Continuous Reservoir Sedimentation Management: Cost-Effective Hydrosuction Dredging Demonstration at John Redmond Reservoir, Kansas

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Focal Area (water for energy & energy for water): Advancing cost- and energy-efficient reservoir sedimentation management operations through hydrosuction dredging technology, sustained by leveraging an existing adjacent grid or developing integrated microgrid.

Existing Challenges: John Redmond Reservoir is a critical multi-purpose reservoir in east-central Kansas that provides water to a public wholesale water supply district, nine municipalities, and six industrial users, including Wolf Creek Nuclear Power Plant (Fig. 1). Sedimentation at John Redmond Reservoir has reduced the reservoir's multipurpose pool water storage capacity by approximately 44% since its construction (1964-2025).

In 2016, contractors to the State of Kansas dredged 3 million yd^3 from John Redmond Reservoir for a cost of \$20M or \$6.67/ yd^3. Updated to 2025 prices[1], the cost would be approximately \$11.0/ yd^3, which equates to more than \$13M/year to remove the annual sediment deposition of 744 ac-ft within the reservoir. The total maintenance cost with this type of dredging is very high for long-term use due to the large volume to be removed.

Without intentional, significant, sustained sediment removal, John Redmond will lose its ability to store water. This jeopardizes the continued function of Wolf Creek Nuclear Power Plant, which supplies its off-channel cooling water reservoir directly from John Redmond. The nuclear power plant generates more than 20% of Kansas's total energy production (Evergy 2025), providing electricity for more than 800,000 homes. = Estimates from the Kansas Water Office indicate that sedimentation at John Redmond Reservoir may result in insufficient yield to support current water supply contracts for Wolf Creek Nuclear Power Plant and downstream communities beyond 2045.

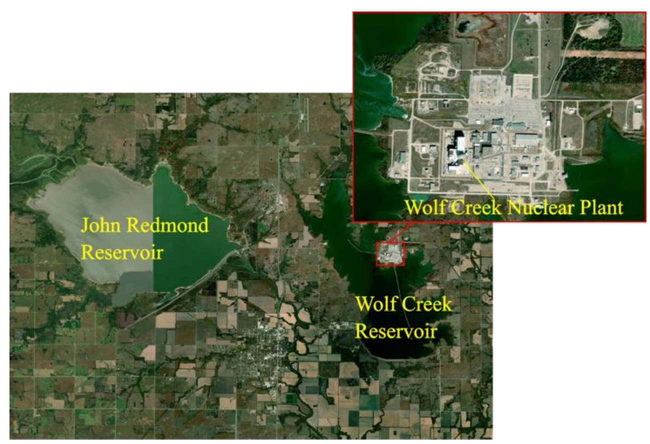

Fig. 1 Aerial imagery of John Redmond and Wolf Creek Reservoirs and Wolf Creek Nuclear Plant

[1]Based on USACE average dredging price increases from 2016 to 2023, as found in USACE (2024), and linearly extrapolating an additional two years. Does not account for tariffs and other factors unique to 2025.

Hydrosuction is a lower-cost sediment removal technique that utilizes the head difference between the upstream reservoir and downstream channel to create a Venturi-like suction to power transport and downstream discharge of sediment. Two types of hydrosuction are possible. At lakes with small dams, the hydrosuction discharge line can be a siphon that travels up and over the dam to discharge at a lower elevation downstream. Theoretically, physics limits the "up-and-over" siphon to dams less than 33.8 ft tall with clear water and a frictionless pipe, though real-world experience of siphoning sediment places a stricter limit. At taller dams, hydrosuction can still be accomplished by transporting sediment through the dam (Fig. 2a). This requires utilizing an existing conduit or a dam retrofit. John Redmond Reservoir features a 30"water line, a conduit that travels from the lakeside to downstream of the dam (Fig. 2b). This conduit, which is rarely used during outlet/stilling basin maintenance, provides a near-ideal opportunity for implementing a hydrosuction sediment removal system at John Redmond Reservoir.

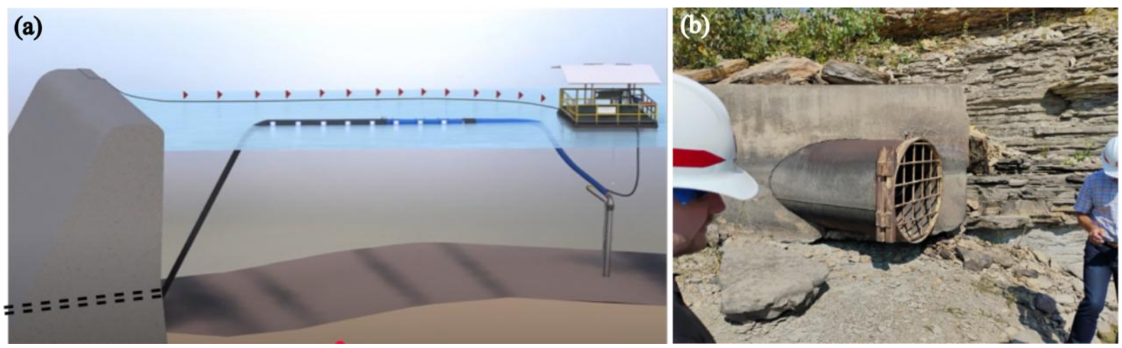

Fig. 2 (a) A schematic view of a hydrosuction sediment removal system (from SediCon, 2025) and (b) Discharge end of 30" water line at John Redmond Reservoir

Hydrosuction significantly reduces costs by not requiring acquisition of nearby land for sediment storage or transport of the sediment slurry to the storage area by pumping it through a pipeline (approximately 50% of total dredging cost). Montoya (2018) estimated a 70% cost reduction for a hydrosuction as compared to a traditional diesel dredge at El Canadá lake in Guatemala. Combining both cost savings at John Redmond could result in as much as an 85% cost reduction— potential savings of $11.2M per year compared to standard hydraulic dredging with land disposal.

Despite the potential of hydrosuction for continuous and affordable reservoir sediment management, further research needs to be conducted to fully unlock the opportunity and enhance energy–water resilience.

(1) Investigating optimal design and operating conditions of a hydrosuction system

As hydrosuction has not been widely deployed as routine reservoir sediment management, its design and operating practices have not been standardized. It is important to conduct a systematic analysis to maximize the energy efficiency of this sediment removal system. For example, the size and shape of intake nozzles should consider the type and size of sediment, as well as the amount of sediment transported downstream. In addition, the diameter of the pipe needs to be carefully chosen, and the system requires an adequate head difference to maintain sufficient flow velocity to prevent clogging.

While the suction and transport operate without external power, the hydrosuction system needs external energy to power water jets that suspend bed material for efficient intake. The velocity and angle of water jets, as well as the distance from the ground to the water injection nozzle, affect the effectiveness of sediment suspension by the external energy, which eventually determines the operating cost.

(2) **Finding solutions to power hydrosuction for continuous sediment removal**
Sedicon (2025) estimates that a hydrosuction sediment removal system for John Redmond Reservoir would require 120 kW for the operation of a smaller-scale demonstration and 500 kW for the operation of a full-sized system that achieves complete water storage sustainability. While these energy requirements for John Redmond may be met by leveraging energy generated from the nearby nuclear plant, there are many reservoir facilities without existing adjacent energy sources. Adjacent sources, transmission, and other grid integration infrastructure would be important considerations for evaluating hydrosuction operations at other facilities.

Near-Term Opportunity: The State of Kansas has allocated $1.5M in their State 2026 fiscal year budget towards a hydrosuction sediment removal project at John Redmond. Investigation at this facility can build on existing partnerships between university (University of Kansas), industry (Bowersock Mills and Power Company), state (Kansas Water Office), and national laboratories (Oak Ridge National Laboratory). John Redmond Reservoir offers a uniquely positioned case for investigating how energy-efficient hydrosuction technology helps improve storage of water within the reservoir (energy for water) and how the additional water can increase energy production by the nuclear power plant (water for energy). Support from the Water Power Technologies Office (WPTO) would enable expansion of scope of the R&D for hydrosuction dredging technology, test its full potential, and find solutions for continuously powering the sediment removal system. Based on National Inventory of Dams (NID) data, fewer than 10% of US dams with reported outlet infrastructure are equipped for sediment management (e.g., sluice gates); indicating dredging may be the only feasible way to maintain water storage at most reservoirs. This demonstration project can pave a path to develop effective and sustainable sediment management for many of aging reservoirs across the U.S.

Success Measure: The success of this project can be quantitatively measured by the amount of restored water storage capacity, the reduced unit cost of the sediment removal operation ($\$/yd^3$), and the expected economic benefits of the restored water used to cool the Wolf Creek Nuclear Power Plant. We can also evaluate the project's success by identifying which other U.S. reservoirs can adopt the demonstrated hydrosuction dredging technology and by quantifying the associated economic benefits.

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