ABSTRACT

This dissertation presents a suite of field observations, flume measurements, and numerical models investigating the response of channel beds to an increased sediment supply. Monitoring the Sandy River, Oregon following removal of the Marmot Dam provides measurements of response to a five-fold sediment supply increase. Where supply increase was the greatest, bed slope became steeper and bed topography became less variable. Reaches with less aggradation responded primarily with bed surface fining. During the initial stages of deposition the bed configuration bore little resemblance to the pre-removal configuration, however, after one year, the planform regained the pre-removal pattern.

In a recirculating field-scale flume with alternate bar topography, sediment supply was increased by manually augmenting the sediment supply in two steps such that the final bed transported three times as much as the initial bed. The initial and final bed topography and texture were very similar and included long stationary alternate bars. The transient bed was very different, dominated by several scales of shorter wavelength migrating bedforms. Further, the adjustment in topographic and textural patterns continued after the bed slope and mean sediment transport had approached steady state.

A one-dimensional (1-D) morphodynamic model predicted steady state slope and transport rates for the flume experiments, but it over-predicted the rate of adjustment. Comparison of 1-D model results with flume observations demonstrated the importance of 2-D adjustments related to the spatial variability of topography and texture.

The ensemble of field, flume, and numerical models highlight four bed responses to sediment supply – changes to the mean and distribution of both bed topography and texture. Adjustments can operate on different time scales, with grain size most likely to respond first. Spatial patterns of topography and texture can adjust to convey an elevated sediment supply without an increase in bed slope. Where slope increases are the dominant response, spatial patterns of topography and texture may moderate the slope effects, introducing systematic errors in one-dimensional model predictions.
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NOTATION

The following symbols are used in this paper:

\( \alpha \) = parameter relating roughness height to surface \( D_{90} \);
\( a_u \) = upwinding coefficient used for spatial derivatives in equations (11) and (12);
\( a_{int} \) = parameter characterizing material released as the bed aggrades;
\( b \) = exponent in the hiding function (equation 7) used to compute bedload transport
\( B \) = flow width;
\( c_1, c_2, c_3 \) = coefficients in dimensionless adjustment time prediction equation(19);
\( C_d \) = drag coefficient;
\( D \) = grain size;
\( D_i \) = representative grain size for the \( i \)th size fraction;
\( D_{xx} \) = grain size for which \( xx\% \) (50, 86, 90) of the grain size distribution is finer;
\( D_{50g} \) = median grain size of the portion of the grain size distribution larger than 2mm;
\( D_{sm} \) = geometric mean grain size of the surface grain size distribution;
\( e \) = water surface elevation;
\( F_i \) = proportion of size \( i \) on the bed surface;
\( F_s \) = fraction of the bed covered in sand (<2 mm);
\( f_{li} \) = proportion of the material of grain size \( i \) in the active layer-substrate interface;
\( \phi \) = ratio of stress to reference stress;
\( g \) = gravitational acceleration;
\( h \) = flow depth;
\( \eta \) = bed elevation;
\( L_f \) = bed length;
\( L_a \) = active layer thickness;
\( \lambda \) = decay parameter;
\( \lambda_p \) = bed porosity (set to 0.35);
\( p_i \) = proportion of grain size \( i \) in transport;
\( Q \) = water discharge (volumetric);
\( Q_i \) = imposed sediment mass flux;
\( Q_0 \) = pre-increase equilibrium sediment mass flux;
\( q^* \) = dimensionless unit sediment volumetric flux;
\( q_b \) = total bedload transport rate per unit width;
\( q_{bi} \) = bedload transport rate per unit width of size \( i \) (volumetric);
\( \rho \) = water density;
\( s \) = sediment specific weight (ratio of sediment to water density) (set to 2.65);
\( S \) = bed slope;
\( S_f \) = friction slope;
\( \tau_0 \) = bed shear stress;
\( \tau_{rm}, \tau_{ri} \) = reference bed shear stress for the mean and \( i \)th grain size;
\( \tau^*_{rmi} \) = reference dimensionless bed shear stress for the mean grain size;
\( \tau^* \) = Shields Stress (equation 6);
\( T_{25} \) = adjustment start time; time required to complete 25\% of the total adjustment;
\( T_{95} \) = adjustment time; time required to complete 95\% of the total adjustment;
\( T^* \) = dimensionless adjustment time;
\( U \) = depth averaged streamwise velocity;
\( u^* \) = shear velocity;
\( W^*_i \) = dimensionless transport rate for the \( i \)th size fraction.
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CURRICULUM VITA

I was born on April 23, 1973 and spent my youth on the Colorado Front Range. Upon graduation from the US Air Force Academy, I received both a Bachelors of Science in Political Science, and a commission as an Air Force 2nd Lieutenant on May 31st, 1995. My career as an Air Force officer and F-16 fighter pilot took me from Asia to the Middle East, and throughout the western United States. After nearly 11 years, multiple deployments, a few Air Medals, and several thousand flying hours, I left the Air Force at the rank of Major. My shift from national security issues to western water issues began in Boise, Idaho as a graduate research assistant at the University of Idaho and a Boise State University student. Fortuitous events brought me east to Baltimore for graduate school where in my coursework and research I endeavored to strike a balance between a technical focus on fluid mechanics and sediment transport on one hand, and the larger context of water resources development, fish ecology, and environmental policy on the other. During my graduate school career, I earned Masters of Science from the Department of Geography and Environmental Engineering, Johns Hopkins University, worked as a hydrologist and geomorphologist for the USGS Alaska Science Center, and spent time researching and living in wonderful places such as Sandy, Oregon, Minneapolis, Minnesota, and Anchorage, Alaska.