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Reservoir Sediment Management Workshop for Milford Lake in the Kansas River Basin

by John E. Shelley and Paul M. Boyd

PURPOSE: This Regional Sediment Management Technical Note (RSM-TN) summarizes a training/brainstorming workshop held on the topic of reservoir sediment management supported by the U.S. Army Corps of Engineers (USACE) Regional Sediment Management (RSM) Program. The workshop consisted of 1½ days of training on reservoir sedimentation and sediment management strategies with specific focus on Milford Lake in the Kansas River basin. This CHETN describes the workshop format and agenda, lists ideas generated, and documents suggestions for improvement.

INTRODUCTION: Sedimentation in USACE reservoirs decreases available storage of water and has deleterious effects on the reservoirs' authorized purposes and benefits. Sedimentation problems are severe in reservoirs on tributaries of the Kansas River (Figure 1) where increasing water demand due to population growth in the watershed must be satisfied by reservoir water storage volume that is shrinking due to decades of reservoir sedimentation. Correspondingly, downstream channels are degrading, and sediment-dependent aquatic species are suffering from a lack of sediment (Shelley et al. 2016). Milford Lake additionally suffers from frequent severe, harmful blue-green algae blooms. On 20–21 July 2016, the USACE RSM Program facilitated the 1½-day training/brainstorming workshop on reservoir sediment management, with a specific focus on Milford Lake in the Kansas River basin. Thirty-seven people attended, with robust participation by 11 State of Kansas agencies, including those responsible for water and natural resources planning, operations, research, and permitting. Other participants included watershed protection groups; the U.S. Geological Survey (USGS); and personnel from the USACE Northwest Division (NWD), Kansas City District (NWK), Omaha District (NWO), and Engineer Research and Development Center (ERDC). This workshop will aid in the development of a framework for future workshops in other locations.

WORKSHOP PREPARATION: Prior to the workshop, available data for Milford Lake was compiled on the hydrology, watershed characteristics, locations and magnitude of in-reservoir sedimentation, sediment physical and chemical composition, outlet works, and results of screening equations. These data were presented during the workshop, prior to breakout sessions to establish a common understanding of this specific reservoir. Workshop topics and speakers were selected to provide comprehensive training with appropriate emphasis on local issues.

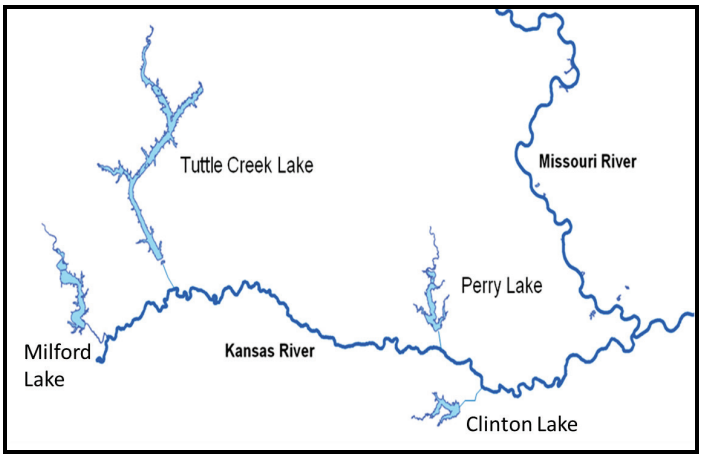

Figure 1. Milford Lake in the Kansas River basin.

WORKSHOP AGENDA: The workshop included technical training by USACE reservoir sedimentation experts, presentations on local impacts and efforts by State of Kansas experts, and hands-on demonstrations to show how sediment management methods work. There were also presentations on the "soft side" of reservoir sediment management (including planning authorities, economics, and permitting), as well as presentations on harmful algae blooms by USGS experts. Information specific to Milford Lake was presented, and breakout groups included brainstorming sessions pertaining to promising solutions and data/analysis gaps for Milford Lake as shown in the following agenda.

- **Wednesday Morning Session (8:30 to 12:00), 20 July 2016.**
  - *Reservoir sedimentation basics (Dr. Paul Boyd, USACE-NWO)*
  - The global picture on reservoirs and sediment management case studies (Dr. Paul Boyd, USACE-NWO)
  - Local impacts of reservoir sedimentation (Erika Stanley, Kansas Water Office)
  - Sediment management strategies (Dr. John Shelley, USACE-NWK)
  - Hands-on demonstrations (Created by Joel Monnig, University of Central Missouri)
  - Downstream benefits/impacts of sediment management (Dr. John Shelley, USACE-NWK)

- LUNCH (12:00 to 1:30)

- **Wednesday Afternoon Session (1:30 to 4:30), 20 July 2016.**
  - Reservoir economics: How did/do we value reservoir functions? (Jenn Henggeler, USACE-NWK)
  - Reservoir planning: What funding/authorities are available to partner with USACE? (Thomas Topi, USACE-NWK)
  - Reservoir permitting: Regulatory considerations (Matthew Mikulecky and Steven Whetzel, USACE-NWK)
  - Sediment management screening methods and equations (Dr. Paul Boyd, USACE-NWO)
  - Numerical models (1D and 2D): The questions they answer and the data required (Dr. Paul Boyd, USACE-NWO)
  - John Redmond 2D model example (Dr. Bryan Young, University of Kansas)

- **Thursday Morning Session (8:30 to 12:00), 21 July 2016**
  - Harmful algae blooms (Jennifer Graham and Guy Foster, USGS)
  - Milford Lake operating procedures, sedimentation, and screening equations (Steven Spaulding and Dr. John Shelley, USACE-NWK)
  - Breakout groups
    (1) What are the most promising solutions for Milford Lake?
    (2) What don't we know yet that you would want to know before supporting (working on, endorsing, approving, or paying for) a sediment management project at Milford Lake?
    (3) What downstream impacts concern you?
    (4) Who wasn't here that needs to be here?
  - Report back
  - Workshop summary and feedback

WORKSHOP TRAINING SUMMARIES: The first day of the workshop followed a training format. Training methods including prepared presentations (Figure 2) and hands-on demonstrations. A brief summary of each presentation follows.

Figure 2. Workshop presentations.

Reservoir Sedimentation Basics. Dr. Paul Boyd (USACE-NWO) educated attendees on the basics of sediment transport for reservoirs. Topics included sediment transport terminology, watershed sediment delivery, Lane's Balance, delta depositional patterns, and monitoring needs and methods.

Reservoir Sedimentation Problems. Dr. Paul Boyd (USACE-NWO) summarized global and national trends in reservoir sedimentation and shrinking water supply storage. The global cost of sedimentation is estimated at $21 billion/year (ICOLD 2009). Dr. Boyd further illustrated the problems associated with reservoir sediment accumulation through three case studies where the sediment is (or is proposed to be) actively managed: (1) Prado Reservoir in California, (2) Paonia Reservoir in Colorado, and (3) Shihmen Reservoir in Taiwan.

Local Impacts of Reservoir Sedimentation. Erika Stanely (Kansas Water Office, the State of Kansas agency responsible for water supply planning) discussed the impending water shortages in the Kansas River basin. Accumulating sediment displaces water storage in the large federal reservoirs. The water supply needs will require purchase of all remaining storage (eliminating flexibility for other authorized purposes except flood control) by 2031. By 2064, even with all multi-purpose pool storage allocated to water supply, the reservoir system will be insufficient to protect against the design drought condition.

Sediment Management Strategies. Dr. John Shelley (USACE-NWK) explained four broad categories of reservoir sediment management actions: (1) Reduce sediment yield from the watershed; (2) Minimize sediment deposition; (3) Increase or recover volume (Kondolf et al. 2014); and (4) Accept diminished benefits, adapt, and decommission. Dr. Shelley explained and provided examples for reallocation, new reservoirs, dam raises, dredging, sediment yield reduction, sediment bypass, sediment sluicing, drawdown flushing, pressure flushing, density current venting, hydrosuction, and inlet extension.

Hands-on Demonstrations. Participants experienced reservoir sediment management hands-on with small-scale "bucket and sand" demonstrations created by Joel Monnig, a senior majoring in Engineering Technology at the University of Central Missouri (UCM). Participants were able to get their hands dirty while gaining an appreciation for how dredging, hydrosuction, inlet extension, and drawdown flushing actually work (Figure 3). Joel Monnig and Dr. Jerry Penland (UCM) led workshop attendees through the hands-on exercises.

Downstream Benefits and Impacts of Sediment Management. Dr. John Shelley (USACE-NWK) challenged the conventional notion of sediment as a pollutant by discussing the geomorphic and environmental impacts of dams and of restoring sediment continuity. He summarized research specific to the Kansas River implicating decreased turbidity in reductions of native turbid-water fish populations (Shelley et al. 2016). Other examples included sand bar degradation downstream from the Missouri River mainstem dams and predation of the federally protected humpback chub on the Colorado River. The type and severity of downstream channel impacts depend on the conditions to which the ecology is accustomed and the timing of infrastructure development relative to the dam closure.

Reservoir Economics. Jennifer Henggeler (USACE-NWK) described the economic analysis that was employed to justify reservoir construction. The method used for Milford Lake was a cost allocation that divided the project costs among the purposes served.

Reservoir Planning. Thomas Topi (USACE-NWK) educated participants on the many authorities and programs through which the USACE could engage in reservoir sediment management actions. His presentation included "Corps 101" describing how the Corps is organized in divisions and districts, the requirements for a Civil Works project, and the basics of the Corps budgeting process. He listed and provided examples of specific authorities that could be employed for reservoir sedimentation related problems.

Figure 3. Hands-on demonstrations.

Regulatory Considerations. Matthew Mikulecky and Steven Whetzel (USACE-NWK) presented on the regulatory considerations for reservoir sediment management. Their presentations included the conditions under which their office would or would not require a permit, as well as local efforts to create a regional general permit to streamline dredging activities at man-made lakes.

Numerical Models. Dr. Paul Boyd (USACE-NWO) demonstrated the capabilities of the USACE Hydrologic Engineering Center River Analysis System (HEC-RAS) water and sediment modeling software. Dr. Boyd compared model results to measured values for a reservoir drawdown flush at Spencer Dam in northern Nebraska. He also discussed the differences between one-dimensional and two-dimensional (2D) modeling.

2D Modeling Example. Dr. Bryan Young (University of Kansas) demonstrated a 2D flow and sediment model for the John Redmond Reservoir in Kansas. His 2D modeling indicated that the strategic dredging of a deep channel in the John Redmond Reservoir could increase the sediment flux from the reservoir by 2.2%.

Harmful Algal Blooms. Jennifer Graham and Guy Foster (USGS) presented information on the interaction between harmful algal blooms and sediment. A myriad of factors influence harmful algal blooms, and the interplay between algae and sediment is complex. Milford Lake experiences frequent harmful algae blooms. Ironically, Tuttle Creek Lake (adjacent to Milford Lake) experiences such high levels of turbidity that insufficient light penetration exists for algae proliferation. In that case, extensive watershed bank stabilization to decrease reservoir sedimentation may actually increase water clarity and the likelihood of algae blooms.

Milford Lake Specifics. Steven Spaulding (USACE-NWK) explained the criteria that govern or limit water releases from Milford Lake. Dr. John Shelley (USACE-NWK) then presented results from screening equations and graphs for which sediment management options may be most effective at Milford Lake.

BREAKOUT GROUPS: Informal discussions were held among the workshop attendees (Figure 4) prior to more formal discussions in organized breakout sessions. Attendees divided into four breakout groups, with a facilitator assigned to each group. Each group addressed the same questions. The ideas generated during the breakout sessions, and during discussions after reconvening, are listed below.

Figure 4. Informal discussions prior to breakout groups.

Question #1: What are the most promising ideas for Milford Lake?

- Sediment management.
- Excavate into the spillway and bury a siphon hose for hydrosuction.
- For water supply, target the lower area near the dam.
- Manage sediment in the system of reservoirs (i.e., store the water supply allotment of Milford in nearby Tuttle so Milford can be flushed without an increased drought risk).
- More best-management practices on upstream channels and in the watershed.
- Sluicing during storms.
- Plan sediment management actions such as dry excavation to be taken during the next drought.
- Harmful algal blooms.

- For water quality, target upstream reaches.
- Scraping the delta via dredging or mechanical means in the winter can remove algae seeds and prevent blooms in the spring.
- These lakes would be green if they weren't so brown.
- No-till increases dissolved phosphorus, which is thought to be associated with interflow.

Question #2: What don't we know yet that you would need to know before supporting (working on, endorsing, approving, or paying for) a sediment management project at Milford Lake?

- Permitting requirements and constraints.
- What is the maximum allowable sediment discharge that the Kansas Department of Health and Environment (KDHE) will allow?
- How do the downstream constraints differ at different flows in the downstream Kansas River?
- Which reservoirs have low-flow gates, what is their elevation, and what is their flow capacity?
- The economic impact of inaction and the economic impact of passing sediment downstream.
- Better quantify the algae/sediment connection. How much sediment (and associated phosphorus) removal is needed to impact the harmful algae problem?
- Are there additional bank stabilization hot spots to be addressed?

Question #3: What downstream impacts concern you? What should be measured or modeled?

- Concerns
    - Threatened and endangered species.
    - Infrastructure.
    - Water quality.
    - Algal bloom moving to the Kansas River.
    - Re-suspension of sequestered pollutants.
    - Downstream flood risk.
- Should be measured or modeled
    - Current survey.
    - Water quality.
    - Need a sediment gage above the reservoir to measure sediment input to the reservoir.
    - Develop discharge vs. sediment transport relationships for incoming sediment.
    - Measure incoming bed load as well as suspended.
    - Model the downstream fate of released sediment.
    - Do a new reservoir bed survey—the previous survey was before the uptick in harmful algae blooms. What changed?

Question #4: Who wasn't present that needed to hear this information?

- Water suppliers.
- Milford USACE project manager.

- Public land managers.
- Regulators at KDHE and Kansas Department of Agriculture, Division of Water Resources.
- Regional Action Committee members.
- Local marina owners.
- Friends of the Kaw (Friends of the Kansas River).
- U.S. Department of Agriculture, Natural Resources Conservation Service, farm services.
- U.S Environmental Protection Agency.
- Conservation districts.
- Geotechnical faculty.
- University students.
- Watershed Restoration and Protection Strategy groups.

(Some of these agencies were in fact represented, but specific experts from these agencies were not present.)

SUGGESTIONS FOR FUTURE WORKSHOPS: After each day of the workshop, participants filled out an assessment survey. Assessment was overwhelmingly positive with some suggestions for improvement, which varied by participant.

Teaching Methods and Effectiveness. Participants arrived at the workshop with varying levels of background on reservoirs and reservoir sedimentation, yet most responded that their knowledge increased.

Customize Future Workshops to a More Narrow Audience. The workshop was geared towards the technically minded non-expert with an intended audience of regulators, planners, and managers. The actual attendees were more diverse, including both the intended audience and also park rangers with less technical experience and researchers with considerably more. One participant suggested expanding the workshop to 3 full days and delving deeper into the technical details of designing solutions; another suggested more specifics on permit requirements while another suggested removing the economics, planning, and permitting information altogether and making a solid 1-day technical course. These varied and contradictory suggestions could in fact be incorporated by creating future workshops with a more refined target audience, such as “Reservoir Sediment Management for Regulators,” “Reservoir Sediment Management for Engineers,” etc.

Revise the Economics. Several participants suggested less time be allotted to understanding the economics of reservoirs while others suggested using actual Milford Lake economic numbers rather than rounded example numbers. The level of detail and breadth covered in this segment is a prime candidate for tailoring to specific audiences. Furthermore, the workshop would benefit from adding material on the economic justification for future reservoir sediment management actions rather than simply the economic analysis used by USACE to originally justify reservoir construction.

Hands-On Demonstrations. A question on the assessment survey specifically asked if the demonstrations added sufficiently to the workshop. The physical demonstrations presented special logistical needs for transport, water sources, and clean up. Most participants, and especially those with less sediment experience, found the hands-on demonstrations very helpful. One participant mentioned that the demonstrations “help to clarify the conceptual thinking I had

on the subjects." Another wrote "they provided a visual demonstration to a theoretical solution." Still others appreciated the chance to "talk with others and break the monotony of classroom setting." On the other hand, several felt they were fun but unnecessary because the presentations had sufficiently explained and demonstrated the processes with graphics and movies or because they were overly simplistic. One participant suggested using them as an ice breaker, and another said that fewer than four demonstrations would be sufficient if transport and setup of four were logistically challenging.

Pilot Projects and Site Visits. One participant suggested pilot projects with cost breakdowns. This is perhaps the most important priority for both improving the education and implementation of reservoir sediment management. More pilot projects are needed to demonstrate the benefits and quantify the impacts and costs of reservoir sediment management. High priority should be given to document, photograph, video, and quantify costs and benefits of reservoir sediment management actions so they can be used as detailed case studies. Another participant suggested incorporating a site visit into the workshop. A site visit to a reservoir actively managing sediment would add tremendous educational value during a week of in-depth training. Potential class locations would be limited, however, as so few reservoirs actually manage sediment. A second option would be a visit to a local reservoir to point out sedimentation impacts (silted-in boat ramps, for example).

CONCLUSION: The reservoir sediment management training/brainstorming workshop held 20–21 July 2016 was highly successful in educating a diverse cross section of State of Kansas and federal employees about reservoir sediment management. The ideas generated for each of the breakout questions can serve as a starting point for future projects.

ADDITIONAL INFORMATION: This Regional Sediment Management Technical Note (RSM-TN) was prepared as part of the U.S. Army Corps of Engineers Regional Sediment Management (RSM) Program by John Shelley of the U.S. Army Engineer District, Kansas City, and Paul Boyd, U.S. Army Engineer District, Omaha. Additional information regarding Regional Sediment Management can be found at the RSM website *http://rsm.usace.army.mil*.

Questions regarding this RSM-TN may be addressed to the following:

John Shelley *John.Shelley@usace.army.mil*
(NWK RSM Point of Contact)

Linda S. Lillycrop *Linda.S.Lillycrop@usace.army.mil*
(USACE RSM Program Manager)

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> Shelley, J. E., and P. M. Boyd. 2017. *Reservoir Sediment Management Workshop for Milford Lake in the Kansas River Basin.* ERDC/TN RSM-17-3. Vicksburg, MS: U.S. Army Engineer Research and Development Center. *http://dx.doi.org/10.21079/11681/22927*

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