Sediment Dredging of Reservoirs for Long-term Sustainable Management

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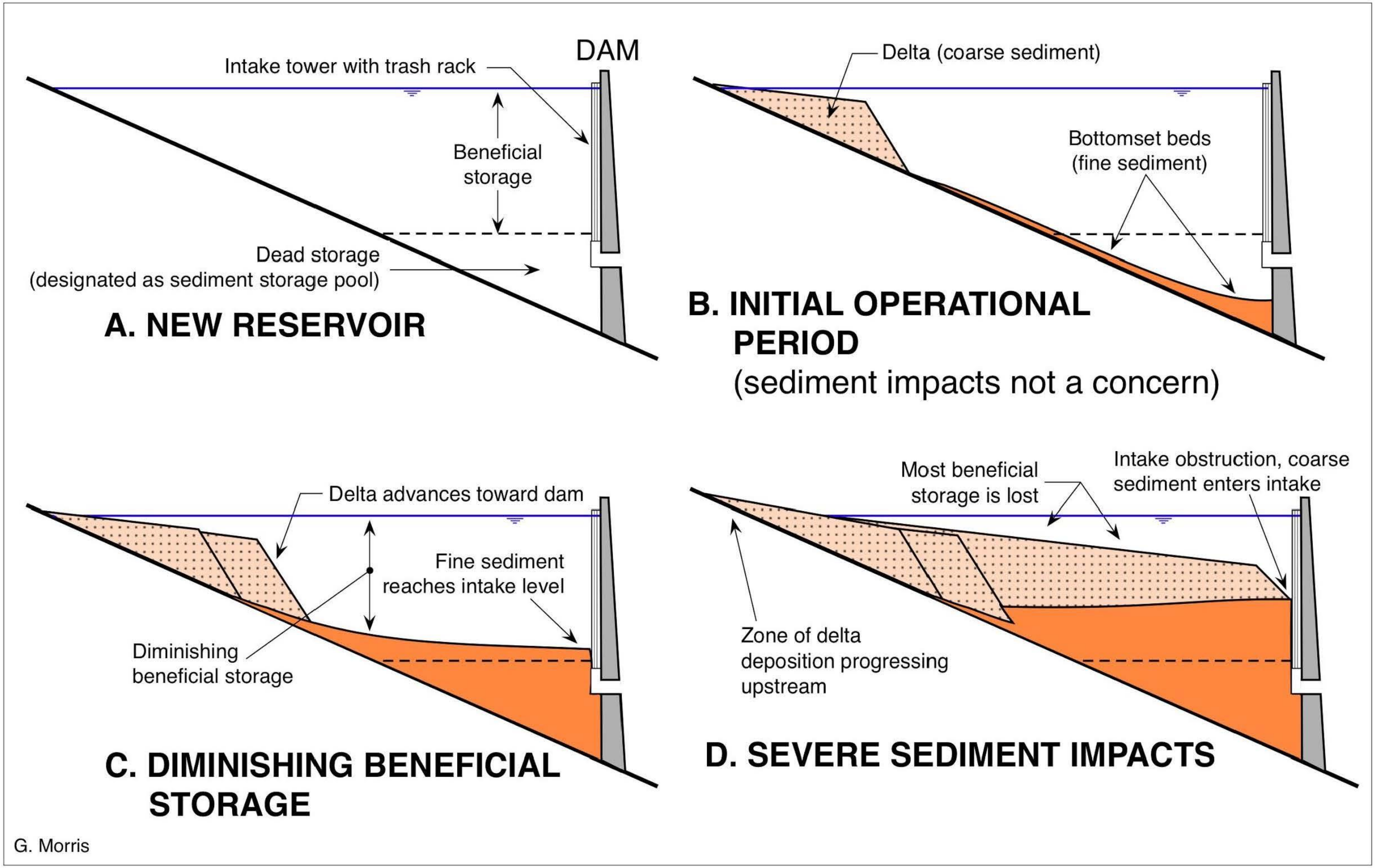
Reservoir Sediment Design Life

- Typically 50 or 100 years
- Estimate the reservoir sedimentation volume and spatial distribution
- Design the dam’s outlet to be above the reservoir sedimentation level over the sediment design life
- Defer future sediment management to future generations

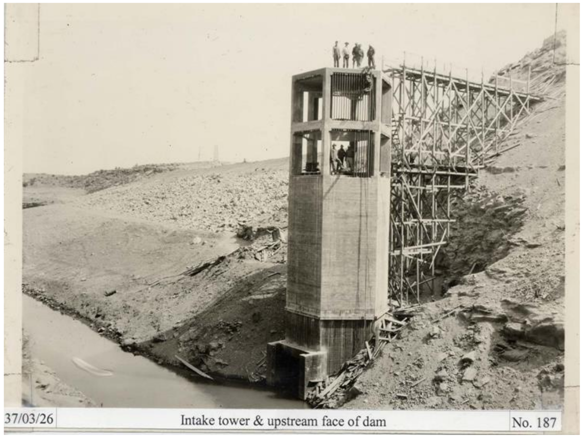
Reservoir Sedimentation



Without Reservoir Sediment Management

The eventual costs can be expensive:

- Lost storage capacity over time for water supply & flood control (increasing water storage needs)
- Buried or impaired dam outlets, reservoir water intakes, boat ramps & marinas




Without Reservoir Sediment Management

The eventual costs can be expensive:

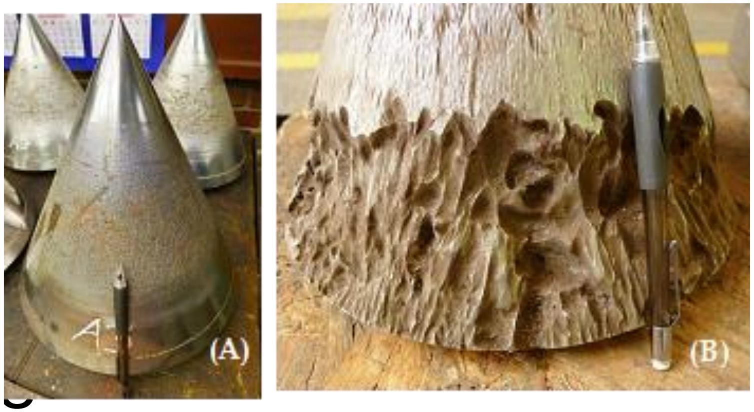
- Downstream channel degradation, infrastructure erosion, and habitat loss

- Dam decommissioning
- New dam construction to create replacement water storage
- With 90,000 dams in the national inventory, the best dam sites have already been taken

Without Reservoir Sediment Management

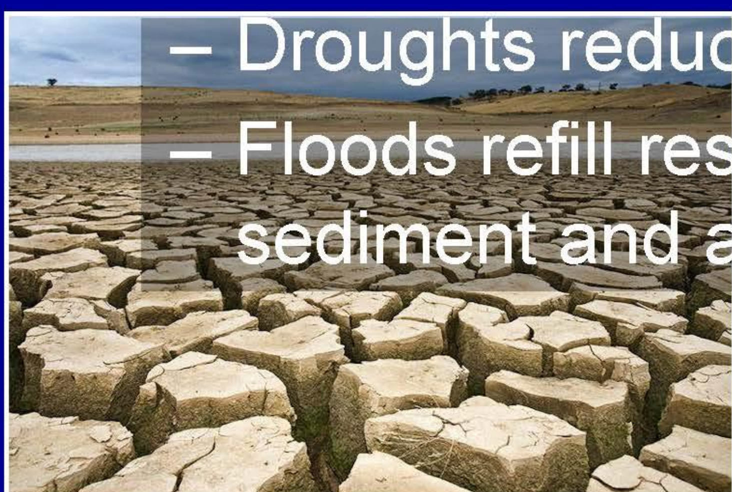
The eventual costs can be expensive:

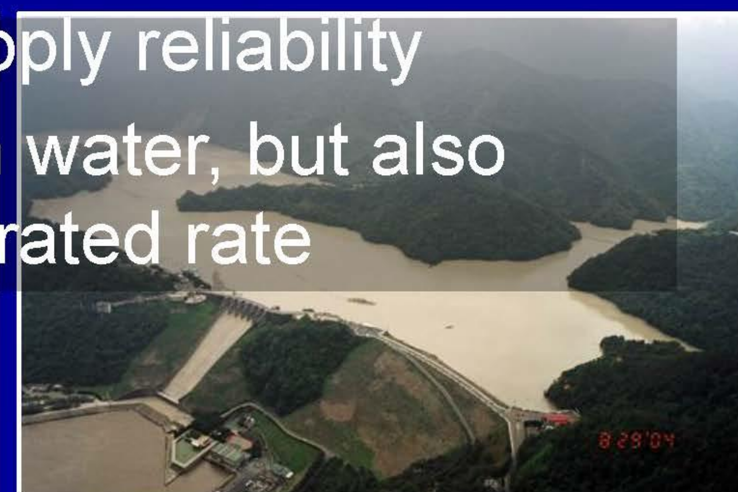
- Abraded turbines, outlets, or spillways
- Reduced surface area for lak recreation
- Upstream channel aggradation and increase and groundw



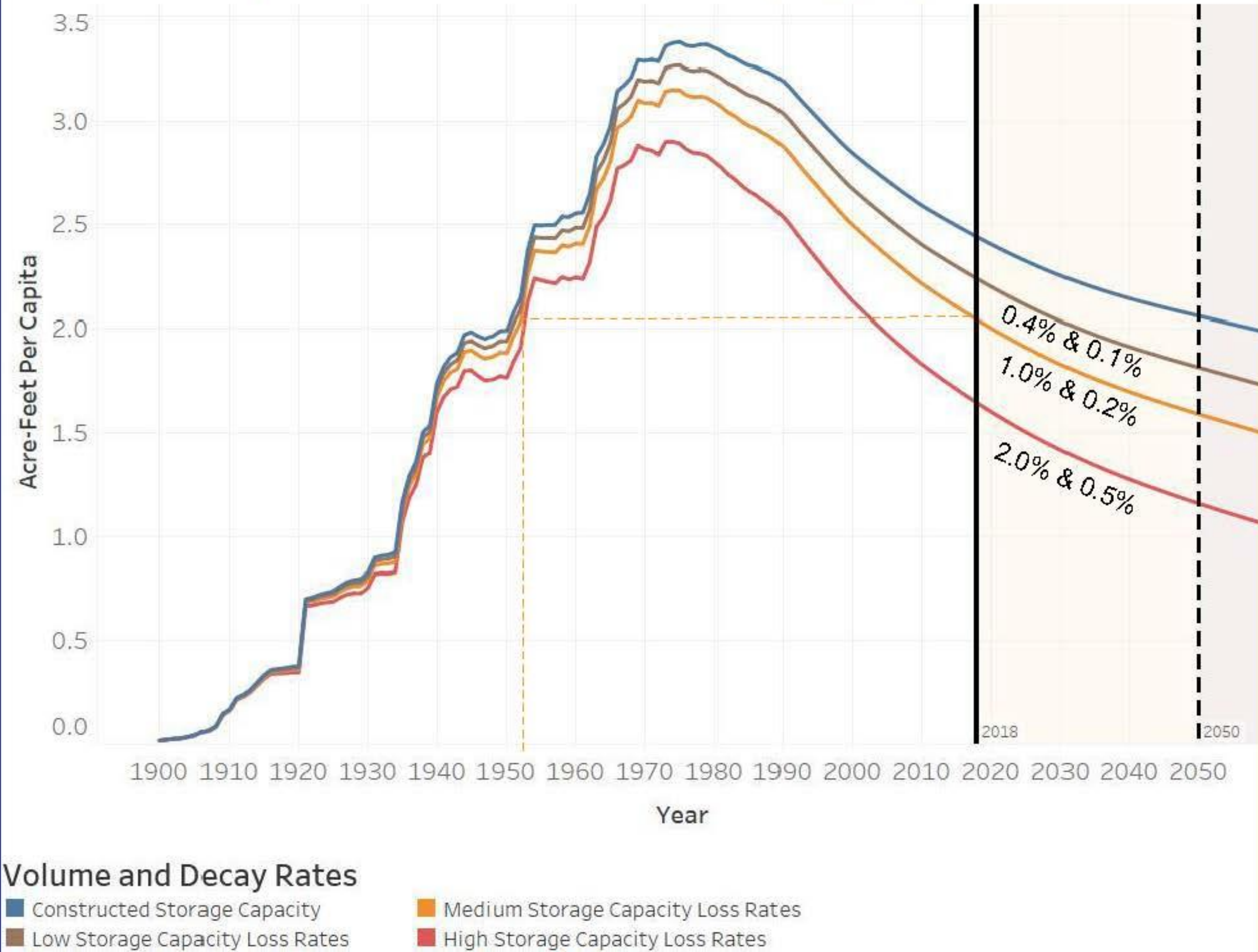
Long Term Outlook

- Population and water demand will increase over time while reservoir storage capacity reduces due to sedimentation.
- In some regions, climate change may lead to increased hydrologic variability.
  - Droughts reduce water supply reliability
  - Floods refill reservoirs with water, but also sediment and at an accelerated rate



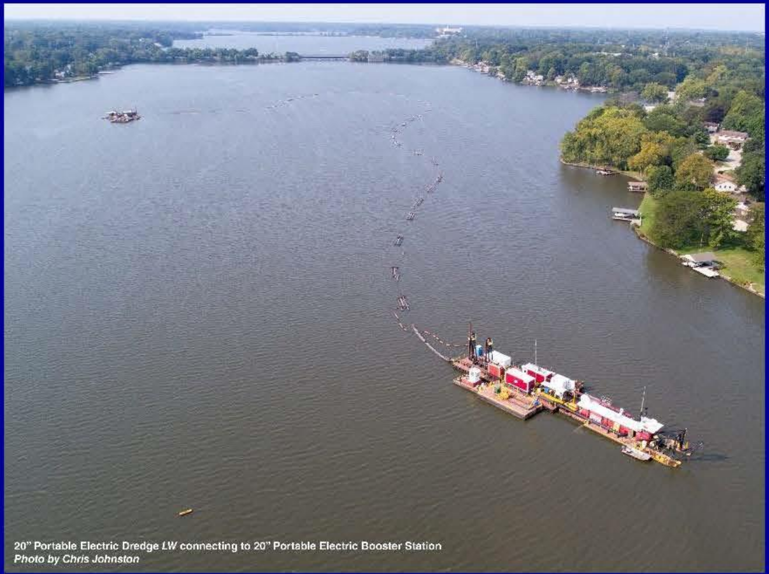


Changes to United States Reservoir Storage Capacity Over Time

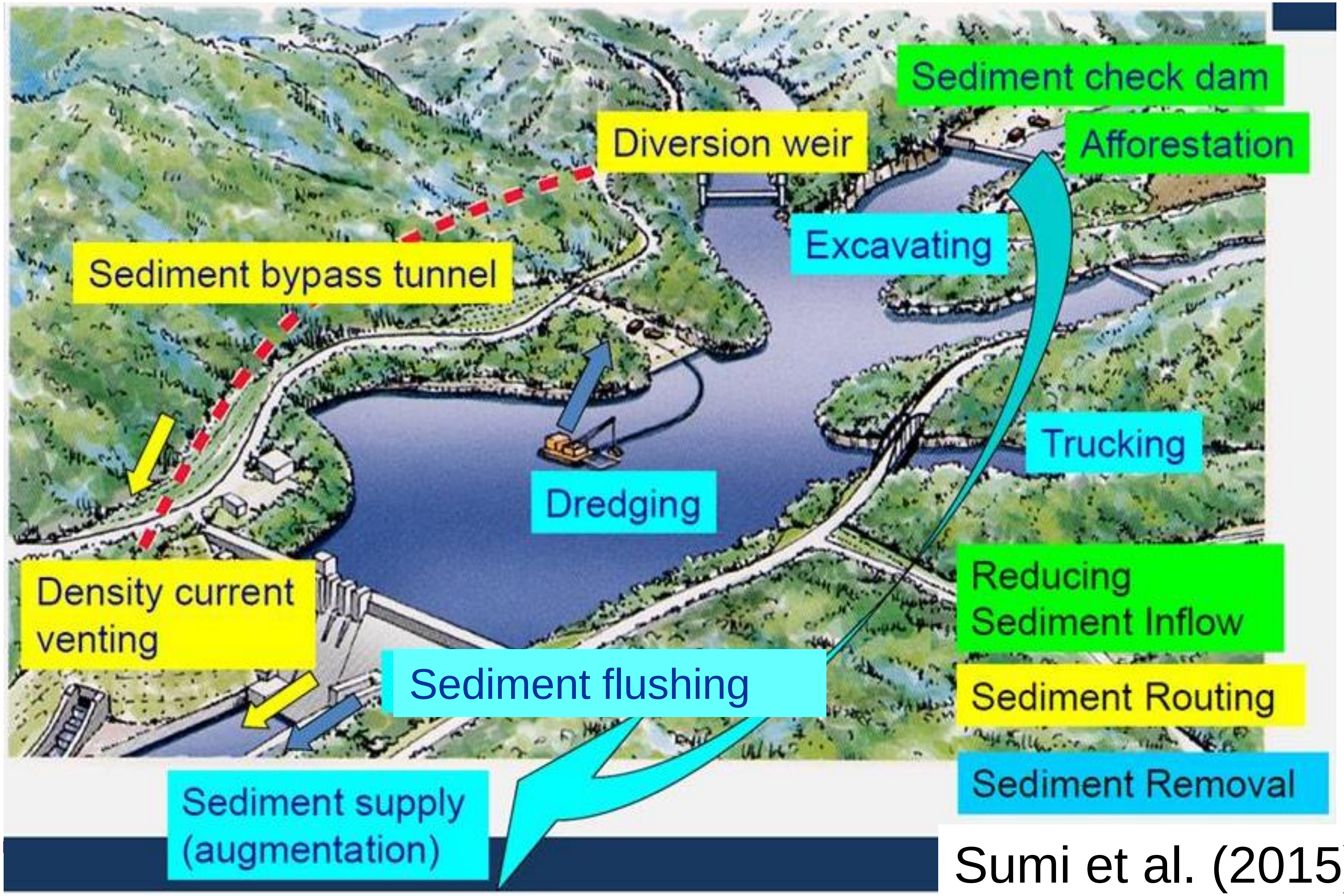


Reservoir Sediment Management Strategy

- Focus on managing recent or future sedimentation rather than past sedimentation
- Manage sedimentation each year
- Over the long term, sediment will have to pass downstream or supply other beneficial uses


20" Portable Electric Dredge *LW* connecting to 20" Portable Electric Booster Station
Photo by Chris Johnston

Sediment Management Alternatives



Sumi et al. (2015)

The Dredging Solution

Collect reservoir sediment for transport to the downstream channel, other beneficial use, or to a disposal site

Dredging past decades of sedimentation may be possible for small reservoirs

However, large reservoirs would focus on annual dredging to keep up with future sediment inflow

Sediment Removal

Mechanical or hydraulic dredging or dry excavation

Transport by slurry pipeline, truck, or conveyor belt for discharge to the downstream river channel, disposal site, or beneficial use

Dredging Costs

- Range from \$2/yd^3 to \$60/yd^3 or \$3,225/acre-feet to \$100,000/acre-feet

- Dredging a 10,000 acre-feet could cost \$33 million to \$1 billion

- Annual dredging of 1,000 acre-feet could cost \$3.3 million/year to \$97 million/year

Dredging Costs

Dredging costs have to be compared with the costs of other sediment management options

Sediment management costs have to be compared to lost project benefits, dam removal costs, and costs of new reservoirs

San Jacinto River – Emergency Dredging

The purpose of the project is to improve river hydraulics by dredging a channel approximately 400 FT wide and 14,200 lf long.

- Flood control - 1,920,000 cy of sandy material, accumulated as the result of Hurricane Harvey,
- Dredging is being completed with two portable cutter suction dredges with five booster stations: - Pump distance exceeded 50,000 LF

Current and Recent Dredging Examples

Crystal Lake, IA John Redman Res., KS Booster
Pump

Lake Worth, TX Mississippi R., IA Mosaic
Fertilizer, FL

Dredging Design Considerations

- Reservoir location, topography, and bathymetry
- Reservoir sediment investigation
- Dredging depth
- Disposition of excavated sediment
- Confined placement facility (CPF)
- Sediment slurry pipeline
- Environmental compliance and required permits
- Mobilization of dredging equipment
- Power for dredge and pumps

Reservoir Location, Topography & Bathymetry

Economic value of reservoir storage

Reservoir topography and bathymetry affect site access and the choice of dredging equipment

Reservoir Sediment Investigation

Spatial distribution and thickness, particle grain-size distribution, bulk density, cohesion, abrasion characteristics, presence of organic wood material, and concentration of any contaminants

Remaining trees or stumps

Reservoir Sediment Investigation

Drill holes:

- Enough holes to characterize the dredge area
- Drill deeper than the planned dredging depth
- I d ete g

Dredging Depth

Portable cutter-suction dredges work in depth from 15 to 60 feet

Modified dredging plant for deeper than 60 feet

Dredging Depth

Larger harbor & coastal cutter suction dredgers, dredges designed for deep water mine sites, and clamshell dredges can work as deep as 100 feet

Dredging is technically possible deeper than 150 feet, but may be cost prohibitive

Disposition of Sediment

- Downstream channel
- Soil augmentation for agriculture
- Land development
- Construction fill
- Concrete aggregate
- Wetland and other shallow water habitat creation
- Shoreline beach development or augmentation
- Offset downstream channel incision

Confined Placement Facility (CPF)

Long-term or temporary containment for beneficial use

Major considerations: nearby land availability, sediment characteristics, dredging methods, and pumping distance

Sediment Slurry Pipeline

- Pumping costs can be significant and increase with distance and elevation
- Booster pumps are needed for long distances
- Land alignments:
  - Topographic elevations changes
  - Crossings of stream channels, roads, and oil & gas pipelines

Reservoir alignments:

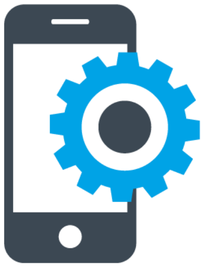
  - Floating on surface
  - Submerged 15 to 20 feet or along the reservoir bottom for boating access and safety

Sediment Slurry Pipeline

- Crossing the dam
- HDPE pipelines (small and short-term)
- Steel pipelines (large and long-term)
- Pumping energy and abrasion depend on sediment size and transport regime

Mobilization of Dredging Equipment

Includes all dredging equipment, slurry pipelines, and any confined placement facilities ready for dredging operations



Cost is a function of the schedule, project complexity, and contract risk

Cost becomes less significant for long-term dredging projects

Power for Dredge and Pumps

Diesel-driven dredging equipment most commonly used

Electric dredges are less expensive and used for long-term larger projects

- Power line and substation needed
- Available power (3 MW for 22-inch diameter cutter suction dredge)

Conclusions

Dredging may be a good option to recover or maintain storage capacity where the reservoir cannot be drawn down for sediment management purposes.

Dredging to recover decades of past sedimentation may only be financially feasible in small reservoirs.

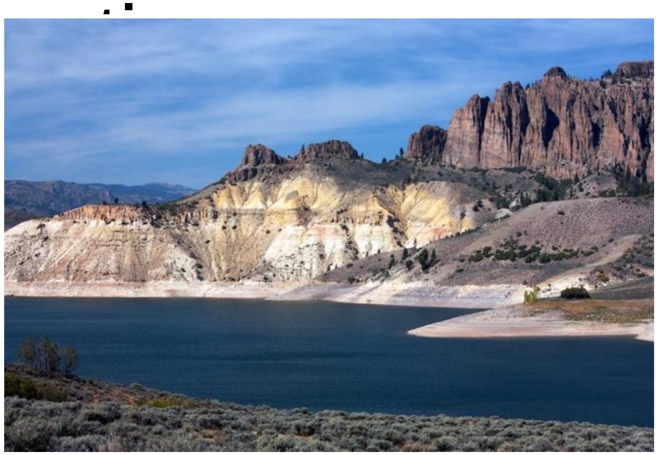
Conclusions

For large reservoirs, a long-term dredging program would be needed to keep up with the annual sediment loads.

Annual delivery of sediment to the downstream river channel would restore sediment continuity. Seasonal patterns of sediment delivery will be important.

Conclusions

Dredging costs would have to be compared with of other sediment management



Sediment management costs should be compared with the cost of eventually losing the reservoir benefits and the cost dam decommissioning.

THANK YOU!