RECONSTRUCTING RESERVOIR STRATIGRAPHY FROM HYDROLOGIC HISTORY AND SIMPLE TRANSPORT CALCULATIONS: ENGLEBRIGHT LAKE, YUBA RIVER, NORTHERN CALIFORNIA

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Abstract: Englebright Dam impounds the Yuba River in the foothills of the Sierra Nevada, creating a 14-kilometer long reservoir. The dam is 80 meters tall and was completed in December 1940 by the California Debris Commission, with the primary purpose of trapping sediment from hydraulic mining activity in the Yuba River watershed and thus reducing flood risk downstream. In 2001-2003, the U.S. Geological Survey conducted an extensive bathymetric survey and coring project of Englebright Lake. Cores were extracted along the length of the reservoir and analyzed for grain size, providing a detailed stratigraphic cross section. Between 1940 and 2001, accumulation of sediment in the lake reduced the original storage capacity by about 26%. This accumulation amounts to 24.8 million metric tons of sediment, which is approximately 20% gravel, 49% sand, 25% silt, and 6% clay. The reservoir longitudinal profile exhibits the classic deltaic configuration, with a topset composed primarily of gravel and sand, a foreset composed mostly of sand and silt, and a bottomset of silt and clay with a small fraction of fine sand.

Prior to construction of New Bullards Bar Dam in 1970, Englebright Lake was drawn down about 20 meters annually during the summer irrigation season. The reservoir has also experienced several very large floods during its history (1995, 1964, and 1997). In order to analyze the relative importance of floods and drawdowns in building the deposit, we performed some simple calculations of reservoir hydraulics and sediment transport. The procedure consisted of backwater calculations (yielding the shear velocity) for two conditions, one representative of floods and one of drawdowns. The shear velocities in the reservoir were then compared with the settling velocities for a range of grain sizes in order to determine the approximate extent of suspended transport of a given grain size.

The computed shear-velocity profiles (inset figure) for representative events from 1997 indicate that both floods (Q=3,821 m^3/s, lake elevation=166 m) and drawdowns (Q=37 m^3/s, lake elevation=151 m) have the potential to transport sand in suspension in the upper reach of the reservoir (the topset and foreset), with floods somewhat more vigorous. In this upper topset reach, shear velocities easily exceed the settling velocity (dashed horizontal lines in the figure) for fine sands and indeed approach the settling velocity for coarse sands; thus, both types of events have the potential to transport and rework sand in topset and foreset sections of the delta. The short duration of floods (hours to days) compared to drawdowns (weeks to months) suggests that although floods may initially transport much of the coarse sediment to the topset and foreset region, significant reworking occurs during drawdown periods.

The calculations indicate that the effects of floods and drawdowns differ downstream from the delta front. The drawdown shear velocities in the bottomset region exceed the settling velocities for clay and fine silt, but not sand. In contrast, shear velocities under flood conditions exceed the settling velocity for fine sand throughout the reservoir, suggesting that most of the fine sand in the bottomset was deposited during floods and not during drawdowns. These results are also consistent with the sedimentological observation that sand finer than ~0.5 mm is not deposited downstream of the delta front. Furthermore, the calculations suggest that fine sediment bypass may be important during large floods.