Reservoir Sediment Management & Analysis for Engineers

Non-modeling Techniques to Develop the Future Without Project (FWOP)

University of Kansas
LEEP2 Building – Room G415
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Outline

- Future Without Project (FWOP)
- Trendline
- Brune Curve
- To model or not to model?
Future Without Project

- Future Without Project (FWOP)
  - Future Reservoir Condition (Typ. 50 Years)

- “Without Project” means continuation of the current sedimentation processes without changed management (not “without dam” or “without reservoir.”)

Specific Questions
- How much reservoir will be left in 50 years?
- How long until the reservoir volume shrinks to defined levels (that trigger lost benefits)?
- How much sediment will annually pass downstream in 50 years?
- When will the delta reach the service gates, dam, spillway, boatramp, water intake, etc.?
Empirical Trends for Delta Location

For this reservoir:
Aerial photos indicate a relatively constant advance of the delta front
Trend Line Projection for Volume Loss

2010

1962

296 M CY

Note: Pre-impoundment survey from 1957 but dam closure in 1962.
- Original Capacity = 686 M CY
- \( \frac{296 \text{ M CY}}{(2010-1962)} = 6.2 \text{ M CY/year} \)
- 2060 year capacity = 85 M CY (15% of original pool remains)
What are potential problems with a simple trend line?
Trend Line Issues: Blue = trend line will overpredict deposition, red = trend line will underpredict deposition, green = uncertain

- Sediment inflow rates equivalent
- Sediment trapping efficiency constant
- Hydrologically representative time period between surveys (i.e. extreme events in the right frequency)
- Ignores measurement error in bathymetry (particularly in the old survey!)
- Ignores further consolidation of old material
- Assumes no trend in hydrology or sediment (i.e. no climate change)
A more robust (still non-modeling) approach

1. Estimate future annual sediment load
   - Account for changes due to land use and climate change, and account for extreme events

2. Transform into a volume via unit weight

3. Estimate trapping efficiency changes over time with the Brune Curve
Trapping Efficiency

- The percentage of the incoming sediment that stays in the reservoir

- Does the trapping efficiency go up or down as the reservoir fills?
Trapping Efficiency

- As a reservoir fills with sediment:
  - The residence time of the water decreases.
  - The average velocity in the reservoir increases.
  - The distance a particle has to travel before it reaches the outlet decreases.
  - The trapping efficiency decreases.
Brune Curve

- Brune (1953) related trapping efficiency to the reservoir volume divided by incoming flow volume.

- The Brune Curve can be used to
  - Provide initial estimate of trapping efficiency and reservoir life
  - Iteratively calculate trapped sediment year by year for a more refined estimate
- We will do both of these in an Excel-based workshop
Brune Curve

- Median curve for normal ponded reservoirs
- Envelope curve for normal ponded reservoirs

References:
- Normal ponded reservoirs
- Normal ponded reservoirs with sluicing or venting operations in effect
- Desilting basins
- Semi-dry reservoirs
Measured Trapping Efficiency at Tuttle Creek Lake

- Measured Trapping Efficiency = 98%

Prepared in cooperation with the Kansas Water Office

Suspended-Sediment Loads, Reservoir Sediment Trap Efficiency, and Upstream and Downstream Channel Stability for Kanopolis and Tuttle Creek Lakes, Kansas, 2008–10
Brune Curve

Tuttle Creek Lake Average Annual Inflow = 2,341 M CY
Capacity (2010) = 390 M CY
C/I = 0.17
TE = 97.5
Trapping Efficiency Changes Over Time

TE computed iteratively over 50 years

Next 40 years
For large reservoirs with high trapping efficiencies, results are very similar.
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Empirical Approaches

- Provide recon-level analyses
  - How big a problem do we actually have?

- Provide a future condition for other analyses (where sediment management is not the subject of the analysis)

- Initial screening of measures to reduce the number of alternatives to model

- Where sufficient data is lacking for good modeling anyway (and there is no time and/or budget to collect it)
Modeling

- To create a FWOP where sediment management is the “project”
  - Provides a consistent analysis method to compare alternatives to the FWOP

- Situations with unique conditions, large implementation costs, high failure consequences
Questions?