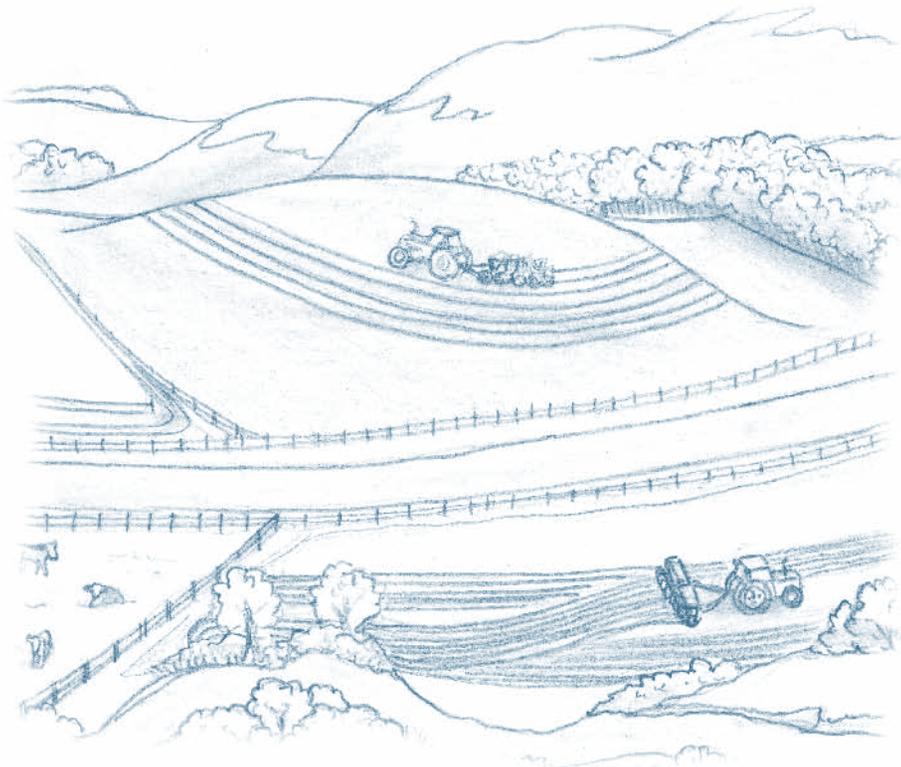


Chapter 8.3

Constructed Erosion Control Measures to Reduce Nutrient Losses In Runoff



→ learning objectives

- List four constructed erosion control measures and briefly explain how each reduces the risk of erosion and nutrient losses due to runoff.



Important Terms

Table 8.3.1 Key Terms and Definitions

Term	Definition
Basin	Earthen structure used to store water as it runs off or is generated from upstream land or facilities. While this water is being held or ponded, solids and some contaminants can be settled out of the water column.
Berm	Generally refers to a low earthen mound above natural ground level. They are used to control erosion and sedimentation by reducing the rate of surface runoff.
Diversion Channel or Interception Ditch	Earthen channels that are constructed below the existing surface to contain water within its banks. Used to divert and/or control water coming onto cropped land and stop water erosion from causing nutrient loss from the soil.
Drop Structures	These structures are often characterized as a vertical drop of several feet onto a horizontal stilling basin to dissipate the energy of flowing water and allow relatively low velocities (nonerosive) to exit the drop structure area. Many types exist such as drop inlet pipe, sloped pipe, chute spillways, grade controls and lined waterways.
Geotextiles	These are permeable, durable fabrics which, when used in association with soil, have the ability to separate, filter, or drain liquid and reinforce or protect soil. Filter cloth is commonly used term for a widely used fabric to keep fine soil particles from washing out from below higher cost materials or structures.
Grassed Waterways	Broad, shallow, saucer-shaped channels, which are grassed and designed to move surface water across farmland without causing soil erosion.
Gullies	A small valley or ravine worn away by running water and serving as a drainage-way after prolonged heavy rains.
Ponding	Water that collects in small depressions, into a pond or large puddle.
Run-on	Surface water originating upslope of a particular parcel of land. This water may be from natural runoff from upslope land parcels, natural areas or controlled releases from facilities.
Sheet Flow or Sheet Runoff	Runoff that flows uniformly across the landscape and not in concentrated channels or gullies.
Vegetative Field Borders (VFB)	Areas of natural or managed vegetation located at the edge of a cropped field to retain and buffer the passage of nutrients onto another land parcel, watercourse or water body.
Water Bodies	Bodies of surface water, including lakes, streams, rivers, wetlands and sloughs.

This chapter looks at more intensive control measures to deal with runoff from snowmelt or rainfall on fields with long, continuous slopes with a greater than 6 % grade. This chapter focuses on constructed erosion control measures to supplement in-field management practices to reduce erosion and nutrient losses in runoff.

The control measures discussed in this chapter are often more expensive and require more planning than the practices described in the previous chapter. Services from a professional engineer may be needed. Also, in contrast to the management practices in the last chapter, their placement on cropped land may reduce the net productive area. Despite these drawbacks, these measures can dramatically reduce the amount of soil and nutrients loss from high-risk areas for many years and even decades if they are properly designed and maintained.

Combining several constructed erosion controls with the practices discussed in the previous chapter is most effective for reducing slope-related runoff nutrient losses.

Note that much of the information available on constructed erosion control measures is based on experience in warmer areas of the United States with high annual precipitation where the majority of runoff is a result of rainfall. Although most runoff is from spring snowmelt, in Alberta some intense rainfall early in the growing season has caused the most erosive runoff events. Because of these differences in types of runoff, not all measures used in the warmer areas are applicable to Alberta. If control measures are applicable, tips are included to successfully implement these controls under Alberta conditions where possible.

Grassed Waterways

Grassed waterways are broad, shallow, saucer-shaped channels designed to move surface water across farmland without causing soil erosion. There are three features of this control measure:

- The key component of this control is the vegetative cover in the waterway, which slows the speed of water flow in the watercourse and serves as a physical filter that removes sediment (and sediment bound nutrients) from water flow. As long as sediment deposition is not excessive, the sediment-bound nutrients trapped by the vegetative cover can then be used to supply the nutrient requirements of waterway vegetation.
- Waterways are typically constructed along the natural surface drainage pattern in a field. In many cases these are built to rehabilitate gullies formed as a result of the erosive force of surface runoff events.
- Ideally, the waterway conducts water to a suitable outlet, typically a ditch, water body or other control structure such as a settling basin.

Advantages of Grassed Waterways

- Earthwork during construction is minimized and potential licensing requirements are reduced when existing field drainage patterns are followed.
- If designed properly, they can be safely crossed by farm machinery.
- Grassed waterways are capable of handling large flows, which makes them suitable for handling larger drainage areas.
- Once vegetation in the waterway is firmly established, maintenance requirements are minimal.
- Provided the waterway is properly maintained, waterway vegetation can serve as a valuable source of forage for livestock.

As a guideline, use grassed waterways when working with a drainage pathway handling runoff from area greater than 20 ha (50 ac). Grassed waterways are most effective on sites where runoff flow tends to concentrate in identifiable channels, which in some cases may erode to form gullies. Use other controls such as zero till for smaller areas.

If properly sized and constructed, grassed waterways will safely transport water down slopes. This characteristic makes them suitable for use as an outlet for contour cropping operations and as run-on diversion channels. Once the velocity of water running down a grassed channel exceeds about 1.2 metres per second (4 ft/s), the grass channel lining may need to be reinforced or alternative methods such as drop structures to reduce the channel grade should be investigated.

more info



The Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA) regulates the practice of engineering, geology and geophysics in our province under a mandate in the provincial *Engineering, Geological and Geophysical Professions Act*.

The association website (www.apegga.org) has some useful advice on how to find a consultant or contact APEGGA with questions:

Phone: Toll free (in North America) 1-800-661-7020

Email: email@apegga.org



tip



Appropriate authoritative agencies such as Alberta Environment should be contacted in regards to any licensing requirements for the outlet of Grassed Waterways or diversions. Phone (780) 427-2700.



Design and Installation Recommendations

Use the following design and installation recommendations to maximize effectiveness and ease of maintenance of grassed waterways. The services of a professional engineer may be required depending on complexity and impact of adjacent landowners or infrastructure.

- Design and construct waterway to handle the required flow of water. The flow of water is influenced by amount and timing of snowmelt or precipitation, site topography, watershed area, soil conditions and crop type. Water flow is also influenced by management practices in the field (e.g., direct seeding and reduced tillage compared to conventional tillage). Ensure that the initial bare-soil condition and the more stable grass-covered condition are considered in the design relative to the potential risk of extreme rainfall events during establishment.
- The degree of erosion control provided by the waterway is related to the density of plant cover in the waterway. Therefore, timing of construction is important. Complete construction and seeding of the waterway in spring to ensure sufficient plant growth before snowmelt runoff the following spring. Construction should begin at the outlet and proceed upstream in the event of a rainfall runoff event during construction.
- Design waterways to be saucer-shaped (Figure 8.3.1). This shape spreads the flow of water over a greater surface area slowing its velocity and reducing its erosive force. This design also makes it easier to cross the channel with machinery and mow or harvest the vegetation. Use a standard width of the bottom of the waterway of 3 m (10 ft). The bottom portion of the channel should not be constructed horizontally but rather tilted slightly to one side so rills do not form in the bottom of the channel during lower flows before grass is established.

- Design waterways in conjunction with other limiting structures. Sometimes routing waterways through existing or newly placed culverts or other control structures is necessary. Care needs to be taken in the hydraulic design of these structures and also the entrance and exit of the waterways to prevent destruction of the structure.
- If the slope is very steep other erosion control structures and materials can be implemented. Some examples are filter cloth, geotextiles, and various drop structures to dissipate some of the energy of the water.

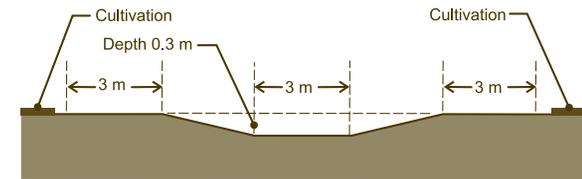
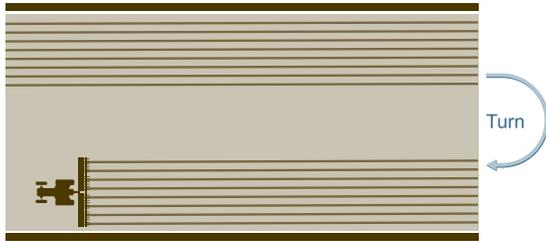


Figure 8.3.1 Cross Section of a Typical Constructed Grassed Waterway

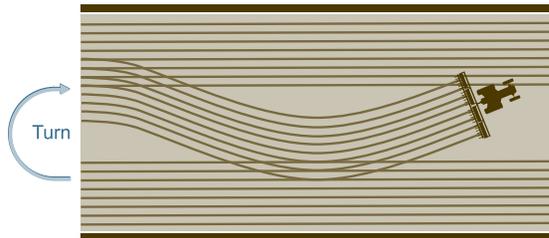
- The side-slopes of the waterway should be 10:1 but no steeper than 4:1. A slope of 4:1 means 4 horizontal feet to one vertical foot. This ensures that the waterway functions properly but can still be crossed with equipment safely.
- Remove brush, rocks and other debris from the work area before construction. If these obstructions are not removed or buried, water will erode more quickly around them causing gullies or ponding to form. Any fill that is used in the channel should be packed hard.
- Remove topsoil from the working area, stockpile and replace after construction. Allow extra depth of the waterway to accommodate return of topsoil after construction. After spreading, level and harrow the topsoil to provide a smooth bottom and a good seedbed. Spread excess soil away from the sides, so runoff from adjoining land can flow easily into the waterway.

- Seed across the waterway (Figure 8.3.2). In the same way that farming the contour of a slope reduces erosion, seeding perpendicular to the direction of the water flow helps increase friction and further slow the flow of water in the waterway.

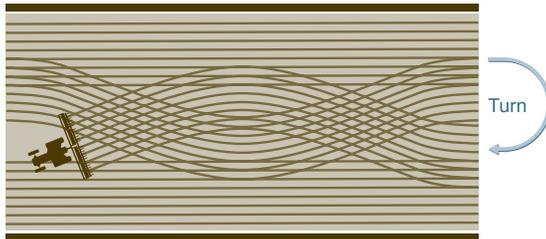
Step 1: Seed along the outer edges, leaving the center one-third unseeded.



Step 2: Seed the center by gently steering from side to side to make one-half of a figure-eight.



Step 3: On the return trip, seed the remaining areas and make the other half of the figure-eight.



- When establishing the waterway, use forage mixes that establish quickly and contain sod-forming, long lived grass species. To be effective, the waterway must have well-established vegetation capable of withstanding the force exerted by the flow of water through the waterway and prolonged submersion under water. Use a hardy cover crop such as fall rye to protect the waterway until grass becomes established. Since fertility can be an issue in newly constructed waterways, apply inorganic fertilizer to help the plants gain a foothold.



more info



For more information on the design, installation and maintenance of grassed waterways can be found in the following online resources:

- **AAFC – PFRA. 1989. Manitoba Soil Conservation Resource Manual - Water Erosion. www.agr.gc.ca/pfra/soil/soilc02a.htm**
- **Ontario Ministry of Agriculture, Food and Rural Affairs. 1994. Grassed Waterways. Agdex 751. www.omafra.gov.on.ca/english/engineer/facts/94-039.htm**
- **AF. 2002. Grassed Waterway Construction. Agdex 573-6.**

Figure 8.3.2 Recommended Seeding Pattern for Grassed Waterways

more info



For more information on the design, installation and maintenance of earthen berms can be found in the following online resources:

- Ontario Ministry of Agriculture, Food and Rural Affairs. 1990. Use of Earthen Berms for Erosion Control. Agdex 751. www.omafra.gov.on.ca/english/engineer/facts/99-047.htm

tip



VFBs are an “edge-of-field” beneficial management practice.

Use them in combination with crop and field management practices that minimize soil and nutrient losses in runoff. The VFB on their own have limited ability to reduce the amount of nutrient lost from a field, particularly from large, sloping sites. They are much more effective if used with direct seeding, reduced tillage and conservation fallow.



Figure 8.3.3 Constructing Grassed Waterways.

Run-on Diversion Channels or Basins

In certain situations it may be possible to divert or control water coming onto cropped land and stop water erosion from causing nutrient loss from the soil. This water may be from natural runoff from upslope land parcels or natural areas or controlled releases from intensive livestock operations.

Diversion Channels or Berms

Earthen channels are constructed below the existing surface to contain water within its banks whereas berms are built above grade and pond or divert water back onto cropped land upslope.

Constructing a run-on diversion channel (or interception ditch) may be most suitable when an alternative waterway, natural or manmade, has adequate safe capacity a short distance away with minimal elevation rise between them. Because a change to natural flow patterns is caused, careful planning and approval is required ahead of construction.

Terracing is a coupling of a channel and a berm and provides a similar result as run-on diversion channels but it is integrated on to the cropped land. Terracing breaks up the length of a slope. Multiple diversion channels or berms are formed at intervals perpendicular to the dominant field slope (following contours) and divert water to a safer, less erodible outlet. Terracing is common in some parts of the world especially where they can be constructed by hand on smaller farms. These have been tried in Alberta with mixed results but are not commonly constructed or seen.

Basins

Basins can store water as it runs off or is generated from upstream land or facilities. While this water is being held or ponded, solids and some contaminants can be settled out of the water column. Water with less sediment in it is less erosive. Examples of basins on agricultural landscapes include feedlot catch basins, exercise yard runoff basins, sediment control basins, and irrigation return flow catchments. Basins are most effective when they are regularly emptied so as to have the maximum volume available for runoff retention with less earthwork construction. Water held temporarily in basins can be emptied in a number of ways including:

- Release it to downstream channel at a lower flow rate or at a better time when less erosion is likely to occur.
- Spray irrigate it over a larger land area at rates not to cause runoff or erosion

Vegetative Field Borders

Vegetative field borders (VFB) are areas of natural or managed vegetation situated between a non-point source of pollution, such as a field that has received manure or fertilizer, and an environmentally sensitive area, most often a water body.

Properly designed VFBs provide protection to surface water quality by removing sediment, organic matter, some nutrients and pesticides from runoff at the edge of the field before it enters the surface water bodies.

Other Benefits of VFBs:

- They provide a habitat for wildlife.
- They provide a source of forage or hay for livestock.
- They become an area to turn equipment around at the end of field rows.

VFBs are most effective on sites with slight to moderate slopes where the runoff pattern from the field tends to be uniformly spread rather than concentrated in channels (i.e., sites prone to sheet erosion).

VFBs reduce nutrient export from fields that have received manure or fertilizer application through two main mechanisms:

- **Physical filtering.** Any sediment-bound nutrients are trapped in the strip rather than being carried into the adjacent water body. Larger-sized soil particles (i.e., sand and silt) and soil aggregates settle from the runoff within a relatively short distance into the filter. Fine particles such as clay may take a longer distance to settle out and, depending on runoff conditions, may not be deposited in the strip to any large extent. This filtering action would have little impact on reducing soluble nutrient concentrations in runoff.
- **Infiltration.** The velocity may be slowed to the point that water is allowed to penetrate into the soil allowing dissolved nutrients to be used by vegetation in the strip. With time this will result in the accumulation of nutrients within the VFB. For the VFB to function properly it must be regularly harvested to remove plant growth and accumulated nutrients. This mechanism does not work well in areas where soil conditions (i.e., compacted or frozen) during runoff impede infiltration.

Periodic monitoring of the nutrient status of the soil is required to prevent the VFB from becoming overloaded and turning into a nutrient source.

Establishing VFBs

When planning installation of a VFB, consider several site-specific characteristics:

- soil properties
- steepness of the slope
- expected quantity and timing of runoff
- shape and area of the field draining into the filter
- management practices in use on the field that drains through the VFB.

The most important factors influencing the effectiveness of a VFB are:

- The width of the VFB depends on its desired function and adjacent spaces. The width of a VFB to stabilize field edges that border steep ditches or steep banks will be smaller than the width necessary to effectively capture nutrients in runoff.
- For the VFB to filter runoff efficiently, runoff must pass through the strip in a shallow, uniform flow (i.e., sheet flow). This means they must be situated where runoff can be filtered before it concentrates in natural or manmade drainage channels which are influenced by the topography within the field.
- VFBs should be seeded perpendicular to the slope to create conditions that allow for shallow, uniform flow to enter the filter.
- Select suitable vegetation to ensure long-term effectiveness of the VFB. Suitable plants should have a dense top-growth, a fibrous root system, provide good, uniform soil cover and be suited to local soil and climatic conditions.
- If border vegetation is to be used for forage production, consider agronomic factors such as yield, feed quality and herbicide compatibility.

sidebar

Heavy use of VFBs as field roadways should be avoided due to the risk of compaction and resulting loss of effectiveness as a filter.



sidebar

Other terms used interchangeably with VFB include grass barriers, riparian buffer strips and conservation buffers. This guide uses the term VFB to refer to all of these structures since they all perform the same basic function.

more info



For more information on the design, installation and maintenance

of VFSs can be found in the following online resources:

- **AF. 2003. Buffer Zones for a Healthy Watershed: [www1.agric.gov.ab.ca/\\$department/deptdocs.nsf/all/irr6419](http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/irr6419)**
- **Ohio State University Extension. The Economics of Vegetative Filter Strips <http://ohioline.osu.edu/ae-fact/0006.html>**



VFBs on Steep Slopes

Runoff from slopes greater than 10 % would overwhelm the capacity of the VFB to remove sediment and contaminants from runoff. Since most major runoff events in Alberta occur during a relatively short period during spring thaw, consider alternative control strategies for sites with steep slopes.

Among vegetation types, grasses are more effective than broadleaf plants in reducing erosion and filtering nutrients since they form a dense sod, have a fibrous root system and provide more extensive ground cover. Sod forming grass species are preferred to bunchgrasses since they form a more consistent ground cover reducing the likelihood of channelling through the VFB, thereby reducing its effectiveness. Legumes such as alfalfa or clovers may be seeded in a mixture with grasses in order to improve fertility of the stand. However, legumes can reduce the capacity to filter sediment, and as such should not be used as the dominant species in a VFB.

Trees and shrubs require additional maintenance but are superior for stabilizing streambanks, reducing flood risk and maintaining groundwater quality. Select tree and shrub species suitable for site conditions, to minimize problems with establishing and maintaining the VFB.

Maintain Natural Wetlands and Sloughs

Water bodies such as wetlands and sloughs provide a place for runoff waters to pond temporarily or completely depending on their size and the area draining to them. Unlike previous measures discussed in this chapter, they may require no additional investment other than their maintenance and protection.

Advantages of Natural Wetlands and Sloughs

- Slow the movement of water through a landscape or watershed reducing the erosion or destruction that can result.
- Provide an interface between surface water, groundwater and the air where shallow groundwater supplies can be recharged or evaporation can generate new rainfall.
- Improved water quality downstream due to the filtering and biological processes that are part of this aquatic environment.
- Provide a habitat for local wildlife.

While land area unavailable for cropping or lost crop production to wildlife may be viewed as disadvantages, the advantages are growing. Those listed above plus potential social and stewardship incentives to maintaining natural wetlands and sloughs are becoming more apparent.

Keeping in place natural waterways leading in or out of wetlands and sloughs may be all that is required to maintain this productive aquatic environment. Conservation farming practices such as zero till can reduce sediment deposit in these water bodies. Sediment deposits can shorten the effective lifespan of these water bodies, reduce their volume holding capacity and cause them to spread further onto productive crop land during major runoff events. Remote livestock watering devices, fencing, or use of alternative pastures for livestock production can reduce damage to key flow components in sloughs or wetlands. Vigilance in reporting unauthorized upstream water diversions or pumping may also keep this water body intact.

summary

- Grassed waterways reduce erosion and nutrient loss by physically holding the soil together and removing suspended sediment through infiltration and filtering from runoff on sites where flow is concentrated in channels.
- VFBs are edge-of-field plantings of sod-forming species that can remove some sediment through infiltration and filtering from runoff on sites where flow is less concentrated and more uniform.
- Diversion channels or berms may be used to divert or control water coming onto cropped land and stop water erosion from causing nutrient loss from the soil. Basins can be used to store water as it runs off or is generated from upstream land or facilities reducing the risk of erosion and the transfer of nutrients from the soil.
- Terracing is a coupling of a channel and a berm. Terracing breaks up the length of a slope and diverts water to a safer, less erodible outlet reducing the risk of erosion and the transfer of nutrients from the soil. This control structure is not typically used on cropland in Alberta.
- Maintaining natural wetlands and sloughs in an agricultural landscape can reduce the damage of major runoff events by collecting and slowing water runoff.
- Remember to follow up on any approval or licensing requirements for the projects you undertake.