Grassed Waterways and Interception Channels

Background

A grassed waterway contributes to soil conservation and is usually combined with other measures aimed at reducing erosion, including reduced tillage, use of cover crops (green manure or grasses), water catchment works and riparian strips. If no other soil conservation practices are in place, a waterway could quickly fill with sediment, increasing the risk of overflow and the creation of other centres of erosion.

Source: Alain Gagnon, MAPAQ

Definitions

Grassed waterways are natural or artificial canals designed to capture runoff and direct it to a safe outlet without causing erosion. Their shallow, open profile allows for effective distribution of flow. The roughness of their plant cover limits water velocity, thereby preventing the formation of ravines.

Interception channels are canals that are similar to waterways, but smaller. They are generally oriented perpendicular to the direction of cultivation in order to intercept surface and subsurface runoff before they cause drainage or gully erosion problems.

Farm ditches also remain useful. Because of their significant depth, they make it possible to lower the water table and can also serve as outlets for subsurface drains. Moreover, they have the capacity to drain large volumes of water without having a large footprint on the land. However, the high flow rates and lack of vegetation can cause erosion problems for their sides and beds. Some farm ditches that have suffered significant erosion can be converted to grassed waterways.

Determining the location of such installations

Where should a waterway be developed?

Where relief is high, a waterway can be developed in a low area of a field, where runoff is concentrated. In relatively even terrain, a waterway can be developed wherever it will interfere the least with operations in the field. Natural relief or existing canals can be used because of their inherent features (low longitudinal slope, significant depth and capacity).

Certain additional parameters must be considered:

- If the selected canal crosses a relatively uneroded wooded area, its plant cover must be preserved to encourage biodiversity.
- Avoid placing a waterway near a shelterbelt because roots could obstruct the waterway subsurface drain.
- Snow accumulation can block a waterway and reduce its capacity to drain runoff. Winter clearing is sometimes necessary to prevent overflow when the snow melts.

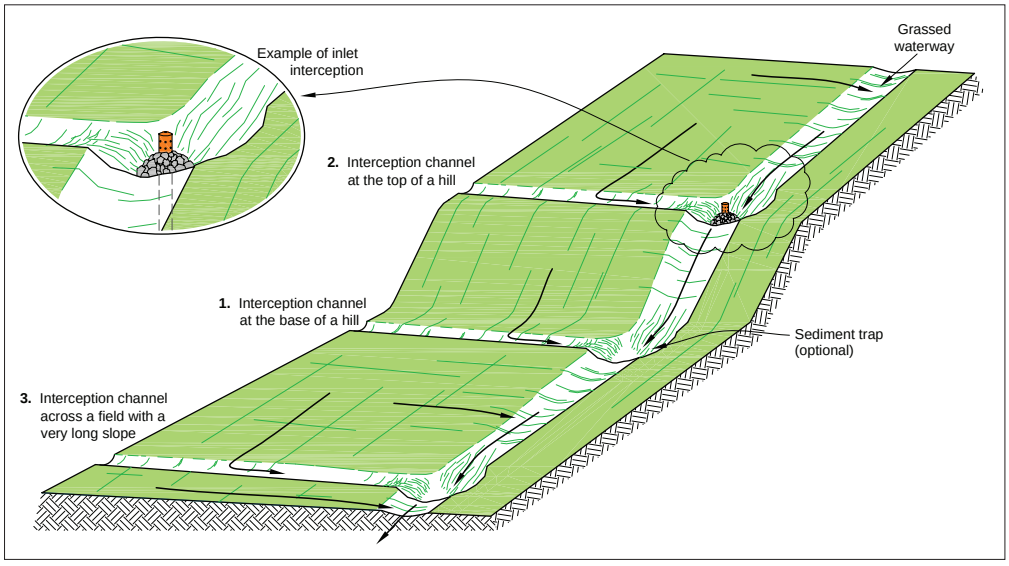
Photos 2 and 3: Waterway designed in an eroded furrow
Source: Mikael Guillou, MAPAQ

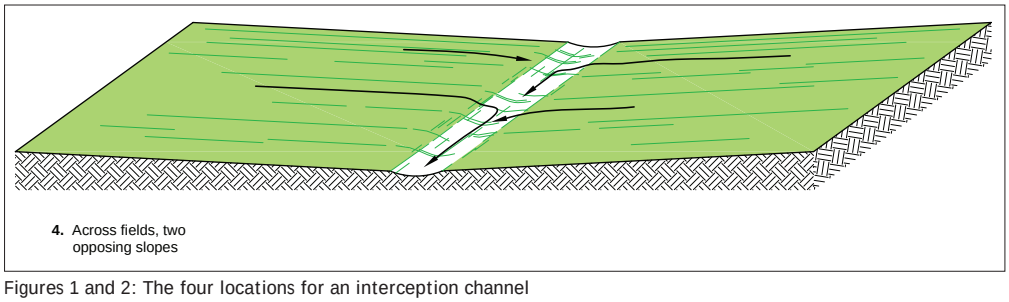
Where should an interception channel be developed?

An interception channel can be developed in the following locations:

1. At the junction of a steep slope and a more gentle downstream slope, e.g., at the base of a hill. In such a case, the main function of the channel is to improve the drainage of a field.
2. At the top of a hill to intercept and divert runoff toward an outlet and minimize the risk of erosion of a steep slope.
3. Across a field with a very long slope, to partition drained surfaces and intercept runoff before it can cause erosion.
4. Across a field to capture the water at the junction of two opposing slopes, if the back slope cannot be eliminated by levelling.

An interception channel generally ends at a grassed waterway, an inlet well or a farm ditch.





Figures 1 and 2: The four locations for an interception channel
Source: Drawing adapted by Luc Lemieux, MAPAQ

Parameters to be considered in conjunction with sizing

The choice of the shape of a grassed waterway, of the associated drainage system, of the outlet and of the cover type form the basis for the design of these installations and determine their effectiveness. These parameters must be analysed in conjunction with sizing.

Choice of the shape of a grassed waterway or a channel

A **parabolic cross-section** is generally preferable because it results in a canal in which the profile of the water is wide and shallow. This increases flow area and reduces water velocity. Flow is more concentrated at the centre, preventing excessive sedimentation when flow rates are low.

A **trapezoidal cross-section** has a broad flat bottom, which spread the profile of the water over a large area at all times. It is recommended for certain areas of steep slopes because it is an effective means of slowing the flow of water. However, it should be avoided in low-slope areas because the slow rate of flow will promote sedimentation and the formation of meanders. Over time, a trapezoidal cross-section becomes more parabolic in shape.

In general, a **V-shaped cross-section** should be avoided because it concentrates the flow at the centre of the waterway and causes retrogressive erosion of the bottom because of the high water velocities created. It can be used in cases of low flow rates (interception channels) or very low slopes.

For ease of maintenance, bank slopes must be less than 1:4 (vertical:horizontal). To allow for machinery crossing, bank slopes must be less than 1:10. Waterways with slopes greater than 1:10 can be crossed locally if culverts or riprapped crossings are installed.

The fact sheet entitled **Sizing Grassed Waterways** describes ways of determining the optimum width and depth of grassed waterways.

Choice of associated drainage system

A drainage system is generally installed near a waterway or channel to dry the bed, encourage development of healthy vegetation, improve the load bearing capacity of the soil and prevent rutting.

A 100-mm (4-inch) perforated high-density polyethylene (Pehd) drain is generally installed parallel to the waterway. The drain must be offset from the centre of the waterway by a distance of at least one quarter of the canal's total width. It is buried at a minimum depth of 0.75 m below the bed of the waterway on the side that receives the greatest amount of runoff. The outlet for the drain is normally installed at the rock chute at the mouth of the grassed waterway.

In sandy, silty and clayey soils with low plasticity, the drain should be wrapped with a geotextile filter to prevent soil particles from entering and blocking it. In contrast, in plastic clay or very gravelly soils, the drain should not be wrapped because this greatly reduces its effectiveness.

If the waterway is more than 15 m wide, a second 100-mm drain can be installed on the other side of the bed.

It is important to avoid residual flow in grassed waterways and interception channels, where prolonged submersion could affect the plant cover that has been established. In the case of perennial flow in the waterway (seepage, drainage outlet, water from a building), runoff catchment installations must be included in the design.

In cases of minor flow, infiltration wells in rocks or chips can be installed at regular intervals starting at the main drain. For more information, consult the fact sheet entitled **Infiltration Wells**.

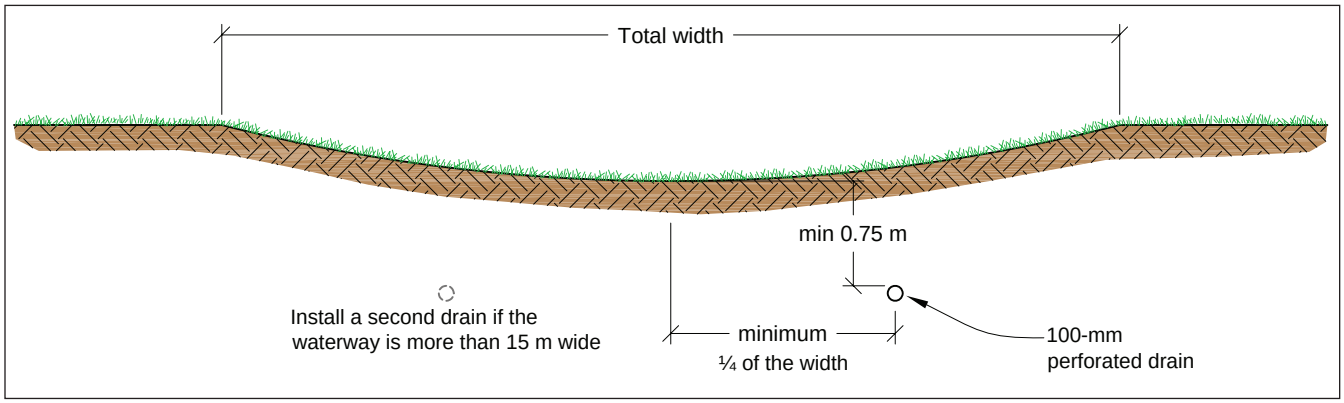


Figure 3: Drainage for a grassed waterway
Source: Brochu and coll. 1992, drawing adapted by Luc Lemieux, MAPAQ

In cases of higher flows, installation of an inlet or drainage well is recommended. The purpose of such a system is not to capture most of the runoff during high-flow events, but rather to intercept regularly occurring residual flows. Most of the peak flow will reach the outlet via the waterway. For example, the first inlet well could be installed at the head of the waterway to tap a source and a second, lower down at the mouth of an interception channel.

Downstream of the inlet well, a dike can be installed to slow flow and promote sedimentation. An emergency spillway should be included. For further details, consult the fact sheet entitled **Use of Earthen Berms for Erosion Control**, Agdex No. 751, published by the Ontario Ministry of Agriculture.

For information on sizing and type of piping, consult the fact sheets entitled **Inlet and Drainage Wells and Calculations for Sizing Inlet Wells**.

Photo 4: Installation of a 100-mm wrapped drain for drainage and a 150-mm non-perforated drain for the inlet well in a steep waterway
Source: Alain Gagnon, MAPAQ

Photo 5: Grassed waterway and inlet well
Source: Georges Lamarre, MAPAQ

Choice of outlet

A waterway generally ends at a rock chute, which provides a stable junction between the waterway and the stream or ditch that serves as its outlet. The dimensions of this installation and the stones used to create it must be based on the peak flow to be discharged and the velocity of the water coming from the waterway and the receiving stream.

The chute apron can be extended to the field level to facilitate access by machinery.

The fact sheet entitled "**rock chute spillway factsheet**" contains information on construction of such installations.

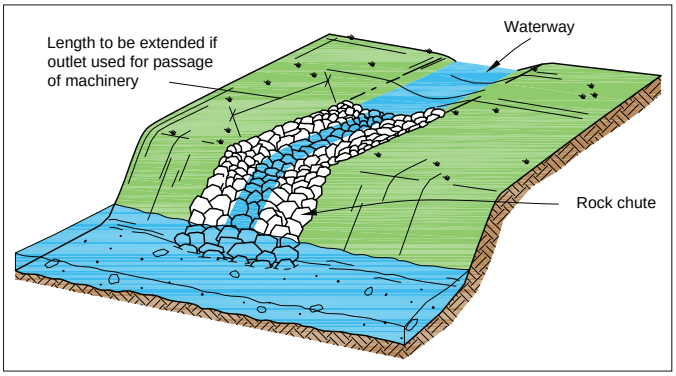


Figure 4: Protecting a waterway outlet
Source: Drawing adapted by Luc Lemieux, MAPAQ

Choice of cover type

A waterway is generally covered with vegetation that will produce a healthy plant cover as quickly as possible to prevent gully formation at the centre of the waterway.

It is recommended, however, that part or all of the waterway be riprapped in the following situations:

- When the water velocity exceeds the capacity of the vegetation or soil to resist erosion.
- When the location chosen for the waterway is not conducive to the development of vegetation (very poorly drained soil, densely forested area).
- When there is perennial flow in the waterway and it is not linked to any drainage system, the centre must be riprapped because plant development will be limited by excess moisture.
- When the waterway must be crossed by farm machinery at a specific location (farm road) on a regular basis.

The choice of cover type will affect flow velocity in the waterway and this aspect must therefore be considered in advance of or during sizing.

Photo 6: Riprapped waterway under dense forest cover
Source: Mikael Guillou, MAPAQ

Construction phases

1. If the waterway is developed in the same location as an existing gully, the gully must be filled without using topsoil. To limit backflow, backfilled soil must be well tamped.
2. Use stakes or drainage flags to mark the centre and the sides of the future waterway as well as changes in slope.
3. Install the drainage system beginning with the outlet. The drain must be placed at a minimum depth of 0.75 m from the projected bottom of the waterway and offset from the centre of the waterway by a distance equal to one quarter of its width on the side that receives the greatest amount of runoff.

Photo 7: Installing a wrapped drain before shaping a waterway
Source: Mikael Guillou, MAPAQ

4. Install the outlet (rock chute).
5. Shape the waterway canal, beginning at the outlet, closing the drain trench by any of the following means:

    5.1. A hydraulic shovel: by excavating the parabolic shape directly from the side of the waterway. It is preferable that a laser be used to monitor depth.

Photos 8 and 9: Installing a channel by lateral excavation
Source: Mikael Guillou, MAPAQ

5.2. A hydraulic shovel: by first using the bucket guided by a laser to excavate a V-shaped ditch and then widening the canal one side at a time with a ditch bucket.

Photos 10: Installing a waterway by widening the V-channel
Source: Mikael Guillou, MAPAQ

5.3. A bulldozer: by working along the edge of the waterway with the angle blade, without moving lengthwise along the drain fill. The parabolic canal is then shaped by successive crosscutting passes. This inexpensive technique is adapted mainly for use in cases of steep slopes (>1%), where the bulldozer has no laser-level system.

Photos 11 and 12: Installing a waterway with a bulldozer
Source: Mikael Guillou, MAPAQ

5.4 The excavated soil can be used to level the field. Extra excavation depth must be allowed in order that topsoil can be added to the surface of the waterway to encourage the establishment of grass cover.

6. Lime if needed, harrow. Avoid creating deep ruts parallel to the waterway because they will intercept some of the runoff and encourage the formation of erosion gullies.

7. Establish a plant cover.

7.1. Seed the plant cover. A healthy plant cover must be achieved as quickly as possible to prevent gully erosion at the centre of the waterway. The most favourable periods for this step are the months of May to June and August to September, with adequate protection provided in the latter case.

- Use an electric seeder mounted on an ATV or a tractor, a seed drill or a Brillon seeder.
- Rate of seeding: 60-100 kg/ha of an adapted seed mix. The following two suggestions are provided as an example:

45% creeping red fescue 30% ray grass 25% alsike clover or white clover Source: Bernard Arpin, MAPAQ	45% creeping red fescue 40% creeping bentgrass 15% ray grass For fall seeding, replace the ray grass with a fall cereal and if the soil is very wet, replace part of the fescue with bentgrass. Source : Brochu et coll. 1992

Photo 13: Tractor-mounted seeder
Source: Mikael Guillou, MAPAQ

7.2. If necessary, install an erosion-control cover in the centre area of the canal.

In some cases, the time period allowed to achieve a good plant cover is very short (fall seeding, risk of storm erosion); in such cases it is recommended that the centre area of the waterway be immediately covered with an erosion-resistant material. Straw blankets (e.g., ARMTEC S75, S150 or SC150) or burlap secured with wooden stakes or metal hooks provide adequate protection.

Photo 14: Protecting the soil in a waterway with burlap
Source: Mikael Guillou, MAPAQ

Photo 15: Protecting the soil in a waterway with a straw blanket
Source: Mikael Guillou, MAPAQ

7.3. Other choice: install sod.

Sod can also be used to provide immediate protection for the soil in waterways that are receiving high flows or that are very sloped. An additional 5 to 10 cm must be excavated in the central area of the waterway to allow for the sod to be placed at the bottom, where the flow cannot bypass it.

Photo 16: Protecting a waterway with sod
Source: Jacques Goulet, MAPAQ

7.4. If necessary, install a buffer strip.

If a significant amount of water is entering from the sides of the waterway, an additional grass buffer strip can be installed on either side to slow runoff and trap some of the sediment coming from the fields before it can enter the waterway.

8. Install a riprap cover.

Depending on the situation, riprap must sometimes be installed on the bottom of the waterway, or sills must be created to reduce longitudinal slope. In addition, if a waterway is crossed frequently by farm machinery at the same spot, a riprap crossing must be installed. Access slopes must be reduced to 1:10.

Photos 17, 18 and 19: Creating a riprap channel on geotextile fabric
Source: Donald Lemelin, MAPAQ

The following table specifies the size of the rocks to be used as a function of calculated water depth in a waterway during peak flow conditions. Table 2 in the fact sheet entitled Sizing Grassed Waterways indicates depth of flow in a waterway as a function of maximum flow velocity selected and longitudinal waterway slope.

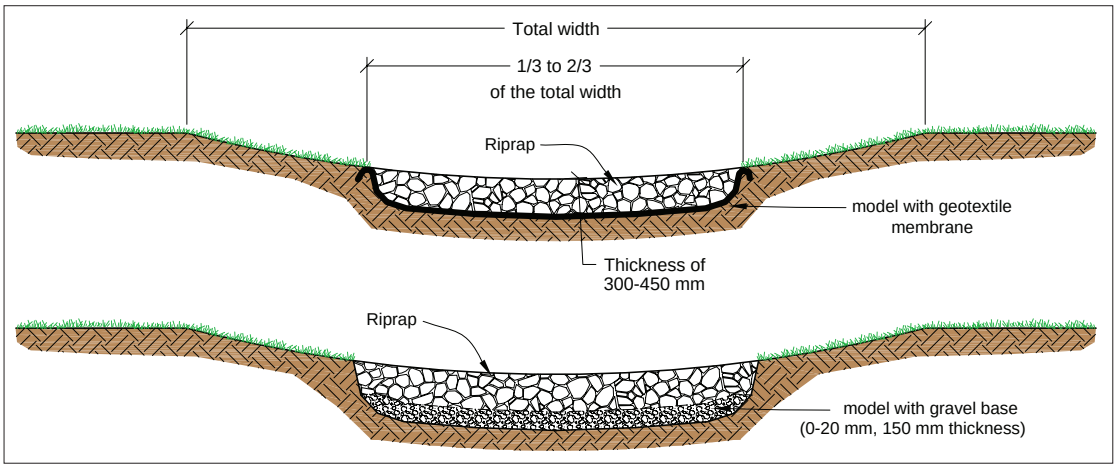


Figure 5: Cross-section through a riprapped waterway
Source: NRCS 1984, chap 7, Grassed Waterways, dessin adapté par Luc Lemieux, MAPAQ

Diameter of rocks to be used (D75* in cm)		
Waterway slope (in %)	**Peak flow depth = 0.3 m**	**Peak flow depth = 0.6 m**
0.5	2.5	5.0
1	5.0	9.0
2	9.0	17.8
3	12.7	25.4
4	16.5	33.0
5	20.0	43.1
10	38.1	76.2

Source: NRCS 1984, chap 7, Grassed Waterways, pages 7-48

***: D75 indicates that 75% of the total mass of the riprap used must consist of rocks that are smaller in diameter than the value indicated in the table. The remainder of the riprap (25% of the total mass) will consist of rocks that are larger in diameter than the value indicated in the table.**

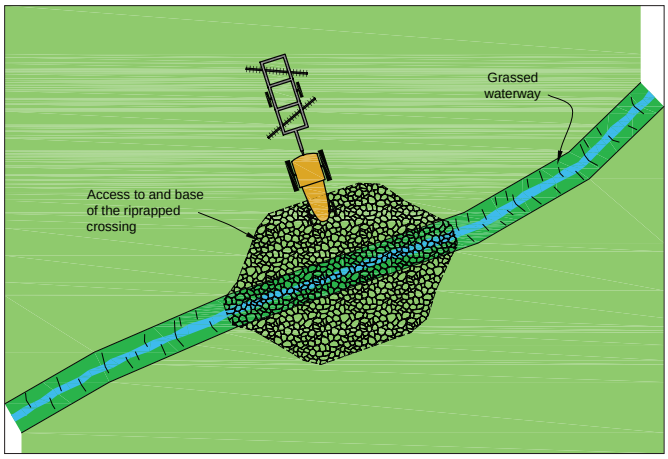


Figure 6: Aerial view of a waterway crossing
Source: NRCS 1984, chap 7, Grassed Waterways, dessin adapté par Luc Lemieux, MAPAQ

The riprap will generally cover between 1/3 and 2/3 of the total width of the waterway and will range from 0.30 to 0.45 m in thickness.

There are several options for preventing erosion of the soil beneath the riprap. A 15-cm thick base of (0 to 2 cm diameter) gravel, a woven geotextile fabric or a non-woven geotextile fabric such as TEXEL 7612 or the equivalent, must be installed.

Photo 20: Riprapped waterway in a steep setting
Source: Alain Gagnon, MAPAQ

Maintenance of waterways or channels

• Vegetation management

Particular attention must be paid to the vegetation cover during the first year, while it is becoming established. If the vegetation is destroyed in specific areas (herbicide drift, tillage tools), it must be reseeded quickly to avoid leaving the soil bare and creating erosion centres.

Ideally, the vegetation should be cut twice yearly to keep the bed of the waterway from becoming blocked.

Weed control in waterways should be avoided and the canals should not be used for pasture or as farm roads.

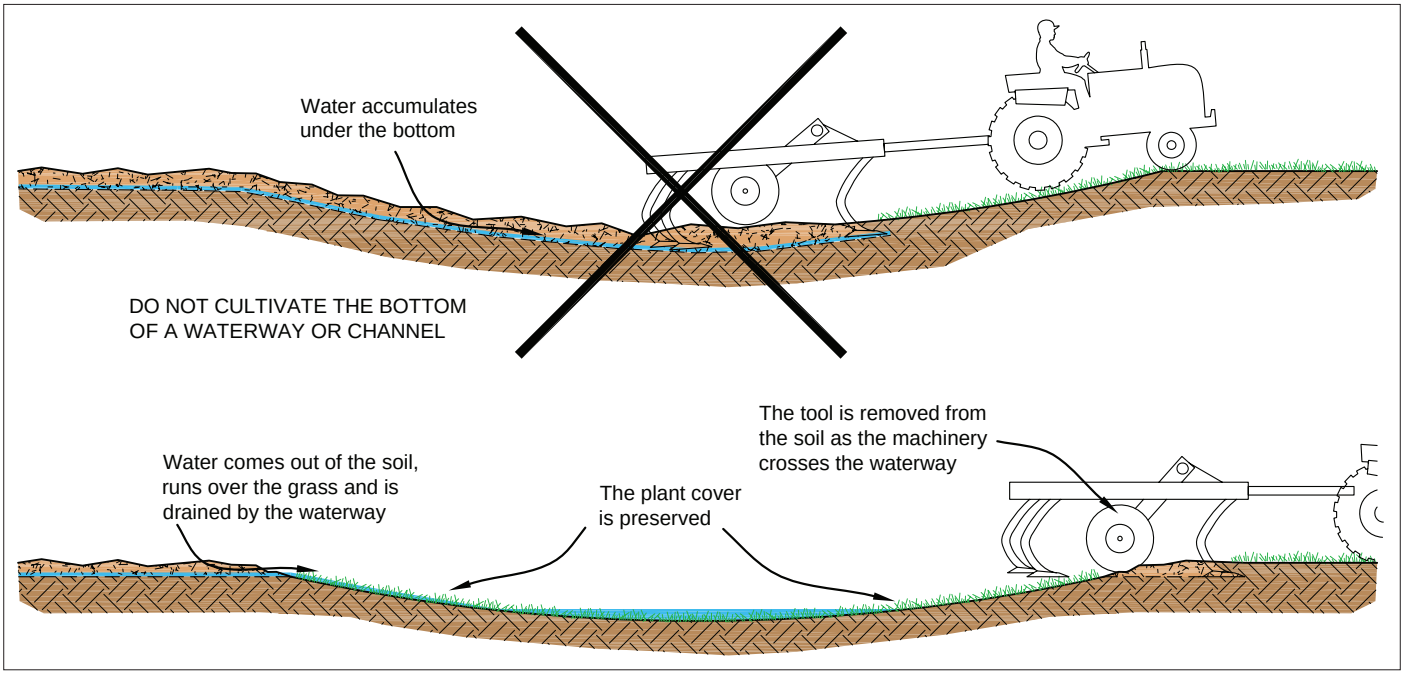


Figure 7: Cultivation near a channel
Source: Drawing adapted by Luc Lemieux, MAPAQ

• Tillage management

It is important to adopt farming practices that support soil cover maintenance with crop residues (direct seeding, chisel, offset, ridge till, etc.), green manure or grassland in rotation. If significant sedimentation occurs in the bed of the waterway, the canal will not have sufficient capacity to drain runoff and it will have to be re-excavated and re-seeded.

Tillage must be adapted to these installations, particularly when they are situated across the direction of cultivation. It is important to avoid tilling the bottom of a waterway or channel in order to preserve the vegetation cover, load-bearing strength and capacity to drain runoff and subsurface flow. Tillage tools must be raised when a waterway or channel is crossed.

Near the waterway, avoid cultivation parallel to the canal: furrows could capture runoff and create gullies.

• Miscellaneous

If the waterway includes inlet wells with sedimentation basins, deposits must be removed at least once annually.

The condition of the rock chute must be checked regularly and any damage repaired in order to prevent retrogressive erosion of the bottom of the waterway.

Snow accumulations must be cleared to prevent blockage of the waterway and reduce the risk of overflows during periods of thaw.

Photo 21: Grassed channel in good condition
Source: Ferme Louis d'Or

Photo 22: Ineffective channel
Source: Mikael Guillou, MAPAQ

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Written by: Mikael Guillou (MAPAQ)

Advisory Committee (MAPAQ): Alain Gagnon, Georges Lamarre, Richard Laroche, Ghislain Poisson, Régis Potvin, Victor Savoie

Advisory Committee (AAFC): François Chrétien, Isabelle Breune

Reviewed by: Nicolas Stämpfli

Computer Graphics: Luc Lemieux, MAPAQ and Erin Cadieu, AAFC Science Publishing and Creative Services.

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For more information:

Agriculture and Agri-Food Canada
Regional Services, Quebec Region
Gare Maritime Champlain
901 Rue du Cap-Diamant, Suite 350-4
Quebec City, Quebec G1K 4K1
Telephone: 418-648-3316

Agriculture, Pêcheries et Alimentation Québec

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