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Manure Transport Rates and Land Application Costs for Tank Spreader Systems

By Tim Harrigan, Extension machinery specialist, Department of Agricultural Engineering

On many farms, daily hauling of manure is being replaced by long-term storage and handling of liquid slurries. Manure from long-term storage is usually more uniform in nutrient content than manure spread daily, and this manure is often spread and incorporated within a few days' time. This allows for timely use of manure as fertilizer and reduces nutrient loss to the environment. Long-term storage and slurry spreading requires a higher initial investment in structures and equipment than daily hauling, but such systems are often preferred because they are easily mechanized and offer a range of equipment options.

Objective

As farms increase in acreage and more animals are housed in one location, it's necessary to transport manure farther for efficient nutrient use. The challenge for the livestock producer is to store, handle and use the manure in a cost-effective and safe manner. Managing manure in such a way requires knowledge of the costs of storage, handling and transport as well as the nutrient value of the manure applied. Tank spreader systems allow for a flexible spreading schedule, timely use of manure as fertilizer, and efficient use of equipment and labor.

The objective of this bulletin is to provide information for livestock producers and farm managers to use in determining a hauling rate (gallons per hour [gal/hr]), machinery costs (dollars per hour [$/hr]) and labor requirements for manure transport and land application using tank spreaders.

Slurry injection conserves nutrients for crop growth.

Tank spreaders

Tractor-drawn tank spreaders currently available range in size from about 800 to 12,000 gallons. Livestock producers use truck-mounted spreader tanks and nurse trucks to transport manure to remote locations in a timely and cost-efficient manner (Borton et al., 1995; Harrigan, 1997). Top-loading tank spreaders can be filled using an auxiliary pump. Vacuum tanks are filled by creating a vacuum in the tank to pull manure into it. In some cases, these vacuum tanks also provide agitation by drawing slurry into the tank and then discharging it back to storage. Vacuum tanks often have a purchase price 30 to 50 percent higher than top-loading tanks of similar volume. Most tank spreaders used on Michigan farms are top-loading. The hauling rates and costs used in this bulletin are representative of top-loading tanks.

Manure-hauling cycle

The manure-hauling cycle time is a measure of the total time needed to complete all steps of the hauling process: load, transport, unload and return. Cycle time varies from farm to farm and field to field. Normal time requirements for various aspects of the manure-hauling cycle measured on several Michigan farms are listed in Table 1.

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Table 1. Representative time and flow rates for manure hauling in Michigan.

	Range	Typical
Loading and unloading (gallons per minute [gpm])[1]		
Spreader loading	950-1,900	1,300
Spreader unloading	900-1,550	1,300
Maneuvering the spreader (minutes)		
Near storage	2-4	3.5
In the field	2-6	4
Nurse truck to tanker hookup	1-2	1.5
Road travel	Variable with distance	

[1]Unloading rates for surface spreading. Rate for subsurface injection is 130 gpm/injector.

Travel distance can greatly influence labor and cost and have a major impact on the manure hauling rate. Average travel speed for tractors and trucks varies with road conditions and number of stops. Higher speeds are likely on paved than unpaved roads. Average speed with an empty spreader is about 20 percent greater than with a loaded spreader. Representative truck and tractor speeds are listed in Table 2. Average speed would be slower in areas with hilly and winding roads.

Table 2. Representative truck and tractor travel speeds for manure hauling.

	Tractor, mph		Truck, mph[1]	
Distance	Loaded	Empty	Loaded	Empty
≤ .5 mile	12	14	20	26
> .5 mile	14	17	25	31

[1] High-speed agricultural tractors with road speeds of 40 mph or more are currently available.

Manure injection and incorporation

Winged injectors distribute the manure over a wide area.

Manure should be injected or incorporated by tillage soon after spreading. Manure runoff from land areas where manure has been spread is a potential source of water pollution. Animal wastes create high biological oxygen demand and free ammonia that are toxic to fish. Excess nutrients promote eutrophication in lakes and ponds, and pathogens contaminate fish and drinking water. Direct injection or rapid incorporation following surface spreading minimizes manure runoff.

Direct soil injection of liquid manure conserves nitrogen and greatly reduces the odor associated with land application. A winged injector can inject almost twice the volume at a given depth as a narrow injector. Winged injectors also distribute the manure over a wider area and decrease the potential for root inhibition and nitrogen loss.

A rolling-tine aerator improves infiltration and nutrient recovery.

Tillage tools are available for manure incorporation. A recent study in Ontario, Canada (Wright, 1994), evaluated a rolling tine aerator mounted behind a tank spreader to improve infiltration and nutrient recovery of liquid hog manure. The aerator loosened the soil in the surface 6 to 8 inches yet left a level, residue-covered surface. Where the aerator had tilled the soil, manure ponded only in holes created by the aerator teeth and soaked away within 20 minutes. No overland flow of manure occurred. Where the aerator was not used and manure was spread on the surface, manure tended to run and pond in wheel tracks. Infiltration took 1½ hours or more. The aerator also resulted in about 12 percent more available nitrogen, presumably because of lower volatilization losses from more rapid infiltration. This type of tillage tool may be particularly useful for livestock producers interested in no-till crop production.

Agitation and pumping

Agitation provides a uniform material for land application.

Manure slurries are agitated before removal from storage to create a homogeneous material for land application. Liquid manure pumps and pump/agitators can be mounted directly to a tractor three-point hitch, mounted on wheels or attached to the walls of aboveground storage structures. On-farm observations of several dairy and swine operations indicate typical spreader loading rates with PTO-powered pumps and pump agitators of 1,300 gpm.

Tractors ranging from 70 to 100 PTO hp are often suitable for small pit and lagoon pumps and agitators; larger pumps, pump agitators and propeller agitators require 100 to 150 PTO hp.

Handling sand-laden dairy manure

Tank spreaders are generally used for hauling flowable slurries with up to 10 percent dry matter. Straw, sawdust and similar organic bedding can be easily handled with proper equipment selection. But many dairy producers use sand bedding to reduce the occurrence of mastitis and maintain foot and leg health. Sand-laden manure presents many challenges in handling and transport. A gallon of dairy manure containing organic solids may weigh about 8 pounds; sand-laden manure may weigh 10 pounds or more. This added weight places added stress on the spreader chassis, tires and spindles. Accelerated machinery wear from pumping sand-laden manure can be costly and time consuming. Also, the sand may settle out in transport and plug the spreader. Refer to Extension bulletin E-2561, Storing and Handling Sand-Laden Dairy Manure, for suggestions about how best to manage sand-laden manure.

Matching tractor and spreader

Matching tractor and spreader is important in maintaining a safe and efficient system. The tractor must have sufficient power to overcome the rolling resistance of the spreader and sufficient weight to safely control the heavy implement in transport. Manufacturer and local experience can provide guidance in the matching of tractor and spreader. Ranges of likely options are listed in Table 3. Select a tank size near the low end of the range if the spreader will be hauled over soft or hilly ground or if the spreader is not equipped with an independent braking system.

Table 3. Representative tank spreader tractor PTO hp requirements.

	Tank spreader volume, gallons		
Tractor PTO hp	Low	Typical	High
60	1200	1500	1800
80	1600	2000	2400
100	2000	2500	3000
120	2400	3000	3600
140	2900	3600	4200
160	3350	4150	4500
180	4000	4900	5800
200	4400	5400	6400
220	4800	5900	7000
240	5200	6400	7500

Tractor-drawn tank spreaders

Farm managers, consultants and others working with manure transport use hauling rate information to select machinery to complete field operations within the time available. Many producers expect to spread about three loads per hour when hauling within ½ mile of storage. However, when hauling farther or using truck-drawn spreaders and nurse trucks, the hauling rate (gal/hr) achieved depends on the equipment set chosen, hauling distance and other farm-specific factors.

The hauling rate (gal/hr) of tractor-drawn spreaders declines rapidly with transport distance (Fig. 1). Selecting a larger tank can increase the hauling rate,

The faster travel speed of truck-mounted spreaders provides an advantage on longer hauls.

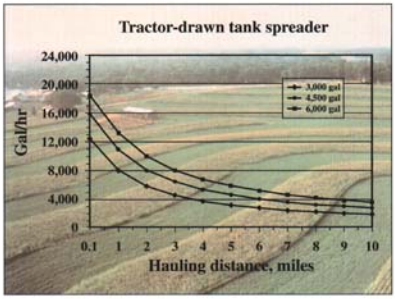

Fig. 1. Hauling rates of tractor-drawn tank spreaders.

but because loading and unloading time also take longer as volume increases, the hauling rate does not increase in direct proportion to tank volume. For instance, doubling tank volume from 3,000 to 6,000 gallons will increase the hauling rate about 60 percent with a 1-mile haul and about 90 percent with a 10-mile haul.

When manure is injected, the hauling rate is usually lower than when it is spread on the surface. The flow rate through each injector is typically about 130 gpm per injector shank, with four to seven shanks generally used. Additional maintenance is often needed for the injector unit, particularly if bedding and other debris that can clog the injector units are mixed with the manure slurry. This combination of a lower unloading rate and additional maintenance often provides for a hauling rate 20 to 30 percent lower than that of surface spreading.

Truck-mounted tank spreaders

There is little difference in hauling rate between truck-mounted and tractor-drawn spreaders when the spreading site is near storage, but the faster travel speed of truck-mounted spreaders provides an advantage with longer hauls (Fig. 2).

A truck-mounted spreader has a hauling rate about 15 percent greater than a tractor-drawn spreader when hauling 1 mile and 60 percent more over

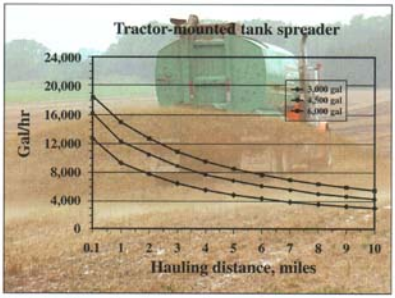

Fig. 2. Manure hauling rate for truck-mounted tank spreaders.

10 miles. When hauling 3 miles, a 3,000-gallon truck-mounted spreader is similar in hauling rate to a 4,500-gallon tractor-drawn spreader. Doubling the tank volume from 3,000 to 6,000 gallons will increase the hauling rate about 60 percent with a 1-mile haul and 85 percent with a 10-mile haul. When using a high-speed agricultural tractor, the hauling rate of a tractor-drawn spreader is similar to that of a truck-mounted spreader.

Nurse trucks

A nurse truck is often used to shuttle manure slurry to a tractor-drawn spreader when hauling far from storage. This machinery set allows rapid road transport and reduces wear on the tractor, but additional time is needed to transfer manure from the nurse tank to the spreader tank. Machinery options for this manure transfer include selection of a vacuum tank spreader to draw slurry from the tank, use of a truck-mounted tank with a tractor-powered auxiliary pump, and use of a nurse truck equipped with a hydraulic pump and swing boom.

Nurse trucks allow rapid road transport for long hauls.

When the hauling distance is 2 to 3 miles, one operator can use a nurse truck to shuttle slurry to a tractor-drawn spreader, transfer the slurry and spread it at about the same rate as using the tractor-drawn spreader alone (Fig. 3). The advantage with this system increases with transport distance. The hauling rate when using the nurse truck for a 5-mile haul will be about 20 to 25 percent greater than that of the tractor-drawn spreader alone and 40 percent greater with a 10-mile haul. Doubling the tank volume from 3,000 to 6,000 gallons will increase the hauling rate about 55 percent with a 1-mile haul and 80 percent with a 10-mile haul.

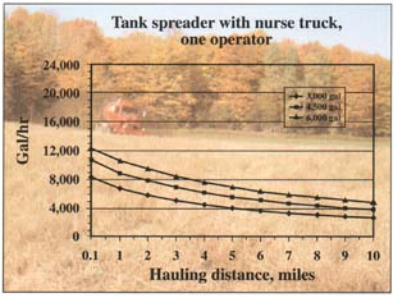

Fig. 3. Manure hauling rate with one operator working a nurse truck and tank spreader.

When two operators are available, a nurse truck can be used in parallel with a tractor-drawn spreader. One person transports manure from storage to field while the other loads the spreader and applies the manure. The spreader works at full capacity over the full range of transport distances because it can spread the

slurry before the nurse truck can travel to storage, refill and return to the field. This system provides a hauling rate nearly equal to that of a truck-mounted spreader (Fig. 4). Doubling the tank volume from 3,000 to 6,000 gallons will increase the hauling rate about 60 percent with a 1-mile haul and 85 percent with a 10-mile haul.

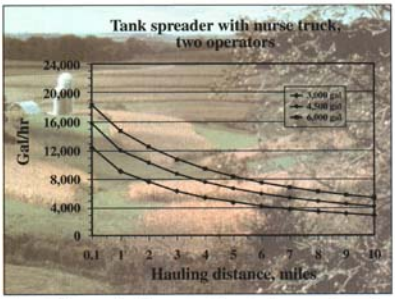

Fig. 4. Manure hauling rate with a tank spreader and nurse truck, two operators.

Two nurse trucks are often used in parallel with a tractor-drawn spreader. This system uses one person to operate each nurse truck and a third to load the spreader and apply the manure. When the spreading site is within a few miles of storage, these nurse trucks are often able to fill the spreader tank, return to storage, refill and return to the field before the spreader tank has had time to unload. Because the spreader does not have to wait for a nurse truck, it is able to operate at full capacity. Two nurse trucks should be able to keep a tractor-drawn spreader working near full capacity with 2-, 2½ - and 3-mile hauls when using 3,000-, 4,500- and 6,000-gallon nurse trucks, respectively (Fig. 5). The hauling rate drops off with longer hauls because the spreader tank must wait for a nurse truck to arrive.

The greatest advantage in using larger equipment is associated with long hauls. Doubling the nurse truck and spreader volume from 3,000 to 6,000 gallons increases the hauling rate about 35 percent with a 1-mile haul, 65 percent with a 3-mile haul and 85 percent with a 10-mile haul.

The hauling rate can also be increased by selecting a nurse truck with twice the volume of the spreader (Fig. 6). When 6,000-gallon nurse trucks are used, the tractor-drawn spreader is allowed to work at full capacity up to 4 miles from storage rather than 2 miles as with the 3,000-gallon nurse trucks. The hauling rate is 45 percent greater at 5 miles and 63 percent greater at 10 miles.

The impact of injection on the hauling rate when using nurse trucks varies with the hauling distance and size of equipment used. When slurry is transported within a

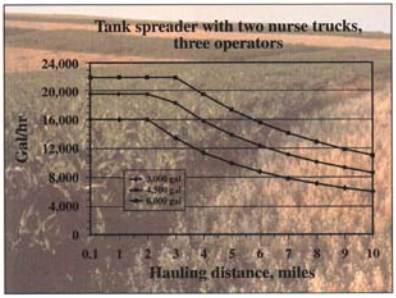

Fig. 5. Manure hauling rate for a tank spreader with two nurse trucks, three operators.

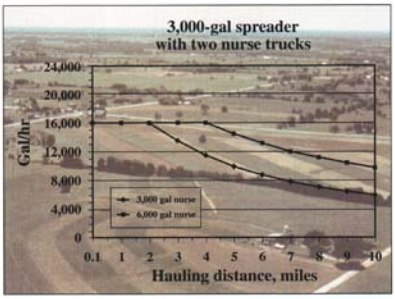

Fig. 6. Manure hauling rate when using a 3,000-gallon spreader with two 3,000- or two 6,000-gallon nurse trucks.

few miles of storage, the system hauling rate is often limited by the capacity of the spreader (Fig. 7). Within this distance, the delays caused by injection may decrease the hauling rate 20 to 30 percent. As the transport distance increases and the spreader is able to unload before a nurse truck arrives, injection has less impact on the system hauling rate — a reduction of perhaps 10 percent due to delays for injector repair and maintenance. Doubling the tank volume from 3,000 to 6,000 gallons will increase the hauling rate about 30 percent with a 1-mile haul and 85 percent with a 10-mile haul.

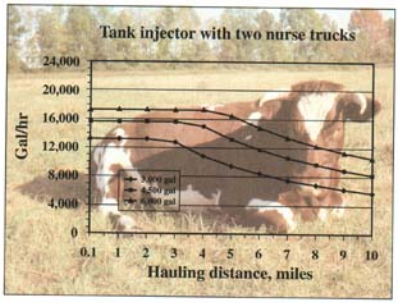

Fig. 7. Hauling rate when using a tank injector with two nurse trucks, three operators.

Machinery and transport costs

Many things need to be considered when selecting a manure-handling and land application system. The best system for any farm will depend on farm size, number and type of animals, labor, crops grown and land available for spreading, hauling distance, terrain, soil type, existing structures and equipment, and many other factors. Ownership and operating costs are important, but the least-cost system may not be best for all farms.

Hourly charges for a range of manure-handling equipment are listed in Table 4. These costs include machinery ownership, repair and maintenance, and are based on accumulated use, fuel and labor associated with agitation, pumping, transport and spreading. Annual costs are presented on a cash-flow, before-tax basis using a real interest rate (approximately nominal rate minus inflation) of 6 percent. Machinery was purchased, depreciated over seven to 10 years and replaced. Charges for machinery ownership, fuel use, and repair and maintenance were based on hours of machine use. Machine use included time normally spent hauling and in short delays waiting for machines to complete their assigned task.

Table 4. Tractor ownership and operating costs.

		Machinery costs, $/hour			
Tractor	Purchase price, $	Own[1]	Repair & maint.[2]	Fuel & lube[3]	Total
60 hp	36,000	5.75	1.75	4.25	11.75
80 hp	48,000	7.25	2.25	5.75	15.25
100 hp	60,000	9.25	3.00	7.25	19.75
120 hp	72,000	11.00	3.50	8.75	23.25
140 hp	84,000	13.00	4.00	10.00	27.00
160 hp	96,000	14.75	4.75	11.50	31.00
180 hp	108,000	16.50	5.25	13.00	34.75
200 hp	120,000	18.50	6.00	14.50	39.00
220 hp	132,000	20.25	6.50	15.75	42.50
240 hp	144,000	22.00	7.00	17.25	46.25

[1] Annual ownership costs include depreciation, interest, insurance and shelter. They are calculated on the basis of an average invested value (straight-line depreciation) where salvage value equals 28 percent of purchase price for tractors of 80 hp or less, and 38 percent for those greater than 80 hp. Insurance equals 0.25 percent of purchase price, shelter equals 35 cents per sq. ft. of storage area. Hourly costs are presented on a cash-flow, before-tax basis using a real interest rate (nominal rate minus inflation) of 6 percent. Tractors are depreciated over 10 years and replaced. Hourly costs are based on usage of 700 hours per year.

[2] Repair and maintenance are based on accumulated use.

[3] Fuel and lubrication are based on diesel fuel at $1.25/gal plus 15 percent for lubrication and filters.

An additional labor requirement estimated as 15 percent of machine use was allowed for time when labor and machines were committed to manure-hauling operations but work was delayed for machine adjustment or unexpected repair and maintenance.

Examples 1 and 2 illustrate how these hourly charges can be used with the hauling rates provided in Figs. 1-7 to estimate a system hauling cost or establish a rate for custom work. Not included in these estimates of a system hauling cost are charges for bedding, manure storage, alley scraping or barn cleaning. Nor is the nutrient value of the manure applied included. Net system costs can be substantially reduced if manure nutrients are retained and accounted for in the cropping program (Harrigan et al., 1996).

Example 3 illustrates how custom hauling provides an opportunity to increase use of specialized equipment and reduce machinery costs per unit of production. Machinery ownership costs such as depreciation, interest, shelter and insurance are fixed costs that do not vary with machine use. Increasing use distributes these costs over more units of production. In providing custom service, the machine owner benefits by creating revenue that helps cover ownership costs. The purchaser of the service benefits by having access to high-capacity, specialized equipment at a lower cost than those of owning similar equipment.

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Table 5. Ownership and operating costs for a range of tank spreader manure-hauling systems.

Machine	Purchase price, $	Machinery costs, $/hour: 150 hr use Own[1]	Repair & maint.[2]	Fuel & lube[3]	Total	200 hr use Own[1]	Repair& maint.[2]	Fuel & Lube[3]	Total	250 hr use Own[1]	Repair& maint.[2]	Fuel & Lube[3]	Total
Tank spreaders													
2,000-gal	8,500	8.25	3.50	—	**11.75**	6.25	4.00	—	**10.25**	5.00	4.00	—	**9.00**
3,000-gal	11,500	11.00	4.75	—	**15.75**	8.25	5.25	—	**13.50**	6.50	5.50	—	**12.00**
4,000-gal	14,400	13.50	6.00	—	**19.50**	10.25	6.50	—	**16.75**	8.25	7.00	—	**15.25**
5,000-gal	20,700	19.50	8.50	—	**28.00**	14.50	9.50	—	**24.00**	11.50	10.00	—	**21.50**
6,000-gal	27,800	25.75	11.50	—	**37.25**	19.50	12.50	—	**33.00**	15.50	13.50	—	**29.00**
7,000-gal	34,800	32.25	14.50	—	**46.75**	24.25	15.75	—	**40.00**	19.50	17.00	—	**36.50**
Truck-mounted spreaders and nurse trucks[4]													
3,000-gal nurse truck	21,000	25.75	7.50	6.00	**39.25**	19.50	7.75	6.00	**33.25**	15.50	8.00	6.00	**29.50**
6,000-gal nurse truck	28,000	34.25	10.00	7.25	**51.50**	25.50	10.25	7.75	**43.50**	20.50	10.75	7.75	**39.00**
3,000-gal truck-mounted spreader	26,000	30.50	9.50	6.00	**46.00**	22.75	10.00	6.00	**38.75**	18.25	10.50	6.00	**34.75**
6,000-gal truck-mounted spreader	33,000	38.75	12.00	7.25	**58.00**	29.00	12.50	7.75	**49.25**	23.25	13.00	7.75	**44.00**
3,000-gal truck-mount/nurse truck	29,000	33.25	10.75	6.00	**50.00**	24.75	11.50	6.00	**42.25**	19.75	12.00	6.00	**37.75**
6,000-gal truck-mount/nurse truck	36,000	41.50	13.25	7.25	**62.00**	31.00	14.00	7.75	**52.75**	24.75	14.50	7.75	**47.00**
Pumps and agitators													
Pit pump, small (70-90 hp)	6,600	6.00	2.75	—	**8.75**	4.50	3.00	—	**7.50**	3.50	3.25	—	**6.75**
Pit pump, large (100-120 hp)	10,600	9.50	4.50	—	**14.00**	7.25	4.75	—	**12.00**	5.75	5.25	—	**11.00**
Lagoon pump, small (80-100 hp)	7,700	7.00	3.25	—	**10.25**	5.25	3.50	—	**8.75**	4.25	3.75	—	**8.00**
Lagoon pump, large (100-150 hp)	12,200	11.00	5.00	—	**16.00**	8.25	5.50	—	**13.75**	6.75	6.00	—	**12.75**
Propeller agitator (100-150 hp)	3,500	6.00	1.25	—	**7.25**	4.50	1.25	—	**5.75**	3.75	1.50	—	**5.25**
Soil injection and incorporation													
Injector ($ per shank)[5]	1,200	1.50	0.25	—	**1.75**	1.00	0.50	—	**1.50**	0.75	0.50	—	**1.25**
Rolling spike harrow (tank-mounted, 12-ft)	7,400	6.50	2.25	—	**8.75**	4.75	2.75	—	**7.50**	3.75	3.00	—	**6.75**

[1] Annual ownership costs include depreciation, interest, insurance and shelter. They are calculated on the basis of an average invested value (straight-line depreciation) where salvage value equals 35 percent of purchase price. Insurance equals 0.25 percent of purchase price and shelter equals 35 cents per sq. ft. storage area. Hourly costs are presented on a cash-flow, before-tax basis using a real interest rate (nominal rate minus inflation) of 6 percent. All equipment is depreciated over seven years and replaced.

[2] Repair and maintenance are based on accumulated use.

[3] Fuel and lubrication are based on diesel fuel at $1.25 per gallon plus 15 percent for lubrication and filters.

[4] Used tandem truck chassis at $15,000 for 3,000-gal tanks, $20,000 for 6,000-gal tanks. Nurse trucks include tank and fittings. A separate auxiliary pump and tractor are required for slurry transfer. Mounted spreaders include tanks, hydraulic pump, hoses and fittings. Combination truck-mounted spreader/nurse truck includes tank, hydraulic pump, hoses and fittings, and a swing boom for manure transfer.

[5] Includes tank hitch and valves. Four to seven injector shanks are typical.

Example 1:

200-cow dairy, 3,000-gallon tractor-drawn tank spreader.

A 200-cow dairy has 1,640,000 gallons of liquid slurry to be spread over three parcels of land: parcel 1 (100 acres) is 1/4 mile, parcel 2 (80 acres) is ½ mile and parcel 3 (60 acres) is 1 mile from storage. A small lagoon pump/agitator with a 100-hp tractor will be used for agitation and pumping. A 3,000-gallon tank spreader with a 120-hp tractor will be used for transport and spreading. Estimate annual ($/yr) and per unit ($/hr, ¢/gal) machinery and labor costs for manure agitation, pumping, transport and spreading.

Hauling rate:

Estimate a slurry hauling rate (gal/hr) based on spreader tank volume (gal) and travel distance (miles) for each major parcel of land.

Method: refer to Fig. 1, hauling rate of tractor-drawn tank spreaders.

Parcel 1	¼ mile haul: 11,000 gal/hr
Parcel 2	½ mile haul: 9,500 gal/hr
Parcel 3	1-mile haul: 8,100 gal/hr

Hauling time:

Estimate an annual hauling time (hr/yr) and the hauling time for each parcel.

Method: (parcel acreage/total acreage) x (total manure spread [gal]) ÷ parcel hauling rate, gal/hr

Parcel 1	(100 A ÷ 240 A x 1,640,000 gal) ÷ 11,000 gal/hr	= 62 hr
Parcel 2	(80 A ÷ 240 A x 1,640,000 gal) ÷ 9,500 gal/hr	= 58 hr
Parcel 3	(60 A ÷ 240 A x 1,640,000 gal) ÷ 8,100 gal/hr	= 51 hr
Total hauling time		= 171 hr

Machinery and labor cost:

Estimate total ($/yr) machinery and labor costs. Specific machine costs ($/hr) are listed in Tables 4 and 5. Use machine costs based on 150 hr annual use. Provide for support labor equal to 15 percent of machine use for unexpected delays.

Method:	*(hauling time [hr/yr]) x (machine hourly charge [$/hr])*	*= machinery, $/yr*
	(hauling time [hr/yr]) x 1.15 x (labor charge [$/hr])	*= labor, $/yr*

Transport and spreading:

120-hp tractor: 171 hr x $23.25/hr	= $3,976/yr
3,000-gal spreader: 171 hr x $15.75/hr	= $2,693/yr
Labor: 171 hr x 1.15 x $10/hr	= $1,967/yr
Total transport and spreading cost	= $8,636/yr

Example 1: *(cont'd)*

Machinery and labor cost (cont'd):

Method: Continuous agitation will be used. Assume half-time labor at the lagoon for agitation and pumping.

Agitation and pumping:

100-hp tractor: 171 hr x $19.75/hr	= $3,377/yr
Small lagoon pump/agitator: 171 hr x $10.25/hr	= $1,753/yr
Labor: 171 hr x 1.15 x $10/hr x 0.5	= $ 983/yr
Total agitation and spreading	= $6,113/yr

Unit costs:

Estimate per unit cost: $/hr, $/gal.
Method: (annual machinery and labor cost) ÷ (hr use) = $/hr
(annual machinery and labor cost) ÷ (gal applied) = $/gal

$/hr

Transport and spreading	$ 8,636 ÷ 171 hr	= $50/hr
Agitation and pumping	$ 6,113 ÷ 171 hr	= $36/hr
Total machinery and labor cost	$14,749 ÷ 171 hr	= $86/hr

$/gal

Transport and spreading	= $8,636 ÷ 1,640,000 gal	= $0.0053/gal = 0.53¢/gal
Agitation and pumping	= $6,113 ÷ 1,640,000 gal	= $0.0037/gal = 0.37¢/gal
Total machinery and labor cost	= $14,749 ÷ 1,640,000 gal	= $0.0090/gal = 0.9¢/gal

Summary:

Agitation, pumping, transport and spreading of 1,640,000 gallons of manure within 1 mile of storage with a 3,000-gallon tank spreader required about 171 hr/year. Agitation and pumping costs were $36/hr; transport and spreading costs were $50/hr. Total machinery and labor costs were $86/hr or 0.9¢/gallon.

Example 2:

A farrow-to-finish swine operation, one 6,000-gallon injection tanker and two 6,000-gallon nurse trucks.

A large farrow-to-finish swine operation has 3 million gallons of manure slurry to spread on 450 acres of land in several fields 2 to 4 miles from storage. All slurry will be injected with a six-point injector (780 gpm) with a 4,500-gallon tank spreader and 180-hp tractor. A large pit pump with a 100-hp tractor will be used for agitation and pumping. Two 4,500-gallon nurse trucks will be used for over-the-road transport. A small pit pump and an 80-hp tractor will be used for in-field transfer of manure from nurse truck to spreader. Estimate an annual ($/yr) and per unit ($/hr, ¢/gal) machinery and labor cost for the swine operation.

Farrow-to-finish operation

Hauling rate:

Estimate a hauling rate (gal/hr) based on spreader tank and nurse truck volume (gal) and travel distance (miles) for each major parcel of land.

Method: refer to Fig. 7 for hauling rates for a tractor-drawn tank injector with two nurse trucks.

Answer: 15,500 gal/hr

Based on Fig. 7, the hauling rate will be about the same for all fields within 2 to 4 miles of storage when two nurse trucks and a tank spreader of equal volume are used. Within this distance, the tank injector will work at full capacity and the nurse trucks will have a short wait to refill the spreader.

Hauling time:

Estimate an annual hauling time (hr/yr) for the farrow-to-finish operation.

Method: total manure spread (gal/yr) ÷ parcel hauling rate (gal/hr) = hr/yr

Answer: 194 hr

3,000,000 gal ÷ 15,500 (gal/hr) = 194 hr

Machinery and labor cost:

Estimate total ($/yr) machinery and labor costs. Tractor costs ($/hr) are listed in Table 4; all other machinery is listed in Table 5. Provide additional support labor equal to 15 percent of machine use for unexpected delays.

Method: (hauling time [hr/yr]) x (machine hourly charge [$/hr]) = machinery, $/yr

(hauling time [hr/yr]) x 1.15 x (labor charge [$/hr]) = labor, $/yr

Base manure machinery costs on 200 hr use per year.

Example 2: *(cont'd)*

Machinery and labor cost (cont'd):

Estimate a representative cost for a 4,500-gal tank spreader and 4,500-gal nurse trucks as midway between existing table values. For instance, based on 200 hr use, a representative cost for a 4,500-gallon tank spreader is $20.50, midway between 4,000-gallon ($16.75) and 5,000-gallon ($24) spreader costs. Continuous agitation at the lagoon, labor charged for half of agitation time. Transfer pump costs are based on actual use (hr).

Transport and spreading:

180-hp tractor: 194 hr x $34.75/hr	= $ 6,742/yr
4,500-gal spreader: 194 hr x $20.50/h	= $ 3,977/yr
Six-point injector: 194 hr x 6 injectors x $1.50/injector	= $ 1,746/yr
Two-4,500-gal nurse trucks: 2 x 194 hr x $38.50/hr	= $14,938/yr
Labor: 194 hr x 1.15 x $10/hr x 3 operators	= $ 6,693/yr
Total transport and spreading	= $34,096/yr

Agitation and pumping:

Method: Lagoon pump agitation (hr) = spreading time (hr) = 194 hr
Transfer pump (hr) = gal spread ÷ 1,300 gpm ÷ 60 min per hr

Transfer pump time = (3,000,000 gal ÷ 1,300 gpm ÷ 60 min per hr) = 38 hr

Lagoon pump/agitator

100-hp tractor: 194 hr x $19.75/hr	= $3,832/yr
Lagoon pump/agitator, large: 194 hr x $13.75/hr	= $2,668/yr
Labor: 194 hr x 1.15 x $10/hr x 0.5	= $1,116/yr

Transfer pump

Pit (transfer) pump, small: 38 hr x $7.50/hr	= $285/yr
80-hp tractor: 38 hr x $15.25/hr	= $580/yr
Total agitation and pumping	= $8,481/yr
Total machinery and labor cost	= $42,577/yr

Example 2: *(cont'd)*

Unit costs:

Estimate per unit cost: $/hr, $/gal.

Method: (annual machinery plus labor cost) ÷ (hr use) = $/hr
(annual machinery plus labor cost) ÷ (gal applied) = $/gal

$/hr

Transport and spreading	$34,096 ÷ 194 hr	= $176/hr
Agitation and pumping	$ 8,481 ÷ 194 hr	= $ 44/hr
Total machinery and labor cost	$42,577 ÷ 194hr	= $220/hr

¢/gal

Transport and spreading	$34,096 ÷ 3,000,000 gal	= $0.0114/gal = 1.14 ¢/gal
Agitation and pumping	$ 8,481 ÷ 3,000,000 gal	= $0.0028/gal = 0.28 ¢/gal
Total machinery and labor cost	$42,577 ÷ 3,000,000 gal	= $0.0142/gal = 1.42 ¢/gal

Summary:

Agitation, pumping and transport of 3,000,000 gallons of manure with two 4,500-gal nurse trucks and spreading with a 4,500-gallon injection tanker requires about 194 hr/year. Agitation and pumping costs are $44/hr, transport and spreading costs are $176/hr. Total machinery and labor costs are $220/hr or 1.42¢/gallon.

Example 3:

The farrow-to-finish swine producer described in example 2 is considering providing custom hauling of 750,000 gallons of swine manure that will require a 6-mile haul. The client will provide pumping of the slurry at the storage lagoon. In setting the custom hauling rate, the operator expects to cover costs plus 15 percent for profit and risk. Estimate a reasonable charge for custom hauling.

Procedure:

In determining a custom hauling rate, base machinery ownership costs on hours accumulated in the farrow-to-finish operation plus hours spent in custom hauling. Machinery use will be based on 250 hours per year. Calculate machinery ownership and operating costs and increase by 15 percent for profit and risk.

Hauling rate:

Estimate a slurry hauling rate (gal/hr) based on spreader tank and nurse truck volume (gal) and travel distance (miles).

Method: refer to Fig. 7 for hauling rates (gal/hr) for a tractor-drawn tank injector with two nurse trucks of similar size.

Answer: 11,600 (gal/hr)

The hauling rate will drop off with a 6-mile haul (see Fig. 7) because the tank injector will apply slurry faster than the trucks can deliver it. The spreader will have a short wait between loads.

Hauling time:

Estimate an annual hauling time (hr/yr) for the custom hauling operation.

Method: total manure spread (gal/yr) ÷ hauling rate (gal/hr) = hr/yr

Answer: 65 hr

750,000 gal/yr ÷ 11,600 (gal/hr) = 65 hr

Machinery and labor cost:

Estimate total ($/yr) machinery and labor costs. Tractor costs ($/hr) are listed in Table 4; all other machinery is listed in Table 5. Provide additional support labor equal to 15 percent of machine use for unexpected delays. Annual machine use equals 259 hours, 194 hours for the farrow-to-finish operation plus 65 hours for custom work. Base manure machinery ownership costs on 250 hr of annual use and transfer pump costs on actual use.

Method: (hauling time [hr/yr] x (machine hourly charge [$/hr]) = machinery, $/yr
(hauling time [hr/yr] x 1.15 x (labor charge [$/hr]) = labor, $/yr
Transfer pump use (hr) = gallons ÷ 1,300 gpm ÷ 60 minutes per hr

Table 5 does not offer cost information for a 4,500-gallon tank spreader or 4,500-gallon nurse trucks, so estimate a representative cost midway between existing table values. For instance, based on 250 hr of use, a representative cost for a 4,500-gallon tank spreader is $18.50, midway between costs for 4,000- and 5,000-gallon spreaders.

Example 3 (cont'd):

Machinery and labor cost (cont'd):

Transport and spreading:

180-hp tractor: 65 hr x $34.75/hr	= $2,259/yr
4,500-gal spreader: 65 hr x $18.50/hr	= $1,203/yr
Six-point injector: 65 hr x 6 injectors x $1.25/injector	= $488/yr
Two-4,500-gal nurse trucks: 2 x 65 hr x $34/hr	= $4,420/yr
Labor: 65 hr x 1.15 x $10/hr x 3 operators	= $2,243/yr
Total transport and spreading	= $10,834/yr

Transfer pump

Transfer pump use = 750,000 ÷ 1,300 gpm ÷ 60 min/hr	= 10 hr
Pit (transfer) pump, small: 10 hr x $6.75/hr	= $68/yr
80-hp tractor: 10 hr x $15.25/hr	= $153/yr
Total pumping	= $221/yr
Total pumping, spreading and transport	= $11,055/yr

Unit costs:

Method: multiply machinery and labor costs by 1.15 to provide 15 percent for profit and risk.

$/hr

Transport and spreading	
$11,055 ÷ 65 hr	= $170/hr
$170/hr x 1.15	= $196/hr

¢/gal

Transport and spreading	
$11,055 ÷ 750,000 gal = $0.0147/gal	= 1.47¢/gal
1.47¢/gal x 1.15 = $0.0169	= 1.69¢/gal

Summary:

Custom hauling of 750,000 gallons of swine manure over 6 miles requires about 65 hr/year with this machinery set. An hourly rate of $196/hr (1.69¢/gal) covers machinery and labor costs and provides a 15 percent return for profit and risk.

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