(f) Cryptosporidium parvum

Cryptosporidium parvum is important as a water-borne pathogen. Many different species of animals shed C. parvum oocysts, including cattle. Oocyst shedding appears to be clustered in young calves (primarily less than 30 days of age) and efforts to detect shedding of oocysts from cows around the time of calving have failed to date (Atwill et al., 1998). The NAHMS 1991-92 national dairy heifer study estimated at least 90% of dairy operations were positive for C. parvum, with 22% of preweaned dairy heifers shedding oocysts at any one point of time and nearly 50% of calves shedding the pathogen 1-3 weeks of age (NAHMS, 1993). Because of the clustering of fecal shedding in very young calves, environmental control may be feasible, with focus on preventing calf feces from contaminating surface water. [79] There have been 14 documented incidents of cryptosporidium disease outbreaks in U.S. and Canada since 1984 (Frey et al., 1998). Four of these events were linked to nonpoint source agricultural pollution, the others were primarily caused by septic tank and human sewage contamination.[80]

(g) Giardia lamblia

Very little is known about Giardia lamblia on dairy operations in terms of prevalence or control measures but the organism has been isolated in 50% of beef calves (NAHMS, 1993). [81]

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Dairy Waste Lagoon Seepage and Runoff Problems

(1) Lagoon Seepage

Waste lagoons, even with clay liners, allow waste to leach into the ground below the lagoon. In fact, lagoon specifications allow leakage through the clay liners at a rate up to 0.036 inches per day. At the maximum allowable rate, a three acre lagoon could legally leak more than a million gallons a year. A study of self-sealing of earthen liquid manure storage ponds found that a seal usually formed within 12 weeks of construction. Earthen-lined dairy manure storage basins have seepage losses primarily because of freezing, earthworm activity, roots, and pedogenesis. Most of the pollutants are lost to ground water through macropores in the sidewalls and these losses can be significant. For example, a study of seepage from a 600,000 gallon clay-lined earthen manure storage system for a 100 cow dairy operation in central Minnesota found that seepage averaged 5 gal/d from the bottom and 102 gal/d from the sidewall of the lagoon during the first 3 years of operation. The main contaminants leached were sodium and chloride, with very small fractions of nitrogen and phosphorus leached. [82]

Lagoon seepage has been calculated with fairly high precision. Ruhl studied earthen basins with above-grade, earth-walled embankments and compacted clay liners. Monitoring systems were installed below the compacted clay liners both in the sides and the bottom of the basin. Seepage from the basin ranged from 400-2200 gallons per day except during 1 month and three month periods when 3800 to 6200 gallons per day. Seepage flow in area units ranged from .025 to .43 inches/day. Except during the first three months when the basin was filling, seepage flow was greater through the sidewalls than through the bottom of the basin.[83] Ham found that after accounting for evaporation, lagoon seepage could be accurately determined to within +/- .5 mm per day. The lagoons studied ranged in size from .5 to 2.5 ha (1.24 to 6.2 acres), had waste depths that varied between 1.5 and 5.6 m (4.92 to 18.4 feet) and were built with compacted soil/bentonite liners. Average seepage rates were 1.2 mm/day (.05 inch).[84]

Seepage from manure holding basins and lagoons can have a very serious impact on ground water quality, especially from nitrate and ammonium. These impacts are greatest with unlined earthen manure storage systems, and lined pits constructed in coarse textured soils. Seepage losses generally occur when the sidewalls become cracked or develop macropores. Lined basins and lagoons which are properly constructed, engineered, and managed can still be a serious threat to ground water quality when they are constructed in coarse textured soils or karst terrain. Unlined earthen manure storage systems may develop a slowly permeable seal after several weeks of operation, but generally pose a much greater risk for pollution of ground water by seepage than lined storage facilities.[85]

(2) Runoff from Dairy Waste

A 1982 study of fecal bacteria was conducted in surface water from 0.2 acre sandy clay loam plots receiving liquid dairy manure, fertilizer or no fertilizer for six years. Liquid manure was applied at three rates, and was either plowed under after harvest, plowed under in spring prior to seeding, or plowed under with split applications in spring and fall. In one treatment, manure was applied to snow or frozen ground. Fecal bacteria levels in runoff from manure applied in fall or spring at any rate were not significantly different from fecal bacteria counts in fertilized or unfertilized plots, and were from one to two orders of magnitude greater than the primary contact level of 200 CFU/100 mL. Application of manure to snow or frozen ground resulted in significantly greater counts of fecal bacteria in runoff than any other treatment. [86]

A 1996 study developed an accurate method for identifying fecal streptococci from waste matter of dairy cattle and other sources in the presence of five antibiotics. Discriminant analysis of the antibiotic resistance patterns from each source was used to classify the source of fecal streptococci in water samples from two streams draining agricultural areas in Virginia. The source of fecal streptococci in Cooks Creek was 59% beef cattle, 18% dairy cattle, 11% human, 11% wildlife, 1% chickens, and 0% turkeys. In Muddy Creek the sources were 68% beef cattle, 15% wildlife, 8% chicken, 6% dairy cattle, 2% turkeys, and 1% human. Thus, in these two watersheds, over 80% of the fecal streptococci were from domestic livestock.[87]

Fecal coliform from surface applications of dairy manure is rapidly transported to subsurface tile drains in fine sandy loam through macropores if the soil was wet before application or a heavy rainstorm occurred within hours of manure application. Rapid transport has also been observed through soil macropores to tile drains (within roughly an hour after the onset of precipitation) under conditions typical of Iowa and Minnesota.[88] Studies of survival and leaching of fecal coliform and fecal streptococci in a soil receiving dairy manure with spring or fall application and no-tillage or conservation tillage show that manure significantly increases fecal bacteria in leachate (3,000 to 60,000 CFU/100 mL) compared to unmanured soils. Neither tillage nor timing of manure application affected fecal coliform concentrations in leachate. For example, a 1999 study of pathogen losses in subsurface drainage water from dairy manure and urea applied to corn found E. coli in 24% of the tile drain water samples from manured plots, but no E. coli were found in tile drain water from fertilized plots.[89] Table I-8 shows the nutrient concentrations in the runoff from feedlots and pastures.

Table I-8. Nutrient concentration in runoff from a dairy feedlot and manured pasture

Parameter	Dairy Feedlot	Manured Pasture
	——— mg/L———	
Chemical Oxygen Demand	1185	181
Total Kjeldahl Nitrogen	76	13.2
Nitrate-Nitrogen	4.5	8.0
Total Phosphorus	34	7.2

Source: Jacobson, Larry D., et al., Generic Environmental Impact Statement on Animal Agriculture, University of Minnesota, College of Agriculture, Food, and Environmental Sciences, http://www.mnplan.state.mn.us/eqb/scoping.html, September, 1999, p. G-35.

Dairy Waste Management and Land Application

This category has such large and complicated potential impacts on the surrounding economic and physical environment that it is the subject of the entire following section.

SECTION II

Dairy Cow Manure Handling

Note**:** It is claimed that when a cow is on rBGH (recombinant bovine growth hormone—used to stimulate milk production) their appetite increases dramatically as does their production of milk. Studies show that rBST is effective in raising milk yields by 14% if the cows are injected every two weeks and about 30% of American dairy cows are being injected.[90] However, published figures for waste excretion from dairy cows are usually based on data and information from animals raised without hormones. If the nutrition and production conditions arising from the use of rBGH are not taken into account, any calculation of waste generation may underestimate the amount of waste from cattle using rBGH. And if rBGH use is accounted for, the waste generated by any operation not using rBGH is overestimated. If the cattle do indeed lose weight and bone mass, and if they die earlier, then the chemical composition of the waste of rBGH-fed cattle is also likely to be different as will be the diets fed to these cattle and the water use per rBGH-fed cow.

(1) Dairy waste generation and storage

Dairy operations vary, and each operation presents its own unique problems. Many older dairy operations were not designed with sufficient consideration of waste management. As a result, a properly designed waste management system may require major modifications or alterations of existing facilities.

Dairy animals are typically managed on pastures in partial confinement. While animals are on pasture, their waste should not be a pollution concern if stocking rates are not excessive, grazing is evenly distributed, manure from other sources is not applied, and grazing is not allowed during rainy periods when the soils are saturated. To reduce pollution of streambeds, access to the stream can be restricted to stable stream crossings and access points.[91]

The primary goal of all waste treatment is to eliminate human pathogens. A secondary goal is to reduce the biochemical oxygen demand (BOD--the carbon and nutrient substrate for microbial decomposition) so that the waters that receive waste runoff do not become anaerobic. Finally, some heavy metals must be removed before the waste is discharged. In a sewage treatment plant for human waste, aerobic decomposition kills human pathogens and reduces the BOD while the settling process removes heavy metals to sludge which then must be safely disposed of.

One reason the concept of diminishing returns should be a powerful deterrent to large CAFOs is that the cost of responsibly handling and treating animal waste is so high. Anaerobic decomposition in animal waste lagoons is less effective at eliminating human pathogens and BOD, and it leaves heavy metals in the lagoon. As opposed to assumptions about its natural and thus, harmless, nature, livestock manure creates pollution with a strength that far exceeds raw municipal sewage. As Table II-1 shows, the BOD concentration in undiluted livestock waste is 160 times more powerful than raw municipal sewage and ammonia is 200 times more concentrated. Even after it has been flushed to lagoons, manure effluent is still 57 times more powerful than raw sewage.

Table II-1. Pollution strength of livestock and municipal waste

Type of Waste	BOD5 mg/l	Ammonia, NH_4N mg/l
Undiluted Livestock Waste	40,000	10,000
Manure Lagoon Effluent	14,400	-
Runoff From a Concrete Lot	1,000	-
Runoff From a Dirt Lot	500	-
Raw Municipal Sewage	250	50
Treated Municipal Sewage	30	1.5

Source: Understanding the Pollution Potential of Livestock Waste, Illinois Environmental Protection Agency, 1991.

Exposure of land-applied wastes to sunlight and microbial activity in the soil will generally finish the job of pathogen control, and the nutrients that affect BOD may be used by crop plants. In effect, application to farm land is a final step in the "treatment" of animal waste if the amount of land to which it is applied is sufficient to perform this function.[92] The need to apply animal waste from CAFOs to the land to destroy human pathogens in the waste exists whether or not methane is generated from the waste to create power. This, in turn, requires the construction of lagoons to hold the effluent until it can be applied to the land.

All of this implies that the dairy CAFO has enough land for responsible nutrient application, and it further implies that the number of animals at the dairy has been decided based on the amount of spreadable acreage available--and not vise-versa. It also implies a climate that is mild enough to allow year-round application, or sufficient, leak-free lagoon capacity to see the CAFO through the winter months. In sum, the requirement to spread the waste to kill pathogens creates a significant decision point in the ability of the CAFO to responsibly handle waste.

Securing the amount of spreadable acreage required by a CAFO is usually a daunting task. If the CAFO is located in areas where the climate is unfavorable for waste application for major parts of the year or where the soil is so poor that few crops are grown and little spreading can occur, spreading the waste on the land may simply be impractical. Many CAFOs have realized this and their response has been to simply put the waste in large lagoons until the liquid evaporates. This creates two major problems: first, lagoons leak and lagoon storage does nothing to destroy the pathogens in the waste. And second, the materials in the waste--nitrogen, phosphorus, heavy metals, and salts--are concentrated in pits for which there are usually no remediation plans even though they would qualify as hazardous waste dumps based on the chemical makeup of the materials.

No matter what collection system is in place, 100 percent of excreted manure is seldom recovered due to physical losses on the farm. A recent survey of Midwest confinement livestock farms, NRCS indicated that percentages of manure (feces and urine) recovered was eighty percent for lactating dairy cows, but only sixty percent for other animals on the dairy farm. Grazing animals will distribute the majority of their manure within the pasture system, so recovery for field application is not necessary, but manure is recoverable inside loafing barns, milking barns, and feeding areas.

(a) Manure output and milk production

One of the major factors contributing to animal manure output and composition is the feeding regimen and digestibility of the feed nutrients. A good example would be the changes in a typical lactation of a dairy cow. Daily and annual excretion estimates of various fractions and nutrients by Holstein dairy cows are shown in Table II-2. This example represents a cow producing 18,150 lbs. of milk per lactation which is about the average level found in herds on the Dairy Herd Improvement Association (DHIA) program, and also about the average production reported by dairy farmers. As milk production increases, the total amount of manure and the ratio of urine to feces increases. The digestibility of the feed averages 62 percent in this example with 38 percent of the dry matter intake (DMI) excreted. The example shows the effect of feeding varying dietary protein, phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) levels. It also shows typical outputs of sodium (Na) and chlorine (Cl).[93]

Phosphorus in the diet will require an additional acre of land per cow to dispose of manure and prevent potential P accumulation effects on the environment. Reduction of dietary P in dairy cow diets is becoming well accepted, and a dietary level of only 0.38% P appears to be adequate. At this level of phosphorus in the dairy cow diet, farmers have a better chance at avoiding P buildup in their soil. Proper balancing of total dietary protein and digestibility of protein for dairy cows at different production levels will help control nitrogen (N) excretion rates as indicated in Table II-2. The amount of K excreted is more critical from an animal health viewpoint since high levels of K in manure are taken up by plants and are returned in the forage.[94]

Table II-2. Daily and yearly excretion estimates of various fractions and nutrients by Holstein cows[a]

	Daily milk and dry feed intake for:				Total for
	0-30 days	31-70 days	71-205 days	206-365 days	Year
Milk, lb/cow	100	70	50	Dry	18,150
Dry feed intake, lb/cow	55.8	46.3	39.2	25.2	14,462
	Excretion for cow described in column above				
Fraction or Nutrient	lb/day	lb/day	lb/day	lb/day	lb/yr/cow
Raw manure (feces + urine)	195.0	160.0	125.0	80.0	47,475
Feces (wet)	125.0	100.0	75.0	45.0	28,825
Urine	70.0	60.0	50.0	35.0	18,650
Total solids (38% of DMI)	21.2	17.6	14.9	9.6	5,496
Volatile solids	17.7	14.7	12.4	8.0	4,580
Total N (NRC, low)	0.899	0.727	0.601	0.364	223
Total N (NRC, high)	1.030	0.846	0.698	0.439	260
Urea + ammonium N (NRC, low)	0.408	0.308	0.249	0.125	92
Urea + ammonium N (NRC,high)	0.500	0.391	0.319	0.178	118
P (diet 0.40% P)	0.123	0.115	0.107	0.101	40
P (diet 0.45% P)	0.151	0.138	0.126	0.103	46
P (diet 0.60% P)	0.235	0.208	0.185	0.151	69
K (diet 0.8% K)	0.296	0.265	0.239	0.201	88
K (diet 1.2% K)	0.519	0.450	0.396	0.302	146
Ca (diet 0.65% Ca)	0.242	0.217	0.195	0.164	72
Ca (diet 0.90% Ca)	0.382	0.333	0.293	0.227	108
Mg (diet 0.20% Mg)	0.102	0.086	0.073	0.050	27
Mg (diet 0.35% Mg)	0.185	0.155	0.132	0.088	49
Na (diet 0.35% Na)	0.145	0.127	0.112	0.088	42
Cl (diet 0.55% Cl)	0.197	0.178	0.161	0.138	60

[a] Adapted from (Van Horn, et al., 1996). Crude protein percent of total diet dry matter used in calculations for cows producing 100, 70, 50, and dry cows for "NRC (National Research Council -nutrient requirements for dairy cattle, 1989), low diets" were 16.0, 14.8, 13.8, and 11.0%, respectively. Respective crude protein percents for "NRC, high diets" were 17.5, 16.4, 15.3, and 12.0% of total diet dry matter.

Source: Jacobson, Larry D., et al., Generic Environmental Impact Statement on Animal Agriculture, University of Minnesota, College of Agriculture, Food, and Environmental Sciences, http://www.mnplan.state.mn.us/eqb/scoping.html, September, 1999, p. J-28.

Feed waste of 10 percent can result in an additional 40 percent of total solids in a dairy waste. Dairy cow stalls are often covered with bedding materials that improve animal comfort and cleanliness. Virtually all of the organic and inorganic bedding materials used for this purpose will eventually be pushed, kicked, and carried from the stalls and added to the manure. The characteristics of these bedding materials will be imparted to the manure. Quantities of bedding materials added to cow stalls and resting areas are shown in Table II-7.[95]

(b) Milk center waste

Milking centers—the milk house, milking parlor, and holding area—can produce about 50 percent of the waste volume, but only about 15 percent of the total solids in a dairy enterprise (Table II-3). Because this very dilute wastewater has different characteristics than the waste from the cow yard, it is sometimes managed by a different procedure. The values used to compute characteristics from milk houses are from research by Cornell University completed in 1979 in New York.[96]

About 5 to 10 gallons of fresh water per day for each cow milked are used in a milking center where flushing of wastes is not practiced. However, where manure flush cleaning and automatic cow washing are used, water use can be 150 gal/d/cow or more. Dairies employing flush cleaning systems use water in approximately the following percentages for various cleaning operations:

Parlor—cleanup and sanitation	10%
Cow washing	30%
Manure flushing	50%
Miscellaneous	10%[97]

Lagoons that receive a significant loading of manure, such as from the holding area or the cow feed yard, generally operate in an anaerobic mode (table II-4). Supernatant (upper liquid layer of the lagoon) concentration in an anaerobic lagoon is much greater than that in an aerobic lagoon. [98]

Sludge accumulates at a rate of about 0.073 cubic foot per pound of total solids added to the lagoon. This is equivalent to about 266 cubic feet per year for each 1,000 pound lactating cow equivalent if 100% of the waste is placed in the lagoon.[99] If a dairy waste lagoon receives wastewater only from the milk house or the milking parlor, the lagoon generally exhibits a very dilute supernatant and operates in an aerobic mode (Table II-4). The rate of sludge accumulation in such lagoons is slow.[100]

Table II-3. Dairy waste characterization—milking center

Component	**Units**	**- - - - - - Milking center* - - - - - -**			
		MH	**MH+MP**	**MH ****	**+MP +HA *****
Volume	ft^3/d/1000#	0.22	0.60	1.40	1.60
Moisture	%	99.72	99.40	99.70	98.50
TS	% w.b.	0.28	0.60	0.30	1.50
VS	lb/1000 gal	12.90	35.00	18.30	99.96
FS	"	10.60	15.00	6.70	24.99
COD	"	25.30	41.70		
BOD	"		8.37		
N	"	0.72	1.67	1.00	7.50
P	"	0.58	0.83	0.23	0.83
K	"	1.50	2.50	0.57	e3.33
C:N ratio		10	12	10	7

* MH – Milk house; MP – Milking parlor; HA – Holding area.
** Holding area scraped and flushed—manure excluded.
*** Holding area scraped and flushed—manure included.
Source: Agricultural Waste Management Field Handbook, US Department of Agriculture, Soil Conservation Service, April, 1992, p. 4-9.

Table II-4. Dairy waste characterization — lagoon

Component	**Units**	**- - - - - - Lagoon - - - - - - - - -**		
		- - - Anaerobic - - - -		**Aerobic***
		Super-natant	**Sludge**	**Super-natant**
Moisture	%	99.75	90.00	99.95
TS	% w.b.	0.25	10.00	0.05
VS	lb/1000 gal	9.16	383.18	1.67
FS	"	11.66	449.82	2.50
COD	"	12.50	433.16	1.25
BOD$_5$	"	2.92`		0.29
N	"	1.67	20.83	0.17
NH_4-N	"	1.00	4.17	0.10
P	"	0.48	9.16	0.08
K	"	4.17	12.50	
C:N ratio		3	10	

* Milk house and milking parlor wastes only.
Source: Agricultural Waste Management Field Handbook, US Department of Agriculture, Soil Conservation Service, April, 1992, p. 4-10.

(2) Dairy waste collection, transfer and storage

The first step in evaluating a manure-handling system is to estimate how much manure and wastewater are generated. The housing system used by the dairy influences the amount of bedding or dilution water used, which influences manure characteristics. Table II-5 lists manure production and nutrient content for typical dairy cow weights. The manure nutrient values are for fresh manure and urine without storage and handling losses-- variation can be expected due to animal age, feed ration, type of confinement, method of manure handling, and other factors. [101]

Manure containing less than 15 percent total solids (or more than 85 percent water) will be a slurry when mixed and can be handled as a "liquid." Generally, if the total solids are greater than 15 percent, as when bedding is added or drying occurs, the manure is handled as a solid. [102]

Table II-5. Manure production and nutrient content

Animal	Animal	Manure	Manure	Manure	N	P	K
Species	size, lb	lb/day	cu ft/day	Gal/day	------lb/day-----		
Dairy cattle	150	13	0.19	1.5	0.06	0.011	0.04
	250	22	0.32	2.4	0.11	0.023	0.07
	500	43	0.66	5.0	0.22	0.047	0.15
	1000	89	1.32	9.9	0.45	0.094	0.29
	1400	120	1.85	13.9	0.59	0.131	0.41

Source: Jacobson, Larry D., et al., Generic Environmental Impact Statement on Animal Agriculture, University of Minnesota, College of Agriculture, Food, and Environmental Sciences, http://www.mnplan.state.mn.us/eqb/scoping.html, September, 1999, p. J-27.

Solid manure is a combination of urine, bedding, and feces with no extra water added, such as that found in a loafing barn, bedded pack, calving pen, or open lot with good drainage. Semi-solid manure has little bedding and no extra liquid added. Little drying of semi-solid manure occurs before handling. Solid and semi-solid manure is generally handled with tractor scrapers, front-end loaders, or mechanical scrapers.

Liquid manure has water added to form a flowable mixture that can be handled by solids-handling pumps. Liquid manure is usually less than 8 to 10 percent solids. Very liquid manure is usually only 1 to 2 percent solids and is common with flushing and lagoon systems. Liquid and slurry manure are handled with scrapers, a flushing gutter, gravity-flow gutters, or storage under slotted floors. Liquids are spread on fields with tank wagons or irrigation.

Open-lot systems require scraping and open-front shelters for manure packs. Solid manure from a shelter or lot is moved to storage with a tractor scraper and front-end loader. A sheltered system can store manure in a tank under the building or in outdoor storage. For an under-the-building storage tank, manure is transferred through a slotted floor or drain plug and collected in the tank. With outdoor storage, manure is removed from the building with a mechanical or tractor scraper, front-end loader, flushing gutter, or gravity-flow channel. [103]

The manure in paved holding areas generally is easier to manage, and the areas are easier to keep clean. If the holding areas are unpaved, the traffic of the livestock tends to form a seal on the soil that prevents the downward movement of contaminated water. Care must be taken when removing manure from these lots so that damage to this seal is minimized.[104] Paved lots generally produce more runoff than unpaved lots. On unpaved lots, the runoff may be controlled by diversions, sediment basins, and underground outlets. The volume of runoff can be reduced by limiting the size of the confinement area, and uncontaminated runoff can be diverted if a roof runoff management system and diversions are used.[105]

The method used to transfer the waste depends largely on the consistency of the waste. Liquid and slurry wastes can be transferred through open channels, pipes, or in a portable liquid tank. Pumps can be used to transfer liquid waste as needed. Solid and semi-solid waste can be transferred by mechanical conveyance equipment, in solid manure spreaders, and by pushing them down curbed concrete alleys. Semi-solid waste has been transferred in large pipes through the use of gravity, piston pumps, or air pressure.[106]

<u>(3) Liquid Dairy Waste Systems</u>

Liquid handling is used in many dairy facilities with free-stall housing where manure is collected and removed from the barn with a tractor-mounted scraper, mechanical alley scraper, flushing system, or slotted floor. Depending on site conditions, manure can be stored in earth basins, below-ground tanks, or above-ground tanks. Common methods for transferring liquid dairy manure to storage include gravity, large piston pump, pneumatic pump, and centrifugal chopper pump.[107]

Free-stall manure with little added bedding can be transferred to storage by gravity. In general, 4 to 6 feet of elevation drop between the floor of the barn and full storage level is adequate for manure to flow over 100 feet. Terrain that slopes about 10 percent away from the barn for 250 to 300 feet can provide enough head pressure for both filling and emptying a liquid storage by gravity.[108]

A key factor in the design of any liquid-storage structure is provision for agitating the waste prior to irrigating or loading the tank spreader. Without complete agitation, solids will accumulate in the structure and reduce storage capacity. When placed in a storage structure, undiluted manure from cattle usually will develop a crust of floating solids. This crust helps control odors and should not be disturbed until the waste is agitated, just prior to field spreading.[109]

The principal advantage of the flush system for collecting manure is that it can be automated. To minimize the amount of water to be field spread, some means of recycling clarified wastewater for flushing may be desirable. In a flush system, a large volume of water flows from one end of a building to the other, down a sloped, shallow gutter. The water scours manure from the gutter or alley and removes it to a lagoon or storage. Two types are common on dairy farms:

* Wide open gutter, used in dairy free-stall alleys, holding areas, and milking parlors.
* Under-slat gutter, used in beef buildings where residue or disease transmission is a concern.[110]

Water may be recycled from a lagoon, holding pond, or earthen storage. If irrigating, producers may use fresh water for flushing rather than recycled water. In a flushing system, a pump transports either fresh or recycled water to a flush tank at the high end of the gutter. The flush tank periodically releases a large volume of water into the gutter. Some systems use a large-capacity pump operated by a time clock to supply flush water instead of a flush tank. Pump flushing uses much more water than tank flushing.[111] Table II-6 provides the volumes of water used per animal serviced by a flushing system.

	Gated tank	Pump flush
Gal/d/ft^2 alley surface	2.5	15.0

Gal/d/cow	80.0	550.0

Dairies that have gated tank flush cleaning and automatic cow washing commonly use 100 to 150 gal/d/cow, but multiple flushing and alternative equipment may double this amount.[112]

Table II-6. Recommended total daily flush volumes (MWPS 1985)

Animal type	**gal/head**
Swine	
Sow and litter	35
Prenursery pig	2
Nursery pig	4
Growing pig	10
Finishing pig	15
Gestating sow	25
Dairy cow	100
Beef feeder	100

Source: Agricultural Waste Management Field Handbook, US Department of Agriculture, Soil Conservation Service, April, 1992, p. 10-5.

(4) Semi Solid or Solid Dairy Waste Systems

Where adequate amounts of bedding are used to make manure stackable, manure can be stored on an open or covered stacking slab with or without retaining walls. Any rainwater that falls on the storage must be collected and contained in a storage tank, earth basin, or holding pond. [113] Solid handling is used by many dairy operations with comfort-stall or free-stall barns with added bedding. Typical manure storage time varies from 3 months or more to a few days with a daily haul system. An second, liquid-handling system is required for milking-center waste. (See 4 below) The storage area can be a stacking slab or covered storage. Roofed storage keeps out precipitation so manure can be handled as a solid or semi-solid.

(a) Estimating Solid and Semi-Solid Storage Capacity Requirements

A minimum storage capacity of 3 months is necessary, but for better management and hauling flexibility 6 months or more of storage capacity should be available. Storage capacity requirements are based on animal manure production, amount of bedding used, and any stored liquids (rain, snow, runoff). [114]

Table II-7. Daily bedding requirements for dairy cattle

	- - - - - - - - - - Barn type - - - - - - - - - -		
Material	Stanchion stall	Free-stall	Loose housing
	- - - - - - - lb/d/1000# - - - - - - -		
Loose hay or straw	5.4		9.3
Chopped hay or straw	5.7	2.7	11.0
Shavings or sawdust		3.1	
Sand, soil, or limestone		1.5	

Source: Agricultural Waste Management Field Handbook, US Department of Agriculture, Soil Conservation Service, April, 1992, p. 4-7.

To estimate the required storage volume of manure and bedding, add the manure production volume to half of the bedding volume because bedding volume is usually halved during use. If animals have access to an outdoor lot and manure from the lot is not added to the solid or semisolid storage, assume half the daily manure production volume when estimating storage capacity. Additional capacity would be required for drainage water, lot runoff, and, possibly, lot scrapings. Therefore:

> Storage capacity = Number of animals x Daily manure production {Tables II 2, 5} x Desired storage length in days + Half total bedding volume[115]

<u>(5) Milking-Facility Dairy Waste Systems</u>

(a) Human Waste

Toilet water from milking facilities must be handled separately from milking center wastewater. A septic tank/leach bed system is normally used. Milking-center toilet wastes may also be piped to the waste system of a nearby house. Under no circumstances should they be mixed into animal waste systems. [116]

(b) Milking Facility Waste

Milking house waste and contaminated runoff must be stored as a liquid in a waste storage pond or structure. Manure may be stored as a slurry or liquid in a waste storage pond designed for that purpose or in a structural tank. It can be stored as a semi-solid in an unroofed structure that allows for the drainage of excess water and runoff or as a solid in a dry stacking facility. In humid areas the stacking facility should have a roof. [117]

Both the daily volume and the strength of milking-center wastewater must be considered when designing milking facilities. Table II-8 provides estimated daily quantities of wastewater. As herd sizes increase, less water is used per cow because the milking equipment wash water does not increase proportionately. The values given are for facilities with parlors and they assume that holding areas are scraped and not washed down. Milking in stanchions produces less wastewater per day, and the quantity of wastewater from milk rooms will be only one-third to one-half of the values given in Table II-8. [118]

Table II-8. Estimated quantities of wastewater discharged from milking centers

Cows Milked	Quantity
Up to 50	7 to 10 gal/cow-day
50 to 150	4 to 6 gal/cow-day
More than 150	2 to 4 gal/cow-day

Source: <u>Ohio Livestock Manure And Wastewater Management Guide</u>, Bulletin 604, http://oh.nrcs.usda.gov/fotg/OhioNRCSstandards1.htm, 1979-1999 various.

(c) Food wastes and wastewater

Food processing of dairy products can result in considerable quantities of solid waste and wastewater. Many of these wastes can be used in by-product recovery procedures, and not all of the waste must be sent to disposal facilities. Food processing wastewater may be a dilute material that has a low concentration of some of the components of the raw product. On the other hand, solid waste from food processing may contain a high percentage of the raw product and exhibit characteristics of that raw