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Channel widening quantification under laboratory conditions

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Channel widening constitutes about 80% of total soil loss, especially in the presence of a plow pan which manifests a less or nonerodible soil layer. Channel bank erosion quantification is prerequisite to couple effectively the bank sediment supply system with fluvial sediment transport fluxes. The objectives of this study were to: 1) describe and evaluate methods for monitoring and data post-analysis of channel widening and 2) investigate how inflow rate, slope gradient and initial channel width affect channel widening processes in the presence of a non-erodible layer. Technology was developed to capture 5-cm spaced cross-sections along a soil flume at 3-s time intervals. Two off-the-shelf digital cameras were positioned 3-m above the soil bed and controlled by a program to trigger simultaneously and download images to the computer. Methods utilizing color differences in images and elevation differences in DEMs were applied to detect discontinuities between channel walls and the soil bed. Channel widths were calculated by differentiating the coordinates of these surface discontinuities. A volumetric method was used to calculate flow velocity with measurements of flow depths obtained from ultrasonic depth sensors. Sediment concentration was determined by manual sampling.

The results showed that different channel width calculation methods exhibited comparable outcomes and achieved satisfactory accuracy. Sediment discharge showed a significant positive linear correlation with channel widening rate, while exhibiting a 5 to 25-s time lag compared to the peak of channel widening rate. Total sediment discharge calculated by photogrammetry was 3.1% lower than that calculated by manual sampling. Flow velocity decreased with time and showed a significant negative power correlation with channel width. Sediment delivery and channel width increased with the increase of inflow rate, bed slope and the decrease of initial channel width. Exponential equations were used to predict the channel width time series. Toe scour, crack development, sidewall failure and block detachment and transport, in sequence, were the four main processes of channel widening. Basal scour arc length, tension crack length and width decreased with initial channel width and increased with time, flow discharge and bed slope. Basal scour arcs were divided into three patterns according to different shapes in comparison to the failure arcs. Sediment delivery equations based on the disaggregation of concentrated flow entrainment and mass failure were also fitted. Advantages of the described methodology include automated high spatial and temporal monitoring resolution, semi-automated data post-processing, and the potential to be generalized to large scale river/reservoir bank failure

monitoring. This study provides new insight on improving channel widening measurements and prediction technology.