Reservoir Sedimentation and Dredging

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WEDA Western Dredging Association

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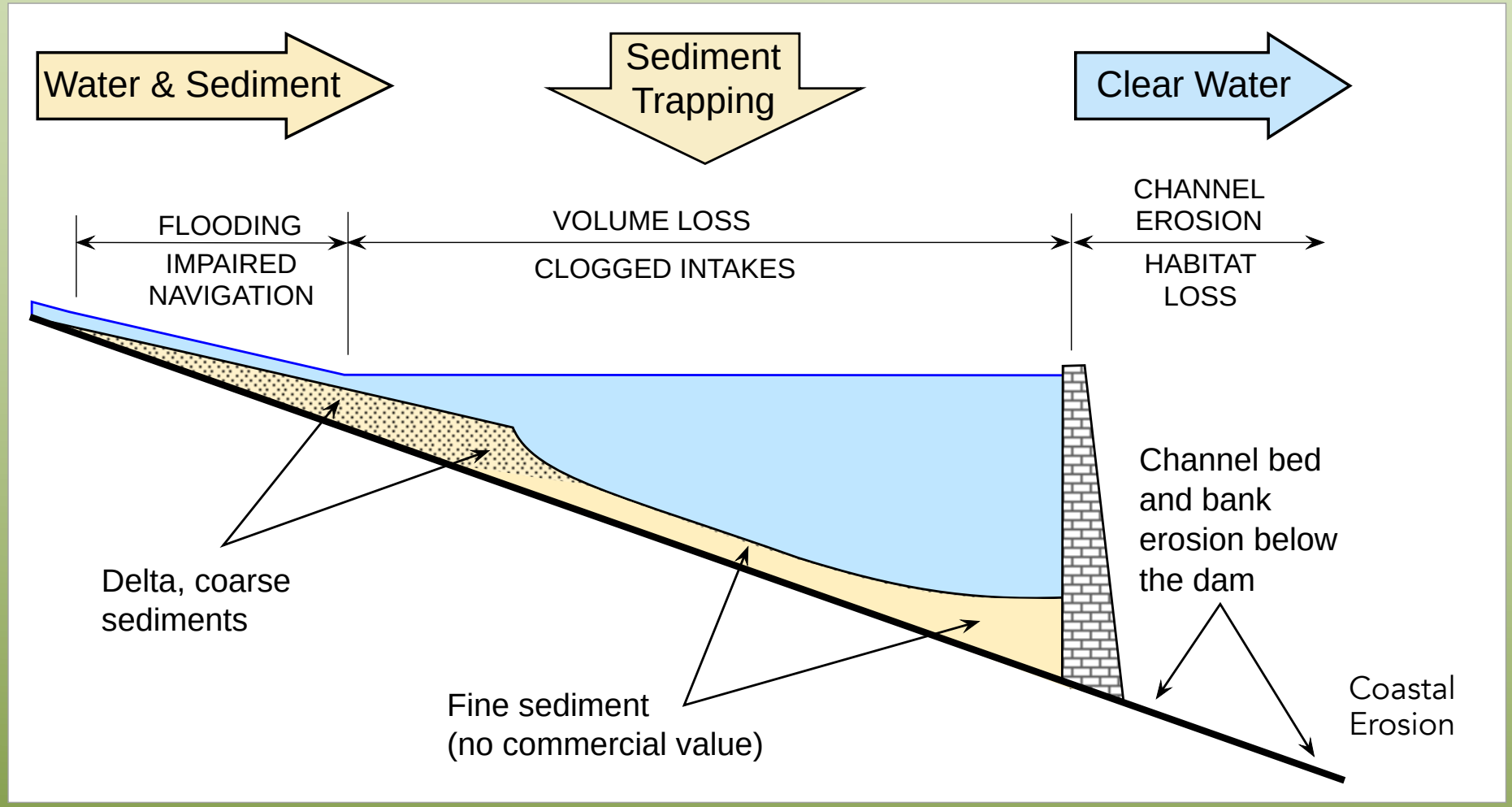
Sedimentation Patterns & Consequences



Playas, Colombia

Tarbela, Pakistan

Delta with silt and fine sand

Gravel-dominated delta
Yeso dam, Chile

Delta deposits and plunging turbidity current, Looking upstream, Porce-2 Reservoir (Río Medellín, Colombia)

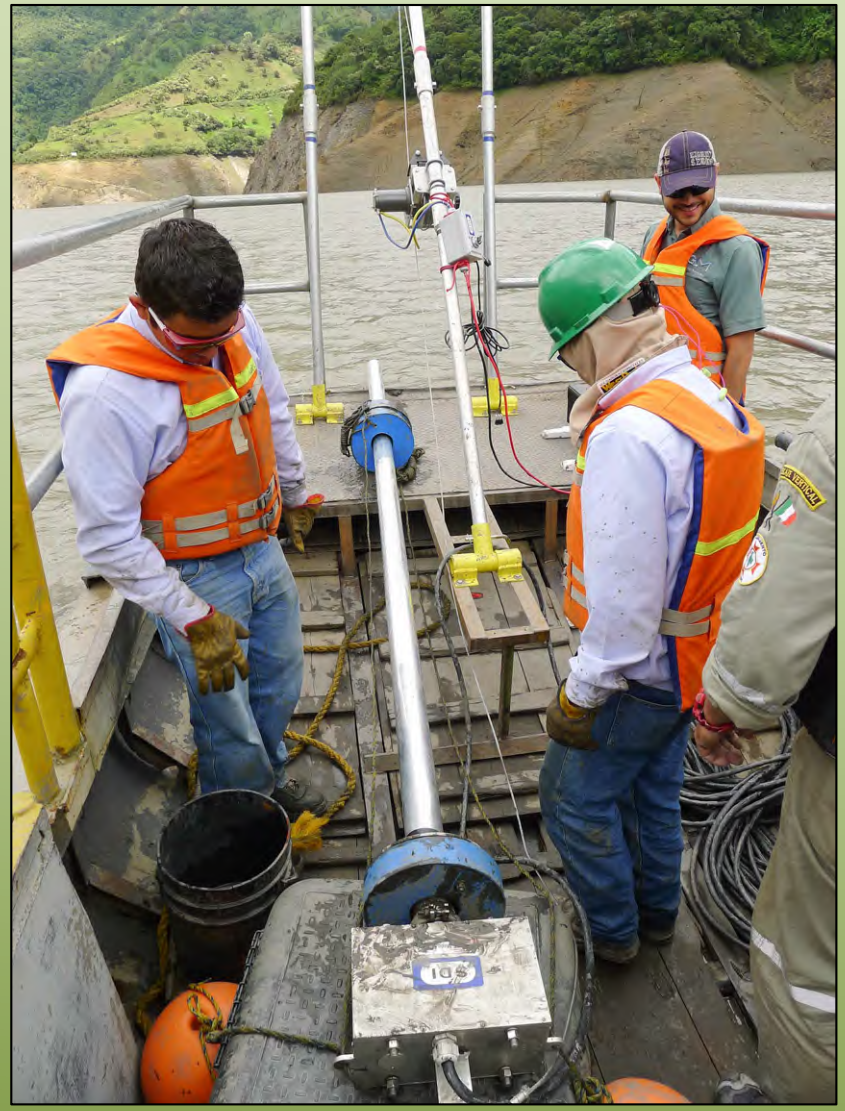

Sri Rama Sagar Reservoir
Andhra Pradesh, India

Fine sediment deposits downstream of the delta

Most reservoir sediments consist of fines: silts and clays without commercial value.

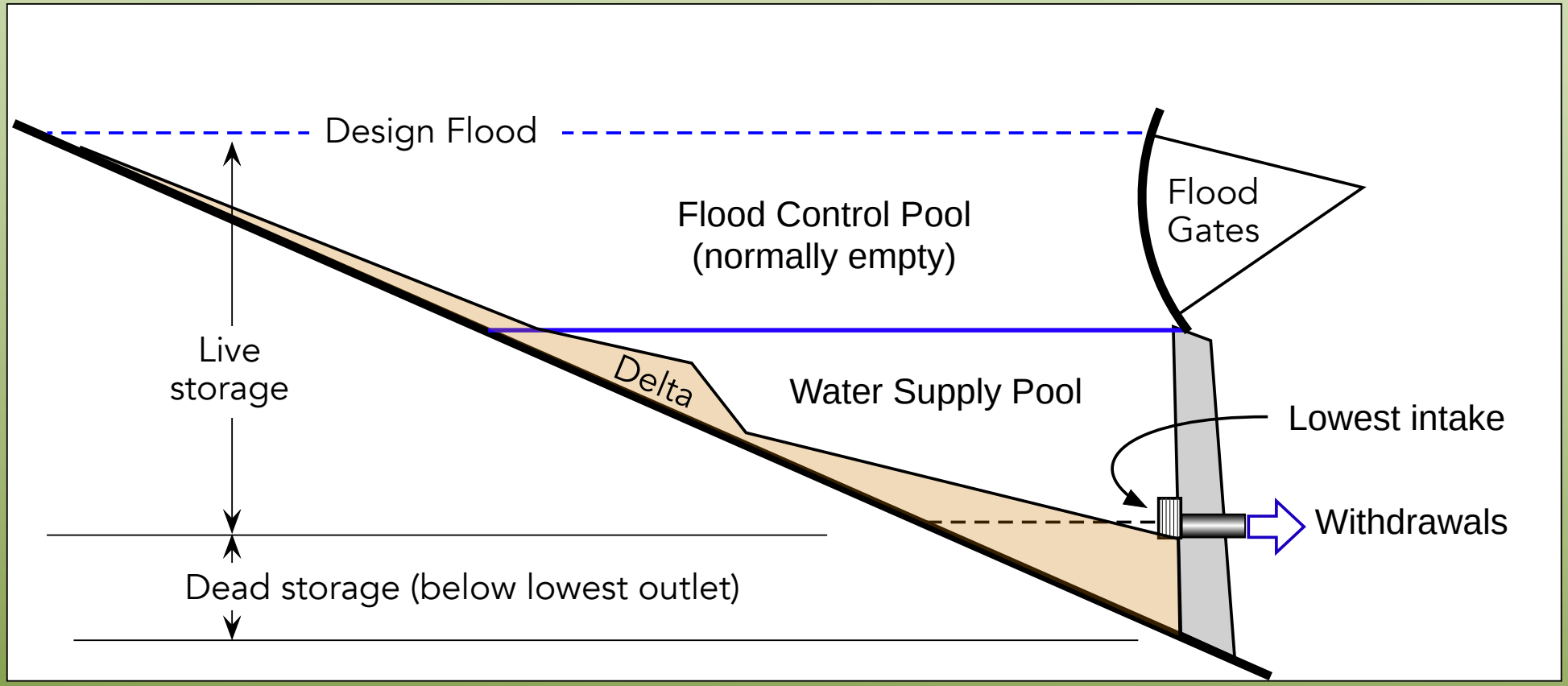

Lago Prieto, Puerto Rico

Sampling Fine Sediment (Chivor, Colombia)

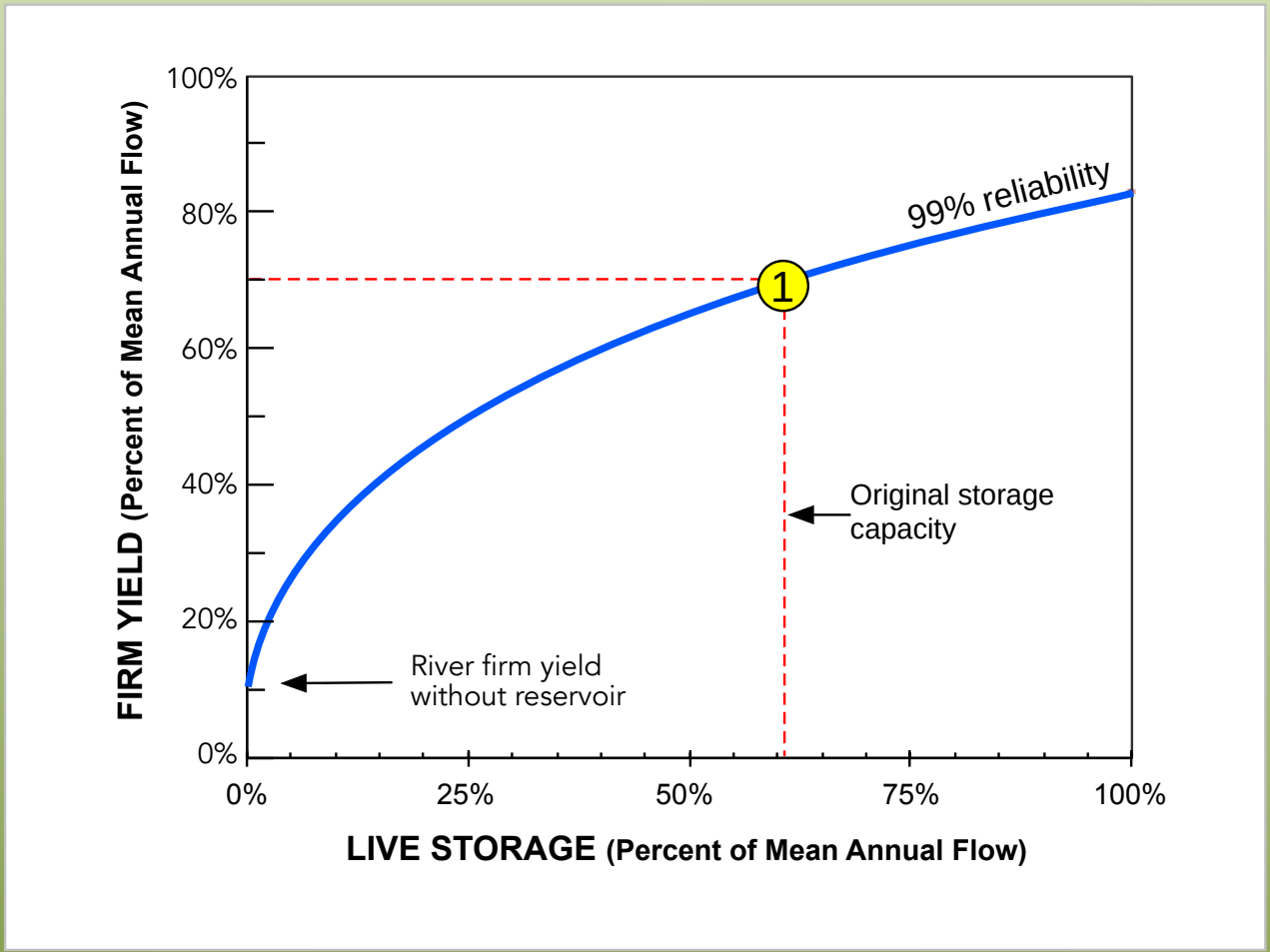


After the dead pool fills with sediment, all additional sedimentation affects beneficial use pools

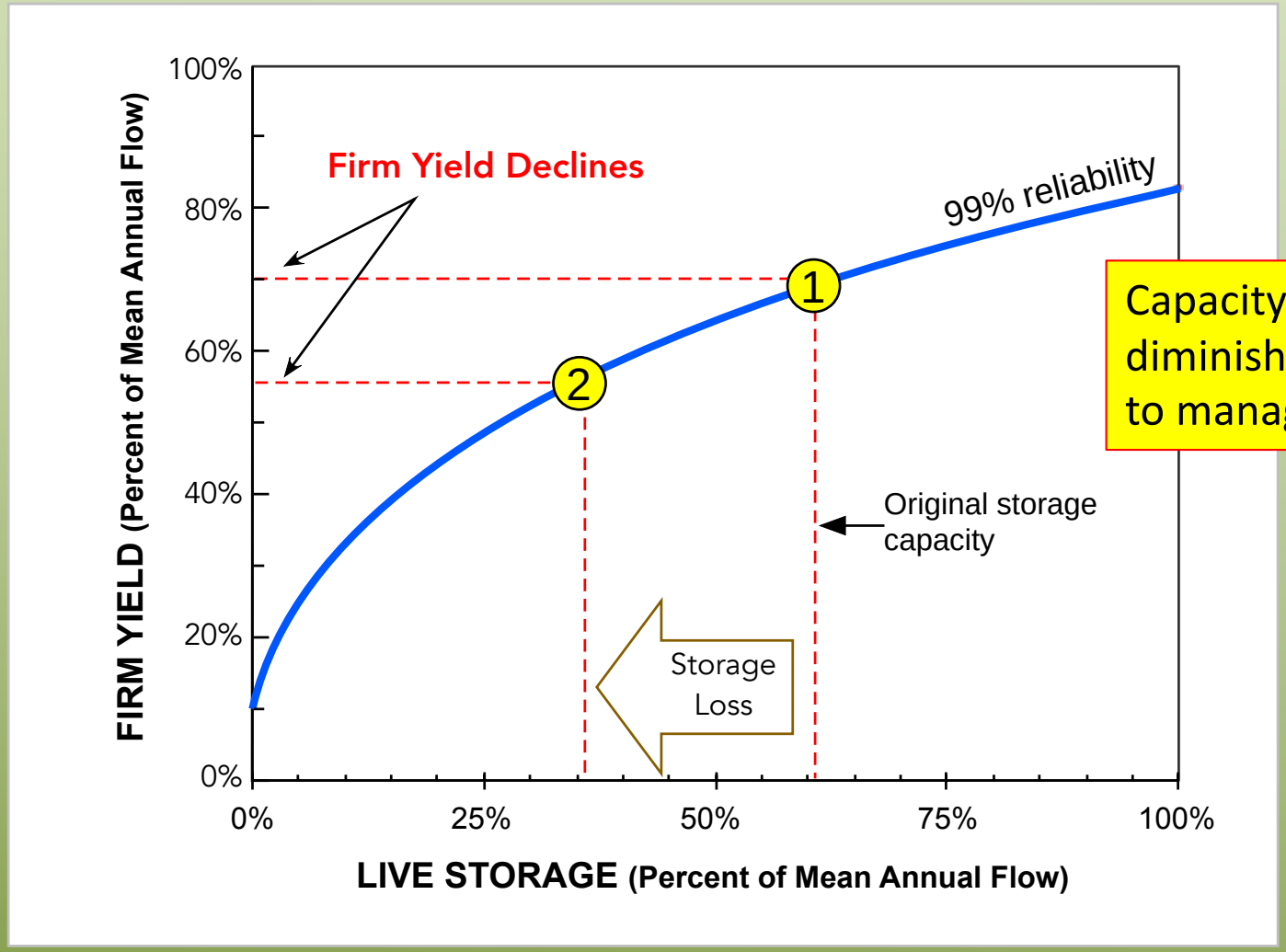
Dead pool typically assigned to “sediment storage”



- Storage is needed to provide reliable water supplies.
- The STORAGE-YIELD CURVE defines the relationship between reservoir capacity and yield

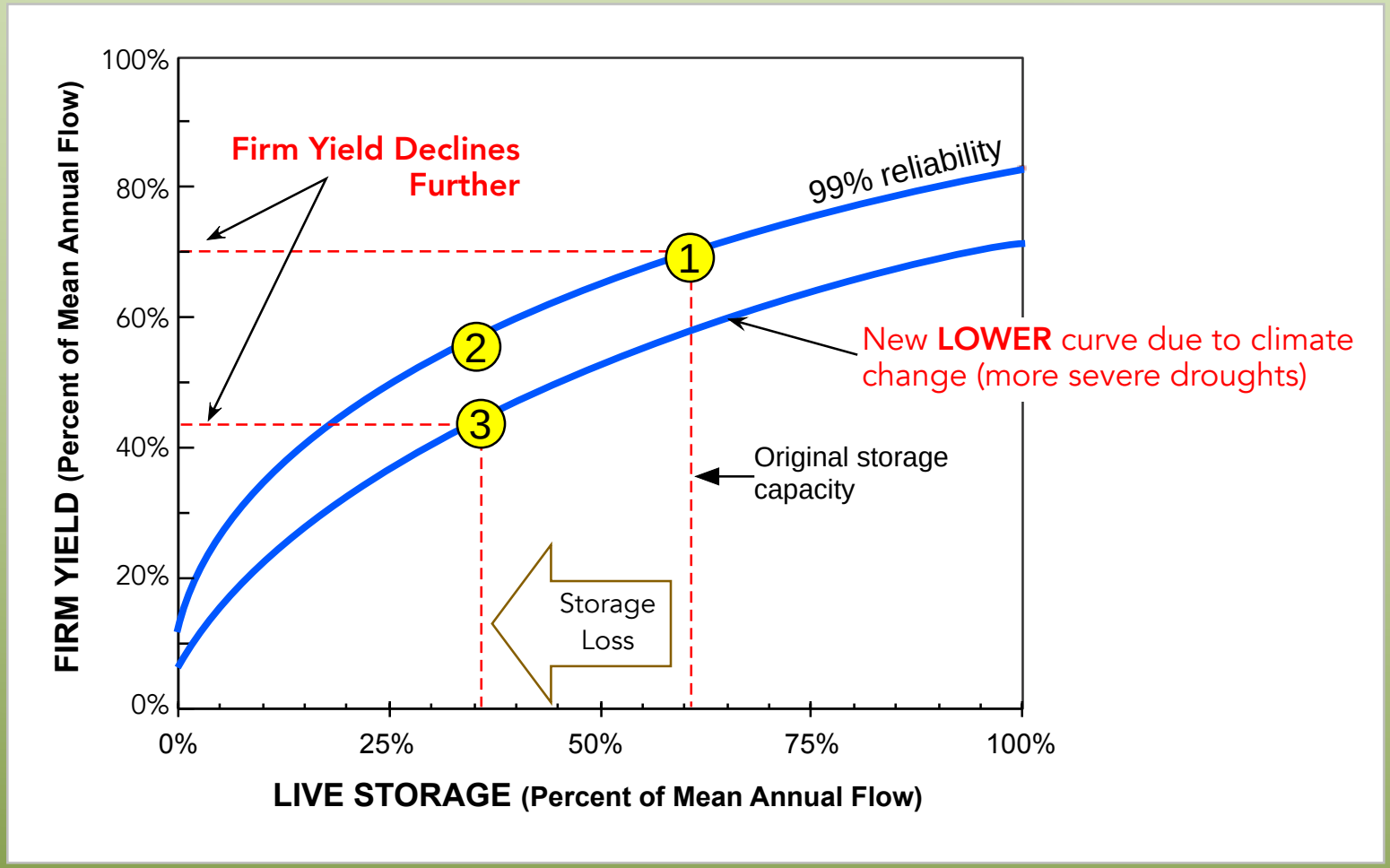


- As “live” storage capacity is lost to sedimentation, reliable (firm) yield declines

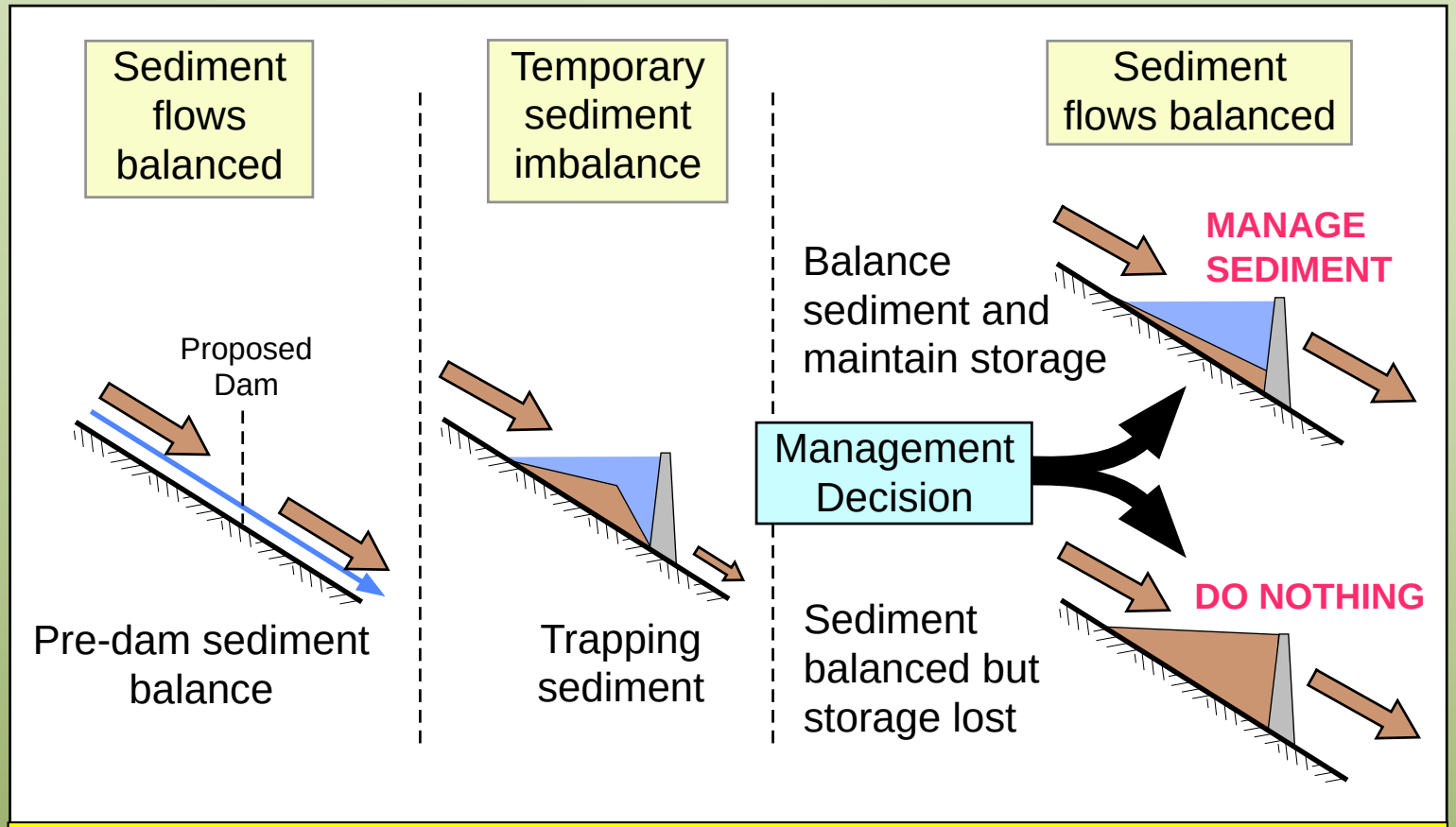


Capacity loss also diminishes the ability to manage floods

- Global Warming = more climate variability
  i.e. **more severe droughts and floods**
- The storage-yield curve MOVES DOWN
  This further reduces water yield



Without sediment management, all reservoir storage is a non-sustainable resource

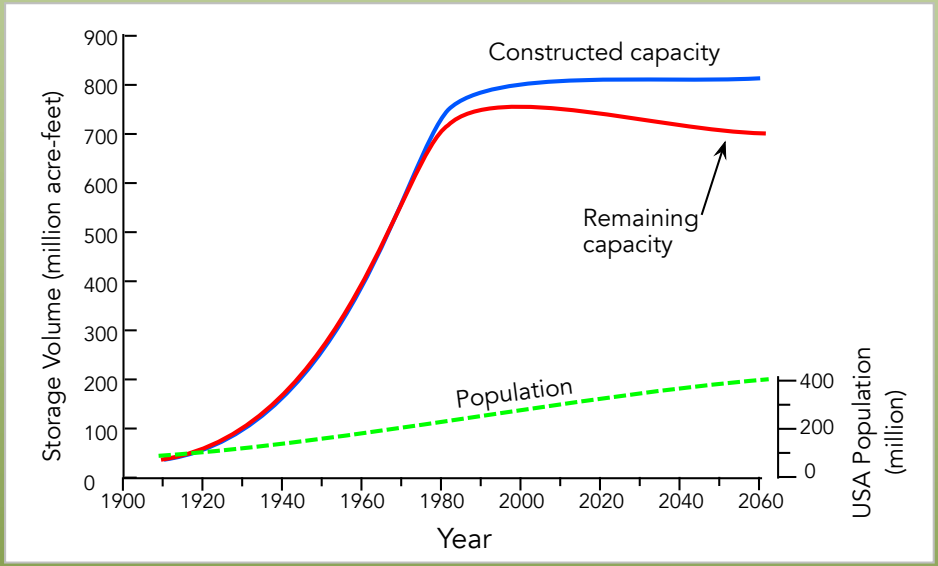


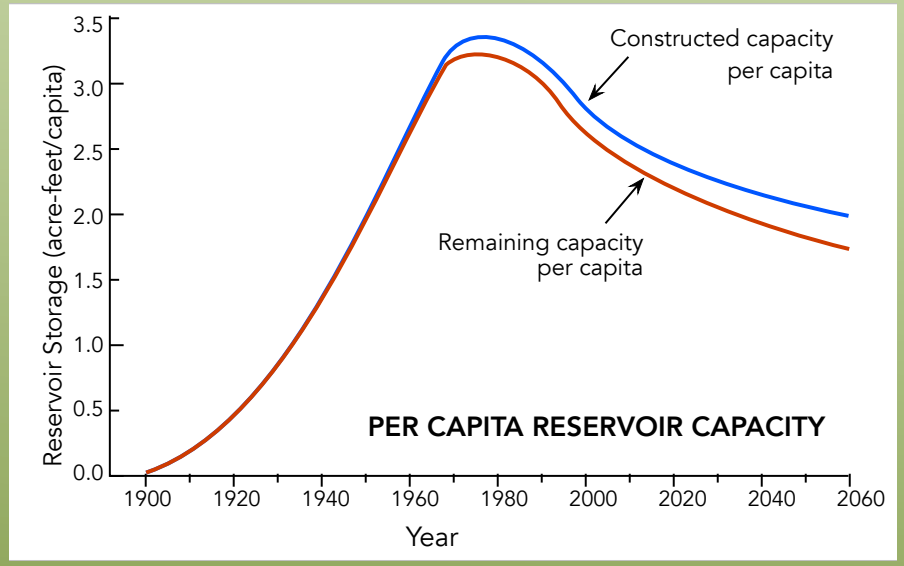
Sustainable reservoir management → Bring sediment inflow and outflow into a long-term balance. Preserve as much usable storage as possible while minimizing environmental harm.

How Much Sediment is Collecting?

- We don't have good data, but estimate at 0.4% average annual loss for USA reservoirs.
- An order-of-magnitude estimate is ~ 5 km^3/year

  (~6 billion cubic yards/year)



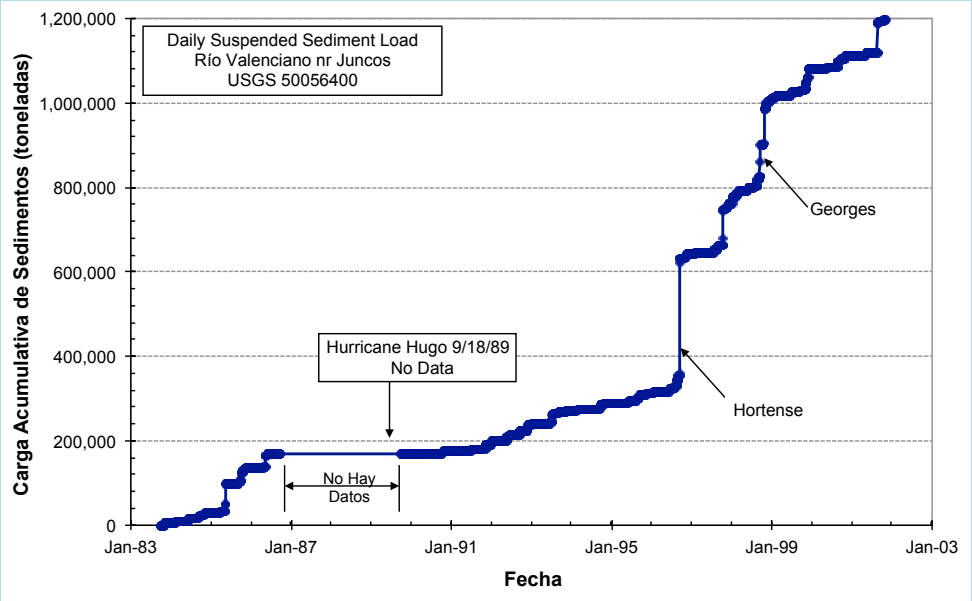


Sediment Yield is Highly Episodic:

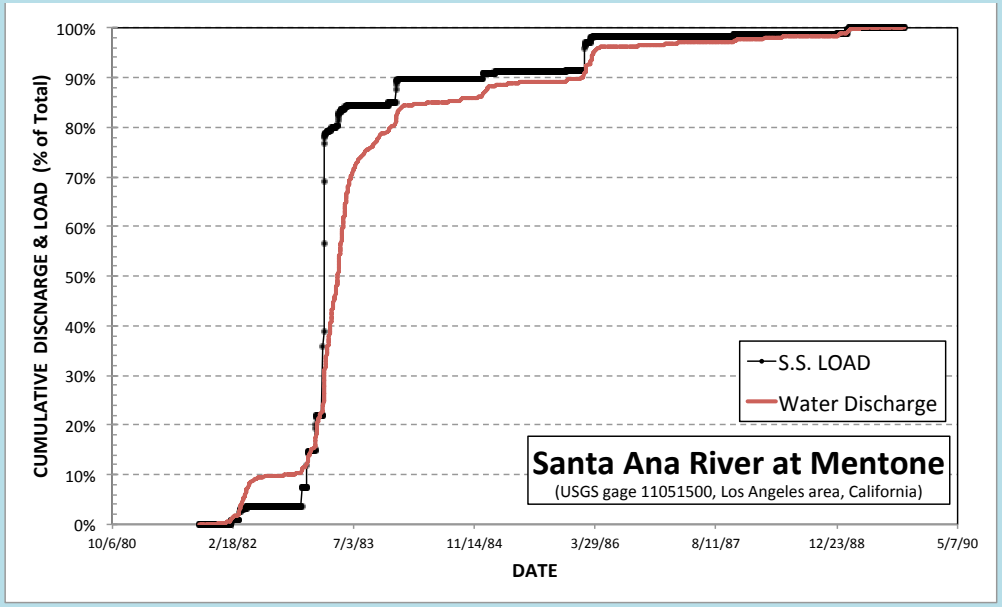
FLOODS = SEDIMENT

In many areas, 3 - 4 days/year contribute half the sediment.

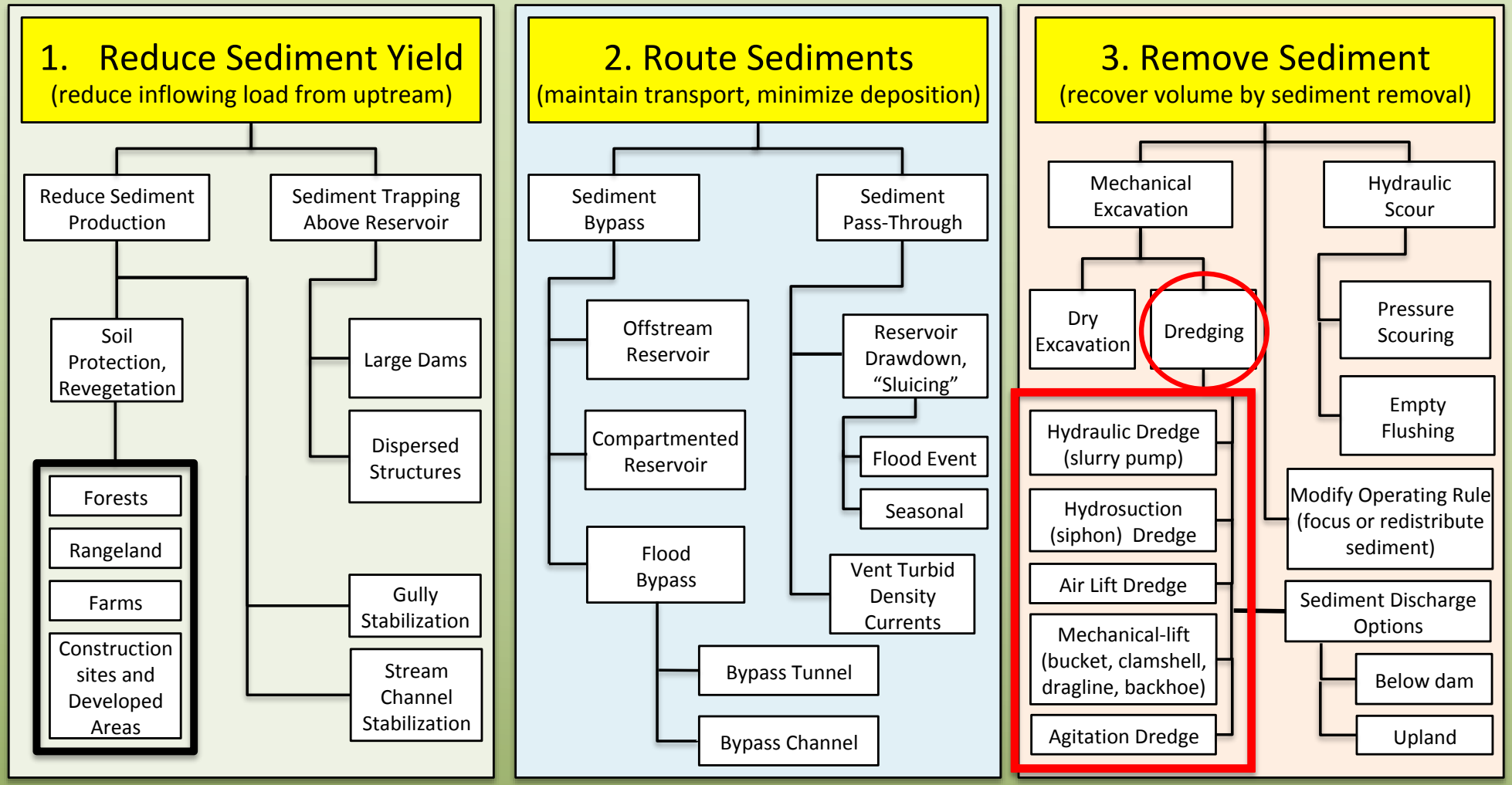
Cumulative suspended sediment load during 9 years.
Río Valenciano, Puerto Rico



Cumulative suspended sediment load during 8 years.
Río Santa Ana, near Los Angeles, California.



Sediment Management Strategies in Reservoirs



4. Adaptive Strategies
(does not alter sediment balance)

- Increase Storage Volume
- Modify Structures or Equipment
- Modify Operational Rules
- Optimize Regional Water Resource System
- Users Adapt to Reduced Benefits
- Decommission Infrastructure

Monitoring: Required for All Strategies

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www.reservoirsedimentation.com

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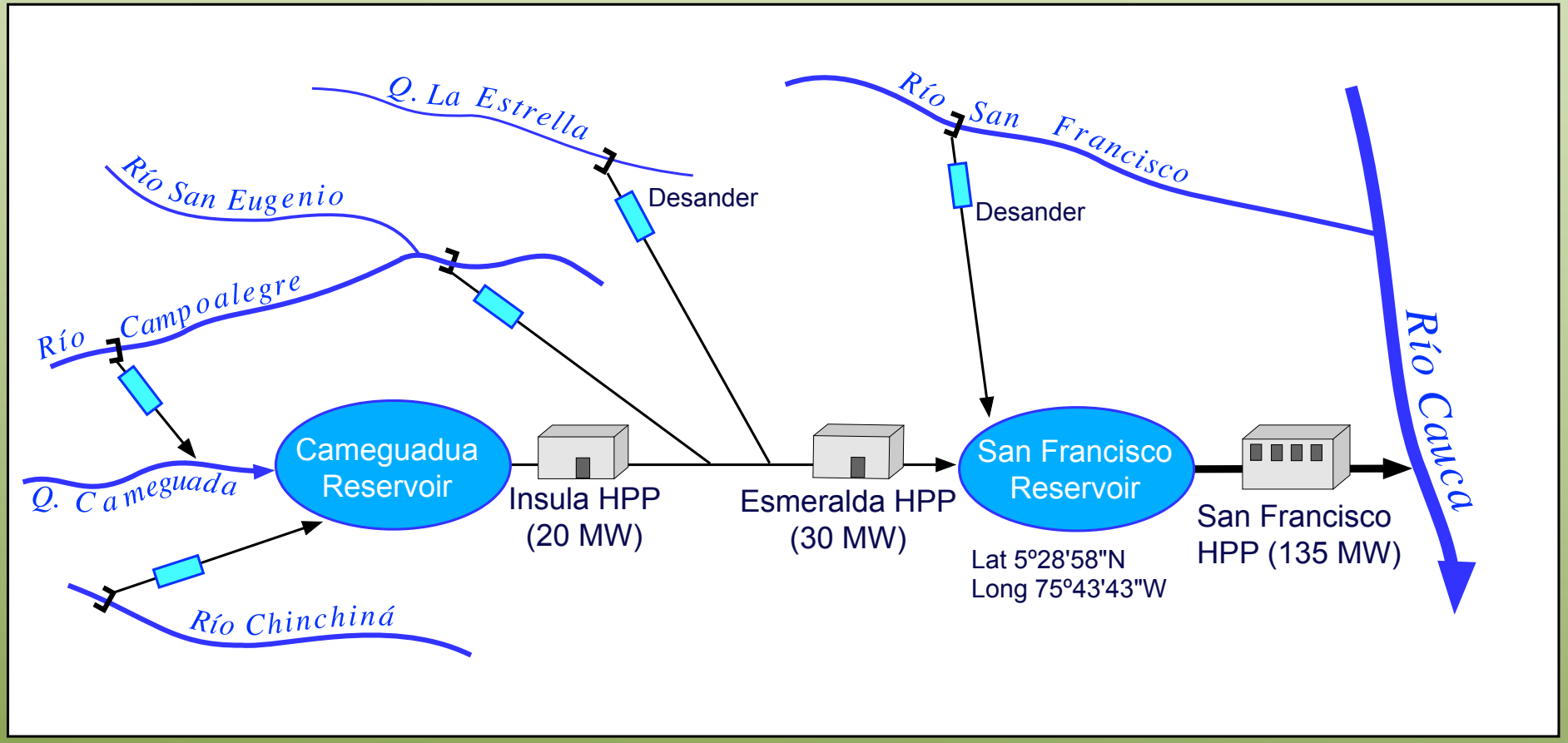
Dry Excavation at Baihe Reservoir, Taiwan (2019)

Cost ~ USD \$2-\$3/m^3 with disposal to downstream side of dam
Cost ~ USD \$10 – 20/m^3 for haul and dispose to more distant location

Offstream hydropower regulating reservoirs (Colombia)



Offstream reservoirs also collect sediment, but because the sedimentation rate is low dredging may be economical

(San Francisco offstream hydropower peaking reservoir, Montería, Colombia, 106 MW, built 1969)

Dredging has been performed since 1962 at Bajo Anchicayá hydropower reservoir to maintain intake free of sediment

Sauerman dragline

Hydraulic cutterhead dredge

Bajo Anchicayá, Colombia

Hydro plant 74 MW, 83 m^3/s, 72 m head

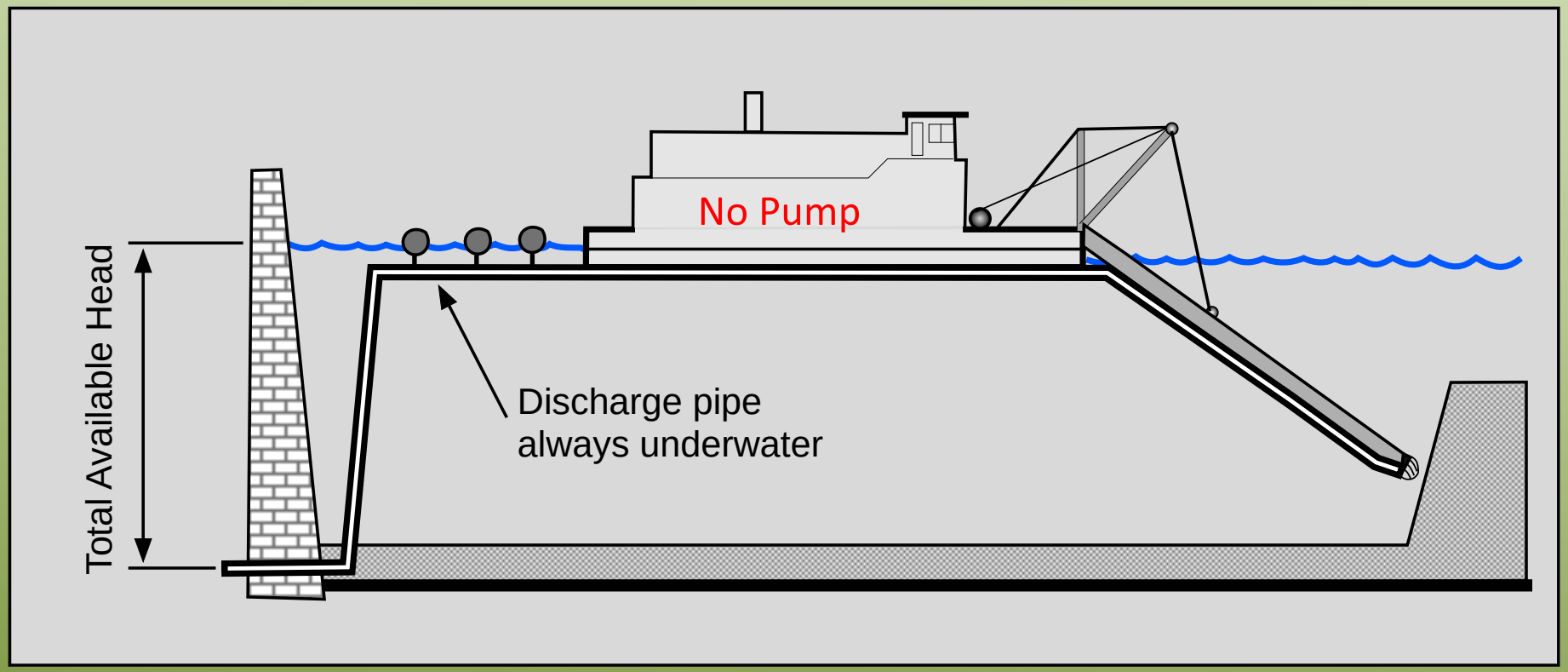
Sauerman (fixed dragline)

Bajo Anchicayá, Colombia

Hydrosuction dredge

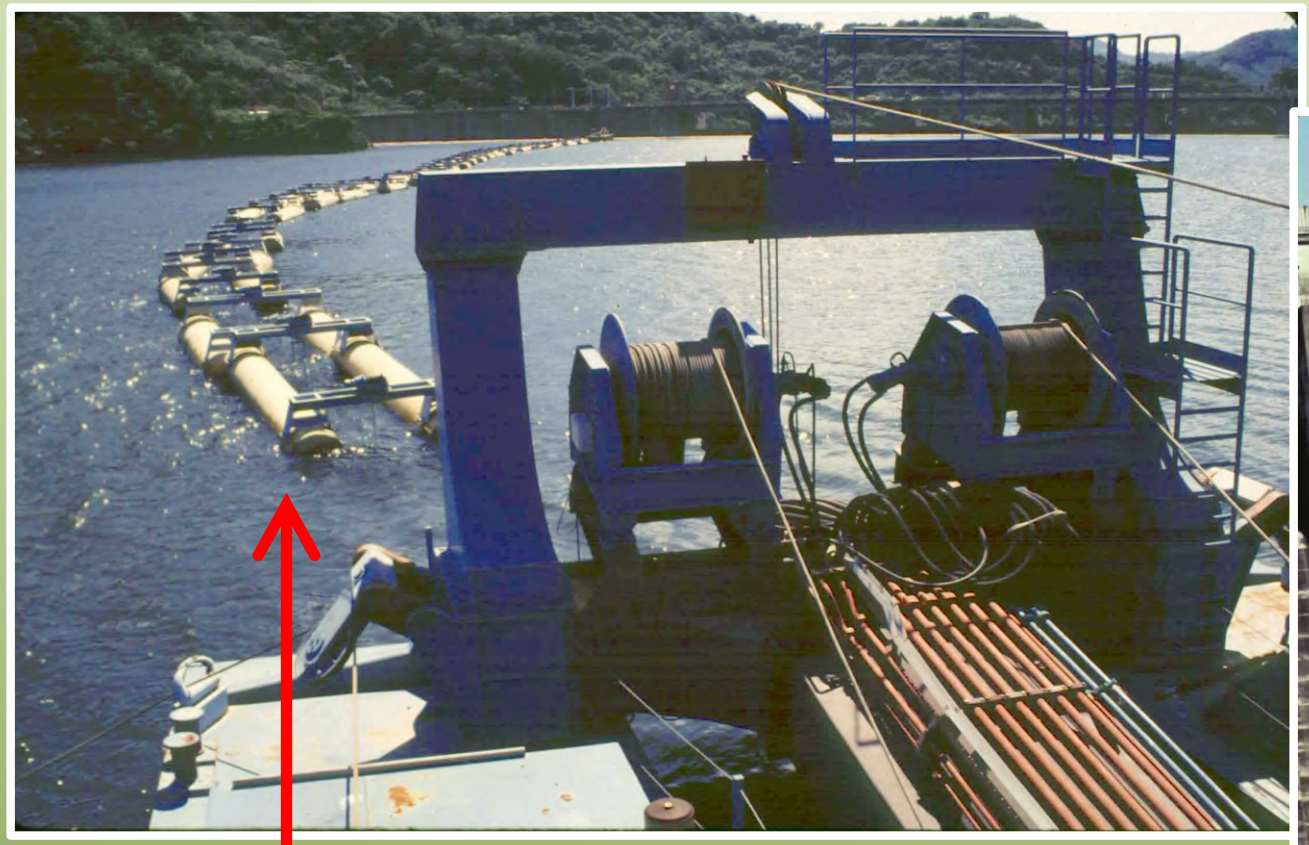
(also caller siphon or gravity dredge)

- Reduces energy costs by eliminating pump, using head difference between water level and discharge point as motive force.
- Normally must discharge into river below the dam, and distance from dam limited to about ~2 kilometers due to friction losses and the limitation in available energy from head difference.



700 mm (27”) Siphon Dredge

Valdesia dam, Dominican Republic



Submerged discharge line

Discharge point at base of dam

Factors Favoring Dredging

- A well-developed technology
- Can exactly control the amount of sediment removed
- Can be scaled to any size (using multiple dredges)
- Uses relatively small amount of water
- Does not require reservoir operation to be changed (as in sluicing or flushing)
- Sediment does not have to go downstream; it can be transported as far as your money will reach
- Clean way to transport sediment (no trucks)
- Hydropower sites, can use self-supplied energy.
- Can be used when other methods won't work (strategy of last-resort)

Factors Limiting Dredging

- High cost
- Energy-intensive
- Not sustainable in the long term if disposal sites are limited. Strictly speaking, it is only sustainable if the sediment is discharged back into the river.
- Environmental impacts (highly variable and site specific)

Implications

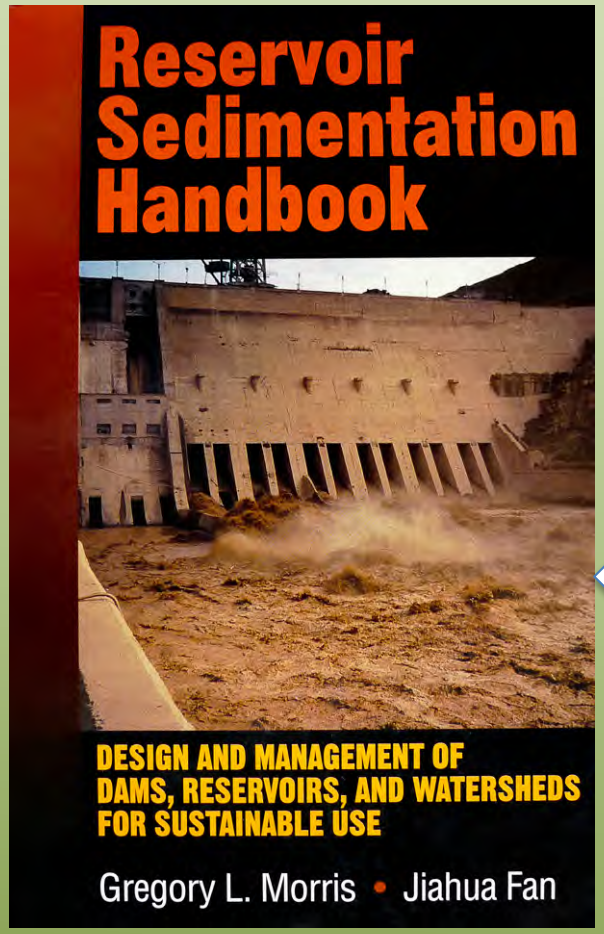
20th century = reservoir construction

21st century = manage sedimentation

- Multiple strategies need to be used – there is no silver bullet.
- Dredging will be a big part of the picture.
- Where will the sediment be placed?
  - Much sediment will need to go downstream, restoring sediment continuity along rivers.

Technical resources – available without cost on the Internet

www.reservoirsedimentation.com

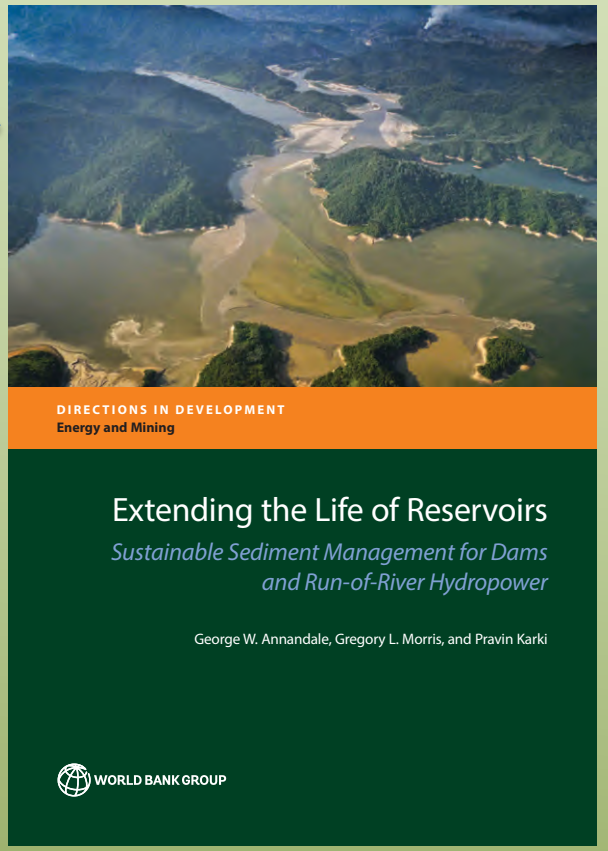


748 page PDF

Reservoir Sedimentation Handbook
McGraw-Hill Book Co., New York

Extending the Life of Reservoirs
World Bank, Washington, DC

World Bank Publication



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