pork industry handbook

MICHIGAN STATE UNIVERSITY EXTENSION

Recirculation Systems for Manure Removal

(Key Words: Manure, Lagoon, Pit Recharge, Flush)

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The two types of recirculation systems used in swine production facilities are underslat flushing and pit recharge systems. Both systems use a shallow gutter that is flushed or drained periodically to remove waste from the building to the lagoon. Open gutter systems have been used in the past but are seldom used now because of concerns with disease transmission.

A flushing system operates by pumping water into a flush tank at the high end of the gutter. The flush tank periodically releases the water into the gutter (Figure 1). Tank size and flush frequency are designed to provide enough water to 'scour' manure from the gutter. Large volume pumps are sometimes used to provide flush water instead of flush tanks and smaller pumps. Spent flush water and manure enter the lagoon where it is treated and later reused for flushing. In areas where irrigation is practiced, fresh water may be used for flushing instead of recycled water and the flushed wastewater stored for later land application.

Pit recharge involves the periodic (one to three weeks) draining of the pit contents by gravity to a lagoon, then recharging the pit with about 12 inches of new liquid in less than four hours. Regular pit draining removes much of the manure solids that would otherwise settle and remain in the bottom of the pit. Liquification of settled solids increases their likelihood of removal at the next pit draining. With less organic matter available for bacterial digestion, there is less gas production in the dilute pit

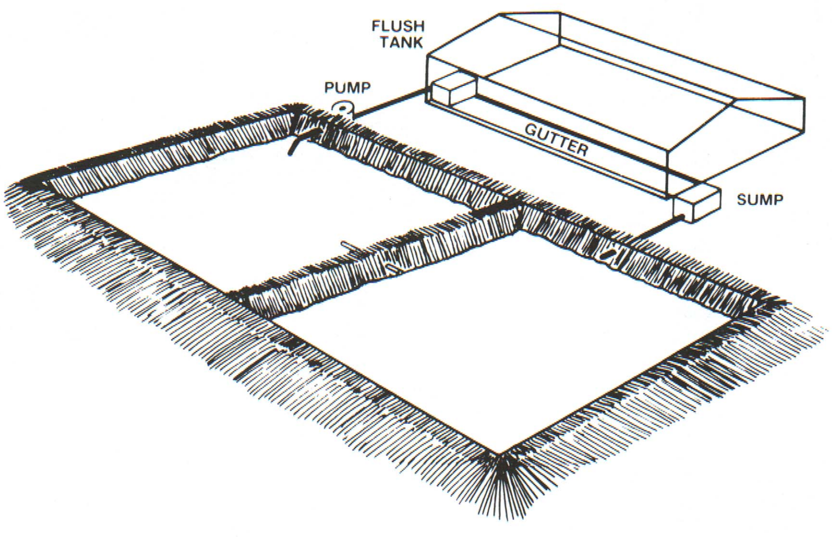

Figure 1. Perspective showing the components of a flush gutter system.

contents, and a better in-house environment results. In addition, fewer odorous gases are exhausted from the pits to the surrounding building vicinity. A reduction of corrosive gases decreases metallic equipment deterioration. Regular loadings of manure also enhance lagoon performance. In farrowing and nursery buildings, pits typically are drained and refilled between groups. During winter months, cleanup water may be used as refill water to minimize discomfort due to radiant heat loss from the small animals to cold recycled lagoon water.

Advantages and Disadvantages

Recirculation systems have the greatest appeal to operators who wish to store manure outside the building, and to those with suitable locations for lagoon construction. Assuming that the hog operation can accommodate a recirculation system, what are its advantages and disadvantages?

Advantages

- Reduces in-house gases and odors. Frequent removal of the manure significantly reduces the characteristic 'clinging' odor inside the building and improves air quality. A three-year study in North Carolina demonstrated that pit recharge systems have lower ammonia levels than either underslat flush or deep pit systems.
- Adapts to building conversion. Older buildings are more easily converted to shallow recirculation gutters than deep pits since less construction is required.
- Requires less land for manure application since up to 80% of the fertilizer nutrients are lost in the lagoon. (It should be noted that the P and K are concentrated in the lagoon sludge and may eventually be land applied.)

Disadvantages

- Greater nutrient loss. Lagoon-treated animal manure has a greater nutrient loss than manure stored under a slotted floor.
- Requires a relatively large land area. A lagoon takes 4-6 times more land area than the building itself.
- Subject to mechanical problems. A recirculation system has mechanical components, flush tanks and pumps, that are subject to breakdown.
- Lagoons are a potential odor source if not designed and operated properly. They are not suitable in some locations, due to prolonged cold weather or proximity to neighboring residences.
- Higher humidity caused by flushing may require a higher ventilation rate in cold weather.

Basic Parts of a Recirculation System: Design and Operation

Pit Recharge System

A pipe from the main recharge line is installed into each pit, preferably as far as possible from the drain outlet. However, the location of this recharge pipe is not critical since liquid addition to the pit is the objective rather than a high velocity scouring action for flushing. The inlet pipe can be either stubbed directly into the pit wall with a conveniently located and protected butterfly valve outside the building, or it can enter the building wall near ceiling level and drop down to the pit with an inside-the-building valve. The diameter should not be reduced between mainline and pipe discharge.

The discharge point should be located between the slotted floor and maximum pit liquid level. The recharge system can be managed successfully with a flat pit floor, although a minimum slope of 1 inch in 20 feet to the drain is recommended to overcome uneven concrete construction. Enough pit depth must exist to cover the upper end of the pit floor with at least 6 inches of liquid while leaving at least 12 inches between the slats and the liquid at the highest part of the pit floor.

Under Slat Flush Gutter Design

At least one-third of the floor area should be slotted. Manure removal from a flushed underslat gutter depends on the velocity, depth, duration and frequency of the flush. These factors are determined by the dimensions and slope of the gutter and by the rate flush water is added to the gutter. To adequately clean the gutter a flush velocity of at least 2.5 ft per second is needed. A minimum of a 2.5 in. depth of flow with at least a 10 second flush is recommended. For channels longer than 150 ft or with flushing devices which have a longer flush duration, such as siphons, increase the flush volume proportionally to provide the needed cleaning action. A rule of thumb is to increase the initial depth of flow by 50%, or 0.5 in. for each 25 ft of gutter length beyond 150 ft.

The flush device determines the initial depth of water flow. For instance, a 3 in. siphon provides water for only about a 1 in. depth of flow in a 24 in. wide gutter, whereas larger siphons provide greater depths and can flush wider gutters. Since 3 in. and 4 in. diameter siphons release water in about 30 seconds, flush volume must be increased to compensate for the lower flowrate. A 'tipping bucket' flush tank can deliver a 3 in. depth of flow in almost any width gutter with a 5 to 10 second release, while the door opening and volume of a 'trap door' tank can be designed to provide almost any depth of flow and flush duration.

Consider depth of flow in selecting the gutter slope. Table 1 presents the recommended slopes for flushed gutters with various initial flow depths. To achieve the same cleaning action with less gutter slope, a greater depth of flow is required.

Table 1: Recommended slope for flushed gutters.

Initial depth of flow (in.)	Underslat gutter slope (%)
2.5	1.50
3 or greater	1.25

Slightly crown (1/4 in.) the gutter floor and give a smooth finish. Gutters wider than 4 ft should be subdivided into widths of 1.5 to 2 ft except for the first 10 ft to 20 ft to allow the flush water to evenly distribute across the gutter width. This keeps water from channeling around waste deposits as it moves down the gutter. Inverted concrete hog slats or 6 in. vinyl strips or 1x6 P.T. plank embedded in the floor work well for this purpose (Figure

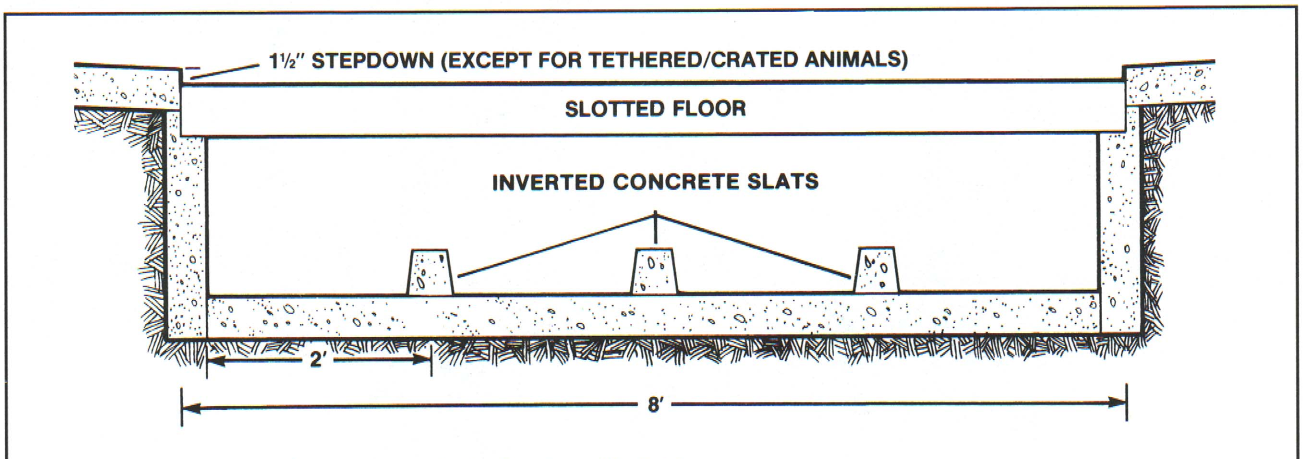

Figure 2. Cross section of an underslat flushed gutter with dividers.

2). For gutters longer than 200 ft, consider draining both ends toward the middle of the building, and consult a knowledgeable building engineer for assistance.

Wherever possible, use gravity to carry waste to the lagoon. Generally, a sewer line 8 in. in diameter with a 0.5% slope is sufficient to carry manure to the lagoon. For flush tanks larger than 1000 gal or where the same sewer must handle several flush tanks, contact a knowledgeable engineer to determine if a larger sewer line or additional slope is needed. Locate a sump pit at the discharge (or runoff) end of the flushing gutter to collect the spent wastewater. The drain line to the lagoon should be vented.

Table 2: Minimum required volume of flush water/day.

Type of animal	Flush volume (gal)
Sow and litter	35
Nursery pig	4
Finishing pig	15
Gestation	25

Table 3: Minimum gallons of water required to flush gutters at various depths of flow (5-10 second release).

Initial depth of flow (in.)	Gal/ft of gutter width
2.5	45
3.0	52
3.5	60

Table 4: Tank discharge rates required to flush gutters at various depths of flow.

Initial depth of flow (in.)	Discharge rate (gal/min) per ft of gutter width
2.5	190
3.0	225

Flush Equipment Design

Flush Frequency

The required frequency of flushing is determined by two factors-animal density and the solids-carrying capacity of the water. The minimum flushing frequency can be determined by dividing the total daily flush volume (Table 2) by the recommended flush volume (determined by channel geometry in Table 3). Flush frequencies range from twice per day for farrowing, nursery, and gestation buildings to four times per day for finishing buildings. When underslat gutters are flushed manually, the volume per flush is determined by simply dividing the flush volume per day by the number of flushes per day. Odors from underslat floors can be lessened by flushing at least four times a day, although pit ventilation in addition to frequent flushing is needed for best control of ammonia odors.

To insure cleaner pens in partially slotted buildings, keep hog density at about 4 sq ft per 100 lb of animal weight and use solid partitions except at the gutter area to help establish the desired dunging patterns. Producers may need to floor-feed pigs during their first week in the building to help establish good dunging habits on partially slotted floors. A 1.5 in. stepdown to the slats from the solid area also helps establish desired dunging habits.

Flush Devices

Several types of flush devices have been developed to provide the required flush volumes; automatic siphon tanks, tipping buckets, trap door tanks, manual dump tanks and large volume pumps.

Automatic siphon tank: This tank has the singular advantage of no moving parts (Figure 3). As the tank slowly fills with water, an air bubble trapped under the bell is forced out a siphon pipe until it triggers the siphoning action. An automatic siphon tank can be placed above the pens to reduce tank floor space requirements.

Commercially available 8 to 24 in. diameter automatic siphons can handle very large volumes of water. These flush units use a 1-1/2 in. air-release pipe to trigger the large siphon. Large siphons are well suited to flushing underslat gutters.

Tipping tank: A tipping tank dumps when it fills to a depth where the center of gravity of the water volume

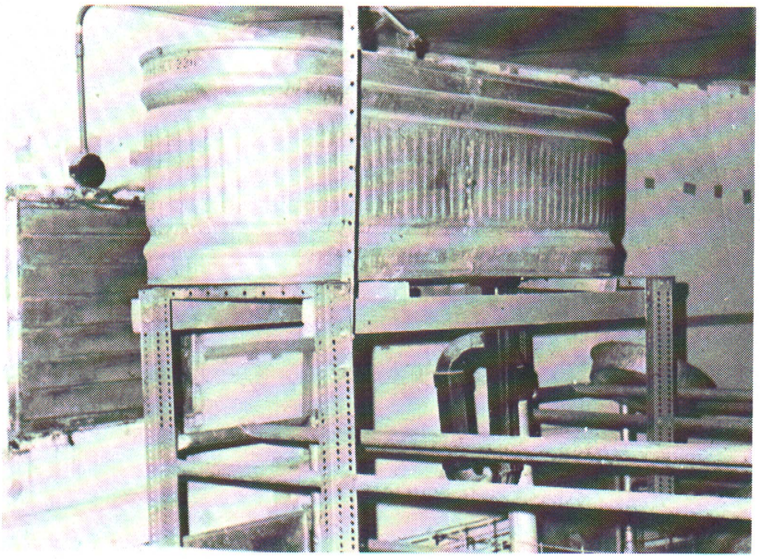

Figure 3. An elevated automatic siphon tank being used in a farrowing house.

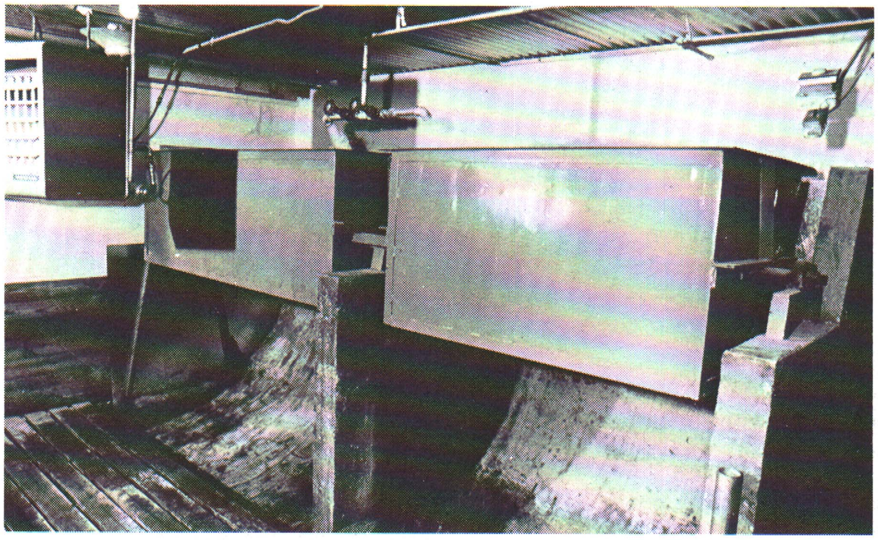

Figure 4. Tipping bucket tank used for flushing underslat gutters.

overbalances the pivot point. Usually the tank is elevated 4 to 6 ft off the floor and the water is dumped backwards onto a curved spillway. This increases the velocity and lowers the head of water so it will clear a 9- to 10-inch opening between the bottom of the first slat and the surface of the gutter. Because the water discharges all at once, flushing velocity and depth are high and can cover a gutter 8 to 10 ft wide (Figure 4). Splash guards may be necessary in the first pen.

Trap door tank: This flush tank has more moving parts than either of the above but allows greater design flexibility because both tank volume and trap door can be modified to meet individual needs. Care and precision are necessary to get a water-tight seal around the door.

An automated version of the trap-door or hinged-gate valved tank gives the flexibility of more frequent flushings when the operator is not present. The valve consists of a float-controlled flat plate which sets against a section of the PVC pipe in the tank bottom.

Manual flush tank: Manual tanks are best suited to twice-a-day flushing in underslat systems. These are most commonly found in farrowing houses where the operator is present several times a day. Figure 5 shows a simple but effective manual flush tank.

Large volume pumps: Large volume pumps can be used for flushing if sized to provide at least 100 gpm per ft of gutter width, about 1-1/2 in. water depth. The pump should operate 4 to 5 min per flush channel at least two times a day for adequate flushing. Since additional cleaning is possible by operating the pump for a longer period, depth of flow does not need to be as great as with flush tank and flow dividers become more important.

Waste Treatment Lagoons

A properly designed and operated lagoon is essential to the success of a flushing system (Figure 6). Although a single stage lagoon can operate satisfactorily in an underslat flushing system, a two-stage lagoon is preferred to minimize odor and potential disease transmission.

The design criteria for lagoons used with recirculation systems are the same as for conventional swine manure lagoons. See PIH-62, “Lagoon Systems for Swine Waste

Treatment," or MWPS-18, "Livestock Waste Facilities," available from Midwest Plan Service, for design information on lagoons in your area.

Pumps and Pipes

In recirculation systems, pumps transport effluent from the lagoon to the building. In some cases, pumps are also needed at the low end of the gutter to transport wastewater to the lagoon.

Lagoon-to-Building Pump

In pit recharge, a low-pressure, self-priming centrifugal or submersible pump with enough flow capacity to recharge the largest building pit with 12 inches of liquid in 4 hours or less is normally recommended. The pump intake is generally an open-ended suction pipe floating approximately 18 inches beneath the liquid surface of the lagoon, but may be screened with a 1-inch wire mesh fence or a basket with a diameter at least five times the suction pipe diameter.

Slow speed pumps (1725 rpm or less) cost more initially but usually last longer than higher speed pumps (3450 rpm). Because of their shorter service life, it is a good idea to keep a replacement pump on hand. Minimize the use of metal parts in contact with recycled lagoon water to prevent salt deposition which can plug the line.

A lagoon-to-building pump can be placed on the lagoon bank in an insulated enclosure or in a wet-well sunk in the bank (Figures 7 and 8). The pump must be protected from freezing weather.

The intake pipe from the lagoon to the wet-well should be at least 18 in. below the lagoon surface, several feet from the bank and as far away as practical from the point where the waste enters the lagoon. Locate the pump as close as practical to the high water level of the lagoon (preferably below the low water level using a flooded suction) to minimize pump priming problems.

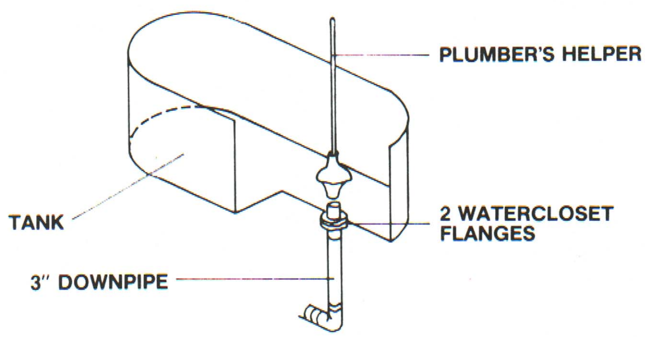

Figure 5. Cut-away view of manual flush tank.

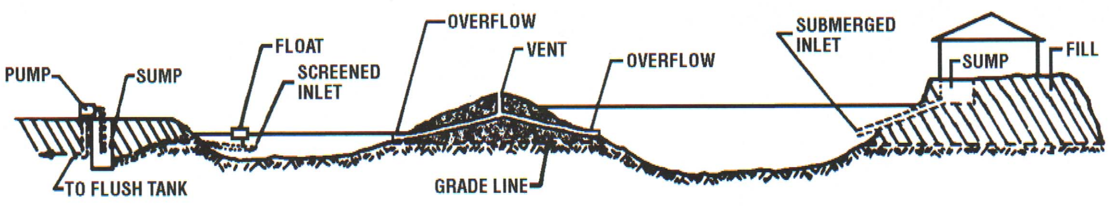

Figure 6. Cut-and-fill construction for two-stage swine waste lagoon system.

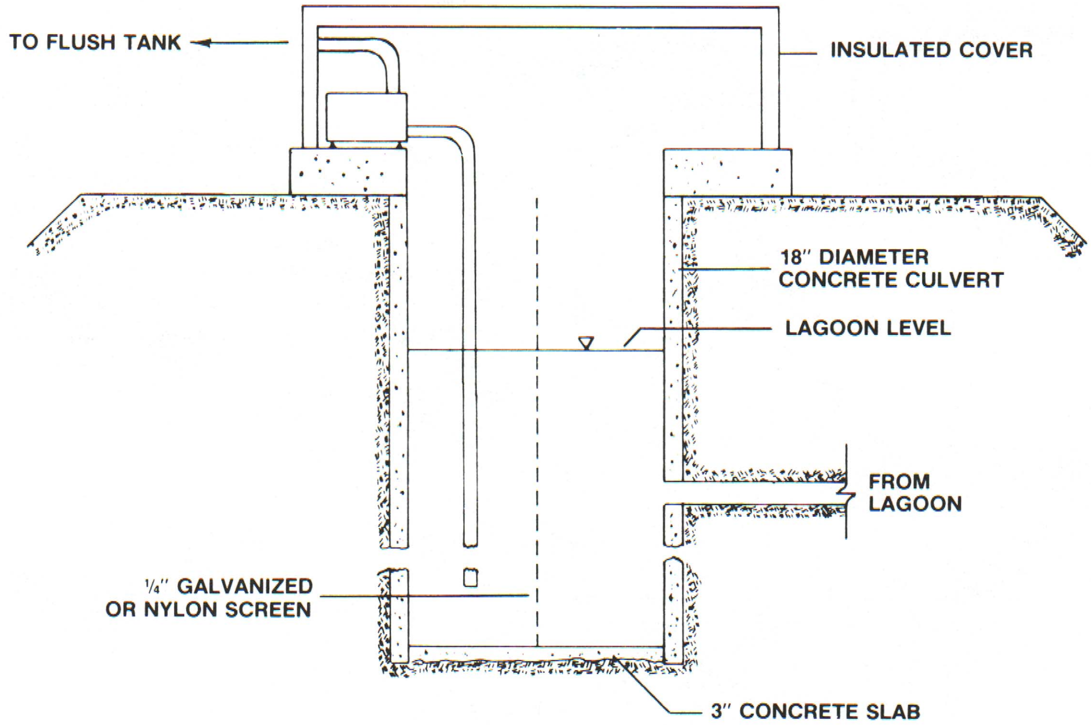

Figure 7. Diagram of a wet-well configuration.

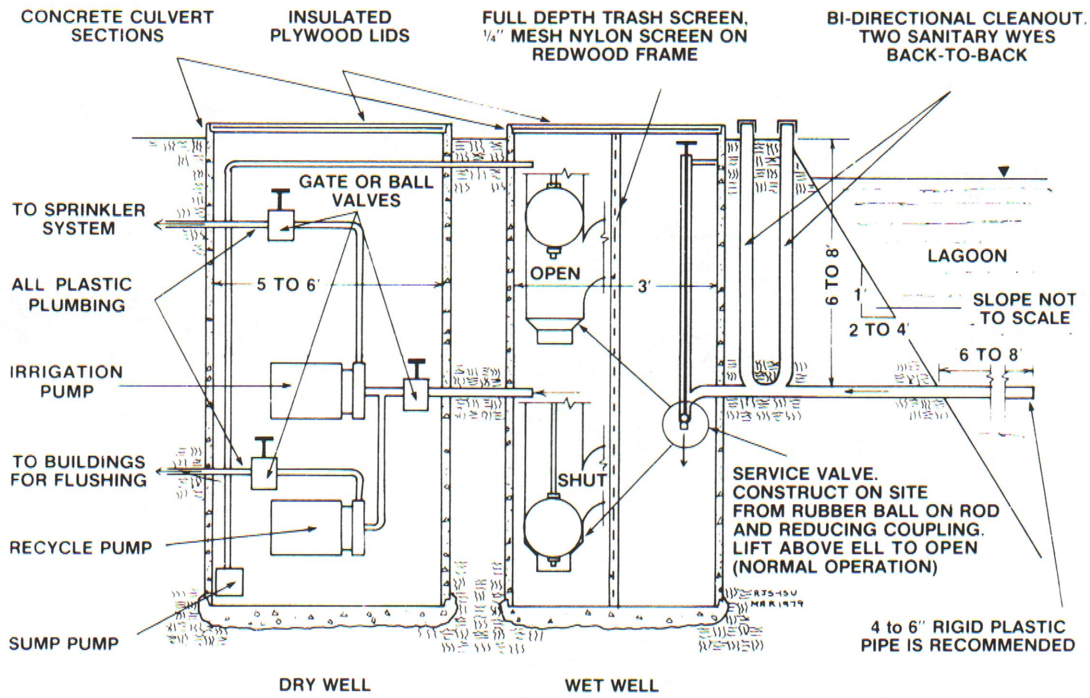

Figure 8. Pumping from a lagoon using a wet-well and dry-well configuration.

Flush Gutter-to-Lagoon Pump

If a pump is needed to lift effluent from the building to lagoon, it should be a commercial grade, sewage lift-type activated with a float switch. Pump capacity should be determined in relation to the size of the sump which collects the spent wastewater to adequately handle the highest flow rate resulting from the flush tank discharges. Pump intake should have adequate cleanable screen area.

Piping

The pipe from the lagoon pump to the gutter can be relatively inexpensive plastic pipe and, if possible, should be one continuous piece. See Table 5 to determine the size you will need.

Salt Deposition Problems

If water is recycled from the treatment lagoon, salt buildup in pumps and pipes is a common problem. Avoid sharp turns in the supply pipe because they add to pressure drop and create turbulence conducive to salt precipitation. Regular addition of dilution water to the lagoon and removal of salts by irrigation will reduce problems. In most areas of the U.S., add a volume of dilution water which is equal to the volume of waste added. Use fresh water, lot runoff, roof runoff or other sources for dilution water.

Dilute acetic or hydrochloric (muriatic) acids can be used to dissolve salt deposits. Muriatic acid can be bought in paint and hardware stores and is usually available at 20% solution. Plastic pipe can be dosed with undiluted 20% muriatic acid solution by filling the piping system with this acid, letting it stand overnight and then flushing the acid solution through the system. If possible, field spread this acidic high salt material at a very low rate, rather than back to the lagoon. If the flush system has metallic parts such as pump housing or metal valves, the acid should be diluted (1 part acid to 12 parts water) to prevent damage to the metal. CAUTION: DO NOT ADD WATER TO CONCENTRATED ACID! WHEN MAKING THE DILUTION- ALWAYS ADD THE CONCENTRATED ACID TO WATER. Use care and wear protective equipment because mixing acid can be very dangerous!

Table 5: Recommended pressure pipe sizes for various flow rates (Max. flow velocity = 2.5 fps).

Pump capacity (gal/min)	Pipe diameter (in.)
10	1.5 Minimum
20	2.0
30	2.5
50	3.0
75	3.5
100	4.0
200	6.0
400	8.0
600	10.0
800	12.0
1000	12.

The following recommendations can reduce the rate of salt buildup on a recycling system:

- Ground the electric pump-housing to prevent an electrostatic charge from building up on the metallic parts of the pumping system. Even if the pump is grounded through the electrical system, ground the pump by attaching a cable to the pump-housing and to a ground rod driven into damp soil.
- The pump suction line must be large enough to prevent cavitation (excess turbulence, resulting in a sharp pressure drop and increased salt deposition). A rule of thumb is that the suction line should be one standard size larger than the discharge of the pump. Locate the pump below or as close to the lagoon water level as possible to minimize the suction lift.
- If the pump does not run continuously, modify the system so the pipes can drain between use.
- The pipe from the lagoon to the gutter should have a minimum diameter of 1-1/2 in. The problems are not as great in larger lines as they are in smaller ones.
- Consider oversizing the supply pump and piping system, operating it on a timer and allowing the system to drain when not in use. While more expensive to purchase, contact time between the pump and pipes and the lagoon water can be greatly minimized in this manner.

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Worksheet for Designing and Equipping Recirculation Systems

Example Situation

A farmer wants to construct a 300 head finishing room (160 lb average). He is considering either an underslat flush or a pit recharge system with a lagoon. The building will be 36 ft wide x 76 ft long with a total slotted floor under the pens. Pen size will be 8 ft x 16 ft with 16 pigs per pen and a solid floor center aisleway. From the above assumptions and the information in this publication, design the manure collection system and determine types and sizes of equipment needed.

Calculations	Our Example	Your Situation
Underslat Flushed Gutter Option		
1. Determine dimensions of gutters. a. Gutter width: 16 ft gutter width with dividers 2 ft o.c. b. Initial depth of flow: See Table 1 for recommendations. c. Gutter slope: From Table 1	 16 ft 2.5 in. 1.5%	 ________ ________ ________
2. Determine flush volume and tank capacity: a. Required daily flush volume: Number finishing hogs (300) x gal of flush water per head per day (15 gal from Table 2). b. Minimum flush volume: From Table 3 (45 gal/ft of gutter width); if gutter is longer than 150 ft increase volume by 50%. Total flush volume: gutter width (16 ft) x 45 gal/ft = 720 gal. c. Flush volume for desired flush intervals. If tank is to be flushed 5 times a day, tank capacity should be 1/5 the total flush volume (Step 2a): e.g., 4500/5 = 900 gal (must be equal to or greater than 2b)	 4500 gal 720 gal 900 gal	 ________ ________ ________
3. Determine size of return pump from the lagoon to flush tanks. a. Pump capacity to supply required flush volume: Step 2a (4500 gal/1440 minutes per day. b. Minutes between flushes: Step 2b [(640 gal) x no. tanks per pump (2)]/Step 3a = 256 min (In this example, 3.1 gpm. However, assume a 10 gpm. pump is available and will be used).	 3.1 gpm 128 min	 ________ ________
4. Determine size of return pipe (lagoon to flush tanks).* a. Select from Table 5 using flow rate for pump selected in Step 3.	 1.5 in.	 ________
Pit Recharge Option (Calculations)		
Determine drop in gutter floor due to slope: Step 1. Assume the gutter slopes 1 in./20 ft. In 76 ft, this is 1 in./20 ft x 76 ft = 3.8 in.	3.8 in.	________
Step 2. Gutter width (16 ft wide with dividers 2 ft o.c.)	16 ft	________
Step 3. Gutter recharge depth at high end: minimum depth of 6 in.	12 in.	________
Step 4. Gutter volume if floor were level: length x width x depth at high end (step 3). 76 ft x 16 ft x 1 ft = 1216 cu ft	1216 cu ft	________
Step 5. Gutter volume due to sloping floor: 1/2 x drop (step 1) x length x width 1/2 x 3.8 in. x 1 ft/12 in. x 76 ft x 16 ft = 129 cu ft	193 cu ft	________
Step 6. Total recharge volume: step 4 + step 5 1216 cu ft + 193 cu ft = 1409 cu ft	1409 cu ft	________
Step 7. Total recharge volume in gallons: step 6 x 7.5 gal/cu ft = 10,568 gal	10,568 gal	________
Step 8. Recycle pump capacity needed to charge pit in 4 hr: step 7/(4 hr x 60 min/hr) = 44 gal/min	44 gal/min	________

*Consider a larger pump and piping system and operating with a timer and float to minimize contact with corrosive lagoon water and salt deposition. A good rule of thumb is to operate the pump no more than 2 hr/day total.