Dam Removal Webinar Series

Part 2A:
Conceptual Overview of Sediment Management

November 3, 2020

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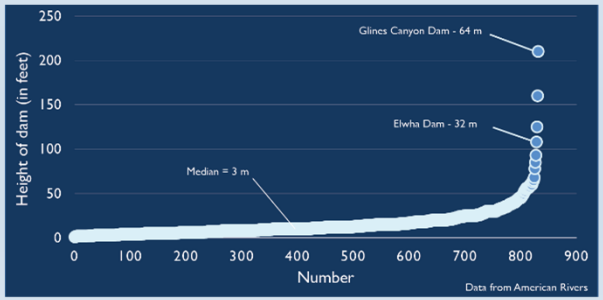
ERDC Environmental Laboratory

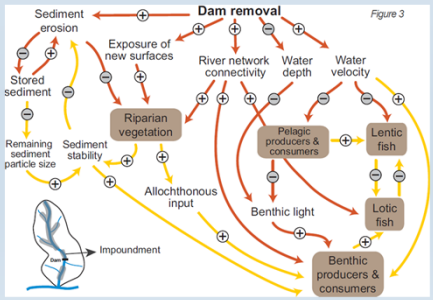
Refresher from Part 1

- Dam removal is one of many tools in the asset management toolbox.
- The number of dam removals is increasing in response to many motivating factors (e.g., aging infrastructure, environmental reasons, flood hazard,…).
- Removals are predominantly focused on smaller structures (median height < 10 ft).
- Multiple management alternatives exist for executing removals.
- The body of knowledge is growing rapidly relative to the geomorphic and ecological consequences of dam removals.



(Figure: Jeff Duda)

Old Berkshire Mill (Randle et al. 2015)



Bellmore et al. 2019 BioScience

Resources Mentioned in Part 1

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- **Tullos D.D., Collins M.J., Bellmore J.R., Bountry J.A., Connolly P.J., Shafroth P.B., and wilcox A.C. 2016. Synthesis of common management concerns associated with dam removal. Journal of the American Water Resources Association, doi: 10.1111/1752-1688.12450.**
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Sediment Impacts Associated with Dam Removal: Assessing the state of the science

Six major focal topics:

1. What alternatives exist for managing sediment before, during, and after dam removal?
   - See Part 1

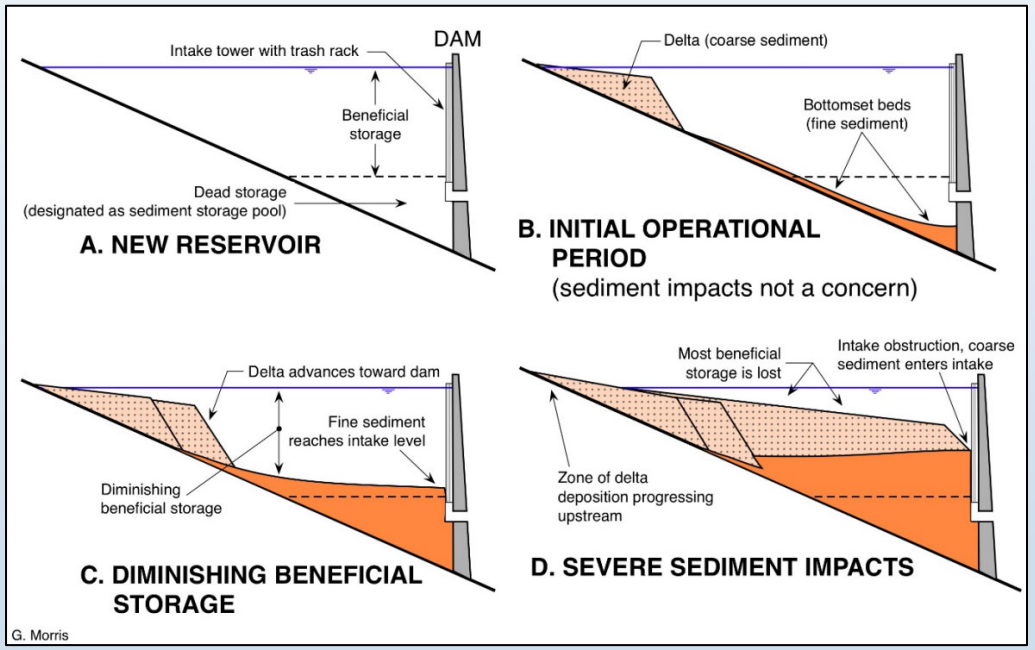
McKay
2. **How much sediment is stored behind a dam?**
3. **What are the geomorphic effects of removal?**

Bailey
4. **What is the quality of the sediment?**
5. **How do these (and other) factors influence permitting decisions?**
6. What are the ecological impacts of sediment or contaminant release?

Interagency Workshop Team
(August 23-24, 2017)

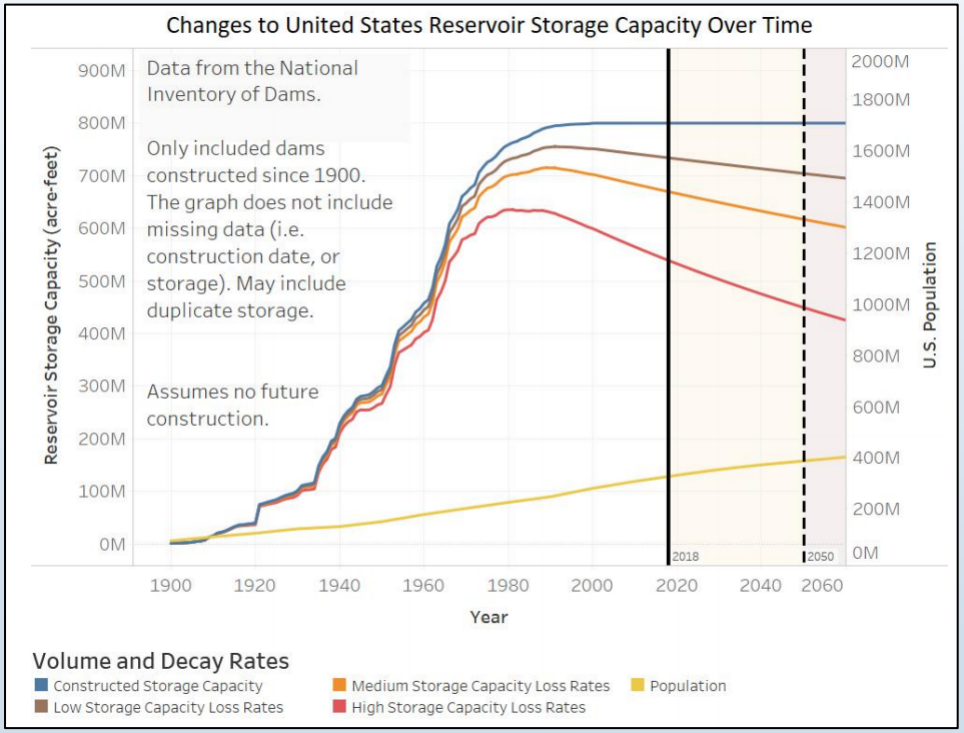
Topic 2
How much sediment is stored behind a dam?

- Reservoir sedimentation
- Methods for estimating sediment volume
- Research update on sediment volume estimation



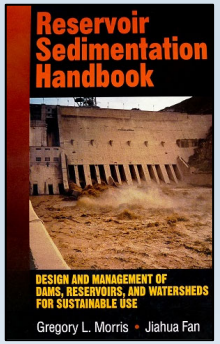
National Reservoir Sedimentation and Sustainability Team White Paper (2019)

Reservoir Sedimentation



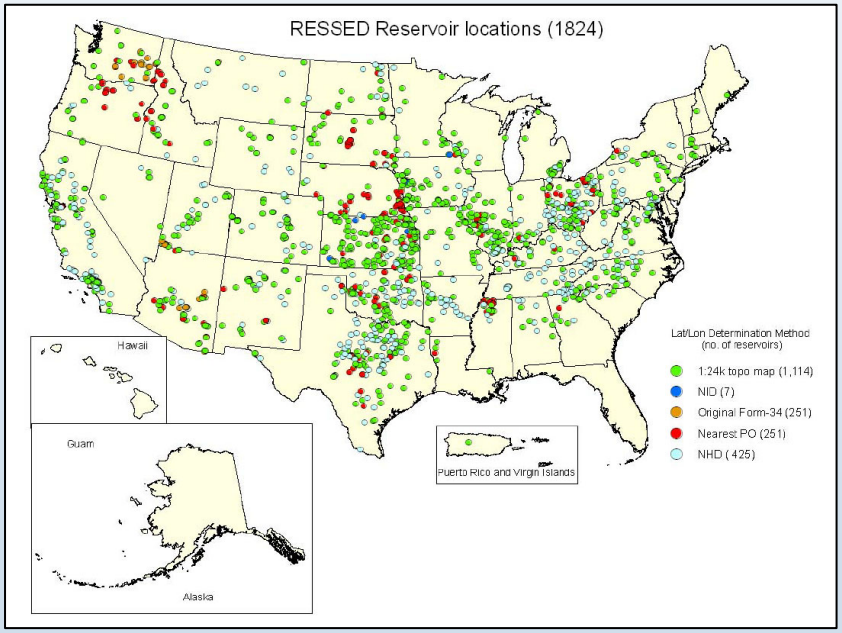
National Reservoir Sedimentation and Sustainability Team White Paper (2019)

- Key component of dam design life
- Major issue for sustainability of reservoirs (in general)
- Management with bypassing, sluicing, density currents, excavation, etc.
- Rich body of literature:
  - Morris and Fan (2009)
  - George et al. (2016, J. of Hyd Eng)
  - Podolak and Doyle (2015, J. of Hyd Eng)
  - Kondolf et al. (2014, Earth's Future)
  - …



Estimating Reservoir Sediment Volume: (1) Use Databases

- Reservoir Sedimentation Survey Database (RESSED; Ackerman et al. 2009, Gray et al. 2010)
- Reservoir Sedimentation Information (RSI; Cooper 2015, Pinson et al. 2016)
- Databases tend to emphasize larger structures and only cover 2-3% of large dams (i.e., ~2,000 structures)
  - Often misaligned with dam removals



Gray et al. (2010)

Estimating Reservoir Sediment Volume: (2) Site-specific surveys

- Bathymetric mapping
- Longitudinal profiling
- Probing and sounding
- Hyper-local measurement (e.g., seismic, GPR)

- Aligns well with collection of other useful data (e.g., grain size)
- May need to knit with abovewater survey

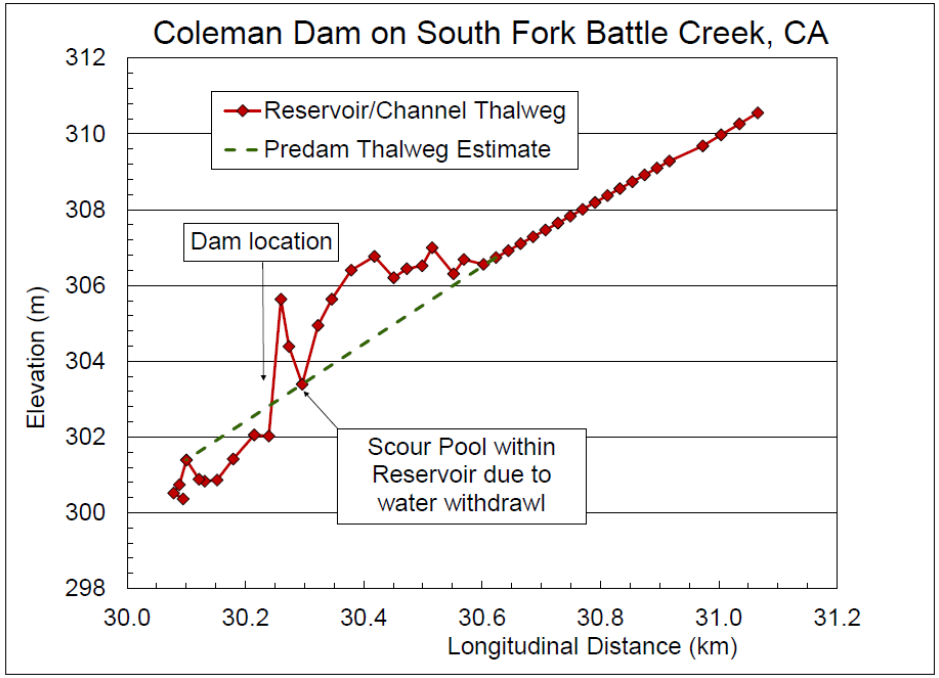


Figure 8.—Example estimate of the predam profile through reservoir sediments at Coleman Dam on South Fork Battle Creek, CA.

Randle and Bountry (2017)

Estimating Reservoir Sediment Volume: (3) Estimate sedimentation process

- Sediment loading rate (Morris and Fan 2009, Alighalehbabakhani et al. 2017)
  - Typical yield vs. event-based loading (landslides, fires, etc.)
- Structural age and trapping efficiency (Brune 1953, Churchill 1948, Randle and Bountry 2017)
- Upstream trapping (Minear and Kondolf 2009)

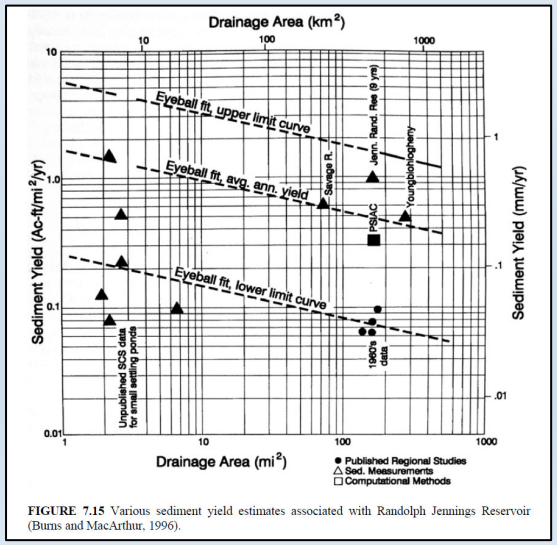


FIGURE 7.15 Various sediment yield estimates associated with Randolph Jennings Reservoir (Burns and MacArthur, 1996).

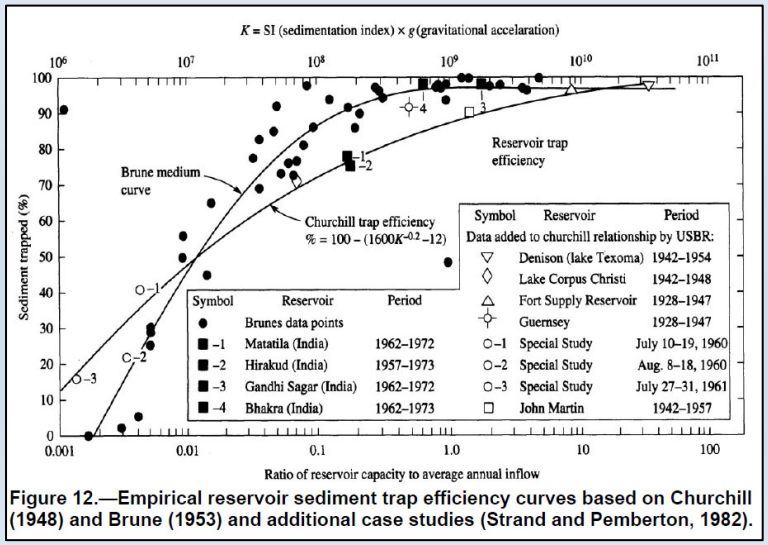
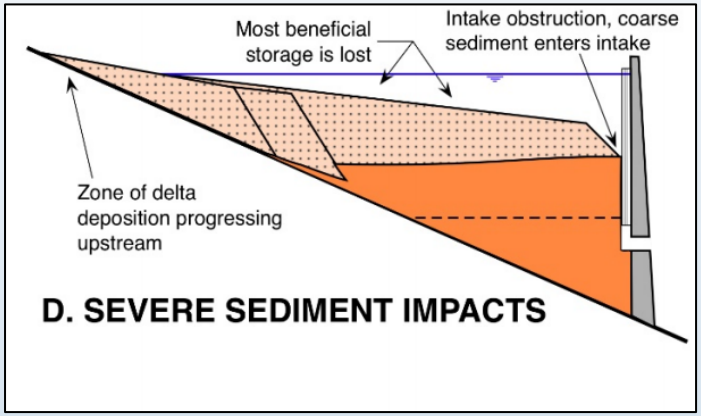


Figure 12.—Empirical reservoir sediment trap efficiency curves based on Churchill (1948) and Brune (1953) and additional case studies (Strand and Pemberton, 1982).

Figures:
Morris and Fan (2009)
Randle and Bountry (2017)

Estimating Reservoir Sediment Volume: (4) Reservoir volume as a proxy

- Total reservoir volume
  - May overestimate storage
  - HOWEVER, dams targeted for removal may have severe sedimentation
- Some data are available in the National Inventory of Dams
- Geometric assumptions using observable properties:
  - Cube (overestimate)
  - Wedge (overestimate)
  - Tetrahedron



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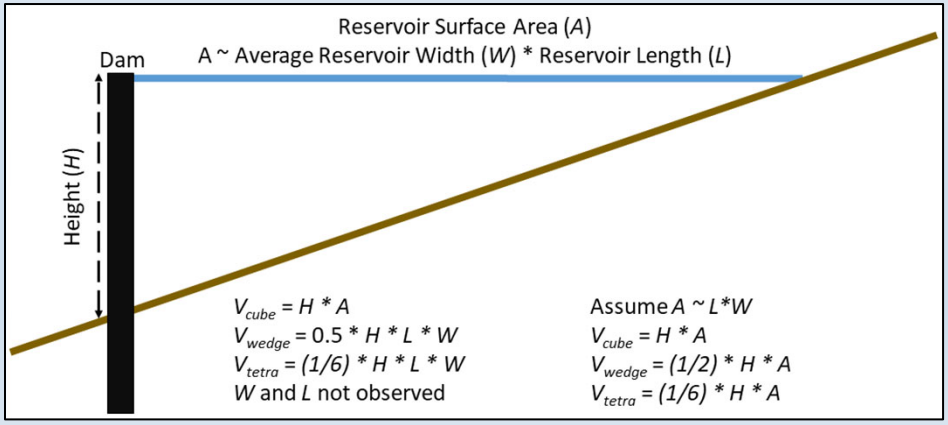
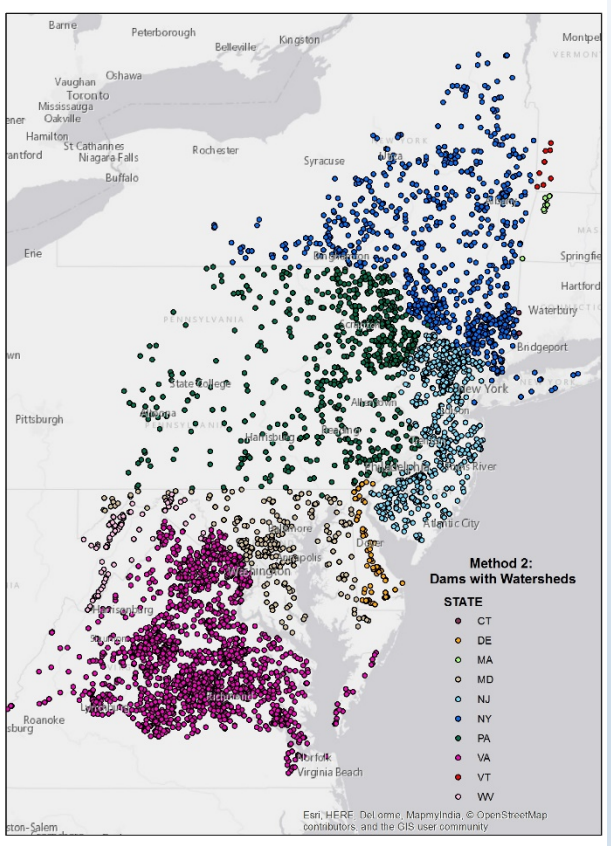


McKay et al. (in prep)

Ongoing EMRRP Research: Estimating reservoir volume

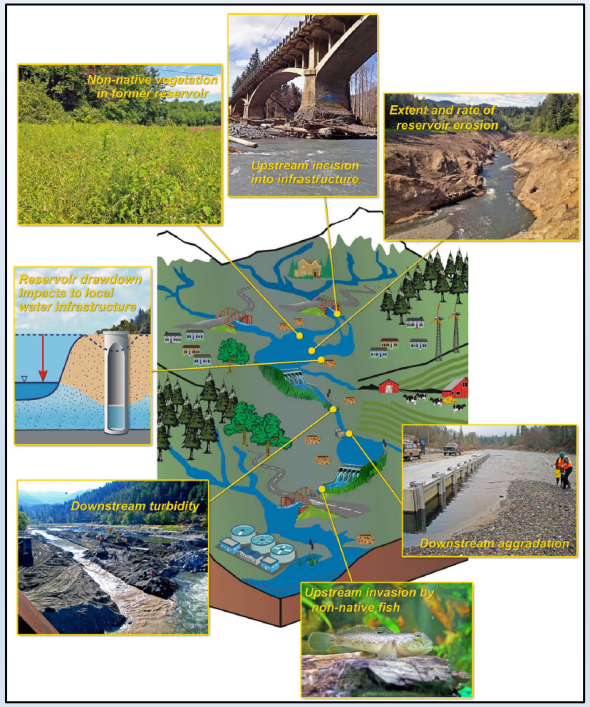
- Chesapeake Bay pilot study
- Use NID data to test models for estimating volume
- Model 1: geometric assumptions
- Model 2: statistical model using watershed and dam properties
  - Dam height, reservoir area, watershed area, watershed land use, stream length,…
- Prediction out of set to "fill in" non-surveyed dams in the watershed



McKay, Hernandez-Abrams, Tyler, Reif, and Dunkin (*in prep*)

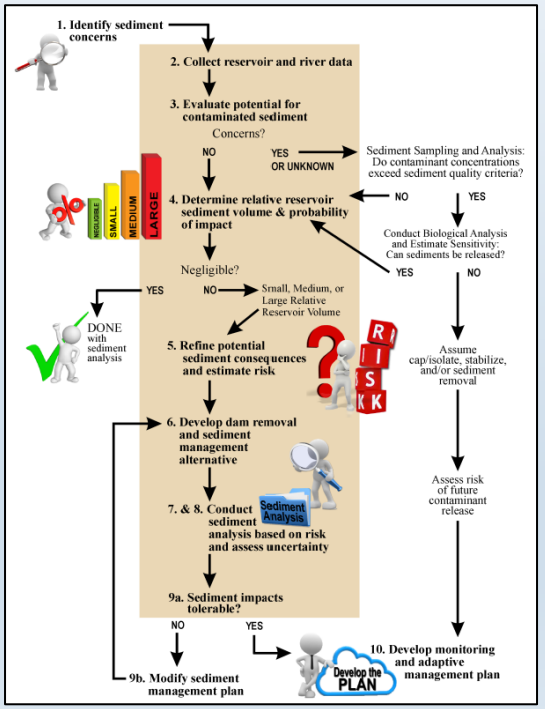
Topic 3
What are the geomorphic effects of removal?

Common (Sediment) Management Concerns in Dam Removal Projects (Tullos et al. 2016, JAWRA)



TAKE A BREAK

Sediment Risk Assessment Framework (Randle and Bountry 2017, BOR)



Common Management Concerns in Dam Removal Projects

(Tullos et al. 2016, JAWRA)

Sediment-Related CMCs

1. Degree and rate of reservoir sediment erosion
2. Excessive channel incision upstream of reservoirs
3. Downstream sediment aggradation
4. Elevated turbidity

Non-Sediment CMCs

5. Drawdown impacts to local water infrastructure
6. Non-native plant colonization of reservoirs
7. Expansion of non-native fish

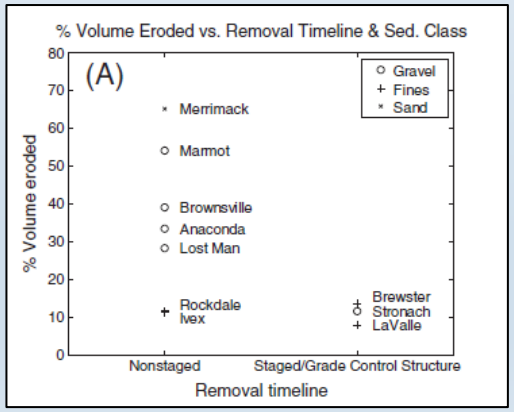
For each topic:

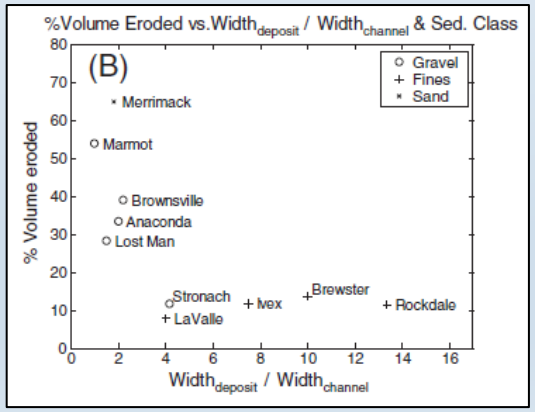
- Describe key management questions
- Present key metrics and empirical findings to date

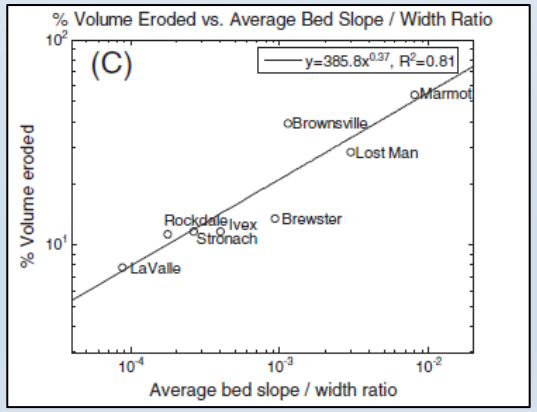
Supplement CMCs with: Foley et al. (2017), Major et al. (2017), Randle and Bountry (2017), others

CMC1: Degree and rate of reservoir sediment erosion

- Key management questions:
  - How much of the sediment impounded within a reservoir will erode?
  - How quickly will the eroded sediment move through the downstream river corridor?
- Key metrics:
  - High % fine grained sediment
  - Deposit width / Channel width > ~2.5
  - Phased removal
  - Degree of base level drop



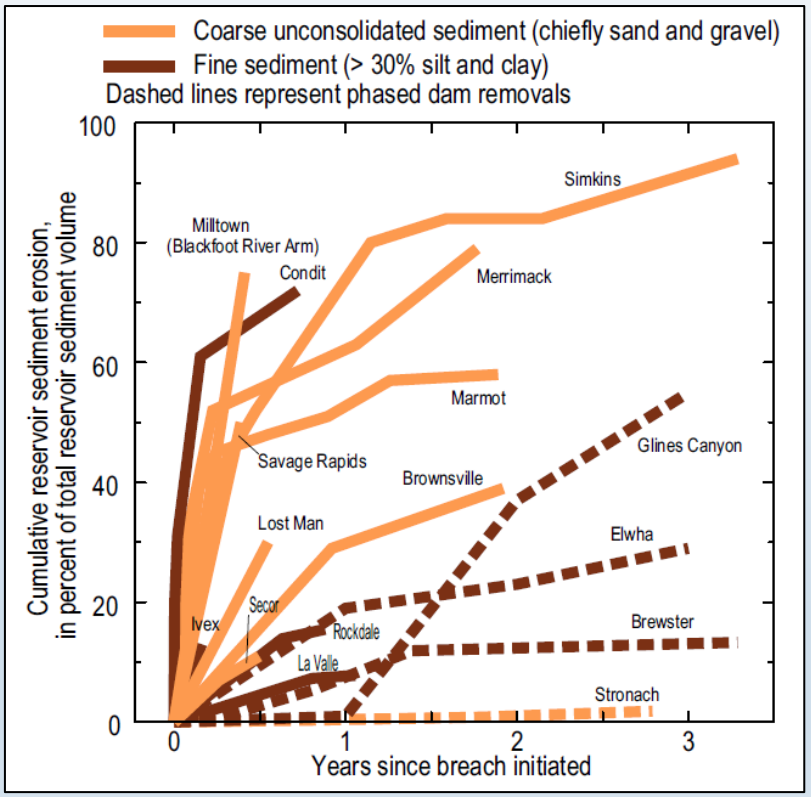




Sawaske and Freyberg (2012, Geomorphology)

CMC2: Excessive channel incision upstream of reservoirs

- Key management questions:
  - Will a "knick point" form and propagate upstream? If so, how far?
  - Will upstream infrastructure be affected (e.g., bridge piers)?
- Key metrics:
  - Reach-scale incision downstream
  - High % fine grained sediment
  - Phased removal
  - Channel slope (e.g., base level drop, presence of grade control)



Foley et al. (2017, Water Resources Research)

CMC3: Downstream sediment aggradation

- Key management questions:
  - Where will sediment deposit longitudinally (on avg and around infrastructure)?
  - Will bedforms be affected (e.g., pool filling)? Will sediment fill interstitial spaces (i.e., embeddedness)? Will channel complexity be reduced?
  - Will downstream water bodies be impacted?
  - Will flood levels increase?
- Key metrics:
  - Proximity to dam
  - Low slope / unconfined channel
  - High relative sediment volume
    - stored volume / avg ann volumetric loading rate
  - Coarse grain size
  - Sediment pulse dispersion or translation

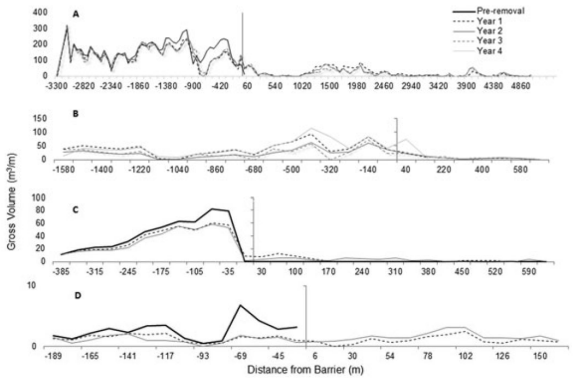
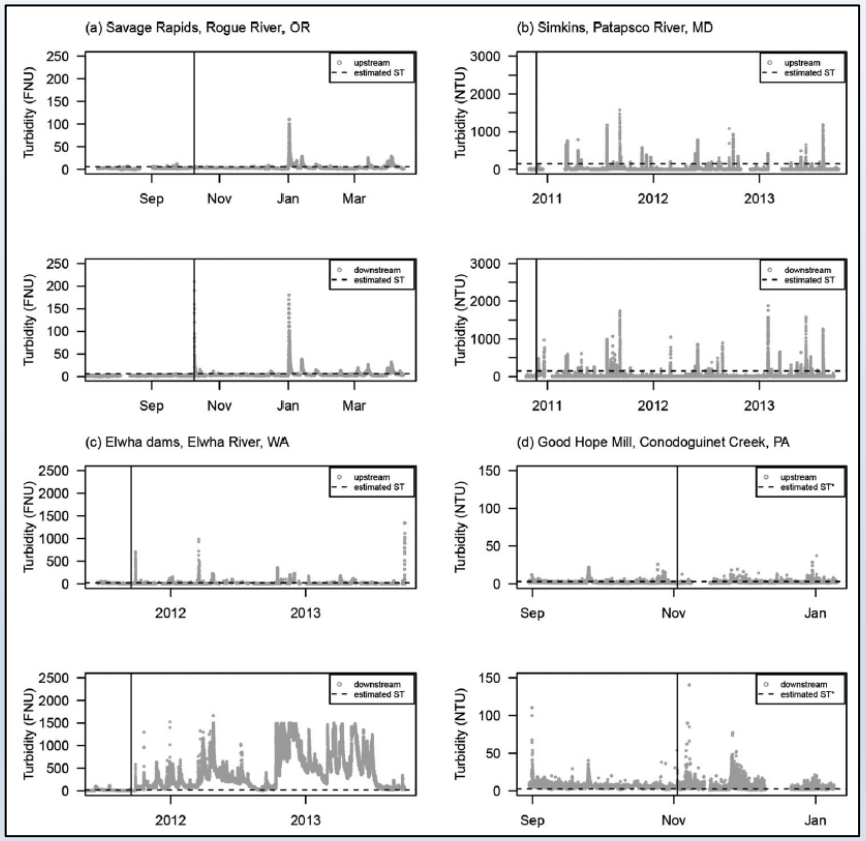


Figure 5. Gross volumes at (A) Gold Ray, (B) Savage Rapids, (C) Brownsville and (D) Oak Creek

Pace et al. (2016, River Res and App)

CMC4: Elevated turbidity

- Key management questions:
  - Will suspended sediment exceed ecological or regulatory thresholds?
  - Will turbidity influence human uses of the river (e.g., recreation, water intake)?
- Key metrics:
  - High % fine grained sediment
  - High relative sediment volume (V^*)
    - stored volume / avg ann volumetric loading rate
  - High relative sediment erosion (E^*)
    - eroded volume in Yr-1 / avg ann volumetric loading rate
  - Rapid reservoir drawdown
  - Background turbidity levels



Tullos et al. (2016, JAWRA)