

Differentiated Hazard Mechanisms and Thresholds of Mouth Bars in Sediment-laden Reservoirs

Wang Qiang^{1,2,*}, Wang Ting^{1,2}, Ren Zhihui^{1,2}, Ma Huaibao^{1,2}, Jia Menghao^{1,2}

¹Yellow River Institute of Hydraulic Research, Yellow River Conservancy Commission, Zhengzhou, China

²Key Laboratory of Yellow River, Ministry of Water Resources, Zhengzhou, China

Email address:

1041830131@qq.com (Wang Qiang)

*Corresponding author

Abstract

Reservoir mouth bars are typical depositional landforms at confluences of main stems and tributaries. Their development occupies effective storage capacity and threatens flood control, beneficial uses, and sediment reduction. Current studies lack systematic cross-type comparisons and a unified risk assessment framework. Based on long-term field data (24–64 years) from three representative reservoirs on the Yellow River — Xiaolangdi, Sanmenxia, and Liujiaxia — this study reveals three differentiated hazard mechanisms from the perspectives of flood control, beneficial uses, and sediment reduction: tributary-type (Xiaolangdi), backwater-end type (Sanmenxia), and mid-reservoir type (Liujiaxia). A two-tier evaluation system consisting of a “specific hazard index + comprehensive risk index” is developed together with a four-level threshold system. The results show: (1) The tributary-type at Xiaolangdi exhibits a chain positive feedback of “development-sediment trapping-sedimentation reduction”, with a specific hazard index (bar height/10 m) >1.0 corresponding to high risk; (2) The backwater-end type at Sanmenxia is characterized by rising Tongguan elevation which backwaters the Weihe River flood level; the specific hazard index (elevation rise/3.5 m) >1.2 indicates extremely high risk; (3) The mid-reservoir type at Liujiaxia features “storage loss – multi-functional coupling damage”; after operation of the sediment flushing tunnel, the sediment delivery ratio increased from 0.2 to 0.6, effectively mitigating the risk. Based on the three mechanisms, a comprehensive risk index T (0–1) is constructed and a four-level threshold is established: low risk $T < 0.3$, moderate risk $0.3 \leq T < 0.5$, high risk $0.5 \leq T < 0.7$, and extremely high risk $T \geq 0.7$. This study provides a scientific basis for risk identification and targeted prevention of mouth bars in sediment-laden reservoirs.

Keywords

Reservoir Mouth Bar, Hazard Mechanism, Risk Threshold, Yellow River