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Effect of Hydropeaking Operations on Hyporheic Zone Thermal Regime

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Hydropeaking, the alternating storage and release of water from reservoirs for the purpose of hydropower generation, perturbs the thermal regime of many large rivers. While the effects of hydropeaking, and more broadly all types of hydropower operations, on stream thermal regimes have been long studied, there is a paucity of work on how dam operations impact the thermal regime of the streambed hyporheic zone. Streambed temperature is an important control on both biotic (N, C) and abiotic (metals) constituents as well as habitat suitability for benthic organisms (invertebrates, fish eggs, and microbial populations). Thus, developing a more complete understanding of how frequent river fluctuations from dam operations affect the streambed thermal regime will enable more comprehensive characterization and prediction of the effects of dam operations on river ecosystems.

This study uses a novel field dataset combined with numerical modeling to investigate hydropeaking's impact streambed thermal regime in a large regulated river. The field data was collected from the 4th order Lower Colorado River at a site 12 km downstream from a dam that induces large daily flow variations. We used 24 vertical thermistor arrays to obtain time series data of streambed temperatures in the shallow 50 cm of streambed across the entire ~70 m channel. The data was collected over 7 days of continuous daily flow oscillations. Our field data revealed two distinct regions in the streambed. The near-bank areas of the streambed were highly dynamic thermally, transitioning between river and groundwater temperatures on a daily basis. This was in contrast with the rest of the streambed located away from the bank where the thermal regime was more similar to that of the river.

To aid in the interpretation of the field observations and to provide a more general explanation of the observed phenomenon, we ran 2-D fluid flow and heat transport models for a river channel subjected to the same forcings as our study site and with similar hydraulic properties. We additionally explored the effect that hydraulic conductivity and groundwater conditions have on the formation of the two distinct regions observed in the field data. Our modeling results demonstrate that strongly gaining groundwater conditions and high hydraulic conductivity favor the development of thermally dynamic zones near river banks, while low hydraulic conductivity and/or gaining groundwater conditions result in more muted temperature fluctuations. These patterns could help predict thermally sensitive processes in the streambeds of hydropeaked or flooding rivers.