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A Structured Approach to Sediment Transport Prediction

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There are two types of sediment transport problem. One, flow competence, concerns the conditions that initiate motion of grains on the bed surface. The other, transport capacity, concerns the rate at which sediment is transported and involves sediment found locally on the bed as well as sediment delivered from upstream. The two problems can be linked by the critical stress for incipient motion. A model for critical stress is used directly to predict flow competence. The Ashida/Parker similarity hypothesis provides a useful approximation of transport rates and incorporates local sediment effects entirely via the reference stress, a surrogate for critical stress. Although critical stress is key to both predictions, its application is quite different. The difficult problem of wash load – sizes found in transport in quantities much larger than would be predicted by their presence in the bed – makes the distinction clear and challenges any attempt to predict transport rate from a competence-like approach based on hydraulics and bed material alone. The Shields Diagram and a hiding function provide models for critical stress for uni-size and mixed-size sediment. In addition to grain size – both absolute and relative – other factors alter the critical stress of bed material. These include the proportion of fine-grained material, the aging or freshening of bed material via biologically mediated processes, and the development of bed structure at flows close to the critical stress. Although these factors directly influence the prediction of competent flows, their effect on transport rate is less clear. As flow increases, to what extent does bed strengthening through structuring and other mechanisms persist in dampening transport rate? The answer involves the condition of partial transport in which some grains in a size fraction are active and others remain inactive. Tracing of grains in the flume and field provide guidance on the domain of partial transport and thus on the influence on transport rates of bed strengthening. A surface-based transport model can be used with a bed-sorting algorithm to predict the evolution of the bed surface under active transport. The same transport model can be used in inverse form to predict the combination of flow, transport, and bed surface grain size under steady-state conditions. These formulas provide a useful starting point for documenting the effect of bed structuring on sediment transport rate. Careful (although not complex) consideration of the type of transport problem – competence or capacity – and the nature of the time-varying boundary conditions are needed to make accurate predictions of sediment transport.