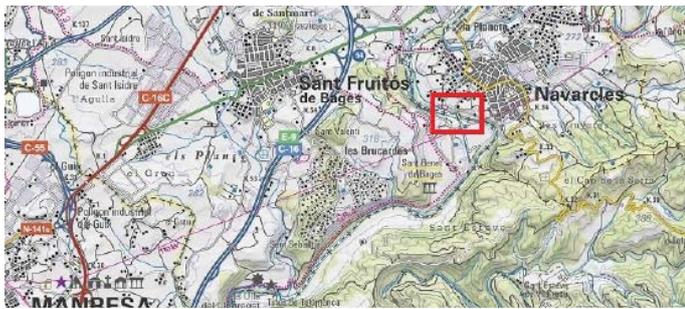


# Drafting of the executive project for the construction of a fish passage in the Llobregat River in the area of Món Sant Benet

## SUMMARY

The Foundation Catalunya-La Pedrera commissioned Naturalea to draw up the executive project for the construction of a fish ramp at the weir located on the Llobregat River, between the towns of Navarcles and Sant Fruitós (Bages region). On several occasions, the fish passages built do not comply with some speed or depth parameters and end up being little or not used at all. In order to avoid this situation, and thanks to the collaboration of the Mediterranean Rivers Study Centre (CERM), an environmental diagnosis of the area was carried out and some technical prescriptions for the design of the device were determined. Given the importance of landscape integration and the challenge of guaranteeing the functionality of the infrastructure for a wide range of species and flows, a fish ramp with a rough bed was chosen and located upstream of the weir. For the sizing of the device, a hydraulic study was carried out using the IBER two-dimensional hydraulic modelling program to estimate draughts and speeds inside the ramp.



Location and orthophoto of the area

## OBJECTIVES

The main objective of the project is to minimize the current impact the weir has, in relation to connectivity, on the Llobregat River. The fish passage device must be functional for a wide spectrum of flows and species, especially for the four native species identified during the preliminary study: *Anguilla anguilla*, *Barbus haasi*, *Squalius laietanus* and *Salmo trutta*. In addition, the intention is to take advantage of its privileged location to make it an educational and dissemination area integrated into the Món Sant Benet complex. Finally, the greatest possible integration into the landscape is pursued.



Sant Benet weir and left bank

## CURRENT PROBLEM

The project area is located on the river Llobregat, at the entrance of the Món Sant Benet meander, between the municipalities of Navarcles and Sant Fruitós de Bages. At this point there is a weir that diverts part of the water into the Sant Benet irrigation channel, which is used for hydroelectric purposes. At the moment, with its 1.8m height, the weir is an insurmountable obstacle for the fauna.

## METHODOLOGY

For the design of the fish ramp, a multi-disciplinary team has been brought together to tackle all different requirements.

First of all, the team of the Mediterranean Rivers Study Centre (CERM) has carried out an evaluation of the ecological state of the Llobregat river in the area of the weir, and has established the basic design criteria from the environmental and functional point of view. Based on these criteria, the location, geometry and dimensions of the fish ramp have been defined. In this pre-design, in addition to the criteria determined in the aforementioned report, other conditioning factors such as integration into the environment or visual integration from the shore, have been taken into account.

The pre-design has been hydrologically validated to ensure that the fish ramp complies with the requirements for maximum flow velocity and minimum depth, considering both the ecological and the ordinary flow, with a first phase of pre-sizing with analytical calculation and a second phase of two-dimensional modelling. Finally, the stability of the infrastructure has been tested for extreme events, for which a return period of 100 years has been considered. With all this information, the internal part of the fish ramp has been defined in detail.



Sant Benet weir, gate and channel entrance

# Drafting of the executive project for the construction of a fish passage in the Llobregat River in the area of Món Sant Benet

## PRE-DESIGN

Different solutions of the “close-to-nature” type were considered when choosing the design of the fish ramp. Finally, the device was placed in one part of the weir. The lower part of the ramp coincides with the alignment of the weir, with its upstream development. Some of the assessed advantages of this typology over others were: its efficiency for all types of living organisms and its integration into the landscape. During the assessment, there was the restriction that the derivation channel had to remain operational.

The ramp bed will be made of granular material whenever possible for stability reasons as it is more favourable, from an ecological point of view, than a concrete base. In addition, the presence of stones provides a high roughness, which complemented with the placement of large dispersed blocks, ensures the desired flows and depths.

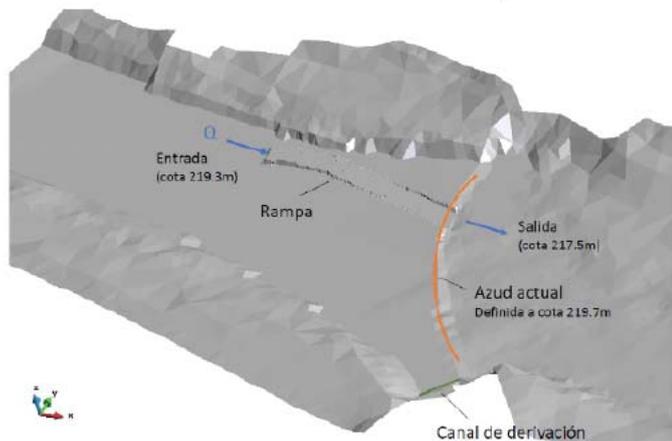
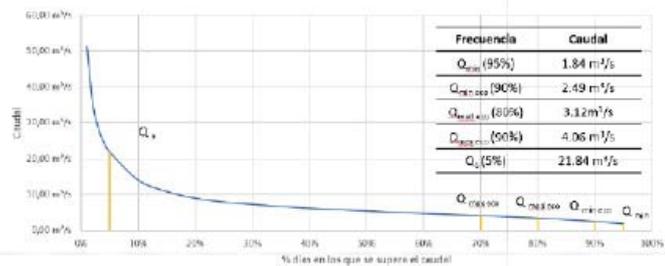
Table 1. Technical specification of the fish ramp

Parameter	Value
Width	>1:20 river width
Average water depth	> 0.4m
Longitudinal slope	1:25-1:30
Average speed	1.0-1.5m/s

## HYDRAULIC STUDY

### Pre-dimensioning

First of all, a pre-sizing phase has been carried out to determine the length and width of the passage device by using analytical calculations. The aim is to ensure that the device is functional for low or normal flows. For this purpose, the ecological flows set by the Catalan Water Agency (ACA) have been taken as a reference, which adopt a different value according to the time of year (ecological maximum, average or minimum) and the curve of classified flows from the sum of the data from the Balsareny (Llobregat river) and Artés (Gavarresa river) measuring stations.



Schematic view of IBER modelling

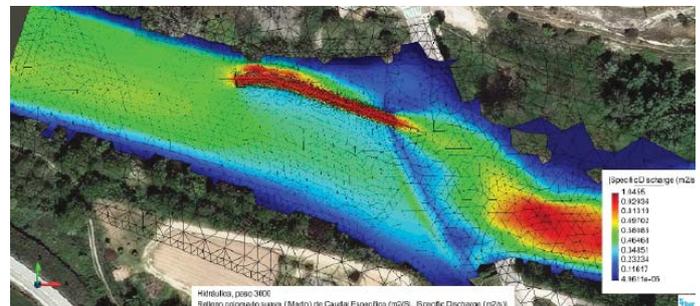


Location of the ramp and barrier to prevent fish from entering the derivation channel

### Validation with IBER two-dimensional model

Secondly, the ramp has been modelled with the IBER 2D software. The results show how the ramp meets the minimum operating requirements in terms of speed and draught in all cases, with results matching those of the pre-dimensioning phase.

For low flows, it is checked that all the water flows through the ramp, whereas the ecological maximum flow is divided between the ramp and the spillway. In all simulations the flow rate is slow at the ramp. It is checked that the ramp is functional for 90% of the days of the year.



View of modeling results with IBER: specific flow rate for a total flow rate of 21,84m<sup>3</sup>/s

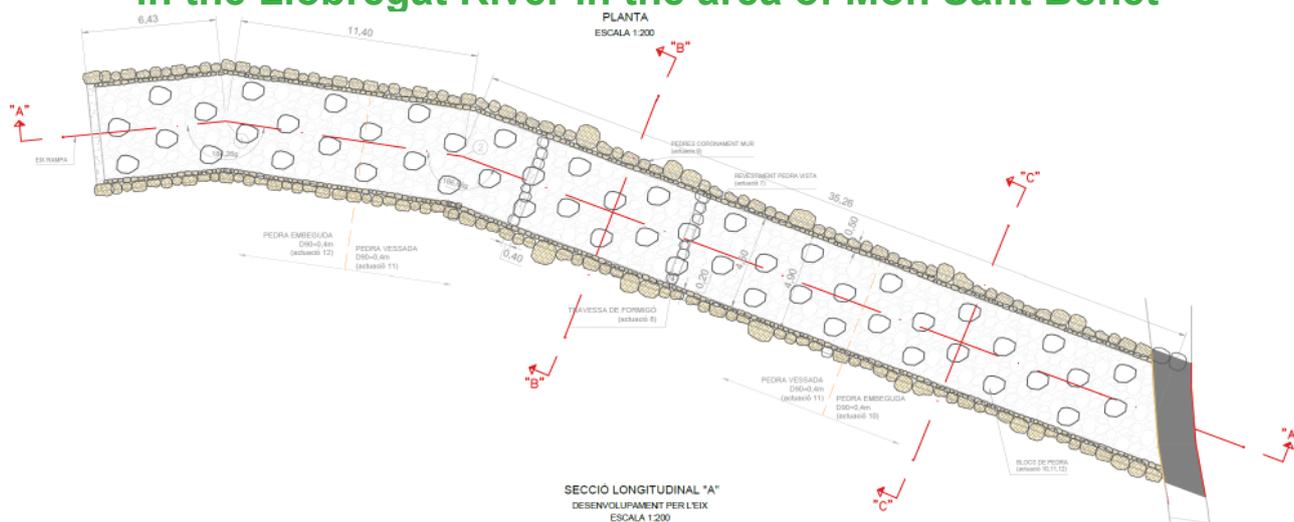
### Flood resistance

The 2D modeling has been done for the Q50 (852.5 m<sup>3</sup>/s) and Q100 (1146.5 m<sup>3</sup>/s) flood flows. Using the results of depth and speed, the resistance of the breakwater has been calculated with the formulation of Maynard *et al.* (1987), which allows an estimation of the specific diameter to avoid entrainment.

For greater resistance to flooding, the ramp has been divided into three sections; at both ends, part of the bed material will be embedded in concrete.



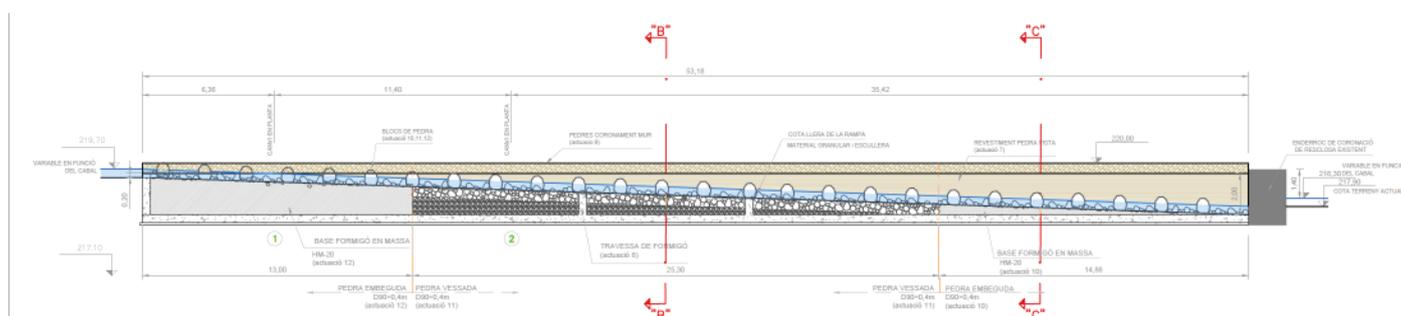
# Drafting of the executive project for the construction of a fish passage in the Llobregat River in the area of Món Sant Benet



## LOCATION

The location of the ramp upstream of the weir and on the left bank has been chosen taking into account: favourable hydraulic conditions; the fact that it would be easy for people to get close to it for informative purposes; and, above all, that it would be easy for the fish to locate it when coming from downstream. Since the weir is slightly oblique in relation to the direction of the flow, the fact of placing the lower part of the ramp coinciding with the alignment of the weir, allows a fish that reaches any point of the weir to follow the obstacle against the current until it finds the ramp.

The curved shape in floor plan is justified for several reasons. The first reason is to locate the entrance in the spot of maximum water depth, at the bottom of the weir and far from the exit of a rainwater collector that is just at the height of the weir on the left bank. The second reason is that the outlet upstream of the ramp should be far from the left bank, in order to respect the current flow dynamics and avoid possible erosion on the ramp. Finally, it is important for educational and informative purposes, allowing people to approach the ramp, so that they can properly observe the device. For this reason, the central section of the ramp has been placed near the bank.



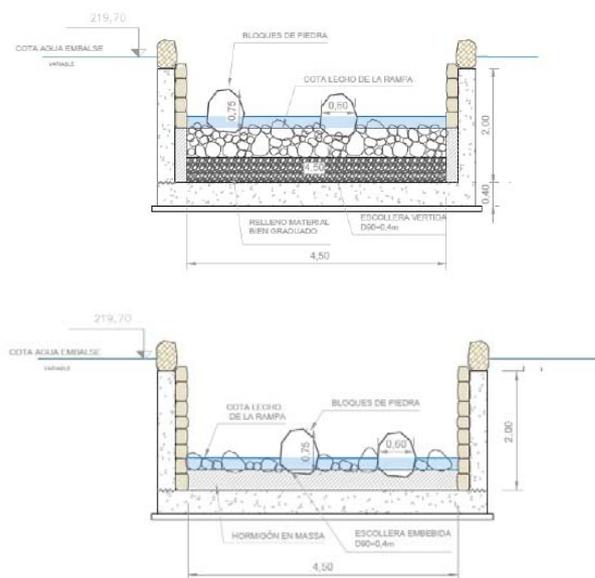
## FINAL DESIGN

The ramp will have a total length of 55 m and a useful width of 4.5 m. The difference in level to be overcome is 1.8 m, resulting in a slope of 1:30.

The structure of the ramp will consist of a "U" shape made out of concrete that will be filled with loose material creating a granular bed. At certain points, where the demands in the event of a flood are greater, or at points where it is impossible to give sufficient thickness to the layer of loose material, some blocks will be fixed with mass concrete. Sleepers will also be built at two points to hold the loose material. On top of the loose material, stone blocks will be placed in rows of two elements every 2 meters.

To ensure that the ramp is integrated into the surroundings, the concrete walls and the top of the wall will be covered so that the stone conceals them completely.

The functioning of the ramp will be such, that for low flows all the water will pass through the ramp, so that it will always be the point of maximum flow, attracting the fish towards it.



A-A' section (upper) and B-B' section (lower)