Removing small dams: and now, what do I do with the sediment? Lessons learned

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INTRODUCTION

The removing of small dams lets the restoration of the river system hydro-sedimentary dynamics. Nevertheless, there is a risk of a massive mobilization of sediment with serious effects on the morphology of the river and the river ecosystem if the management of the sediment retained by the dam is not considered before the dam demolition. Four cases studies are here presented in the Catalan Basin District (NE Iberian Peninsula) to show both how sediment management has been carried out in the elimination of the small dams and what has been the response of the river system.

The Ritort Hydroelectric Power Station dam

In October 2020, the Ritort Hydroelectric Power Station 8-meter-high dam, full filled by approximately 4,000 m^3 of gravel and pebbles, was demolished in a single phase (Fig. 5).

Figure 5. Demolition works of the Ritort Hydroelectric Powe Station in October 2020.

However, the demolition project did not consider how to manage the volume of sediment retained by the dam. As a preventive measure, between 60% and 70% of the total sediment trapped was extracted; since any study available on the (potential) mobility of the sediment during floods nor any idea of the river reach length that could be affected. In parallel to these works, the longitudinal slope of the river in the old dam reservoir was softened and a low-water channel was built.

Figure 6. A) Extraction of the sediment trapped into the reservoir; B) New channel form of the Ritort River after demolition works; C) River channel after one-year.

A monitoring program was carried out to evaluate the hydromorphological and biological response of the river system. After one year of the dam demolition, the hydromorphological and ecological restoration of the river dynamics was totally accomplished

The small dam of the Bojons Mill

The demolition of the Molí de Bojons dam, in the Riera Major River, was designed in 3 consecutive phases, with the dam being lowered gradually over several years (Fig. 1A). But the demolition project was delayed because administrative reasons and, in October 2017, the dam was demolished in a single phase (Fig 1B). As a preventive measure, around 1,400 m^3 of sediment from the total of 9,300 m^3 of medium and coarse sand computed to be retained into the reservoir, were removed by mechanical means.

Figure 1. A) Initial design of he Bojons Mill dam demolition project; B) Demolition works of the small dam in January 2018

In spite, a massive mobilisation of the material package occurred (Fig. 2) and led to the total modification of the riverbed with a strong consequence on the ecosystem (Fig. 3A i B).

Figure 2. Progress of the sediment wave over time. Data in blue, wave not detected, in gold, wave detected.

Figure 3. View of the same point before (A) and after (B) the pass of the sediment wave

As a corrective measure, three sediment traps were built to slow the advance of the sediment wave and prevent further damage (Fig. 4). In 7 months, around 2000 m^3 of sediment was dragged from the traps. In June 2018, a monitoring study of the impact recommended to abandon the use of traps.

In October 2018, a flood slightly lower than the bankfull was recorded and in January 2021, an extraordinary flood. Both episodes allowed the total transit of the material derived from the demolition of the dam and the complete recovery of both the channel morphology and the river ecosystem.

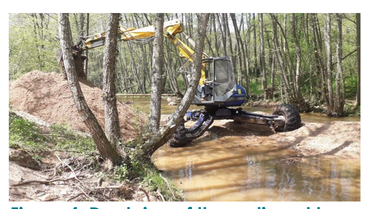

Figure 4. Dredging of the sediment traps

The Sant Salvador small dam

The Sant Salvador dam is an structure made up of two consecutive dams: the first with a height of about 2 m and a length of 20 m, and the second (Fig. 7) with a height of 1.7 m and about 30 m long.

In 2021, was registered the most significant flood since 1995. As a result, the dam acted as a sediment trap and the reservoir was absolutely filled (Fig. 8) with a direct impact on the riparian forest and aquatic habitats.

Figure 7. View of the Sant Salvador dam

Figure 8. View of the reservoir

The City Council considered the demolition of the dam and, as a first step, an hydraulic and sediment transport modelling of the river was carried out to evaluate the river bed response under different demolition scenarios (Fig. 9).

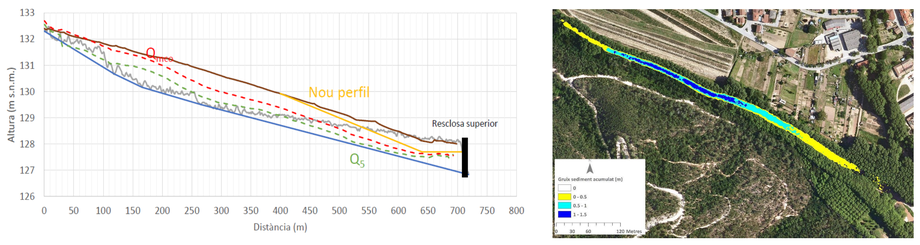

Figure 9. Modelling of the riverbed response under different scenarios

The study concluded that the best strategy consisted of a phased demolition, with an initial reduction of 1/3 of the height of the dam, and the mechanical removal of 1,400 m^3 of sediment (of the total of 4,500 m^3) in the first 350 m upstream of the dam.

Sediment extracted has been relocated downstream of the dam in sections of the active channel where ordinary floods could mobilize it. These sections were established from the analysis of the existing orthophoto images taken after the extraordinary flooding of 2021 (Fig. 10).

Figure 10. Localization of points in active channel areas where sediment extracted could be relocated: A) 2018; B) 2021

These works were carried out throughout 2023 and it is expected that in a period of between 2 to 5 years, the second and final phase of the demolition could be carried out.

The Colonia Rio small dam

The Colonia Rio dam (Fig. 11A), located in the Calders River, was a 5.6-meter-high and 56-meter-long dam. In its reservoir around 13,000 m^3 of sediment was trapped causing a strong sediment deficit. Consequently, some parts of the first 400m of the river channel were bedrock (Fig. 11B) because the sediment exhaustion.

Figure 11. A) General view of the Colonia Rio dam; B) View of the bed rock downstream dam

In December 2023, the dam and the diversion canal were demolished in a single phase. A low probability to mass movement was expected because sediments stored into the reservoir were a mixture of sand, gravels, and pebbles. When the dam wall was demolished, an abrupt discontinuity (break slope) was generated in the longitudinal profile of the river (Fig. 12A).

Figure 12. Demolition of the Colonia Rio dam

Figure 13. Sediment barriers to reduce turbidity

Therefore, part of the sediment retained in the reservoir was relocated at the front of the old dam while a new morphology of the river channel was traced into the reservoir (Fig. 14 & Fig. 15). In addition, a monitoring program was carried out to evaluate the hydromorphological and biological response of the river system.

A rapid response of the morphological system after the occurrence of small flood events (Fig. 16).

Figure 14. Relocation of the sediment in front of the old dam

Figure 15. New river channel form (old reservoir) I n January 2024

The sediment deficit was compensated by riverbed accretion (up to 50-100 cm) with the sediment eroded from the sedimentary package (Fig. 17). Furthermore, a braided channel with a complex riverbed morphology was formed.

Figure 16. Evolution of the sediment package retained into the old reservoir: A) April 2024; B) June 2024; C) March 2025

Figure 17. Riverbed accretion downstream dam after demolition. Affected area: 500m river channel length.

FINAL REMARKS

- Prior to the remove a dam, it is essential to analyse both, the response of the sediment package retained into the reservoir and, the potential effects downstream to determine whether it is better to leave the sediment "in situ", or, in contrast, extract part or all the sediment.
- Individualised studies must be carried out for each obstacle to define how manage the sediment trapped by the dam. The chosen option will determine the way in which the dam is demolished as well as the type of demolition.
- Sediment management is a complex mission where zero risk does not exist. But in most cases, impacts on the river are limited both in space and time and these should be understood as part of the restoration process.
- River sediments, joint with morphological processes and dynamics are key aspects for the correct functioning of the entire fluvial system. Therefore, the extraction of sediment from the reservoir should be considered as the last of the alternatives and only be proposed in those cases where, a serious impact (persistent in time and space) is expected.