Morphological evolution of the Rhone River in the Martigny bend

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INTRODUCTION

Sustainable water management is a principal matter to ensure safety of waterways (Berga, 2016). In this framework, the correction of the Martigny bend is a priority measure of the 3rd Rhone River correction in Switzerland, which aims at increasing the flood protection in the region while ensuring sustainable conditions for the Rhone River (Arborino and Jordan, 2014). The project foresees widening the bed of the river to the regime width and lowering the bed in the bend (Saugy et al., 2022). A numerical model is built to represent the priority measure, in order to assess the impact of the project on the sediment transport capacity and the morphological evolution in the long term.

METHODOLOGY

Numerical simulations are run using BASEMENT v.2.8 software (Vetsch et al., 2020). The model represents a 4870 m long segment of the Rhone River, including the Martigny bend, and the confluences with the Dranse River and the Trient River. The model uses shallow water equations (SWE) to predict flow features and has the following characteristics:

- Transient analysis (2D modeling)
- Multiphase flow modeling
- Meyer-Peter & Müller formulation adapted for multiple grain size classes by Hunziker (MPM-H)

A mesh sensitivity analysis allows to define the optimal mesh characteristics.

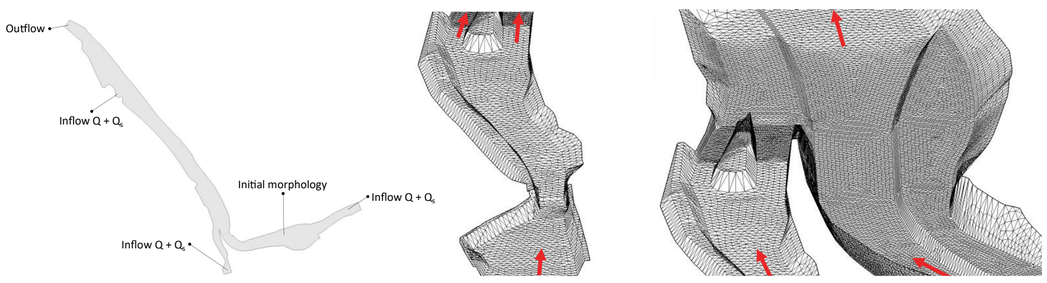

Figure 1 Computational domain and mesh characteristics

In addition, the validity of the numerical model is assessed comparing the results with those obtained from a physical model built at the Platform of Hydraulic Constructions (PL-LCH) at EPFL (Saugy et al., 2022). The morpho-dynamic behavior is analyzed using a steady-flow simulation for a 10- year return period flood over a 15-days duration.

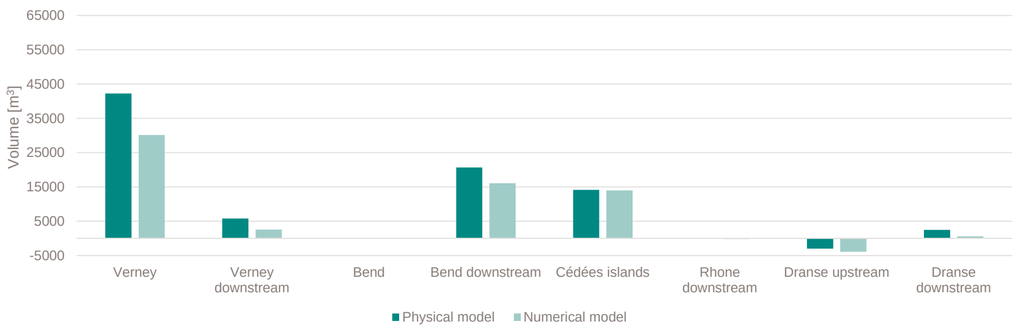

Figure 2 Sediment deposits volume per zone; comparison between physical and numerical results

RESULTS

The widening in the Rhone River decreases the water velocity, with an acceleration of the flow prior to the bend. In the Dranse River, results indicate that the hydraulic ramps on both side of the bridge pier in the Dranse works as expected, with an acceleration of the flow. Flow velocities in the basin after the confluence on the left bank are close to zero.

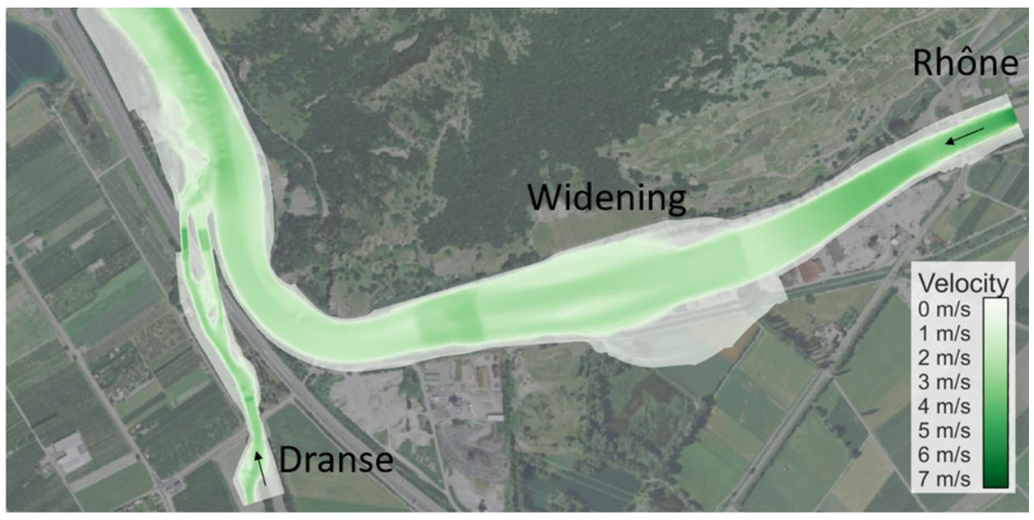

Figure 3 Velocity of the Rhone River after 15 days, upstream part of the model

Results highlight a deposition zone in the widening with an advancing sediment front close to the bend. At the upstream boundary of the Dranse River, complex interactions between flowing water and sediments lead to the formation of a preferential channel. The Dranse River is bringing a greater concentration of sediments, which are transported and deposited in the Rhone and create a second deposition zone with advancing front.

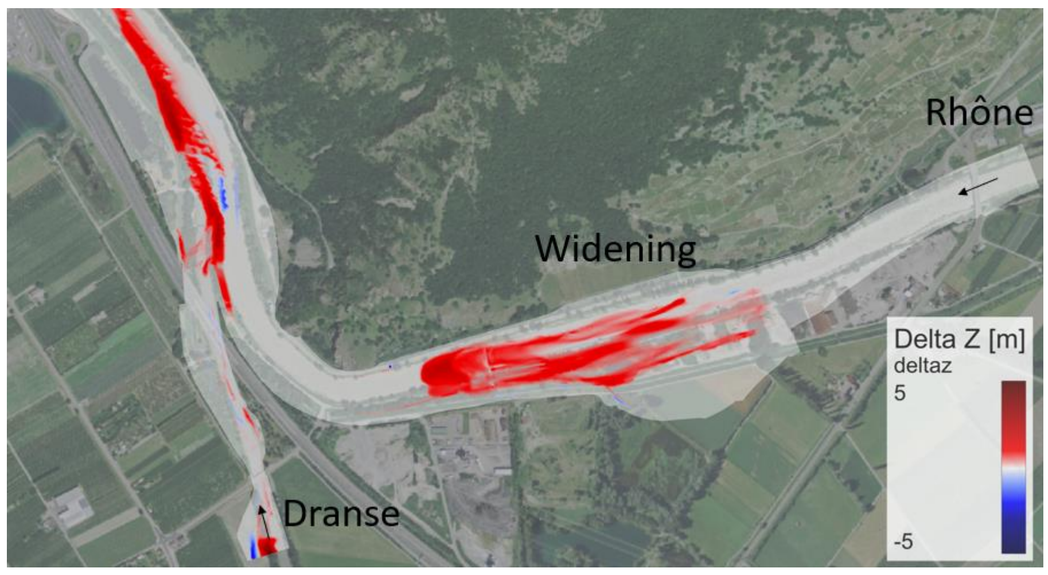

Figure 4 Bed variation in the Rhone River after 15 days, upstream part of the model

The grain size evolution indicates that there is a grain size sorting and that the deposits are composed of finer sediments than the bed bottom grain size, both in the widening and at the confluence of the Rhone. The areas with the highest d_{50} (200 mm) correspond to non-erodible zones.

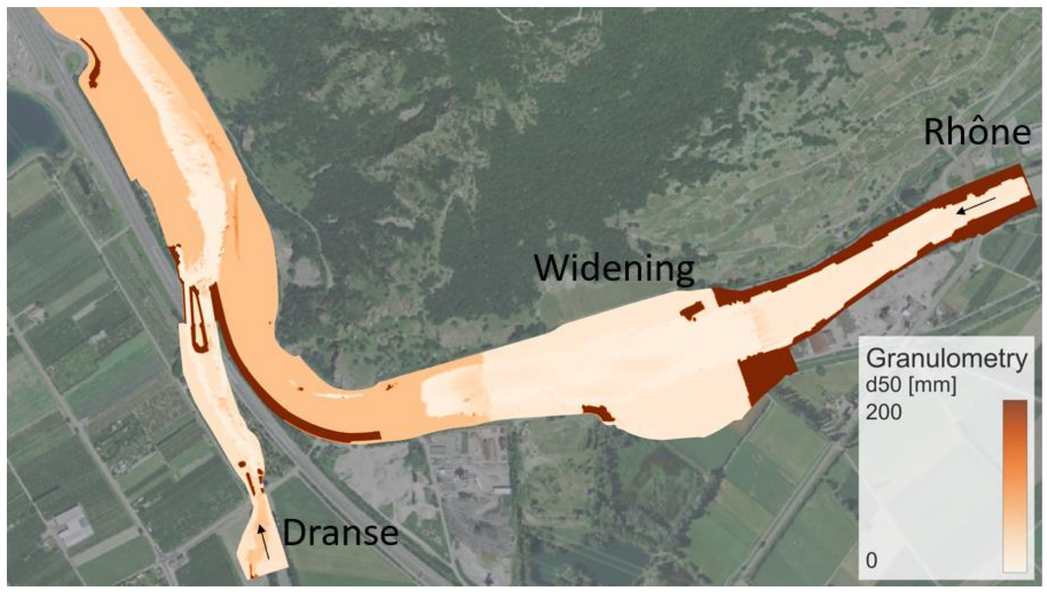

Figure 5 Diameter d_{50} of the Rhone River granulometry after 15 days, upstream part of the model

CONCLUSION

A numerical model of the priority measure of the 3rd Rhone River correction is built to assess the impact of the project on the sediment transport capacity and the morphological evolution in long term. Results indicate that the river reach has a dynamic behaviour. Erosion and deposition zones are identified and highlight that a preferential channel is created. In addition, sediment grain size sorting is observed on the river reach.

REFERENCES

Arborino, T., Jordan, J.-P., 2014. Flood protection along the Alpine Rhone river: Overall strategy and 3rd correction project, in: Swiss Competences in River Engineering and Restoration. CRC Press, pp. 49–59.

Berga, L., 2016. The Role of Hydropower in Climate Change Mitigation and Adaptation: A Review. Engineering 2, 313–318. https://doi.org/10.1016/J.ENG.2016.03.004

Saugy, JN., Amini, A. & De Cesare, G. Flow structure and grain motion assessments of large river widening in a physical model using ultrasonic Doppler velocity measurements. Exp Fluids 63, 115 (2022). https://doi.org/10.1007/s00348-022-03430-9

Vetsch, D., Bürgler, M., Gerke, E., Kammerer, S., Vanzo, D., Boes, R., 2020. BASEMENT – Softwareumgebung zur numerischen Modellierung der Hydro- und Morphodynamik in Fließgewässern. Österr Wasser- und Abfallw 72, 281–290. https://doi.org/10.1007/s00506-020-00677-6

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