TECHNICAL FIELD GUIDE

Design of Livestock Watering Facilities for Streambank Protection

Agriculture, Pêcheries
et Alimentation
Québec

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1. INTRODUCTION

Traditionally, livestock producers have used streams and municipal watercourses to water cattle freely during the grazing season. Nearly half of the livestock farms still permit their herds free access to waterways, according to the Portrait agroenvironnemental des fermes du Québec published in 1998.

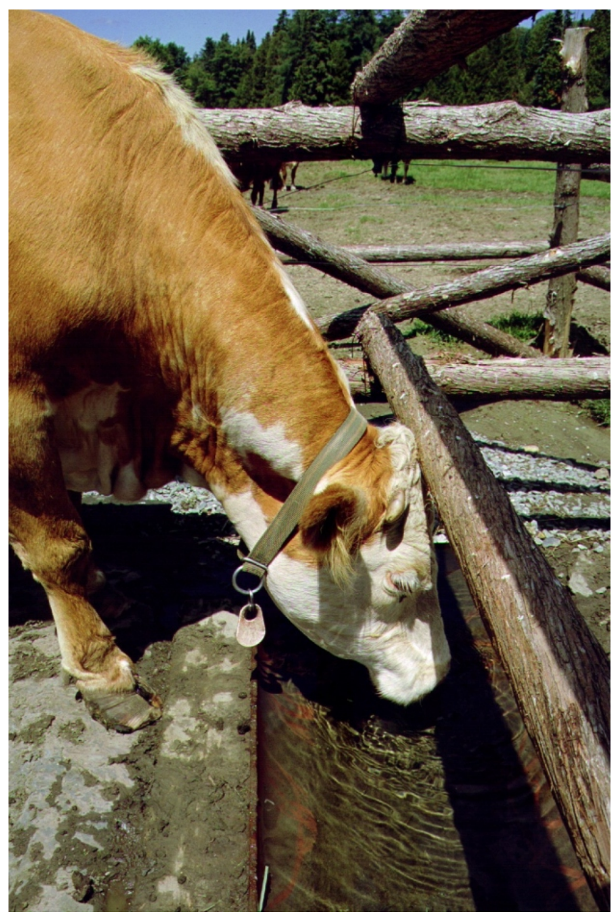
When you examine closely the condition of the streambanks near pasture sites, you observe that the slopes have often been trampled bare of vegetation. Constant pugging by cattle degrades the banks and makes them vulnerable to erosion. Runoff coming from the fields as well as the forces generated by peak flows in the spring or after heavy rains will degrade the waterways and the riparian zone. Soil and sediments are then carried away by the flow, and water quality is adversely affected, notably by the introduction of a suspended solids, nutrients (nitrogen and phosphorus), bacteria and manure load.

Degraded streambanks may prove to be dangerous as much for the cattle itself as for machinery operators near waterways during harvesting and other field operations. The loss of a single head of cattle is often more expensive than installing a livestock watering facility.

Beyond safety considerations, the poor quality of the water available to the herd may affect the health of the animals as well as increase the need for veterinary services. Free access to waterways by drinking animals results in the pollution of their own source of water with their manure. This may lead to disease problems, particularly in the case of calves and young cattle (diarrhea, infections, etc.).

Milk production or the growth rate of the herd are closely related to the amount of feed they ingest. There is a direct correlation between the dry matter intake and the amount of water consumed. Quality water tastes better so cattle will drink more and, hence, eat and produce more.

In short, limiting the free access of cattle to the waterways and offering them quality water with a watering facility provides numerous advantages, from an environmental, an economic as well as a safety point of view. This is a simple and efficient way to conserve our natural resources and to protect the quality of public surface waters.



Watering Facility

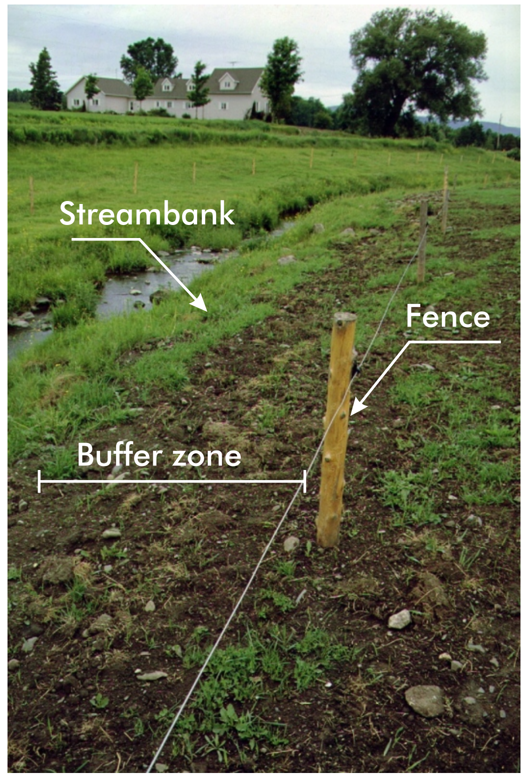
2. LIMITING STREAMBANK DEGRADATION

Streambank access by the herd must be limited or controlled by fencing the immediate vicinity of the waterways. A seasonal electrical fence, comprised of light plastic or metal pickets and wire, is the ideal setup to prevent streambank degradation by trampling and erosion.

When pastures are located on both sides of a watercourse, a crossing facility may be constructed to permit access to the whole property and to use the grazing resources available to the optimum. These crossings must restrict cattle access to the water and should be used only briefly when needed. Their sides should be fenced and their access limited.

Some producers would favor limited access ramps permitting the animals to continue to drink from the watercourse. These contraptions are not recommended as such. **It is always preferable to invest in a watering system that keeps cattle as far away as possible from the streambanks.**

Fencing costs vary from 1 to 2 dollars per *metre*, depending on the extent and the nature of the materials used to protect the banks.



Fencing of Streambanks

Something to avoid

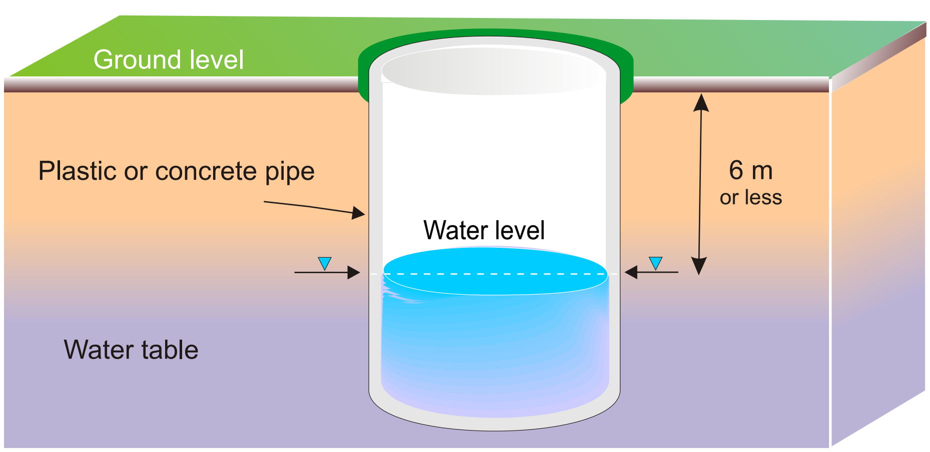
3. WATER AVAILABILITY

Water should always be plentiful, clean and free of fecal bacteria. When technically feasable, a water line originating from the barn and connected either to a deep well or to the municipal water system constitutes the best alternative to feed water to the herd. This water is of excellent quality, coming from wells dug into the bedrock.

Surface water coming from rivers or streams may also be used to water livestock, providing it is of suitable quality. However reports from the Quebec Ministry of the Environment indicate generalized contamination of our watercourses. Higher animal concentrations, high levels of fertilization and annual soil cultivation have all contributed to the contamination of our surface waters by nitrogen, phosphorus, suspended solids, pesticides and pathogens. If you must utilize water originating from a waterway, always have it tested beforehand to be sure it is safe and tastes and smells good.

Surface wells can also be used to provide water for cattle. These are shallow wells exploiting the water table usually found between the surface of the soil and a depth of about 6 metres. Ground water can be extracted from homogenous sand stratas or at the foot of a ridge in hilly terrain. Sections of concrete or plastic pipe 3 to 4 feet in diameter can be used to line the sides of the well. Joints should be sealed with clay or bentonite to prevent water contamination by leaching. A vegetated buffer zone should always be conserved around a surface well to prevent water contamination from seepage, runoff or manure spreading (typically *30 metres*).

Springs are sometimes found, particularly in hilly terrain with rock outcroppings. These springs may have a constant but weak output so water must be collected and stored in a reserve tank. A gravity water line can be used to fill troughs located downstream from the collecting tank.



Sketch of a Surface Well

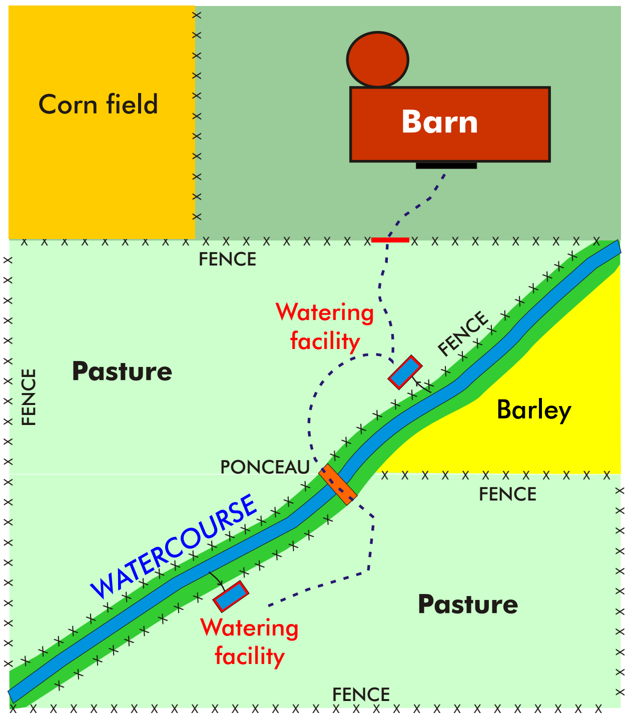
4. TERRAIN CHARACTERIZATION AND DESCRIPTION

Before setting up a livestock watering facility, a quick topographic survey must be conducted to measure the distance between the water source and the farthest watering site as well as their respective elevations. This data is necessary to choose a water pipe with a diameter sufficient to provide the peak flow needed according to the size of the herd as well as to estimate the friction losses in the plastic pipe. Peak flow and friction losses are used to determine the capacity and the power of the pump, if a pressurized system is necessary.

An aerial picture of known scale can be used to decide the optimal location of the water troughs. ***Research has shown that cattle prefer to graze less than 250 metres from their water source***. At distances less than *250 metres*, individual animals will access the watering site without the rest of the herd always coming to drink as a group. This lessens the effect of the dominance phenomenon. The herd hierarchy results in dominated animals having less access to the water in the presence of so-called "boss" cows.

To remedy this situation, troughs may be installed at *500 metre* intervals so as to split the herd in a few sub-units. This reduces competition between the animals and permits an optimal exploitation of the grazing resources of the farm.

The streambanks should also be surveyed if they have been degraded by cattle who had free access in the past. The length of the banks and the state they are in should be evaluated to plan rehabilitation strategies and estimate repair costs.



System Layout

Watering Facility

5. GRAVITY OR PRESSURIZED FLOW SYSTEMS

The relative elevation of the troughs and of the water source determine whether a gravity or pressurized flow system can be implemented. If the water source is substantially higher than the troughs, a gravity flow system can be used. Otherwise, if the troughs are higher than the water source, then a pressurized flow system using a pump will be needed.

GRAVITY FLOW SYSTEMS

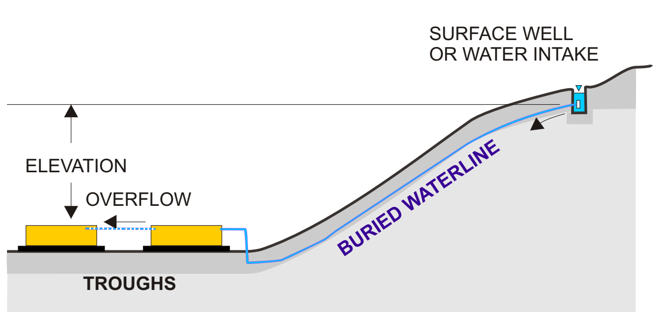
No external energy sources are needed for these applications. Water can be drawn from the upper reaches of a watercourse and then be used to fill troughs located farther down. Likewise, water from a surface well can be directed by gravity towards troughs located at a lower elevation. To do so, plastic pipes *(made of PVC or polyethylene)* varying between 3/4 of an inch *(19 mm)* and 2 inches *(50 mm)* in diameter and supporting pressures of 75 or 100 psi are utilized. The higher the peak flow and the longer the pipe, the larger the diameter of the pipe must be to reduce friction losses. Head losses are generated by the friction between water and the walls of the plastic pipe and they limit the ultimate flow capacity of the conduit. A one and a half inch pipe permits a flow three times superior to that of a one inch pipe in similar conditions.

PRESSURIZED SYSTEMS

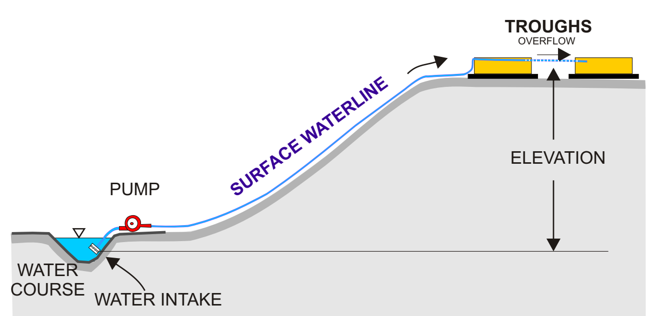
Sometimes water must be elevated from a low spot (the bottom of a stream for example) and transported to a pasture site situated at a higher altitude. A pressurized system using a pump *(submersible or suction)* must then be used. The capacity of the pump must be sufficient to lift the water to the higher elevation and to combat friction losses in the pipe and in the valves or flow control system. In most cases an electrical powered pump with a 1/2 to 1 hp *(375 to 750 watts)* motor is adequate.

This type of application is ideal if an electrical line is close at hand, otherwise the cost of setting up a low-voltage electrical line (120–240 volts) specifically to operate a water pump is prohibitive (25 000 $/kilometre when done according to Hydro-Québec specifications). On the other hand, various alternative energy systems are offered on the market: solar panels and battery packs to power a small direct current motor and pump (rather expensive and low transport capacity), hydraulic rams (low peak flow) or pasture pumps activated by the animals themselves (watering a single animal at a time).

CASE # 1 : WATER SOURCE HIGHER THAN TROUGHS
GRAVITY FLOW SYSTEMS



CASE # 2 : WATER SOURCE LOWER THAN TROUGHS
PRESSURIZED SYSTEMS



6. CHOOSING WATER PIPE SIZES

A mature lactating cow can drink up to *150 litres* of water on a hot summer day. Part of this water will be consumed in the barn while milking but the rest must be provided on the pasture site by a watering facility. Daily water needs in the field have been estimated at *80 litres* per cow per day. The critical watering period extends for 8 hours a day.

The maximum water delivery rate of the system is obtained by multiplying the number of cows to feed by a factor of 10.

Quality Water !

Example of the water delivery rate for 100 cows :

$$Q_{max} = \frac{100 \text{ cows X } 80 \text{ L/cow}}{8 \text{ h}} = 1000 \text{ L/h}$$

NOTE. *1000 litres per hour* corresponds to 4,4 U.S. gallons per minute

Bernouilli's equation is used to estimate the total head of pressure to operate the watering system :

PRESSURE = elevation + friction losses +operating pressure

The difference of elevation between the water source and the farthest trough is expressed as a head of water, which translates to pressure units (in the American system, a column of water 2,31 feet high corresponds to 1 pound per square inch (1 psi); in the metric system, *1 bar* corresponds to a *10 metre* water column or *100 kPa,* which is the normal atmospheric pressure.

Units equivalents:
1 psi = 6,9 kPa — *1 U.S. gallon = 3,78 litres*
1 bar = 14,5 psi — *1 imperial gallon = 4,54 litres*
1 Hp = 746 watts

To design pipes and pumping systems, please refer to ***Dimensionnement des installations d'abreuvement des bovins au pâturage***, MAPAQ, juin 2001, available on the Agri-réseau WEB site *(www.agrireseau.qc.ca* under *Agroen-vironnement)* or at MAPAQ service centers

6. CHOOSING WATER PIPE SIZES

Let's consider for example a source of water located *10 metres* (32,8 feet) higher than the farthest water trough downstream. The difference of elevation creates a pressure of :

$$\frac{32{,}8 \text{ feet}}{2{,}31 \text{ feet/psi}} = 14{,}2 \text{ psi}$$

Friction losses are determined by using tables or graphs published either by universities or by pipe manufacturers. They are a function of the friction coefficient between plastic and water, the required peak flow as well as of the length and diameter of the pipe. **Table 1** appearing hereafter indicates friction losses in "pounds per square inch per hundred feet of pipe" for diameters varying from three quarters of an inch *(19mm)* to two inches *(50mm)* and for flow rates varying between one and fifty gallons per minute. **Table 2** is in the metric system.

Operating pressures of water delivery equipment can vary between 5 and 20 pounds per square inch, according to the various sources of information found in technical literature. A minimal pressure of 5 psi is needed to actuate the floatation valve that controls the water level in the water trough.

One should always remember that the total head of pressure must never exceed the nominal resistance of the pipe (either 75 or 100 psi).

Plastic Waterline

The following examples were computed in the American system to simplify the text and because American units are still commonly used in commerce. Let's take the case of a herd of 200 heads of cattle that consumes *80 litres* of water per cow during a period of 8 hours. Peak flow will be *2000 litres* per hour or 8,8 U.S. gallons per minute. Supposing that the water line measures *1200 metres* (4000 feet) in length and that the elevation difference is around *7 metres* (22 feet), Table 1 indicates that for a one inch pipe, friction losses are 84 psi (2,1 psi/100 ft X 4000 ft = 84 psi). An elevation gradient of 22 feet corresponds to a pressure of 10 psi. If the operating pressure of the flow control valve is 5 psi, the total head of pressure would then be 99 psi, exceeding the nominal resistance of 75 psi pipes offered on the market, but barely suitable for a 100 psi pipe.

A new computation with a one and a quarter inch pipe must be made. In this case, friction losses would amount to 22 psi (0,55 psi/100 ft X 4000 ft = 22 psi) and the total head of pressure (including 10 psi for elevation gradient and 5 psi for valve operation) would lower to a value of 37 psi, which is acceptable for 75 or 100 psi commercial pipes.

In practice, farmers prefer 100 psi pipes because they better resist crumpling or pinching during installation, thanks to thicker sidewalls, while not being overly expensive

7. DESIGNING WATERING FACILITIES

Setting up a watering facility involves numerous steps, notably purchasing "plumbing materials" (spools of plastic pipe, connecters, fittings, fasteners, troughs, control valves, etc), installation of a concrete platform under each trough and wooden reinforcements around the troughs, burying of the water lines, installation of a shielded water intake in a surface well or in a clean waterway, acquisition of a pumping system and installation of a dedicated power line if needed, fencing and finally restoration of streambanks previously degraded by free roaming animals.

The installation of the water intake must be made very carefully. It should be encased in a wooden box *1,20 metres* by *1,20 metres* or a large vertical pipe with a tight lid to prevent water contamination by exterior sources. In the case of a gravity flow system, one must be certain that water flows freely before burying the plastic pipe. During installation, the pipe should never be crushed or pinched and it should be protected with sod or loose gravel. A mole-drain machine is a good method to lay the pipe efficiently and rapidly.

A pump or a water line may have to be primed before it can convey water efficiently. The circuit must be full of water and free of air bubbles to work adequately. If the water line has been laid without a rigourous inspection of the slope with a surveyer's level, it might be plagued with important undulations or dips that could trap air and hinder flow.

The construction of platforms under the water troughs requires *20 Mpa* (3000 psi) grade concrete. Metallic mesh wire must be installed at mid-height in the forms. During the hot summer months, concrete should be allowed to cure undisturbed for a whole week and it must be kept humid constantly during this period using a polyethylene sheet. A slight slope helps to drain water away from the trough and keep the slab dry and clean. Instead of pouring concrete on the site, prefabricated concrete slatted panels measuring *1,20 metres* by *3 metres* can be installed around the water troughs. This type of material is used to build floors in large swine or cattle buildings. Always try to locate the troughs on an elevated spot rather than in a depression.

A Productive Investment

8. COSTS OF WATERING EQUIPMENT

A livestock watering facility may cost as little as $500 or as much as $5 000, depending on the farm site and herd size (the number of heads of cattle, the remoteness of the pasture from farm buildings, the availability of water, the proximity of a power line, etc.) A simple water line coming from the barn and a *195 litre* trough cost about **$500**. Digging and lining a surface well, installing an electrical pump, hundreds of metres of pipe and multiple *575 litre* troughs can reach ***$5 000***.

Cost of commercial plastic pipes
(100 psi ou 690kPa grade)

$0,80/metre	for 3/4 in. diameter *(19 mm)*
$1,30/metre	for 1 in. diameter *(25 mm)*
$2,00/metre	for 1 1/4 in. diameter *(32 mm)*
$2,60/metre	for 1 1/2 in. diameter *(38 mm)*
$3,00/metre	for 2 in. diameter *(50 mm)*

Cost of polyethylene water troughs

195 litres	@	$100	(50 U.S. gallons)
378 litres	@	$140	(100 U.S. gallons)
575 litres	@	$200	(150 U.S. gallons)

Cost of galvanized steel water troughs

310 litres	@	$185	(80 U.S. gallons)
475 litres	@	$260	(120 U.S. gallons)
810 litres	@	$360	(200 U.S. gallons)
1250 litres	@	$500	(300 U.S. gallons)

Cost of submersible pumps

1/4 hp	*(187 watts)*	@	$175
1/3 hp	*(250 watts)*	@	$250
1/2 hp	*(375 watts)*	@	$400

Cost of centrifugal pumps

1/2 hp	*(375 watts)*	@	$500
3/4 hp	*(500 watts)*	@	$700
1 hp	*(750 watts)*	@	$800

Cost of hydraulic rams

1/2 inch	*(12 mm)*	@	$300
1 inch	*(25 mm)*	@	$800
2 inches	*(50 mm)*	@	$2000

Cost of solar powered systems

$1500 to $4500

Cost of nose pumps

$300 to $500

Cost of concrete to build platforms

Around $125 per *cubic metre*

Cost of prefabricated slatted panel

Around $250 *(1,2m X 3m)*

Source: *Coop Fédérée,*
prices as of june 2001.

9. MAINTENANCE OF WATERING FACILITIES

Cattle watering equipment is used on a seasonal basis. It must be put in place in the spring then removed and stored in the fall. Heated troughs are offered on the market, particularly aiming at beef cattle that spend the whole winter outside, but they are quite expensive ($700 to $800).

Shallow water lines (*30 centimetres*, for example) must be purged to prevent bursting due to freezing in the fall. If year-round use is necessary, the pipe must be laid below the frost line (usually about *1,20 metres*). Light electrical fences must also be removed and reinstalled the following season.

During the summer, algae may appear in the troughs due to the presence of sunlight, heat and nutrients in the water (nitrogen and phosphorus). These blooms must be removed from time to time if they become too thick in the troughs. A slight application of chlorine, copper sulfate or hydrated lime as needed will help control their growth in the future.

The useful life of watering equipment will vary from 5 to 10 years at the most. Plastic or metal components that are constantly exposed to the elements degrade quite rapidly. The farmer should inspect his equipment regularly and replace it as needed.

10. DEGRADED STREAMBANK RESTORATION

When cattle have free access to streambanks, they trample and degrade them and contaminate water with their feces. After they have invested in livestock watering facilities, farmers should consider rehabilitating degraded streambanks and restoring the riparian habitat.

Streambank restoration usually implies first smoothing the side slopes to an angle of 1 : 1,5 (or less, i.e. 1 : 2 or 1 : 3, as needed) and then establishing a perennial vegetative cover composed of red fescue, agrostis and ray-grass using a seeding rate of 1.2 pound per 1000 square feet (*60 kilograms per hectare*). This type of work costs about $10 per *metre*. Various species of shrub can be used to embellish and enrich the riparian habitat. Willows are particularly well adapted to these edaphic conditions. A windbreak composed of trees (poplars or pines) could also be considered as a finishing touch.

If a bank is particularly unstable, it may be necessary to use rip-rap to reinforce the foot of the slope under the normal level of the water. Quarry stone varying in size from *0 to 1 000 mm* should be crushed into place using a hydraulic shovel of medium or high power. This type of intervention may cost up to about $30 per *metre*.

NOTE: Always ask for a permit from your municipality, your MRC or the Ministry of the Environment of Québec before undertaking any streambank restoration work.

Streambank Restored with Rip-rap
and Vegetative Cover

Stabilization with Shrubs

TABLE 1

Friction Losses in Plastic Pipes
(psi per 100 feet)

Discharge (U.S. gpm)	¾ in	1 in	1 in¼	1 in½	2 in
1	0,12	0,04	0,01		
2	0,45	0,14	0,02		
3	0,95	0,29	0,08	0,04	0,01
4	1,62	0,50	0,13	0,06	0,02
5	2,44	0,76	0,20	0,09	0,03
6	3,43	1,06	0,28	0,13	0,04
7	4,56	1,41	0,37	0,18	0,05
8	5,84	1,80	0,47	0,22	0,07
9		2,24	0,59	0,28	0,08
10		2,73	0,72	0,34	0,10
11		3,27	0,86	0,41	0,12
12		3,82	1,01	0,48	0,14
14			1,34	0,63	0,19
16			1,71	0,81	0,24
18			2,13	1,01	0,30
20			2,59	1,22	0,36
22			3,09	1,46	0,43
24				1,72	0,51
26				1,99	0,59
28				2,28	0,68
30				2,59	0,77
35					1,02
40					1,31
45					1,63
50					1,98

Source : Alberta Agriculture, Food & Rural Development

TABLE 2

Friction Losses in Plastic Pipes
(kPa per 100 metres)

Discharge (L/h)	19 mm	25 mm	32 mm	38 mm	50 mm
225	2,71	0,90	0,23		
455	10,17	3,16	0,45		
680	21,47	6,55	1,81	0,90	0,23
905	36,61	11,30	2,94	1,36	0,45
1135	55,14	17,18	4,52	2,03	0,68
1360	77,52	23,96	6,33	2,94	0,90
1590	103,05	31,86	8,36	4,07	1,13
1815	131,98	40,68	10,62	4,97	1,58
2040		50,62	13,33	6,33	1,81
2270		61,70	16,27	7,68	2,26
2495		73,90	19,44	9,27	2,71
2720		86,33	22,83	10,85	3,16
3175			30,28	14,24	4,29
3630			38,64	18,31	5,42
4080			48,14	22,83	6,78
4535			58,53	27,57	8,14
4990			69,83	32,99	9,72
5445				38,87	11,53
5895				44,97	13,33
6350				51,53	15,37
6805				58,53	17,40
7940					23,05
9070					29,60
10205					36,84
11340					44,75

Source : Alberta Agriculture, Food & Rural Development
Adaptation : Environnement et développement durable, MAPAQ

EXPRESSION OF GRATITUDE

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