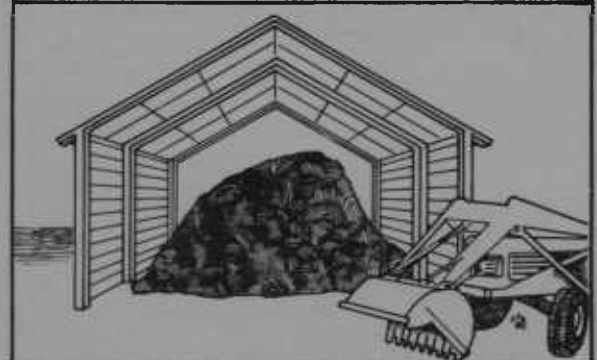
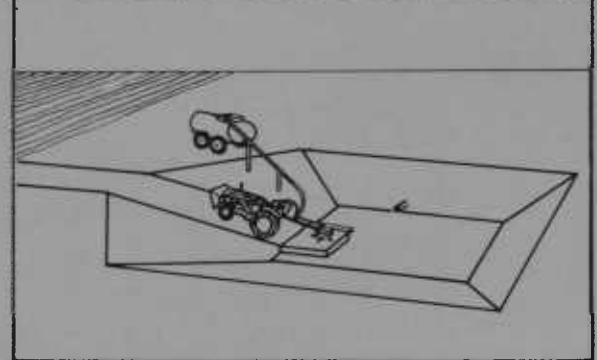
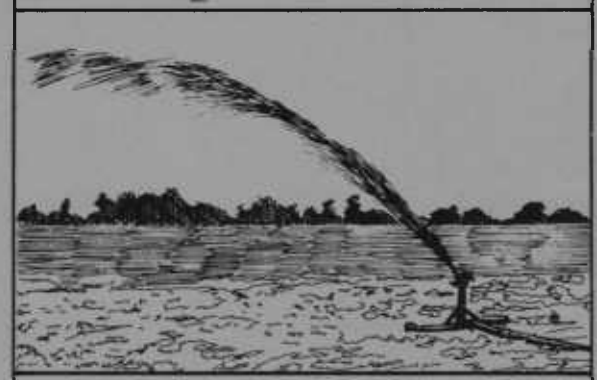
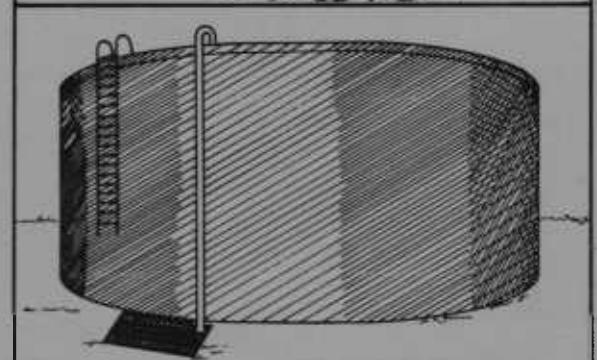
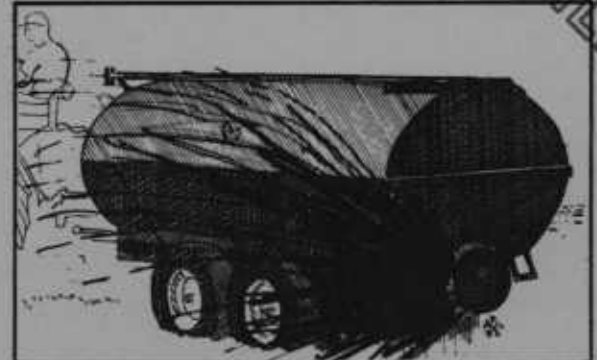


*Selecting  
a Dairy  
Waste  
Management  
System for  
the Willamette  
Valley*



EC 1102    September 1982  
**Oregon State University**  
**Extension Service**

As a dairy operator thinks about building a new facility or expanding or modifying an existing one, a number of factors influence that decision: rainfall, temperature, soil type, surface drainage, topography, water table depth, farm size, cropping and feeding practices, availability of cropland to receive manure, existing buildings and machinery—all are important to consider.

Herd size, availability of labor and capital, future expansion plans, and operator's age also influence the selection of a waste management system.

Another very important factor in the selection of a waste management system is to recognize your own preference as the operator and your management capabilities. While this is extremely difficult to quantify and categorize, you must include it in any decisionmaking process.

Because of the number of influencing factors, there is no one "best" waste management system that can be recommended to a dairy operator. As with most decisionmaking, it is a series of trade-offs that offers choices, advantages, and disadvantages. We prepared this circular to help narrow the choices and provide an evaluation of possible alternatives. Its purpose is not to offer precise instructions, but rather to suggest areas for comparison that will be helpful to you as a dairy operator.

We attempted to assign costs to equipment and structures that are components of the six waste management systems compared here. These costs will vary widely; the availability of concrete, labor, lumber, and material will influence the total cost. When you can adjust these suggested costs, you will more accurately compare the various systems for your specific situation.

The six systems represent combinations of components that you can use successfully to handle and manage dairy waste. Each of the systems was adjusted for milking herd sizes of 100, 200, and 300 cows. The livestock waste you must manage is generated by milking cows, dry cows, replacement heifers,



Figure 1. A rear-mounted tractor-scraper is commonly used to collect manure on dairy operations.

calves, and a cleanup bull (table 1). Multiply values in this table by two and three for herds of 200 and 300 milking cows.

Liquid wastes include rainfall on outside lots and holding area, milking parlor and milkhouse waste water for all systems. The outdoor lot area was assumed to be 15 square feet per milking cow. This includes open alleyways between buildings, outside feed areas, and other exposed lots where manure will contaminate rainwater. The rainfall for the 150-day storage period (Nov.-Mar.) averages 27.8 inches. Waste water was assumed to be generated at a rate of 0.79 cubic feet per milking cow day.

Other assumptions include a small tractor (figure 1) to scrape, store, and load manure mixed with bedding and a larger tractor to pull the box spreader for the solid manure

and the tanker for the liquid manure. As the herd size increases, the solid- and liquid-storage units, box spreader, and liquid tanker all increase in size. Each of the systems is defined in additional detail, and the assumptions for each are stated in the following sections.

#### SYSTEM 1, DRY STACK

This system assumes the daily use of 6 pounds of bedding per milking cow for the 5 months of the winter season, 3 pounds per cow-day for 3 months during the late fall and early spring, and 1 pound per cow-day for the remaining 4 months when the cows will be on pasture during the summer season. Dry and young stock are bedded at 10% of the rate of the milking cows. The dry-stack

Table 1. Average manure production from a 100-milking-cow dairy

Animal	Number of animals	Average wt./head	Manure production					
			Per animal day			Per group year		
			Pounds	Pounds	Cubic feet	Gallons	Tons	Cubic feet
Lactating cow <sup>1</sup> .....	100	1,400	115	1.85	13.9	2,099	67,525	507,350
Dry cow <sup>2</sup> .....	16	1,400	103	1.65	12.4	308	9,636	72,416
Replacement calves <sup>3</sup> .....	37	500	41	0.66	5	277	8,913	67,525
Replacement heifers <sup>4</sup> .....	37	1,000	82	1.32	9.9	554	17,827	133,700
Cleanup bull <sup>5</sup> .....	1	1,400	115	1.85	13.9	21	675	5,073
Total, herd/yr .....						3,259	104,576	786,064
Total, herd/day .....						8.9	288	2,154

<sup>1</sup> The average cow is kept for 3 lactations. For Jerseys and other small cows (weighing about 1,000 pounds), multiply values in the table by 0.7 or 70%.

<sup>2</sup> A calving interval-lactation cycle includes being dry for 60 days.

<sup>3</sup> Sell bull calves the first week and lose 18 percent of heifers the first year.

<sup>4</sup> This stock freshens at 27 months.

<sup>5</sup> Artificial insemination is used for most dairy breeding. A single bull on premises will help identify and settle the heifers that did not conceive.

storage has a paved, sloping floor and a truss-supported metal roof. The storage unit is designed for 150-day capacity (figure 2).

Seepage from the stack is directed to, and collected in, a liquid holding tank. The seepage is generated at a rate of 1.3 gallons per cow-day. The liquid storage capacity of the holding tank is 75 days.

### SYSTEM 2, EARTHEN STORAGE

A small tractor scrapes manure daily into an earthen storage facility. Bedding is used at a rate of 30% of the drystack system (#1), about 1.8 lbs. per milking cow daily for the winter season.

A PTO agitator/removal pump empties the storage unit. The storage unit is designed to hold the wastes for 150 days. In addition to the lot area and milking parlor wastes, the unit is designed to hold the rain that falls into the storage unit. A tractor drives the pump and pulls the tank spreader to the field (figure 3).

### SYSTEM 3, DAILY SPREAD

A small tractor scrapes and loads manure daily. It loads this semisolid waste into a flail spreader and spreads it on nearby cropland. Bedding is used at a rate of 40% of System 1 or 2.4 lbs. per milking cow daily in the winter season. The liquid wastes are channeled to a holding tank with a 75-day storage capacity. A tractor powers the pump to load the liquids into the tanker and to pull both the solid and liquid waste to the field.

### SYSTEM 4, ABOVEGROUND TANK

A small tractor with scraper daily collects the manure from the free-stall area and moves it to a collection sump. The waste water also is routed to this unit. After agitation, the slurry is pumped into an aboveground storage unit. An agitator in the storage unit mixes the manure slurry prior to withdrawal and loading into a tank spreader. A tractor provides the power for both agitation pumps and pulls the tanker to nearby cropland for land application. The storage unit has the capacity to store all liquid and solid wastes for 150 days. Bedding is used at a rate of 30% of System 1.

### SYSTEM 5, LAGOON FLUSH

Manure is flushed twice a day into the nearby lagoon. Liquid from the far side of the lagoon is withdrawn and recycled as flushing water. While the other facilities have storage capacity of less than 6 months, the lagoon provides sufficient storage capacity for 1 year.

Bedding is used at 30% of the rate for the dry-stack system. A tractor is required in this system to power the irrigation pump for the annual land spreading operation. An electric

motor drives the recycle pump. A complete irrigation system is charged against this system as a necessary component of waste handling.

### SYSTEM 6, LAGOON FLUSH WITH SEPARATOR

This system has all of the components described in System 5 above and adds a collection sump to gather the flushing waste water. A float-controlled motor and pump feed the separator, which is placed on top of a tower. This tower allows gravity flow, in most cases, of the liquid fraction to the lagoon. The separated solids fall to a concrete slab at the base of the tower (figure 4).

After heating, the solids can be used in the dairy operation as bedding. Twice as much bedding material is produced as is used in the operation, allowing a positive allowance to the system for bedding.

### COST COMPUTATIONS

The major components and equipment items for all systems are listed in tables 2, 3, and 4. The items stay the same for all systems; however, the sizes change for some units. We obtained the initial cost for the farm equipment from the *Official Guide, Tractor and Farm Equipment 1981*. This contains sizes and price information, and is distributed by the National Farm and Power Equipment Dealers' Association.



Figure 2. Heavily bedded manure is collected and handled as a solid with the tractor-mounted front-end loader. The solid manure is stored in a bunker-type covered building.

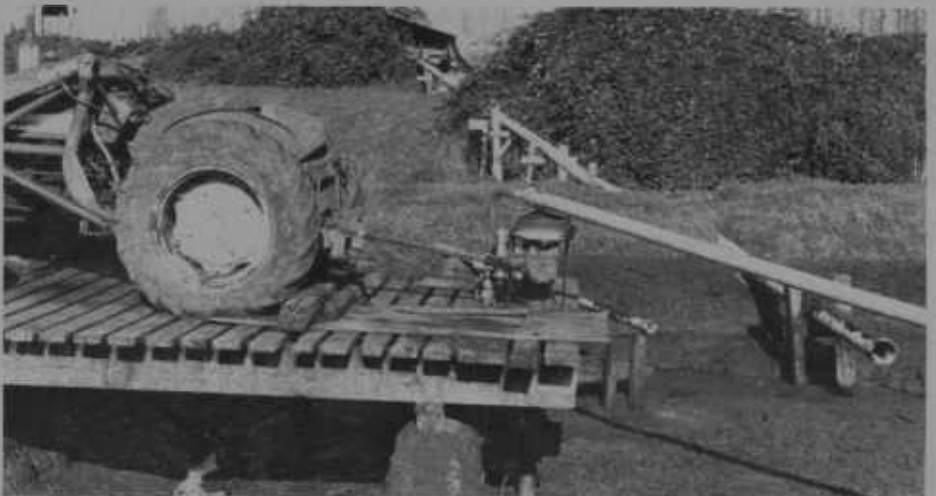


Figure 3. The pipe from the barn moves the manure to an earthen storage unit. The wooden dock allows the tractor to agitate and pump the manure slurry to nearby fields, where it is applied through sprinklers.

**Table 2. Manure handling systems for 100-milking-cow herds**

System	Initial cost (\$)	Insurance repair, taxes (%)	(\$/yr)	Life (yr)	% of time devoted to manure handling	Capital recovery (\$/yr)
<b>1) Covered dry stack</b>						
pump PTO 1,000 gpm	3,000	3	90	8	100	669
small scrape tractor, 37 hp	14,000	3	336	5	80	3,175
storage structure (\$6/ft <sup>2</sup> )	31,600	1	316	20	100	5,048
box spreader, 138 bu	4,000	3	120	8	100	862
tractor, 105 hp	27,000	3	81	10	10	525
liquids tank, 11,140 ft <sup>3</sup>	15,800	1	158	20	100	2,524
tanker for liquids (800 gal)	5,000	3	153	8	100	1,099
<b>Total</b>	<b>100,400</b>		<b>1,254</b>			<b>13,902</b>
<b>2) Earthen storage</b>						
small scrape tractor, 37 hp	14,000	3	336	5	80	3,175
earthen pond, 95,400 ft <sup>3</sup>	2,200	1	22	20	100	352
agitation/removal pump, 10 ft	4,800	3	144	8	100	1,035
tractor for agitating, 105 hp	27,000	3	162	10	20	1,050
tank spreader, 1,500 gal	8,150	3	245	8	100	1,757
<b>Total</b>	<b>56,150</b>		<b>909</b>			<b>7,369</b>
<b>3) Daily spread</b>						
pump PTO 1,000 gpm	3,000	3	90	8	100	669
small scrape tractor, 37 hp	14,000	3	336	5	80	3,175
flail spreader, 177 bu	4,700	3	141	8	100	1,013
tractor for spreading, 130 hp	30,000	3	90	10	10	583
liquids tank 9,840 ft <sup>3</sup>	13,600	1	136	20	100	2,173
liquid tanker, 800 gal	5,100	3	153	8	100	1,099
<b>Total</b>	<b>70,400</b>		<b>946</b>			<b>8,712</b>
<b>4) Aboveground storage tank</b>						
small scrape tractor, 37 hp	14,000	3	336	5	80	3,175
agitation pit	2,500	1	25	20	100	399
agitation transfer pump	4,800	3	144	8	100	1,035
aboveground tank, 73,000 ft <sup>3</sup>	74,400	1	744	20	100	11,814
tractor for agitator, 105 hp	27,000	3	162	10	20	1,050
tank spreader, 1,500 gal	8,150	3	245	8	100	1,157
<b>Total</b>	<b>130,850</b>		<b>1,656</b>			<b>18,630</b>
<b>5) Lagoon flush</b>						
tractor, 105 hp	27,000	3	40	10	5	262
recycle pump, ½ hp, 5-hr day	250	3	7	8	100	54
flush tanks, manual gate	6,000	1	60	20	100	959
lagoon, 627,450 ft <sup>3</sup>	11,300	1	113	20	100	1,805
irrigation pump, 500 gpm, PTO	6,800	3	204	10	100	1,321
travelling big gun, 1,200-ft hose	17,000	3	510	10	100	3,387
mainline 6-inch PVC, 1,400 ft	2,440	1	24	15	100	417
<b>Total</b>	<b>70,790</b>		<b>958</b>			<b>8,205</b>
<b>6) Lagoon flush—separator</b>						
Includes all in #5 above	70,790		958			8,205
collection sump	2,500	1	25	20	100	399
separator tower	6,000	1	60	20	100	953
separator	22,000	3	660	10	100	4,275
pump & motor (35 hp-150 gpm)	4,000	3	120	8	100	891
float control	800	3	24	5	100	239
<b>Total</b>	<b>106,090</b>		<b>1,847</b>			<b>14,962</b>

Table 3. Manure handling systems for 200-milking-cow herds

System	Initial cost (\$)	Insurance repair, taxes (%)	(\$/yr)	Life (yr)	% of time devoted to manure handling	Capital recovery (\$/yr)
<b>1) Covered dry stack</b>						
pump PTO 1,000 gpm	3,000	3	90	8	100	669
small scrape tractor, 37 hp	14,000	3	336	5	80	3,175
storage structure (\$6/ft <sup>2</sup> )	63,200	1	632	20	100	10,097
box spreader, 275 bu	4,900	3	147	8	100	1,056
tractor, 105 hp	27,000	3	81	10	10	525
liquids tank, 22,280 ft <sup>3</sup>	31,000	1	310	20	100	4,953
tanker for liquids (1,500 gal)	7,200	3	216	8	100	1,552
<b>Total</b>	<b>150,300</b>		<b>1,812</b>			<b>22,027</b>
<b>2) Earthen storage</b>						
small scrape tractor, 37 hp	14,000	3	336	5	80	3,175
earthen pond, 181,000 ft <sup>3</sup>	3,900	1	39	20	100	623
agitation/removal pump, 10 ft	4,800	3	144	8	100	1,035
tractor for agitating, 105 hp	27,000	3	162	10	20	1,050
tank spreader, 2,220 gal	7,920	3	238	8	100	1,707
<b>Total</b>	<b>57,620</b>		<b>919</b>			<b>7,590</b>
<b>3) Daily spread</b>						
pump PTO 1,000 gpm	3,000	3	90	8	100	669
small scrape tractor, 37 hp	14,000	3	336	5	80	3,175
flail spreader, 360 bu	8,200	3	246	8	100	1,768
tractor for spreading, 130 hp	30,000	3	90	10	10	583
liquids tank 19,680 ft <sup>3</sup>	27,500	1	275	20	100	4,393
liquid tanker, 1,500 gal	7,200	3	216	8	100	1,552
<b>Total</b>	<b>89,900</b>		<b>1,253</b>			<b>12,140</b>
<b>4) Aboveground storage tank</b>						
small scrape tractor, 37 hp	14,000	3	336	5	80	3,175
agitation pit	2,500	1	25	20	100	399
agitation transfer pump, 10 ft	4,800	3	144	8	100	1,035
aboveground tank, 149,000 ft <sup>3</sup>	123,800	1	1,238	20	100	19,658
tractor for agitator, 105 hp	27,000	3	162	10	20	1,050
tank spreader, 2,220 gal	7,920	3	238	8	100	1,707
<b>Total</b>	<b>180,020</b>		<b>2,143</b>			<b>27,024</b>
<b>5) Lagoon flush</b>						
tractor, 105 hp	27,000	3	40	10	5	262
recycle pump, ½ hp, 10-hr day	250	3	7	8	100	54
flush tanks, manual gate	12,000	1	120	20	100	1,917
lagoon, 1,254,900 ft <sup>3</sup>	19,400	1	194	20	100	3,099
irrigation pump, 500 gpm, PTO	6,800	3	204	10	100	1,321
travelling big gun, 1,200-ft hose	17,000	3	510	10	100	3,387
mainline 6-inch PVC, 2,600 ft	4,880	1	49	15	100	834
<b>Total</b>	<b>87,330</b>		<b>1,124</b>			<b>10,874</b>
<b>6) Lagoon flush—separator</b>						
Includes all in #5 above	87,330		1,124			10,874
collection sump	2,500	1	25	20	100	399
separator tower	6,000	1	60	20	100	953
separator	22,000	3	660	10	100	4,275
pump & motor (35 hp-150 gpm)	4,000	3	120	8	100	891
float control	800	3	24	5	100	239
<b>Total</b>	<b>122,630</b>		<b>2,013</b>			<b>17,631</b>

**Table 4. Manure handling systems for 300-milking-cow herds**

System	Initial cost (\$)	Insurance repair, taxes (%)	(\$/yr)	Life (yr)	% of time devoted to manure handling	Capital recovery (\$/yr)
<b>1) Covered dry stack</b>						
pump PTO 1,000 gpm	3,000	3	90	8	100	669
small scrape tractor, 37 hp	14,000	3	336	5	80	3,175
storage structure (\$6/ft <sup>2</sup> )	94,800	1	948	20	100	15,145
box spreader, 510 bu	13,100	3	393	8	100	2,834
tractor, 105 hp	27,000	3	81	10	10	525
liquids tank, 33,420 ft <sup>3</sup>	45,000	1	450	20	100	7,189
tanker for liquids (2,200 gal)	7,920	3	238	8	100	1,707
<b>Total</b>	<b>204,820</b>		<b>2,536</b>			<b>31,244</b>
<b>2) Earthen storage</b>						
small scrape tractor, 37 hp	14,000	3	336	5	80	3,175
earthen pond, 265,000 ft <sup>3</sup>	5,540	1	55	20	100	885
agitation/removal pump, 10 ft	4,800	3	144	8	100	1,035
tractor for agitating, 105 hp	27,000	3	162	10	20	1,050
tank spreader, 3,200 gal	9,820	3	295	8	100	2,117
<b>Total</b>	<b>61,160</b>		<b>992</b>			<b>8,262</b>
<b>3) Daily spread</b>						
pump PTO 1,000 gpm	3,000	3	90	8	100	669
small scrape tractor, 37 hp	14,000	3	336	5	80	3,175
flail spreader, 510 bu	13,200	3	396	8	100	2,846
tractor for spreading, 130 hp	30,000	3	90	10	10	583
liquids tank 29,500 ft <sup>3</sup>	36,000	1	360	20	100	5,751
liquid tanker, 2,200 gal	7,920	3	238	8	100	1,707
<b>Total</b>	<b>104,120</b>		<b>1,510</b>			<b>14,731</b>
<b>4) Aboveground storage tank</b>						
small scrape tractor, 37 hp	14,000	3	336	5	80	3,175
agitation pit	2,500	1	25	20	100	399
agitation transfer pump	4,800	3	144	8	100	1,035
aboveground tank, 195,000 ft <sup>3</sup>	178,200	1	1,782	20	100	28,296
tractor for agitator, 105 hp	27,000	3	162	10	20	1,025
tank spreader, 3,200 gal	9,820	3	295	8	100	2,117
<b>Total</b>	<b>236,320</b>		<b>2,744</b>			<b>36,047</b>
<b>5) Lagoon flush</b>						
tractor, 105 hp	27,000	3	40	10	5	262
recycle pump, ½ hp, 15 hr day	250	3	7	8	100	54
flush tanks, manual gate	18,000	1	180	20	100	2,876
lagoon, 1,882,400 ft <sup>3</sup>	26,300	1	263	20	100	4,202
irrigation pump, 500 gpm, PTO	6,800	3	204	10	100	1,321
travelling big gun, 1,200-ft hose	17,000	3	510	10	100	3,387
mainline 6-inch PVC, 3,800 ft	7,320	1	73	15	100	1,252
<b>Total</b>	<b>102,670</b>		<b>1,277</b>			<b>13,354</b>
<b>6) Lagoon flush—separator</b>						
Includes all in #5 above	102,670		1,277			13,354
collection sump	2,500	1	25	20	100	399
separator tower	6,000	1	60	20	100	953
separator	22,000	3	660	10	100	4,275
pump & motor (35 hp-150 gpm)	4,000	3	120	8	100	891
float control	800	3	24	5	100	239
<b>Total</b>	<b>137,970</b>		<b>2,166</b>			<b>20,111</b>



Figure 4. The lagoon in the foreground collects, treats, and stores the liquid wastes. The separation screen (left) removes the solids, which can be used as bedding material.

We used the Washington State University Cooperative Extension publication, *Costs of Owning and Operating Farm Machinery in Washington*, in selecting values for the repair, maintenance, insurance, taxes, and years of life. The term *capital recovery* indicates the cost of annual ownership of a piece of equipment or structure and is explained in the 1980 edition of the *Midwest Plan Services Structures and Environment Handbook*. We used this formula to obtain the capital-recovery values in tables 2 to 4:

$$CR = \frac{V_a - V_s}{SPWF} + V_s \cdot i$$

where CR = capital recovery

$V_a$  = value when acquired (\$)

$V_s$  = value when salvaged (\$)

SPWF = series present worth factor (uses the expected life and interest rate)

$i$  = interest rate, decimal fraction

A salvage value of 10% of initial cost was used for all machinery. The interest rate selected for this circular was 15%.

Energy costs are becoming a bigger item in most dairy budgets. One of the larger energy items for these six manure handling systems is the diesel fuel and lubrication costs. The magnitude of these is related to the fuel price, consumption per hour, and the number of hours the engine is operated. The fuel and lubricating costs were determined by using the following formula:

$$FLC = \frac{PTO \text{ hp} \times \text{load factor} \times \text{price/gal}}{K} \times 1.15 \times \text{hrs of use}$$

where FLC = fuel and lubrication costs

K = constant for engine type (11.2 for diesel engine)

load factor = 75% for tractors with a horsepower rating of 100 and above; 65% for ratings less than 100

1.15 includes 15% of fuel expenditures for lubrication costs

For this study, we set the value of diesel at \$1.05 per gallon, since farmers receive a rebate for off-the-highway operation. We set electrical energy at 3 cents per kilowatt hour.

It was difficult to determine the hours needed to scrape, haul manure, agitate the tank, etc. These tasks will vary in time requirements with the farmstead layout, labor source, season, and personal preference—to name just a few variables. The following is an example of the level of calculations that were conducted to determine the time required to spread the manure.

First, what about the nutrient content of the manure and wastes after storage in each of the six different systems? (This will be discussed later, but the data are included in table 8.) We assumed that each of the operations would have some pastureland for the cattle and that this land would receive the manure. The application rate used was 60 lb of nitrogen per acre.

Dividing the total nitrogen available from each system by 60 lb/acre provided the total acreage needed to receive the annual manure generated. The farmstead was selected to sit

on the edge of the square field. The average travel distance was calculated for the land-spreading operation and varied as the field size varied.

Recent research has furnished loading and emptying times for various sizes and types of manure spreaders. Using these values, and assuming a travel speed of 6 mph, the total time spent hauling and spreading manure was calculated. Similar calculations were made for systems milking 200 and 300 cows. The total waste volume (which is different for each system) then allows you to calculate the number of trips necessary to land-spread all the waste.

Using the total numbers of hours for the tasks listed in tables 5, 6, and 7 gives the total labor required. The labor costs can then be determined, using a \$4.00/hour value, and this is totaled in the tables.

All of the agitating and pumping of manure slurries were done using tractors to power PTO-driven pumps. The one situation in which an electrical motor is necessary is the need to return lagoon recycle water to the flush tanks in Systems 5 and 6. The pumps were sized to operate at 20 gallons per minute. This then required that they be operated for 5, 10, and 15 hours per day for the three herd sizes. System 6 also uses an electric motor to pump the liquid slurry up to and over the separator.

As energy costs increase, the cost of fertilizer for croplands goes up proportionately. One of the ways to reduce out-of-pocket costs is to use manure as a fertilizer to the greatest extent possible. See the O.S.U. Extension publication, *Calculating the Fertilizer Value of Manure from Livestock Operations* (EC 1094, January 1982).

**Table 5. Annual energy and labor costs, 100-cow dairy**

System	Task (Hrs)	Labor cost (\$4.00/hr)	Fuel and lubrication (Cost)	Electricity (\$0.03/kWh)	
				kWh	Cost
<i>Dry stack</i>					
	small scrape tractor	145	376		
	tractor (hauling)	102	870		
	tractor (loading solids)	16	135		
	tractor (loading liquids)	5	42		
	<b>Total</b>	<b>268</b>	<b>1072</b>		
<i>Earthen storage</i>					
	small scrape tractor	145	376		
	tractor (agitation & loading)	39	335		
	tractor (spreader)	158	1342		
	<b>Total</b>	<b>342</b>	<b>1368</b>		
<i>Daily spread</i>					
	small scrape tractor	145	376		
	tractor (spreader)	96	1009		
	tractor (loading liquids)	4	36		
	<b>Total</b>	<b>245</b>	<b>980</b>		
<i>Aboveground tank</i>					
	small scrape tractor	145	376		
	tractor (agitation/transfer)	40	344		
	tractor (spreader)	119	1010		
	<b>Total</b>	<b>304</b>	<b>1216</b>		
<i>Lagoon flush</i>					
	recycle pump			680	20
	tractor (irrigation pump)	64	543		
	flushing alleys	30			
	moving big gun	16			
	<b>Total</b>	<b>110</b>	<b>440</b>		<b>20</b>
<i>Lagoon flush—separator</i>					
	all of lagoon flush	110	440		20
	pumping over separator			6342	190
	solids handling & screen maintenance	91	364		
	<b>Total</b>	<b>201</b>	<b>804</b>		<b>210</b>

The annual value of nitrogen, phosphorus, and potassium in the manure from a dairy of 100 milking cows is shown in table 8. A range of the percentages of each of the three nutrients retained through collection and storage is also shown. Using summer 1981 values for these nutrients, the annual worth of manure is shown for each of the six systems.

Bedding is the one major operational cost item evaluated for each system. The amounts used are explained in the system descriptions. The bedding most commonly used in Oregon is shavings or sawdust. Availability and price vary widely by area, and you can substitute local costs when you know specific values.

For this circular, a value of \$100.00 for the purchase and delivery of a five-unit load makes bedding cost 1 cent per pound. The lagoon flush separator system uses half the recovered solids as bedding in the dairy. An equal amount is sold. This may go to another dairy as bedding, to a nursery as a soil amendment, or even used as feed.

#### NET ANNUAL COSTS

The net annual costs are summarized in table 9 for herd sizes of 100, 200, and 300 head. For the 100-cow dairy, systems 2, 3, and 5 have low annual fixed costs (capital recovery) and correspondingly low repair, taxes, and insurance costs. The high bedding cost for the dry-stack system is one reason

why it is one of the more expensive systems; reusing the solids helps to pay for the cost of the separator in system 6. The earthen storage system has the highest energy and labor costs, but it still is the least expensive system on an annual basis. The lagoon-flush systems are not as economical, partly because of the small manure-return value.

When one looks at the data for the 200-cow herds, the earthen storage system is quite appealing, being about \$6,000 cheaper than the next least expensive system. The low investment cost is primarily responsible for its ranking. The costs of the aboveground storage unit and the two lagoon systems drop slightly; the daily-spreading system's costs decrease significantly.



**Table 6. Annual energy and labor costs, 200-cow dairy**

System	Task (Hrs)	Labor cost (\$4.00/hr)	Fuel and lubrication (Cost)	Electricity (kWh)	Electricity Cost (\$0.03/kWh)
<i>Dry stack</i>					
small scrape tractor	290		752		
tractor (hauling)	155		1316		
tractor (loading solids)	32		272		
tractor (loading liquids)	10		84		
Total	487	1948	2424		
<i>Earthen storage</i>					
small scrape tractor	290		752		
tractor (agitation & loading)	70		593		
tractor (spreader)	321		2725		
Total	681	2724	4070		
<i>Daily spread</i>					
small scrape tractor	290		752		
tractor (spreader)	156		1640		
tractor (loading liquids)	8		68		
Total	454	1816	2460		
<i>Aboveground tank</i>					
small scrape tractor	290		752		
tractor (agitation/transfer)	75		637		
tractor (spreader)	240		2038		
Total	605	2420	3427		
<i>Lagoon flush</i>					
recycle pump				1360	41
tractor (irrigation pump)	128		1087		
flushing alleys	60				
moving big gun	32				
Total	220	880	1087		41
<i>Lagoon flush—separator</i>					
all of lagoon flush	220	880	1087		40
pumping over separator				12682	380
solids handling & screen maintenance	182	728	82		
Total	402	1608	1169		420

A similar pattern is followed with the data for the 300-cow herds. The annual costs of the earthen storage system and daily-spreading options continue to decrease as herd size increases. The other four systems stay about the same in total cost. Even by staying the same, the cost per cow will decrease sharply as herd size doubles and triples.

The addition of a separator does not appear to be economically justified. However, other factors not considered in this circular make the addition of a separator to a lagoon-flush system more appealing. These include a constant and known supply of bedding (which will likely become more expensive in

the future), a reduction of maintenance and plugging problems when the lagoon effluent is spread on the field, and a slightly reduced organic loading to the lagoon-treatment unit.

Economics is only one factor to consider when you select a dairy waste management system. Safety is an item that is difficult to translate into dollars—yet it is very important. Daily haul has no storage unit to serve as a potential hazard, which is an advantage. However, the dry-storage unit offers little potential as a safety problem. The above-ground-storage unit is difficult to get to, which reduces its hazard potential. While all

earthen storage units and lagoons should be fenced, you should still consider them as hazards.

Pollution control is another factor to consider when you evaluate waste management systems. All systems have a storage component except daily haul, which increases the pollution potential for that system. A storage unit provides the operator flexibility to put the manure on when the crop can use the nutrients and minimize runoff and escape. The two lagoon systems might have a slight advantage since they have 12 months' storage versus 150 days' for systems 1, 2, and 4.

**Table 7. Annual energy and labor costs, 300-cow dairy**

System	Task (Hrs)	Labor cost (\$4.00/hr)	Fuel and lubrication (Cost)	Electricity (\$0.03/kWh)	
				kWh	Cost
<i>Dry stack</i>					
small scrape tractor	435		1128		
tractor (hauling)	191		1622		
tractor (loading solids)	49		416		
tractor (loading liquids)	15		126		
Total	690	2760	3292		
<i>Earthen storage</i>					
small scrape tractor	435		1128		
tractor (agitation & loading)	105		892		
tractor (spreader)	421		3574		
Total	961	3844	5594		
<i>Daily spread</i>					
small scrape tractor	435		1128		
tractor (spreader)	220		2313		
tractor (loading liquids)	13		110		
Total	668	2672	3551		
<i>Aboveground tank</i>					
small scrape tractor	435		1128		
tractor (agitation/transfer)	112		951		
tractor (spreader)	314		2666		
Total	861	3444	4745		
<i>Lagoon flush</i>					
recycle pump				2040	61
tractor (irrigation pump)	192		1622		
flushing alleys	90				
moving big gun	48				
Total	330	1320	1622		61
<i>Lagoon flush—separator</i>					
all of lagoon flush	330	1320	1622		61
pumping over separator				19026	570
solids handling & screen maintenance	273	1092	123		
Total	603	2412	1745		631

The nearness and availability of cropland was assumed in determining spreading costs. However, land may not always be nearby, and its location is very important in influencing the labor and equipment costs in land-spreading operations. While retaining nutrients is beneficial and the system is credited with a fertilizer savings, it does take more

land to receive the manure from a nutrient-conservative system.

In some locations, the lagoon systems are desirable; additional water for crop production will be important and valuable. In other settings or years, the additional water volume may be detrimental.

The most important factor, and one of the most difficult to assign a value, is level and

amount of management required. Because of its complexity, we made no attempt here to assign a value; however, each dairy operator should try to evaluate this factor. Another companion item is operator preference. This also should be objectively evaluated when expanding or selecting a waste management system.

**Table 8. Annual value of nitrogen (N), phosphorus (P), and potassium (K) in the manure from a dairy of 100 milking cows<sup>a</sup>**

System	Percent retained through collection and storage			Average value <sup>b</sup>			Total value (\$)
	N	P	K	N	P	K	
1 Dry stack	60-80	80-95	80-95	4785	3298	3124	11,207
2 Earthen storage	60-80	80-95	80-95	4785	3298	3124	11,207
3 Daily haul	70-85	85-95	85-95	4194	2559	2343	9,096
4 Aboveground tank	70-85	85-95	85-95	5592	3412	3124	12,128
5 Lagoon flush	20-35	30-50	40-70	1960	1516	1974	5,450
6 Lagoon flush—separator	20-35	30-50	40-70	1960	1516	1974	5,450

<sup>a</sup> Losses occurring after storage and before crop uptake were assumed to be 20% for N and zero for P and K, for all systems except daily haul, which experiences a 40% loss of N.

<sup>b</sup> Price per pound: N = \$.27, P = \$.67, K = \$.18.

**Table 9. Net annual system cost**

System	Capital recovery	Repair, taxes + and insurance ±	Bedding +	Energy	+ Labor -	Manure Value =	Net Annual Costs
<i>100-cow dairy</i>							
Dry stack	13,902	1,254	1,420	1,423	1,072	11,207	7,864
Earthen storage	7,369	909	426	2,053	1,368	11,207	918
Daily spread	8,712	946	568	1,421	981	9,096	3,532
Aboveground tank	19,230	1,656	426	1,730	1,218	12,128	12,132
Lagoon flush	8,205	958	426	563	440	5,450	5,142
Lagoon flush—separator	14,962	1,847	- 426	794	804	5,450	12,531
<i>200-cow dairy</i>							
Dry stack	22,027	1,812	2,840	2,424	1,948	22,414	8,637
Earthen storage	7,590	919	852	4,070	2,724	22,414	-6,259
Daily spread	12,140	1,253	1,136	2,460	1,816	18,192	613
Aboveground tank	27,024	2,143	852	3,427	2,420	24,256	11,610
Lagoon flush	10,874	1,125	852	1,128	880	10,900	3,959
Lagoon flush—separator	17,631	2,013	- 852	1,589	1,608	10,900	11,089
<i>300-cow dairy</i>							
Dry stack	31,244	2,536	4,260	3,292	2,760	33,621	10,471
Earthen storage	8,262	992	1,278	5,594	3,844	33,621	-13,651
Daily spread	14,731	1,510	1,704	3,551	2,672	27,288	-3,120
Aboveground tank	36,047	2,744	1,278	4,745	3,444	36,384	11,874
Lagoon flush	13,354	1,277	1,278	1,683	1,316	16,350	2,558
Lagoon flush—separator	20,111	2,166	-1,278	2,382	2,412	16,350	9,443



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