
بسم الله الرحمن الرحيم

Design of Flood Control Structures

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WHAT IS MEANT BY FLOOD?

Floods of all natural hazards capable of producing a disaster, a flood is the most common in causing loss of life, human suffering inconvenience, widespread damage to buildings, structures, crop, infrastructure, and other national assets.

WHAT IS MEANT BY FLOOD?

- Floods occur when discharge exceeds bank full capacity.
- Water leaves channel to cover adjacent land – the flood plain.
- Human occupancy of this flood zone creates need for hazard response.

HUMAN RESPONSE TO FLOODING:

- **Flood protection** – decreases risk of bankfull capacity being exceeded
- **Flood abatement** – reduces stormflow and reduces peak discharge levels
- **Behavioural responses** – societies adopt different coping strategies
- Most activity tends to increase flood risk, by reducing the **interception store** and thus increasing the amount of **surface run-off**:

HUMAN RESPONSE TO FLOODING:

- **Deforestation**
- **Urbanisation**
- **Cultivation**
- Whereas **afforestation** reduces the flood risk by encouraging infiltration.

HUMAN RESPONSE TO FLOODING:

❖ **<u>Spreading grounds</u>**:

- Diverting flood water to low impact flood plain zones, for storage
- Reduces downstream peak flows
- **Low impact zones** can be recreational land use
- Flood water will evaporate or eventually infiltrate, **replenishing** groundwater supplies
- E.g. Los Angeles basin

HUMAN RESPONSE TO FLOODING:

❖ **<u>Debris dams</u>**:

- To trap sediment in upper catchments to prevent downstream bed **aggradation**
- Maintains higher bankfull capacities downstream
- Periodic need for emptying, but can be used for construction materials
- Especially important in semi-arid, mountainous catchments
- E.g. Los Angeles Basin

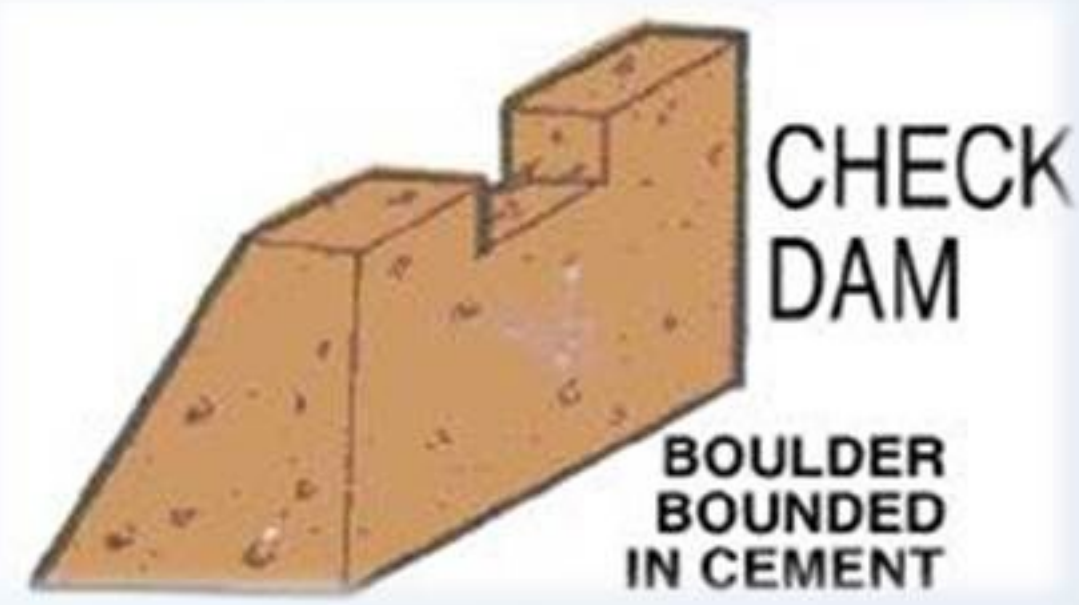
HUMAN RESPONSE TO FLOODING:

- **Dam construction**:
- **Multi-purpose**, but key tool for flood protection
- Controlled release of water stored in reservoir through **sluice gates** can spread discharge over a longer period (reducing **peak flows**)
- Effectiveness depends on **relative scale** of reservoir's catchment area to that of the whole drainage basin
- **Geo-politics** can cause problems –
- e.g. India and Bangladesh (Ganges), Spain and Portugal (Tagus), Zimbabwe and Mozambique (Limpopo

TYPES OF FLOOD CONTROL STRUCTURES

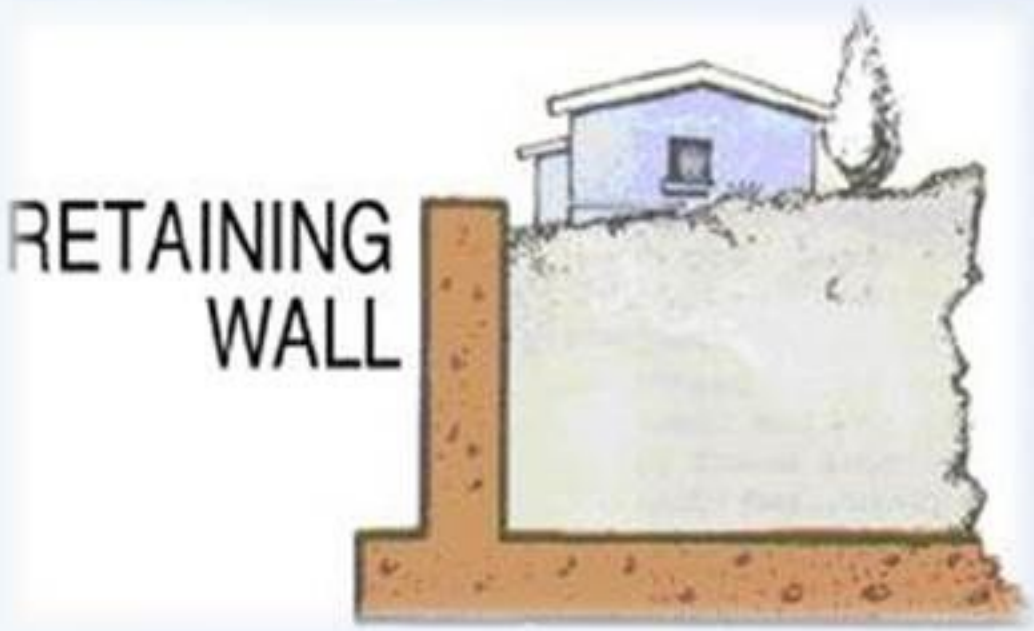
- Check dams
- Retaining walls
- Bunding
- Sausage groynes
- Gabion/mattress groynes
- Paved drains
- Reservoirs

❖ CHECK DAMS



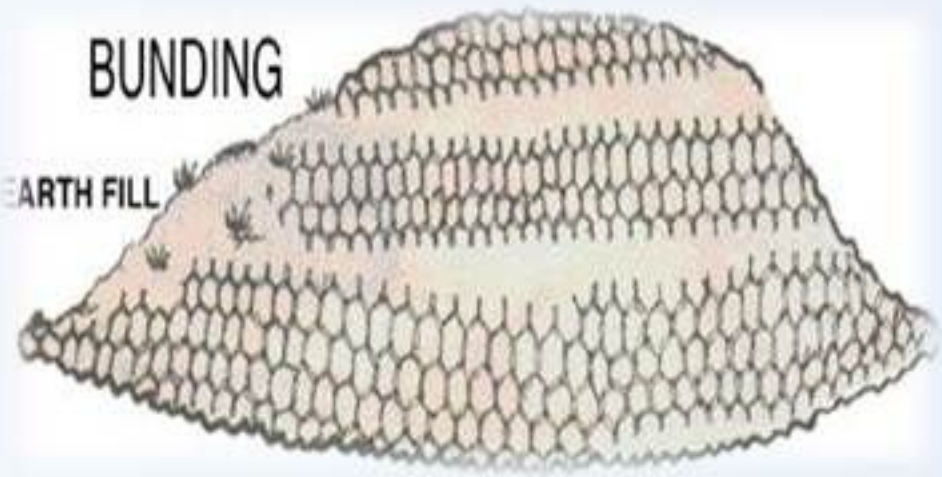
- These are small gravity dams, usually constructed with rocks and mortar or concrete, of variable height and width.
- This type of structures are located in small or medium-sized gullies to stabilize riverbed slopes and prevent soil erosion.
- Check dams, protect gullies from being eroded by rainfall and runoff impact.

❖ RETAINING WALLS



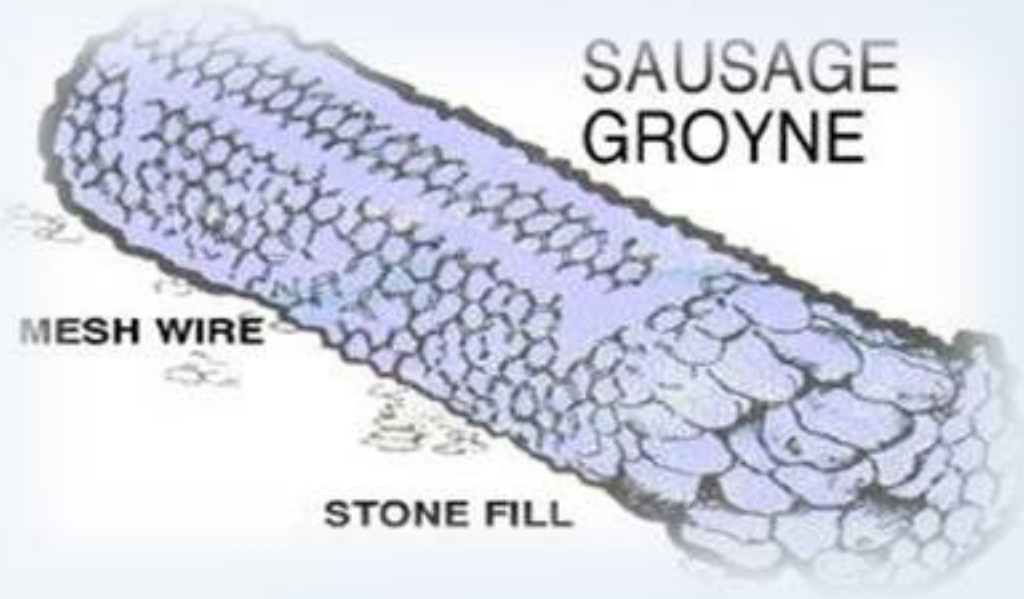
- These are rock/concrete block structures built on steep slopes anywhere in the watershed, where the erosion of the base foundation threatens lands and/or homes.

❖ BUNDING



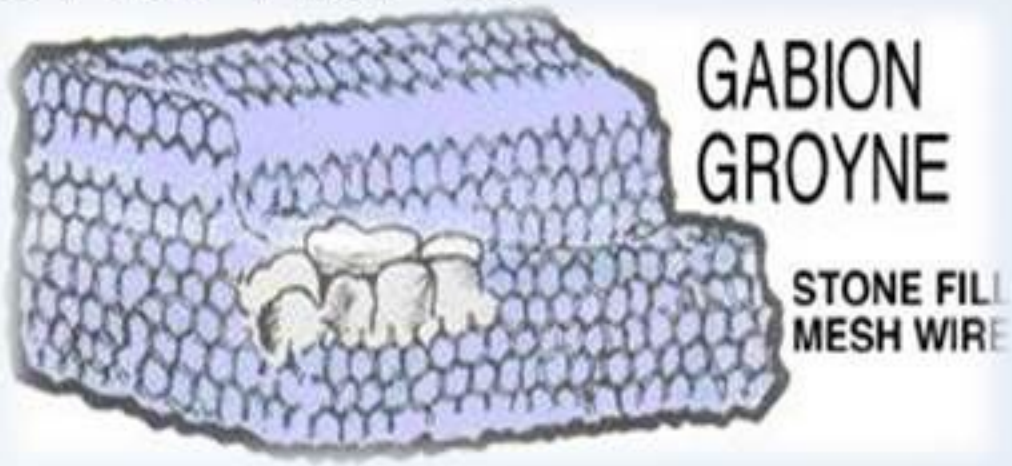
- Bunding is the general name used in Jamaica for flexible structures of variable thickness and length, composed of galvanized wire mesh, stone, wild-cane and riverbed materials.
- Bunding is used to prevent bank erosion and landslips and to protect agricultural lands from being flooded.

❖ SAUSAGE GROYNES



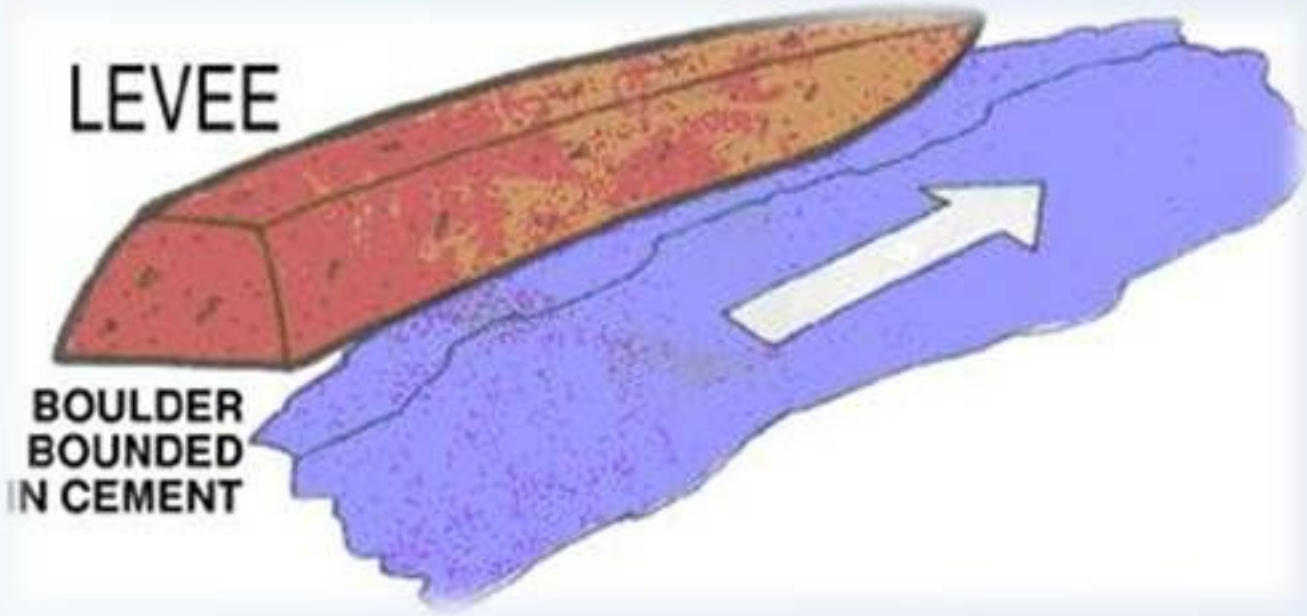
- These are long, cylindrical, slightly flexible structures of variable thickness, composed of wire and rocks.
- Groynes are placed at the foot of banks along small, slow-moving streams, where there are signs of undermining and threats to permanent structures.
- Sausage groynes are designed to stop such action by allowing the bank to collapse to an angle of repose in such a manner as to form a moderate slope, which encourages the growth of vegetation.

❖ GABION/MATTRESS GROYNES



- These are long, flexible structures of variable thickness, composed of wire and rocks.
- They are placed on the shaped banks of large, fast-moving streams where severe erosion is occurring and many pose a danger to permanent structures.
- Mattress groynes are designed to prevent the further erosion of the riverbank. They trap soil particles to allow a build-up of soil; thereby encouraging the growth of vegetation.

❖ PAVED DRAINS



- These are U-Shaped concrete structures designed to quickly remove water from highly susceptible erodible areas such as road-sides, under-bridges and steep slopes.
- **Levees:**

  These serve the purposed of confining flood waters to the stream and to portions of the flood plain.

❖ PAVED DRAINS

- Levees are made of clay or earth fill material are being used with some structural modifications and have proven quite effective. The slopes of an earth fill levee should be no more than 2:1. The base should be wide to allow for a gradual slope. Trees and bushes should not be planted on or near a levee because their root systems tend to weaken it.

❖ PAVED DRAINS

- **Flood Walls of reinforced concrete**:

  Flood walls require very little space and are often used to protect cities and developed areas. They are costly to construct, but involve minimal maintenance costs.

- **Channel Alterations**:

  Reduce floods by deepening and widening the channel by cutting meanders. Sometimes these works can have undesirable effects, by aiding the sediment transport process. Care must be taken when channel alternatives are considered.

❖ PAVED DRAINS

- **Detention Ponds:**

  Ponds placed on and off-side, can minimize the damage to downstream structures by reducing peak flows. They should be considered in the design of downstream protective structures.

- **Dams:**

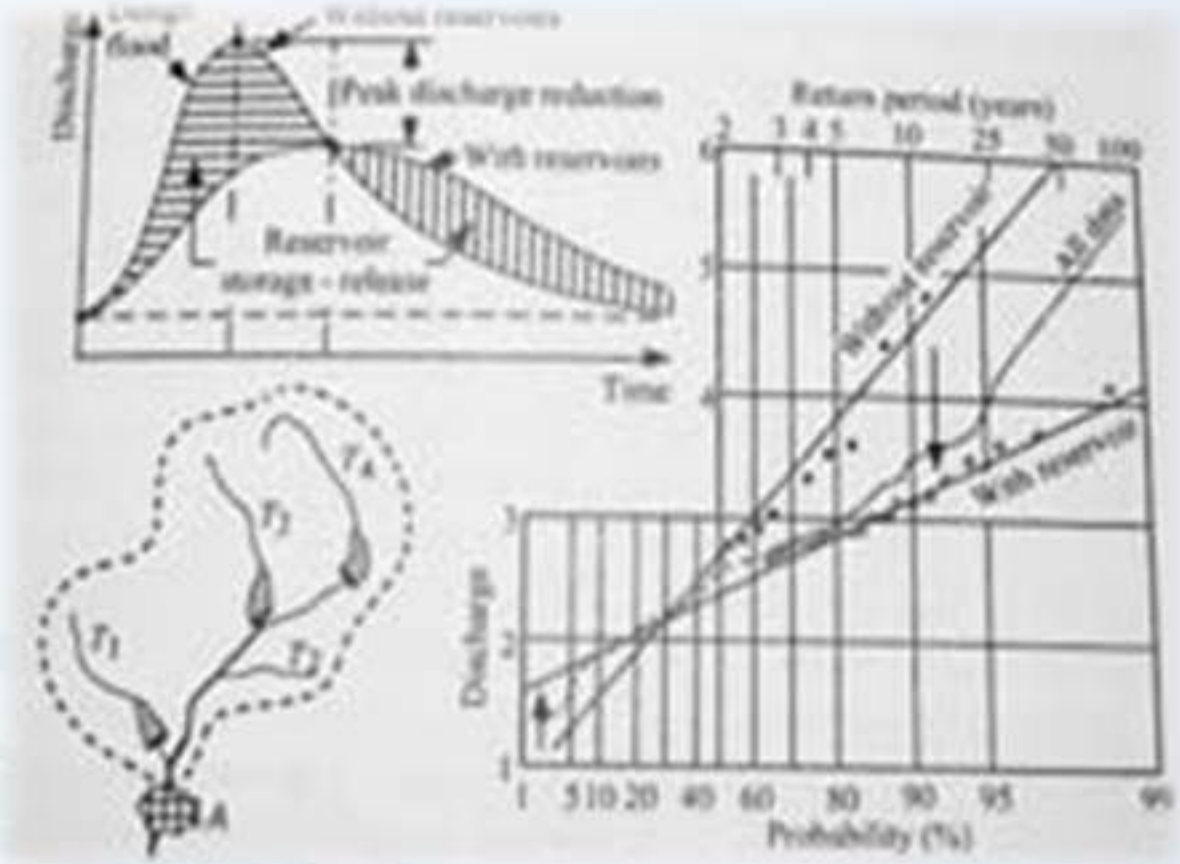
  These structures can be used to control flood peaks, provided suitable impounding sites can be found. Dams are designed for return periods usually exceeding 25 years. Their cost, however, is usually high and their design and construction require careful planning.

❖ RESERVOIRS

- Reservoirs are one of the most direct methods of flood control through storing surface runoff; thus, attenuating flood waves and storing flood water to be redistributed without exceeding downstream flood conditions.
- Urban location – small detention ponds.
- Regional location – large reservoirs, often constructed to meet multiple needs (e.g., downstream flood control, hydropower, water supply, and recreation).
- For flood control, it is ideal to maintain the reservoir at the lowest level possible for storage. On the other hand, keeping the reservoir at a high level provides the ability to maintain low flows and hydropower production in droughts
- Flood control storage is often variable depending on season and hydrologic conditions. In regions with predictable rainy or dry seasons, reservoir levels can be maintained accordingly

❖ RESERVOIRS

Figure 3 shows the floodwave attenuation properties of reservoirs when operated correctly. The following case study demonstrates the impact when reservoirs lack



❖ Floodway's

- As defined in *River Mechanics,* floodway's are dedicated pathways to divert floodwaters into a topographical depression near the river or into another large body of water.
- Entrance is controlled by hydraulic structures near the floodplain to capture overbank floodwaters.
- Sedimentation and scour must be considered in floodway operation and design given the high sediment concentration often found in floodwaters.
- It is important to periodically operate these facilities to ensure proper operation during a flood event.

❖ Floodway's

Yuen Long Bypass Floodway, Hong Kong

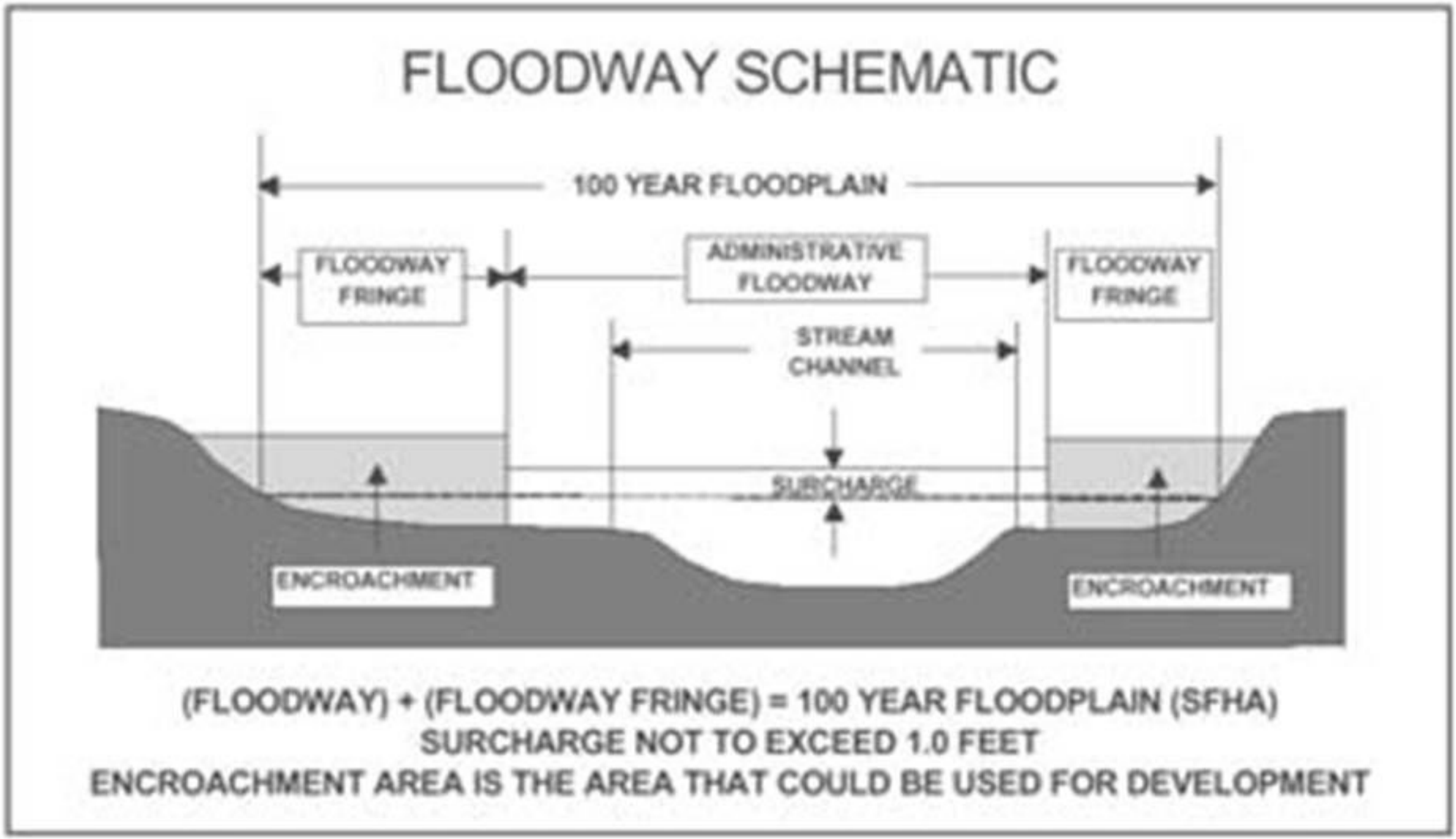
Red River Floodway

 Note:

 Floodway's may also be defined as the channel and overbank areas of a river that must remain open to carry floodwaters.

 These areas must accommodate flood

❖ Floodway's


FLOODWAY SCHEMATIC
100 YEAR FLOODPLAIN
FLOODWAY FRINGE
ADMINISTRATIVE FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
SURCHARGE
ENCROACHMENT
ENCROACHMENT
(FLOODWAY) + (FLOODWAY FRINGE) = 100 YEAR FLOODPLAIN (SFHA)
SURCHARGE NOT TO EXCEED 1.0 FEET
ENCROACHMENT AREA IS THE AREA THAT COULD BE USED FOR DEVELOPMENT

❖ Flood destruction in Pakistan

- Flood have caused massive damage to infrastructure and crops in Pakistan, besides loss of life.
- Monetary losses during the major floods since 1950 aggregate billion Dollars.
- Major floods during the years 1955, 1973, 1976, 1988, 1992, 2010 & 2011 resulted in inundation of millions of acres of land in various parts of Pakistan, which constituted one of the most serious environmental hazards.
- Over 10,668 people lost their lives during these floods.

❖ Flood control structure in Pakistan

- The complete prevention of floods is almost a physical impossibility.
- In order to safeguard the Indus Valley and other flood prone areas from inundation, 5,822 Km (3,600 miles) of embankments have been constructed along major rivers and their tributaries in Pakistan.
- The protect embankment, to channelize flows through barrages and bridges, and to save lands and areas from erosion, 577 spurs have so far been constructed.

❖ Conclusions

Flood controls are not meant to prevent a flood of any size. Their design is meant to attenuate floodwaters and flood waves of a certain return period based on a cost risk analysis (oftentimes 100-yr events).

- An increase in channel conveyance provides flood control by allowing flood waves to pass more freely downstream.
- Levees create a physical barrier to contain floodwaters and protect the floodplain from being flooded.
- Reservoirs attenuate flood waves through providing floodwater storage.
- Floodway's provide flood wave attenuation through diversion away from the river.

❖ Conclusions

- With the increasing trend in fatalities and damage costs from floods, it becomes more important to appropriately manage the aging flood control infrastructure and even consider implementing new controls in some areas.

- With rising construction cost and governmental budget constraints, identifying critical infrastructure to receive limited funding is an increasingly difficult task for water resource management.

❖ References

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THANKS

ANY QUESTION･･･???