Vegetative Filter Strip Systems *for* Animal Feeding Operations

K-STATE Kansas State University Research and Extension

Introduction

Vegetative filter strips, in conjunction with sediment basins, are recognized by the Kansas Department of Health and Environment (KDHE) as an effective system for controlling and reducing nutrient runoff into surface water from confined feeding operations. Only feeding operations with fewer than 1,000 animal units can utilize this type of waste management system. Also, the use of a "discharging" filter system may not be a viable option in a watershed where water quality in the receiving water body is impaired by nutrients or fecal coliform bacteria. In these cases, total retention may be the only alternative.

The Environmental Protection Agency (EPA) Nonpoint Discharge (NPDES) permits apply to operations of more than 1,000 animal units. Table 1 shows the number of head per 1,000 animal units for different types of livestock.

A vegetative filter strip system is a designed, constructed, and maintained area of vegetation that receives runoff during a rainfall event from a confined animal feeding operation. Milk parlor wash water cannot be discharged onto a vegetative filter strip. The filter strip system is a simple method of reducing pollutants. Its purpose is to prevent the pollutants associated with livestock waste from leaving the producer's property. This type of animal waste treatment system has been shown to reduce the amount of ammonia, total nitrogen, total solids, COD, phosphorus, and potassium in effluent runoff by as much as 96 percent.

Uniform, level slope across a filter strip.

In cropland, a vegetative buffer strip should be an area greater than 50 feet wide around the edge of the field. A vegetative filter for animal feeding operations is designed differently. In this situation, a filter strip often requires an area of land equal to or greater than the drainage area. The livestock production area should be located at least 400 feet from streams or property lines before a vegetative filter can be considered.

The purpose of this publication is to help producers determine if a vegetative filter system might be an acceptable alternative waste treatment method for their confined feeding areas. KDHE has final approval for any vegetative filters designed to

Table 1. Number of Head Per 1,000 Animal Units

Livestock	1,000 Animal Units
Beef < 700 lbs	2,000 Head
Beef > 700 lbs	1,000 Head
Dairy	700 Head
Swine < 55 lbs	10,000 Head
Swine > 55 lbs	2,500 Head
Sheep	10,000 Head

Water being held in sediment basin prior to release.

reduce nutrient runoff from a confined feeding area.

Design Considerations

A vegetative filter strip system consists of three distinct parts: a sediment basin, a flow distribution device, and the filter strip area. Many different designs are possible.

Sediment Basin

Runoff from confined feeding operations typically contains solid material such as manure, feed, or debris, which may settle out. Vegetative filters are not designed to receive large volumes of such solids. To prevent these solids from directly entering the vegetative filter strip area, feedlot runoff must first be retained in a settling basin for at least 30 minutes.

The size of a sediment basin depends on the total amount of acreage in the drainage area, including any extraneous drainage areas. For most of Kansas, capacity of the sediment basin should be 2 acre-inches per acre of drainage area. This capacity will achieve the 30-minute retention objective. As an example, a drainage area of 4 acres would require a sediment basin with a storage capacity of 8 acre-inches (0.67 acre-foot), or approximately 29,000 cubic feet.

Such a design will retain approximately 50 percent of the nutrients that leave the lot. The sediment basin should have a depth of 3 to 4 feet. This will enable it to dry out during the summer. The bottom of the basin should be at least 10 feet wide to allow room for cleaning equipment. A sediment basin could consist of a broadbased terrace with closed ends across the back of a set of pens.

Flow Distribution Device

The flow distribution device is a critical component of the filter strip system. Uniform application across the face of the filter helps distribute solids, nutrients, and flow. It also reduces channeling of flow. If channel flow occurs, treatment effectiveness is significantly reduced.

Vegetative Filter Strip Area

Preliminary considerations

The larger the drainage area contributing to the vegetative filter, the larger the filter area requirement. For this reason, all unnecessary runoff should be excluded from the system. Many livestock waste management systems fail because extraneous surface water is not diverted away from the system. Runoff from clean surface areas, such as roofs, driveways, the farmstead and land adjacent to the feedlot, and so forth, should be directed away from the feedlot, settling basin, and vegetative filter.

Size requirements

KDHE recognizes two methods for sizing the filter area for controlling the nutrient loads leaving a feedlot. The first is a mass balance method based on the amount of nitrogen excreted per animal. In some watersheds, phosphorus may be the limiting nutrient and the filter area must handle the P_2O_5 loads. Table 2 shows how much nitrogen is produced by various livestock enterprises. It is necessary to estimate how much of the N or P produced by an animal will enter the filter area.

About 75 percent of the N produced by an animal is lost in the pen and never leaves the area. Of the remaining N which leaves the pen, about 50 percent will settle out in a sediment basin, which provides a 30-minute retention time. Therefore, about 12.5 percent of the total N produced by an animal will enter the filter strip. For the preliminary design and estimation of the filter area requirements, assume that 10 percent of the total N produced will remain on the filter. An animal producing about a half-pound of N per day in waste will place about $^{1}/_{20}$ pound of N per day into a vegetative filter. Based on the 10 percent factor, Table 2 shows an estimate of the annual N production that will be deposited in the vegetative filter strip. The values in Table 2 can be adjusted according to the number of days per year the facility is being used. The filter strip is sized according to the annual nutrient requirements of the vegetation.

The second method can be used with beef operations, and is based on rainfall events. This method assumes that 22 pounds of N per acre-inch of runoff per acre of drainage unit leaves a feedlot operating year-round (30 pounds of N for a backgrounding operation).

If cattle are not in the lots, the method assumes there is no N production. However, research indicates about 9 pounds of N per acre-inch of runoff leaves a lot when cattle are not present.

For preliminary design considerations, it can be assumed that 30 percent of the rainfall during the feeding period will run off. For example, assume a 3-acre backgrounding lot is located in an area that receives 9 inches of rainfall between October 1 and April 1. The expected runoff would be 2.7 acre-inches (9 inches × 30 percent) and the total runoff for the 3-acre lot would be 8.1 acre-inches. The expected

Table 2. Animal Capacity Per Year Per Acre of Vegetative Filter Strip

Kind and size of animal	Nitrogen produced per year (lbs)	Nitrogen available to filter strip (lbs)	Number of head per year per acre of filter strip*
Dairy			
150 lb	22	2.2	110
250 lb	37	3.7	67
500 lb	73	7.3	34
1,000 lb	186	18.6	13
1,400 lb	208	20.8	12
Beef			
500 lb	62	6.2	40
750 lb	95	9.5	26
1,000 lb	124	12.4	20
1,250 lb	157	15.7	16
Swine			
35 lb	25	2.5	100
65 lb	47	4.7	49
150 lb	110	11.0	21
200 lb	142	14.2	18
Sheep			
100 lb	33	3.3	76
Horse			
1,000 lb	96	9.6	20

* Based on using a cool-season grass, such as tall fescue.
Source: Midwest Plan Service MWPS-18 *Livestock Waste Handbook*

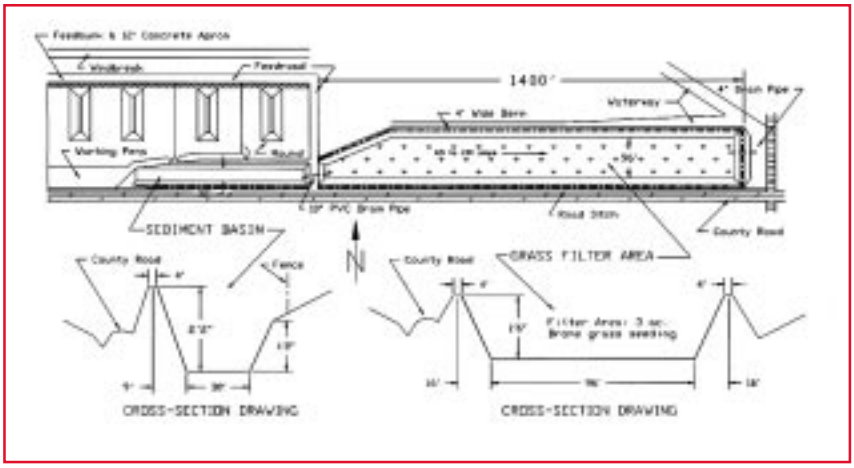

Figure 1. Engineer-designed grass filter strip that has been approved by KDHE.

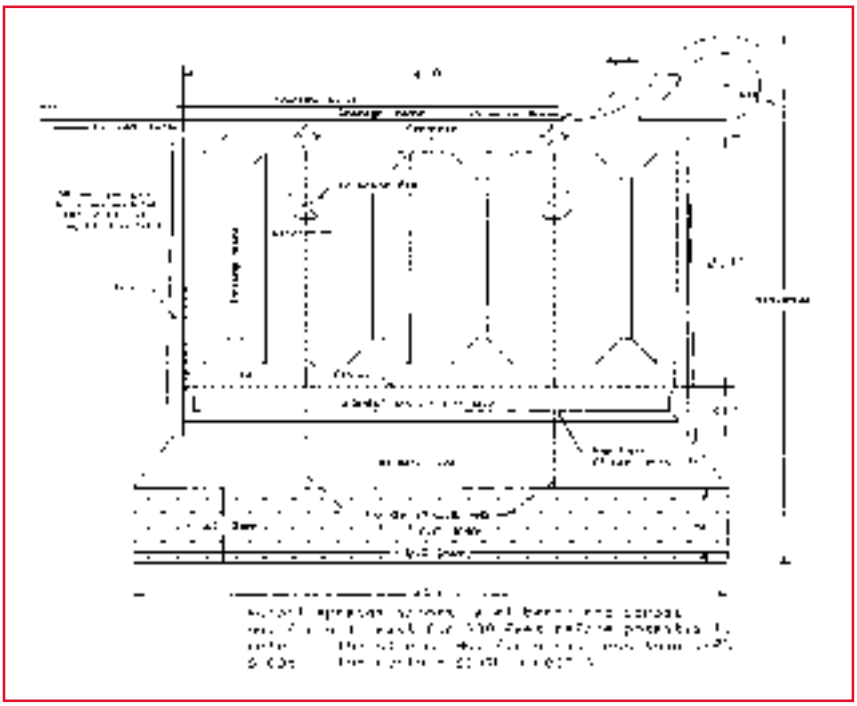

Figure 2. Modified vegetative filter area used with a 100-animal unit operation.

N leaving the lot would be 243 pounds (8.1 acre-inches of runoff × 30 pounds N per acre-inch of runoff). In environmentally sensitive areas, consideration also should be given to the N leaving the lots during non-usage. The grass filter area is then sized according to the N requirements of the grass.

The filter strip size must be large enough to retain the flow from the sediment basin for a minimum of 30 minutes. Many runoff events enter a vegetative filter and never reach the discharge end of the filter. During an intense storm, however, a discharge may occur from the filter.

Slope and length

To be effective in removing nutrients and other pollutants, runoff water and effluent must be evenly distributed over the vegetative filter strip. This requires a broad, gently sloping area for the filter strip. It is recommended that suitable grass filter sites have a uniform slope of between 0.5 and 4 percent.

Slopes of less than 0.5 percent create maintenance problems and may result in inadequate movement of runoff water. Slopes of more than 4 percent should not be used because of excessively high runoff velocities, reduced filter effectiveness, and possible erosion. Proper slope is often the factor that limits whether a filter strip system can be used for a livestock operation or whether some land grading will be required.

Existing guidelines suggest that vegetative filters be a minimum of 200 feet long per 1 percent slope. Therefore, if the slope is 2 percent, the filter strip must be at least 400 feet long before the water leaves the filter strip area. As a general site appraisal guideline, the filter strip area must be at least equal to the size of the drainage area.

To accomplish a uniform distribution of flow over the filter strip area, it is necessary to use perforated or gated pipe, overflowed ditches, sills, or other methods. The filter strip should be constructed with a uniform slope along the length and level across the slope to promote uniform depth and velocity of runoff. Differences across slope should be no more than 0.1 foot from a level line, and these differences should be random along the length of the filter. It is recommended that a berm be placed across the filter every 200 to 400 feet to redistribute the runoff.

Examples of vegetative filter strip systems are shown in Figures 1 through 3. Figure 1 shows an engineer-designed grass filter strips that has been approved by KDHE. The filter strip is approximately 5 acres in size and contains runoff from a 3-acre, 300-head backgrounding lot. This particular lot is limited to 120 days of utilization per year. The grass filter area is approximately 100 feet wide and a quarter-mile long and has a slope of about 1.2 percent throughout its length.

Figure 2 shows a modified vegetative filter area used with a 100-animal unit operation. The existing terrain was such that the field could naturally be surface irrigated. A level bench at the outlet was used to distribute the water across a 6-acre bromegrass field located between the pens and a nearby stream.

Figure 3 shows a filter strip with ridges. An easy way to create ridges is with ridge-till equipment or equipment used to create furrows for surface irrigation. Earth moving equipment cannot make ridges as uniformly.

Operation and Maintenance Considerations

Sediment Basin

The sediment basin must be properly maintained in order for the system to function adequately. Some of these guidelines are:

1. Remove solids from the settling basin when 2 to 4 inches accumulate. When the sediment basin dries, it should be scraped and cleaned. The nutrients should be applied to suitable crop land.
2. Scrape the feedlot regularly. However, do not scrape the waste into the settling basin. Place it in a separate area and utilize as soon as possible on suitable cropland or pasture.

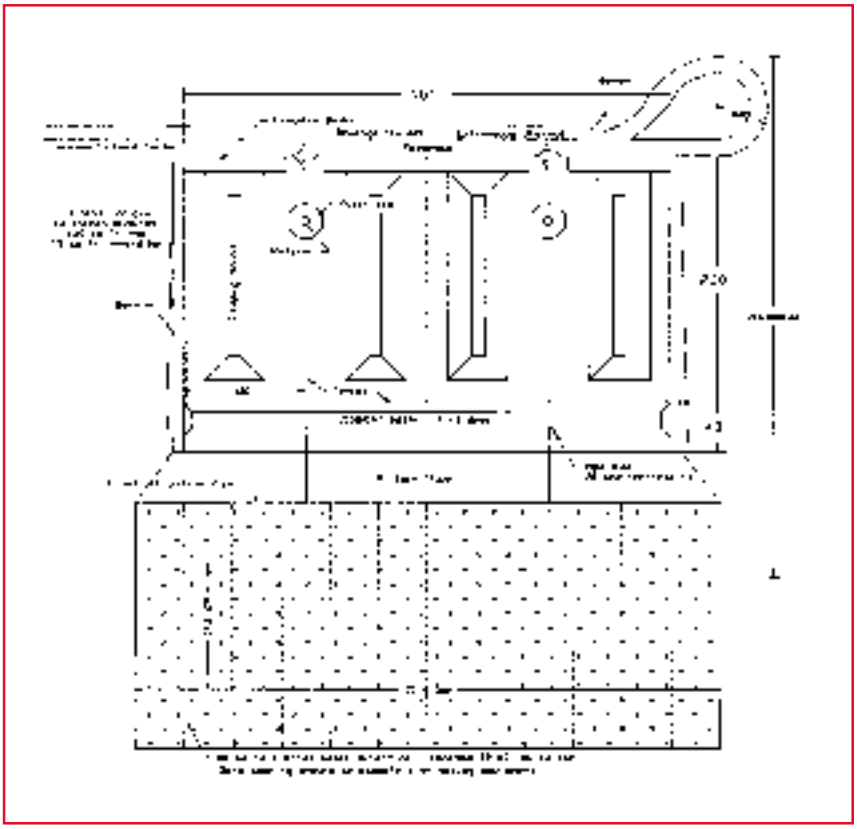

Figure 3. Filter strip with ridges.

Vegetative Filter Strip

The effectiveness of vegetative filter strips depends on:

1. selecting the most appropriate plant species;
2. proper establishment of the plant species; and,
3. maintenance of the vegetative filter strip following establishment.

Selecting the Most Appropriate Plant Species

The plant species used in vegetative filter strips should have dense crown and root development; rapid top growth to reduce the velocity of runoff water; a fibrous root system to reduce

Haying the filter strip.

Poor filter strip maintenance. Equipment was used on the filter strip when wet, which led to channelization.

erosion; and a perennial growth habit that will persist over a long period of time. The plant species selected should be adapted to the soil and climate of the area. Because the vegetation will need to be hayed to remove accumulated nutrients, the species selected should have good hay quality at the time of year the hay is harvested.

Grass species are more effective than broadleaf species for reducing erosion in the filter strip. Cool-season grasses are desirable since most of their growth is in the spring and fall when runoff across the filter strip is most likely to occur. In addition, cool-season grasses establish more rapidly and with less cost than warm-season grasses. Sod-forming grasses are more effective than are bunch grasses. Bunch grass should only be used in a mixture with other plant species. The grass used must be able to tolerate waterlogged soil during some parts of the year.

Table 3 provides characteristics of the various types of grasses that producers can use for vegetative filter strip systems in Kansas.

Proper Establishment of the Plant Species

Practices used for establishment of the plant species are similar to those recommended for pastures and waterways. Land grading and other required soil surface alterations must be finished before seeding the filter strip. Runoff should not be allowed to run across the filter strip until the plant species are established. Any channels or gullies that are formed prior to plant establishment will reduce the long-term effectiveness of the filter strip. Lime and other nutrients must be applied and incorporated into the seedbed before seeding as recommended by soil tests. If extensive land grading was required before establishing the vegetative filter strip, a more thorough soil testing program may be needed. Organic matter or micronutrients may need to be added, too. Check with your local county Extension agent for assistance with soil testing.

The filter strip can be seeded with or without a companion crop. A companion crop, such as wheat or spring oats, may be required for plant species that require longer

Table 3. Characteristics of Species for Vegetative Filter Strips in Kansas

Species	Seedling vigor	Drought tolerance	Wet soil persistence	Growth habit	Forage quality	N uptake	P uptake
Cool-season grasses							
Smooth bromegrass	High	Medium	Low	Sod-forming	High	High	High
Tall fescue	High	Medium	High	Bunch grass	Medium	High	High
Tall Wheatgrass	Medium	Medium	High	Bunch grass	Medium	High	High
Warm-season grasses							
Eastern gamagrass	High	Low	High	Bunchgrass	High	High	Medium
Switchgrass (Kanlow)	Medium	Medium	Medium	Sod-forming	Low	Medium	Medium
Big bluestem	Low	Medium	Low	Sod-forming	Medium	Medium	Medium
Indiangrass	Low	Low	Low	Sod-forming	Medium	Medium	Medium

establishment periods or if weed infestations are a concern. Companion crops should also be used if the area is subject to wind or water erosion. Vegetation should be planted at optimum planting times on a firm seedbed. It may be necessary to mulch the filter strip following planting to prevent channel or gully formation.

Maintenance of the Vegetative Filter Strip Following Establishment

Maintenance of the vegetative filter strip is essential to the effectiveness of the filter strip. Proper maintenance requires several steps:

1. Periodic inspection of the vegetative filter strips for gully erosion. Gullies should be repaired as soon as possible.
2. Reseed areas of the filter where vegetation is thin or bare.
3. Mow at least two or three times per year and harvest residue to promote a dense vegetative stand and remove accumulated nutrients. Mowing frequency needs to be based on the kind of grass present. Mowing should be no closer than 6 inches.
4. Apply additional fertilizer as recommended by soil tests to establish a vigorous stand of vegetation.
5. Do not use vegetative filter strips as roadways. Roadways should only be located on the downslope side of the filter strip.
6. Keep livestock from the filter strips at all times and particularly during periods of wet weather.
7. Regrade and reseed vegetative filter strips that have accumulated enough sediment to alter flow through the filter strip area.
8. Control brush, trees, and noxious weeds.

Importance of Adequate Maintenance

Failure of the operator to maintain a vegetative filter strip system in good operational condition could result in a violation of environmental laws or other applicable regulations.

Vegetative filter strips are often damaged by grazing and harvesting under wet conditions. While it is necessary to harvest the vegetation periodically in order to remove accumulated nutrients, every effort should be made to avoid damaging the vegetation during the process. Good year-round vegetative stands are important to the success of a vegetative filter strip system.

Advantages and Disadvantages of a Vegetative Filter Strip System

The biggest advantage of a vegetative filter is that the producer does not have to worry about pumping out or maintaining a storage structure. There is some maintenance requirement for the sediment basin, but this can normally be done with ordinary farm equipment. If excess nutrients accumulate near the inlet of the filter strip, the topsoil may have to be removed and replaced with other topsoil and the nutrient-rich soil distributed on cropland.

The main disadvantage of vegetative filter strips is the amount of land and earth work required to properly construct a filter. For the most part, only smaller livestock producers will be able to utilize vegetative filter strip systems. In many cases, it may cost more to build a filter strip system than it would to construct a holding pond. However, the cost of pumping equipment can be avoided with vegetative filters.

Filter strip systems are limited to locations where the feeding area is at least 300 to 400 feet (preferably 1,000 or more feet) from the nearest creek, stream, lake, or pond. Vegetative filters are not a viable alternative where the feeding area is located near a man-made or natural watercourse.

SUMMARY

Kansas livestock facilities can utilize vegetative filter systems which are designed and constructed to meet the basic expectations of livestock control Kansas statutes and KDHE regulations. No livestock production enterprise can have a significant pollution potential. A properly designed, constructed, and maintained vegetative filter strip is an effective means for some producers to achieve this expectation. A vegetative filter plan must be submitted to KDHE for approval before implementing the design to insure the proposed plan can be used at the site.

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K-State Research Shows Filter Strips Can Be Effective

Vegetative filter strips reduced concentrations of phosphorus and nitrogen from animal feeding operations at K-State research sites in Herington and Cheney Reservoir. Design of the filter strips had a major impact on their effectiveness.

Established grasses, particularly bromegrass and tall fescue, are most effective in removing sediments and nutrients. Grasses generally need three to four years to gain maximum cover, density, and strength. The bromegrass at Herington, in its fourth year, had better results than did 1- to 2-year-old stands at Cheney. The filter strip at Herington was 1,400 feet long, 100 feet wide, and set on a gradual slope. At Cheney, the filter strip was only 700 feet long and narrowed from a width of 50 feet. The slope on this filter strip increased from 1 to 4 percent at the tail end.

Few cattle were in the feedlot at either site during the study period. However, two runoff events were captured at the Herington site when 199 cattle were being fed.

The research found that a straight filter strip with consistent width and gradual slope was the most effective design. Mowing and occasional weeding also increased effectiveness. Getting an even flow across the filter strip was the major challenge. Runoff had a tendency to channel, rendering 70 to 80 percent of the filter strip area largely unused. To solve this problem, new research is being conducted that involves placing wooden berms every 200 feet to distribute water more evenly.