AN ECONOMIC ANALYSIS OF NEW AND OLD DAIRY WASTE HANDLING TECHNOLOGIES

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INTRODUCTION AND PURPOSE

New methods of moving manure to storages, new manure storage structures and new manure spreading technologies are now found on dairy farms. Consequently, farmers are in need of labor requirements, investment and annual cost data. The purpose of this article is to present current investment, labor and annual cost information that will aid farmers in making economical decisions relative to selecting alternative manure handling systems. Manure handling systems presented in Table 1 were planned for freestall housing and 75, 150 and 300 cow herd sizes. These systems were based on a survey of 98 dairy farms in the Monocacy River Watershed (Holik and Lessley), data from the Agricultural Engineering Department of the University of Maryland,[1] the Soil Conservation Service[2] and the Midwest Plan Service. The manure handling systems and herd sizes modeled are considered to be representative of dairies found in Maryland.

DESCRIPTION OF MANURE HANDLING SYSTEMS

Equipment common to all systems included a 40 horsepower utility tractor equipped with a rear mounted scraping blade,[3] manure spreader and 100 horsepower tractor for hauling and spreading.

Systems Without Storage

Scrape, Gutter Cleaner, Spread: In this system, the operator scrapes manure into a gutter, where paddles convey it out of the area, up a short elevator, and into the spreader. No separate loading operation is necessary. Box spreaders of 112, 160 and 235 cubic feet struck load capacity were selected for use with this system and all other semisolid manure handling systems. The box spreader sizes reflect equipment complements found on farms in Maryland and were matched to the 75, 150 and 300 cow herd models presented. A summary of equipment requirements by manure handling systems without storage is presented in Table 2.

Scrape, Ramp, Spread: Manure is scraped from the barn area and pushed off a reinforced concrete ramp into the box spreader. The ramp incorporates loading and scraping operations allowing the operator to clean up without using a front end loader.[4]

Scrape, Load, Spread: The barn area is scraped and manure is loaded into a box spreader. The operator uses a front end loader with this system and loading is considered to be a separate operation.

The three preceeding systems handle manure as a semisolid material, and require daily spreading of manure unless unfavorable weather, field or labor conditions are present. As herd size increases, the ability to store manure without a consciously planned manure storage structure decreases. The systems that follow incorporate planned manure storage structures.

Storage Systems

Structures for manure storage were planned with assistance from the Agricultural Engineering Department of the University of Maryland, the Soil Conservation Service, the Midwest Plan Service, equipment dealers and contractors. Costs were then estimated for these structures. Structure designs included:

1. An open air poured concrete storage pit, enclosed on three sides. A treated wooden picket dam with drain was placed in one corner of the pit to provide an outlet for rain water.
2. An underground poured concrete liquid manure tank, designed according to specifications provided in Midwest Plan Service Plan 74303.
3. An open air earth berm manure storage with concrete floor and treated wooden picket dam for drainage. This structure was designed to be unloaded with semisolid handling equipment.
4. An open air earth berm manure storage with reinforced concrete loading ramp. This structure does not have a concrete floor or picket dam and was designed to be used with liquid manure.
5. Glass fused to steel above ground liquid manure tanks. These tanks were constructed with glass coated steel panels bolted together and set on a reinforced concrete foundation. Agitation pumps were built on or into the tank for unloading.
6. Treated wooden semisolid manure storage buildings. These building designs had a reinforced concrete foundation and roof.

Manure and dairy waste water production data were obtained from the Midwest Plan Service's

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[2] Owen Unangst, District Conservationist, Frederick Field Office, Soil Conservation Service, Frederick, MD.

[3] A skid loader with manure bucket may be used instead of the utility tractor. For the investment and annual cost analysis that follows, a distinction between using skid loader or utility tractor was not made since interviews with equipment dealers showed that both machines had similar prices and expected lives.

[4] Manure handling systems should be designed to take advantage of gravity flow by natural or artificially constructed slopes whenever possible. Such designs will save fuel and operator labor.

Table 1. Manure Handling Systems.

System	Item		
	Type of Material	Storage Capacities	Storage Structure Used
Scrape, Gutter Cleaner, Spread	Semisolid	None	None
Scrape, Ramp, Spread	Semisolid	None	None
Scrape, Load, Spread	Semisolid	None	None
Scrape, Store, Load, Spread	Semisolid	30, 60, 90, 180 Days	Concrete Pit or Earth Berm
Scrape, Ramp, Store, Load, Spread	Semisolid	30, 60, 90, 180 Days	Concrete Pit or Earth Berm
Scrape, Stack, Store Load, Spread	Semisolid	30, 60, 90, 180 Days	Concrete Pit or Earth Berm
Scrape, Ram Pump, Wood Bldg., Storage, Load, Spread	Semisolid	30, 60, 90, 180 Days	Wood Building
Scrape, Ram Pump, Store, Load, Spread	Liquid	30, 60, 90, 180 Days	Earth Berm
Scrape, Air Pump, Store, Load, Spread	Liquid	30, 60, 90, 180 Days	Earth Berm
Scrape, Liquid Manure Tank, Load, Spread	Liquid	30, 60, 90, 180 Days	Concrete Tank
Scrape, Steel Tank, Load, Spread	Liquid	30, 60, 90, 180 Days	Steel Tank

Table 2. Equipment Requirements by Manure Handling System Without Storage

Equipment	System		
	Scrape Gutter Cleaner Spread	Scrape Ramp Spread	Scrape Load Spread
Tractor (40 horsepower)	X	X	X
Tractor (100 horsepower)	X	X	X
Scraper	X	X	X
Box Spreader	X	X	X
Gutter Cleaner	X		
Ramp		X	
Front End Loader			X

Livestock Waste Facilities Handbook, verified for Maryland conditions, and were used to develop storage capacities required for 30, 60, 90 and 180 days. Due to the diversity of youngstock housing and handling practices found on dairy farms in Maryland, manure and waste water production data used were based on the number of mature animals in the milking herd.

Semisolid Systems

Equipment requirements for the semisolid systems with storage are presented in Table 3.

The scrape, store, load, spread and scrape, ramp, store, load, spread systems' equipment requirements reflect the addition of storage structures to the scrape, load, spread and scrape, ramp, spread systems described previously. Two storage structures may be used, a concrete pit or an earth berm with picket dam and concrete floor.

Scrape, Stack, Store, Load, Spread: Equipment requirements for this system are similar to the scrape, store, load, spread system, except for the manure stacker. The stacker conveys manure from the barn area to the storage compound.

Scrape, Ram Pump, Wood Building Storage, Load, Spread: Equipment requirements for this system include a hydraulic ram pump to move manure into a wood building storage, and the same tractors, loader, scraper and spreader used in the other semisolid spreading systems. Four building sizes were used for the systems. No building design had capacity to store manure for the 300 cow herd size for 180 days.

Liquid Systems

Equipment requirements for the liquid storage systems are presented in Table 4. Equipment common to all liquid systems included a 40 horse-

Table 3. Equipment Requirements by Semisolid Storage System

Equipment	System			
	Scrape Store Load Spread	Scrape Ramp, Store Load Spread	Scrape Stack, Store Load Spread	Scrape Ram Pump Wood Building Storage Load, Spread
Tractor (40 hp)	X	X	X	X
Tractor (100 hp)	X	X	X	X
Scraper	X	X	X	X
Box Spreader	X	X	X	X
Front End Loader	X	X	X	X
Storage	X	X	X	X
Ramp		X		
Stacker			X	
Ram Pump				X

Table 4. Equipment Requirements by Liquid Storage System

Equipment	System			
	Scrape Ram Pump Store, Load Spread	Scrape Air Pump Store, Load Spread	Scrape Liquid Manure Tank Load Spread	Scrape Steel Tank Load Spread
Tractor (40 hp)	X	X	X	X
Tractor (75 hp)	X	X	X	X
Tractor (100 hp)	X	X	X	X
Scraper	X	X	X	X
Liquid Spreader	X	X	X	X
Storage	X	X	X	X
Ram Pump	X			
Lagoon Pump	X	X		
Air Pump		X		
Chopper Pump			X	
Reception Pit and Pump				X

power tractor for scraping, 75 horsepower tractor for agitation and loading, 100 horsepower tractor for hauling and spreading, scraper and 3,200 gallon liquid spreader.

Scrape, Ram Pump, Earth Berm Storage, Load, Spread: Manure is scraped into the hopper of the ram pump with the utility tractor and scraping blade. The ram pump pushes the manure through a pipe into an earth berm storage compound. A tractor PTO-operated lagoon pump is used to agitate the waste and load the liquid spreader.

Scrape, Air Pump, Earth Berm Storage, Load, Spread: The equipment used in this system is the same as the ram pump system with the substitution of a compressed air pump and its related components. To operate the air pump, manure is scraped into a steel holding tank. The tank is sealed and the manure is forced by compressed air through pipe into the earth berm storage compound.

Scrape, Liquid Manure Tank, Load, Spread: Manure is scraped into the liquid manure tank through an opening in the tank top. Stored manure and waste water are agitated and pumped into the liquid spreader by a chopper-agitator pump mounted on the three-point hitch of a 75 horsepower tractor.

Scrape, Reception Pit, Glass Fused to Steel Storage Tank, Load, Spread: Manure is scraped into a reception pit with a utility tractor and scraper blade. The reception pit may be concrete or fiberglass, and has a limited capacity for manure and waste water. An electric chopper-agitator pump combines manure and waste water into a slurry, and pumps the slurry through a pipe into the steel tank. The storage tank may be unloaded by using a 75 horsepower tractor with the chopper-agitator pump system built on the structure.

LABOR REQUIREMENTS BY MANURE HANDLING SYSTEM

Labor requirements for manure handling systems on dairy farms depend upon size of herd and handling system used. The following tables present labor requirements in hours per year for each system and respective herd size. The labor requirements are based on field timings and observations made by the authors at fifteen dairies during 1980 and 1981.

Scrape, Gutter Cleaner, Spread; or Scrape, Ramp, Spread: Annual labor requirements for

Table 5. Annual Labor Requirements for the Scrape, Gutter Cleaner, Spread (Scrape, Ramp, Spread) Systems by Herd Size

Operation	Herd Size (No. of Cows) 75	150	300
	Hours		
Scrape	254	508	1,106
Haul and Spread	142	204	328
Total	396	712	1,344

Table 6. Annual Labor Requirements for the Scrape, Load, Spread System by Herd Size

Operation	Herd Size (No. Cows) 75	150	300
	Hours		
Scrape	254	508	1,016
Load	33	78	153
Haul and Spread	142	204	329
Total	429	790	1,498

Table 7. Annual Labor Requirements for Liquid Manure Handling Systems

Operation	Herd Size (No. Cows) 75	150	300
	Hours		
Scrape	254	508	1,016
Load	13	22	42
Haul and Spread	51	89	166
Total	318	619	1,224

these systems are shown in Table 5. A gutter cleaner or ramp deposits manure into the spreader, eliminating loading labor.

Scrape, Load, Spread: Scraping and hauling labor requirements are identical with the systems previously described. A separate loading operation is necessary, and a utility tractor and end loader are used to load the box spreader.

Semisolid Systems with Storage: Since manure moving operations are the same, labor requirements for the semisolid storage systems are the same as the scrape, load, spread system described above.

Table 7 presents annual labor requirements for the liquid manure systems by herd size.

The scraping operation required the largest proportion of labor for all herd sizes and systems. Hauling and spreading labor requirements followed, and loading required the least labor in all herd sizes and systems. Annual labor requirements for loading, hauling and spreading operations in the liquid systems were less than the annual labor requirements for loading, hauling and spreading operations in the semisolid systems. The labor requirements for the storage systems within a herd size did not vary with length of storage.

INVESTMENT AND ANNUAL COSTS OF MANURE HANDLING SYSTEMS

Equipment and construction prices and specifications used to develop the investment and annual costs for the manure handling systems described above were obtained from farmers, equipment manufacturers and local dealers, contractors and Soil Conservation Service. All prices used in the analysis were collected during 1981.[5]

Tractor investment costs were prorated to reflect annual hours of use in the manure handling. The prorating method was based on 1,000 hours of annual tractor use and on costs of $12,500, $20,654 and $31,333 for the 40, 75 and 100 horsepower tractors, respectively.[6]

Annual costs of ownership were calculated for equipment and structures. Tractor, front end loader, ram and air pump annual ownership costs were based on 8 years expected life and 20 percent salvage value. Scraping blade, lagoon pump, chopper pump and stacker annual ownership costs were based on 8 years expected life and no salvage value. Spreader annual costs of ownership were based on 5 years expected life and no salvage value. Annual costs of ownership for all structures were based on 20 years expected life and no salvage value. Annual costs of ownership included depreciation, 12 percent interest on average investment, repairs at 5 percent of cost for machinery and one percent of replacement cost for structures, taxes on structures of $2.39 per $100 assessed value (50 percent assessment of market value) and insurance at one percent of average value for machinery and one percent of replacement cost for structures (Stevens, Wysong and Lessley). There is no personal property tax on farm machinery in Maryland. Insurance coverage is for fire and theft.

Variable costs for manure handling may include labor, tractor fuel, lubricants and electricity. Labor costs for the systems were calculated from annual labor requirements and a wage rate of $4.00 per hour. Fuel costs for each tractor were based upon hours of use in manure handling operations, expected fuel consumption and an on farm price of fuel of $1.20 per gallon. Oil and lubricants were calculated at 15 percent

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5 Investment and annual costs calculated do not include income tax considerations and were made prior to the passage of the 1981 Economic Recovery Tax Act.

6 Prorating example: The 40 horsepower tractor is used 254 hours per year for scraping (75 cow herd, Table 5 of Labor Requirements). Based on a new price of $12,500 and 1,000 hours of annual use, the prorated investment cost is $12,500 x .254 = $3,175. The same procedure is used for all tractor investment costs. If a tractor is used over 1,000 hours a year, the new price of the tractor is used as the investment cost.

TABLE 9. INVESTMENT AND ANNUAL COSTS FOR ALTERNATIVE WASTE HANDLING SYSTEMS BY TYPE STORAGE AND HERD SIZE.

Item	75 Cow Herd				150 Cow Herd				300 Cow Herd			
	Storage (Days)				Storage (Days)				Storage (Days)			
	30	60	90	180	30	60	90	180	30	60	90	180
	Dollars				Dollars				Dollars			
Semisolid Systems												
Scrape, Concrete Storage												
Investment	28,546	35,505	41,302	58,338	45,796	56,973	68,629	100,298	69,684	91,782	113,009	167,579
Annual Costs	9,883	10,871	11,694	14,113	16,526	18,113	19,768	24,265	27,074	30,212	33,226	40,975
Per Cow	132	145	156	188	110	121	132	162	90	101	111	137
Scrape, Earth Berm Storage												
Investment	20,428	21,472	22,787	26,504	31,763	33,799	36,795	43,391	46,510	50,583	56,102	67,764
Annual Costs	8,730	8,879	9,065	9,593	14,534	14,823	15,248	16,185	23,784	24,362	25,146	26,802
Per Cow	116	118	121	128	97	99	102	108	79	81	84	89
Ramp, Concrete Storage												
Investment	30,546	37,505	43,302	60,338	47,796	58,973	70,629	102,298	71,684	93,782	115,009	169,579
Annual Costs	10,167	11,155	11,978	14,397	16,810	18,397	20,052	24,549	27,358	30,496	33,510	41,259
Per Cow	136	149	160	192	112	123	134	164	91	102	112	138
Ramp, Earth Berm Storage												
Investment	22,428	23,472	24,787	28,504	33,763	35,799	38,795	45,391	48,510	52,583	58,102	69,764
Annual Costs	9,014	9,163	9,349	9,877	14,818	15,107	15,532	16,469	24,068	24,646	25,430	27,086
Per Cow	120	122	125	132	99	101	104	110	80	82	85	90
Stack, Concrete Storage												
Investment	35,533	42,492	48,289	65,325	52,783	63,960	75,616	107,285	76,671	98,769	119,996	174,566
Annual Costs	11,623	12,611	13,434	15,853	18,330	19,917	21,572	26,069	29,005	32,143	35,157	42,906
Per Cow	155	168	179	211	122	133	144	174	97	107	117	143
Stack, Earth Berm Storage												
Investment	27,415	28,459	29,774	33,491	38,750	40,786	43,782	50,378	53,497	57,570	63,089	74,751
Annual Costs	10,470	10,619	10,805	11,333	16,338	16,627	17,052	17,989	25,715	26,293	27,077	28,733
Per Cow	140	142	144	151	109	111	114	120	86	88	90	96
Ram Pump, Wood Building												
Investment	1	1	53,792	59,187	1	64,083	69,478	91,058	76,794	87,584	103,769	1
Annual Costs	1	1	14,170	14,936	1	19,889	20,655	23,719	28,977	30,509	32,807	1
Per Cow	1	1	189	199	1	133	138	158	97	102	109	1
Liquid Systems												
Ram Pump, Earth Berm Storage												
Investment	35,048	35,756	35,992	36,935	41,425	41,896	42,604	43,782	53,038	53,981	54,688	59,046
Annual Costs	11,310	11,410	11,444	11,577	15,278	15,345	15,445	15,613	23,031	23,165	23,265	23,884
Per Cow	151	152	153	154	102	102	103	104	77	77	78	80
Air Pump, Earth Berm Storage												
Investment	40,050	40,757	40,993	41,936	46,426	46,897	47,605	48,783	58,039	58,982	59,689	64,047
Annual Costs	12,451	12,551	12,585	12,718	16,419	16,486	16,586	16,754	24,172	24,306	24,406	25,025
Per Cow	166	167	168	170	109	110	111	112	81	81	81	83
Scrape, Liquid Tank Storage												
Investment	37,753	49,171	57,135	88,008	51,422	70,841	85,676	134,766	77,400	108,236	137,903	233,745
Annual Costs	11,126	12,748	13,879	18,263	16,066	18,824	20,931	27,901	25,732	30,111	34,324	47,933
Per Cow	148	170	185	244	107	125	140	186	86	100	114	160
Scrape, Steel Tank Storage												
Investment	1	1	70,181	87,631	76,350	81,[illegible]27	93,800	114,985	93,819	111,719	123,377	168,282
Annual Costs	1	1	17,249	19,718	21,253	21,[illegible]23	23,722	26,733	29,933	32,480	34,322	40,758
Per Cow	1	1	230	263	142	1[illegible]6	158	178	100	108	114	136

[1]Because of fixed building or tank ca[illegible]city, insufficient or excess capacities exi[illegible] for these storage periods, hence no costs are included for these storage periods.

of fuel cost. Electricity costs were based on hours of use and a cost of $0.05 per kilowatt hour.

Investment and annual costs of each system will be discussed separately and are presented in the following sections.

Systems Without Storage

Scrape, Gutter Cleaner, Spread; Scrape, Ramp, Spread; Scrape, Load, Spread: The prorated investment for the 100 horsepower tractor is the largest single investment item for all systems without storage. Tractor use and costs increase as herd size increases. Gutter cleaner, scraping blade, ramp and front end loader investments remain constant as herd size increases. Box spreader capacities and costs increase as herd size increases. Total manure handling system investment per cow decreases as herd size increases.

For a given herd size, systems without storage have lower investment requirements than systems including storage. The scrape, ramp, spread system has the lowest investment requirements by herd size of the systems without storage. The scrape, gutter cleaner, spread system has the highest investment requirements by herd size of the systems without storage. Investment and total annual costs of these systems are shown in Table 8.

Total annual costs for all systems increase as herd size increases; however, total annual costs per cow decrease as herd size increases. Annual ownership costs per cow decrease as herd size increases. Annual ownership costs make up a smaller proportion of total annual costs as herd size increases. For the 300 cow herd size, variable costs are greater than annual ownership costs in all systems.

Semisolid Storage Systems

For all semisolid storage systems, tractor use and costs increase as herd size increases. Within a given herd size, the prorated tractor investment, front end loader, scraper, box spreader, labor and tractor operation costs are the same for all of these systems. Semisolid storage system investment costs increase as length of storage increases within a herd size, reflecting higher storage structure costs. Front end loader and scraper costs remain constant across herd sizes, storage lengths and systems.

Scrape, Store, Load, Spread: Investment for the scrape, store, load, spread system reflects the addition of a storage structure to the scrape, load, spread system. Total investment for a given herd size and length of storage is higher if concrete storage is selected (Table 9).

Scrape, Ramp, Store, Load, Spread; Scrape, Stack, Store, Load, Spread: Investment requirements for these two systems are similar to the scrape, store, load, spread system, but include a loading ramp or manure stacker. Ramp or stacker costs are constant for all herd sizes (Table 9).

Scrape, Ram Pump, Wood Building Storage, Load, Spread: Additional investment requirements for this system include a hydraulic ram pump and wood building storage. Investment costs reflect the fixed building sizes available.

Investments for semisolid systems with storage ranged from $20,428 to $174,566, while annual costs ranged from $8,730 to $42,906. The scrape, earth berm storage system had the lowest investment requirements and annual costs of these systems (Table 9). Earth berm storage systems have lower investment requirements in comparison to other systems.

Table 8. Investment and Annual Costs for Manure Handling Systems Without Storage by Herd Size

Manure Handling System	Herd Size (No. Cows)		
	75	150	300
		Dollars	
Scrape, Gutter Cleaner, Spread			
Investment	19,174	28,901	42,586
Annual Fixed Costs	4,776	7,272	10,504
Annual Variable Costs	3,738	6,492	11,997
Total Annual Costs	8,514	13,764	22,501
Total Annual Costs Per Cow	114	92	75
Scrape, Ramp, Spread			
Investment	15,837	25,564	39,249
Annual Fixed Costs	3,843	6,339	9,571
Annual Variable Costs	3,675	6,365	11,743
Total Annual Costs	7,518	12,704	21,314
Total Annual Costs Per Cow	100	85	71
Scrape, Load, Spread			
Investment	17,447	27,738	40,449
Annual Fixed Costs	4,382	7,007	10,017
Annual Variable Costs	3,924	6,955	12,906
Total Annual Costs	8,306	13,962	22,923
Total Annual Costs Per Cow	111	93	76

Liquid Storage Systems

For all liquid storage systems, tractor investment requirements, annual tractor and annual labor costs increase as herd size increases; however, for a given herd size, annual tractor and labor costs for the liquid systems were lower than annual tractor and labor costs for the semi-solid systems. Within a particular herd size, the prorated tractor investment, scraper, liquid spreader, labor and tractor operation costs are the same for all systems. All systems except the liquid manure tank system had electric components and costs. As length of storage increases for a given herd size, investment costs increase, reflecting larger storage structure costs. For example, at 180 days storage, investment in the concrete liquid manure tank makes up over 70 percent of total investment for all three herd sizes.

Scrape, Ram Pump, Earth Berm Storage, Load, Spread: The ram pump and lagoon pump investments are constant for all herd sizes and storage periods. Concrete loading ramps are necessary for all herd sizes and storage lengths (Table 9).

Scrape, Air Pump, Earth Berm Storage, Load, Spread: Investment requirements for this system are identical to the scrape, ram pump, earth berm storage, load, spread system with exception of the compressed air pump and related equipment being substituted for the ram pump (Table 9). The air pump investment is constant for all herd sizes and storage periods.

Scrape, Liquid Manure Tank, Load, Spread: Tank costs constitute the major proportion of the investment in this system (Table 9). The chopper pump cost is constant for all herd sizes.

Scrape, Steel Storage Tank, Load, Spread: The investment cost of the steel storage tank includes the tank and its base, concrete reception pit, electric chopper-agitator pump for the reception pit, PTO operated agitator pump for the storage tank, valves and pipes. Investment in the tank and related equipment reflects fixed tank capacities and makes up the major proportion of cost for this system (Table 9).

Investment in the liquid systems with storage ranged from $35,048 to $233,745, while annual costs ranged from $11,126 to $47,933. For all herd sizes and storage lengths, the ram pump, earth berm storage had the lowest investment requirements of all liquid systems (Table 9). With one exception, the ram pump, earth berm storage also had the lowest annual costs of all liquid systems.

For all manure handling systems with storage, investment and annual costs increase as herd size and length of storage increase; however, for a given system and storage period, investment and annual costs per cow decrease as herd size increases (Table 9).

Nutrient Value of Manure by System

Annual fertilizer values of manure for the various handling systems were calculated from nutrient content data presented by the Midwest Plan Service, and prices of $.28, $.26 and $.15 per pound for nitrogen, phosphorus and potassium, respectively. Since manure nutrient content varies widely among farms, manure nutrient and soil tests are recommended for individual analyses. Manure handling systems with storage may allow the dairy operator to spread manure during periods when the risk of field nutrient loss is low, assuming proper management practices. Where this is the case, the numbers presented in Table 10 would need to be adjusted for this benefit. Table 10 presents a summary of manure values by

Table 10. Annual Value of Dairy Manure*

System	Element			
	Nitrogen	Phosphorus	Potassium	
	Dollars Per Cow			Total
Scrape, Gutter Cleaner, Spread	35	8	18	61
Scrape, Ramp, Spread	35	8	18	61
Scrape, Load, Spread	35	8	18	61
Ram Pump, Wood Building	35	8	18	61
Scrape, Store, Load, Spread	30	8	20	58
Scrape, Ramp, Store, Load, Spread	30	8	20	58
Scrape, Stack, Store, Load, Spread	30	8	20	58
Scrape, Ram Pump, Store, Load, Spread	34	9	19	62
Scrape, Air Pump, Store, Load, Spread	34	9	19	62
Scrape, Liquid Manure Tank	34	9	19	62
Scrape, Steel Tank	34	9	19	62

* Based on manure nutrient content data from the Midwest Plan Service and prices of $.28, $.26 and $.15 per pound for nitrogen, phosphorus and potassium, respectively. Method of manure application was broadcast without cultivation. Data presented may need to be adjusted for soil characteristics, weather, etc. See Midwest Plan Service Livestock Waste Facilities Handbook, Table 45, 46 and 48.

Table 11. Net Annual Cost Per Cow for Alternative Daily Waste Handling Systems by Herd Size

System	Herd Size (No. Cows)		
	75	150	300
	Dollars		
Scrape, Gutter Cleaner, Spread	53	31	14
Scrape, Ramp, Spread	39	24	10
Scrape, Load, Spread	50	32	15

type of handling system. It is important to note that the total manure credits per cow varied in a small range from $58 to $62 among the systems.

Net Annual Cost Per Cow by System

By subtracting the annual per cow fertilizer value of manure from annual per cow costs, net annual costs by manure handling system are derived. Net annual costs by daily system and herd size are shown in Table 11. The net cost per cow ranges from $10 for the scrape, ramp, spread system with 300 cows to $53 for the 75 cow herd using the scrape, gutter cleaner, spread system.

Net annual cost per cow for various storage systems by herd size are presented in Table 12. The scrape, earth berm system has the lowest net annual costs until the 150 cow herd is reached with 60 days storage. At this level, the substitution of capital for labor causes a liquid system (ram pump, earth berm) to become cheaper. For all semisolid systems, some particular earth berm structure shows the lowest costs. Except for the shortest storage period in the 75 cow herd, an earth berm system also shows lower costs than any of the other liquid systems included in the analysis.

If earth berm structures cannot be constructed because of limited space or dirt, operators should look closely at the other available systems. For semisolid systems, the scrape, concrete storage system has lower costs until 180 days storage (150 cows) and 60-90 days storage with 300 cows. If one considers semisolid and liquid systems (except for the 30 and 60 days storage for 150 cows) the scrape, concrete system has lower costs until the scrape, liquid tank (30 - 60 days) and the scrape, steel tank systems (90 - 180 days) for 300 cows become the lower cost systems. The latter two systems replace the concrete system because of capital substitutions, labor requirements, manure credits and the sheer volume of concrete needed for 90 - 180 days storage for the 300 cow herd.

CONCLUSIONS

This article has shown that investment and annual costs for manure handling systems can be high relative to the nutrient value of the waste realized.

Each dairy farm has a unique set of land, labor, capital and management resources. Selection of a manure handling system must take resource combinations into account. When selecting a manure handling system, a farmer must make decisions pertaining to storage of manure, type of storage structure and desired type of material to be handled.

A dairy operator should choose a manure handling system that can easily be operated by farm workers, meets regulations, may be adapted to existing farm structures and future plans, maximizes or retains the nutrient content of the wastes, and minimizes costs. Farmers must also consider the proximity of neighbors and streams, land slopes, soil types, cropping patterns and personal tastes. After careful consideration of all these factors, a wise decision relative to a type of manure handling system may be made.

Table 12. Net Annual Cost Per Cow for Alternative Waste Handling Systems by Herd Size and Length of Storage

System	Length of Storage (Days)											
	30	60	90	180	30	60	90	180	30	60	90	180
	75 Cow Herd				150 Cow Herd				300 Cow Herd			
	Dollars											
Semisolid Storage												
Scrape, Concrete	74	87	98	130	52	63	74	104	32	43	53	79
Scrape, Earth Berm	58	60	63	70	39	41	44	50	21	23	26	31
Ramp, Concrete	78	91	102	134	54	65	76	106	33	44	54	80
Ramp, Earth Berm	62	64	67	74	41	43	46	52	22	24	27	32
Stack, Concrete	97	110	121	153	64	75	86	116	39	49	59	85
Stack, Earth Berm	82	84	86	93	51	53	56	62	28	30	32	38
Ram Pump, Wood Building	—	—	128	138	—	72	77	97	36	41	48	—
Liquid Storage												
Ram Pump, Earth Berm	89	90	91	92	40	40	41	42	15	15	16	18
Air Pump, Earth Berm	104	105	106	108	47	48	49	50	19	19	19	20
Scrape, Liquid Tank	86	108	123	182	45	63	78	124	24	38	52	98
Scrape, Steel Tank	—	—	168	201	80	84	96	116	38	46	52	74

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