Calculations for Sizing Inlet Wells

Introduction

This sheet presents methods for sizing inlet wells aimed at effectively managing surface runoff while limiting erosion problems in fields. All of the technical information on how to select locations for this type of structure and how to construct and maintain it is presented in the "Inlet and Drainage Wells" sheet.

Source : Mikael Guillou (MAPAQ)

There are three different types of inlet wells, each requiring a specific approach.

Case 1:
Inlet wells equipped with an emergency overflow or located in a grassed watercourse

In these situations, any sizing of the piping is generally unnecessary. In fact, when water runs quickly on the surface of the ground, the infiltration capacity of the inlet wells is often much lower than the runoff flows. The function of the inlet wells used in these situations is therefore to capture residual flows and sufficiently dry up the grassed watercourses to ensure proper implementation of the vegetation cover. The drains generally have a diameter of 0.10 m (4 inches) or 0.15 m (6 inches) so as to capture between 5 and 10% of the peak flow from the drainage basin. Therefore, only step 1 (presented in the next section) is necessary.

Case 2:
Inlet wells without an emergency overflow and incapable of holding surface runoff water or market garden plots

Given the risk of erosion or damage to crops in the event of prolonged submersion, the inlet well should have a drainage capacity equal to the peak flow of the drainage basin.

Mathematical formulas or nomograms can be used to determine the necessary diameter of an inlet well and drain that will ensure a drainage flow that is equivalent to the peak flow of the drainage basin. The diameter of the inlet well and drain must be considered, as well as the slope and type of drain (smooth or corrugated interior).

To size the inlet wells in this type of situation, follow steps 1, 2 and 4 presented in the following pages.

Case 3:
Inlet wells located in depressions capable of holding runoff water without an emergency overflow

The inlet well must have a sufficient drainage capacity so that the holding time does not exceed the submersion tolerance of the crops. Generally, the water should be drained in less than 24 hours for annual crops and in less than 12 hours storage crops (potatoes, onions, etc.).

Steps 1 through 6 presented below are followed for sizing inlet wells in such cases.

List of Steps

Step 1: Survey the land to locate where the inlet well should be installed and determine the direction and slope of the drain.
Step 2: Calculate the peak flow of the drainage basin (Qp). Evaluation of the peak flow is the subject of a separate sheet.
Step 3: Calculate the volume of runoff water (Vr).

$$Vr = 3600 \times Tc \times Qp$$

Where

Vr: Volume of runoff water (m3)
Tc: Concentration time (h)
Qp: Peak flow of drainage basin (m3/s)

Step 4 : : Select an inlet and drain diameter and determine the maximum flow of the structure (Qm). The system's capacity can be limited by the inlet (inlet well) or the outlet (drain). **The maximum flow of the structure is either**

the maximum flow at the inlet or the maximum flow at the outlet, whichever of those values is smaller. Mathematical formulas or nomograms can be used to determine the maximum flows at the inlet and outlet.

This step therefore requires an arbitrary selection of the diameter of the inlet well and drain, then the calculation of the corresponding maximum flows and determination of the type of flow (control at the inlet or outlet) and the maximum flow of the structure. Several attempts may be necessary to determine the most appropriate sizing.

Calculating the flow of the inlet well (maximum flow at the inlet):

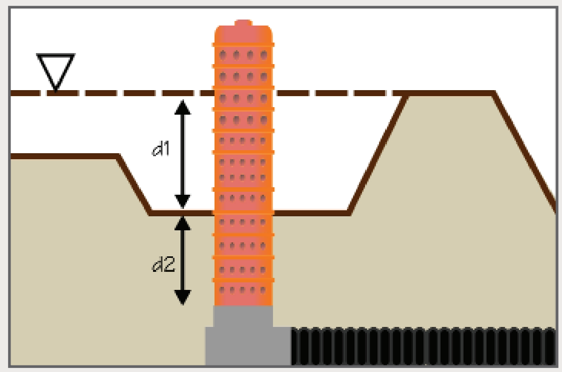
$$Q_{inl} = 2.66 \times A_{inl} \times H_{inl}\ 0.5$$

Where

Q_{inl}: Maximum flow of the inlet well (m3/s)
A_{inl}: Area of the inlet well section (m2)
H_{inl}: Water height at the inlet (m)

$$H_{inl} = 0.7 \times d_1 + d_2$$

d_1 :Water height between the bottom of the basin (ground) and the crest of the emergency overflow (m)
d_2 : Water height between the bottom of the basin (ground) and the base of the inlet well (m)



Calculation of the Drain Flow (Maximum Flow at the Outlet)

$$Q_{out} = \frac{A_{out} \times (19.6\ H_t)\ 0.5}{(1 + Ke + Kb + Kc \times L)\ 0.5}$$

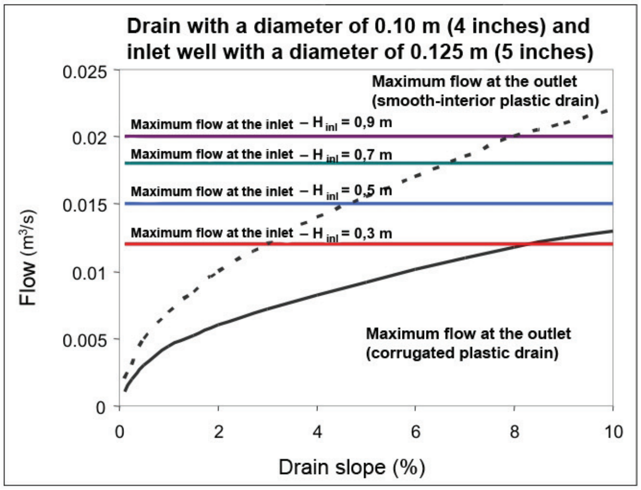
Where

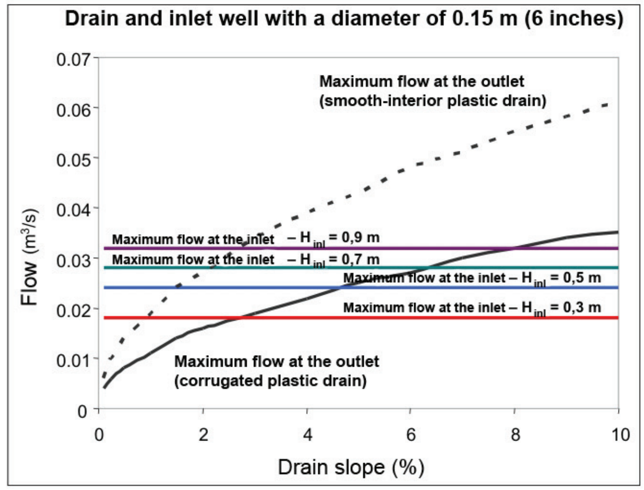
Q_{out} : Maximum controlled flow at the outlet (m^3/s)
A_{out} : Area of the drain section (m^2)
H_t : Total change in level between the water level at the crest of the overflow and outlet of the drain pipe (m; $H_t = H_{inl}$ + change in level of the drain)
Ke : Load loss coefficient at the inlet (Ke = 1.7 for the inlet wells)
Kb : Coefficient for load loss in the elbows (Kb = 0.9 if the inlet well is installed on a 90° elbow, and Kb = 1.8 if the inlet well is installed on a T connection)
L : Pipe length (m)
Kc : Unit load loss coefficient (see the values below)

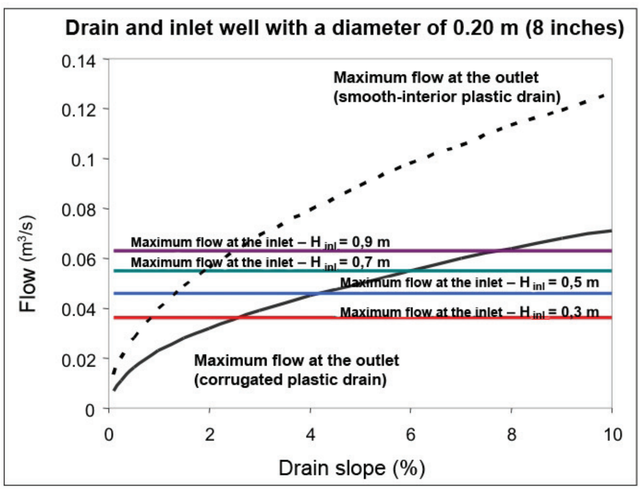
Piping Diameter (mm)	Manning Roughness Coefficient	Value of Kc
Corrugated piping		
100	0.016	0.68
150	0.017	0.45
200	0.018	0.34
250	0.019	0.28
300	0.020	0.25
Smooth Piping		
100	0.009	0.22
150	0.009	0.13
200	0.009	0.09
250	0.009	0.06
300	0.009	0.05

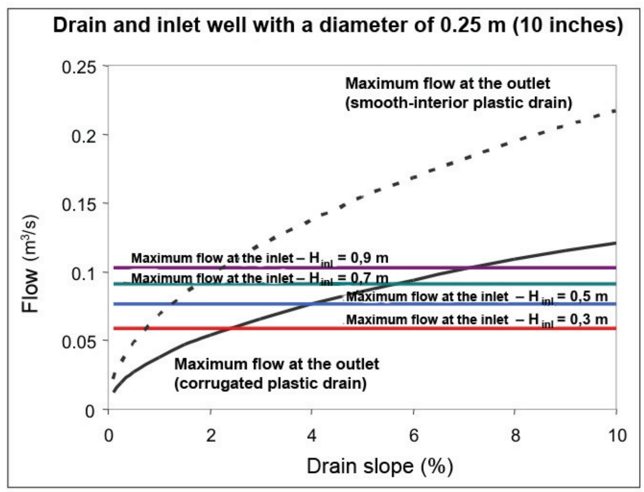
Source : MAPAQ (1990)

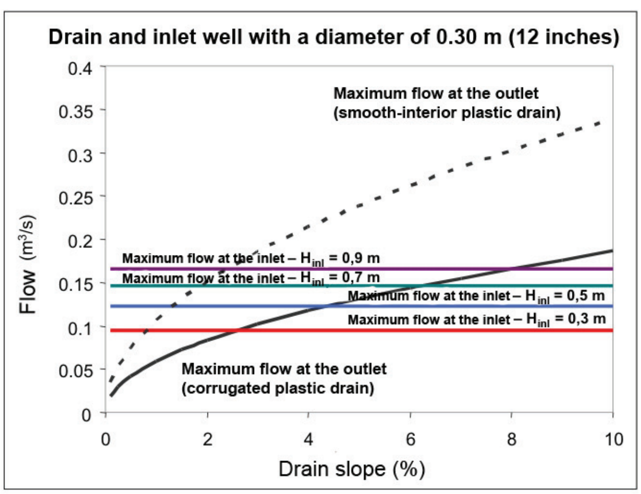
In the following graphs, the horizontal lines represent the maximum flows for control at the inlet for various water heights in the inlet well basin (0.3 m, 0.5 m, 0.7 m and 0.9 m). The curves represent the maximum flows for control at the outlet by slope and diameter of this type of drain.











Step 5: Calculate the time required to drain the surface runoff.

$$T_{drain} = 2 \times Tc + \frac{[Tc \times (Qp-Qm)^2]}{(Qp \times Qm) \times 3600}$$

Where

T_{drain} : Time required to drain surface runoff (h)
Vr : Volume of runoff (m^3)
Qp : Peak flow of drainage basin (m^3/s)
Qm : Maximum flow of the structure (m^3/s)
Tc : Concentration time (h), calculated based on information presented in the "Evaluation of Peak Flows for Small Agricultural Drainage Basins in Quebec" sheet

If the calculated drainage time exceeds the submersion tolerance of the crops, you must go back to step 4 and recalculate by increasing the diameter of the drain and inlet well used or the drain slope, or by choosing a drain with less internal roughness.

Step 6 : Calculate the necessary volume of the water retention pond.

$$Vb = \frac{Vr \times (Qp - Qm)^2}{Qp^2} = \frac{Tc \times (Qp - Qm)^2}{Qp}$$

Where

Vb : Volume of retention pond (m^3)
Vr : Volume of runoff (m^3)
Qp : Peak flow of drainage basin (m^3/s)
Qm : Maximum flow of the structure (m^3/s)
Tc : Concentration time (h)

If the calculated volume of the retention pond exceeds the water-holding capacity of the field, you must go back to step 4 and recalculate by increasing the diameter of the drain and inlet well used or the drain slope, or by choosing a drain with less internal roughness.

References

Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec. 1990. *Normes de conception et d'exécution pour les travaux de conservation et gestion du sol et de l'eau*. Internal publication.

Schwab, G.O., D.D. Fangmeier, W.J. Elliot and R.K. Frevert. 1993. *Soil and Water Conservation Engineering, 4th edition*. John Wiley & Sons, USA.

United States Department of Agriculture (USDA). 1984. "Hydraulics". Chapter 3 in Engineering Field Manual. Soil Conservation Service. http://www.info.usda.gov/CED/ftp/CED/EFH-Ch03.pdf (page visited on April 18, 2007).

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