FINE SEDIMENT SOURCES AND MOBILIZATION OF SAND DOWNSTREAM OF FRIANT DAM WITHIN SAN JOAQUIN RIVER SPRING-RUN CHINOOK SPAWNING REACH, CALIFORNIA

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Introduction

The upper 7 miles of the mainstem San Joaquin River (SJR) is expected to be the primary spawning and egg incubation reach for spring-run Chinook salmon. However, the habitat quality is negatively impacted due to significant in-channel sand storage that clogs the gravel bed and reduces hyporheic exchange, thereby reducing salmon egg-to-emergence success. Given that the coarse sediment supply from upstream was disconnected by Friant Dam in the mid-1940s, several questions exist regarding the source of large volumes of in-channel fine sediment storage and the extent to which fine sediment is evacuated from the reach by high flows.

Figure 1. San Francisco State University (SFSU) Bray Rivers Lab cataraft. Cableway and towers allow lateral traversing across the channel and the crane boom lowers a bedload sampler into the channel.

Planned flood control releases from Friant Dam, coupled with a large forecasted rainstorm, presented a unique opportunity to examine sediment transport in the mainstem SJR and tributary Cottonwood Creek (CTK) during the week of March 13-16, 2023. We conducted bedload sampling at two sites (Figure 2) to begin addressing the following questions:

1. What is the magnitude of sand delivery from CTK to the mainstem SJR?
2. What is the magnitude of sand transport in the mainstem SJR at Ledger Island between 6,000 – 8,000 cubic feet per second (cfs)?
3. Does sand delivery from CTK explain sand stored in the mainstem SJR (e.g., inform a fine sediment budget)?
4. Is CTK bedload discharge (sand) correlated with streamflow discharge?
5. How do bedload transport measurements in the mainstem SJR at Ledger Island compare to those previously collected (GMA 2011)?

Figure 2. Site map of the two bedload sampling locations in proximity to Friant Dam.

CTK meets the mainstem SJR 1000 feet downstream of Friant Dam.

The mainstem SJR at Ledger Island is 4.5 miles downstream of Friant Dam

Methods

Bedload transport data were collected from a cataraft-based sampling platform (Figures 1 and 4). The cataraft was attached to a cableway tensioned perpendicular to flow, allowing the cataraft to traverse laterally across the river. A TR-2 bedload sampler was lowered from the cataraft to the riverbed, collecting samples within a 0.5mm mesh bag.

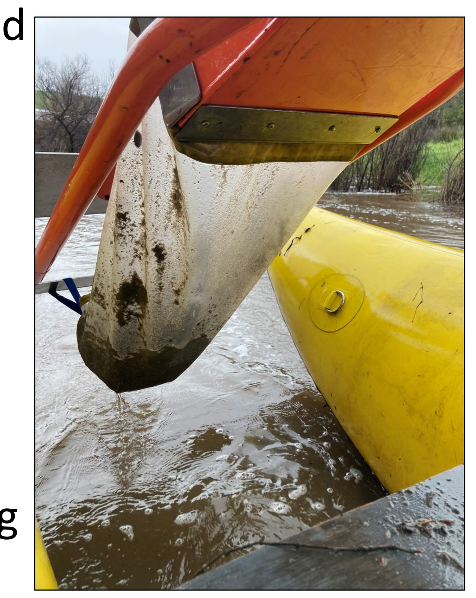

Figure 3. TR-2 bedload sampler raised from cataraft with sample collected in mesh bag.

The TR-2 sampler has a 6 x 12-inch entrance nozzle and a low expansion ratio, providing low hydraulic efficiency to minimize the suction effect and over-sampling of sand (Figure 3).

Standard bedload sampling methods were used (Edwards and Glysson 1999), such that each sample consists of a single "pass" across the channel with several TR-2 deployments at even spacing intervals across the channel and specified down-times.

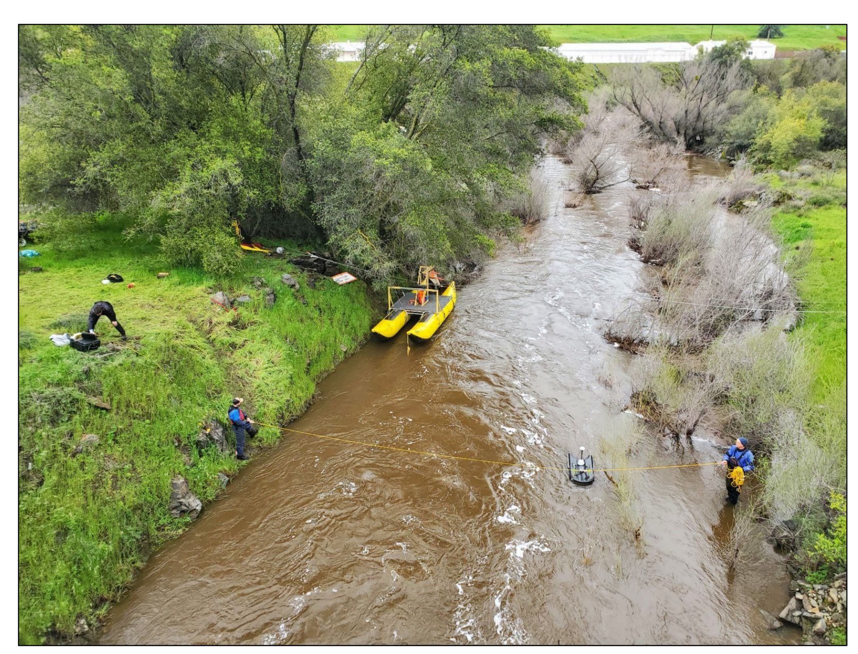

Figure 4. Bedload sampling during high flows on CTK with cataraft sampling platform. Field crew are measuring stream discharge with an ADCP. View is looking downstream toward the mainstem SJR.

Results

Preliminary analysis of the data from this sampling effort indicate four findings of interest:

1. **Sand is transporting at flows of 6,700 cfs on the mainstem SJR at Ledger Island**

- Figure 5 shows the hydrograph of the mainstem SJR with the rates and times of bedload samples.
- Bedload at Ledger Island was 8.8 tons/day (mean), falling below GMA 2011 power function transport rate (Figure 6).
- By comparison, mean bedload at CTK was 28.6 tons/day.
- Bedload was primarily coarse sand; however, the maximum grain size diameter was 40 mm.

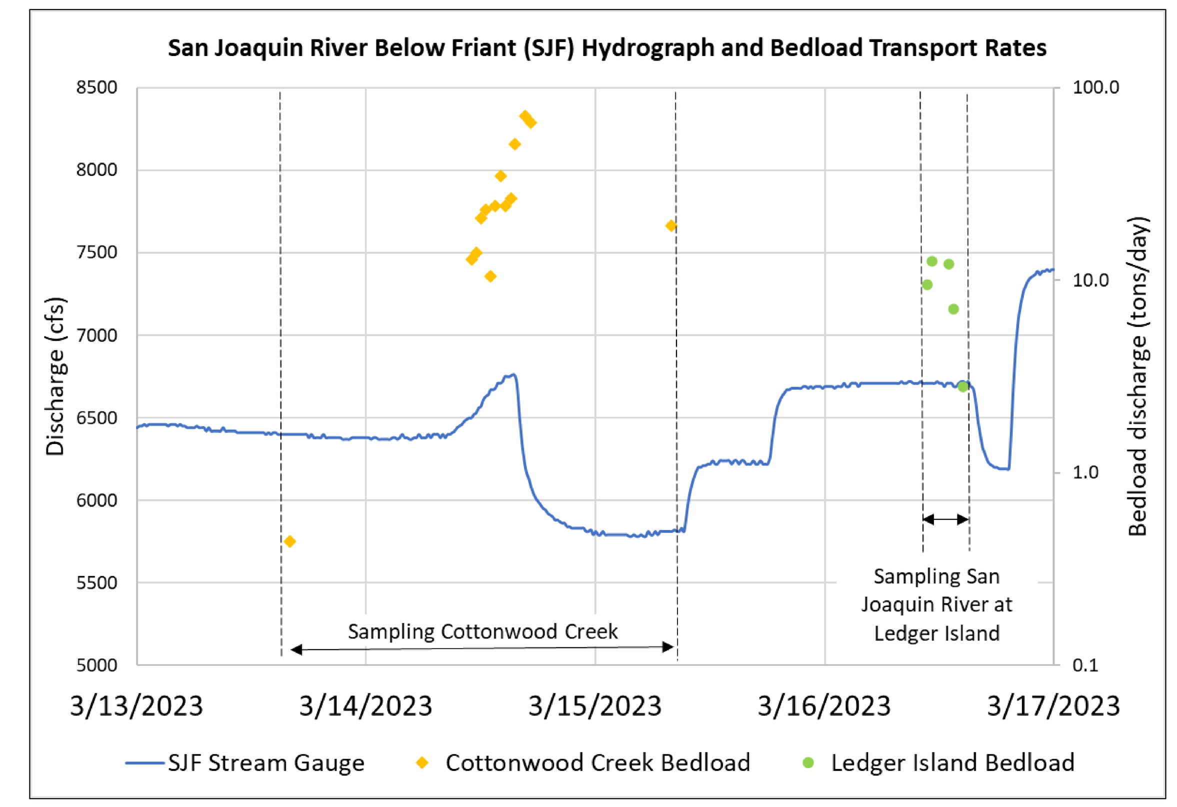

Figure 5. Hydrograph of mainstem SJR at stream gauge SJF (~ 1.5 miles downstream of Friant Dam) with bedload sample times and rates. Sampling at CTK occurred over 2 days with changes in mainstem flow during the sampling at CTK, but stable flow conditions were present while sampling in mainstem SJR at Ledger Island.

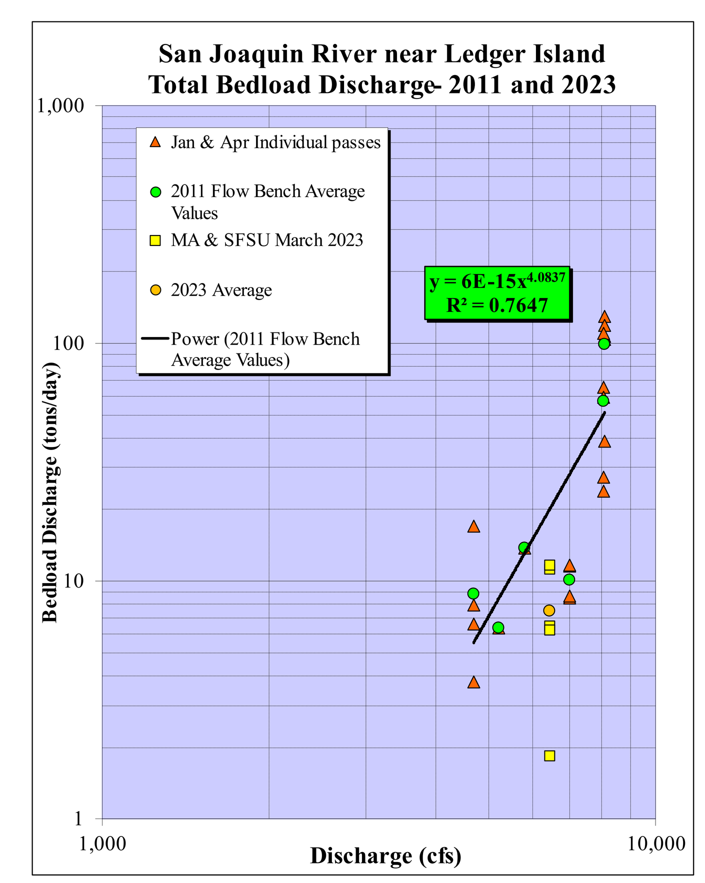

Figure 6. Bedload transport rates on the mainstem SJR at Ledger Island, measured by GMA in 2011 with 2023 transport rates superimposed.

2. **A preliminary sedigraph (Figure 7) for CTK suggests that 37.4 tons of sand were transported over a 2-day period at flows ranging from 160 to 470 cfs**

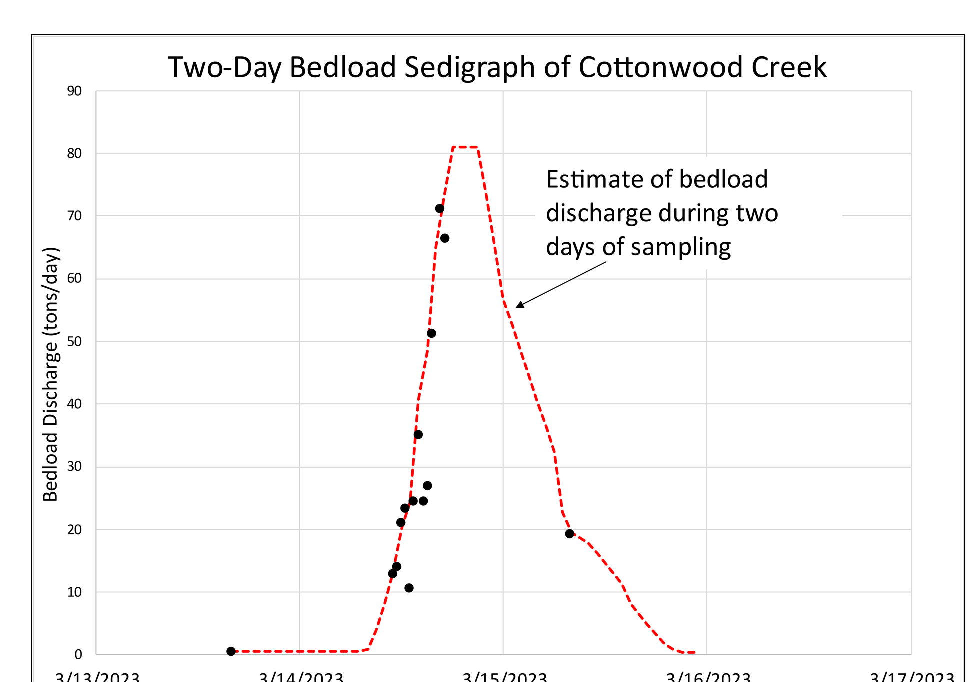

Figure 7. Preliminary sedigraph with potential volume of sand supplied to mainstem SJR during 2 days of sampling.

3. **Hysteresis was observed in CTK sand transport, potentially due to changes in a backwater effect from the SJR**

- Bedload discharge was not correlated with streamflow discharge during the CTK sampling.
- Figure 5 shows most CTK samples being taken on rising limb of SJR hydrograph; however, samples collected after the sharp flow reduction revealed a continued increase in bedload transport on CTK.
- Mainstem SJR flow reduction resulted in a stage decrease on CTK without a commensurate decrease in discharge.
- It is possible that a backwater effect in CTK was reduced as mainstem SJR flows reduced, which in turn increased CTK hydraulic gradient and sediment transport capacity.

4. **The highest sand transport rates along the SJR channel transect did not occur where flow velocity was the highest**

- Sampling efforts were focused in the area of observed bedload transport indicated by the white arrow in Figure 8.
- Figure 8 represents a discharge measurement collected with an ADCP.

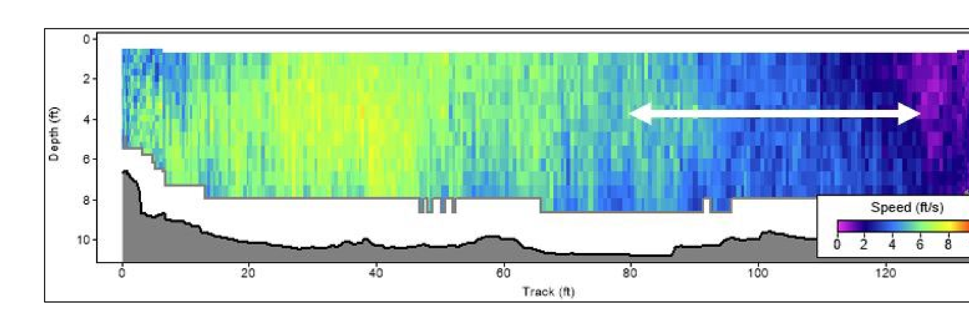

Figure 8. Cross-sectional velocity profile of sampling section at Ledger Island. Samples were collected in the width of the white arrow.

Next Steps

These results confirm that the SJR has an intermittent but large sand source immediately below Friant Dam which is being activated during high tributary flows. More questions are raised about how effective the SJR is at flushing the sand supplied by CTK and how high flows can be more effective in flushing fine sediment from Reach 1A of the SJR. Future work will analyze bedload grain size distribution, changes to in-channel sand storage, and perform additional bedload sampling across a greater range of flows and locations.

References

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