Irrigation and Drainage Engineering

(Soil Water Regime Management)

(ENV-549, A.Y. 2025-26)

4ETCS, Master option

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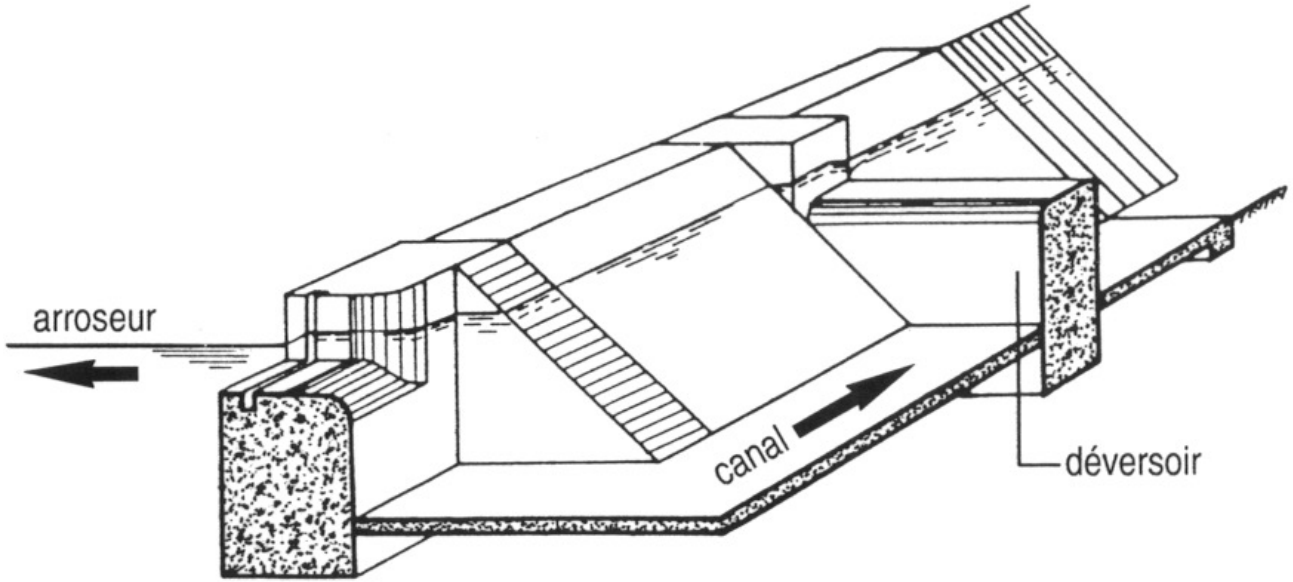
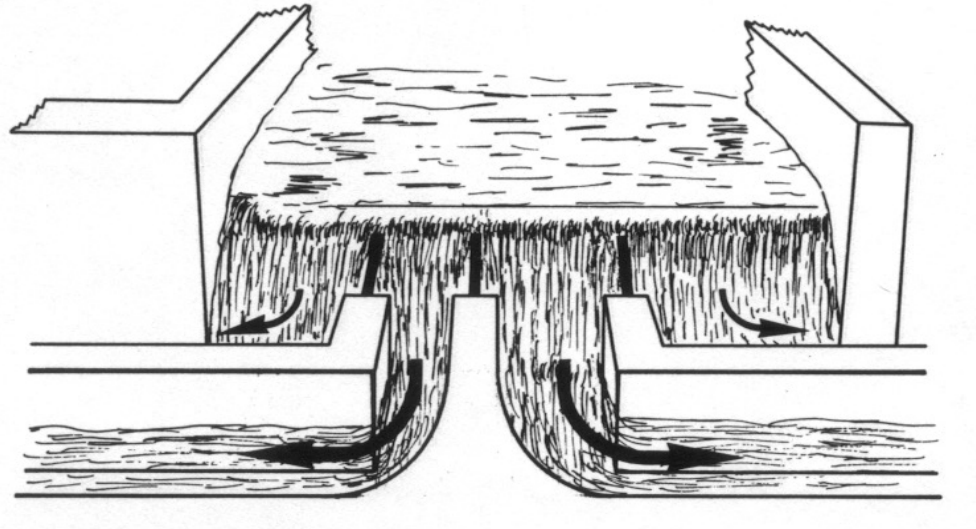
Platform of Hydraulic Constructions

Lecture 5.2. Gravity irrigation: Safety infrastructures and redistribution at the plot

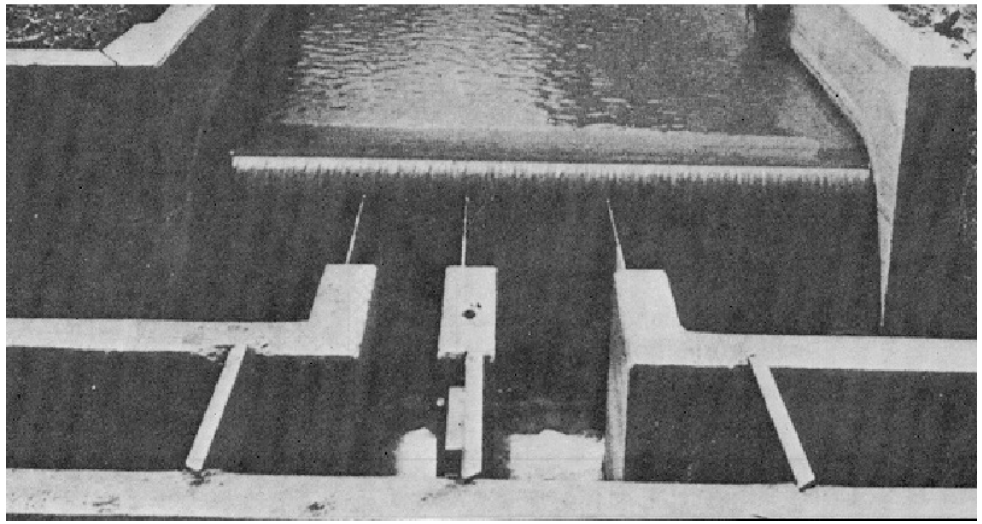
Proportional distribution

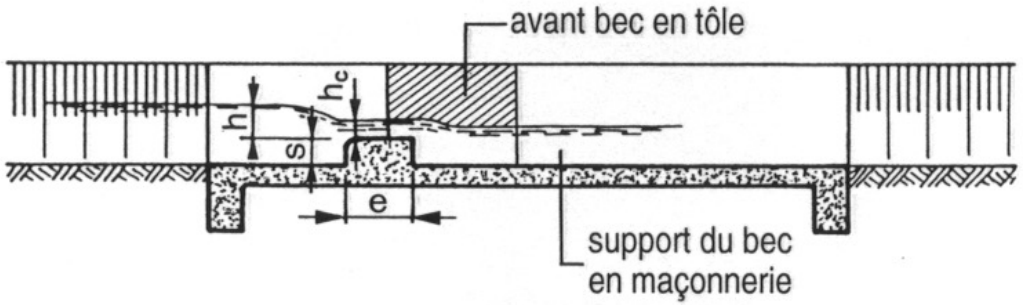


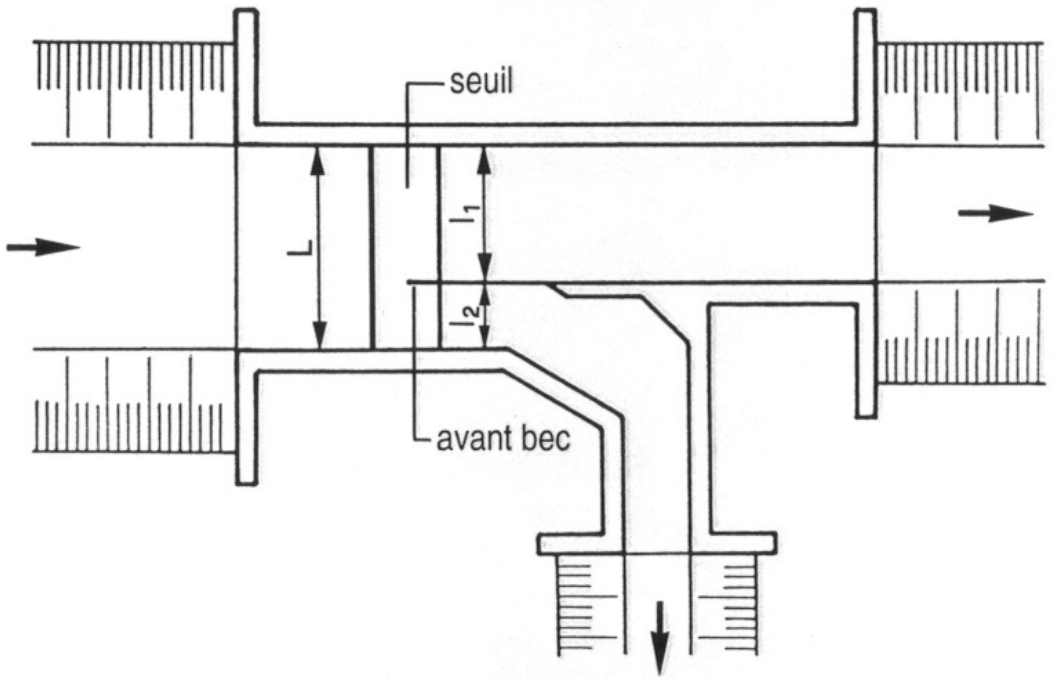
Intake weir



Proportional divider

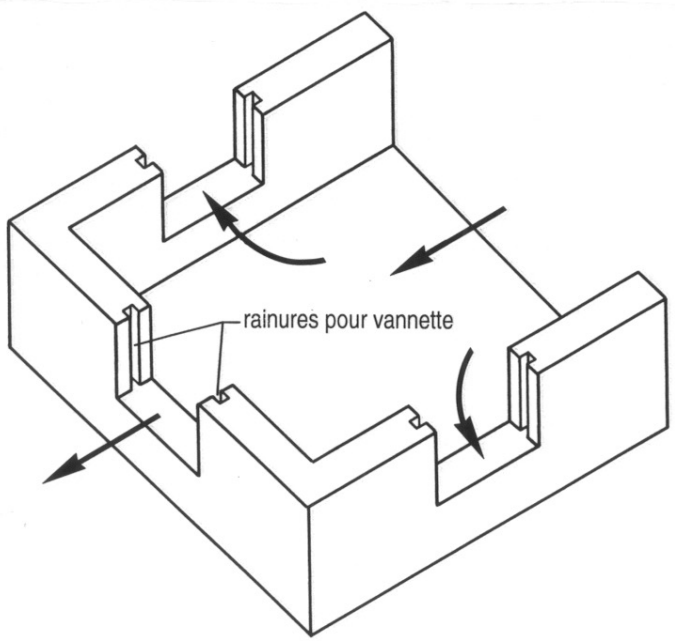


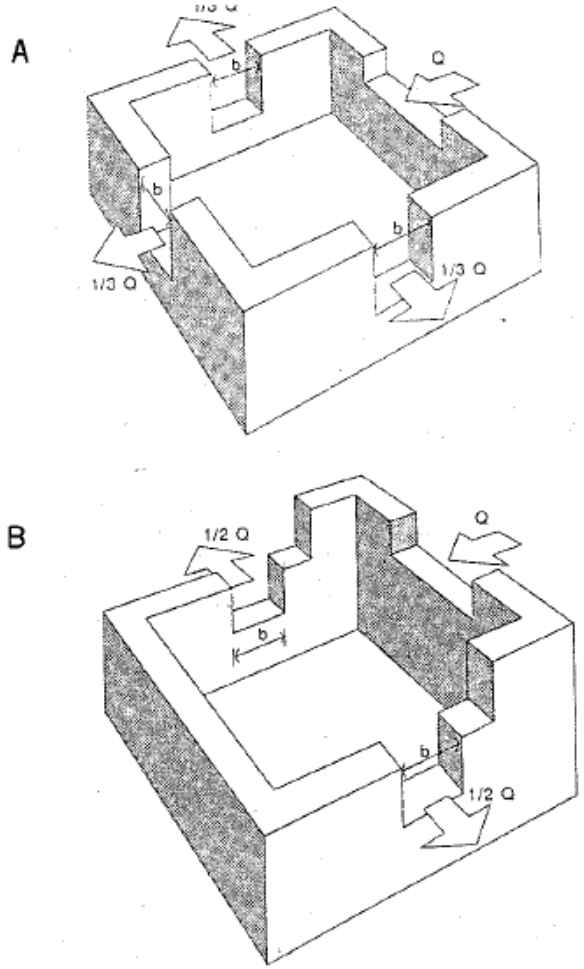


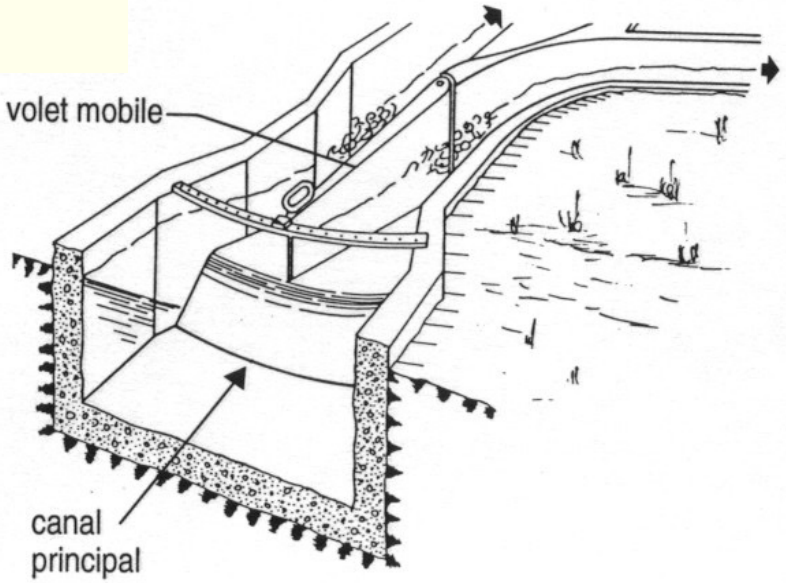


Fixed threshold dividers

Distribution chambers



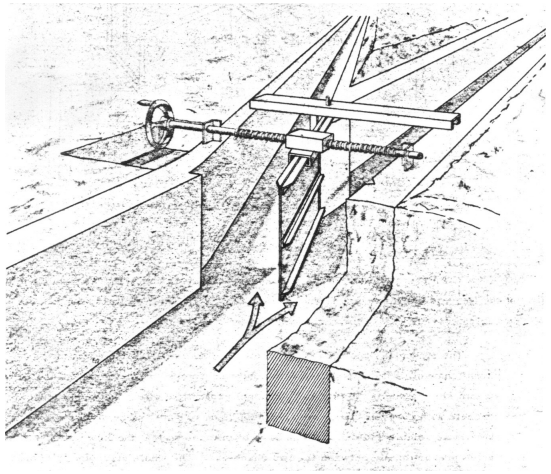


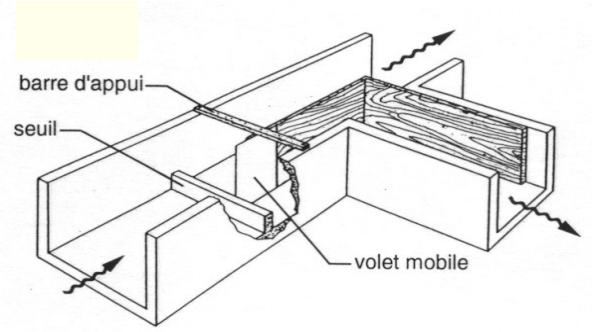


Mobile dividers

Field

Campus

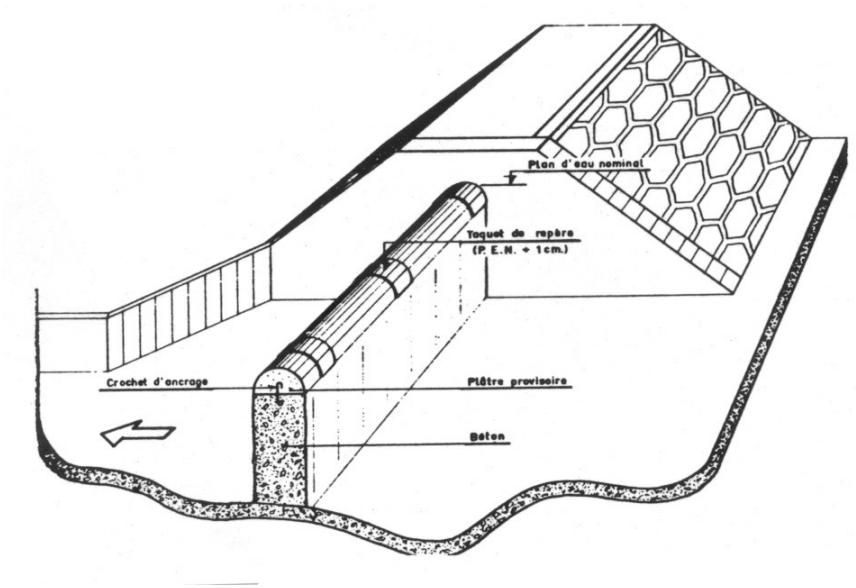


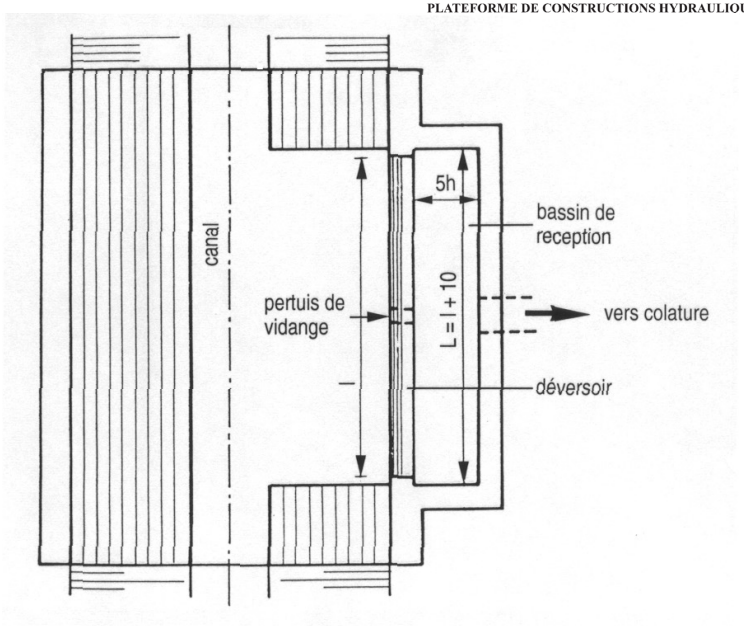


Safety hydraulic structures

Safety weirs

- Head of network
- change of section
- before structures likely to be obstructed[1]
- end of channels
- …

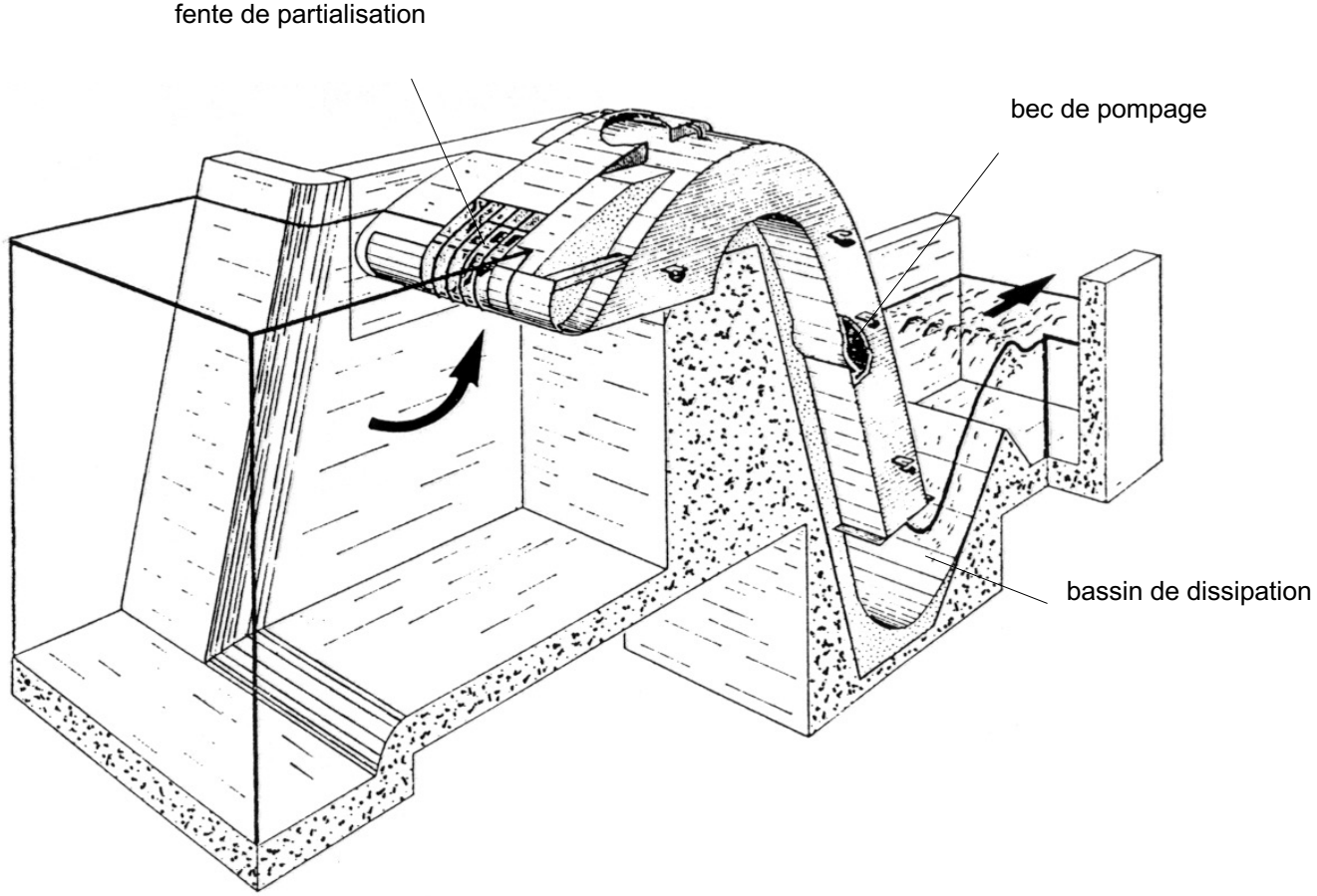




Security weir

[1] Reverse siphons, canal bridges, automatic valves, etc.

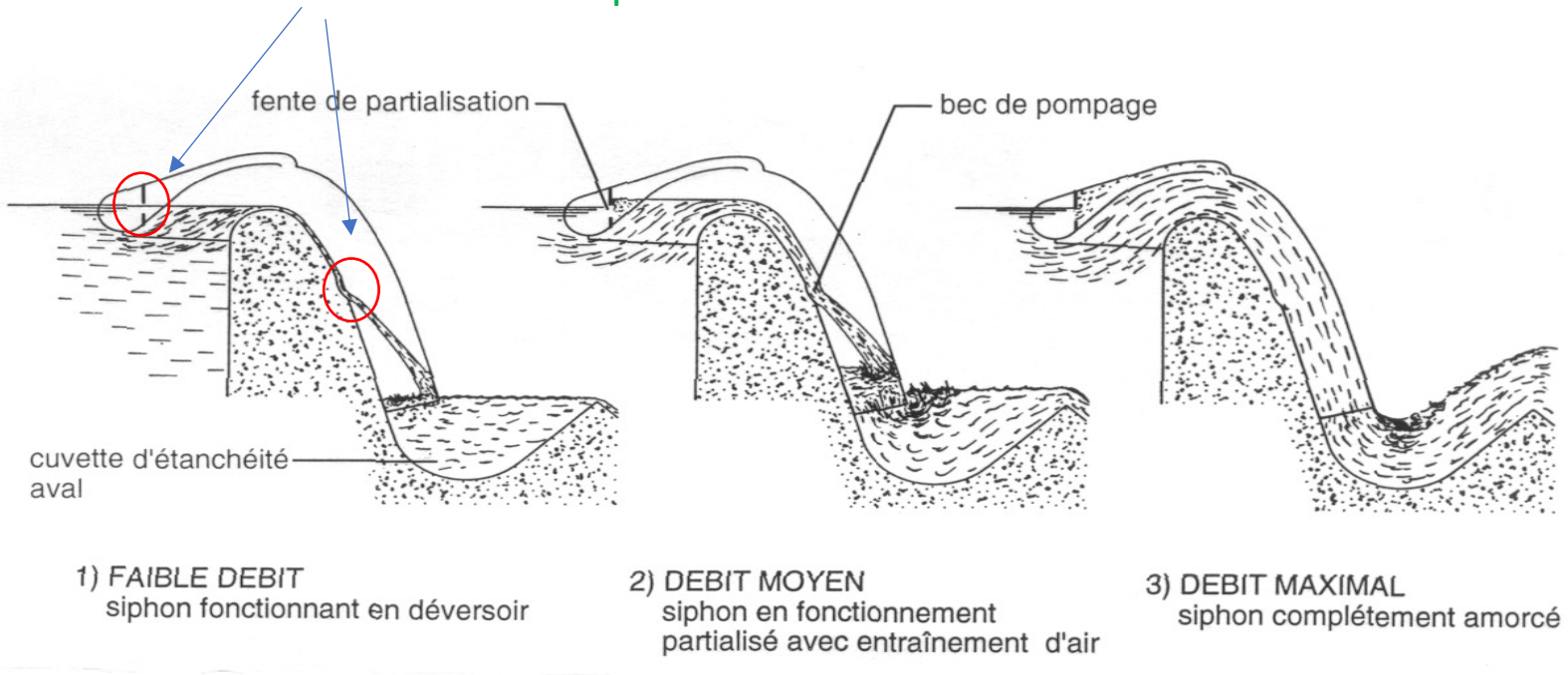
Safety siphon



Campus

Safety siphon in operation

Notice the two important construction details!



The key issue is to design a system that can start without being triggered. The safety siphon has this capability, which makes it very suitable to deplete rising water level and solve emergency situations.

Water application methods and distribution at the plots

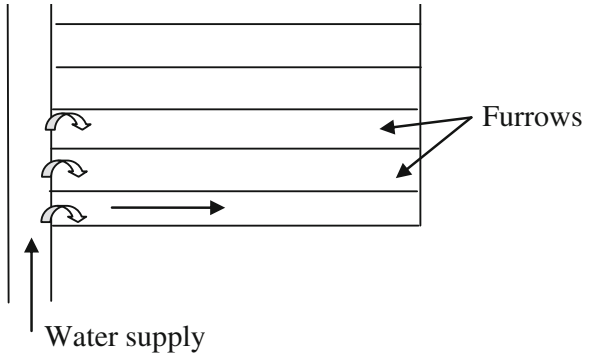
Part of this material is sourced from:
Ali, Practices of irrigation and on-farm water management, Springer, 2011

Water distribution systems at plot level

- **runoff or spillage**
  - **gutters**
  - **Boards (Border irrigation)**
  - **inclined and counter-inclined planes (Basin irrigation)**

"A form of irrigation where the soil surface is used as a conduit"

- **per furrow**



"A partial surface flooding method of irrigation in which water is applied in furrows (narrow channels dug between the rows of crops) or "rows of sufficient capacity" to contain the designed irrigation system"

- **per submersion (flood irrigation)**
  - **natural: flood spreading**
  - **artificial: submergence basins**

"A system in which the entire soil surface of the field is covered by ponded water"

Choosing an application method for distributing water over the plots

"To choose an irrigation method, the farmer must know the advantages and disadvantages of the various methods. He or she must know which method suits the local conditions best. Unfortunately, in many cases, there is no single best solution: all methods have their advantages and disadvantages. Testing of the various methods under the prevailing local conditions provides the best basis for a sound choice of irrigation method. Based on the local soil, climate, crop and water availability, and the suitability and limiting criteria of the methods (described in earlier sections, and also summarized in Table 2.1), the irrigation engineer will prescribe the appropriate method for the particular area."

(from Ali, 2011)

Controlling factors

- **ground slope and topography**
- **soil type**
- **type of crops**
- **available flow**
- **labour**
- **available capital**
- **Energy required**
- **ability of irrigators**
- **local habits**
- **epidemic and diseases**
- **etc.**

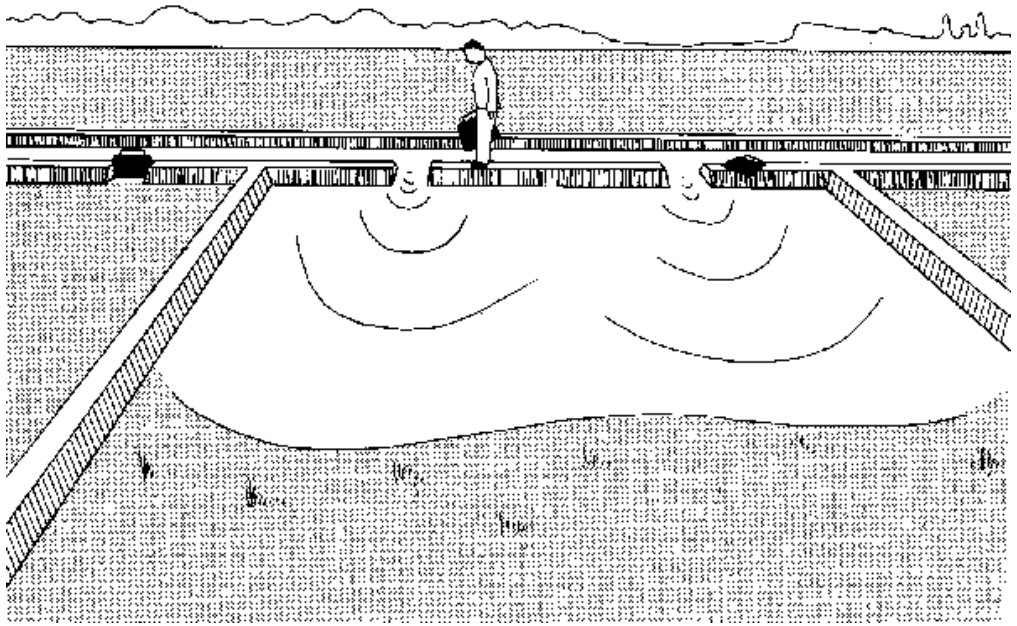
Site and situation factors	Suitability/preferred factor under the irrigation system		
	Basin	Border	Furrow
Soil	Loam to heavy soil	Loam to heavy soil	Loam to heavy soil
Infiltration rate	Moderate to low	Moderate	Moderate
Topography	Flat/nearly level ground	Flat-to- small slope	Flat-to- small slope
Crop	Close growing crops, suited to standing water	Close growing crops, not suited to standing water	Widely spaced row crops
Water supply/stream size	Large stream	Medium-to- large stream	Medium stream
Water quality	All category	All category	All category
Windy climate	No problem	No problem	No problem
Attainable irrigation efficiency	80–90%	70–85%	65–75%
Capital required/initial investment	Medium cost for establishment of basin	Low cost	Medium cost
Labor requirement	High for establishment, but low for operation	Medium	Medium, low if automated
Energy requirement	No energy required (only if groundwater is to be supplied)	No energy required (only if groundwater is to be supplied)	No energy required (only if groundwater is to be supplied)
Skill required	Skill required to establish basin	No skill required	Moderate skill required
Epidemic diseases	No problem	No problem	No problem
Operation and maintenance	Easy; low operation and maintenance cost	Easy; low operation and maintenance cost	Easy; low operation and maintenance cost

Source: Ali, Practices of irrigation and on-farm water management, Springer, 2011

Irrigation by runoff or spillage

Water is discharged from the distribution gutters by partially or totally blocking them.

The water flows down the slope in a thin layer, moistening the soil.



3 cases :

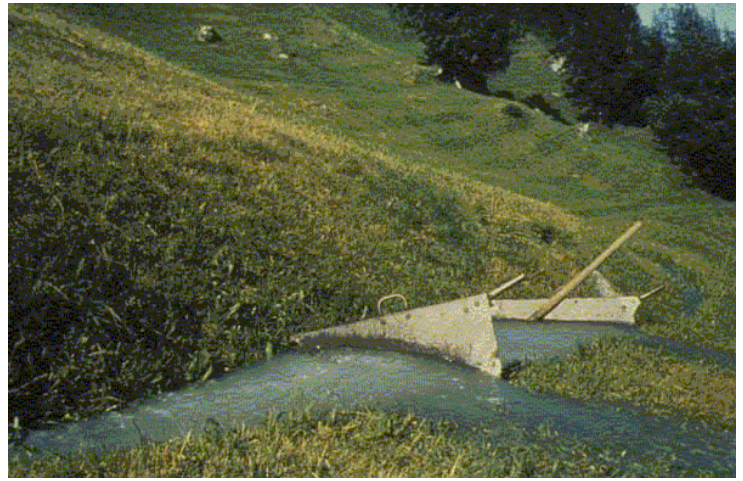
- the water flows freely (gutter irrigation)
- the blade is guided between 2 dikes (Board or border irrigation)
- the soil is artificially modelled to allow good water circulation (Basin irrigation using inclined or counter inclined planes)

Gutter irrigation

The water discharged progresses freely down the plot, without prior levelling of the ground (length of gullies: 10 to 50 m; spacing of gullies: a few metres to a few tens of metres).

Advantages

- inexpensive
- no prior ground works required
- applicable to steeply sloping land with full vegetation cover

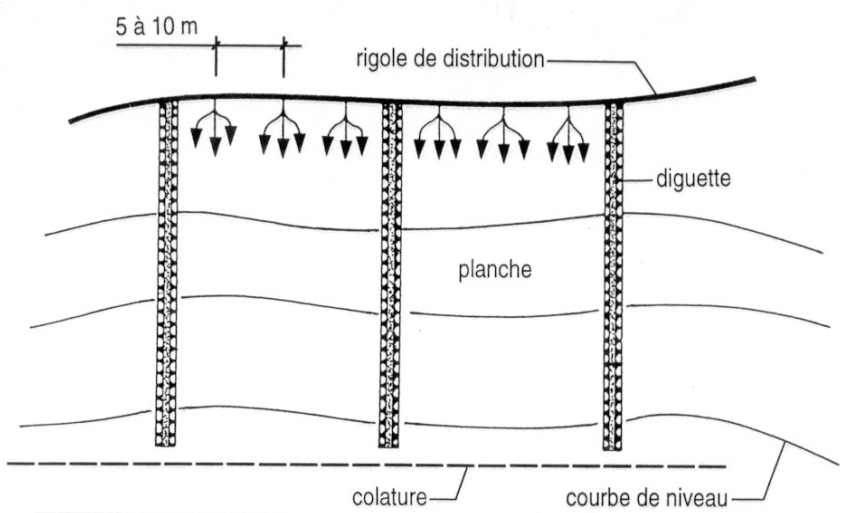


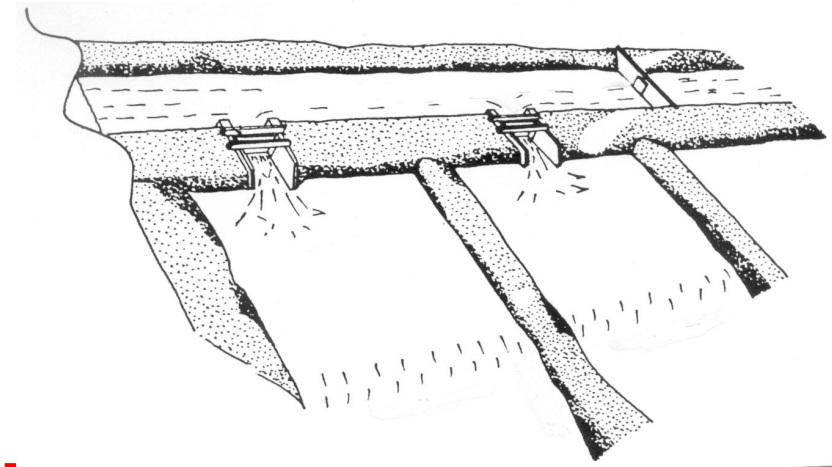
Disadvantages

- labour-intensive
- inputs can be difficult to control
- risk of erosion

Board or border irrigation

Border irrigation is defined as the application of water to an area typically downslope and surrounded by two border ridges or dikes to the ends of the strip





Length L of the boards

- **plot size**
- **soil type (Ks)**
- **slope**
- **crops**
- **available flow**

Safe to consider
100 < L < 300 m and more

Width l of the boards

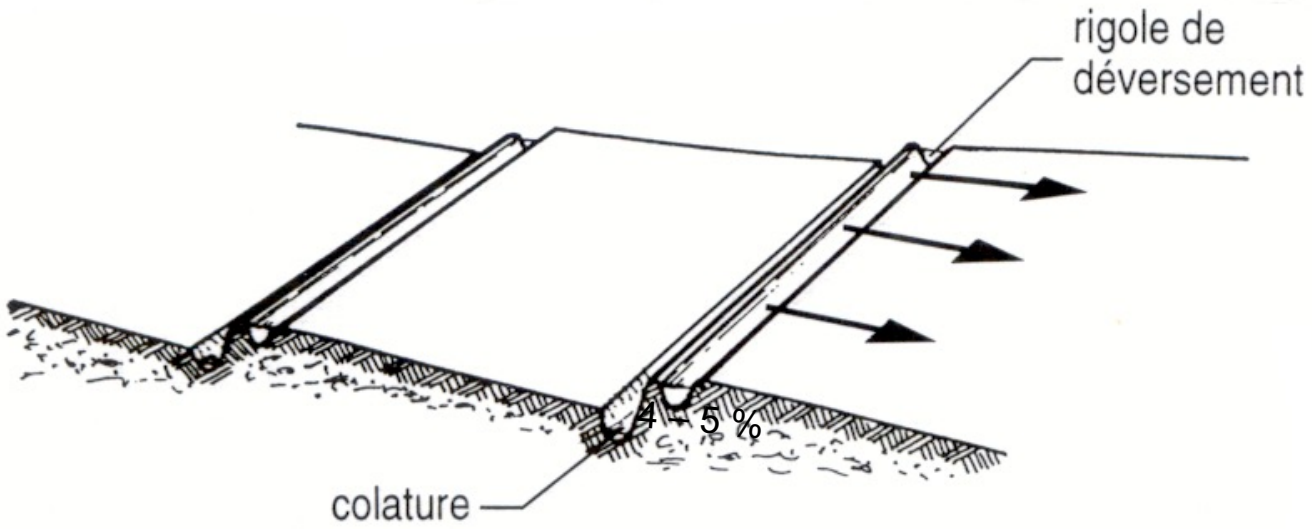
- **topography**
- **slope**
- **farm machinery characteristics**

Safe to consider
5 < l < 30 m

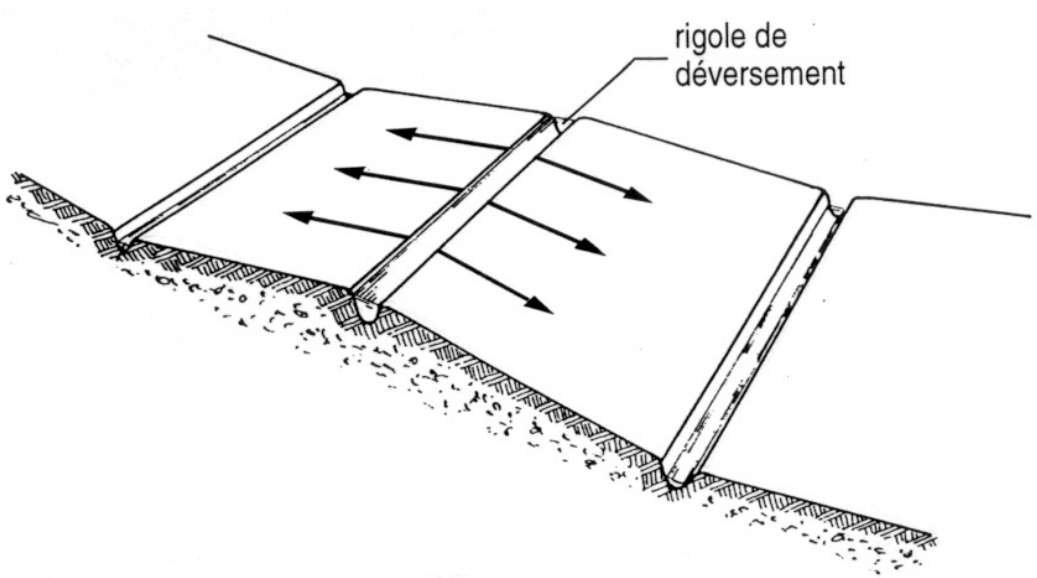
Basin Irrigation

Basin irrigation is defined as the application of water to an area typically leveled to zero slope and surrounded by dikes or check banks to prevent runoff.

Basin Irrigation using inclined planes



Counter-inclined planes



- **major earthworks required**
- **impediments to mechanisation**

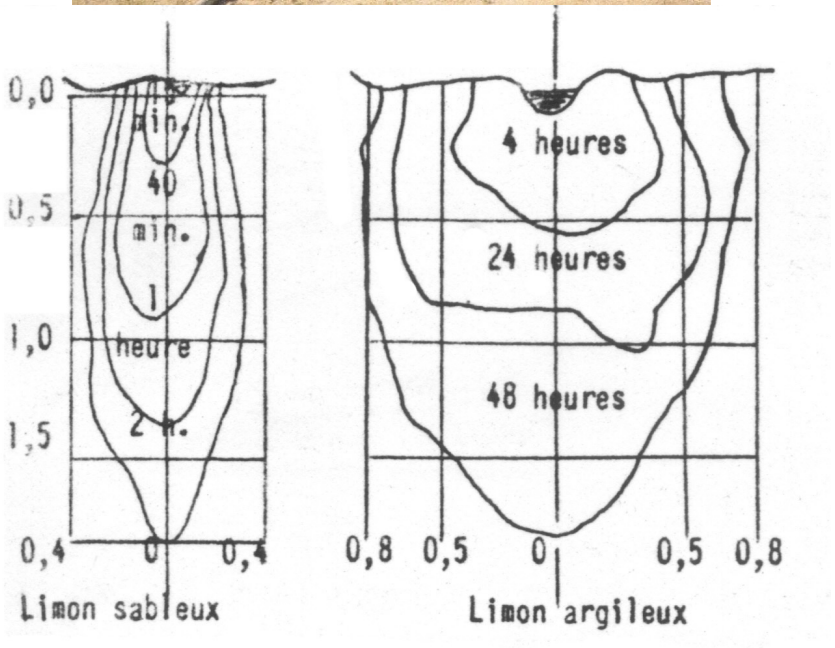
Furrow irrigation

(Row or line irrigation)

Maximum length of rows: 100 to 200 m and more

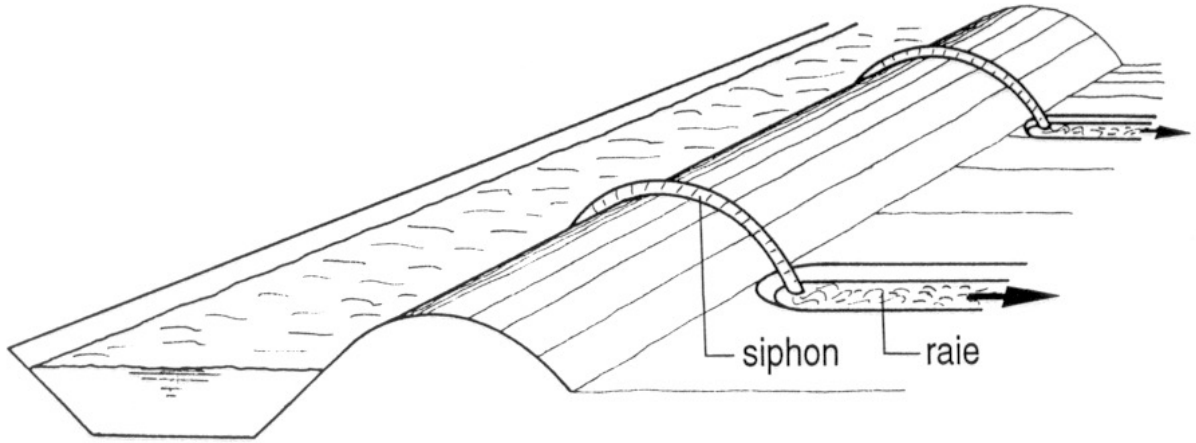
Line spacing: f(crop type, soil type, line shape): 0.5 to 2 m

Shape of lines: wide, shallow lines, triangular lines



Forme du bulbe d'humidification dans 2 sols différents

Furrow feeding techniques



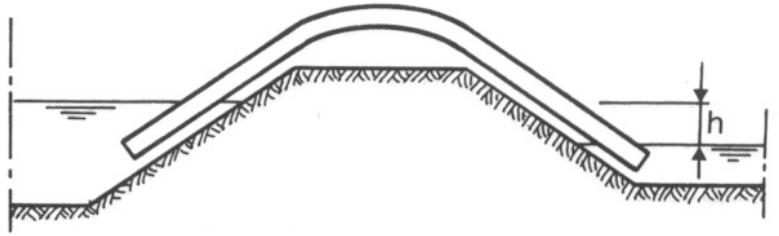
Use of siphons

Advantages

- partial soil moistening
- applicable to all types of soil
- low risk of compaction or surface crusting

Disadvantages

- labour-intensive
- discomfort caused by rows
- high water losses



$$Q = C\ S\ \sqrt{2g}\ h^{1/2} \quad \text{with :}$$

$$C = 0.83\ \sqrt{\frac{D^{4/3}}{0.86 \cdot 10^{6}\ K^{2}\ L + D^{4/3}}}$$

D: internal diameter of syphon; K: roughness coefficient, L: syphon length

Irrigation by submersion

PLATEFORME DE CONSTRUCTIONS HYDRAULIQUES

Advantages

- can be done on flat ground
- little monitoring
- encourages silt deposits
- necessary for many rice varieties

Disadvantages

- risks of settlement and soil deterioration
- risks of creep
- obstructions to traffic
- right of way for bunds

Techniques

- flood spreading (natural submersion)
- artificial submersion
  - irrigation of rice (prolonged submersion)
  - irrigation of other crops (temporary submersion)

Flood spreading (natural submersion)

Suitable environments :

Soils capable of rapidly accumulating a large stock of water, i.e. :

- **deep soils**
- **good water retention capacity**
- **good infiltration capacity**

➔ **conflicting requirements**

Can be used on bare soil or soil covered with crops that can withstand temporary submersion.

Irrigation by temporary artificial flooding

Suitable environments :

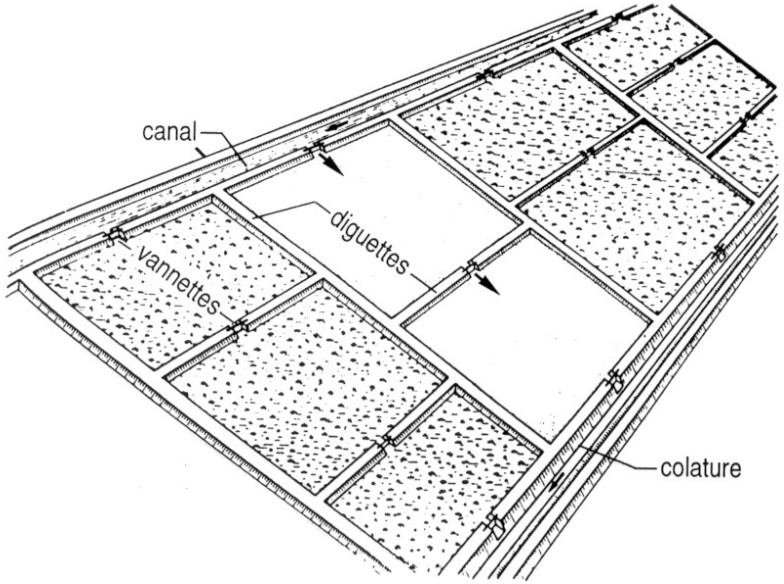
Soils capable of rapidly replenishing the water stock in the root zone, namely:

- **good water retention capacity**
- **good infiltration capacity**

➔ **conflicting requirements**

Can be used on soil covered with crops that can withstand temporary submersion.

Irrigation by prolonged artificial submersion



Basin surface area S

- type of soil (low permeability)
- slope
- available flow

500 m² and less < S < 1500 m² and more

- low-slope basins (1 to 2‰)

Irrigation by submersion with dependent basins