2D numerical flow modelling of a river confluence in order to know the geomorphic consequences of the backwater effect

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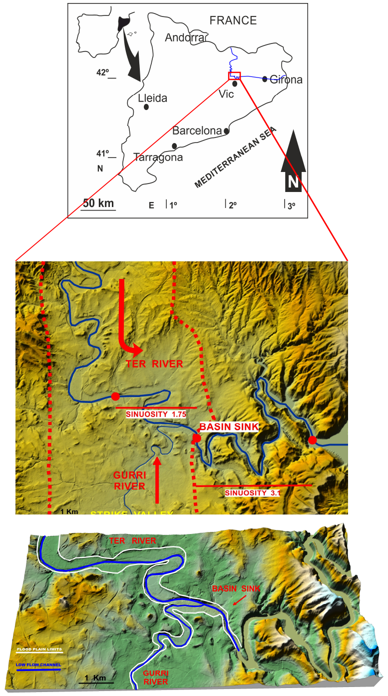
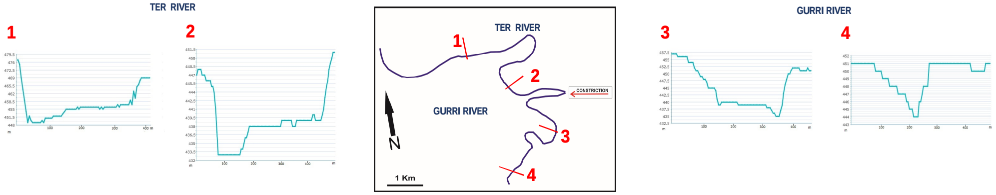
INTRODUCTION

The Ter River flows from its headwaters in the south eastern Pyrenees, in the Iberian Peninsula, to the Mediterranean Sea. It flows from north to south through a strike valley in a channel pattern of incised meanders in the study area . Its tributary, the Gurri River, flows from south to north in a straight channel pattern until near the confluence. In this area, the Ter River bends towards the east incising into hard layers forming a canyon. The entrance in the canyon forms a constriction. Notice the difference in shape and in sinuosity in both sets of meanders before and after the constriction. The incision of the cuesta is made by taking advantage of a fracture pattern forming structural pseudomeanders with a sinuosity of 3.1. Otherwise, the river flows through a meandering pattern of 1.75 in sinuosity just before the constriction. The confluence of the main river and the tributary is just before the lithological constriction.



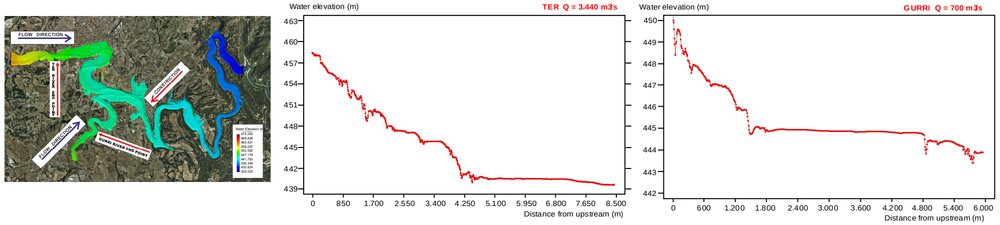
THE TWO PAIRS OF MEANDRES

Observing the layout of the floodplains and the low flow channels, just before the constriction, a suspicious geomorphic feature can be observed. The last pair of meanders of the main river is replicated in the tributary. This replication can only be due to the backwater effect formed in the constriction. The figure shows the two pairs of meanders. Both channel cross sections of the Ter River have similar shape and dimensions. In the case of Gurri River there is an obvious difference in the two cross sections. There has been a change between points 3 and 4. The channel cross section 4 is upstream from the end point of the backwater effect.



THE END POINT CONCEPT

According to Ven Te Chow (1954), the end point of the backwater effect is the place in the channel where the rise in water finishes to cause damage. This point can be placed geomorphologically where the channel pattern of the tributary changes. The water level in this point calibrates the water level of the end point in the main channel. Additionally, it can be used a 2D numerical flow model to find the position of the end points. The simulation applies discharges upstream from the pairs of meanders. The backwater effect and the location of the respective end points are showed in water level profiles. The concept of end point is important in two senses: on the one hand, it delimits the reach of the backwater effect; on the other hand, it establishes the water level in the channel. Both, limits of the channel reach and water level, are used in flood routing modelling.



APPROACH TO A HYPOTHESIS

➢ The two pairs of meanders were bent in the Holocene by a recurrent backwater effect developed upstream from the constriction.

➢ The reach of the backwater effect is marked by the end point which can be located by the change of channel pattern and tested with a 2D numerical flow model (Iber).

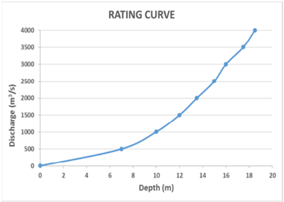
➢ Assuming the previous, both pairs of meanders can be seen as a problem of flood routing, with an entrance in the reach (backwater effect's end point), an outlet of the reach (constriction), water storage (meanders' sinuosity) and a flood wave crossing the reach in the former parameters. The conceptual model can be expressed as it follows:

HOLOCENE AVERAGE FORMATIVE HYDROGRAPH + WATER STORAGE (SINUOSITY)

⬌ CONSTRICTION + CANYON SINUOSITY

➢The solution of this conceptual model may be estimated by applying a 2D numerical flow model which allows the calculation of the discharge of the Holocene average formative flood in equilibrium with measured data.

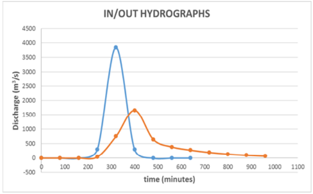
FLOOD ROUTING



H (m)	Q (m3/s)
0	0
7,0	500
10,0	1000
12,0	1500
13,5	2000
15,0	2500
16,0	3000
17,5	3500
18,5	4000
19,5	4500

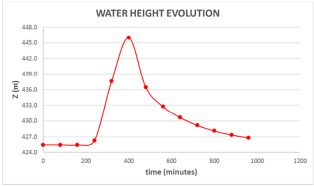
Rating curve in the constriction:

Constriction
+
Canyon sinuosity



H (m)	Q (m³/s)	Water Storage(m3)
0	0	0
7,0	500	7082564
10,0	1000	10117949
12,0	1500	12141538
13,5	2000	13659231
15,0	2500	15176923
16,0	3000	16188718
17,5	3500	17706410
18,5	4000	18718205
19,5	4500	**19730000**

Modelled incoming and outgoing hydrographs with the resulting water storage. Incoming peak discharge 3840 m^3/s (Q_Ter + Q_Gurri). Total runoff volume 30,18 hm^3. Water storage 19,73 hm^3. Outgoing peak discharge 1660 m^3/s.



Water height evolution in the constriction

CONCLUSIONS

➢ Flood routing process under backwater conditions results in sinuosity.

➢ Evaluation of sinuosity formed under backwater conditions allows us to infer other hydraulic parameters such as water discharge.

➢ Analysis of flood routing demonstrates the autoregulation of floods in certain reaches when discharges exceed the hydraulic capacity of constrictions.

➢ In this case study the autoregulation of the flood is around two thirds of the runoff volume and the peak of the outgoing hydrograph is a third fewer.

➢ This model can be applied to other scenarios which also create backwater effect and sinuosity such as river junctions, a base level (sea), or abrupt changes in slope.

➢ It can be added that the condition of formative flood does not need to be an extreme event.