TECHNICAL NOTES

USDA-Natural Resources Conservation Service
Boise, Idaho – Salt Lake City, Utah

TN AGRONOMY NO. 9 **OCTOBER 2008**

Vegetative Filter or Buffer Strips

Loren St. John, Manager, NRCS, Plant Materials Center, Aberdeen, Idaho
Dan Ogle, Plant Materials Specialist, NRCS, Boise, Idaho

Vegetative filter strips (also referred to as buffer strips or contour buffer strips) are areas of herbaceous perennial vegetation, usually grass, or in some cases, annual small grain species planted and managed to intercept sediment, nutrients, pesticides and other contaminants in runoff water before the runoff can enter water bodies.

Filter or buffer strips can be incorporated into a farm management plan for the specific purpose of maintaining soil within a field on sloping lands. Water quality can be maintained or improved by placing filter or buffer strips between contaminant sources (e.g., dryland or irrigated cropland, livestock confinement – feeding and dairy facilities, highways and construction sites) and receiving bodies of water such as canals, streams, ponds and lakes.

Planning considerations and procedures for the installation and operation of filter or buffer strips are described in the following technical note.

VEGETATIVE FILTER OR BUFFER STRIPS

Loren St. John, Manager, NRCS, Plant Materials Center, Aberdeen, Idaho
Dan Ogle, Plant Materials Specialist, NRCS, Boise, Idaho

Vegetative filter or buffer strips are narrow areas or strips of close-growing vegetation intended to slow the velocity of runoff water, allowing settling of suspended soils particles, infiltration of runoff and soluble pollutants in runoff, adsorption of pollutants on soil and plant surfaces and uptake of soluble pollutants by plants.

Simply said, filter or buffer strips slow runoff and trap sediment, nutrients, pathogens, and pesticides.

The Effectiveness of the Filter or Buffer Strip Depends on Several Factors

- **Type of pollutant** – sediment; soluble nutrients and pesticides; sediment-bound nutrients and pesticides; plant nutrients; pathogens
- **Source of pollutant** – runoff and erosion from susceptible construction and development sites, livestock confinement areas, cropland where manure and inorganic fertilizer are applied, and other point and non-point sources of contaminants
- **Soil properties** – soil texture, slope, soil permeability, surface roughness and compaction all affect runoff, as does the erosivity of the soil
- **Plant cover** – the amount of plant cover, the type of plant cover and whether the cover is a perennial or annually planted vegetation all influence the effectiveness of the filter strip

Filter or Buffer Strips Improve Water Quality

Research has helped us understand the effectiveness of filter or buffer strips for various purposes.

In a Virginia study, orchardgrass, a bunchgrass, was observed for its ability to filter sediments and nutrients. It was found that a 30- foot filter strip of orchardgrass removed an average of 90 percent of the incoming sediment, 80 percent of the total phosphorus (P) and 70 percent of the total nitrogen (N).

In a Minnesota study of contamination from livestock feedlots and confinement; corn, orchardgrass, sorghum and oat filter strips reduced suspended solids and dissolved nutrients by 80 percent, with total N reduced 84 percent, soluble P reduced 76 percent and bacterial contamination (fecal coliform) reduced about 70 percent during a 2.5 inch/hour- 70 minute rainfall event.

Regarding the effectiveness of filter strips to reduce nutrient runoff from pastures fertilized with manure or inorganic nutrient sources, a 30- foot filter strip of tall fescue, a bunchgrass, removed 90 percent of the incoming N and P in the runoff.

30 feet of Filter Strip

- Trapped 80-90% of sediment
- Removed 80% of total P
- Removed 70% of total N

In northern states, dairy operations are often faced with accumulating and storing animal waste for periods of 4- 6 months, when soils are frozen and land application is not practical. Studies in Montana evaluated tall fescue planted in 90- foot filter strips compared to fallow conditions and the resulting reduction of nitrates and bacteria originating from stockpiled dairy livestock manure:

- Significant concentrations of nitrate nitrogen were measured in the untreated runoff water
- Concentration of nitrate nitrogen was less than 0.1 mg per liter in runoff leaving the tall fescue filter strips
- Filter strips reduced the nitrate nitrogen losses in runoff water more than 95 percent
- Reduction in bacterial contamination compared to the control ranged from 54 to 87 percent in the runoff water after passing through the tall fescue filter strip
- The filter strip resulted in 87 percent reduction in bacterial contamination, however, fecal coliform populations in the runoff water from the filter strip remained substantially elevated
- Although the filter strip did not eliminate bacterial contamination, the concentration of bacteria was reduced significantly by the filter strip

The Bridger, Montana, NRCS, Plant Materials Center studied sediment trapping from fallowed cropland fields using perennial grass and annual small grain filter strips. Western wheatgrass, thickspike wheatgrass, pubescent wheatgrass, intermediate wheatgrass, smooth brome, crested wheatgrass and spring and fall- seeded wheat were evaluated in 40- foot strips. The following summarized these studies:

- All filter strip species evaluated were effective in significantly reducing sediment concentration in runoff as compared to no vegetative cover
- The filter strips reduced the sediment concentration by about 80 percent
- Annual small grain filter strips were not as effective as perennial cool season grasses in reducing sediment in runoff

However, studies by the Agricultural Research Service at Kimberly, Idaho have determined that small grain filter strips planted at the end of furrow irrigated fields can be very effective at reducing pollutants in irrigation tail water. Their research indicates:

- Filter strips filter both surface and shallow groundwater before it enters drainage canals, streams, ponds or lakes
- Reduces up to 60 percent of sediment (maintains sediment in the field)
- Reduces approximately 40 percent (on average) of adsorbed phosphorus
- Removes nitrate and phosphorus from surface runoff which is stored in growing plants in filter strip
- May remove up to 60 percent of pathogens from runoff
- Provides food and cover for wildlife and improved fish habitat in perennial streams, ponds and lakes

Considerable research has shown that filter or buffer strips can remove large quantities of sediment and nutrients, as well as infiltrating a significant portion of the inflow. However, there is likely to be significant variability in the performance of these systems. In general, sediment reductions of 50% or greater are typical. Nutrients and pesticides that are strongly bound to sediment have reductions similar to, but slightly lower than, sediment reductions. Dissolved contaminants have lower reductions on average, and the magnitude of reduction is positively correlated with infiltration. A variety of factors (ratio of drainage area to filter or buffer strip area, soil properties, storm characteristics, site topography, vegetative characteristics, etc.) impact the effectiveness of vegetative filters, so the design of filter or buffer strips must consider these factors in order to achieve water quality objectives.

Designing Vegetative Filter or Buffer Strips

The following represents the minimum criteria for design of the filter or buffer strip.

1. Filter strips should be located between the contaminant source and water body being protected

2. Filter strips should be designed on or near the contour of the land

3. Select plant species that are adapted to the soils and climatic conditions in the area

4. Sod- forming species reduce runoff most effectively. A mixture of sod- forming and bunch- forming species may be appropriate when objectives are to preserve soil quality and also maintain cover, food and habitat for wildlife

5. Manage plantings so dense, stiff and upright vegetation is maintained at all times – this may require periodic mowing to a 3- 5 inch height

6. The width of the filter strip will vary according to drainage area, slope and soil texture – as soil textures become finer, the percentage of silt and clay increases and water permeability decreases; on sites with soil textures finer than silt loams, width of filter strip should be increased. Drainage area to filter strip area ratios that exceed 50:1 may require wider strips.

Slope	Minimum Width
0- 3 percent	**20 feet**
4- 9 percent	**25 feet**
10- 15 percent	**30 feet**
16 + percent	**40 feet**

Additional Criteria for Filter Strips under Surface (Furrow) Irrigated Conditions

Filter strips slow the velocity of water at the end of a furrow, allowing sediment to settle before it enters the tail water ditch. Follow these tips to plan a filter strip that works at optimum efficiency:

1. Use on 1- 3 % slopes
Filter strips for surface irrigated conditions are most effective on field slopes near 2 percent with shallow water flow conditions. They are not suitable on fields with steep slopes because runoff will flow to and through the strip too fast resulting in concentrated flows. Fields with nearly level slopes such as laser leveled basins are also not suitable, because the gradient is not sufficient to allow water to flow through the filter strip.

2. Use a combination of conservation practices to reduce erosion
Filter strips reduce the amount of soil leaving a field but do not affect how much erosion is occurring within a field. Filter strips with excess sediment loading will rapidly fill with sediment and become ineffective. Filter strips on furrow irrigated fields usually have a useful life of about 1- 2 years. When low residue producing crops such as beans, sugar beets, or potatoes are being produced in a field, the operator should seriously consideration the use of small grain species as a filter strip. In many cases, sediment basins are used in conjunction with filter strips. Implementing practices such as irrigation water management, residue- tillage- mulch till management and the use of polyacrylamide or cultural practices such as placing straw in irrigation furrows for erosion control can also help keep soil in place.

A small grain strip filtering sediment at the lower end of a sugar beet field

3. Maintenance is required

Filter strips are not carefree. For filter strips to be effective, they must be properly operated and maintained. After 1 or more years of sediment collection by the filter strip, field shaping may be necessary to re-distribute sediment and maintain field slope. Perennial filter strips may require harvesting multiple times per year. Harvesting frequency should consider forage quality, regrowth ability of the species, harvest height and the filtering ability of the species. Commitment is essential.

Small Grain Filtering Irrigation Runoff from New Bean and Corn Crops

Installation and Operation

The type of crop you choose to use in a filter or buffer strip should fit your farming operation. Any close growing vegetation can be effective in filtering runoff. If you are growing low residue producing crops such as beans, sugar beets or potatoes, consider using small grains for a filter strip. Small grains are ideal, because filter strips on furrow irrigated fields usually have a useful life of about one to two years.

If the field is coming out of alfalfa or grass, leaving a strip of perennial vegetation at the toe of the field to act as a filter is also very effective.

Seeding rates for small grain filter strips should be 1.5- 2.0 times the normal seeding rate for that particular crop (see Table 1). Sediment removal is dependent on stand thickness, which is not always related to an increased seeding rate. Vegetation with stems less than 1 inch apart will trap the most sediment.

Determine actual filter strip widths to fit the situation based on your planting and harvesting equipment. Wider filter strips will collect more sediment.

A furrow irrigated filter strip needs a tail water ditch on the down slope edge to collect runoff that has run through the filter strip.

When using established vegetation (existing alfalfa or grass) as a filter strip, do not leave a dead furrow in front of the strip. A dead furrow will act as a ditch and field runoff will not reach and flow through the filter strip.

Vegetation in a filter strip should be 3- 4 inches tall before the first irrigation for it to function properly. Small grains should be planted as early as possible so they are well established prior to beginning irrigation. The first irrigation of the season can result in almost half of the entire season's soil loss.

Extremely important: Pull furrows or corrugates one-third of the way into the filter strip. This will reduce cross channeling and ponding and assure even distribution of runoff through the filter. Do not pull furrows all the way through the filter strip because it destroys the filtering effect.

See Table 1 for species and seeding rates recommended for filter strips.

For more information contact your nearest Natural Resources Conservation Service field office or the Aberdeen Plant Materials Center at 1691 A South 2700 West, P.O. Box 296, Aberdeen, Idaho 83210, phone (208) 397-4133.

References

Bauder, J.W., J.J. Fajardo, D. Cash and R.A. Fasching. 2002. What is a Vegetative Filter Strip. USDA, NRCS, Montana Agronomy Technical Note No. 87. 4p.

Berg, R.D.; Carter, D.L. 1980. Furrow Erosion and Sediment Losses on Irrigated Cropland. J. Soil and Water Conservation; 35:6; pp. 267-270.

Calkins, B.L., Walker, D.J., Michalson, E.L. and Hamilton, J.R. 1985. Economic Evaluation of Practices for Reducing Sedimentation Under Irrigated Agriculture in Southcentral Idaho. Research Bulletin No. 133. University of Idaho Cooperative Extension Service, Moscow. 19pp.

Carter, D.L. 1990. Soil Erosion on Irrigated Lands. In: Irrigation of Agricultural Crops. Agronomy Monograph no.30. American Soc. Agron. pp. 1143-1171

Carter, D.L.; Berg, R.D.; Sanders, B.J. 1985. The Effect of Furrow Irrigation on Crop Productivity. Soil Sci. Soc. Am. J.; 49: pp. 207-211.
Clary, W.P., Abt, S.R., Thornton, C.I. 1993. Sediment entrapment by stream channel vegetation. In: Management of Irrigation and Drainage Systems - Integrated Perspectives. ASCE, New York, New York. pp. 335-343.

Clausen, J.C.; Meals, D.W. 1989. Water Quality Achievable with Agricultural Best Management Practices. Journal of Soil and Water Conservation; 44:6, pp. 593-596.

Dillaha, T.A., Reneau, R.B., Mostaghimi, S., Shanoltz, V.O. and Magette, W.L. 1987. Evaluating nutrient and sediment losses from agricultural lands: Vegetative Filter Strips. CBP/TRS 4/1987. U.S. Environmental Protection Agency, Region III, Chesapeake Bay Liason Office, Annapolis, MD.

Dillaha, T.A.; Sherrard, J.H.; Lee, D.;Mostaghimi, S.; Shanholtz, V.O. 1988. Evaluation of Vegetative Filter Strips as a Best Management Practice for Feedlots. Water Pollution Control Fed.; 60: pp. 1231-1238.

Everts, C.; Brockway, C. February 1982. Reducing Soil Losses with Filter Strips. Current Information Series No. 587; University of Idaho Cooperative Extension Service, Moscow. 4 pp.

Fogle, A.W.; Barfield, B.J. 1958-. A Low Head Loss Sampling Device for Monitoring Inflow to Natural Vegetated Filter Strips. Trans.- ASAE. St. Joseph Michigan: American Society of Agricultural Engineers; May/June 1993. Vol. 36 (3): pp. 791-793.

Groffman, P.M.; Axelrod, E.A.; Leymunyon, J.L.; Sullivan, W.M. July/September 1991. Denitrification in Grass and Forest Vegetated Filter Strips. Journal of Environmental Quality, Madison, Wisconsin: American Society of Agronomy; Vol. 20(3): pp. 671-674.

Hansen, Niels and Marlon Winger. USDA, NRCS, Salt Lake City, UT. Personal communication relating to filter strips. 2008.

Kouwen, N. and Li, R.M. 1980. Biomechanics of Vegetative Channel Linings. J. of the Hydraulics Division, ASCE, Vol. 106 No.Hy6 pp.1085-1203.

Kouwen, N. 1988. Field Estimation of the Biomechanical Properties of Grass. J. Hydraul. Res.; 26(5): pp. 559-568.

Lemunyon, J.L. 1991. Grass Species Influence on the Fate of Nitrogen Entrapped in Vegetated Filter Strips. Abstract of Thesis, University of Rhode Island, USA. 149pp.

Lentz, R.D., I. Shainberg, R.E. Sojka, D.L. Carter. 1992. Preventing Irrigation Furrow Erosion with Small Applications of Polymers. Soil Sci. Soc. Am. J. 56:1926-1932.

Magette, W.L.; Brinsfield, R.B.; Palmer, R.E.; Wood, J.D. 1986. Vegetated Filter Strips for Nonpoint Source Pollution Control. Am. Soc. Agri. Eng. Microfire Collect. St. Joseph, Michigan: The Society. 16pp. Maps.

Magette, W.L.; Brinsfield, R.B.; Palmer, R.E.; Wood, J.D. 1989. Nutrient and Sediment Removal by Vegetated Filter Strips. Transactions of the ASAE, American Society of Agricultural Engineers; 32:2, pp. 663-667.

Magette, W.L. 1987. Vegetated Filter Strips for Agricultural Runoff Treatment. Philadelphia, PA: Region III, U.S. Environmental Protection Agency, XV, 125pp.: ill.

Martel, C.J., Jenkins, T.F., Diener, C.J. and Butler, P.L. 1982. Development of a rational design procedure for overland flow systems. CRREL Report 82-2. U.S. Army Cold Regions Research and Engineering Lab., Hanover, NH

Masterman, R.; Thorne, C.R. 1992. Predicting Influence of Bank Vegetation on Channel Capacity. J. Hydraul. Engineering; 118(7): pp. 1052-1058.

Neibling, W.H.; Alberts, E.E. 1979. Composition and yield of soil particles transported through sod strips. ASAE. Paper No. 79-2065. 12 pp.

Ree, W.O.; Palmer, V.J. 1949. Flow of Water in Channels Protected by Vegetative Linings. USDA-Soil Conservation Service Technical Bulletin 967.

Schellinger, G.R.; Clausen, J.C. 1992. Vegetative Filter Treatment of Dairy Barnyard Runoff in Cold Regions. J. Environ. Quality; 21: pp. 40-45.

Tollner, E.W.; Barfield, B.J.; Hayes, J.C. 1982. Sedimentology of Erect Vegetal Filters. J. Hydraul. Div.; 108 (HY12); pp. 1518-1531.

Walker, D.J., Patterson, P.E., Hamilton, J.R. 1986. Costs and Benefits of Improving Irrigation Return Flow Water Quality in the Rock Creek, Idaho, Rural Clean Water Project. Research Bulletin No. 139. University of Idaho Cooperative Extension Service, Moscow. 30pp.

Wright, P.E.; Lynch, D.F.; Capre, J.L. 1993. Vegetative Filter Areas for Agricultural Waste Water Treatment. Presented at 1993 ASAE International Meeting, Paper 932594. ASAE, 2950 Niles Rd., St. Joseph, MI 49085-9659 USA.

Yankey, Richard. USDA, NRCS, Twin Falls, ID. Personal Communication Relating to Furrow Irrigated Filter Strips. 2000.

TABLE 1
PLANTS RECOMMENDED FOR FILTER OR BUFFER STRIPS

COMMON NAME	SCIENTIFIC NAME	SEEDS/FT^2	LBS/ACRE
GRASSES - PERENNIAL			
20- 30 inch rainfall or irrigated			
Creeping foxtail	*Alopecurus arundinaceus*	90	5 lbs/ac
Orchardgrass	*Dactylis glomerata*	96	8 lbs/ac
Kentucky bluegrass	*Poa pratensis*	100	2 lbs/ac
17- 20 + inch rainfall or irrigated			
Smooth brome	*Bromus inermis*	48	16 lbs/ac
Meadow brome	*Bromus biebersteinii*	48	24 lbs/ac
Tall fescue	*Festuca arundinaceus*	50	10 lbs/ac
13- 16 + inch rainfall			
Intermediate wheatgrass	*Thinopyrum intermedium*	48	24 lbs/ac
Pubescent wheatgrass	*Thinopyrum intermedium*	48	24 lbs/ac
Tall wheatgrass	*Thinopyrum ponticum*	48	24 lbs/ac
Western wheatgrass	*Pascopyrum smithii*	48	16 lbs/ac
Thickspike wheatgrass	*Elymus lanceolatus*	48	16 lbs/ac
Streambank wheatgrass	*Elymus lanceolatus*	48	16 lbs/ac
< 12 + inch rainfall			
Crested wheatgrass	*Agropyron cristatum/desertorum*	48	12 lbs/ac
Siberian wheatgrass	*Agropyron fragile*	48	12 lbs/ac
LEGUMES – PERENNIAL			
Alfalfa	*Medicago sativa*	50	10 lbs/ac
SMALL GRAINS - ANNUAL			
Barley	*Hordeum vulgare*	45	150 lbs/ac
Oats	*Avena sativa*	45	150 lbs/ac
Triticale	*Triticosecale rimpaui*	45	150 lbs/ac
Wheat	*Triticum aestivum*	45	150 lbs/ac