Chapter 4

Flood in Urban area

4.2 Flood Control in Urban Area

- A flood is an unusual high stage of a river overflowing its banks and inundating the marginal lands.
- Design magnitudes of floods are needed for the design of spillways, reservoirs, bridge openings, drainage of cities and air ports, and construction of flood walls and levees (flood banks).
- The maximum flood that any structure can safely pass is called the '**design flood**'.

4.2.1 Major Flood Controlling Mechanisms

- The damages due to the devastating floods can be minimized by the following flood control measures, singly or in combination.

i. by confining the flow between high banks by **constructing levees** (**flood banks**) ,**dykes**, or **flood walls**.

ii. by channel improvement by **cutting, straightening or deepening** and following river training works.

iii. by **diversion of a portion of the flood** through bypasses or flood ways.

- In some cases a fuse plug levee is provided. It is a low section of levee, which when once over topped, will wash out rapidly and develop full discharge capacity into the flood-way

iv. by providing a temporary storage of the peak floods by constructing **upstream reservoirs** and **retarding basins (detention basins).**

v. by adopting **soil conservation measures** (land management) in the catchment area.

vi. by temporary and permanent **evacuation of the flood plain**, and **flood plain zoning** by enacting legislation.

vii. by flood proofing of specific properties by constructing a **ring levee or flood wall** around the property.

viii. by setting up **flood forecasting—short term, long term, rhythm signals and radar, and warning centers** at vulnerable areas.

4.2.1.1 Flood Control by Reservoirs

- The purpose of a flood control reservoir is to temporarily store a **portion of the flood** so that the **flood peaks are flattened out**.

- The reservoir may be ideally situated immediately upstream of the area to be protected and the water discharged in the channel downstream at its safe capacity (known from its stage-discharge curve), i.e. The **peak has been reduced** by **AB, Fig. 4.1**

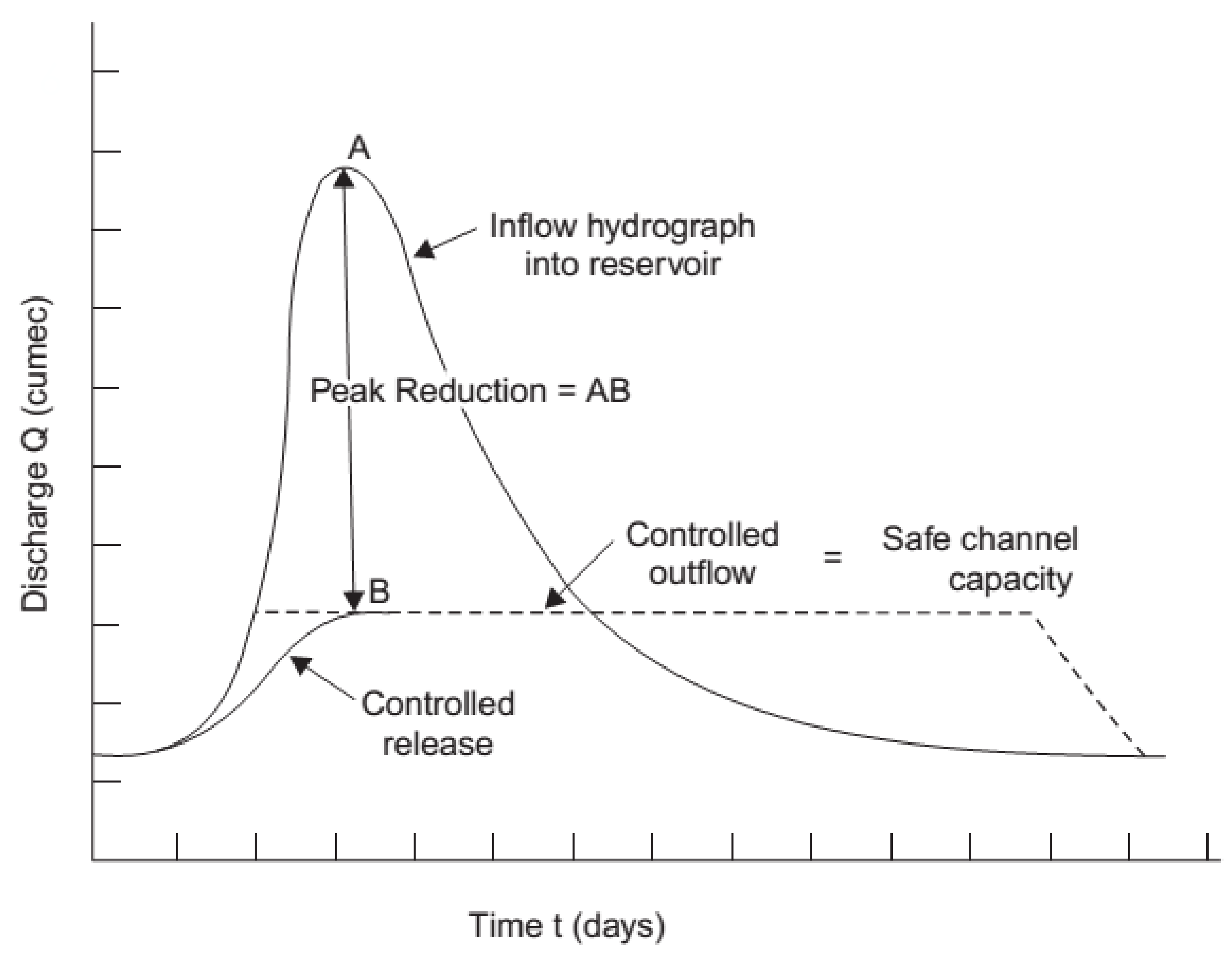
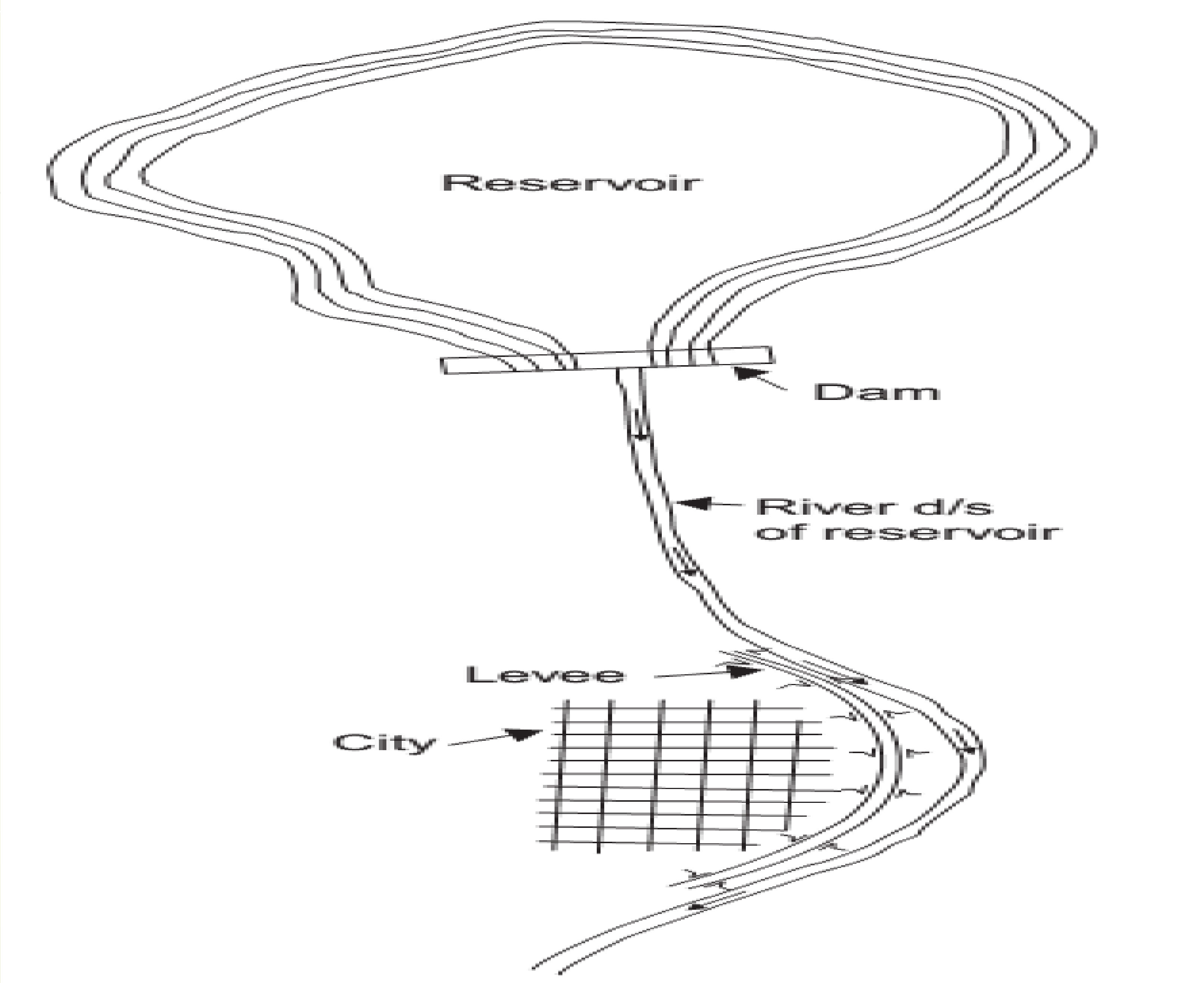


Fig. 4.1 Flood control by reservoirs

- The effectiveness of the reservoir in reducing peak flows, increases as its storage capacity increases.

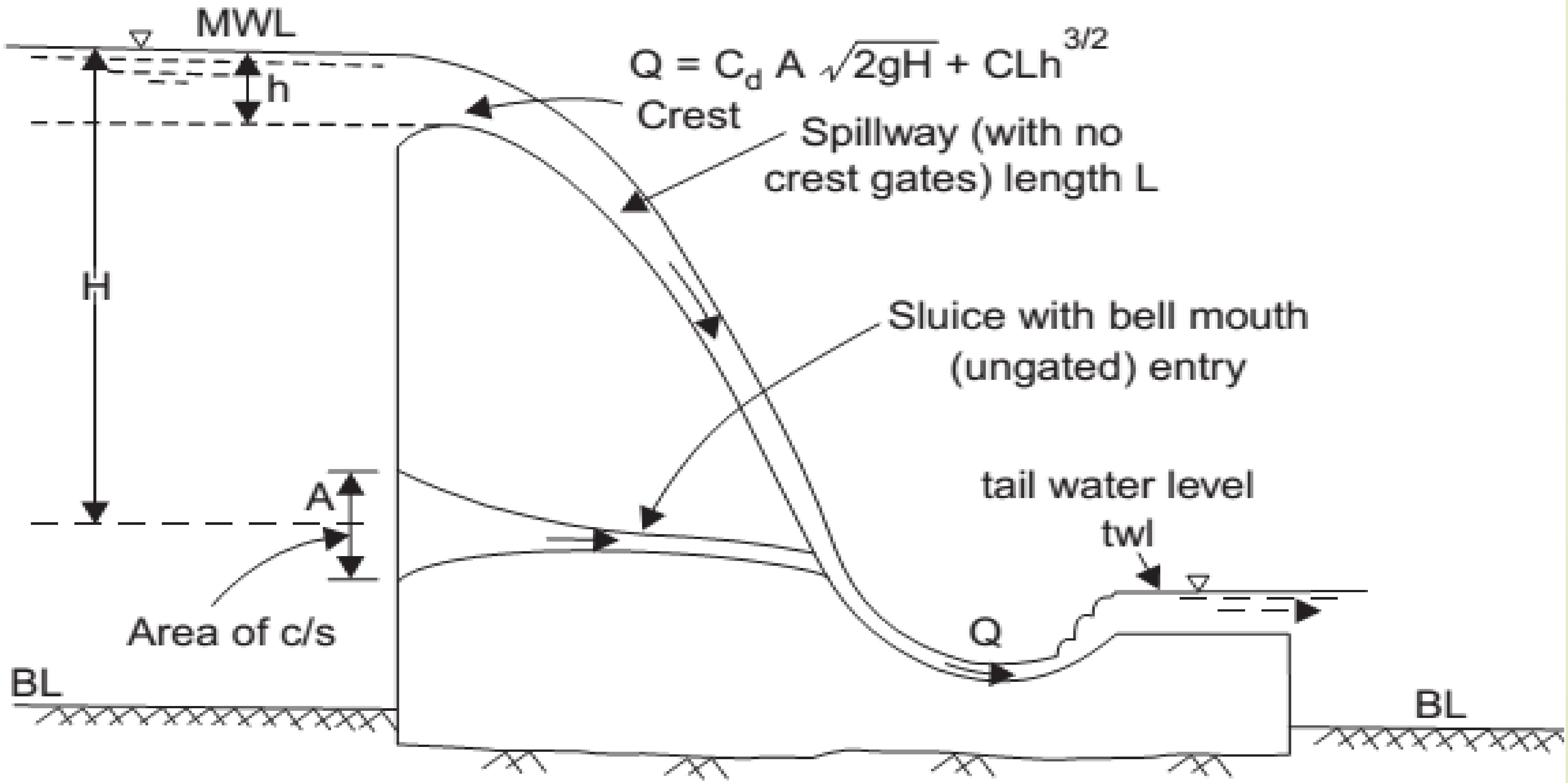
Fig. 4.5 Flood protection by reservoir and levees for a city



4.2.1.2 Retarding Basins

- The release from a storage reservoir is controlled by gates and valves and regulated by the project engineer.
- A retarding basin is provided with outlets like a large spillway and sluices with no control gates.
- The sluice discharges like an orifice, i.e., $Q = C_d A \sqrt{2gH}$, and there is a greater throttling of flow when the reservoir is nearly full than would a spillway discharging like a weir, i.e., $Q = CLh^{3/2}$ (fig 4.2).

Fig 4.2 Retarding basin



4.2.1.3 Construction of Levees

- The construction of levees (flood banks or dykes) is extensively followed in India, since it is an economical, direct and immediate method.
- The design and construction of levees are similar to those of an earth dam. The levees are constructed beyond the meander belt of a river, Fig. 4.3 (a) and they tame a river not to change its course.
- As far as possible, there should be very few curves in their alignment. They require constant watch and after the floods recede, repairs and restoration of levees should be resorted to.

The effects of levees on flood flow are;

1) Increase in the rate of flood flow
2) Increase in the flood water elevation
3) Increase in the carrying capacity of the channel
4) Increase in the scouring action
5) Decrease of surface slope of stream above the leveed section

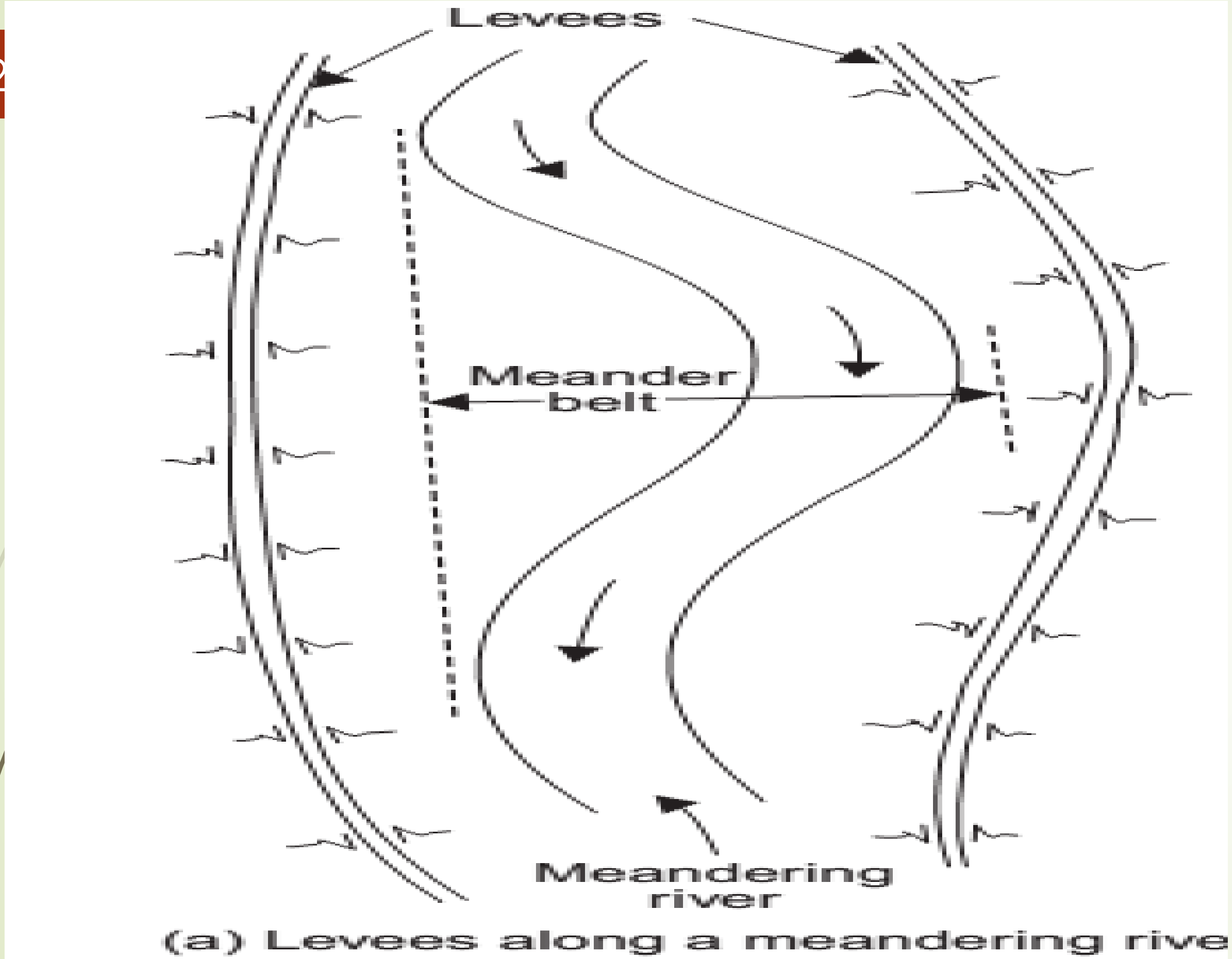
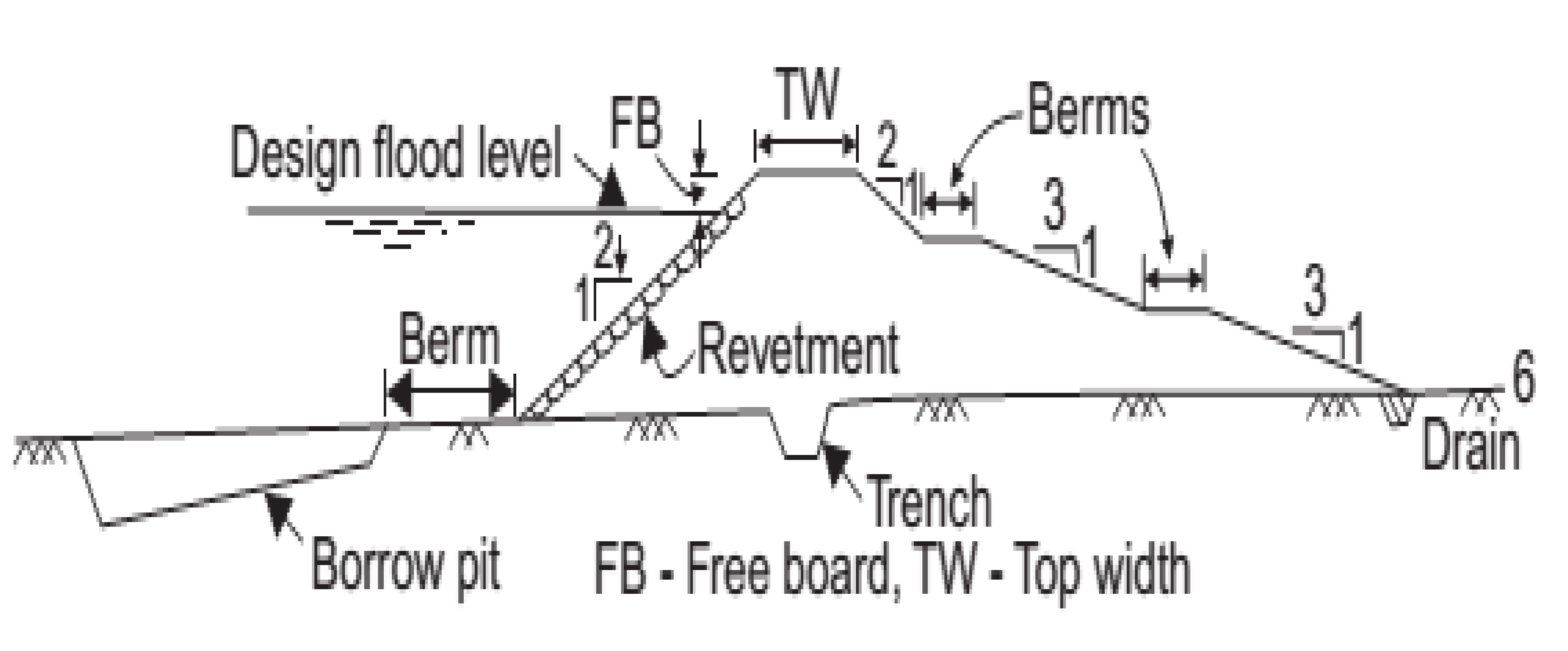


Fig 4.3 flood control by levees

(a). Levees along meandering river.


TW
FB
Design flood level
2
1
Berms
3
1
2
1
3
1
Berm
Revetment
6
Drain
Trench
Borrow pit
FB - Free board, TW - Top width

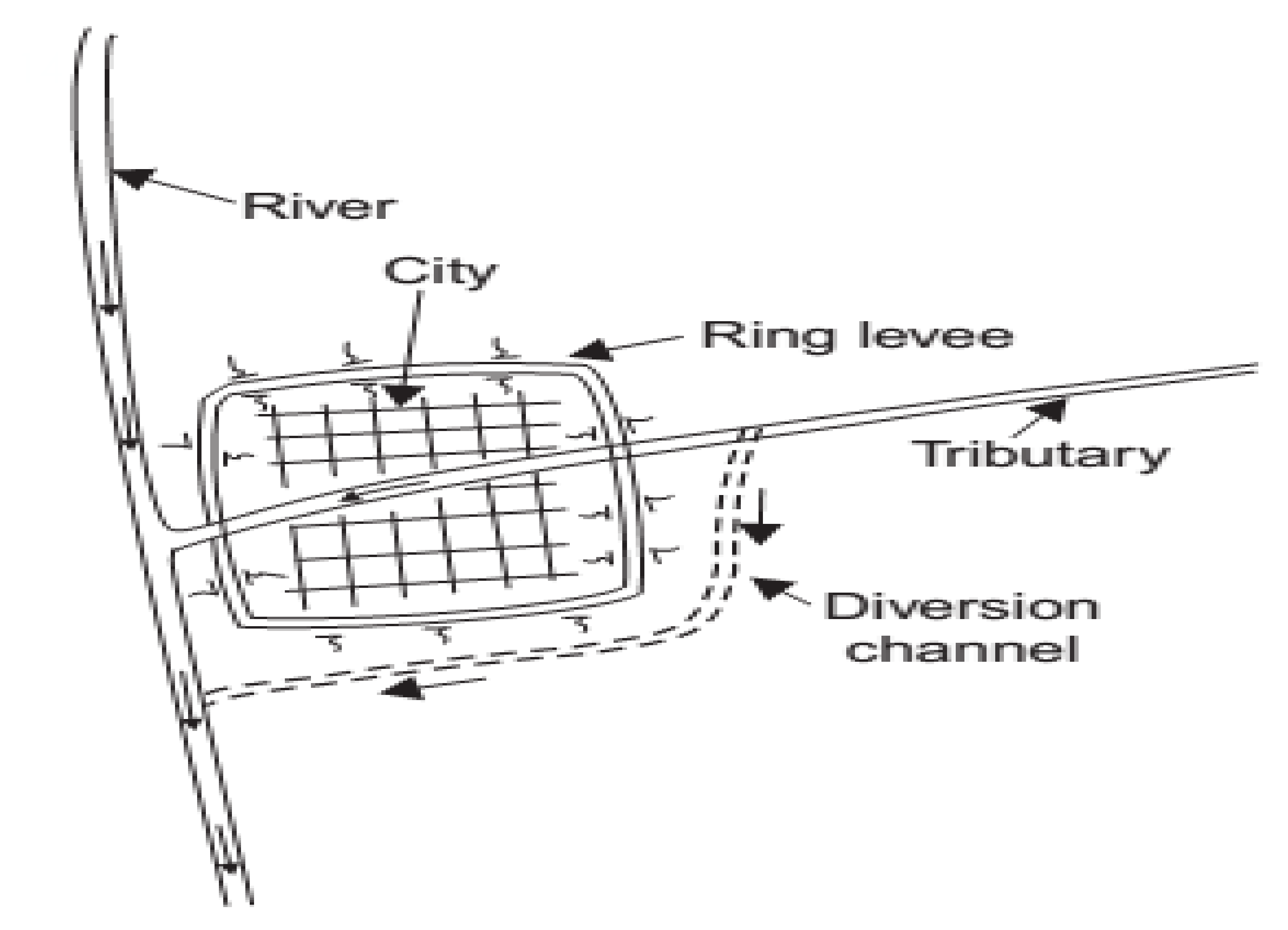


Fig. 4.4

- **Ring levee** to protect a city

4.2.1.4 Channel Improvement

- Channel improvement increases the discharging capacity of the stream thereby **decreasing the height** and **duration of the flood**.

- Flood carrying capacity can be increased either by **increasing the cross-sectional area** or by **increasing the velocity** along the river.

- Enlarging the section is attempted only for **narrow** and **shallow channels** with small watersheds, the limit of such enlargement in width being 30-40 m.
- **Deepening is preferred** to **widening,** since the hydraulic mean radius increases more with depth (for the same increase in the sectional area) thus increasing the velocity.

- The **channel velocity** (given by Manning's or Chezy's formulae) is affected by **hydraulic mean radius**, **slope of river bed** and **roughness of the bed** and sides.
- Roughness can be reduced by

a) removing sand bars

b) prevention of cropping on river beds near banks.

c) removal of fallen trees and other snags.

d) elimination of sharp bends of meander's by providing **cutoffs** (**Fig. 4.6**).

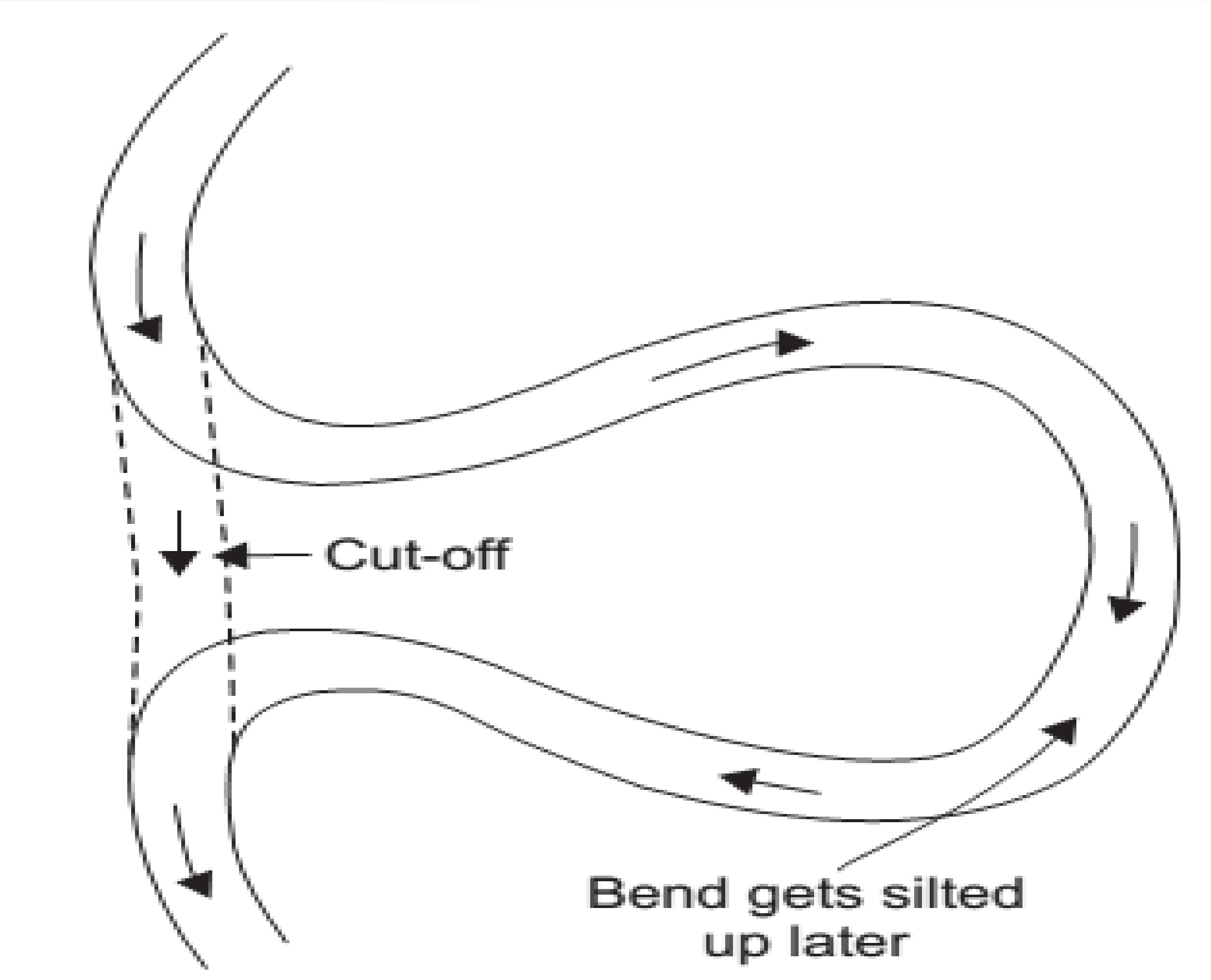


Fig. 4.7

- Cut-off in a meandering river

- **Deepening can be resorted** to only when cutoffs are provided, when the slope of the channel is increased due to the reduction in the length of flow.
- Thus, a **cutoff helps**;

(i) **in increase the velocity by increasing the slope,**

(ii) **to shorten the path of flow by elimination of meander's, and consequently**

(iii) **to shorten the levees necessary to confine flood water**

Example 1

- A channel has a bottom width of **200 m,** depth **6 m** and side slopes **1:1.** If the depth is increased to **9 m** by dredging, determine the percentage increase in velocity of flow in the channel. For the same increase in cross sectional area, if the channel is widened (instead of deepening), what is the percentage increase in the velocity of flow.

Solution

Solution Chezy's formula, $V = C\sqrt{RS}$

where V = velocity of flow in the channel

R = hydraulic mean radius

S = bed slope of the channel

C = a constant, depending on the roughness of the bed and sides

Assuming the bed slope and roughness are the same in both the cases of deepening and widening, $V \propto \sqrt{R}$

- increasing the depth by **9m**

Putting the subscript 'o' for the original area of cross section (A), wetted perimeter (P) and the hydraulic mean radius (R), *i.e.*, before deepening Fig 8.12,

$$A_0 = (200 + 1 \times 6)6 = 1236 \text{ m}^2$$

$$P_0 = 200 + 2 \times 6\sqrt{1^2 + 1} = 217 \text{ m}$$

$$R_0 = \frac{A_0}{P_0} = \frac{1236}{217} = 5.7 \text{ m}$$

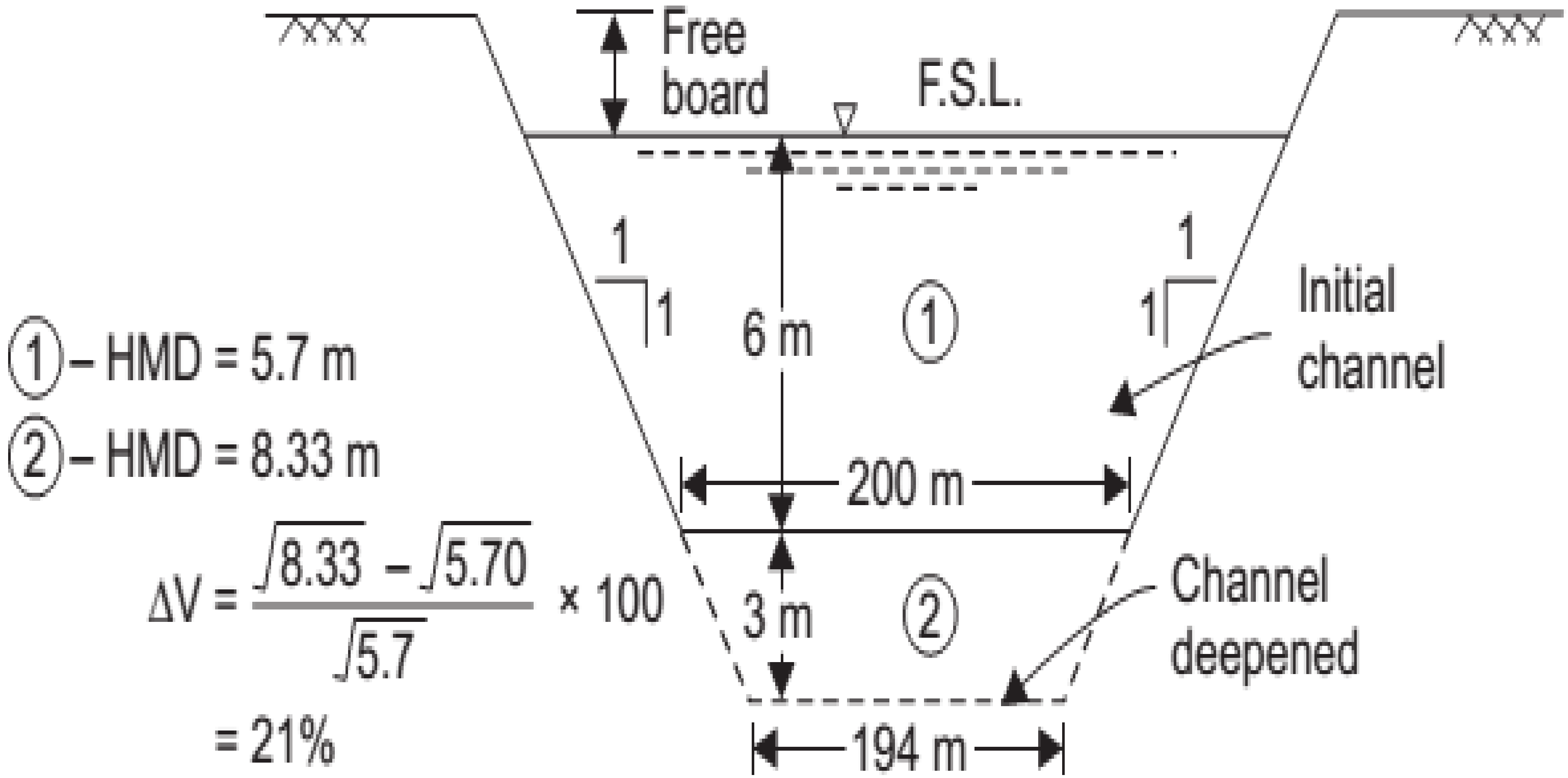
After deepening from 6 m to 9 m, Fig. 8.12,

$$A = (194 + 1 \times 9)9 = 1827 \text{ m}^2$$

$$P = 194 + 2 \times 9\sqrt{1^2 + 1} = 219.4 \text{ m}$$

$$R = \frac{A}{P} = \frac{1827}{219.4} = 8.33 \text{ m}$$

$$\text{Velocity increase by deepening} = \frac{\sqrt{8.33} - \sqrt{5.70}}{\sqrt{5.7}} \times 100 = \mathbf{21\%}$$



Free board
F.S.L.
1
1
1
1
6 m
①
Initial channel
① – HMD = 5.7 m
② – HMD = 8.33 m
200 m
ΔV = (√8.33 – √5.70) / √5.7 × 100
= 21%
3 m
②
Channel deepened
194 m

4.3 Soil conservation measures

- The best way to prevent **silt deposition** is to arrest silt at the place of its origin, i.e., by undertaking soil conservation measures in the catchment area.

- Soil conservation measures for the entire catchment like contour bunds, check dams, terraces, gully plugging, vegetative cover (strip cropping), afforestation, land management, stream bank protection, etc.

- Fig. **4.8 to 4.11** are very necessary to retard the velocity of runoff, to control soil erosion, to absorb more water in the soil and to protect the dams and reservoirs from being silted up.

- For example, a change in land use by surface vegetation increases the infiltration capacity and reduces surface runoff.

- Soil conservation is a subject of its own and **Fig. 4.8-4.11** given here illustrate only the principle, and the reader may refer to standard works on the subject.

- The choice of the management practices should be based on information of the hydrologic cycle of the watershed.

- A coordinated effort by engineers, agronomists, foresters, geologists, hydrologists and economists would be very desirable.

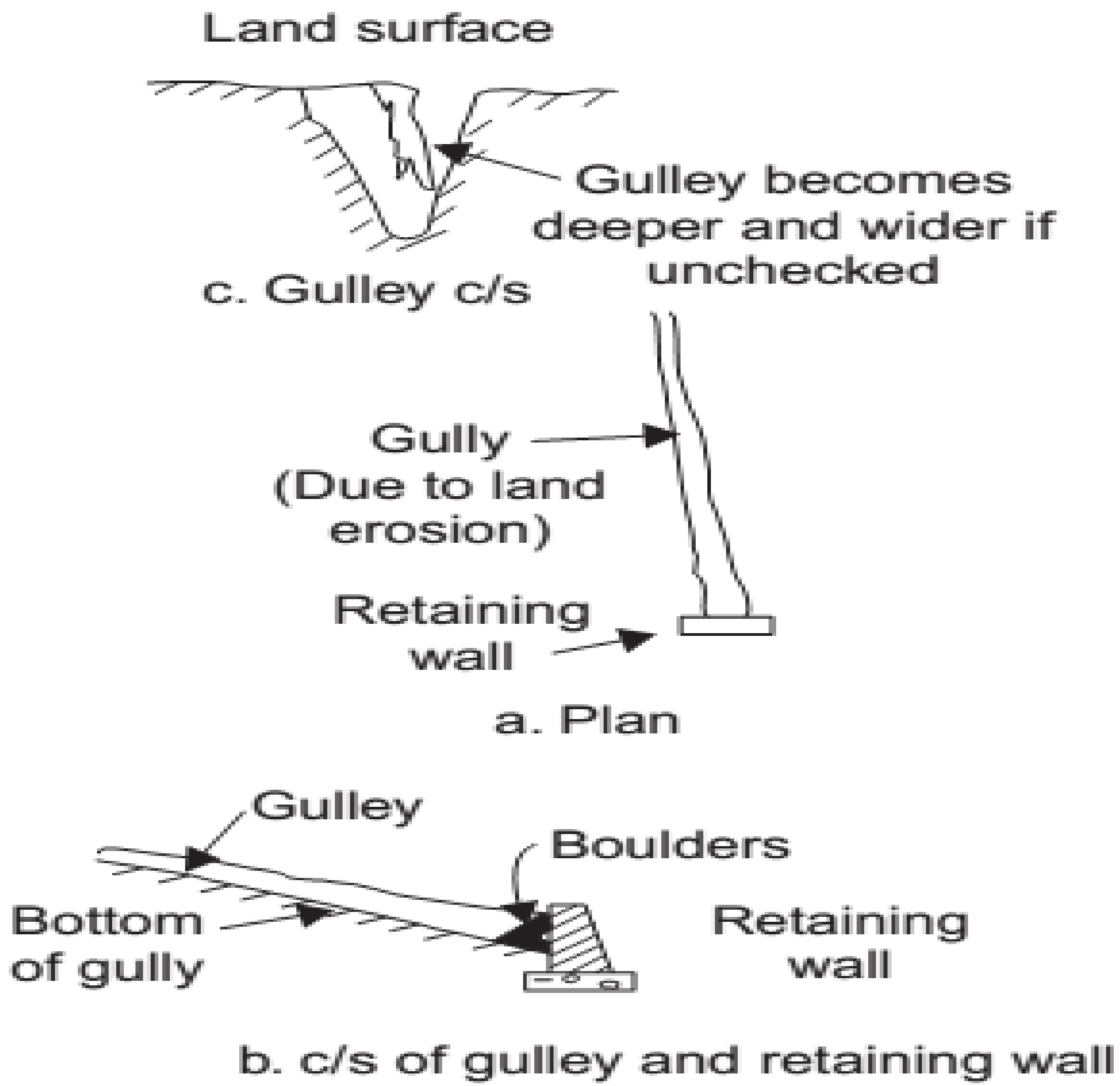


Fig 4.8

Gully plugging

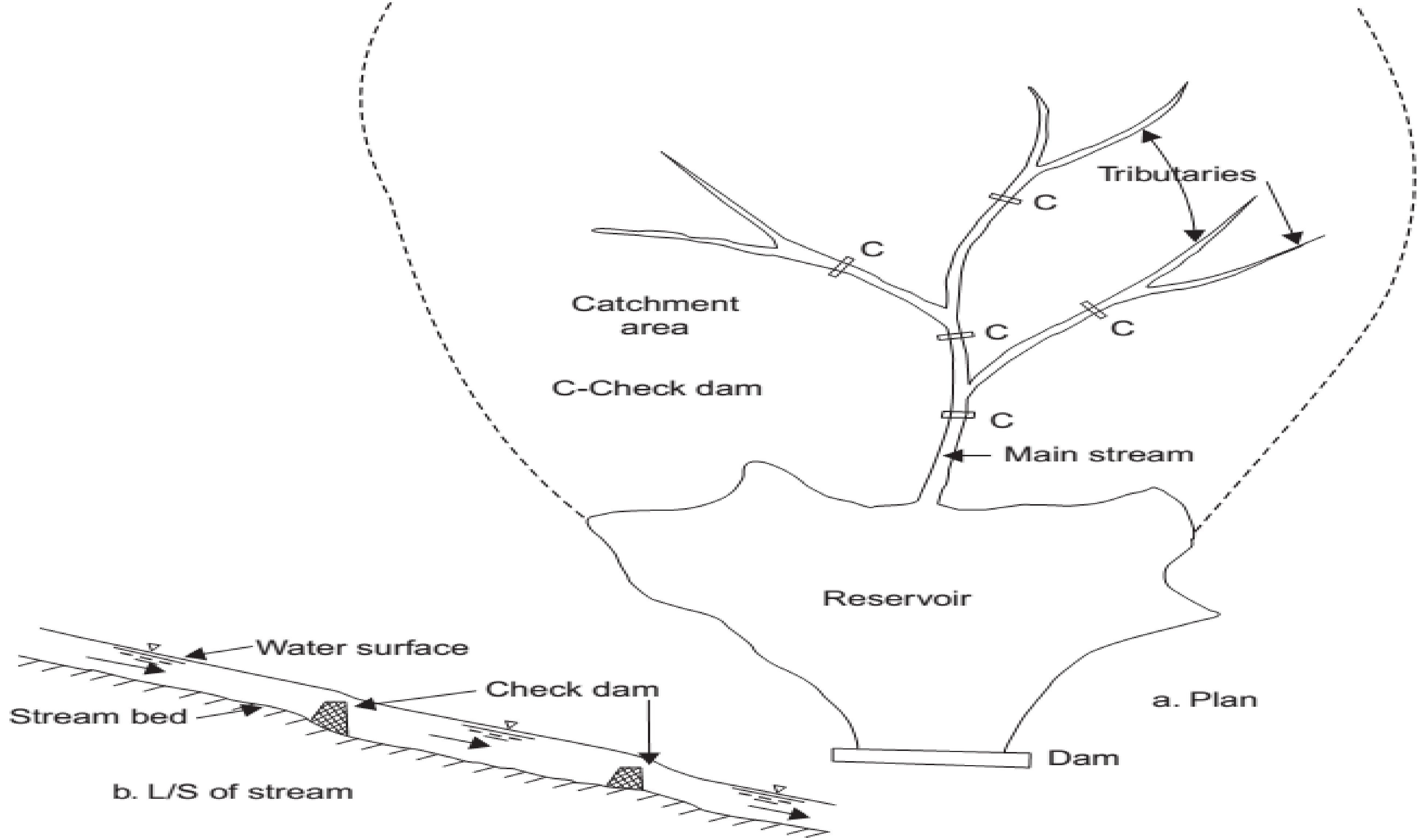


Fig 4.9 Cheek Dam

- **Flood plain zoning:-** Areas, very near to the river are the most vulnerable and therefore should not be allowed to be used for building houses.
- They may be used for parks, recreation grounds, etc.
- So that inundation of such land may not result in loss of human lives or any significant damage to property.
- Raising place for habitations above flood heights can be viewed as an adjunct to embankments.

Fig. 4.10 Contour farming

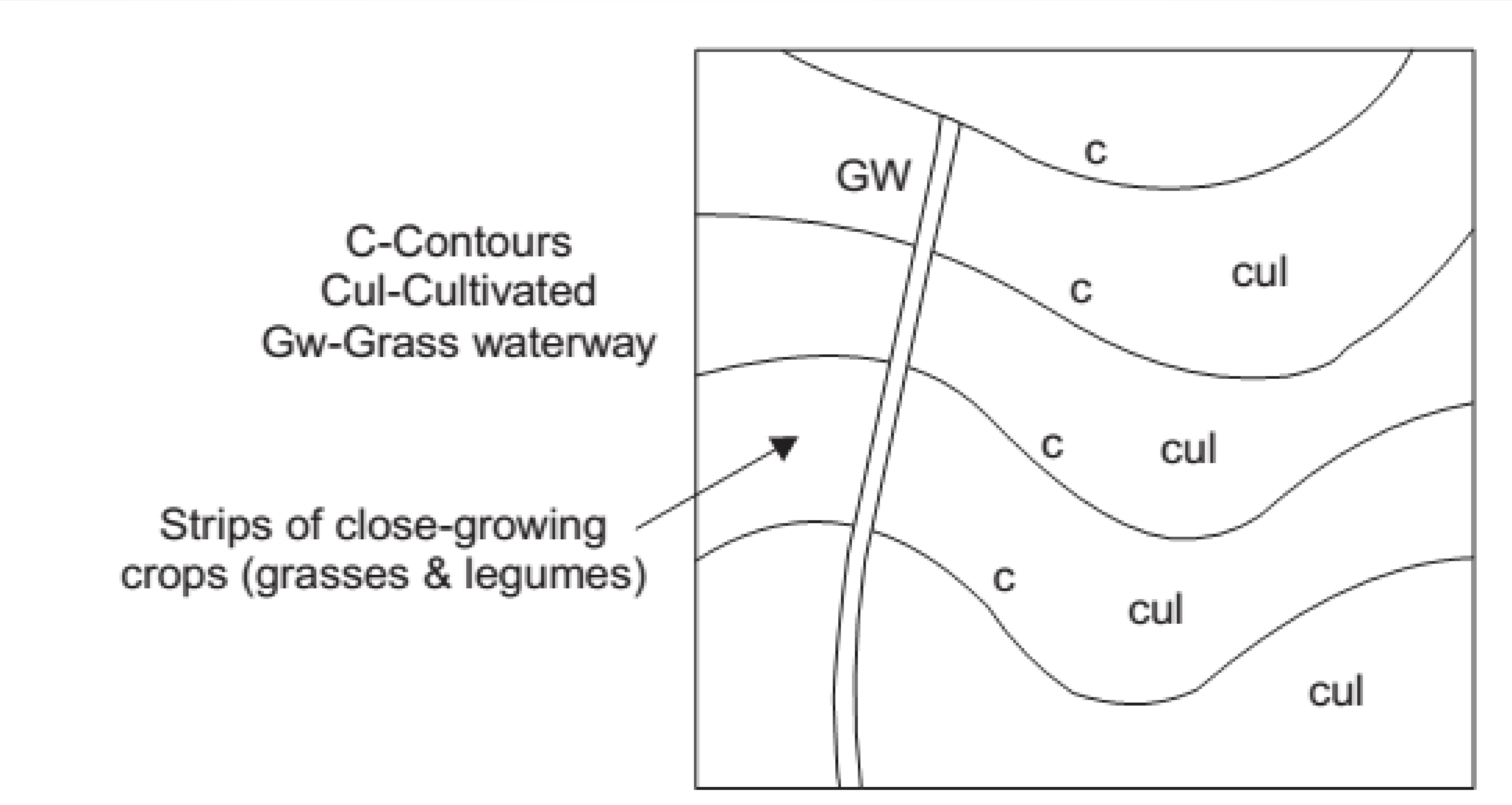


Fig. 4.12 Contour terrace

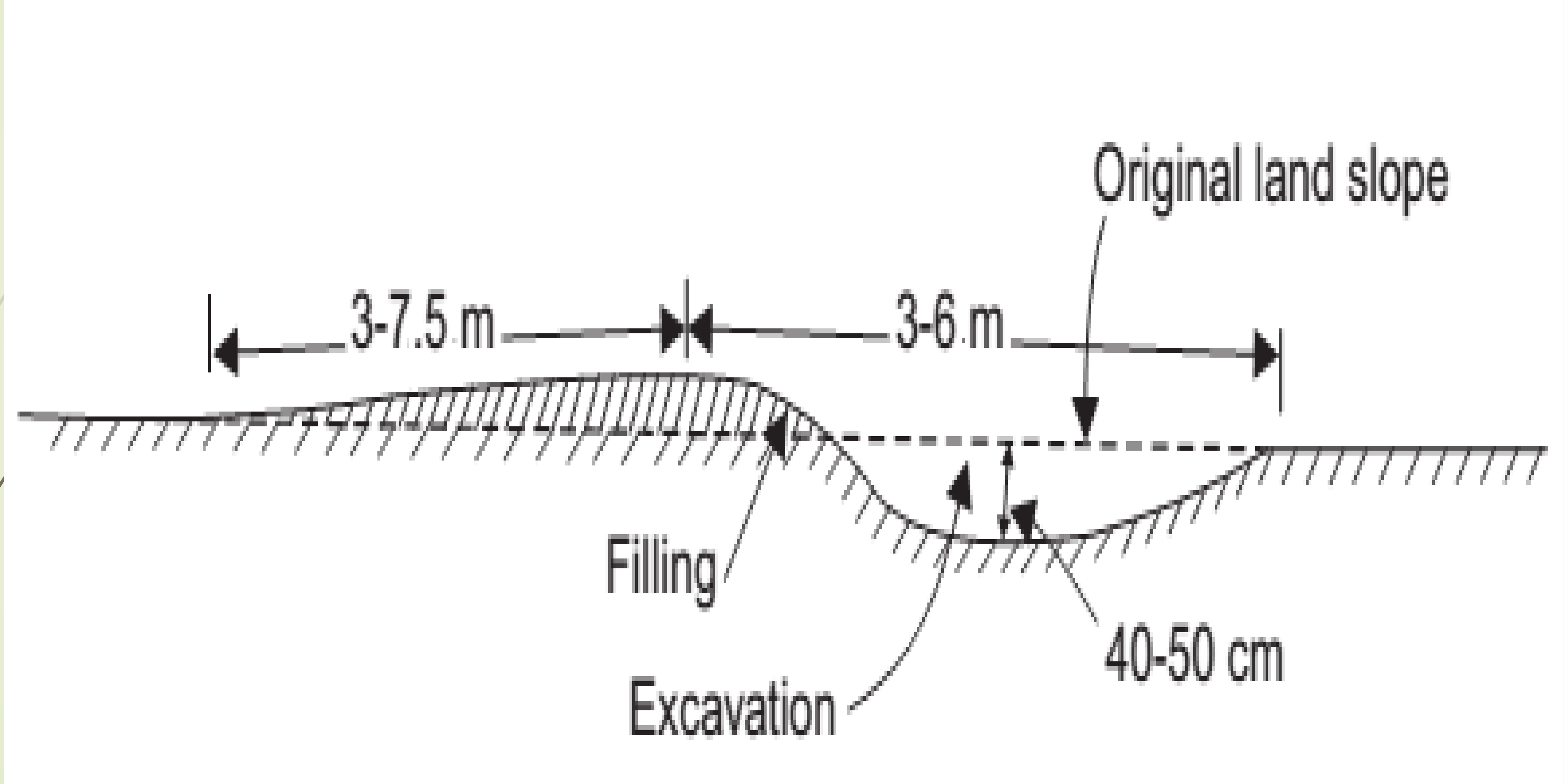
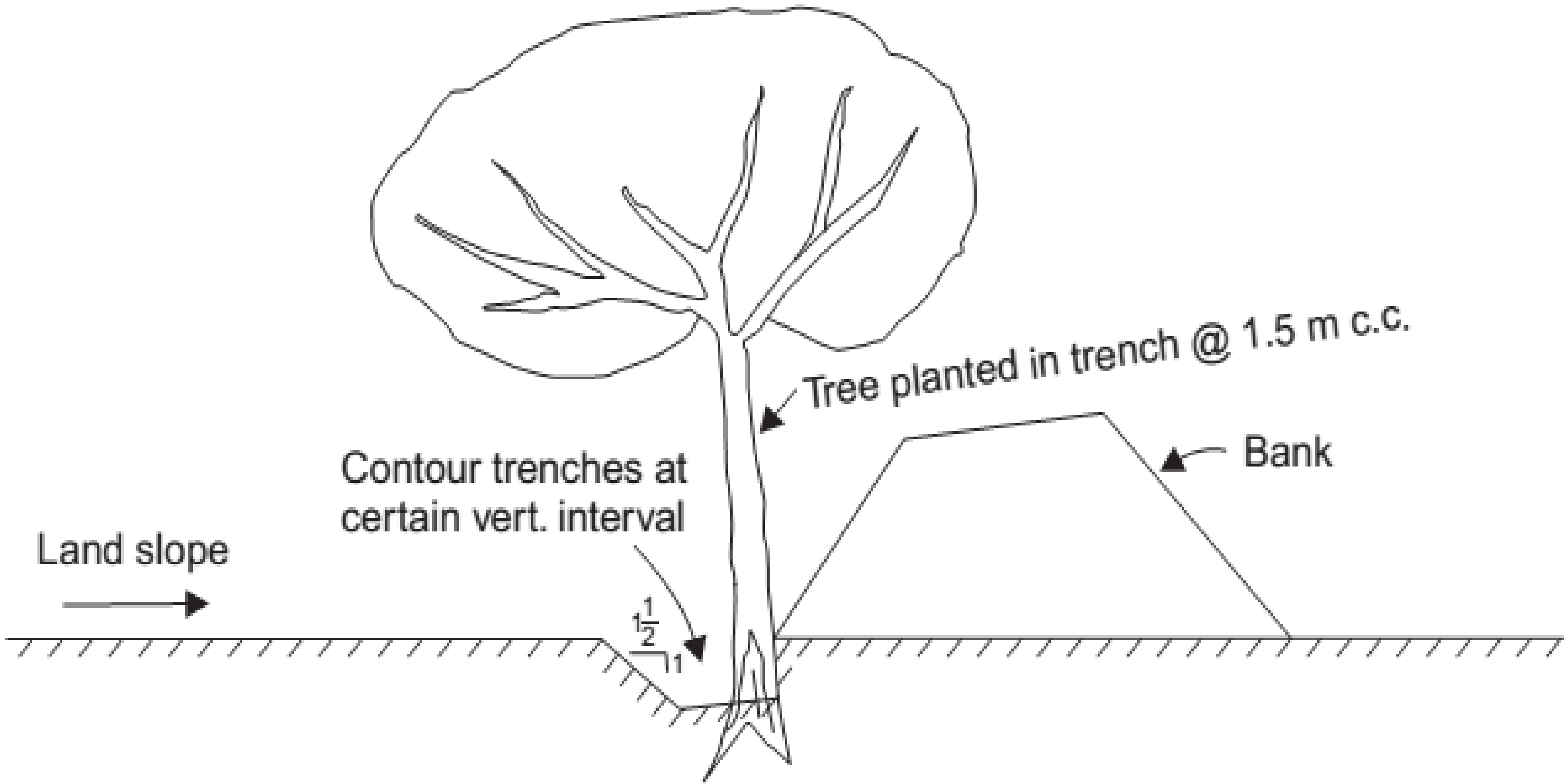


Fig.13 Contour trenching



4.3 Flood forecasting and warning

- The flood forecasts are issued on the basis of the analysis of weather charts and indicate the likelihood of heavy rainfall over the specified areas with the next 24 to 48 hours.
- **Radar:-** is very effective in the detection and tracking of severe storms. Meteorological satellites give an excellent idea of the cloud cover over the whole of India and neighboring countries.
- After the formulation of forecast, it must be disseminated amongst persons concerned at the fastest speed. This can be done by utilizing all available media of communications like telegraph, tele-printer, telephone and wireless and organizing a hierarchy for onward transmission, if necessary.

- **One of the methods of forecasts in The Bureau of Meteorology, Australia comprises the following procedural steps:**

I. Collection of previous 24-hour rainfall in respect of each catchment
II. Updating the Antecedent Moisture Index
III. Working out the average depth of rainfall
IV. Assessment of likely extent of the rain from weather charts
V. Collection of river stages
VI. Issue of preliminary warnings with all factual data collected at every 6-hour interval;