CONCEPTUALIZATION OF HYDRAULIC AND SEDIMENTARY PROCESSES IN DOWNSTREAM REACHES DURING FLUSHING OF RESERVOIRS

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The need to preserve reservoir volume capacity through reservoir flushing, often leads to flows with extreme sediment concentrations released to the downstream reaches. Sedimentation rates increase rapidly leading to fine-grained deposition coats on coarser river bed material, and a shifting of sediment problems from one reservoir to another downstream reservoir may occur (Brandt, 2000a). In this paper the hydraulic and sedimentary processes downstream from dams during flushing, will be conceptualized. Through an understanding of the hydrology and sedimentary processes, physical effects can be anticipated and also, e.g., aid in understanding biological effects, i.e. they form a reference frame for other processes.

To illustrate hydraulic and sedimentary processes during flushing, the Reventazón River downstream from the Cachí Dam and Reservoir in Costa Rica is used. Also see Brandt (1999), Brandt & Swenning (1999) and Jansson & Erlingsson (2000). Predicting the sedimentological effects during flushing is difficult due to the altered hydraulic and sedimentary conditions that exist. For example, friction coefficients will change due to deposition. Also, the downstream effects during flushing should not be confused with "normal" effects downstream from dams. In fact, there are no normal conditions downstream of dams. The effects depend on the purpose of the reservoir, released water flow and sediment characteristics as well as the physical characteristics of the river (see Brandt, 2000b). Flushing operations often result in opposite effects compared with those most commonly occurring downstream from dams. Fig. 1 shows typical water discharge, sediment concentration, and sediment load curves for three gauging stations downstream from the Cachí Dam. The only normal looking behaviors are the small sediment peaks at 21:00 and 15:00, more than 24 hours after the flushing was begun. These peaks are attributed to rainfall and subsequent sediment transport in the river.

The first, or main, difference is the extreme sediment concentration. The water is loaded with an extra amount of sediment that the flow cannot sustain or transport for any longer distances (see Fig 1). The second difference, that must be emphasized, is the different times when the water flow peak and the sediment concentration peak occur at a downstream station. This time lag increases in the downstream direction. The time lag between the water discharge peak and the sediment concentration peak will affect the sedimentation rate. At some distance the sediment concentration peak is lagging behind so much that the water peak has already passed, leaving only a fraction of the sediment transport capacity of the peak discharge to transport the sediments. Therefore, during the rapid recession of the water discharge peak, large amounts of sediment will be deposited on the river bed (see station 10 km downstream from dam in Fig. 1). Since the water discharge peak may arrive earlier than the sediment concentration peak, actually there may

be some erosion of the river bed (see Fig. 2).

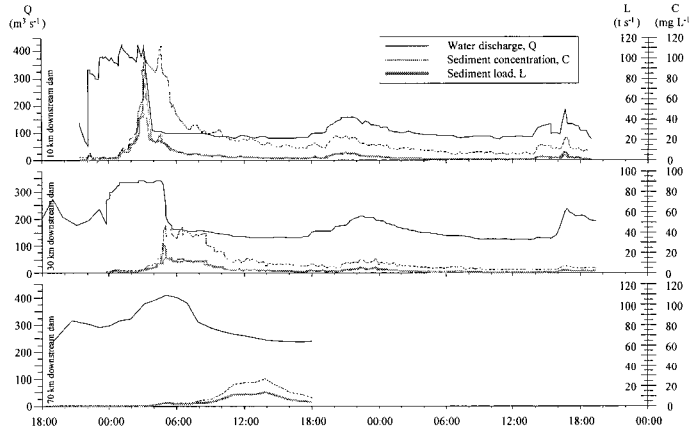

Fig. 1 Water discharge, sediment concentration and load for three gauging stations, 10, 30, and 70 km downstream from the Cachí Dam during the flushing in 1996 (From Brandt, 1999).

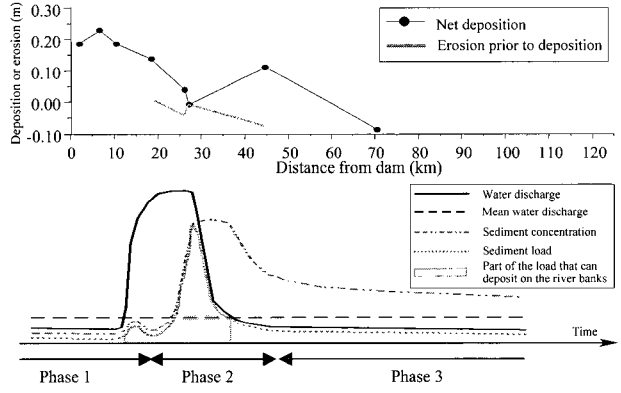

Fig. 2 Erosion and deposition in the Reventazón River during flushing in 1996 (above), and schematic illustrations on water discharge, changes in sediment transport with time, and flushing phases in the downstream reaches (below).

The time lag between water and sediments also has an impact on where the deposition of sediments will occur. During the water discharge peak, sediment can deposit on both the river bed as well as on the banks (Fig. 2). After the water discharge peak has passed, sedimentation can only occur on the river bed. Therefore, decreasing amounts of bank deposition can be expected when going in the downstream direction (Brandt & Swenning, 1999). Downstream effects may occur all the way to the river outlet in the sea if no other dams and reservoirs hinder the flow. Effects that that may have influence on, e.g., coral reefs along the coasts.

Keywords: downstream effects, flushing, desiltation, reservoirs, dams, rivers, sediment erosion, transport, deposition

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