The Texas A&M
University System

B-1446

Texas
Agricultural
Extension
Service

Zerle L. Carpenter, Director
College Station

DAIRY MANURE HANDLING SYSTEMS AND EQUIPMENT

TABLE OF CONTENTS

Acknowledgements

The technical review and suggestions of the following individuals were a valuable contribution to the completion of this publication: Gene Vittetoe, State Conservation Engineer, Soil Conservation Service, U.S. Department of Agriculture, Temple, Texas; John P. Burt, Environmental Engineer, Soil Conservation Service, U.S. Department of Agriculture, Fort Worth, Texas; and Dr. James C. Barker, Extension Agricultural Engineer, North Carolina State University, Raleigh, North Carolina.

DAIRY MANURE HANDLING SYSTEMS AND EQUIPMENT

John M. Sweeten, Ph.D., P.E.*

A manure management system for a modern dairy should be capable of controlling solid or liquid manure and wastewater from the open corrals (manure and rainfall runoff), free stall barn, feeding barn, holding lot or holding shed, milking parlor, milk storage room, and calf barn. Waste streams that have similar consistency and are produced at the same times should be combined in most instances. Manure scraped from dirt corrals should be handled as a solid material. Scraped manure of semi-solid consistency from feeding barns, free stall barns, or concrete lots presents the biggest materials handling challenge and also the widest range of system choices.

Objectives of Manure Management Systems

The *main objective* of dairy manure management should be to prevent direct discharge of manure and wastewater onto adjacent neighbors' land. Water pollution control laws in the United States declare that it is not legal to discharge contaminated wastewater without a permit. The *second objective* is to prevent nuisance from odors and flies. Nuisance is defined as anything that interferes with the normal use and enjoyment of property. A *third objective* is to capture and utilize manure and wastewater as fertilizer. A *fourth objective* is to enhance efficiency of the dairy operation by streamlining the manure management system.

*Author is Extension Agricultural Engineer—Waste Management, the Texas Agricultural Extension Service, The Texas A&M University System, College Station, Texas, U.S.A. 77843. (Telephone 409/845-7451).

Selecting a Manure Management System

A variety of systems and equipment have been developed to fulfill these waste management objectives to varying degrees. Selection and design of dairy waste management systems is highly site-specific. No one system is right for every dairyman.

The major factors to consider in choosing the dairy manure handling system are as follows: operator preference, existing facilities and structures, land availability, manure consistency, manure volume, efficiency, fly control, odor potential, distance to streams, water supply, soil type, ground water depth, climate, crops (varieties and rotations), nutrient recycle potential, regulatory requirements, maintenance requirements, cost, and labor requirement. Any one of these factors can rule out the use of a particular system that would otherwise work on a different dairy.

Amount and Characteristics of Dairy Manure

Manure production rates vary in proportion to cattle body weight. They are also influenced by ration digestibility and intake.

Dairy cattle produce manure (feces and urine) at the average rate of 8.2 percent of their body weight daily (Table 1). This wet manure contains 12 to 13 percent solid material, of which 82 to 83 percent is organic matter (volatile solids) and the remainder is ash. The amount of fertilizer nutrients in dairy manure is approximately 3.9 percent nitrogen, 1.6 percent phophorus (P_2O_5) and 3.1 percent potassium (K_2O) on a dry matter basis. Each year, a 1300 pound dairy cow will excrete 2½ tons of dry manure solids, 195 pounds of nitrogen (N), 80 pounds of phosphorus (P_2O_5), and 150 pounds of potassium (K_2O).

The amount of time cattle are kept in confinement dictates how much of the manure must be actually handled. For a typical Texas dairy, cattle may spend only six hours per day in confinement waiting or being milked. The remainder of time is spent on pasture or in feeding corrals. In such a case, the liquid manure system should be designed for only ¼ of the total manure production. But with a free stall barn, cattle may spend up to 24 hours per day in confinement during wet weather, in which case the liquid manure system should be designed to handle 100 percent of the manure load plus bedding, spilled feed, and washwater, even though the full system capacity would be used infrequently.

Table 1. Amount and Characteristics of Fresh Dairy Cattle Manure per 1000 lbs. Body Weight

Parameter	Percent of:	Amount lbs/day	Amount lbs/year
1. Wet Manure (WM), Feces and Urine	8.2% LVW	82	29,900
2. Total Solids (TS)	12.7% WM	10.4	3,800
3. Volatile (organic) solids (VS)	82.5% TS	8.6	3,100
4. Nitrogen (N)	3.9% TS	0.41	150
5. Phosphorus (P_2O_5)	1.6%TS	0.17	60
6. Potassium (K_2O)	3.1% TS	0.32	120

Dairymen should try to *estimate washwater usage before planning* a liquid manure handling system to avoid large, expensive errors in design. Washwater utilization varies enormously, as the following examples from Extension field studies illustrate. A South Texas dairy generated 110 gallons of wastewater per cow per day. This included flush water from the free stall barn, milking parlor and holding pens. A Central Texas dairy that utilized sprinkler cow washers in the holding pen in addition to a flush system for the milking parlor and holding pen, generated 82 gal./cow/day of wastewater. By contrast, a Southeast Texas dairy generated only 20 gal./cow/day because the milking parlor and holding shed were first manually scraped and then rinsed down to a concrete holding tank.

From this discussion, it is obvious that manure handling methods have profound effects on moisture and nutrient contents as shown in Tables 2 and 3.

Table 2. Typical Solids and Nutrient Contents of Dairy Manure and Wastewater (Percent wet basis)*

	Solids %	Nutrient Content, % Wet Basis N	P_2O_5	K_2O
1. Raw Dairy Manure	13	0.5	0.2	0.4
2. Corral-Scraped Manure	72	2.2	1.1	1.6
3. Liquid Manure — Anaerobic Storage Pit	5-13	0.1-0.5	0.1	0.2-0.3
4. Anaerobic Lagoon Effluent	0.3	0.02	0.004	0.03
5. Open Lot Runoff — Stored Effluent	0.02-0.07	0.01	0.01	0.03
6. Milking Center Waste	0.5-1.0	0.1-0.2	0.01-0.02	——

*To convert to *pounds per 1,000 gallons*, multiply values shown by 83. To convert to *pounds per acre inch*, multiply by 2270. To convert to *pounds per ton*, multiply by 20.

Table 3. Average Chemical Analysis of Dairy Cattle Manure

	Fresh Cattle Manure, %	Dairy Corrals, %	Dairy Manure Stockpile, %
Moisture	76.5	34.0	4.3
Nitrogen	2.20	2.13	1.72
Phosphorus (P_2O_5)	1.31	0.82	0.76
Potassium (K_2O)	0.81	1.96	1.43
Calcium	1.52	1.81	2.04
Magnesium	0.50	0.61	0.67
Iron	0.059	0.16	0.23
Zinc	0.0079	0.0071	0.0045
Sodium	0.32	0.44	0.45
Sulfur	0.28	0.21	0.12
Manganese	0.011	0.012	0.014
Copper	0.0019	0.0020	0.0019
Ash	15	33.9	46.2
Soluble Salts	3.7	4.74	3.78

*All data except moisture are on a dry weight basis.

From: Arrington, R. M. and C. E. Pachek, 1981. Soil Nutrient Content of Manures in an Arid Climate. In: *Livestock Waste: A Renewable Resource*, Proceedings 4th International Symposium on Livestock Waste 1980, American Society of Agricultural Engineers, St. Joseph, Michigan, pp. 150-152.

Basic System Alternatives

Basic systems that have proved workable for storage and disposal of dairy manure in the Southwestern United States are:

1. Liquid manure storage pit, followed by tank wagon application
2. Liquid manure storage pit, followed by direct slurry irrigation
3. Treatment of liquid manure in lagoons (anaerobic), followed by sprinkler irrigation
4. Solid manure collection and stockpiling, followed by application with a spreader truck or tractor-towed spreader.

The first two systems involve short-term storage prior to land application. Their major emphasis is on maximum recovery of fertilizer value with necessary manure storage while soil conditions or crop rotations temporarily inhibit land application.

By contrast, lagoon systems are used primarily for biological treatment (bacterial digestion) of organic wastes and for long term storage (200 days or more). Through destruction of organic matter, 70-80% of the nitrogen is lost to the atmosphere, and most phosphorus and potassium sink to the bottom with sludge. Land application is a secondary (though necessary) consideration.

The suitability of these systems depends in part on collection methods, particularly the amount of washwater added. Table 4 can be used as a guide to selection of the type of dairy manure management system.

Table 4. Selection of Manure Handling System Based on Solids Concentration

Solids Concentration % Wet Basis	Optimum Manure Handling System
0-2	Lagoons with sprinkler irrigation
2-7	Storage pit and direct slurry irrigation
4-12	Storage pit and tank wagon or truck
10-20	Direct loading to box or flail spreaders
20 +	Manure stacking with box or flail spreaders

Storage Pit/Spreader Tank Wagon System

Liquid manure storage pits or structures consist of underground concrete tanks, above ground tanks (concrete or glass-lined), or earthen holding basins. A typical underground storage tank is shown in Figure 1. Storage structures should have

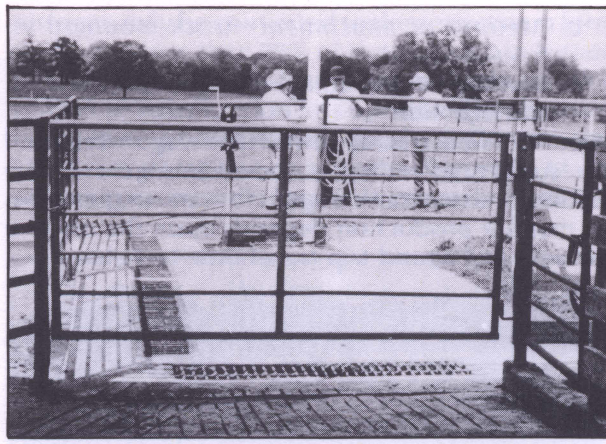

Figure 1. Underground liquid manure storage tank with a low-head, submersible, chopper-agitator manure pump installed at a Northeast Texas dairy.

minimum capacity to store manure and wastewater during wet weather when access to fields is not feasible. Depending upon soils and crops grown, 30 days minimum capacity is recommended for warm, humid regions. For some crop rotations, it may be desirable to store manure for 60 to 150 days. For desert climates, only two days' storage capacity may suffice.

Since needed capacities may be very large, earthen storage basins with adequate method of agitation may be the most economical. Special tractor power take-off (PTO) driven pumps are available to agitate manure storage basins and pits. Above-ground storage structures, which are now being marketed, have provisions for agitation using the tractor PTO.

Figure 2. Tank wagon equipped for surface spreading of liquid dairy manure.

Tank wagons or tankers can be classified according to:

a. *Method of loading*—vacuum vs. pump filled

b. *Method of attachment*—truck-mounted vs. tractor-towed
c. *Method of unloading*—surface spreading vs. soil injection

A pump-filled, tractor-towed tank wagon designed for surface spreading is shown in Figure 2. The optimum size of tank wagons for various quantities of manure production depends upon the manure volume and round trip travel time to fields.

Advantages of storage pit/tank wagon systems for hauling and spreading liquid dairy manure include:

1. Timely use of manure for fertilizer
2. Widespread availability of equipment
3. Mobility to reach remote spreading areas

Disadvantages of these systems are:

1. High initial cost
2. High operating cost
3. Limited access to fields in inclement weather
4. Potential soil compaction
5. Odor potential upon spreading
6. Low to moderate manure handling capacity

Subsurface injection of manure slurries containing up to 15 percent solids is feasible in many instances (Figure 3). Nitrogen losses are only 5 percent after soil injection as compared to 25 percent or more with surface spreading. With current nitrogen prices, soil injection appears to be economically justifiable when injection equipment use exceeds 25 hours per year.

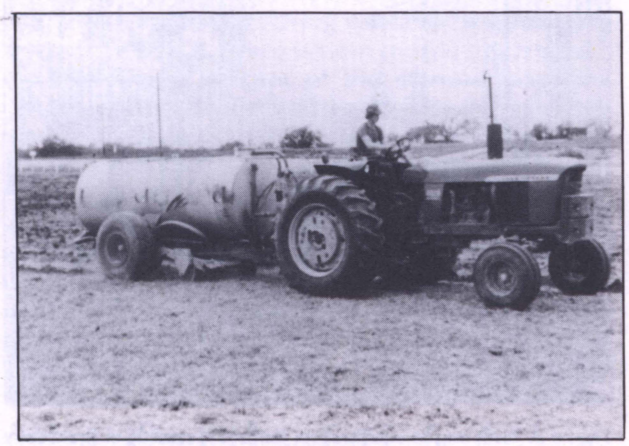

Figure 3. Subsurface injection of liquid manure reduces nitrogen losses, odors, and water pollution potential.

Other advantages of soil injection are reduced odors, decreased runoff quantity, and improved runoff quality. Higher application rates can be tolerated without adverse environmental effects. However, soil injection requires a larger tractor or slower travel speeds. Soil injection is more difficult and perhaps undesirable in permanent pastures.

Storage Tank/Direct Slurry Irrigation

Direct irrigation of manure slurry through a large-diameter sprinkler nozzle is ideally suited to dairies that produce large quantities of manure and wastewater and that have nearby pasture or croplands (Figure 4). One advantage of direct slurry

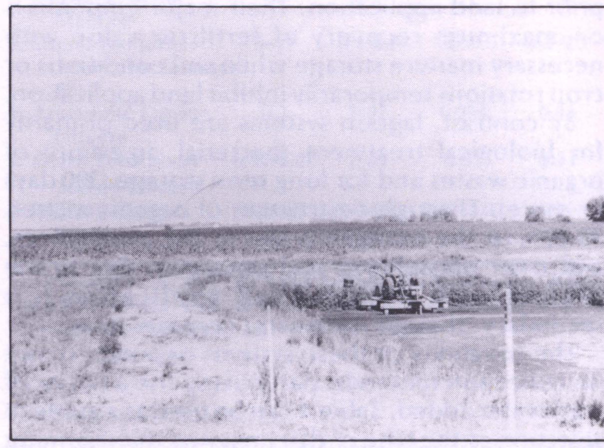

Figure 4. Slurry irrigation systems provide efficient application of stored liquid manure and lagoon effluent. Agitation and pump selection are keys to successful manure slurry irrigation.

irrigation is the ready access to fields within hours after rainfall. For this reason, less storage capacity is needed than for tank wagon systems. Direct slurry irrigation systems have higher capacity than tank wagon systems (Table 5) and require much less

Table 5. Comparison of Effective Capacities of Land Application Equipment

Type System	Nominal capacity	Effective Capacity, gal./hr. manure slurry @4,000 gal./ac.	lagoon effluent @40,000 gal./ac.
Tank Wagon, Surface spread*	1,500 gal.	4,500	4,900
Tank Wagon, Surface spread*	3,000 gal.	8,250	9,000
Tank Wagon, Soil injection*	3,000 gal.	7,500	7,500
Irrigation, Stationary gun	300 gal./min	9,000	16,400
Irrigation, Traveling gun	300 gal./min	12,400	17,200
Irrigation, Traveling gun	500 gal./min	17,100	28,000

*Assumes pump loaded tank wagon and 2000 ft. haul distance labor. The total cost of pump, irrigation pipe, and traveling gun sprinkler is similar to the cost of a tank wagon system excluding the power unit (tractor). Direct slurry irrigation systems can serve the dual purpose of both manure disposal and application of supplemental irrigation water. Direct slurry irrigation systems require pump selection. A high pressure (100-120 psi), high volume (200-500 gpm) pump is necessary. The pump must be able to pass 1.5 to 2.0 in. diameter solids or larger, and should have a chopper blade.

Over-application of wastes is a major concern with slurry irrigation systems. Frequent moving of sprinkler nozzles is necessary to avoid excessive nitrogen application rates. Traveling gun sprinklers are strongly recommended for sprinkler distribution of waste slurries.

The range of total solids concentration that is amenable for disposal with slurry irrigation equipment is 0 to 7 percent. High friction losses result from pumping manure containing more than 4 percent solids content.

Lagoon Systems

In many cases, liquid manure should be stored in earthen holding ponds (5 to 60 day capacity) or treatment lagoons (150 to 300 day capacity) before application to crop or pasture land. During storage and treatment, nitrogen and phosphorus are reduced in concentration. Phosphorus tends to accumulate in sediment which may be removed infrequently. Reduction in phosphorus levels of 60 to 80 percent are common. Nitrogen is lost from the pond or lagoon surface in the form of nitrogen gas and ammonia, the two gaseous end products of protein decomposition. Nitrogen losses from lagoons and holding ponds range from 30 to 80 percent depending on temperature, storage duration, and pH. Nitrogen losses are much more rapid during warm weather. During anaerobic storage and/or treatment, most of the organic

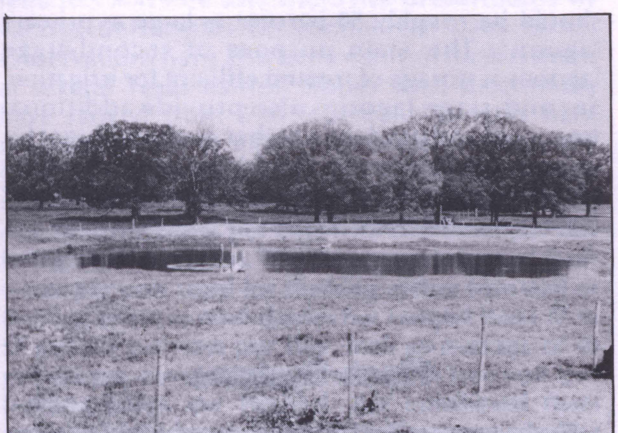

Figure 5. Two-stage anaerobic lagoon systems provide excellent biological treatment and storage of dairy manure and wastewater prior to land application.

nitrogen may be converted to the ammonium form (NH_4 +). More than 80% of the nitrogen in lagoon effluent may be in the form of ammonium, which is subject to volatilization loss upon land application.

Lagoons provide biological treatment and long term storage of dairy wastes (Figure 5). Major advantages include low-cost construction, low

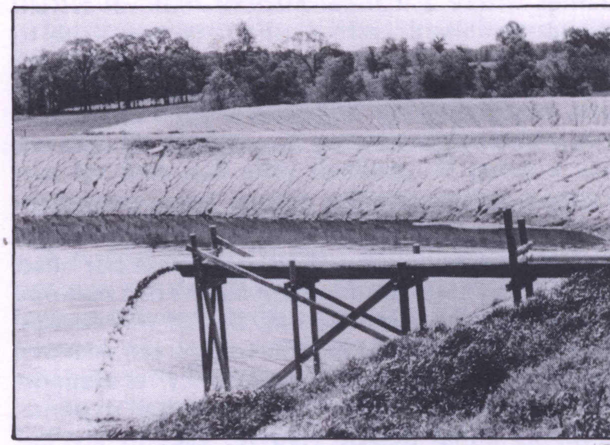

Figure 6. Design criteria for anaerobic lagoons include retention time, organic solids loading rate, and sludge storage volume.

labor and energy requirements, low operating costs, and fly control. Lagoons are efficient from an operational standpoint because manure application on land can be scheduled only once or twice annually. Bacterial destruction reduces the solids and nitrogen content and therefore reduces land area requirements for disposal by 50 to 75%. In addition, lagoons are compatible with hydraulic flush systems for manure removal.

However, lagoons have several major disadvantages which may make them unsuitable in many situations. They frequently produce offensive odors. If a fibrous floating mat develops, fly breeding can occur. The loss of nitrogen through volatilization and loss of phosphorus through settling may be undesirable to dairymen who can effectively utilize these nutrients. Groundwater pollution is possible, although a biological seal usually develops on the bottom and sides.

But perhaps the largest and least recognized lagoon management problem is sludge accumulation. Lagoon sludge consists of fixed or non-biodegradable solids, slowly digestible fibrous solids, and soil particles washed off the cattle.

Three design criteria should be satisfied in designing a first-stage anaerobic lagoon for manure treatment (Figure 6). The first criterion is adequate *liquid retention time.* The lagoon should provide 200-365 days of liquid storage capacity to achieve good digestion of manure organic matter. When hydraulic flush systems are used, contributing more than 50 gallons of wastewater per cow per day, the retention time may be the limiting factor.

The second criterion for anaerobic lagoon design is *volatile solids (VS) loading rate*. Research and experience have shown that volatile solids loading rates should not exceed 6 lbs. VS/day/1000 cu. ft. for the southern United States. For Texas, the recommended rate is 3 to 5 lbs. VS/day/1000 cu. ft. for North to South Texas, respectively. The volatile solids loading rate may be the limiting factor for dairies where a manual manure removal system (scrape and hand wash) is used. It is more likely to be the limiting factor for poultry, swine, and beef cattle manure lagoons than dairy lagoons.

The third criterion is *sludge storage volume*. Recent research has shown that lagoon sludge accumulates at the rate of 250 cubic feet per head per year in a total confinement dairy. For a six-hour per day confinement period, sludge will occupy about 63 cubic feet of lagoon volume per year per dairy cow. The "sludge life expectancy" of a lagoon (i.e., time before it gets ½ full of sludge) depends upon its initial design volume. Lagoon life expectancy can be estimated from Table 6.

Table 6. Life Expectancy of Anaerobic Dairy Lagoon Before Sludge Removal

Lagoon liquid volume per unit of cattle liveweight cubic feet/pound	Time until lagoon is half full of sludge yrs.
1	2.5
2	5.0
3	7.5
4	10.0
5	12.5

To reduce lagoon sludge problems, many dairymen have installed mechanical separators including static, vibrating, or rotating screens to remove fibrous material from the liquid waste stream before it enters the lagoons (Figure 7). Approximately 20 to 30 percent of the solids can be removed with these mechanical separators and composted for use as bedding or soil conditioner. Gravity settling basins can remove 50 to 60 percent of the manure solids from flushed manure, but require frequent cleanout with tractor loader or dragline. Dairymen may also purchase trailer or floating platform-mounted trash handling pumps to remove lagoon sludge when necessary.

Figure 7. Screening of flushed dairy manure removes fiber that reduces lagoon storage and treatment capacity and reclaims a useful bedding material.

All three anaerobic lagoon design criteria are usually met when the lagoon liquid volume is 3 to 4 cu. ft. per lb. of cattle liveweight, assuming total confinement. The lagoon size would be proportionately smaller for partial confinement systems; for example 1 cubic foot per pound liveweight for a cattle confinement period of 6 hours per day.

Where space is available, it is recommended that a second-stage lagoon be constructed to improve effluent treatment and management flexibility. Second stage lagoons, which are usually anaerobic, should be roughly 50 percent as large as primary lagoons. The main purpose of second-stage lagoons is storage of treated effluent for irrigation. Second-stage lagoons also provide additional treatment and produce a higher quality effluent for recycling as flush water. In addition, small diameter sprinkler nozzles can be used to irrigate effluent from a second stage lagoon.

Flush Systems

Flush systems for manure removal have performed satisfactorily under a wide variety of conditions in free stall barns, feeding lots or barns, holding lots, and milking parlors. Types of flush

Figure 8. Flush system design should consider slope, channel length, width, water volume or flowrate, flushing frequency and surface texture.

devices used for dairies have included: vertical lift dam, lift or sluice gate, sealed circular orifice, hydraulic guillotine gate, and high capacity siphons. In addition, high-capacity effluent recirculation pumps can be used for flushing gutters and alleys.

Sudden-release devices convert the potential energy of stored water into kinetic energy which cleans the alley surface for the first 30 to 50 feet or so downstream. Beyond that initial zone, channel slope and flow depth must be great enough to maintain sufficient kinetic energy to continue scouring manure. Because the solids load is continually increasing downstream, it takes even more energy (depth and/or slope) at the downstream end than at the upstream end.

The amount of water used for flushing paved feed lots and free stall alleys has been studied by various universities on commercial dairy farms. Observations have also been made of flush systems at several Texas dairies. Slopes used successfully have ranged from 2 to 6 percent. Lengths have ranged from 120 to 300 feet for channel widths of 9 to 16 feet. Curb heights of 9 to 12 inches are most common. Flushing frequencies have ranged from one to seven times per day, with two times per day being most common. The average amount of flush water per cow used for flushing either free stall or feeding alleys at nine dairies has ranged from 27 to 57 gallons per cow per day, with an average of 40 gallons per cow per day. Where both free stall and feeding alleys are flushed, the combined flush water volume has averaged 85 gallons per cow per day (average of seven dairies). On the basis of *surface area*, flush water usage at 10 dairies averaged 1.9 gallons per square foot per day (range of 1.3 to 3.2 gallons/square foot/day).

Flush tanks for milking parlors generally have a capacity of 500 to 1000 gallons each and are located at the head of each milk alley or holding pen. They are dumped one to three times per milking with flush water from the milking parlor used to flush the adjacent holding pen also. Sanitation requirements dictate that the milking center be flushed only with clean water.

The total wastewater production at three dairies has been evaluated. At a South Texas dairy it averaged 110 gallons per cow per day. At a Mississippi dairy it averaged 128 gallons per cow per day. Of the latter, 37 percent of the washwater was for free stall alley flushing, 47 percent was washwater used in the milking parlor, and six percent was used in the prep stalls.

A typical North Carolina dairy used 90 gallons per cow per day of which 58 percent was recycled lagoon effluent used for free stall alley flushing, 32 percent was fresh water used for milking center cleanup, and 10 percent was used in prep stalls.

The following are some general recommendations for design of flush systems for free stall or feeding alleys (Figure 8):

1. **Cross-slope**—flat or crowned to 0.5 to 1.0 inches higher in center than sides.
2. **Longitudinal slope**—3 percent
3. **Maximum length**—200 feet
4. **Alley width**—10-14 feet
5. **Curb height**— 9 inches
6. **Floor finish**—smooth parallel grooves 2 inches apart lengthwise or diamond grooving pattern on 4-inch grid.
7. **Water requirements**—40 gal./cow/day, or 2 gal./sq. ft./day

High-rate pumping of lagoon effluent can be used to flush feeding alleys, free-stall barns, or collection gutters for scraped manure. General design guidelines for high-rate pumped flushing are 1 to 3 percent slope and a flow-rate of 75 to 100 gpm per foot of channel width.

Lagoon effluent recirculated for flushing may cause accelerated metal corrosion or crystalline deposits in pumps and pipelines. Plastic pipe and valves are recommended. Lagoon effluent also contains pathogenic organisms, and the increased disease risk should be recognized. The solids content of lagoon effluent can reduce its efficiency of solids removal in flushing.

Manure Spreading Methods

Selection of equipment and procedures for manure application will depend principally on manure moisture content, transportation distances, and application rates. Types of equipment available for transportation and land application of manure are summarized in Table 7 according to the moisture content of manure to be handled. Manure containing less than 4 percent solids can be pumped readily with less than 10 percent increase in hydraulic friction (head) loss as compared to irrigation water. Large diameter (big gun) sprinklers provide efficient disposal of large volumes of liquid manure and wastewater. Conventional medium bore sprinklers with ¼ to ⅜ inch nozzle diameter can be utilized for mechanically screened liquid manure, for second-stage lagoon effluent, or runoff stored in holding ponds. Open ditches, furrows or borders are not recommended for distribution of liquid manure because of solids settling and non-uniform distribution of organic matter.

Most vacuum-loaded tank wagons or trucks discharge liquid manure directly behind the unit, although some commercial tank wagons have side discharge nozzles. Application rates can be controlled by compressed air pressure and ground speed.

To retain nitrogen and minimize odors, surface application of liquid manure should be followed by disking to a depth of 4 to 6 inches. This will limit volatization of ammonia to 5 percent or less. Otherwise, ammonia loss can reach 25 to 70 percent depending upon soil pH, temperature, and other factors. Soil injection attachments for knifing or chiseling liquid manure to 8 to 12 inches soil depth from tank wagons have become commonplace for liquid manure application in row crops during early spring or late fall.

Open-tank, flail-chain spreaders are used to spread semi-solid or semi-liquid manure. This includes fresh manure with little or no dilution water as well as wet corral-scraped manure collected after rainy weather or from pot holes on the feedlot surface. Capacities of flail-chain spreaders range from 600 to 1800 gallons. These spreaders require tractor sizes of 55 to 110 horsepower. Short chains attached to a PTO-driven center shaft discharge the manure to either side.

Tractor drawn box spreaders for solid manure are available in capacities of 2.5 to 12 cubic yards. If the manure source is nearby, or if manure has been stockpiled near the fields, it can be reloaded and spread efficiently. Tractor power requirements range from 30 horsepower for the smallest spreader to 100 horsepower for the largest models.

Solid manure spreader trucks consist of 11 to 21 cubic yard beds mounted on single or dual axle truck chassis. Chain-driven flights on the truck bed move the manure to the rear during unloading. Serrated augers or beaters at the rear of the truck beds provide particle size reduction and improve manure spreading uniformity. These manure spreader trucks are mainly used in large drylot dairies where large tonnages must be moved each year to fields up to 15 miles away.

Table 7. Types of Manure Spreading Equipment

Consistency	Solids Content % w.b.	Types of Spreading Equipment
Solid manure	35-80	Spreader trucks (11-21 cu. yds.) or tractor-drawn box spreader (2.5-12 cu. yds.)
Semi-solid or semi liquid manure	10-35	Side-discharge flail manure spreader, tractor-drawn (600-1800 gals.)
Liquid slurry	2-12	Tank wagon or tank truck (500-3500 gals.) (a) surface spread vs. soil incorporation (b) vacuum vs. pump loaded
Liquid Manure (with fiber separation)	0-7	Irrigation, (a) big gun sprinkler (1-1½ in. diameter nozzle), or (b) gated pipe
Lagoon or holding pond water	0-2	Irrigation (a) conventional sprinkler nozzle, or (b) big gun sprinkler, or (c) gated pipe

Water and Air Pollution Control

Producers and advisory personnel should acquaint themselves with pollution control and milk sanitation officials to learn requirements and criteria for manure and wastewater management.

Water and air pollution abatement requirements of the Texas Department of Water Resources and the Texas Air Control Board, respectively, are explained in another Extension publication, "Pollution Control for Dairy Farms," B-1386. That publication also contains information on technology for achieving "no-discharge" and for reducing odors. Milk sanitation regulations pertaining to manure management are also covered.

SUMMARY

A major challenge to today's dairy producers and those in advisory roles is to be aware of advantages and disadvantages of developing manure management technologies so that the most appropriate series of storage, treatment, and utilization components can be incorporated into the overall dairying operation. Designers should be striving for operational simplicity in meeting the four objectives of: 1) pollution control, 2) operational efficiency, 3) manure utilization, and 4) nuisance reduction. Flexibility should be designed into manure management systems so that as new options become available or current techniques become more feasible they can be added to the production system with a minimum of renovation. After weighing advantages, disadvantages, cost, and other important points, the dairyman must make a decision on a manure management system and then commit himself to providing the attention and management necessary to make that system function.

Related Extension Publications

B-1386 Pollution Control for Dairy Farms
L-1053 Feedlot Runoff Disposal on Grass or Crops
L-1094 Manure Management for Cattle Feedlots
L-1100 Control of Flies around Feedlots
L-1188 Chemical Control of Manure Odor
L-1198 Consider Prevailing Winds in Feedlot Site Selection
L-1220 Fertilization of Crops with Feedlot Wastes on the Texas High Plains
L-1449 Odor Regulation by Nuisance Laws

Sources and Additional Information

- *County and area offices of the Texas Agricultural Extension Service, The Texas A&M University System.*
- *County and area offices of the Soil Conservation Service — United States Department of Agriculture.*
- *Texas Department of Water Resources, P. O. Box 13087, Capitol Station, Austin, Texas 78711.*
- *Texas Air Control Board, 6330 Highway 290 East, Austin, Texas 78723.*
- *Texas Department of Health, Division of Milk and Dairy Products, 1100 West 49th Street, Austin, Texas 78756.*

Cooperative Extension Work in Agriculture and Home Economics, The Texas A&M University System and the United States Department of Agriculture cooperating. Distributed in furtherance of the Acts of Congress of May 8, 1914, as amended, and June 30, 1914.
6M—5-83, New