EMRRP

Dam Removal Webinar Series

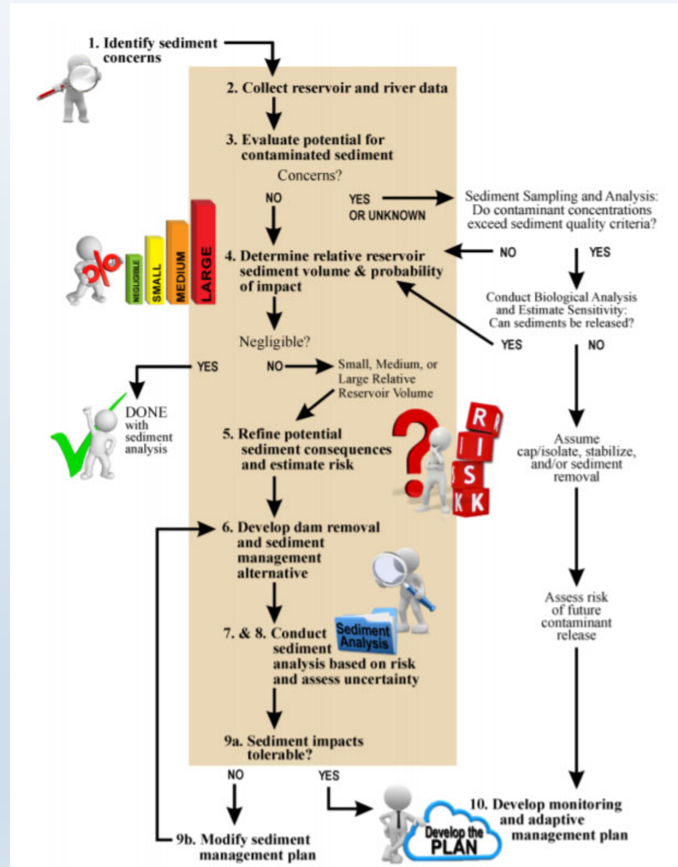
Part 4A:
1D Numerical Model Applications: Simkins Dam Case Study

November 19, 2020

Ms. Waleska Echevarria-Doyle, P.E.
(ERDC Coastal and Hydraulics Laboratory)

Is the sediment behind a dam a concern?

- Identify sediment concerns
  - Dam Removal Analysis Guidance for Sediment (2017):
    - provide guidelines to determine if sediment impacts are considered negligible.
    - sediment analysis may not be required if sediment impacts are considered negligible.

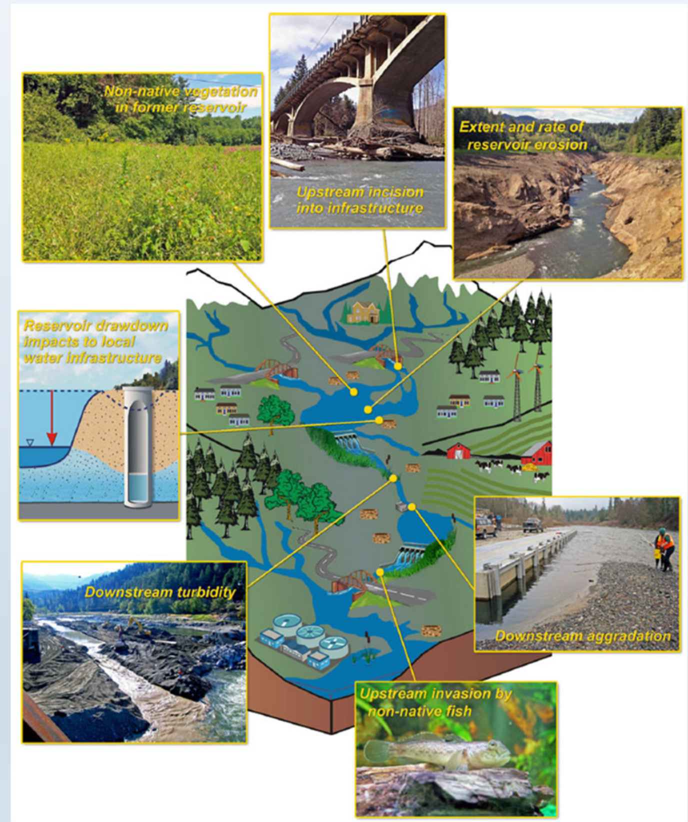


Flow Chart: **Sediment analysis guideline steps for dam removal.**

Randle and Bounty, 2017 USBOR

Common Management Concerns (CMCs) related to sediment

- Degree and rate of reservoir sediment erosion
- Excessive channel incision upstream of reservoirs
- Downstream sediment aggradation
- Elevated turbidity



Tullos et al., 2016 JAWRA

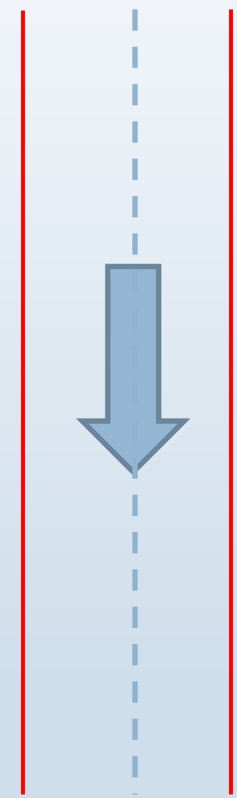
What methods/tools could be used to quantify the geomorphic implications of dam removal?

General increase in complexity ↓

General List of Tools/Methods
Conceptual model
Generalized rule
Geomorphic analysis
Preliminary sediment analysis
1-D Sediment transport Modeling
2-D Sediment transport Modeling
Lagrangian transport modeling
3-D Sediment transport Modeling

1D numerical hydraulic models

- Equations of water motion 1D form (TD 41):
  – Forces acting on the body of water are predominant along the river centerline.
  – Vertical and lateral forces on the body of water are considered negligible.
- Hydraulic input is required for 1D sediment transport models to rout sediment or update channel cross sections.

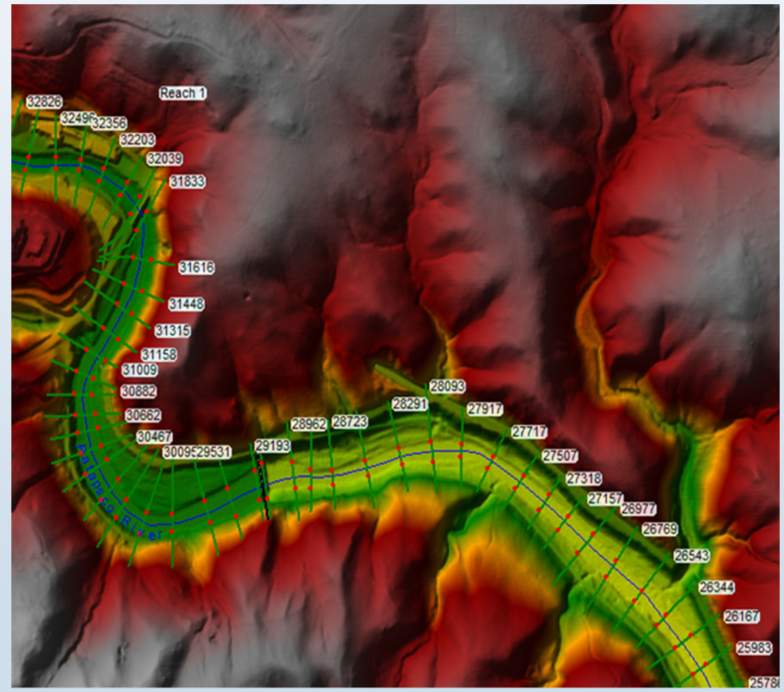


TD 41: “*Modeler Application for Steady vs UnSteady & 1-D vs 2-D vs 3-D Hydraulic Modeling*”

1D Numerical Sediment Transport Model – HEC-RAS 5.0.7

- Includes capabilities to route sediment and adjust channel cross sections (aggradation or degradation) along the river reach of interest.

- Model outputs that could inform CMCs related to sediment:
  - Profile elevation change
  - Volume change
  - Sediment Concentrations



Simkins Dam Case Study

Cui et al., 2018

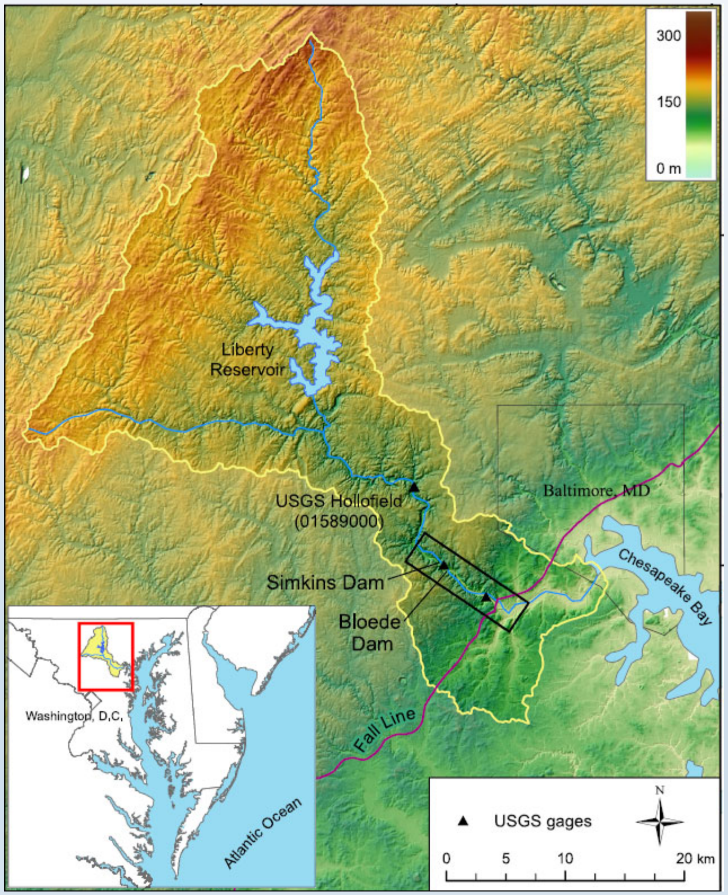
Cui et al., 2018

Collins et al., 2017

Simkins Dam removal site on Patapsco River, MD before (left), during (center) and after (right).

Site Description

- Location
  - Patapsco River
    - Watershed area – 950km^2 (367 mi^2)
    - Study reach ~ 13km (8 miles)
    - Maryland Piedmont
      - Gravel-bedded
      - Steep slope (~ 0.002)
    - Atlantic Coastal Plain
      - Sand-bedded
      - Lower gradient (~ 0.0004)
    - Bloede Dam: located ~1km (3,280 feet) downstream of the Simkins Dam
- Hydrology
  - Base flow - 1.9 m^3/s (67 ft^3/s)
  - Mean annual discharge – 7.5 m^3/s (265 ft^3/s)
  - Mean annual flood – 400 m^3/s (14,126 ft^3/s)



Collins et al. (2017)

Site Description

- Dam description
  - Height: 3 meters (9.8 feet)
  - Width: 66 meters (217 feet)
  - Operation: run of river
  - Construction: 1889
  - Full Removal: Fall 2010
    - Improve public safety, aquatic habitat, and migratory fish passage
  - Removal mechanism: mechanical (hoe ram)
  - Stored sediment texture: dominantly sand with some gravel

Collins et al., 2017

Site Data Collection

Surveys

- Sep 2010 (pre-removal)
- Feb 2011
- Apr 2011
- Sep 2011
- Apr 2012
- Nov 2012
- Nov 2013

Data

- Channel geometry
  - 28 cross sections
  - 5 monitoring areas
- Bed material
  - grain size distributions
    - Gradations
    - Pebble counts
  - facies maps
  - bulk density: Simkins and Bloede stored deposits

Gage Data

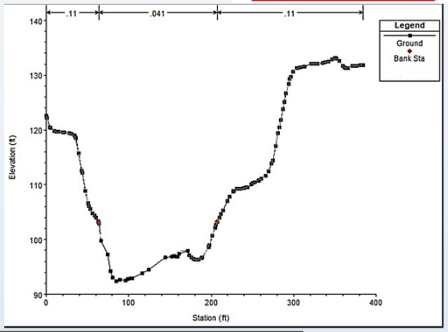
USGS Gages

- USGS 01589000
  - Patapsco River at Hollofield, MD
- USGS 01589025
  - Patapsco River near Catonville, MD
- USGS 01589035
  - Patapsco River near Elkridge, MD

Data

- water discharge
- water stage
- water temperature
- sediment discharge
- suspended sediment concentrations
- water quality samples

1D Numerical Sediment Transport Model – HEC-RAS 5.0.7

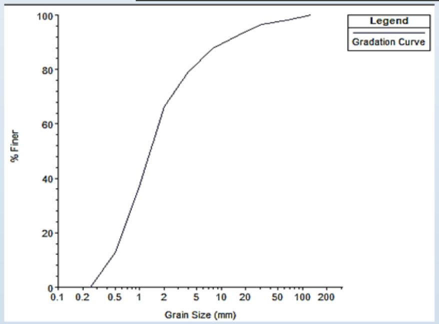


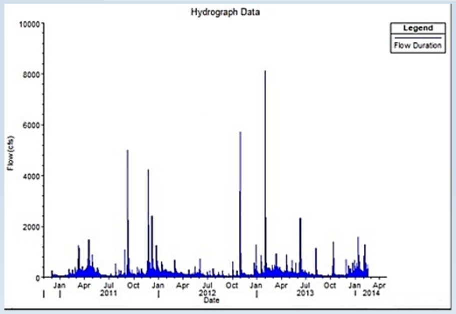
Data Requirements

- Cross sections or bathymetry
- Bed material gradations
- Incoming sediment load
- Bedrock locations
- Discharge
- Water Temperature

Sediment Model Files

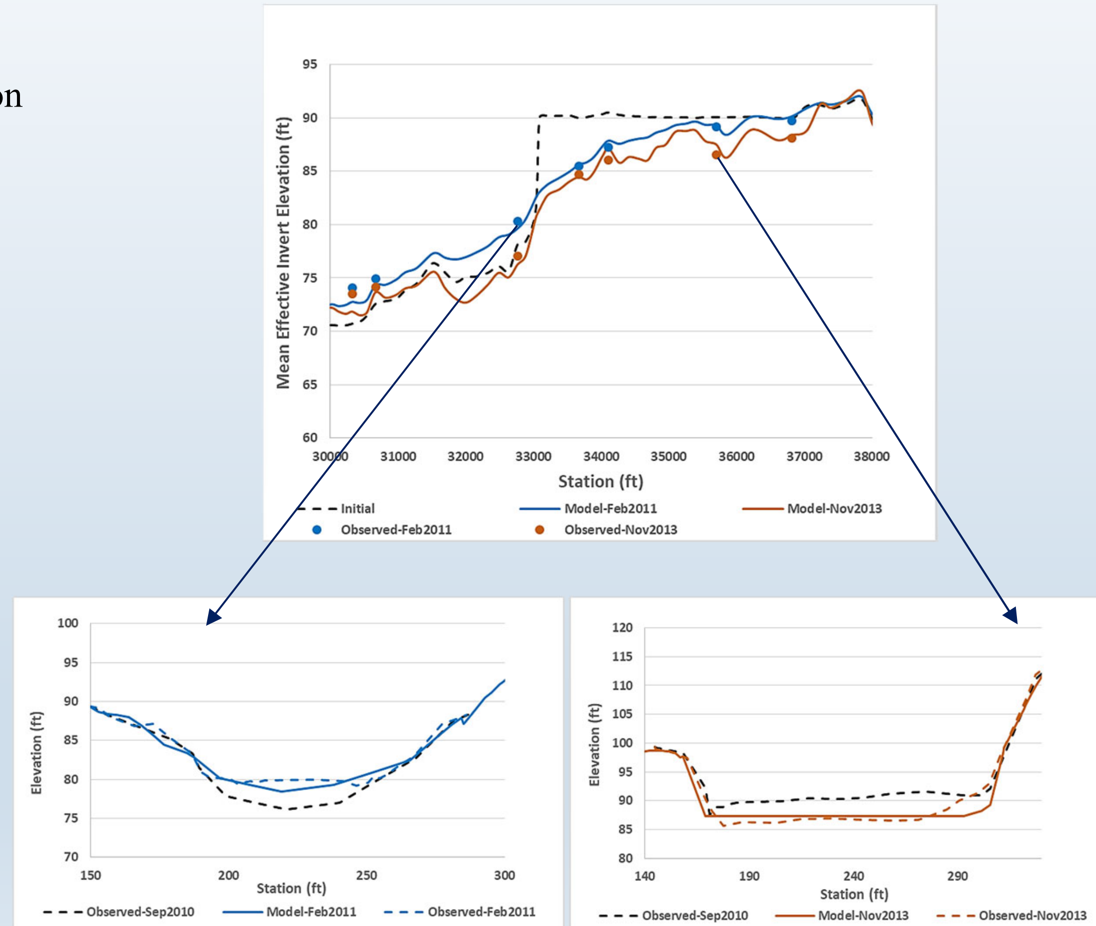
- Geometry file
- Sediment data file
- Flow file





Simkins Dam HEC-RAS sediment transport model

- **CMCs related to sediment:**
  - Degree and rate of reservoir sediment erosion
  - Excessive channel incision upstream of reservoirs
  - Downstream sediment aggradation
  - Elevated turbidity
- **Model output that could inform these CMCs:**
  - Profile elevation change
  - Volume change
    - Volume eroded from reservoir in November 2013 ~ 56,350m^3 (73,703 yd^3), Cui et al., 2018
    - Model estimated a volume < 10% difference
  - Sediment concentrations
    - Predicted an increase in sediment concentrations after removal (mostly higher than observed data)



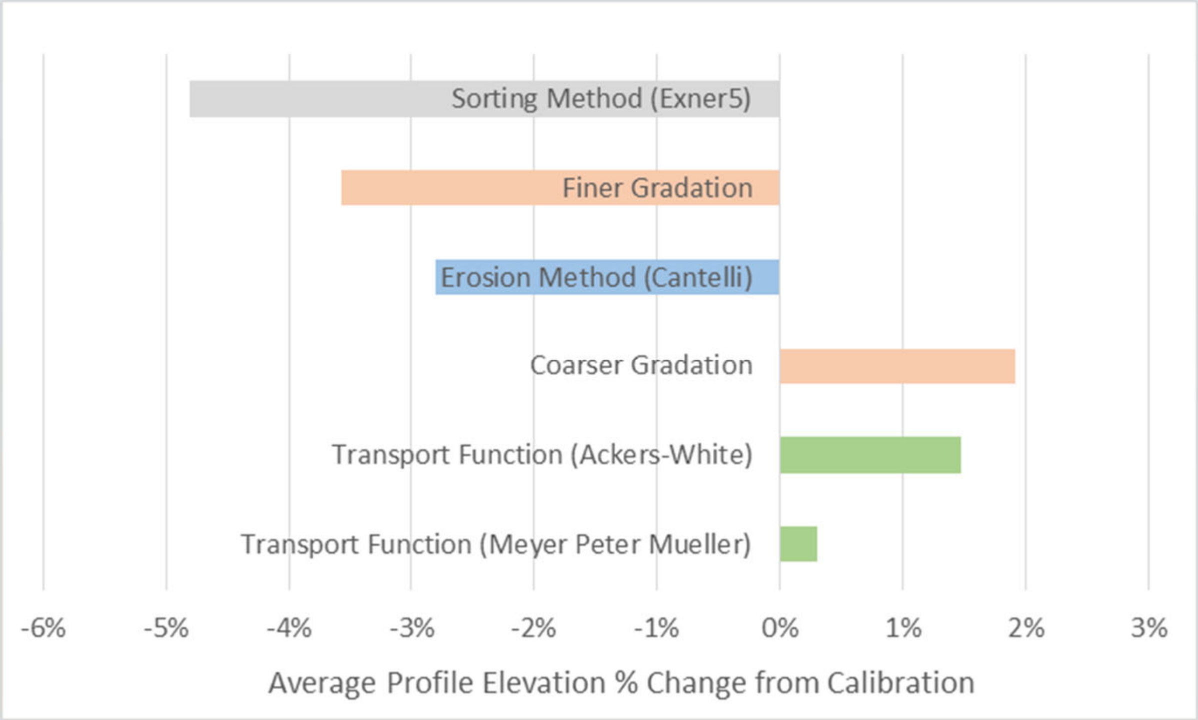
Simkins Dam HEC-RAS sediment transport model

- Sensitivity Analysis
  - commonly used to examine how model outputs deviate from model calibration results because of the variation of input factors. (Pianosi et al, 2016).

	Rationale for examination	Baseline parameterization in HEC-RAS	Sensitivity Scenarios
Data inputs			
Sediment gradations	Provide grain size distribution for the bed material.	Develop a bed material gradation for the Simkins reservoir using grain size distributions from collected samples in the reservoir	Compare to a coarser gradation and finer gradation for the Simkins reservoir
Model structure			
Sediment Transport Function	Predicts rates of sediment transport from given hydraulics parameters and sediment properties.	Yang – used for calibration	Compare to Ackers-White and Meyer Peter Mueller transport functions
Sorting Method	Simulated bed sorting and armoring.	Active Layer – used for calibration	Compare to Exner5
Erosion for Reservoir deposits	"Veneer Method" is the default option to change cross sections in HEC-RAS. The area within the movable limits erodes or aggrades.	Veneer Method – used for calibration	Compare to the channel evolution model – Cantelli Algorithm: Modified approach to estimated erosion specifically for reservoirs. An estimated width and side slope are input parameters required to define the incision channel. Parameters used for this study: Width = 80ft, Side slope =0.5ft/ft

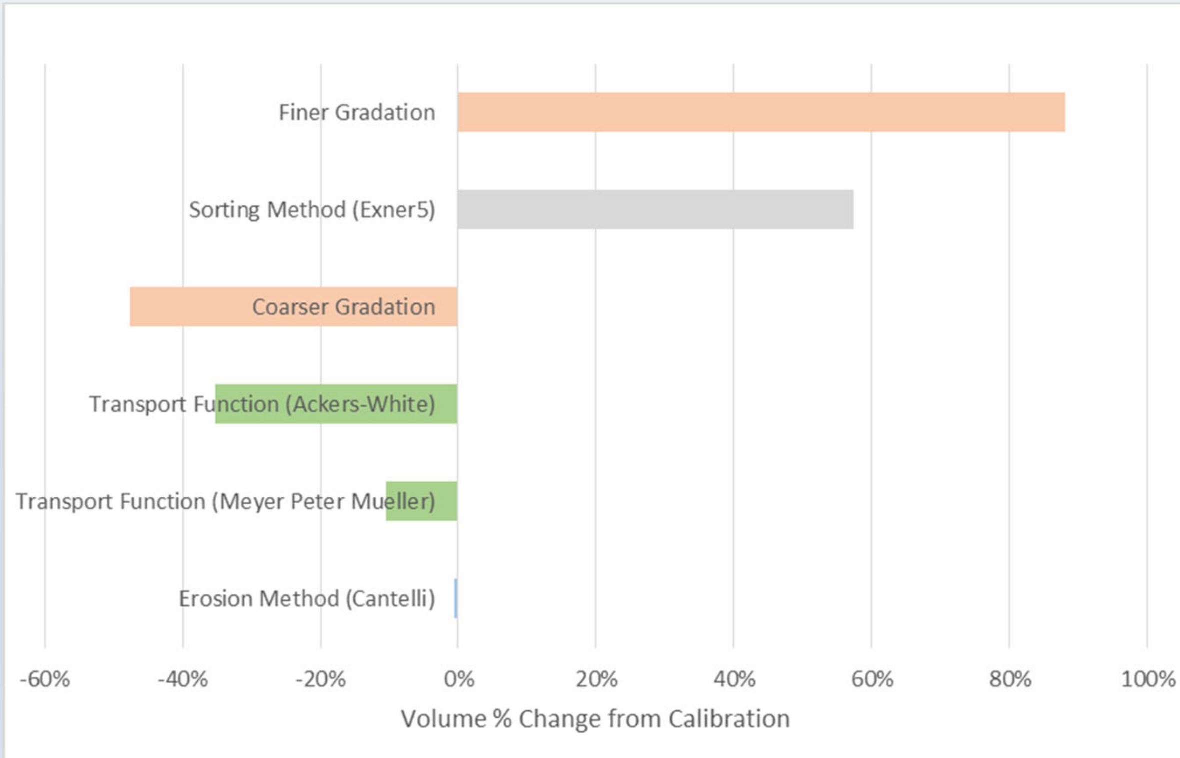
Simkins Dam HEC-RAS sediment transport model

- Sensitivity Analysis: Profile elevation along reservoir



Simkins Dam HEC-RAS sediment transport model

- Sensitivity Analysis: Eroded Sediment Volume from reservoir - November 2013 survey



Summary

- 1D HEC-RAS model outputs that could inform CMCs related to sediment:
  - Profile elevation and volume of eroded sediments
    - Degree and rate of reservoir sediment erosion
    - Excessive channel incision upstream of reservoirs
    - Downstream sediment aggradation
  - Sediment Concentrations
    - Elevated turbidity
- Sensitivity Analysis:
  - Model results for the Simkins case study are:
    - Highly sensitive to bed material gradations and sorting method
    - Sensitivity to the channel evolution model “Cantelli” can vary based on the selection of channel width and side slope parameters.
    - Less sensitive to transport function

Acknowledgments

- Mr. Matt Collins –NOAA
- Dr. Kyle McKay – ERDC Environmental Laboratory
- Ms. Susan Bailey – ERDC Environmental Laboratory

Questions?

Type your questions in the chat box.

http://archive.vcstar.com/news/matilija-dam-others-across-nation-featured-in-new-film-ep-459265401-351467581.html