to the increase in acreage required for the land application of animal waste as herd sizes increase. Nitrogen-based applications will have a higher application cost per acre as compared to phosphorus-based applications because the nitrogen-based applications require less land. For small operations with systems that have a higher total annual system cost, their cost per acre will be higher than for small operations with systems that have a lower annual system cost. Since the manure value as fertilizer is set based on current prices for commercial fertilizer, the lower the application cost per acre is the greater your manure value as fertilizer net return will be for a given application system.

For operations ranging from 50 to 200 cows phosphorus-based applications generally produce the highest net values. Once an operation's size reaches 400 cows it is more beneficial to base applications on nitrogen in order to gain maximum returns for manure value as fertilizer. This trend follows the pumping systems more closely than it does the hauling systems. When hauling distance increases to 4.5 miles the results showed that better returns will be received from phosphorus-based applications when using a hauling system. Appendix Table 11 shows phosphorus versus nitrogen net values for each system at each transport distance.

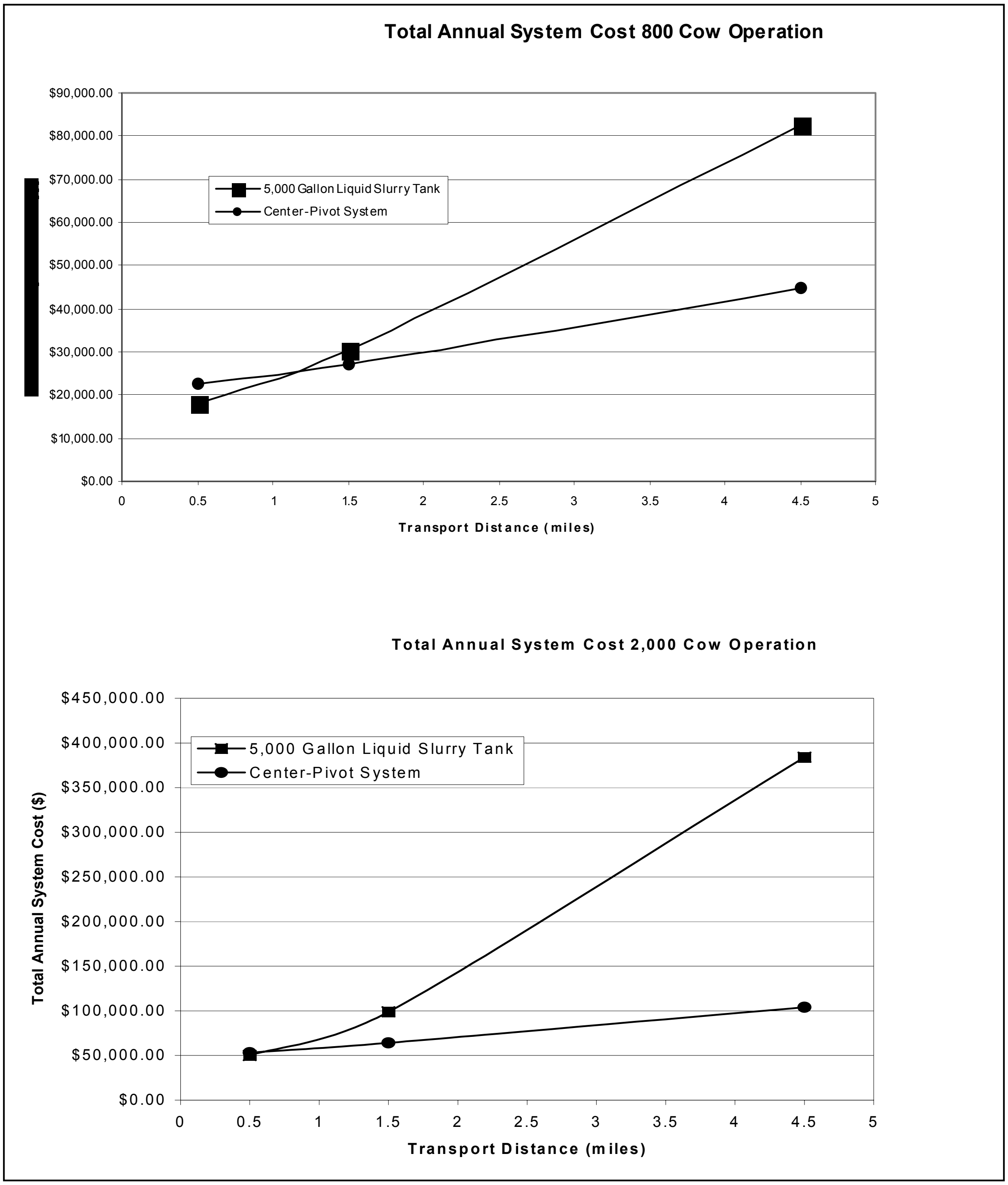
Impact of Transport Distance on Cost

As transport distance increased so did the total annual system cost for each system combination. The hauling systems were more affected by distance increases than were the pumping systems. The costs associated with pulling the slurry tanks further distances increased at a greater rate than the costs associated with pumping the liquid waste further distances. The additional pump and transport pipe needed to transport the waste further distances had lower costs than the additional costs required to operate a slurry tank being pulled by a tractor. As herd size increased the total amount of liquid waste to be handled increased. For the smaller operations, the hauling systems were still well suited for the longer transport distances. However, as herd size reaches around 400 cows the total amount of waste produced increased to a point where it was not justifiable to haul the liquid waste at distances much over 1.5 miles. This is due to the costs that are associated with loading and transporting the liquid waste. Figure 2 presents the total annual system cost for a 5,000 gallon liquid slurry tank and a center pivot system for an 800 versus a 2,000-cow operation where application is based on phosphorus with no incorporation. The hauling systems look feasible until transport distance exceeds 1.5 miles. At distances greater than 1.5 miles the hauling costs start to increase at a much larger rate than do the pumping costs.

Conclusion

Hauling systems were the most effective for small dairies with short transport distances. For larger operations with longer transport distances these systems did not prove to be economically viable. For larger operations and longer transport distances, pumping systems were the lowest cost. The actual costs of applying on phosphorus as compared to nitrogen showed minimal differences in total annual cost for the presented system combinations, but these cost differences did not account for the cost of acquiring the additional land needed for the phosphorus based applications. Although these systems showed minimal differences in total annual costs, the net value producers received from the manure value as fertilizer was affected by applying based on phosphorus or nitrogen applications for various systems. Some systems were more affected by the size of the operation and the transport distance than others. This had a direct affect on these systems' application cost per acre. The systems that had the lower application costs per acre in return had higher manure values as fertilizer. For this study, application rates were based on a 20-ton per acre corn silage crop. The results presented in this study apply to crops that have similar nutrient requirements as the 20-ton per acre corn silage crop, but will differ considerably for crops that have different nutrient requirements.

Figure 2. Total annual system cost for an 800 and 2,000 cow operation comparing the impact of transport distance on cost for a 5,000 gallon liquid slurry tank and a center-pivot system



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Appendix

Table 8. Total annual system cost for each sized operation, each transport distance, and for nitrogen and phosphorus applications

Table 9. Cost per cow for each system

Table 11. Application cost per acre, manure value as fertilizer per acre, and net value per acre for each size dairy, each transport distance, and for phosphorus or nitrogen based applications

Equations used for determining costs

Table 8a. Total annual system cost for a 50 cow herd

System Type	0.5		1.5		4.5	
	Transport Distance (miles)					
	P	N	P	N	P	N
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$3,911.27	$3,911.27	$4,323.68	$4,323.68	$5,646.41	$5,646.41
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$4,119.82	$4,028.57	$4,721.24	$4,630.00	$5,854.96	$5,763.71
5,000 Gallon Liquid Slurry Tank Injected	$4,668.30	$4,668.30	$5,104.11	$5,104.11	$6,523.93	$6,523.93
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$6,362.96	$6,362.96	$6,706.24	$6,706.24	$7,772.20	$7,772.20
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$6,571.51	$6,480.26	$6,914.78	$6,823.54	$7,980.74	$7,889.50
10,000 Gallon Liquid Slurry Tank Injected	$8,810.97	$8,810.97	$9,181.11	$9,181.11	$10,374.69	$10,374.69
Drag Hose System	$9,342.37	$9,342.37	$11,502.25	$11,502.25	$20,370.16	$20,370.16
Big Gun Hard Hose Traveler Broadcast w/ No Incorporation	$9,427.27	$9,181.43	$11,651.49	$11,381.23	$20,696.90	$20,322.30
Big Gun Hard Hose Traveler Broadcast w/ Incorporation	$9,635.81	$9,538.95	$11,860.03	$11,796.30	$20,905.45	$20,971.29
Big Gun Soft Hose Traveler Broadcast w/ No Incorporation	$7,587.34	$6,899.37	$9,820.61	$9,082.61	$18,902.62	$17,950.88
Big Gun Soft Hose Traveler Broadcast w/ Incorporation	$7,795.88	$7,313.42	$10,029.16	$9,590.57	$19,111.17	$18,840.27
Center-Pivot System Broadcast w/ No Incorporation	$8,314.18	$8,048.11	$10,568.18	$10,447.29	$19,736.92	$20,197.60
Center-Pivot System Broadcast w/ Incorporation	$8,522.73	$8,021.49	$10,776.73	$10,360.84	$19,945.47	$19,875.63
	50 Cow Herd Size					

Table 8b. Total annual system cost for a 200 cow herd

System Type	0.5		1.5		4.5	
	Transport Distance (miles)					
	P	N	P	N	P	N
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$6,337.70	$6,337.70	$8,271.14	$8,271.14	$15,400.21	$15,400.21
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$7,171.88	$6,806.91	$9,105.32	$8,740.35	$16,234.39	$15,869.42
5,000 Gallon Liquid Slurry Tank Injected	$7,199.76	$7,199.76	$9,299.86	$9,299.86	$17,102.31	$17,102.31
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$9,274.92	$9,274.92	$10,841.65	$10,841.65	$16,223.03	$16,223.03
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$10,109.10	$9,744.13	$11,675.83	$11,310.86	$17,057.21	$16,692.24
10,000 Gallon Liquid Slurry Tank Injected	$11,966.89	$11,966.89	$13,761.53	$13,761.53	$20,033.09	$20,033.09
Drag Hose System	$12,180.70	$12,180.70	$14,522.78	$14,522.78	$24,362.37	$24,362.37
Big Gun Hard Hose Traveler Broadcast w/ No Incorporation	$14,082.11	$12,930.48	$16,876.18	$15,569.28	$28,125.01	$26,236.32
Big Gun Hard Hose Traveler Broadcast w/ Incorporation	$14,916.29	$13,738.00	$17,710.36	$16,445.83	$28,959.19	$27,391.95
Big Gun Soft Hose Traveler Broadcast w/ No Incorporation	$13,586.93	$10,550.35	$16,442.23	$13,059.40	$27,914.54	$23,234.97
Big Gun Soft Hose Traveler Broadcast w/ Incorporation	$14,421.11	$11,473.35	$17,276.41	$14,090.31	$28,748.72	$24,703.54
Center-Pivot System Broadcast w/ No Incorporation	$10,964.40	$10,434.52	$13,499.15	$12,540.49	$23,771.82	$22,329.23
Center-Pivot System Broadcast w/ Incorporation	$11,798.58	$11,012.45	$14,333.33	$13,483.08	$24,606.00	$23,508.69
	200 Cow Herd Size					

Table 8c. Total annual system cost for a 400 cow herd

System Type	0.5		1.5		4.5	
	Transport Distance (miles)					
	P	N	P	N	P	N
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$9,917.82	$9,917.82	$14,535.11	$14,535.11	$33,225.68	$33,225.68
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$11,586.18	$10,856.24	$16,203.48	$15,473.53	$34,894.04	$34,164.10
5,000 Gallon Liquid Slurry Tank Injected	$10,981.50	$10,981.50	$16,032.89	$16,032.89	$36,505.00	$36,505.00
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$13,574.41	$13,574.41	$17,249.29	$17,249.29	$30,987.19	$30,987.16
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$15,242.77	$14,512.83	$18,917.66	$18,187.71	$32,655.53	$31,910.20
10,000 Gallon Liquid Slurry Tank Injected	$16,634.59	$16,634.59	$21,022.19	$21,022.19	$37,108.50	$37,108.50
Drag Hose System	$16,456.43	$16,456.43	$19,234.01	$19,234.01	$30,673.38	$30,673.38
Big Gun Hard Hose Traveler Broadcast w/ No Incorporation	$21,381.99	$18,739.88	$25,266.23	$22,216.11	$40,471.85	$35,949.18
Big Gun Hard Hose Traveler Broadcast w/ Incorporation	$23,050.35	$20,168.59	$26,934.60	$23,735.77	$42,140.22	$37,828.14
Big Gun Soft Hose Traveler Broadcast w/ No Incorporation	$22,391.72	$15,805.15	$26,435.25	$18,937.51	$42,210.86	$31,431.45
Big Gun Soft Hose Traveler Broadcast w/ Incorporation	$24,030.08	$17,423.36	$28,103.61	$20,690.45	$43,879.22	$33,721.77
Center-Pivot System Broadcast w/ No Incorporation	$14,446.26	$13,020.27	$17,561.35	$15,888.39	$29,987.99	$27,414.83
Center-Pivot System Broadcast w/ Incorporation	$16,114.62	$14,427.76	$19,229.72	$17,376.21	$31,656.35	$29,196.16
	400 Cow Herd Size					

Table 8d. Total annual system cost for a 800 cow herd

System Type	0.5		1.5		4.5	
	Transport Distance (miles)					
	P	N	P	N	P	N
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$18,223.85	$18,223.85	$30,455.32	$30,455.32	$82,747.17	$82,747.17
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$21,560.57	$20,100.69	$31,759.84	$30,299.96	$86,083.90	$84,624.02
5,000 Gallon Liquid Slurry Tank Injected	$19,819.38	$19,819.38	$33,198.56	$33,198.56	$90,185.38	$90,185.38
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$23,585.08	$23,585.08	$33,093.34	$33,093.34	$70,000.00	$70,000.00
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$26,921.80	$25,461.92	$36,430.07	$34,970.18	$73,336.73	$71,876.84
10,000 Gallon Liquid Slurry Tank Injected	$27,983.83	$27,983.83	$39,117.30	$39,177.30	$82,224.22	$82,224.22
Drag Hose System	$26,182.80	$26,182.80	$29,893.34	$29,893.34	$45,395.52	$45,395.52
Big Gun Hard Hose Traveler Broadcast w/ No Incorporation	$38,571.89	$32,288.11	$45,336.48	$37,966.17	$70,634.08	$59,501.31
Big Gun Hard Hose Traveler Broadcast w/ Incorporation	$41,908.61	$35,009.71	$48,673.20	$40,836.32	$73,920.81	$62,934.88
Big Gun Soft Hose Traveler Broadcast w/ No Incorporation	$41,991.78	$27,260.23	$49,173.32	$32,038.99	$75,934.06	$50,407.09
Big Gun Soft Hose Traveler Broadcast w/ Incorporation	$45,328.51	$30,309.56	$52,510.05	$35,293.86	$79,270.79	$54,452.00
Center-Pivot System Broadcast w/ No Incorporation	$22,547.62	$19,743.59	$27,166.83	$23,827.30	$44,971.95	$39,734.74
Center-Pivot System Broadcast w/ Incorporation	$25,884.34	$22,171.47	$30,503.56	$26,356.88	$48,308.68	$42,635.19
	800 Cow Herd Size					

Table 8e. Total annual system cost for a 2,000 cow her

System Type	0.5		1.5		4.5	
	Transport Distance (miles)					
	P	N	P	N	P	N
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$50,034.00	$50,034.00	$99,020.18	$99,020.18	$384,133.67	$384,133.67
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$57,063.82	$54,596.12	$105,335.67	$103,299.19	$390,449.16	$388,412.67
5,000 Gallon Liquid Slurry Tank Injected	$53,861.00	$53,861.00	$106,991.71	$106,991.71	$409,030.31	$409,030.31
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$64,652.95	$64,652.95	$99,340.32	$99,340.32	$274,566.76	$274,566.76
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$70,197.49	$67,123.72	$105,655.81	$103,619.33	$280,882.25	$278,845.77
10,000 Gallon Liquid Slurry Tank Injected	$74,264.08	$74,264.08	$114,809.78	$114,809.78	$312,395.12	$312,395.12
Drag Hose System	$59,977.03	$59,977.03	$68,310.81	$68,310.81	$100,053.68	$100,053.68
Big Gun Hard Hose Traveler Broadcast w/ No Incorporation	$101,148.07	$81,305.95	$120,003.03	$96,248.80	$186,647.41	$149,590.63
Big Gun Hard Hose Traveler Broadcast w/ Incorporation	$107,781.88	$87,728.47	$126,636.83	$103,062.27	$193,281.22	$157,799.68
Big Gun Soft Hose Traveler Broadcast w/ No Incorporation	$105,754.13	$65,009.18	$126,120.36	$76,332.85	$197,944.69	$118,563.17
Big Gun Soft Hose Traveler Broadcast w/ Incorporation	$112,387.94	$72,231.31	$132,754.16	$84,042.02	$204,578.50	$128,088.72
Center-Pivot System Broadcast w/ No Incorporation	$53,096.65	$44,941.45	$64,128.50	$54,120.19	$104,118.18	$87,745.59
Center-Pivot System Broadcast w/ Incorporation	$58,989.08	$50,029.01	$70,889.73	$59,501.70	$110,879.41	$94,160.42
Note: Phosphorus applications are shaded gray	2000 Cow Herd Size					

Table 9. Cost per cow for each system

System Type	Distance (miles)					
	0.5		1.5		4.5	
	P	N	P	N	P	N
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$78.23	$78.23	$86.47	$86.47	$112.93	$112.93
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$82.40	$80.57	$94.42	$92.60	$117.10	$115.27
5,000 Gallon Liquid Slurry Tank Injected	$93.37	$93.37	$102.08	$102.08	$130.48	$130.48
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$127.26	$127.26	$134.12	$134.12	$155.44	$155.44
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$131.43	$129.61	$138.30	$136.47	$159.61	$157.79
10,000 Gallon Liquid Slurry Tank Injected	$176.22	$176.22	$183.62	$183.62	$207.49	$207.49
Drag Hose System	$186.85	$186.85	$230.05	$230.05	$407.40	$407.40
Big Gun Hard Hose Traveler Broadcast w/ No Incorporation	$188.55	$183.63	$233.03	$227.62	$413.94	$406.45
Big Gun Hard Hose Traveler Broadcast w/ Incorporation	$192.72	$190.78	$237.20	$235.93	$418.11	$419.43
Big Gun Soft Hose Traveler Broadcast w/ No Incorporation	$151.75	$137.99	$196.41	$181.65	$378.05	$359.02
Big Gun Soft Hose Traveler Broadcast w/ Incorporation	$155.92	$146.27	$200.58	$191.81	$382.22	$376.81
Center-Pivot System Broadcast w/ No Incorporation	$166.28	$160.96	$211.36	$208.95	$394.74	$403.95
Center-Pivot System Broadcast w/ Incorporation	$170.45	$160.43	$215.53	$207.22	$398.91	$397.51

50 Cow Herd Size

System Type	Distance (miles)					
	0.5		1.5		4.5	
	P	N	P	N	P	N
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$31.69	$31.69	$41.36	$41.36	$77.00	$77.00
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$35.86	$34.03	$45.53	$43.70	$81.17	$79.35
5,000 Gallon Liquid Slurry Tank Injected	$36.00	$36.00	$46.50	$46.50	$85.51	$85.51
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$46.37	$46.37	$54.21	$54.21	$81.12	$81.12
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$50.55	$48.72	$58.38	$56.55	$85.29	$83.46
10,000 Gallon Liquid Slurry Tank Injected	$59.83	$59.83	$68.81	$68.81	$100.17	$100.17
Drag Hose System	$60.90	$60.90	$72.61	$72.76	$121.81	$121.81
Big Gun Hard Hose Traveler Broadcast w/ No Incorporation	$70.41	$64.65	$84.38	$77.85	$140.63	$131.18
Big Gun Hard Hose Traveler Broadcast w/ Incorporation	$74.58	$68.69	$88.55	$82.23	$144.80	$136.96
Big Gun Soft Hose Traveler Broadcast w/ No Incorporation	$67.93	$52.75	$82.21	$65.30	$139.57	$116.17
Big Gun Soft Hose Traveler Broadcast w/ Incorporation	$72.11	$57.37	$86.38	$70.45	$143.74	$123.52
Center-Pivot System Broadcast w/ No Incorporation	$54.82	$52.17	$67.50	$62.70	$118.86	$111.65
Center-Pivot System Broadcast w/ Incorporation	$58.99	$55.06	$71.67	$67.42	$123.03	$117.54

200 Cow Herd Size

System Type	Distance (miles)					
	0.5		1.5		4.5	
	P	N	P	N	P	N
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$24.79	$24.79	$36.34	$36.34	$83.06	$83.06
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$28.97	$27.14	$40.51	$38.68	$87.24	$85.41
5,000 Gallon Liquid Slurry Tank Injected	$27.45	$27.45	$40.08	$40.08	$91.26	$91.26
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$33.94	$33.94	$43.12	$43.12	$77.47	$77.47
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$38.11	$36.28	$47.29	$45.47	$81.64	$79.78
10,000 Gallon Liquid Slurry Tank Injected	$41.59	$41.59	$52.56	$52.56	$92.77	$92.77
Drag Hose System	$41.14	$41.14	$48.09	$48.09	$76.68	$76.68
Big Gun Hard Hose Traveler Broadcast w/ No Incorporation	$53.45	$46.85	$63.17	$55.54	$101.18	$89.87
Big Gun Hard Hose Traveler Broadcast w/ Incorporation	$57.63	$50.42	$67.34	$59.34	$105.35	$94.57
Big Gun Soft Hose Traveler Broadcast w/ No Incorporation	$55.98	$39.51	$66.09	$47.34	$105.53	$78.58
Big Gun Soft Hose Traveler Broadcast w/ Incorporation	$60.08	$43.56	$70.26	$51.73	$109.70	$84.30
Center-Pivot System Broadcast w/ No Incorporation	$36.12	$32.55	$43.90	$39.72	$74.97	$68.54
Center-Pivot System Broadcast w/ Incorporation	$40.29	$36.07	$48.07	$43.44	$79.14	$72.99

400 Cow Herd Size

System Type	Distance (miles)					
	0.5		1.5		4.5	
	P	N	P	N	P	N
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$22.78	$22.78	$38.07	$38.07	$103.43	$103.43
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$26.95	$25.13	$39.70	$37.87	$107.60	$105.78
5,000 Gallon Liquid Slurry Tank Injected	$24.77	$24.77	$41.50	$41.50	$112.73	$112.73
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$29.48	$29.48	$41.37	$41.37	$87.50	$87.50
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$33.65	$31.83	$45.54	$43.71	$91.67	$89.85
10,000 Gallon Liquid Slurry Tank Injected	$34.98	$34.98	$48.90	$48.97	$102.78	$102.78
Drag Hose System	$32.73	$32.73	$37.37	$37.37	$56.74	$56.74
Big Gun Hard Hose Traveler Broadcast w/ No Incorporation	$48.21	$40.36	$56.67	$47.46	$88.29	$74.38
Big Gun Hard Hose Traveler Broadcast w/ Incorporation	$52.39	$43.76	$60.84	$51.05	$92.40	$78.67
Big Gun Soft Hose Traveler Broadcast w/ No Incorporation	$52.49	$34.08	$61.47	$40.05	$94.92	$63.01
Big Gun Soft Hose Traveler Broadcast w/ Incorporation	$56.66	$37.89	$65.64	$44.12	$99.09	$68.07
Center-Pivot System Broadcast w/ No Incorporation	$28.18	$24.68	$33.96	$29.78	$56.21	$49.67
Center-Pivot System Broadcast w/ Incorporation	$32.36	$27.71	$38.13	$32.95	$60.39	$53.29

800 Cow Herd Size

System Type	Distance (miles)					
	0.5		1.5		4.5	
	P	N	P	N	P	N
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$25.02	$25.02	$49.51	$49.51	$192.07	$192.07
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$28.53	$27.30	$52.67	$51.65	$195.22	$194.21
5,000 Gallon Liquid Slurry Tank Injected	$26.93	$26.93	$53.50	$53.50	$204.52	$204.52
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$32.33	$32.33	$49.67	$49.67	$137.28	$137.28
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$35.10	$33.56	$52.83	$51.81	$140.44	$139.42
10,000 Gallon Liquid Slurry Tank Injected	$37.13	$37.13	$57.40	$57.40	$156.20	$156.20
Drag Hose System	$29.99	$29.99	$34.16	$34.16	$50.03	$50.03
Big Gun Hard Hose Traveler Broadcast w/ No Incorporation	$50.57	$40.65	$60.00	$48.12	$93.32	$74.80
Big Gun Hard Hose Traveler Broadcast w/ Incorporation	$53.89	$43.86	$63.32	$51.53	$96.64	$78.90
Big Gun Soft Hose Traveler Broadcast w/ No Incorporation	$52.88	$32.50	$63.06	$38.17	$98.97	$59.28
Big Gun Soft Hose Traveler Broadcast w/ Incorporation	$56.19	$36.12	$66.38	$42.02	$102.29	$64.04
Center-Pivot System Broadcast w/ No Incorporation	$26.55	$22.47	$32.06	$27.06	$52.06	$43.87
Center-Pivot System Broadcast w/ Incorporation	$29.49	$25.01	$35.44	$29.75	$55.44	$47.08

2000 Cow Herd Size

Table 11. Application cost per acre, manure value as fertilizer per acre, and the net value per acre for each system

Syatem Type	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value
	0.5 Mile			1.5 Mile			4.5 Mile		
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$57.40	$52.68	-$4.72	$63.46	$52.68	-$10.78	$82.87	$52.68	-$30.19
	$127.57	$78.00	-$49.57	$141.02	$78.00	-$63.02	$184.16	$78.00	-$106.16
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$60.47	$57.74	-$2.73	$69.29	$57.74	-$11.55	$85.93	$57.74	-$28.19
	$105.12	$78.00	-$27.12	$120.81	$78.00	-$42.81	$150.39	$78.00	-$72.39
5,000 Gallon Liquid Slurry Tank Injected	$65.52	$62.81	-$2.71	$74.91	$62.81	-$12.10	$95.75	$62.81	-$32.94
	$101.51	$78.00	-$23.51	$110.98	$78.00	-$32.98	$141.86	$78.00	-$63.86
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$93.39	$52.68	-$40.71	$98.43	$52.68	-$45.75	$114.07	$52.68	-$61.39
	$207.53	$78.00	-$129.53	$218.73	$78.00	-$140.73	$253.20	$78.00	-$175.20
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$96.45	$57.74	-$38.71	$101.49	$57.74	-$43.75	$117.13	$57.74	-$59.39
	$169.09	$78.00	-$91.09	$178.05	$78.00	-$100.05	$205.86	$78.00	-$127.86
10,000 Gallon Liquid Slurry Tank Injected	$129.32	$62.81	-$66.51	$134.45	$62.81	-$71.64	$152.27	$62.81	-$89.46
	$191.59	$78.00	-$113.59	$199.63	$78.00	-$121.63	$225.59	$78.00	-$147.59
Drag Hose System	$137.12	$62.81	-$74.31	$168.82	$62.81	-$106.01	$298.97	$62.81	-$236.16
	$203.14	$78.00	-$125.14	$250.11	$78.00	-$172.11	$442.93	$78.00	-$364.93
Big Gun Hard Hose Traveller Broadcast w/ No Incorporation	$138.36	$52.68	-$85.68	$171.01	$52.68	-$118.33	$303.76	$52.68	-$251.08
	$299.46	$78.00	-$221.46	$372.21	$78.00	-$294.21	$662.83	$78.00	-$584.83
Big Gun Hard Hose Traveller Broadcast w/ Incorporation	$141.42	$57.74	-$83.68	$174.07	$57.74	-$116.33	$306.82	$57.74	-$249.08
	$248.90	$78.00	-$170.90	$307.80	$78.00	-$229.80	$547.20	$78.00	-$469.20
Big Gun Soft Hose Traveller Broadcast w/ No Incorporation	$111.36	$52.68	-$58.68	$144.13	$52.68	-$91.45	$277.43	$52.68	-$224.75
	$225.03	$78.00	-$147.03	$296.24	$78.00	-$218.24	$585.49	$78.00	-$507.49
Big Gun Soft Hose Traveller Broadcast w/ Incorporation	$114.42	$57.74	-$56.68	$147.19	$57.74	-$89.45	$280.49	$57.74	-$222.75
	$190.83	$78.00	-$112.83	$250.25	$78.00	-$172.25	$491.60	$78.00	-$413.60
Center-Pivot System Broadcast w/ No Incorporation	$122.02	$52.68	-$69.34	$155.11	$52.68	-$102.43	$289.67	$52.68	-$236.99
	$262.50	$78.00	-$184.50	$340.75	$78.00	-$262.75	$658.77	$78.00	-$580.77
Center-Pivot System Broadcast w/ Incorporation	$125.09	$57.74	-$67.35	$158.17	$57.74	-$100.43	$292.73	$57.74	-$234.99
	$209.30	$78.00	-$131.30	$270.34	$78.00	-$192.34	$518.61	$78.00	-$440.61
				50 Cow Herd Size					

System Type	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value
	0.5 Mile			1.5 Mile			4.5 Mile		
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$23.25	$52.68	$29.43	$30.35	$52.68	$22.33	$56.51	$52.68	-$3.83
	$51.68	$78.00	$26.32	$67.44	$78.00	$10.56	$125.57	$78.00	-$47.57
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$26.31	$57.74	$31.43	$33.41	$57.74	$24.33	$59.57	$57.74	-$1.83
	$44.40	$78.00	$33.60	$57.02	$78.00	$20.98	$103.52	$78.00	-$25.52
5,000 Gallon Liquid Slurry Tank Injected	$26.42	$62.81	$36.39	$34.12	$62.81	$28.69	$62.75	$62.81	$0.06
	$39.14	$78.00	$38.86	$50.55	$78.00	$27.45	$92.97	$78.00	-$14.97
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$34.03	$52.68	$18.65	$39.78	$52.68	$12.90	$59.52	$52.68	-$6.84
	$75.63	$78.00	$2.37	$88.40	$78.00	-$10.40	$132.28	$78.00	-$54.28
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$37.09	$57.74	$20.65	$42.84	$57.74	$14.90	$62.59	$57.74	-$4.85
	$63.56	$78.00	$14.44	$73.78	$78.00	$4.22	$108.89	$78.00	-$30.89
10,000 Gallon Liquid Slurry Tank Injected	$43.91	$62.81	$18.90	$50.49	$62.81	$12.32	$73.50	$62.81	-$10.69
	$65.05	$78.00	$12.95	$74.81	$78.00	$3.19	$108.90	$78.00	-$30.90
Drag Hose System	$44.69	$62.81	$18.12	$53.40	$62.81	$9.41	$89.39	$62.81	-$26.58
	$66.21	$78.00	$11.79	$79.11	$78.00	-$1.11	$132.43	$78.00	-$54.43
Big Gun Hard Hose Traveller Broadcast w/ No Incorporation	$51.67	$52.68	$1.01	$61.92	$52.68	-$9.24	$103.20	$52.68	-$50.52
	$105.44	$78.00	-$27.44	$126.95	$78.00	-$48.95	$213.93	$78.00	-$135.93
Big Gun Hard Hose Traveller Broadcast w/ Incorporation	$54.73	$57.74	$3.01	$64.98	$57.74	-$7.24	$106.26	$57.74	-$48.52
	$89.62	$78.00	-$11.62	$107.28	$78.00	-$29.28	$178.68	$78.00	-$100.68
Big Gun Soft Hose Traveller Broadcast w/ No Incorporation	$49.85	$52.68	$2.83	$60.33	$52.68	-$7.65	$102.42	$52.68	-$49.74
	$86.03	$78.00	-$8.03	$106.49	$78.00	-$28.49	$189.46	$78.00	-$111.46
Big Gun Soft Hose Traveller Broadcast w/ Incorporation	$52.91	$57.74	$4.83	$63.39	$57.74	-$5.65	$105.48	$57.74	-$47.74
	$74.84	$78.00	$3.16	$91.91	$78.00	-$13.91	$161.15	$78.00	-$83.15
Center-Pivot System Broadcast w/ No Incorporation	$40.23	$52.68	$12.45	$49.53	$52.68	$3.15	$87.22	$52.68	-$34.54
	$82.61	$78.00	-$4.61	$102.26	$78.00	-$24.26	$182.07	$78.00	-$104.07
Center-Pivot System Broadcast w/ Incorporation	$43.29	$57.74	$14.45	$52.59	$57.74	$5.15	$90.28	$57.74	-$32.54
	$71.84	$78.00	$6.16	$87.95	$78.00	-$9.95	$153.35	$78.00	-$75.35
				200 Cow Herd Size					

System Type	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value
	0.5 Mile			1.5 Mile			4.5 Mile		
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$18.20	$52.68	$34.48	$26.67	$52.68	$26.01	$60.96	$52.68	-$8.28
	$40.43	$78.00	$37.57	$59.26	$78.00	$18.74	$135.46	$78.00	-$57.46
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$21.26	$57.74	$36.48	$29.73	$57.74	$28.01	$64.02	$57.74	-$6.28
	$35.41	$78.00	$42.59	$50.47	$78.00	$27.53	$111.43	$78.00	-$33.43
5,000 Gallon Liquid Slurry Tank Injected	$20.15	$62.81	$42.66	$29.41	$62.81	$33.40	$66.97	$62.81	-$4.16
	$29.85	$78.00	$48.15	$43.58	$78.00	$34.42	$99.22	$78.00	-$21.22
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$24.90	$52.68	$27.78	$31.65	$52.68	$21.03	$56.85	$52.68	-$4.17
	$55.34	$78.00	$22.66	$70.33	$78.00	$7.67	$126.33	$78.00	-$48.33
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$27.96	$57.74	$29.78	$34.71	$57.74	$23.03	$59.91	$57.74	-$2.17
	$47.33	$78.00	$30.67	$59.32	$78.00	$18.68	$104.08	$78.00	-$26.08
10,000 Gallon Liquid Slurry Tank Injected	$30.52	$62.81	$32.29	$38.57	$62.81	$24.24	$68.08	$62.81	-$5.27
	$45.21	$78.00	$32.79	$57.14	$78.00	$20.86	$100.86	$78.00	-$22.86
Drag Hose System	$30.19	$62.81	$32.62	$35.29	$62.81	$27.52	$56.27	$62.81	$6.54
	$44.73	$78.00	$33.27	$52.28	$78.00	$25.72	$83.37	$78.00	-$5.37
Big Gun Hard Hose Traveller Broadcast w/ No Incorporation	$39.23	$52.68	$13.45	$46.35	$52.68	$6.33	$74.25	$52.68	-$21.57
	$76.40	$78.00	$1.60	$90.57	$78.00	-$12.57	$146.56	$78.00	-$68.56
Big Gun Hard Hose Traveller Broadcast w/ Incorporation	$42.29	$57.74	$15.45	$49.41	$57.74	$8.33	$77.31	$57.74	-$19.57
	$65.78	$78.00	$12.22	$77.42	$78.00	$0.58	$123.38	$78.00	-$45.38
Big Gun Soft Hose Traveller Broadcast w/ No Incorporation	$41.08	$52.68	$11.60	$48.50	$52.68	$4.18	$77.44	$52.68	-$24.76
	$64.44	$78.00	$13.56	$77.21	$78.00	$0.79	$128.15	$78.00	-$50.15
Big Gun Soft Hose Traveller Broadcast w/ Incorporation	$44.14	$57.74	$13.60	$51.56	$57.74	$6.18	$80.50	$57.74	-$22.76
	$56.83	$78.00	$21.17	$67.48	$78.00	$10.52	$109.99	$78.00	-$31.99
Center-Pivot System Broadcast w/ No Incorporation	$26.50	$52.68	$26.18	$32.22	$52.68	$20.46	$55.02	$52.68	-$2.34
	$53.08	$78.00	$24.92	$64.78	$78.00	$13.22	$111.77	$78.00	-$33.77
Center-Pivot System Broadcast w/ Incorporation	$29.56	$57.74	$28.18	$35.28	$57.74	$22.46	$58.08	$57.74	-$0.34
	$47.06	$78.00	$30.94	$56.67	$78.00	$21.33	$95.25	$78.00	-$17.25
				400 Cow Herd Size					

Note: Phosphorus applications are shaded gray

Table 11. Application cost per acre, manure value as fertilizer per acre, and the net value per acre for each system (cont.)

System Type	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value
	0.5 Mile			1.5 Mile			4.5 Mile		
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$16.72	$52.68	$35.96	$27.94	$52.68	$24.74	$75.90	$52.68	-$23.22
	$37.15	$78.00	$40.85	$62.08	$78.00	$15.92	$168.68	$78.00	-$90.68
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$19.78	$57.74	$37.96	$29.13	$57.74	$28.61	$78.96	$57.74	-$21.22
	$32.78	$78.00	$45.22	$49.41	$78.00	$28.59	$138.00	$78.00	-$60.00
5,000 Gallon Liquid Slurry Tank Injected	$18.18	$62.81	$44.63	$30.45	$62.81	$32.36	$82.73	$62.81	-$19.92
	$26.93	$78.00	$51.07	$45.12	$78.00	$32.88	$122.56	$78.00	-$44.56
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$21.63	$52.68	$31.05	$30.36	$52.68	$22.32	$64.21	$52.68	-$11.53
	$48.08	$78.00	$29.92	$67.46	$78.00	$10.54	$142.69	$78.00	-$64.69
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$24.70	$57.74	$33.04	$33.42	$57.74	$24.32	$67.27	$57.74	-$9.53
	$41.52	$78.00	$36.48	$57.03	$78.00	$20.97	$117.22	$78.00	-$39.22
10,000 Gallon Liquid Slurry Tank Injected	$25.67	$62.81	$37.14	$35.88	$62.81	$26.93	$75.42	$62.81	-$12.61
	$38.03	$78.00	$39.97	$53.16	$78.00	$24.84	$111.74	$78.00	-$33.74
Drag Hose System	$24.02	$62.81	$38.79	$27.42	$62.81	$35.39	$41.64	$62.81	$21.17
	$35.58	$78.00	$42.42	$40.63	$78.00	$37.37	$61.69	$78.00	$16.31
Big Gun Hard Hose Traveller Broadcast w/ No Incorporation	$35.38	$52.68	$17.30	$41.59	$52.68	$11.09	$64.79	$52.68	-$12.11
	$65.82	$78.00	$12.18	$77.39	$78.00	$0.61	$121.29	$78.00	-$43.29
Big Gun Hard Hose Traveller Broadcast w/ Incorporation	$38.44	$57.74	$19.30	$44.65	$57.74	$13.09	$67.85	$57.74	-$10.11
	$57.09	$78.00	$20.91	$66.60	$78.00	$11.40	$102.63	$78.00	-$24.63
Big Gun Soft Hose Traveller Broadcast w/ No Incorporation	$38.52	$52.68	$14.16	$45.11	$52.68	$7.57	$69.65	$52.68	-$16.97
	$55.57	$78.00	$22.43	$65.31	$78.00	$12.69	$102.75	$78.00	-$24.75
Big Gun Soft Hose Traveller Broadcast w/ Incorporation	$41.58	$57.74	$16.16	$48.17	$57.74	$9.57	$72.71	$57.74	-$14.97
	$49.43	$78.00	$28.57	$57.56	$78.00	$20.44	$88.80	$78.00	-$10.80
Center-Pivot System Broadcast w/ No Incorporation	$20.68	$52.68	$32.00	$24.92	$52.68	$27.76	$41.25	$52.68	$11.43
	$40.25	$78.00	$37.75	$48.57	$78.00	$29.43	$81.00	$78.00	-$3.00
Center-Pivot System Broadcast w/ Incorporation	$23.74	$57.74	$34.00	$27.98	$57.74	$29.76	$44.31	$57.74	$13.43
	$36.16	$78.00	$41.84	$42.98	$78.00	$35.02	$69.53	$78.00	$8.47
				800 Cow Herd Size					

System Type	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value	Application Cost ($/acre)	Manure Value as Fertilizer ($/acre)	Net Value
	0.5 Mile			1.5 Mile			4.5 Mile		
5,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$18.36	$52.68	$34.32	$36.33	$52.68	$16.35	$140.93	$52.68	-$88.25
	$40.79	$78.00	$37.21	$80.73	$78.00	-$2.73	$313.18	$78.00	-$235.18
5,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$20.94	$57.74	$36.80	$38.64	$57.74	$19.10	$143.24	$57.74	-$85.50
	$35.61	$78.00	$42.39	$67.38	$78.00	$10.62	$253.34	$78.00	-$175.34
5,000 Gallon Liquid Slurry Tank Injected	$19.76	$62.81	$43.05	$39.25	$62.81	$23.56	$150.06	$62.81	-$87.25
	$29.28	$78.00	$48.72	$58.15	$78.00	$19.85	$222.32	$78.00	-$144.32
10,000 Gallon Liquid Slurry Tank Broadcast w/ No Incorporation	$23.72	$52.68	$28.96	$36.45	$52.68	$16.23	$100.73	$52.68	-$48.05
	$52.71	$78.00	$25.29	$80.99	$78.00	-$2.99	$223.85	$78.00	-$145.85
10,000 Gallon Liquid Slurry Tank Broadcast w/ Incorporation	$25.75	$57.74	$31.99	$38.76	$57.74	$18.98	$103.05	$57.74	-$45.31
	$43.78	$78.00	$34.22	$67.58	$78.00	$10.42	$181.87	$78.00	-$103.87
10,000 Gallon Liquid Slurry Tank Injected	$27.25	$62.81	$35.56	$42.12	$62.81	$20.69	$114.61	$62.81	-$51.80
	$40.36	$78.00	$37.64	$62.40	$78.00	$15.60	$169.80	$78.00	-$91.80
Drag Hose System	$22.00	$62.81	$40.81	$25.06	$62.81	$37.75	$36.71	$62.81	$26.10
	$32.60	$78.00	$45.40	$37.13	$78.00	$40.87	$54.38	$78.00	$23.62
Big Gun Hard Hose Traveller Broadcast w/ No Incorporation	$37.11	$52.68	$15.57	$44.03	$52.68	$8.65	$68.48	$52.68	-$15.80
	$66.29	$78.00	$11.71	$78.47	$78.00	-$0.47	$121.96	$78.00	-$43.96
Big Gun Hard Hose Traveller Broadcast w/ Incorporation	$39.54	$57.74	$18.20	$46.46	$57.74	$11.28	$70.91	$57.74	-$13.17
	$57.22	$78.00	$20.78	$67.22	$78.00	$10.78	$102.92	$78.00	-$24.92
Big Gun Soft Hose Traveller Broadcast w/ No Incorporation	$38.80	$52.68	$13.88	$46.27	$52.68	$6.41	$72.62	$52.68	-$19.94
	$53.00	$78.00	$25.00	$62.23	$78.00	$15.77	$96.66	$78.00	-$18.66
Big Gun Soft Hose Traveller Broadcast w/ Incorporation	$41.23	$57.74	$16.51	$48.70	$57.74	$9.04	$75.05	$57.74	-$17.31
	$47.11	$78.00	$30.89	$54.82	$78.00	$23.18	$83.54	$78.00	-$5.54
Center-Pivot System Broadcast w/ No Incorporation	$19.48	$52.68	$33.20	$23.50	$52.68	$29.18	$38.20	$52.68	$14.48
	$36.64	$78.00	$41.36	$44.12	$78.00	$33.88	$40.68	$78.00	$37.32
Center-Pivot System Broadcast w/ Incorporation	$21.64	$57.74	$36.10	$26.01	$57.74	$31.73	$71.54	$57.74	-$13.80
	$32.63	$78.00	$45.37	$38.81	$78.00	$39.19	$61.42	$78.00	$16.58
				2000 Cow Herd Size					

Note: Phosphorus applicatios are shaded gray

Equations for determining costs

Depreciation

= (Capital Cost – Salvage Value) / (Useful Life * Annual Hours of Use)

Interest

= {[(Capital Cost + Salvage Value) / 2] * Interest Rate} / (Useful Life * Annual Hours of Use)

Insurance

= (Capital Cost * Insurance Rate) / Annual Hours of Use

Fuel

= Fuel Price * 0.73 (0.006 * Maximum PTO Horsepower)

Salvage Value

= Capital Cost * Salvage Value %

Repairs and Maintenance

= (((((Accumulated Hours of Use + Annual Hours of Use) / 1000)^RF2) * Capital Cost * RF1) –
(((Accumulated Hours of Use / 1000)^RF2) * (Capital Cost *RF1))) / (Annual Hours of Use)

Where:

RF1= Repair factor 1 from Appendix 35 Machinery Cost Calculator

RF2 = Repair factor 2 from Appendix 35 Machinery Cost Calculator