Sediment Transport Processes
Solution

1 Objective

The goal of this workshop is to gain an understanding of basic sediment transport processes such as advection, diffusion, erosion, deposition, hysteresis, and equilibrium vs non-equilibrium transport. The workshop does not require specific knowledge of how these processes are computed or setup in HEC-RAS. It only guides the reader through different examples illustrating and highlighting the effect of specific processes using idealized models. The models utilized are based on a simple river confluence with idealized boundary and initial conditions. The reason for using an idealized dataset is to isolate specific processes as much as possible and to avoid distractions with complicated terrains. However, the examples are complicated enough to be interesting and relevant to field applications.

2 Wash Load Analysis

Question: How do advection and diffusion affect the concentration field?

Advection transports concentration following the current velocities. Diffusion spreads the concentration in the direction of concentration gradients.

Question: In the case with diffusion, what would happen further downstream of this model extent? Would the transverse concentration profile change any further?

Yes, the concentration would continue to mix in the transverse direction until the concentration is completely uniform in the transverse direction.

3 Sand Erosion Downstream of a Confluence

3.1 Equilibrium vs Non-Equilibrium Transport

Question: If the sediment concentration is assumed to be at equilibrium, does the model still need to solve an advection-diffusion equation?

No, this why the equilibrium sediment models do not solve advection-diffusion equations and instead solve a sediment balance equation (i.e. Exner equation) which computes the bed change as a function of the divergence of the equilibrium sediment transport rates.

Question: How can you explain the differences between the actual concentrations and capacities near the confluence?

The sediment does reach equilibrium immediately but rather takes a certain distance to reach equilibrium. The differences are due to the non-equilibrium nature of the sediment model.

Question: What happens to the actual sediment concentrations downstream of the confluence? (Hint: compare to equilibrium values)

The concentrations tend towards the equilibrium values.

Question: What is the main difference between equilibrium and non-equilibrium sediment models?

Equilibrium sediment transport models assume that the sediment transport is at equilibrium whereas sediment non-equilibrium sediment models do not.

Question: When spatially averaging over larger and larger scales, does the sediment transport tend towards an equilibrium model?

Yes, over larger spatial scales sediment transport in on close to equilibrium which is why Exner models such as the one in HEC-RAS 1D work well at larger scales.

Question: How can you explain some of the differences between the equilibrium and non-equilibrium bed change results?

In the case of the equilibrium results, the eroded material near the tributary is immediately deposited downstream when the capacity drops whereas in the non-equilibrium model the sediment is transported further downstream before settling. The non-equilibrium bed change results are further downstream and lower in magnitude. This is a common results for short-term simulations.

3.2 Sediment Horizontal Mixing

Question: Explain the differences in the bed change results with and without diffusion based on the sediment concentrations.

The bed change with diffusion deposits sediment in the overbanks whereas the case without diffusion does not. With diffusion, some of the sediment that eroded from the main channel is diffused into the overbanks and therefore there is a net erosion of sediment in the main channel.

3.3 Sediment Hysteresis

Question: Explain the differences between the concentration time-series with and without the total-load correction factor (i.e. beta)

The correction factor produces a delay in the concentrations with respect to the flow and capacities.

Question: Explain the differences and similarities in the bed change time-series.

The bed change with and without the correction factor are similar during beginning of the triangular hydrograph. The bed change with the correction factor occurs faster during most of the hydrograph because of the delay of the concentrations. The delay in the concentration eventually causes and overloading situation and deposition during the tail end of the hydrograph.