# 457.562 Special Issue on River Mechanics (Sediment Transport)

# .18 Sediment Deposition in Reservoirs

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# Sediment deposition in reservoirs

- Delta deposition can cause a  stream to aggrade upstream of a reservoir and affect flood levels, groundwater levels, bridge clearance, commercial and recreational navigation and environmentally sensitive area.
- The shape of the stage-storage curve will change because of sedimentation.
- Deposition by turbidity currents can interfere with low level intake at the dam, even with as little as 1% storage loss in the impoundment.
- Observations of deposition patterns can also be helpful in developing strategies for sediment management.

# Trapping and Releasing Efficiency

- Trap efficiency:
  - Is the percentage of the total inflowing sediment load that is trapped within a reservoir over a stated period of time.
- Release efficiency
  - Is the amount of sediment exiting a reservoir, expressed as a percentage of the inflowing load

Trap efficiency = sediment trapped/inflowing sediment

Release efficiency = released sediment/inflowing sediment = $(1-\text{trap efficiency})$

- Sediment trapping or releasing efficiency is not constant but is influenced by factors
  - Detention period, inflowing sediment characteristics, and reservoir operation.

# Trapping and Releasing Efficiency

- Primary two methods for screening of sediment trapping or release
  - Capacity : inflow ratio:
    - Temporarily lowering the reservoir pool during flood (pass-through sediment routing) reduces both detention time and sediment trapping.
  - Based on the sedimentation index:
    - The ratio of retention period to mean flow velocity through the reservoir.

# Church and Brune methods

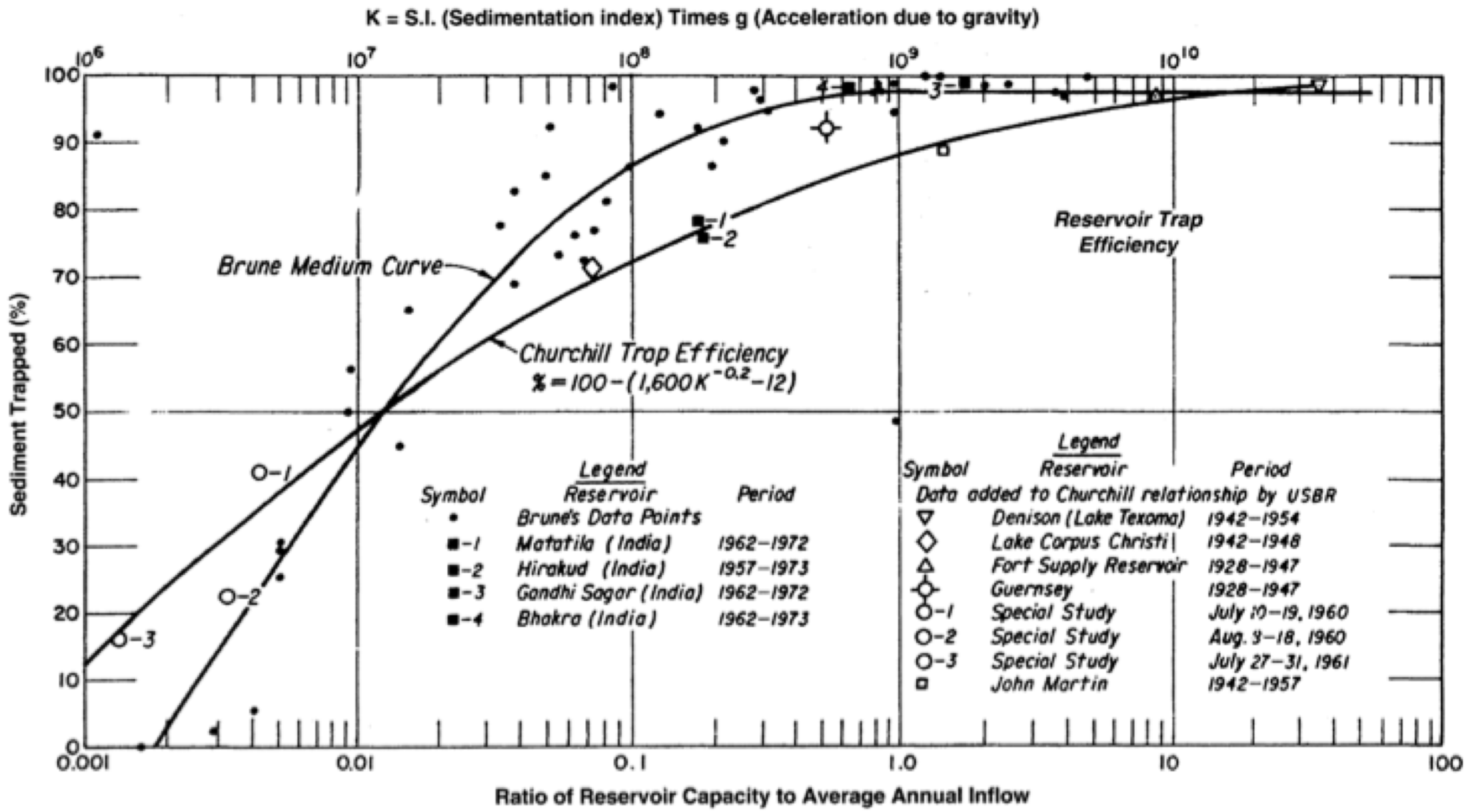


**Fig. 12-10.** Relationship between reservoir hydrologic size (capacity:inflow ratio) and sediment-trapping efficiency by Brune and the sedimentation index approach by Churchill (Strand and Pemberton 1987).

# Important factor determining reservoir capacity

- Depositional geometry
- Turbidity density current
- Bulk density of sediment deposits
- Sediment consolidation over time
  - Sandy sediments attain ultimate bulk density virtually as so on as they are deposited, but fine sediment may compact and consolidate for decades

# Sediment Management in Reservoirs

- Sediment control strategy
  - Sediment yield reduction
    - Apply erosion control techniques to reduce sediment yield from tribu tary water sheds. ‘
    - “soil stabilization and revegetation”
  - Sediment storage
    - Provide some storage for sediment and debris
  - Sediment routing
    - Pass sediment around or through the storage pool to minimize sedi ment trapped
    - Offstream storage, temporarily reservoir drawdown for pass through or density current
  - Sediment removal
    - Dredging or hydraulic flushing
  - Sediment focusing
    - Localized problem.

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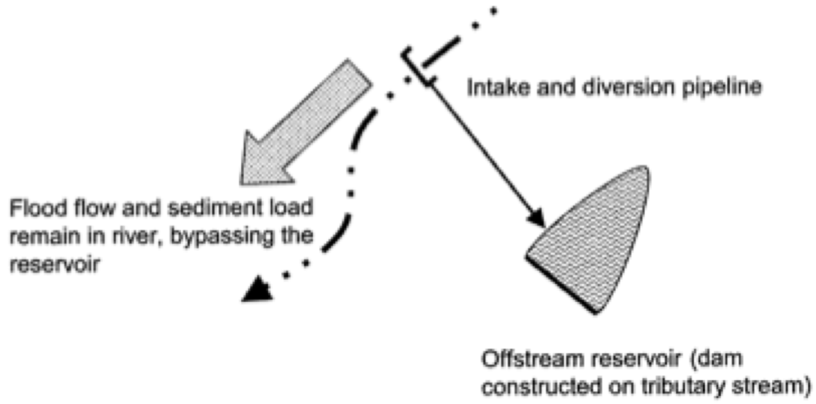
# Sediment Management in Reservoirs

- Sediment Yield reduction
  - Erosion control to reduce sediment yield
    - Most difficult to implement successfully
  - In developing country there is intensive land use, deforestation
  - Accelerated soil erosion has many negative impact in addition to reservoir sedimentation
  - Water quality for recreation use, biological impacts, loss of fertiliz ation etc.
  - Therefore, watershed management is necessarily.
- Provision of large storage volume
  - Sedimentation has traditionally been “controlled” by providing a s torage volume large enough to postpone anticipated sedimentati on problem for 50 to 100 years
  - “the sediment pool” assigned to reservoirs.

# Sediment routing strategies

- Sediment-Routing strategies
  - Offstream reservoir for sediment bypass



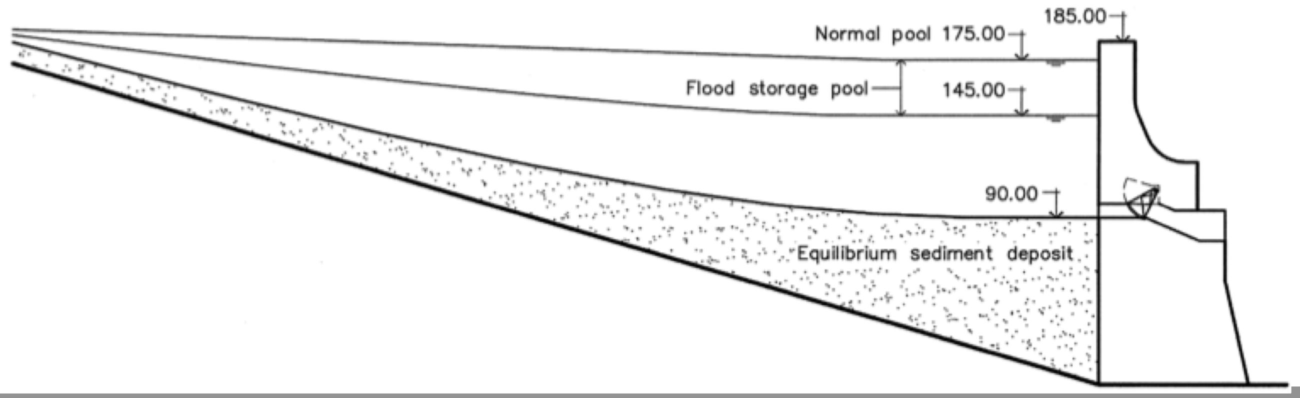

  - High volumes of sediment-laden flood waters can be bypassed a round a storage pool by placing the pool offstream and diverting only relatively clear water from moderate flows into storage.

# Sediment routing strategies

- Benefits of Offstream reservoir for sediment bypass
  - The dam does not pose a barrier to migratory aquatic species or to navigation
  - Instream water quality is not altered by the reservoir
  - Riparian wetland and river corridor habitats are not submerged
  - The dam does not impact bed-load transport processes essentia l to maintain instream sediment transport, river morphology and t he ecological integrity of instream ecosystem.
  - Etc.
- Fajardo in Puerto Rico has the half-time which is estimated to excee d 1,000 years as compared to only 180 years for larger-volume instr eam reservoirs since sedimentation does not to be counted for the c apacity of dam.

# Sediment routing strategies

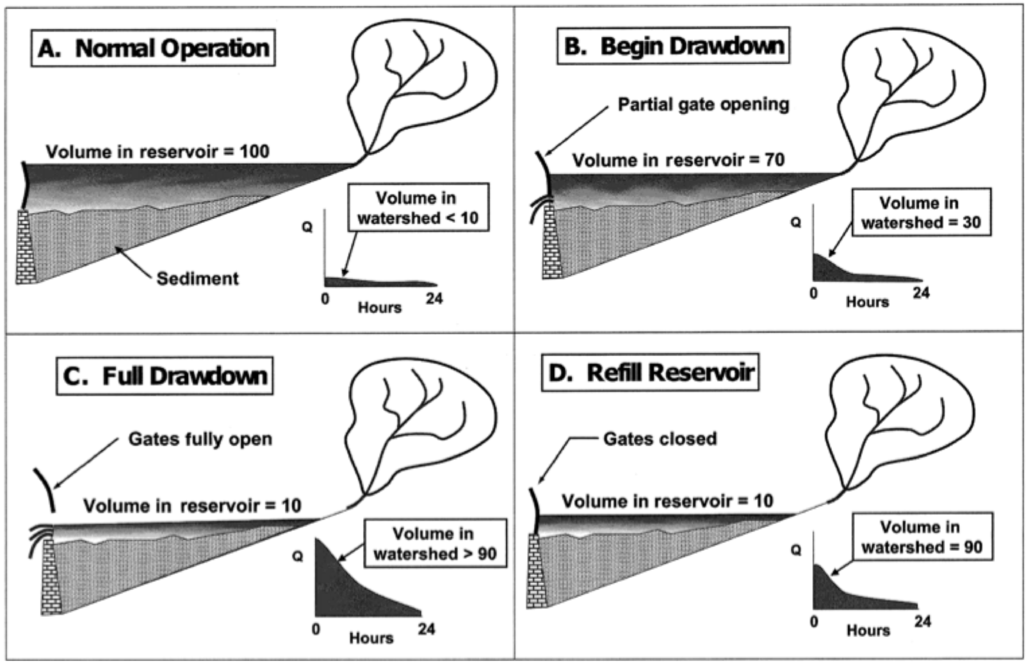
- Sediment bypass of onstream reservoirs.
  - Using trucking or pipeline, deliver to down stream
  - Asahi hydropower dam has tunnel for bypassing sediment
- Pass-through by drawdown
  - By opening high-capacity gates to minimize reservoir level, drawing down the pool as much as possible to pass sedim ent-laden floods at the highest possible velocity.
  - Reservoir pool is refilled at the end of the drawdown.



# Sediment routing strategies

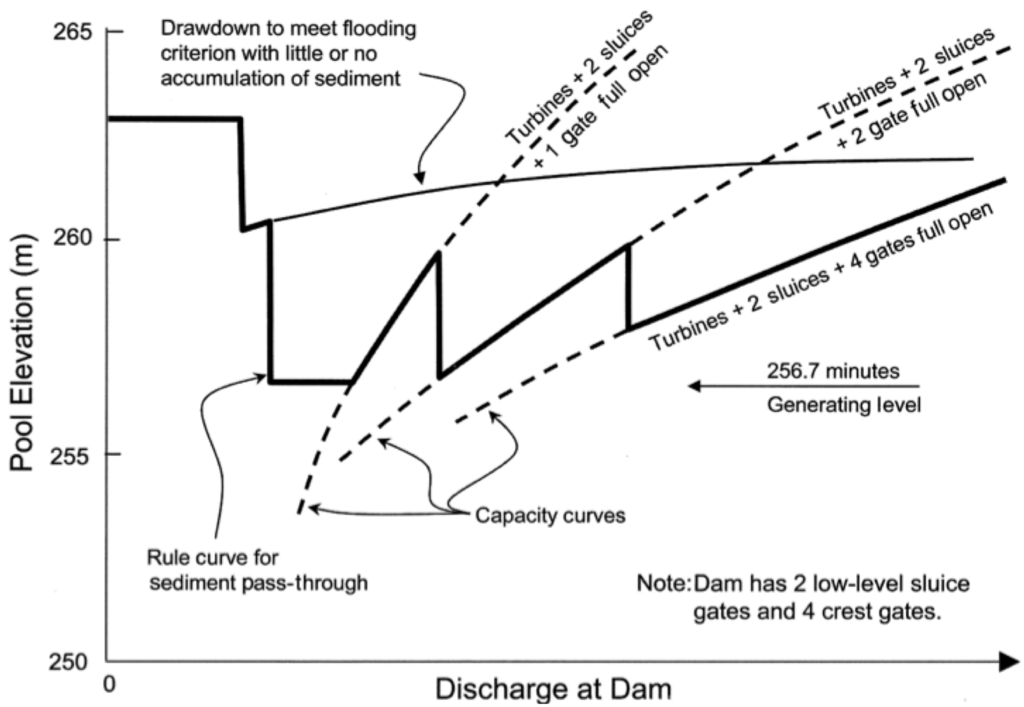
- Drawdown duration and operation rules will vary depending on hydrologic characteristics and reservoir sizes
  - Large reservoir : seasonal basis
  - Smaller reservoir : by the prediction of hydrographs for specific runoff
  - Very small reservoir : on the based of a rule curve that does not require hydrograph prediction.

# Hydrograph prediction based drawdown




- A: when storm begin, reservoir gates opened
- B: As storm continues, lowered until fully opened
- Remain full open
- D: storm recession, the gates closed as soon as the total tributary w ater volume drops to the full reservoir volume

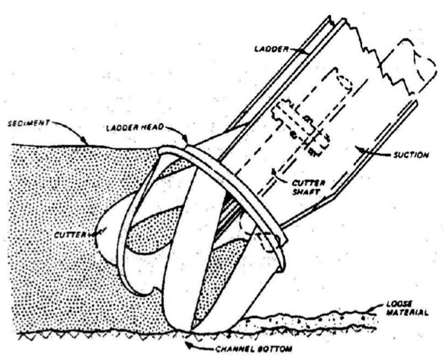
# Drawdown by rule curve

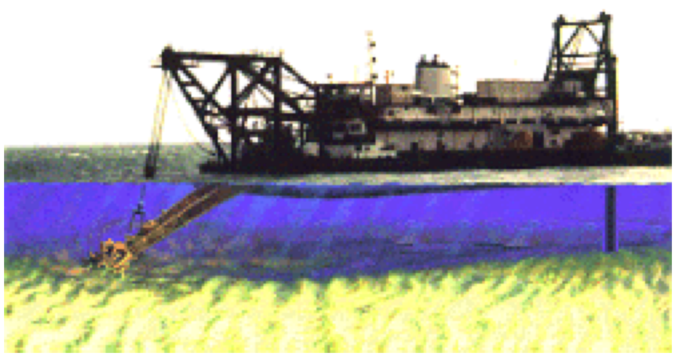



- Small reservoirs

# Sediment Removal by Hydraulic Dredging

- Mainly for a limited area
- Problem is in the infinite repetition. Once dredged then fo rever
- Two major impediments to large-scale dredging
  - High cost and limited availability of sediment disposal sites
  - The cost of slurry transportation to distant sites.
- Conventional dredging is done with a cutter head



# Sediment Removal by Hydraulic Dredging

- Siphon dredge
  - Eliminate pump by discharging through the vase of the da m and into the downstream channel, using the static head i n the reservoir to discharge the dredge slurry
  - Environmentally not good so US does not allow to use it

# Sediment removal by hydraulic flushing

- Hydraulic flushing involves the opening of bottom outlets to completely empty the reservoir and allow stream flow t o scour sediment deposits.
- The difference from pass through is in that its principal o bjective is to scour and remove previously deposited sed iment.
- Flushing flow will erode a “main channel” through the se diments, typically following the original river thalweg, but deposits on the normally submerged “flood plan” will be unaffected by scour.

# Hydraulic Flushing