

Chapter 6

Protective and other canal structures

Canals need to be protected against the erosive force of flowing water. In particular, in places that are susceptible to erosion, canals can be seriously damaged by a scouring water flow. For instance, canal sections immediately downstream of a structure can suffer from the effect of a water jet; low sections of a canal embankment can easily overtop and will suffer from erosion by water that spills over; or curves in a canal can be eroded by the water flow due to locally high flow velocities.

Chapter 6 describes the structures and devices most commonly used to protect canals. In addition, the last section of this chapter deals with crossing structures.

6.1 WHEN IS CANAL PROTECTION NEEDED?

Canal protection may be needed under various circumstances.

- The flow velocity in a culvert can become high, and water that spills over a weir can have a high velocity. Such high flow velocities can cause serious damage to canals if the canals are not protected. In these cases, a *stilling basin* is commonly used as a protection.
- A rising water level within the canal may damage the canal embankments when it reaches the level of the crest of the banks and spills over, known as overtopping. A *spillway* is used here to protect the embankments.
- Where water drops from one canal section into another, the bed of the lower canal section needs to be protected against the force of the falling water. Here a so-called *drop structure* is installed, commonly in combination with a stilling basin.

6.2 STILLING BASINS

A stilling basin is a basin with protected walls and floor and which is filled with water. Its function is to convert the energy of fast flowing water into turbulence, so that the flow enters at low speed into the canal downstream of the basin. Stilling basins are required downstream of structures where flow velocities can be high, such as intake structures, offtakes, culverts, weirs, or drop structures.

Flow velocities in intake structures, for instance, may be high when water flows through a pipe before entering the main canal of an irrigation scheme, and the velocity of water which spills over a weir may be high. Fast-flowing water is highly erosive and can easily damage a canal bank or bed, and so the energy of this fast-flowing water must be dissipated in order for it to flow smoothly into the downstream canal section.

Three common forms that stilling basins can take are illustrated on the next pages.

FIGURE 38
Oil drum used as basin at a tertiary
offtake



FIGURE 39
Concrete stilling basin at main intake



Figure 38 shows a tertiary offtake, where the tertiary canal has a lower level than the secondary canal. The gate is open and water flows at high speed through a PVC pipe into the oil drum. The velocity is broken by the water mass in the drum, and water flows at low speed into the tertiary canal. (The water level is still low because the gate had just been opened).

The concrete basin in Figure 39 is designed for a large flow. Three pumps are going to deliver water into the basin. One of them is pumping water into the basin, and the fast-flowing water that leaves the hose will lose its energy in the basin, and then flow smoothly into the canal.

FIGURE 40
Concrete stilling basin downstream of a weir

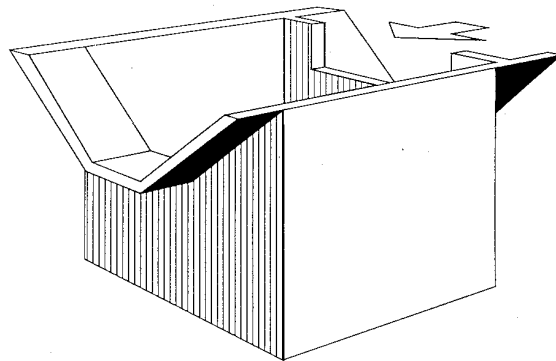
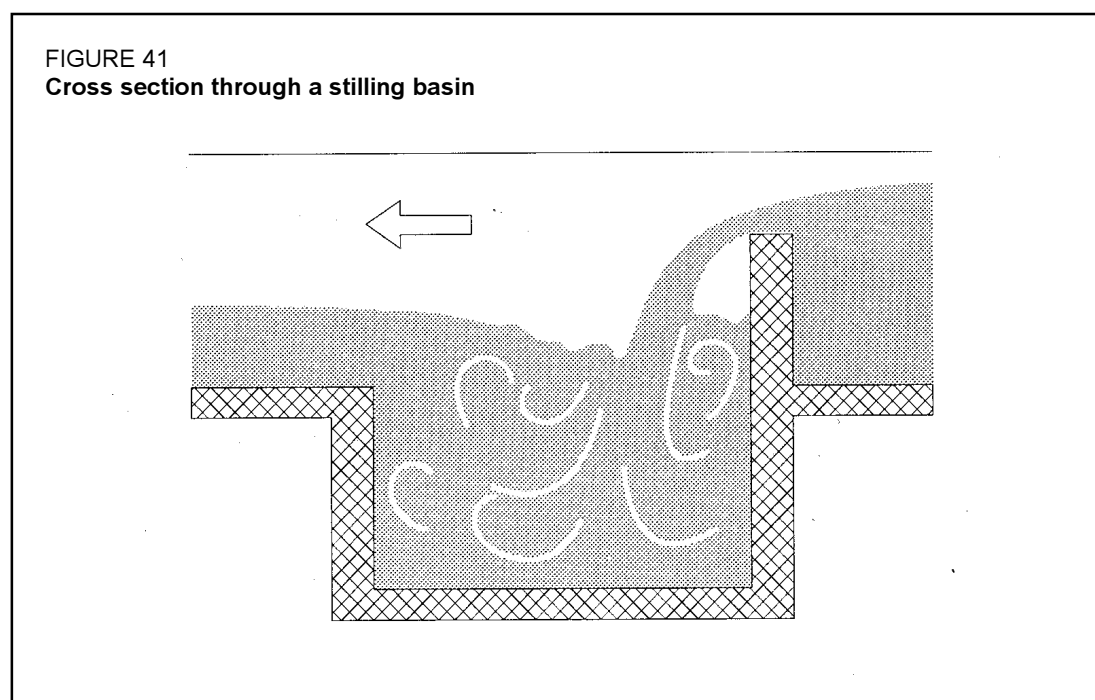


Figure 40 shows a stilling basin downstream of a weir. Water that spills over the weir falls in the basin, loses its energy, and enters the downstream canal section at low speed.

The way a stilling basin functions can be seen in Figure 41. The drawing is a cross-section view of the basin shown in Figure 40. One can see the water jet falling into the basin, but, thanks to the relatively large volume of water in the basin, the energy of the water jet will be absorbed. Having lost its energy, and therefore speed, the water flows smoothly into the downstream section of the canal.



6.3 SPILLWAYS

A spillway is a structure that guides excess water safely to the drainage system.

Water levels in irrigation canals are seldom constant. Depending on the inflow and outflow of the canal section concerned, the water level changes. The water level may rise if the gate of an intake structure is open instead of being closed, or if field intakes are closed instead of open. This can happen even in well managed schemes! When rising, water may pass the free board level, reach the crest of the canal embankment, and start overtopping.

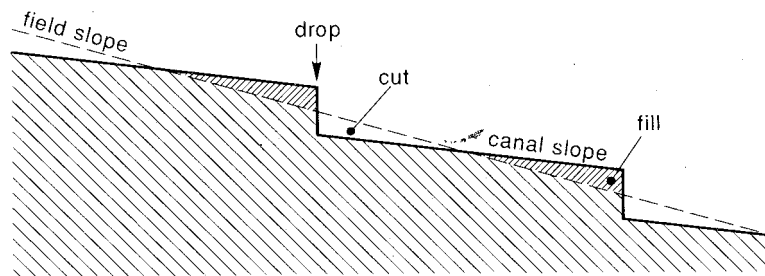
If water reaches the crest of a canal bank and overtops, this can result in destruction of the bank. To avoid this problem, a small section of the canal bank is lowered and is reinforced with concrete or with masonry. As this is the lowest part of the canal bank, rising water will spill over here. This water will be guided to the drainage system.

Figure 42 shows such a structure + a *spillway*, but also called an *emergency outlet* + in a lined canal. One can see the lowered section of the canal bank in the front. The water level in the canal has just reached the crest of the spillway, and if it rises more, water will spill over and be guided to the drainage system of the scheme.

FIGURE 42
Spillway or emergency outlet



FIGURE 43
Longitudinal section of a canal, showing bed level drops



6.4 DROP STRUCTURES

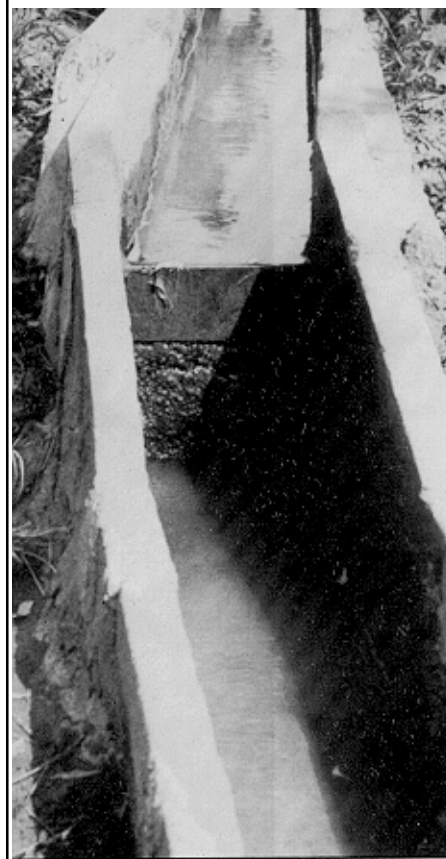
Irrigation water may need to be transported over steeply sloping land. If a canal had the same slope as the surrounding steeply sloping field, the flow velocity in the canal would be very high. In these cases the canal is given a slope which is less than the field slope in order to avoid unacceptably high flow velocities. See also Chapter 4 of Manual 7, *Canals*.

In order for a canal to have a gentler slope than the field, it is split into sections, and part of each section is constructed in cut, and part in fill, with each section having a bed level which is lower than the canal section upstream of the section concerned.

FIGURE 44
Series of drop structures



FIGURE 45
Drop with weir



Bed levels should not be excavated much lower than the field, nor should the bed be much higher than the field. So, in order to avoid large volumes of cut and fill, the drop in bed level is limited and will not exceed some 0.30 to 0.80 m. See Figure 43.

The canal sections are connected to each other by so-called *drop structures*. Such a drop structure can also include a stilling basin, especially if the canal is unlined or the drop in level is relatively large, say 0.50 m or more. See Figure 44.

In Figure 45 note that the sill + the weir crest + functions as a check and maintains the upstream water level above the level of the sill.

6.5 CANAL LINING

Some canal sections are susceptible to erosion because of the type of soil they are constructed in. In particular, those sections where there is a change in flow velocities can suffer a lot. Those sections are, for instance, sharp curves, or sections downstream of a culvert. In the first case the direction of the flow is being changed; in the second case the flow velocity is changed as a result of a sudden change in canal cross-section. Such sections need to be protected, and protection is usually given by lining the section concerned.

FIGURE 46
Protected section of canal



Figure 46 shows a canal section which is lined especially to provide protection for the transitional zone between the start of the wider, unlined section of the canal after the narrow, lined part upstream in the same canal.

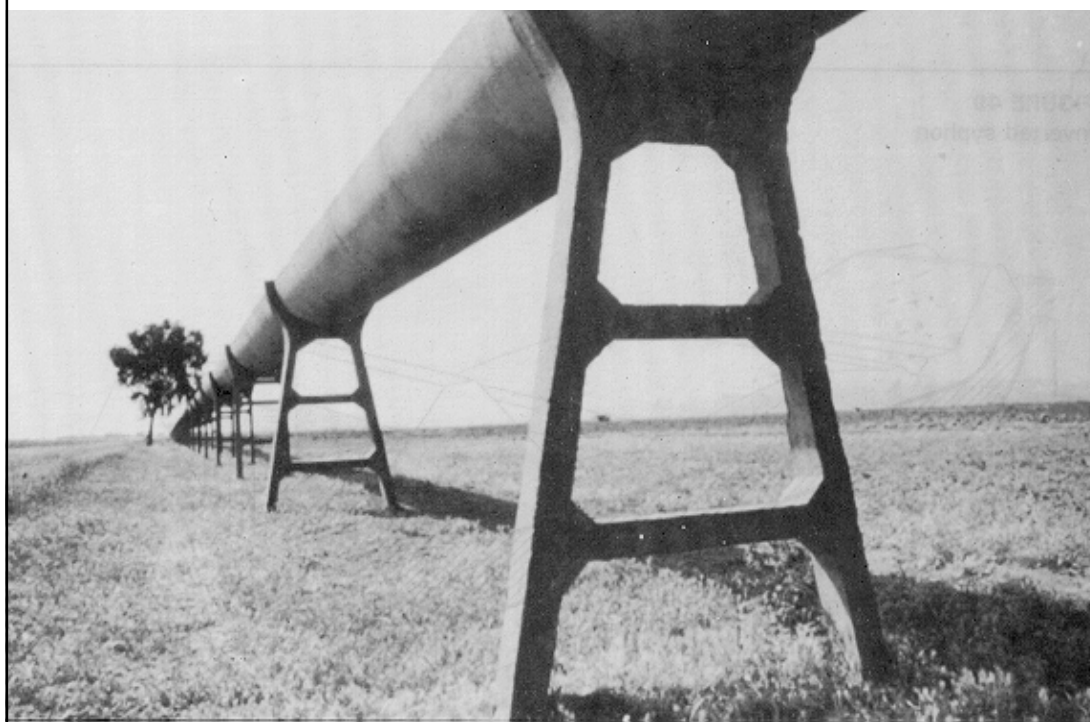
6.6 CROSSING STRUCTURES

Crossing structures are used to pass over or under obstacles in the field. There are three types of crossing structure to transport irrigation water, namely: aqueducts, culverts, and inverted siphons, and there also are crossing structures not meant for water conveyance bridges.

Aqueducts

Aqueducts are self-supporting canal sections used to carry water across drainage canals, gullies or depressions. They can be constructed from wood, metal or concrete. The aqueduct in Figure 47 carries water across a large depression.

FIGURE 47
Aqueduct



Culverts and inverted syphons

Culverts and inverted syphons are buried pipes used to carry irrigation water underneath roadways, drainage canals, natural streams or depressions.

Flow through a culvert may have a free water surface or may be submerged, see Figure 48.

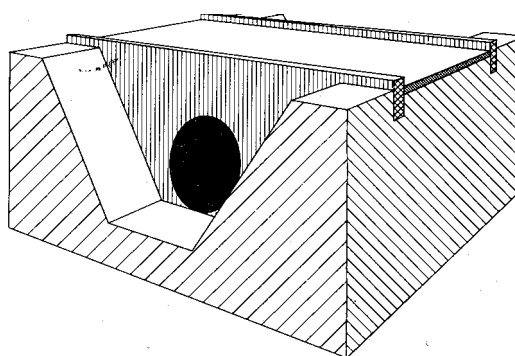
Flow through an inverted syphon does not have a free water surface, and the water is under pressure, see Figure 49.

Bridges

A bridge is a structure that enables people or traffic to cross a canal. If a new canal has to cross a footpath which has been in use for a long time, a bridge may be constructed to let people pass over.

If such a canal is constructed in fill, the outside slopes should be reinforced to prevent it from destruction. See Figure 50.

FIGURE 48
Culvert



Heavy bridges should be supported by pillars which are constructed at the foot of the embankments. The construction of these bridges may be more expensive than the construction of culverts.

