Systems of Runoff Control
Michigan State University
Cooperative Extension Service

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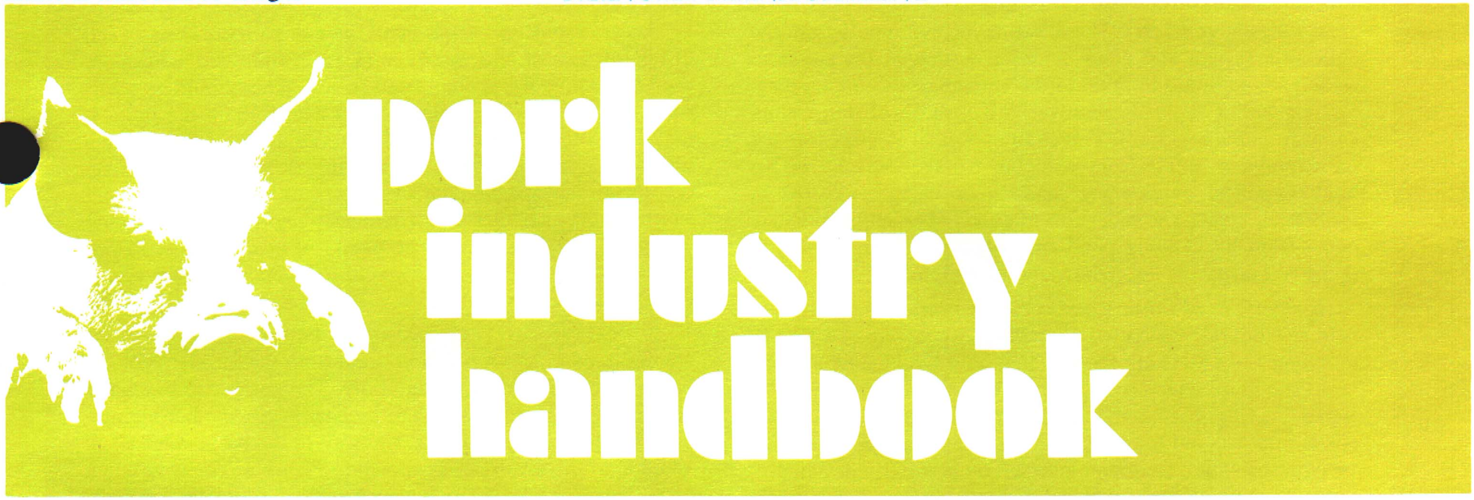

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Runoff from open feedlots contains animal manure and spilled feed and other materials which should not be allowed to enter streams or other surface waters. Runoff control is mandatory in most states, and satisfactory methods of control are available for almost every situation. These may be simple or elaborate, and they can range from relatively low cost to quite expensive. Almost every system is different. Each system requires individual planning to account for physical variations in lot size, rainfall, configuration, topography, soil types and other factors. Proper design should reflect differences in such factors as lot management and local regulations.

The basic principles of controlling runoff are very similar throughout the country. They require you to keep the clean water clean and to minimize, collect, store and apply contaminated runoff water to the land.

This publication provides guidelines for planning runoff control systems. Names of system components tend to vary from state to state, so more than one name for the same component may be used. A common configuration for runoff control systems is illustrated in Figure 1.

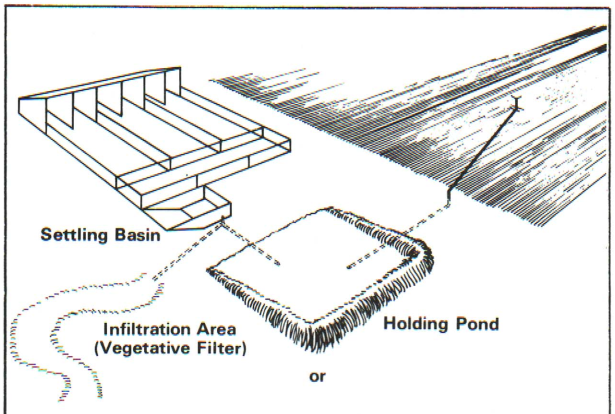

Figure 1. Runoff control system configurations.

Rainfall and snowmelt are major sources of runoff; urine and leakage from waterers create runoff in some situations. Design flow and storage capacities are based on rainfall intensities and amounts, and the surface area producing runoff. Research has shown it is seldom practical to treat runoff for discharge to surface waters. In the systems to be discussed, land application is the only disposal method considered.

Runoff Control System Components

Clean Water Diversion

To minimize the amount of water handled through a runoff control system, unpolluted outside surface water should be prevented from entering the lot. This includes runoff from building rooftops. Use roof gutters and downspouts for roof water, and terraces and channels for surface drainage. Diversion channels and terraces may be either earthen or paved, with earthen used most commonly because of the low cost.

Runoff Collection

Lot runoff is collected and directed to the settling and storage components of the runoff control system. Some lots may have a single outlet point, making collection simple. Others with slopes in more than one direction or with multiple outlet points may require complex collection systems or more than one settling-storage system. Curbs, terraces, channels, dikes, pipes and culverts are examples of components used to collect and direct lot runoff to settling facilities and/or to storage and application.

Settling Basins (Debris Basins)

Settling basins are commonly used to remove solids from the lot runoff before they enter holding ponds or infiltration

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areas (vegetative filters). These basins receive runoff from the collection system and allow a major portion of the solids to settle and the liquid to drain to the storage or infiltration area. Settling basins typically remove 50% to 85% of the manure solids from the lot runoff. This is an important step because the basin prevents solids from reducing storage capacity in the holding ponds, overloading lagoons or being deposited in infiltration areas. The reduction of solids also helps minimize odors from the holding pond and makes the liquid easier to pump and distribute through irrigation equipment.

Many types of settling basins can be used, including channels and boxes constructed of earth and concrete. Two common types of basins are those which hold liquid (like a septic tank) and those which collect runoff that slowly drain dry. The liquid holding basins require liquid manure equipment for solids removal and transport; the drain-dry settling basins can be emptied with a front-end loader. The best basin design provides a relatively large surface area and shallow depth, probably less than 3 feet deep if solids are to be removed from the basin with conventional solid manure handling equipment.

In arid areas, the basins dry out readily. Earthen basins may be satisfactory, but a concrete bottom is generally recommended in all systems. In humid areas, concrete bottoms or complete concrete basins are necessary so equipment can enter the basin for clean-out.

Access ramps to basins should not slope more than 1 inch of fall per foot of horizontal run (1:12) if front-end loaders are used to remove the accumulated solids. When liquid or semi-solid manure handling equipment is available on the farm, it may be easier to handle the manure as a semi-solid or as a liquid. The frequency of basin cleaning depends on basin size, type of lot surface, amount of manure on the lot surface and storm runoff characteristics (frequency and amount). In some instances, cleaning may be necessary after each large storm, but a cleaning frequency of two- to four-times per year seems to be adequate in most cases.

Several types of basin outlets can be used, some of which are designed to allow liquid to drain from the full depth of the basin which allows the solids to dry. The perforated or slotted pipe riser shown in Figure 2 is an example. Another alternative is to use a weir notch or spillway in the basin sidewall in addition to the pipe riser as shown in Figure 3. The weir notch or spillway can be fitted with a piece of metal that extends below the liquid surface to keep floating solids from flowing out the spillway. Most types of outlets develop clogging problems periodically, which usually can be dealt with by manual cleaning.

Basin outlets also can be a weir notch or spillway without a slotted riser pipe. With this method, liquid always remains in the basin, and cleaning must be done by liquid manure handling equipment. Overflow liquid from the settling basin may

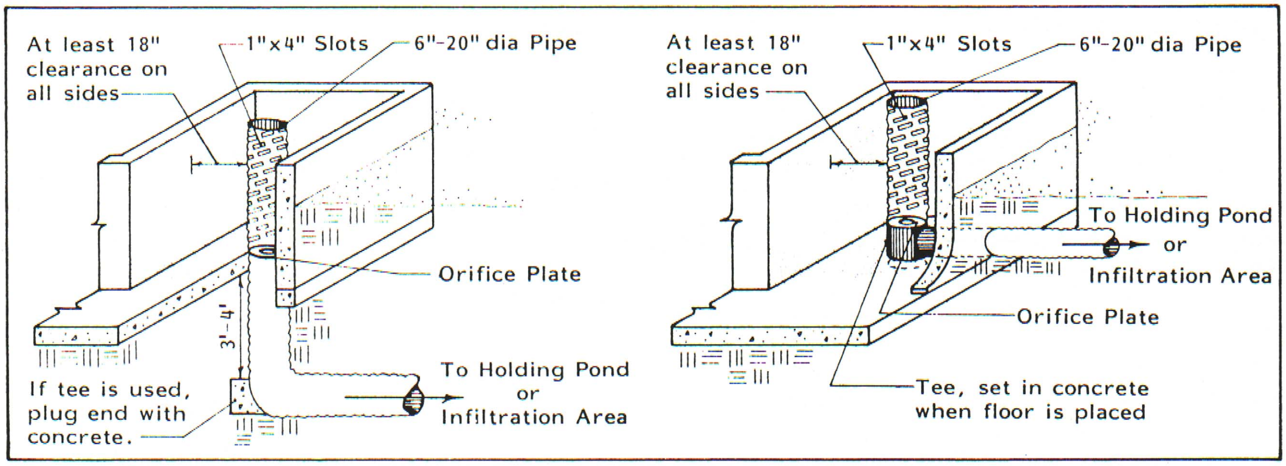


Figure 2. Riser pipe outlets for settling basins. See Midwest Plan Service publication MWPS-18 for design detail for the risers. Reproduced with permission from: ***Livestock Waste Facilities Handbook,*** **MWPS-18, 2nd Edition, 1985(c) Midwest Plan Service, Ames, IA 50011-3080.**

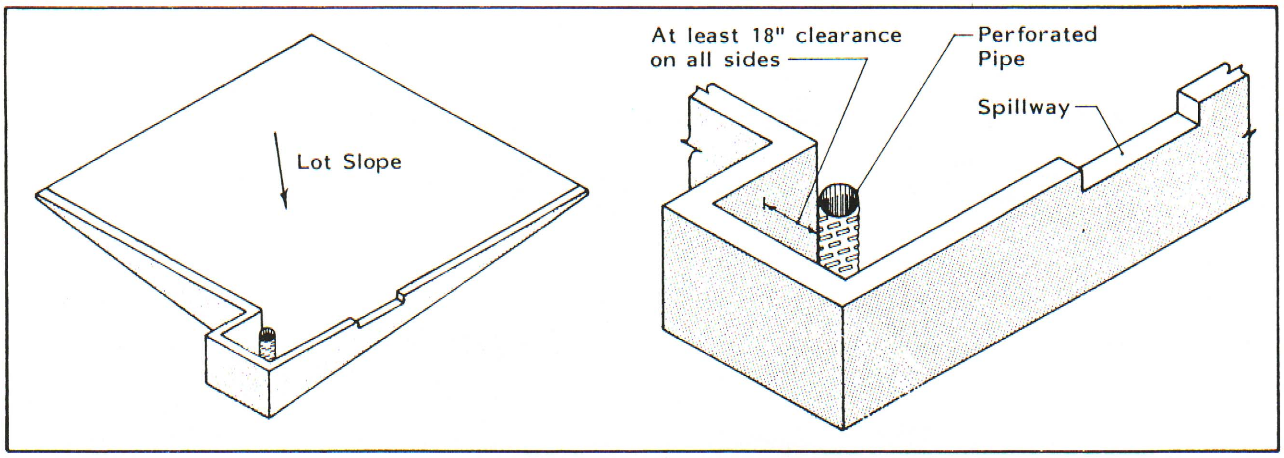


Figure 3. Setting in corner of lot. Settling basins can sometimes be located within a larger lot, if out of main animal traffic routes. Note the emergency overflow for larger storms. Reproduced with permission from: ***Livestock Waste Facilities Handbook,*** **MWPS-18, 2nd Edition, 1985(c) Midwest Plan Service, Ames, IA 50011-3080.**

be pumped or may flow by gravity to storage or the infiltration area, either through underground pipe or open surface channels. Several states in the U.S. base settling basin capacities on a desired storage volume of solids plus temporary storage from storm runoff; for others, it is based on the minimum detention time for a given amount of runoff. Recommended capacities are in the range of 5 to 10 cubic feet per 100 square feet of feedlot area. Recommended settling basin design criteria vary greatly from state to state.

No single design criterion is necessarily best, and no attempt will be made to specify how settling basins should be sized and what their configuration should be. See the Midwest Plan Service publication MWPS-18 for design specifics. Research has shown that most of the solids in runoff that will settle, will do so in less than 30 minutes. Therefore, a retention time of 30 minutes in the settling basin can be used as a design criterion, where no other design criterion is available. Check with your Extension Agent and the Soil Conservation Service office for additional information.

Holding Ponds

The purpose of a holding pond is to store runoff temporarily before final application on land. It is not meant to be a treatment lagoon facility. Almost all holding ponds are of earth construction. In arid areas, evaporation from holding ponds may be adequate for removing the water. The remaining solids will need to be periodically removed and spread on land. For the rest of the country, it is necessary to empty the ponds by other means, usually pumping. Properly designed and constructed holding ponds tend to seal themselves naturally, so seepage losses are not usually a problem. When ponds are constructed in coarse sands and gravels, near fractured bedrock, or in high water table soils, sealing by lining with clay or plastic may be necessary. Be aware that when ponds or manure storages are emptied the seal may be lost, the earth/liner can dry and crack, and seepage may be a problem. Check local and state requirements on using liners and the seepage prevention requirements.

A certain amount of holding pond management is necessary, primarily timely emptying. In general, holding ponds should be pumped down whenever land conditions allow application without runoff or damage to growing crops. Doing so provides adequate storage capacity in the pond to retain lot runoff from the next rainfall. When ponds are sized large enough (Table 1) to provide several months' storage, the added flexibility may allow emptying to be scheduled to avoid frozen or saturated ground and to make maximum use of the nutrients or the stored water for supplemental irrigation.

Table 1. Values of holding pond length (in feet) for various depth and interior widths to provide a selected usable volume.

Useable volume (cu ft x 1,000	Total depth 6 ft					9ft					15 ft				
	Interior width (ft)					Interior width (ft)					Interior width (ft)				
	50	75	100	150	200	50	75	100	150	200	50	75	100	150	200
3	34														
4	41	31													
5	47	34													
6	53	37	31			50									
7	59	41	34			55									
8	65	44	36			60									
9	71	48	39	31		65									
10	77	51	41	32		70	47								
11	84	55	44	34		75	50								
12	90	58	46	35	30	80	52								
13	96	62	48	37	31	85	55								
14	102	65	51	38	33	90	57	47							
15	108	69	53	40	34	95	70	48							
16	114	72	56	41	35	100	62	50							
17	121	76	58	43	36	105	65	52							
18	127	79	61	44	37	110	67	53							
19	133	83	63	46	38	115	70	55							
20	139	86	65	47	39	120	72	57							
22	151	93	70	50	41	130	77	60	46						
24	164	100	75	53	44	140	82	63	48		77				
26	176	107	80	56	46	150	87	67	50		81				
28	188	114	85	59	48	160	92	70	52		85				
30	201	121	90	62	50	170	97	73	54	46	90				
32	213	128	94	65	52	180	102	77	56	47	94				
34		135	99	68	54	190	107	80	58	49	98				
36		142	104	71	57	200	112	83	60	50	102	76			
38		149	109	74	59	210	117	87	62	51	106	78			
40		156	114	77	61	220	122	90	64	53	110	81			
45		173	126	85	67		135	98	69	56	120	87			
50		191	138	93	72		147	107	74	60	130	93	77		
55		208	150	100	77		160	115	79	64	141	99	81		
60		225	162	108	83		172	123	84	67	151	105	86	75	
65		243	174	115	88		185	132	89	71	161	111	90	78	
70		260	187	123	94		197	140	94	74	171	117	94	82	
80		295	211	138	105		222	157	104	81	192	128	102	88	
90		330	235	153	116		247	173	114	89	212	140	111	95	78
100			259	168	127		272	190	124	96	232	152	119	101	82
150			381	244	182			273	174	131	334	212	161	134	104
200				319	236			357	224	167		271	203	166	127
250				394	291			440	274	203		331	245	199	149

Required or recommended holding pond sizes vary by state and locality. As a minimum, the holding pond capacity should be adequate to contain the runoff from a 25-year frequency, 24-hour duration storm. This value varies from about 7 inches of depth over the entire lot area for earthen lots in northern Indiana to 14 inches for paved lots in southern Indiana. Illinois requires at least 12 inches of runoff storage from earthen lots and 15 inches from paved lots. In northwest Iowa, minimum storages are 5 inches of runoff, from systems emptied after significant precipitation, to 14 inches for southeast Iowa systems disposing of collected runoff only once per year. Many states require larger minimum capacities. These examples make it clear that anyone planning a runoff control system should first check state and local regulations to insure the planned system complies legally and performs satisfactorily.

Liquid Handling Equipment

Lot runoff stored in holding ponds is disposed of by applying it on nearby cropland. Pumping and irrigating directly to the land is usually the most economical method of emptying. Irrigation systems do not need to be elaborate. The main objective is to empty the pond within a reasonable length of time without exceeding the infiltration capacity of the soil or the nutrient utilization level of the crop in the application area.

Standard centrifugal pumps usually are satisfactory for pumping lot runoff from holding ponds through sprinkler systems or gated or perforated pipe. Some pumps having plastic or nonmetallic impellers are successfully used to minimize salt buildup problems. Pumping and distribution systems may be simple and low cost or expensive and sophisticated, depending on the size of the operation and operator preference. PIH-91 *Pumping Liquid Manure from Swine Lagoons and Holding Ponds* provides more detailed information on the subject. Whatever the system, pumping to cropland is a simple, efficient means of removing water from holding ponds.

Infiltration Area (Vegetative Filters)

An alternative to the use of holding ponds for runoff detention is the use of infiltration areas or vegetative filters. With this method, runoff flows through the settling basin directly to a vegetated, usually grassed, field area. The system is designed on the premise that the major portion of the feedlot runoff from storms will infiltrate into the soil. When runoff does not totally infiltrate the soil, it will be diluted and treated to such a degree by biological and physical processes during its movement over the vegetated area that it usually can be discharged. While systems of this type are not adaptable or practical for every situation, early experience indicates that they can provide successful, low-cost runoff control for many smaller swine operations.

The vegetated area may be either a channel similar to a long grassed waterway with a slope of less than 1% or a broad, flat, overland flow area with little or no slope surrounded by a berm or dike. All outside surface water should be diverted so that the only water on the disposal area is lot runoff and direct precipitation.

Infiltration areas do not need to be elaborate. Management is minimal, consisting primarily of maintaining the vegetative cover in the area. Periodic removal of the vegetation by harvesting is necessary when conditions permit. Equipment or livestock should not be allowed on the field during wet conditions. Ruts or potholes will reduce the uniform distribution required for even application.

Several approaches have been used to develop design criteria for infiltration areas. One is simply to estimate the infiltration rate of the soil in the disposal area, calculate the quantity of runoff expected from a given storm or series of storms, and size the vegetated area based on a desired time to infiltrate the entire runoff quantity. A second method is to use the estimated water-holding capacity of the soil profile under the vegetated area and size the area so that infiltration from a given storm will not exceed that water-holding capacity. Tables 2 and 3 summarize these design procedures and give some approximate values for design information.

Check for local design criteria and compliance with regulations before installing a system of this type. The infiltration area does a good job of reducing the impact of lot runoff on surface waters. However, these units have the potential to move excess amounts of nitrogen from the lot onto the infiltration area, into the soil profile and on toward the groundwater. Harvesting and removing the grass will remove nitrogen from the area. If you suspect excess nutrients are being applied beyond the agronomic needs of the grass, seek assistance from the Cooperative Extension Service or Soil Conservation Service Office.

Table 3. Approximate infiltration rates and water-holding capacities for various textured soils.

Soil type	Infiltration rate cover in/hr	Infiltration rate bare in/hr	Water-holding capacity (in/5 ft)
Sand	1.0+	1.0+	2.5
Sandy loam	.6	.4	6.5
Silt loam	.5	.3	11
Silty clay loam	.4	.25	10
Clay	.3	.15	9

Table 2. Design information for infiltration areas or vegetative filters.

Design basis	Runoff drainage area	Design rainfall event	Basis for runoff receiving capacity	Design area
Infiltration rate	Lot area	24 hr, 25 yr	Soil infiltration rate, minus rainfall rate, in./hr.	[Lot area X Design rainfall] ÷ [Runoff receiving capacity X Desired infiltration time*]
Water-holding capacity	Lot area	24 hr, 25 yr	Soil water-holding capacity, minus rainfall, in.	[Lot area X Design rainfall] ÷ Runoff receiving capacity
Hydraulic loading	Lot	Annual rainfall	Hydraulic loading, in/yr	[Lot area X Design rainfall] ÷ Runoff receiving capacity

*For example, 12 hours or 24 hours.

Constructing an Infiltration Area

The infiltration channel should not be confused with a diversion waterway. Topsoil in the channel should not be disturbed during construction. If possible, the channel should be laid out along the natural topography, and a diversion terrace built along the channel to prevent outside surface water from entering. The terrace around the channel need not be more than 1 foot high to contain the feedlot runoff in the channel.

If excavation is necessary, topsoil should be returned to the channel bed after removing the required amount of subsoil. Make certain the channel is not compacted during construction.

A grass, such as rye grass or fescue, should be sown in the channel as soon after construction as possible. If a drainage tile is needed to control a seasonal high water table, the subsurface drainage tile should be 4 inches in diameter and installed 30 to 40 inches deep, 10 feet on either side of the channel.

Before Building

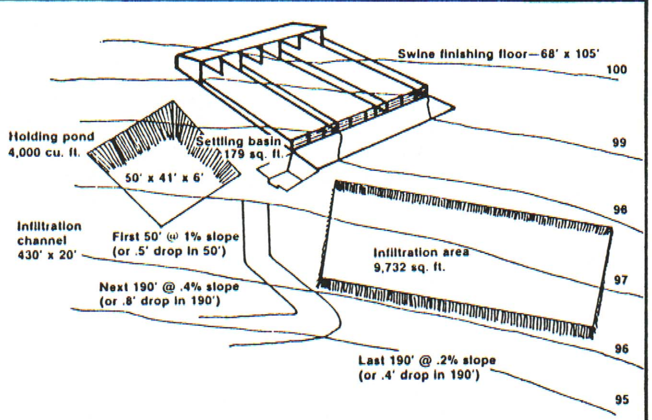
State and local regulations vary, as do recommended runoff control practices in different areas. For this reason, obtain information and help from appropriate state agencies and universities and Soil Conservation Service personnel before planning and constructing any system. Start by calculating dimensions for your system using the Runoff Control System Design Worksheet at the end of the fact sheet.

Another excellent source of planning and design information for all types of manure management, including runoff control systems, is the *Livestock Waste Facilities Handbook,* MWPS-18. This publication contains specific design criteria and specifications for runoff control structures. It is available from the Agricultural Engineering departments of most land-grant universities or from Midwest Plan Service, Iowa State University, Ames, Iowa, 50011.

It is advisable to engage the services of a private consulting engineer for detailed planning work, especially on larger systems. Successful runoff control systems may be simple or complex, cheap or expensive. To insure the success of any system, however, careful forethought and planning is prudent and proper management is imperative.

Runoff Control System Design Worksheet

Example: Design a runoff control system for a paved open feedlot in Lincoln County, Indiana, shown in the illustration. The swine finishing floor is 68 foot wide x 105 foot long. The soil type in the area is silty clay loam. The annual rainfall is 36 inches. The feedlot and settling basin will be cleaned once a month. An infiltration area or vegetative filter may be used in place of the holding pond if more economical.



Solution:	Example	Your Situation
I. Settling Basin		
A. Feedlot area		
Width x Length (measured)	68′ x 105′ = 7,140 sq. ft.	________
B. Runoff to settling basin		
Feedlot area x design rainfall (i.e., 1.2″ in 1 hour for most of Indiana)	7,140 x (1.2″/hr. ÷ 12″/ft.) = 714 cu. ft./hr.	________
C. Basin volume		
1. Design detention time (½ hr.) x runoff to settling basin (B)	½ hr. x 714 cu. ft./hr. = 357 cu. ft.	________
D. Settling basin area		
1. Minimum depth (selected by swine producer, usually 2-4′)	use 2′	________
2. Settling basin area (from C) ÷ depth (2′)	357 ÷ 2 = 179 sq. ft.	________
E. Settling basin depth		
1. Minimum depth (from D1)	2′	________
2. Solid storage (determined by amount of solids in runoff and frequency of cleaning - usually about 1′ of depth for each month solids are stored - some states do not recommend additional solids storage besides the minimum depth)	1 month x 1′ = 1	________
3. Total depth (sum of E1 and E2) (note÷excessive depths make cleaning difficult, especially when cleaning is done with tractor loader)	3′	________

Solution:	Example	Your Situation
II. Infiltration Area (vegetative filter) Runoff to infiltration area from feedlot (24-hr., 25-yr. storm)		
Feedlot area (A) x rainfall (5.5 in. for most of Indiana)	7,140 x (5.5" ÷ 12"/ft.) = 3,270 cu. ft.	____________
A. Water Holding Capacity Method		
1. Available water receiving capacity		
Water holding capacity **(from Table 3)** - rainfall (24-hour, 25-year storm)	10" - 5.5" = 4.5" = 0.38'	____________
2. Infiltration area		
Runoff to infiltration area (from II) ÷ available water receiving capacity (from A1)	3,270 cu. ft. ÷ 0.38' = 8,605 sq. ft.	____________
3. Dimension of infiltration channel		
a. Width (20 ft. maximum)	20'	____________
b. Length = area ÷ width (if greater than 1,200, use multiple channels)	8,605 ÷ 20 = 430'	____________
4. Divide channel into sections		
1st 50' @ 1% (since upper end of channel needs more slope)	50'	____________
½ remaining length @ .4%	(430' - 50) ÷ 2 = 190'	____________
remaining length @ .2%	190'	____________
B. Infiltration Rate Method		
1. Infiltration rate **(Table 3)**	.4 in./hr.	____________
2. Rainfall rate (24 hr., 25-yr. storm, 5.5")	5.5" ÷ 24 hr. = .23 in./hr.	____________
3. Runoff receiving capacity (infiltration rate minus rainfall rate)	0.4 in./hr. - 0.23 in./hr. = 0.17 in./hr. ÷ 12 in./ft. = .014 ft./hr.	____________
4. Infiltration area Runoff to infiltration area (from II) ÷ (runoff receiving capacity x desired infiltration time)	3,270 ÷ (0.014 ft./hr. x 24 hr.) = 9,732 sq. ft.	____________
5. Dimensions of infiltration area—gradually sloping or nearly level field area with surrounding berm or dike	97 ft. x 100 ft.	____________
C. Hydraulic Loading Method		
1. Acceptable hydraulic loading (.5 in./wk. or 26 in./yr. in addition to normal precipitation) (consult with Cooperative Extension Service or Soil Conservation Service for acceptable value for local area)		
2. Yearly rainfall	36 in./yr.	____________
3. Infiltration area—yearly rainfall x lot area ÷ hydraulic loading	36 in./yr. x 7,140 sq. ft. ÷ 26 in./yr. = 9,886 sq. ft.	____________
4. Dimensions—select dimensions as desired, either channel or broad field area shape		
III. Holding Pond		
A. Runoff to be stored in holding pond (Consult Soil Conservation Service)	5.5", 24-hr., 25-yr. storm	____________
B. Holding pond volume Feedlot areas x Runoff	7,140 x (5.5" ÷ 12"/ft.) = 3,270 cu. ft.	____________
C. Holding pond dimension **(Table 1)** (for 4,000 cu. ft.)		
1. Select depth	6'	____________
2. Select width	50'	____________
3. Read length (provides 4,000 cu. ft. storage)	41'	____________

Recommendations: Select among the alternatives which have been presented by using cost comparisons and taking operator preference and special site conditions into consideration.