Effects of obstacles and jets on reservoir sedimentation due to turbidity currents

Christoph Oehy (1999-2002)

Reservoir sedimentation is a subject of major importance in many Alpine reservoirs and is often related to the phenomenon of sediment transport by means of turbidity currents. These density currents with a high suspended-sediment concentration follow the thalweg of the lake to the deepest area, normally near the dam, where the sediments settle down (see Figure 1). They can cover the bottom outlet, affect the operation of the power intake and reduce the storage capacity of the reservoir. To control the sedimentation within the reservoir, the effects of obstacles, screens, water jets and bubble curtains on the turbidity current were investigated with physical experiments and numerical simulations.

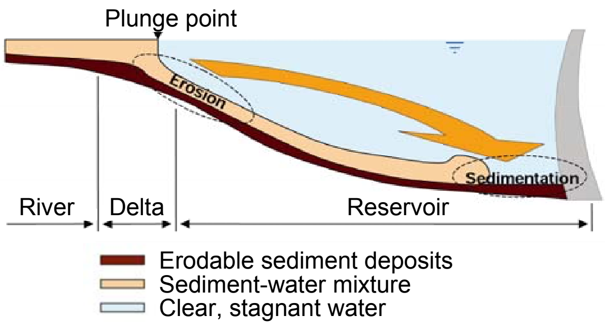

Figure 1 : Scheme of sediment transport within a reservoir due to turbidity currents.

The experimental investigations were carried out in a flume of 7.1 m long, 27.2 cm wide and 90.0 cm high. The tested measures consisted of a continuously fed turbidity current, flowing

- over an obstacle;
- through two vertical screens made of different geotextiles;
- across vertical jets issuing from a multiport diffuser;
- across inclined jets issuing from a multiport diffuser at 45° upstream; and
- across a bubble curtain.

Figure 2 : Experiment of turbidity current flowing through a vertical screen.

For each series, experiments on horizontal and inclined slopes were done (see Figure 2). To measure the deposits a new device, based on the resistance measurement of this sediment layer, was developed. This method allowed measuring of the spatial and temporal evolution of the deposits with an accuracy in the order of 0.15 mm. Furthermore, vertical velocity profiles were measured with an ultrasonic velocity profiler (UVP), and the front velocities were determined from video recordings.

To further investigate the effects of obstacles, screens, and water jets, a three-dimensional numerical model, based on the flow solver CFX-4.4, was developed. In this program, interfaces were added to take into account the settling of the sediments, their erosion and sedimentation at the bed, the fractional suspended-sediment transport and the effect of stratification in the turbulence model. The numerical simulations were compared with good agreement to the physical experiments and the blocking efficiency of the different configurations was computed (see Figure 3).

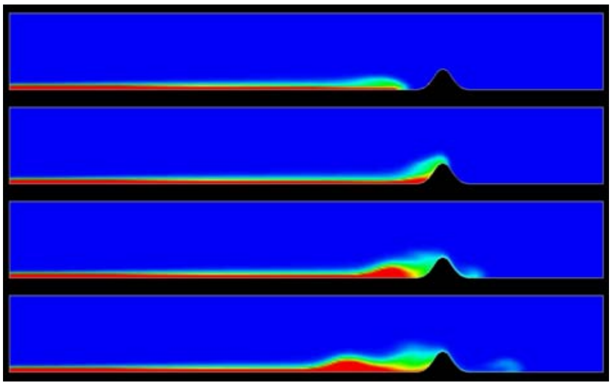

Figure 3 : Numerical simulation of turbidity current flowing over an obstacle.

In a case study in Lake Grimsel, the possibility of influencing the turbidity current with submerged dams was evaluated with the numerical model (see Figure 4). The results showed, that due to the blocking effect of the dam, the sediments can efficiently be retained and sediment deposits in the area of the intake and bottom outlet structures can be prevented.

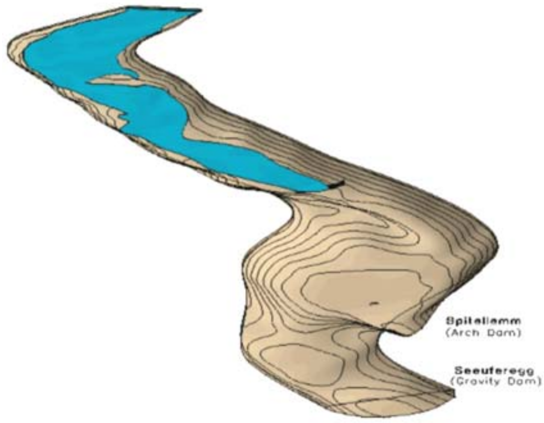

Figure 4 : Numerical simulation of a turbidity current in Lake Grimsel with a submerged dam.

From the physical experiments and numerical simulations, some recommendations, given as rules of thumb, were determined to propose possible applications of the investigated measures to control reservoir sedimentation due to turbidity currents.