8. BASEMENT User Meeting
January 26, 2023

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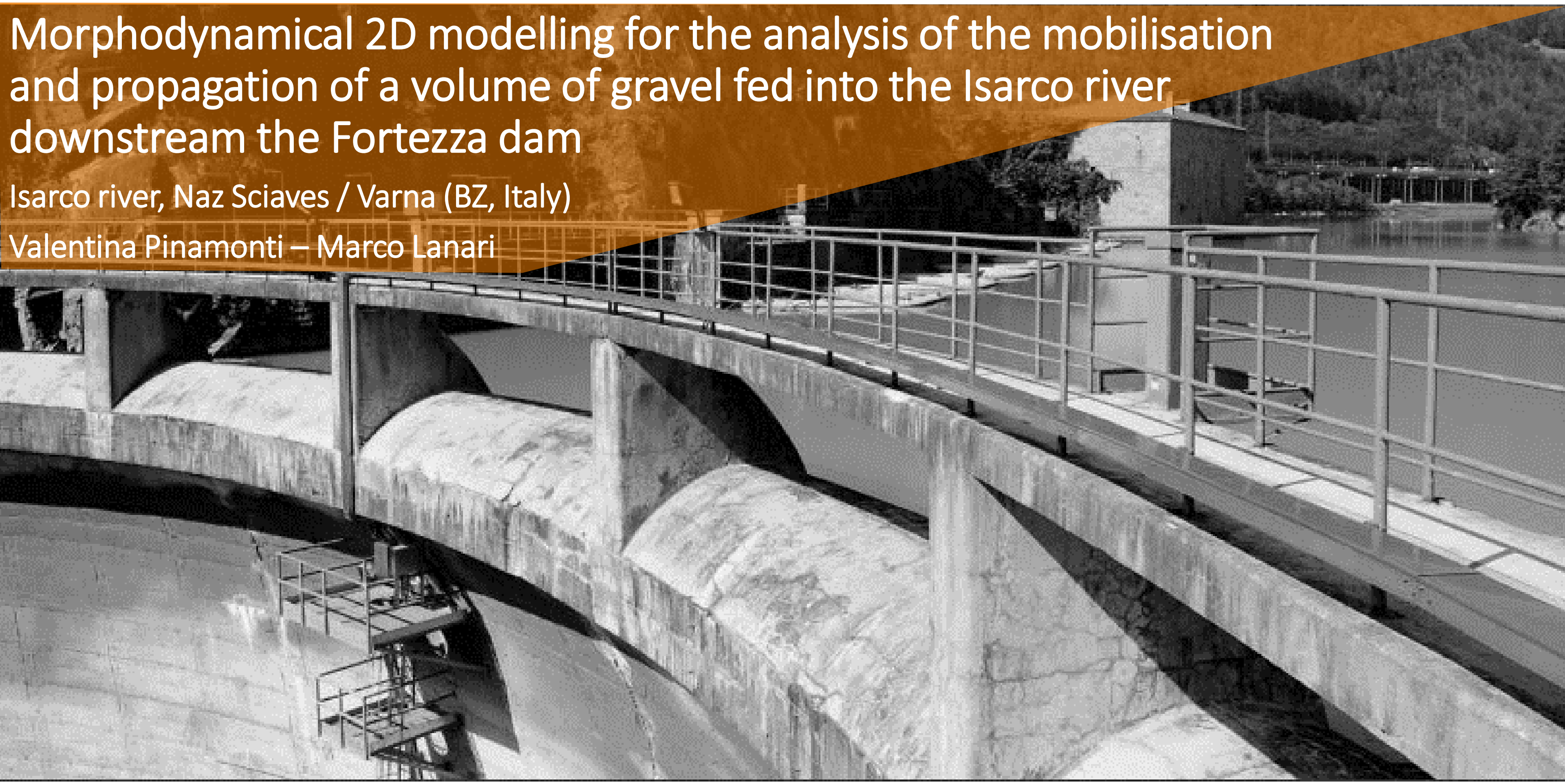
Morphodynamical 2D modelling for the analysis of the mobilisation and propagation of a volume of gravel fed into the Isarco river downstream the Fortezza dam

Isarco river, Naz Sciaves / Varna (BZ, Italy)

Valentina Pinamonti – Marco Lanari



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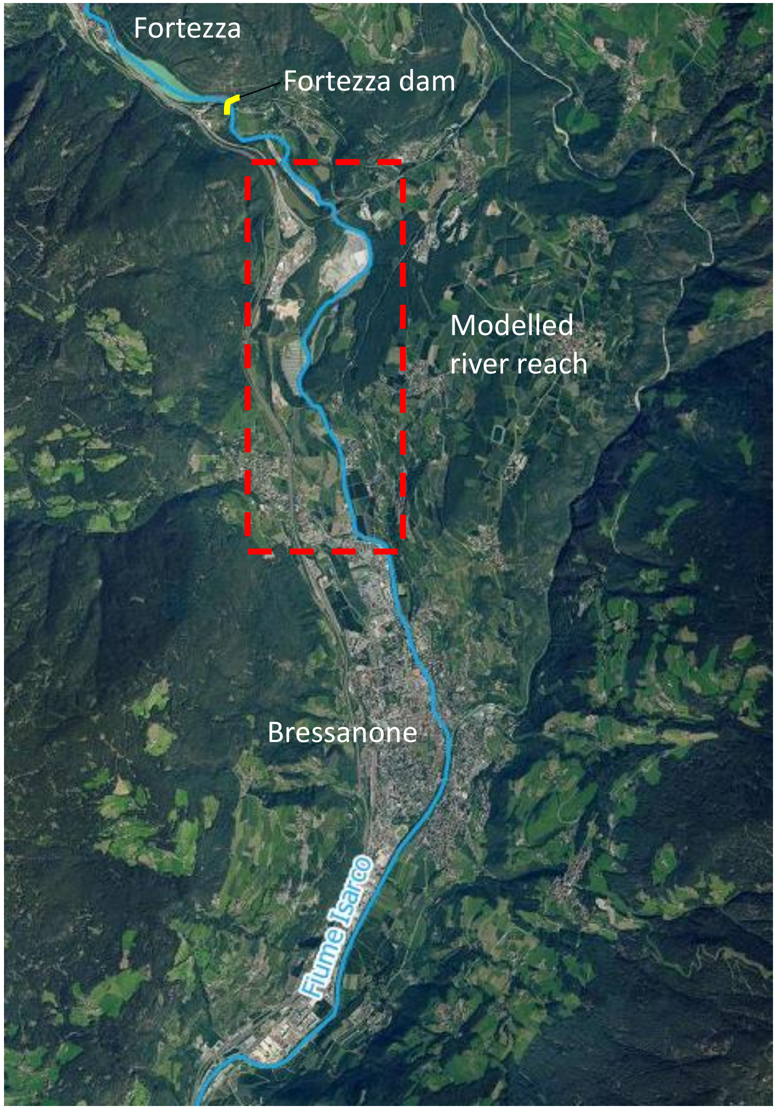
Contents

Overview

Source: Google Maps



Overview

FORTEZZA DAM

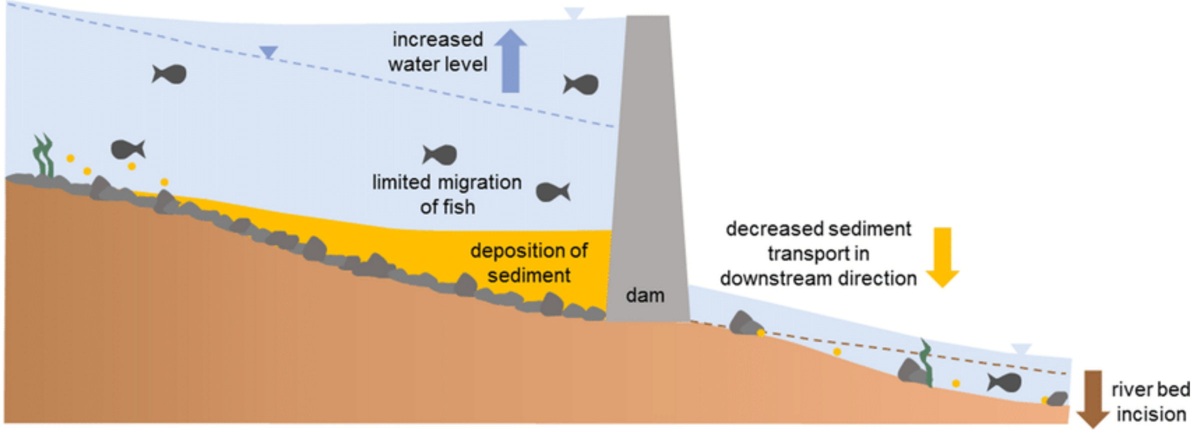
Height: 61 m

Basin surface: 0.23 km^2

Basin capacity: 1.49 million m^3

Drainage basin: 680 km^2

Dam = hydraulic disconnection
Interruption of both sediment transport and mobility of fishes



Source: Maaß, Anna-Lisa & Schüttrumpf, Holger & Lehmkuhl, Frank. (2021). Environmental Sciences Europe.

Downstream the dam:

- Poor morphological and biological quality of the river
- Increased erosion processes

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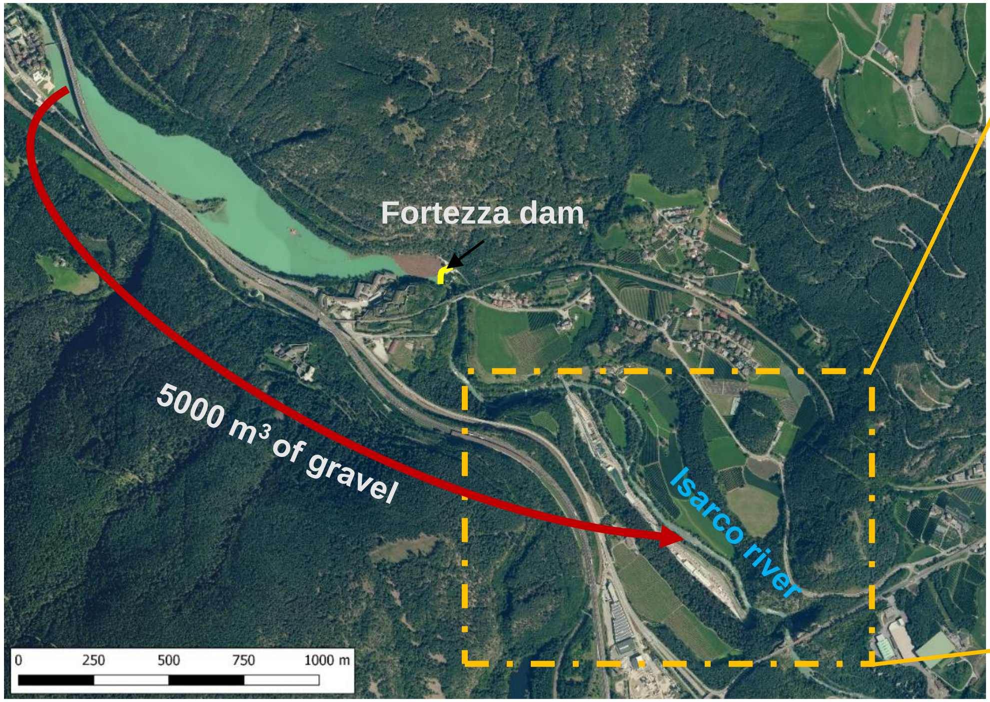
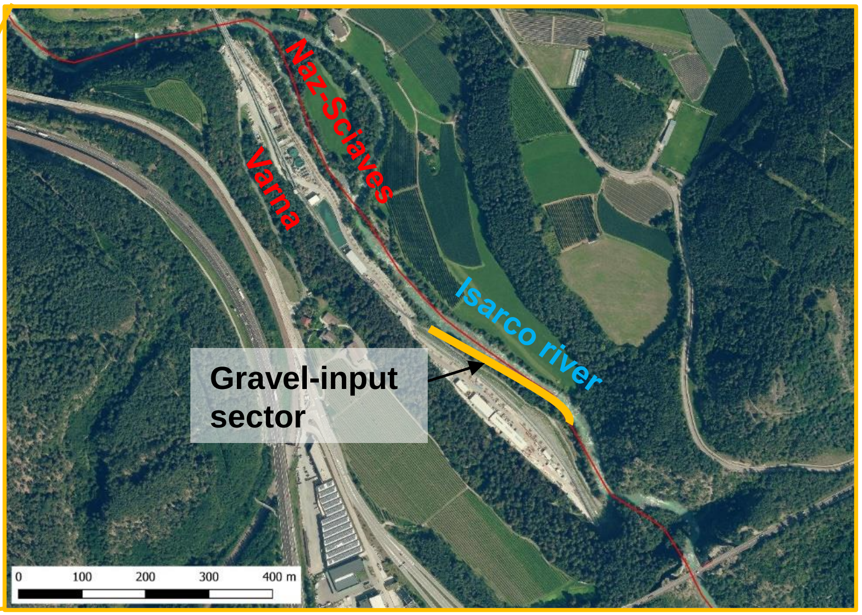
Overview

Plan of the dam managing company of taking a volume of around 5000 m^3 of gravel from the basin upstream and feed it downstream into the river to improve the overall quality of the river





Gravel deposition bar along the right riverbank

Aim of the simulations

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Analyse the mobilisation and propagation of the volume of gravel in case of frequent flood events (1 to 5 years return period).

Understand how the gravel distributes along the river reach and identify the sectors where sediments mostly tend to deposit.

Calculate the volume of gravel deposited within the domain and the volume flowing downstream.

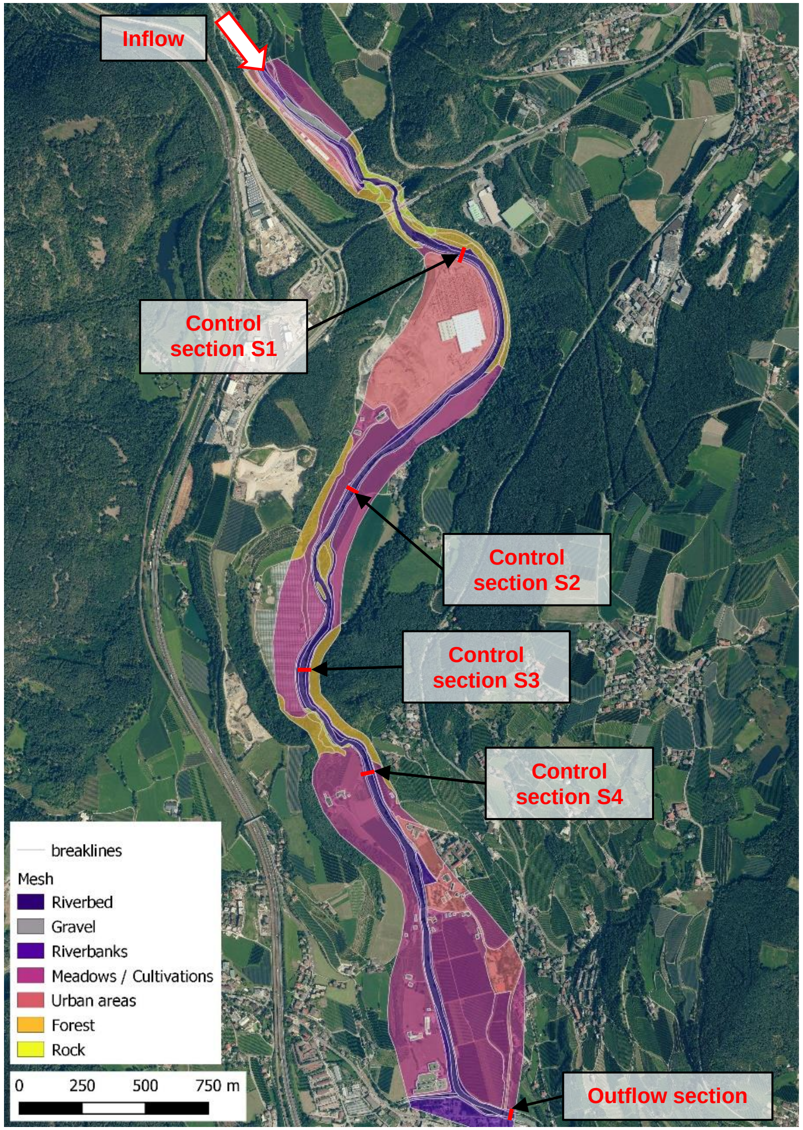
Simulations of extraordinary flood events (return period of 200 years) were also performed within the study to verify the effects of the additional amount of sediments on the hydraulic hazard.

Hydraulic simulations

- **Software:** BASEMENT Version 3.2.0
- **Mesh:**
  River reach length: around 5.3 km
  Domain area: 1.32 km^2
  Number of elements: 98500
  Max area: - riverbed and riverbanks: 8 m^2
  - floodplain: 40 m^2
  4 control sections for output data

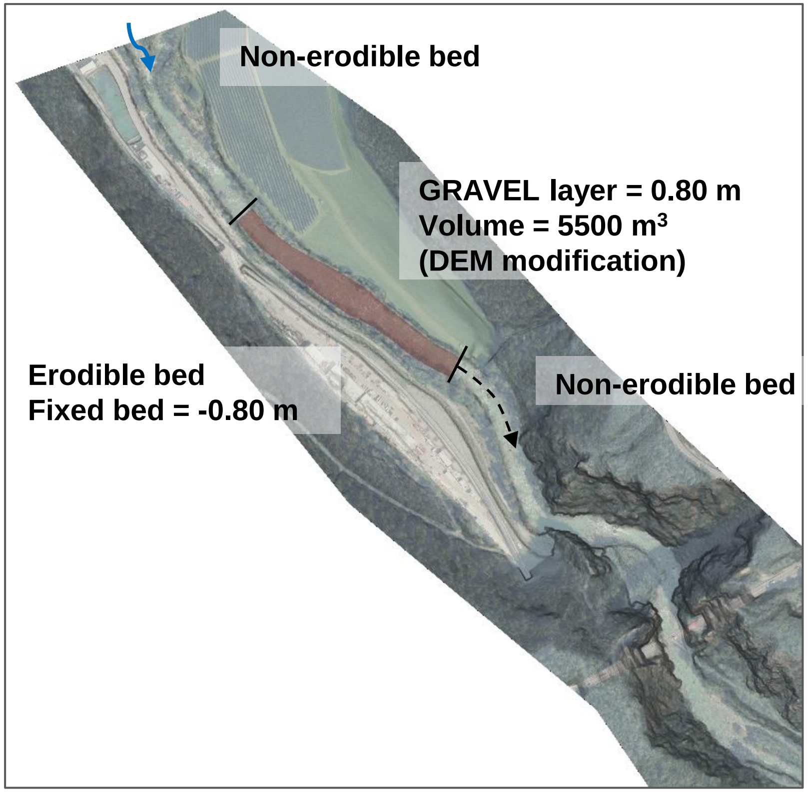
Roughness – Ks ($m^{1/3}/s$)

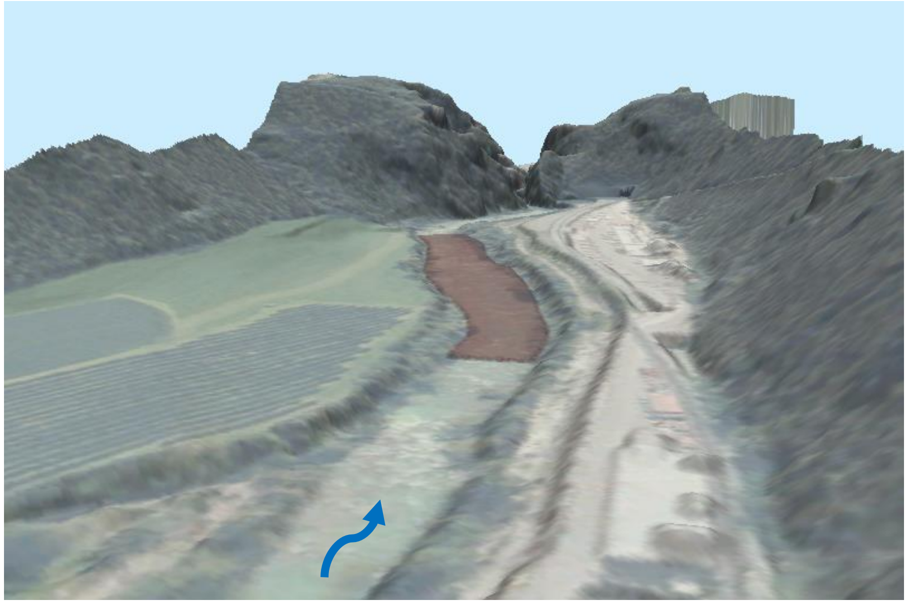
Sector	Ks ($m^{1/3}/s$)
Riverbed	Ks = 25 $m^{1/3}/s$
Gravel	Ks = 35 $m^{1/3}/s$
Riverbanks	Ks = 15 $m^{1/3}/s$
Meadows / Cultivations	Ks = 20 $m^{1/3}/s$
Urban areas	Ks = 40 $m^{1/3}/s$
Forest	Ks = 10 $m^{1/3}/s$
Rock	Ks = 50 $m^{1/3}/s$



Hydraulic simulations

- **Model assumptions:**
  1. Volume of gravel distributed in the riverbed creating an erodible layer of 0.80 m (DEM modification)
  2. Whole downstream reach set as non-erodible





Hydraulic simulations

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- **Boundary conditions**

Upstream

Hydraulics: «uniform_in» condition – input hydrograph (5 yr return period)

Bedload: no sediments downstream the dam (Qs = 0) -> no inflow bedload condition

Downstream

Hydraulics: «uniform_out» condition – average slope (from DEM data)

Bedload: «equilibrium_out» condition – fixed bed elevation

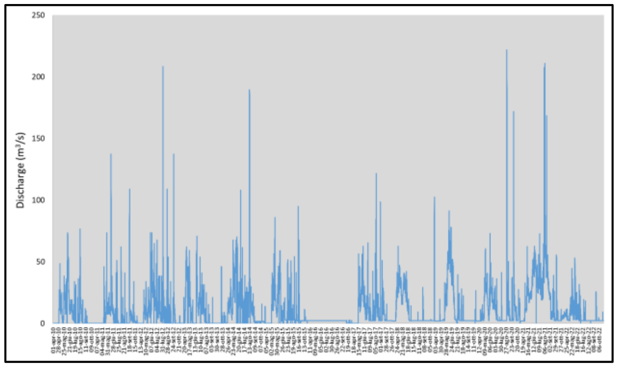
Morphology: single-grain bedload transport (mean diameter of gravel: 18 mm)

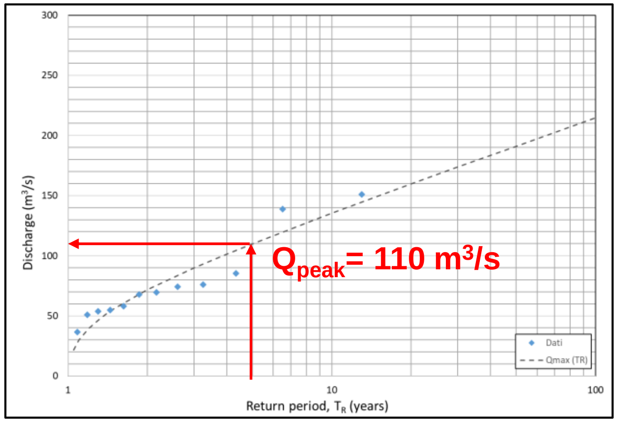
Formula: Meyer-Peter Müller

Hydraulic simulations

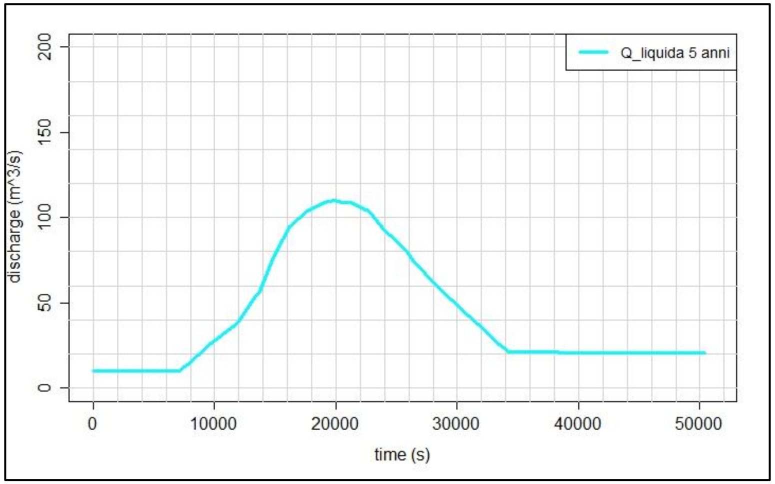
- **Boundary conditions – input hydrograph**

1. Calculation of peak discharge: statistical analysis of the time series of measured outflow at the Fortezza dam (data since 2010)



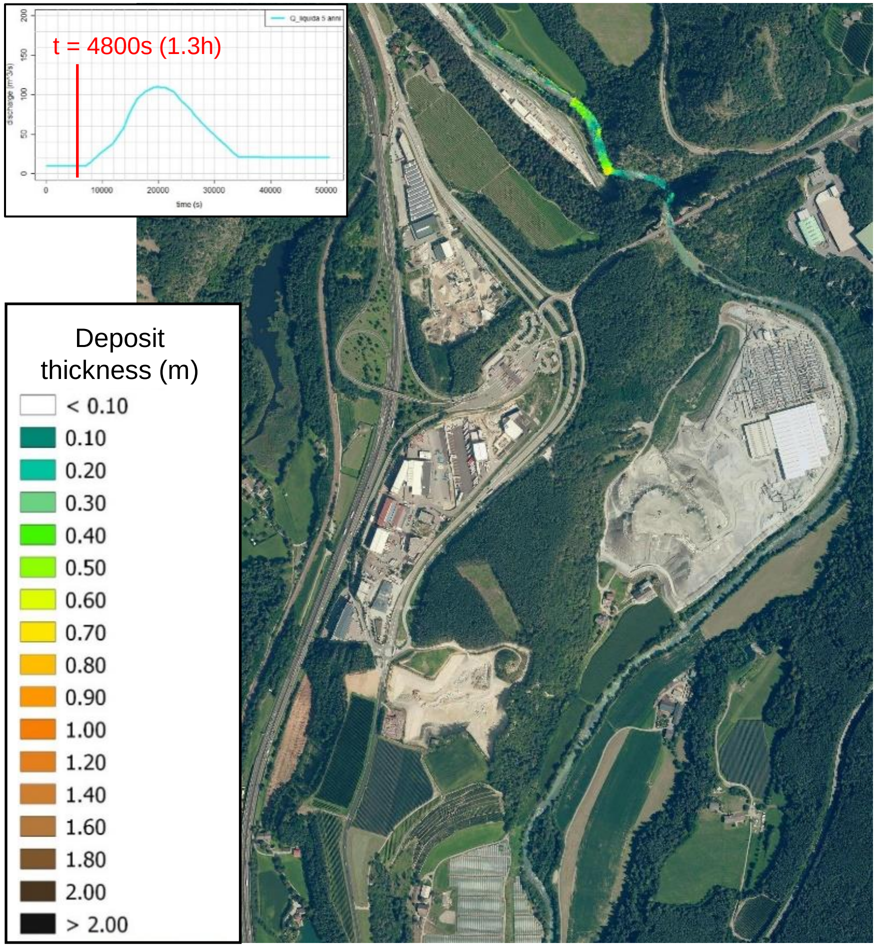


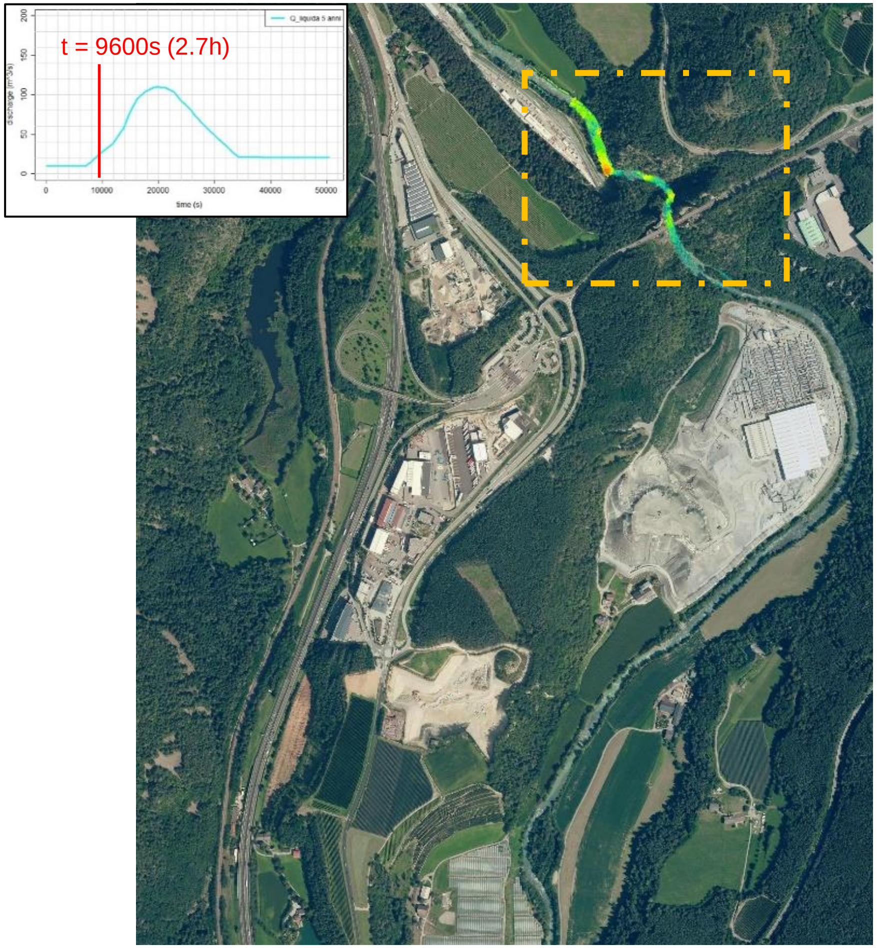
2. Peak discharge used to scale the 200yr hydrograph which was available for the analysed river reach from a previous study (*Flussraum Mittleres Eisacktal - 2010*)



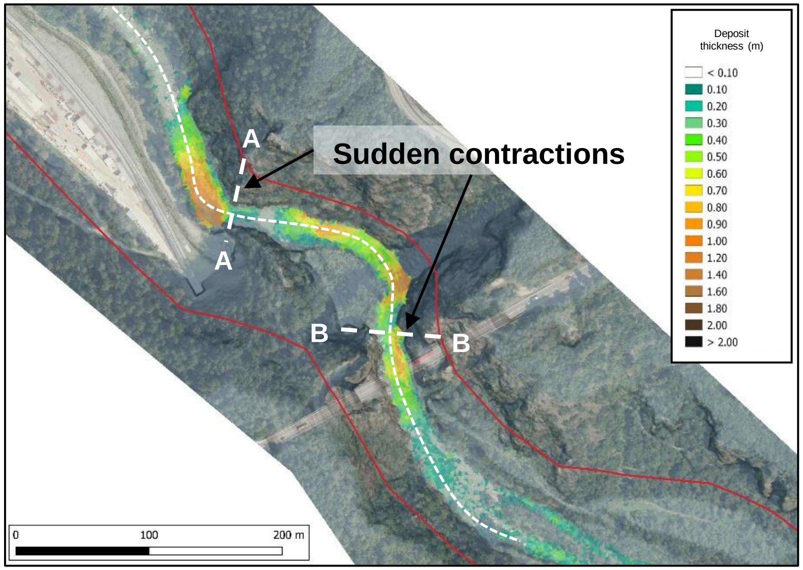
Results

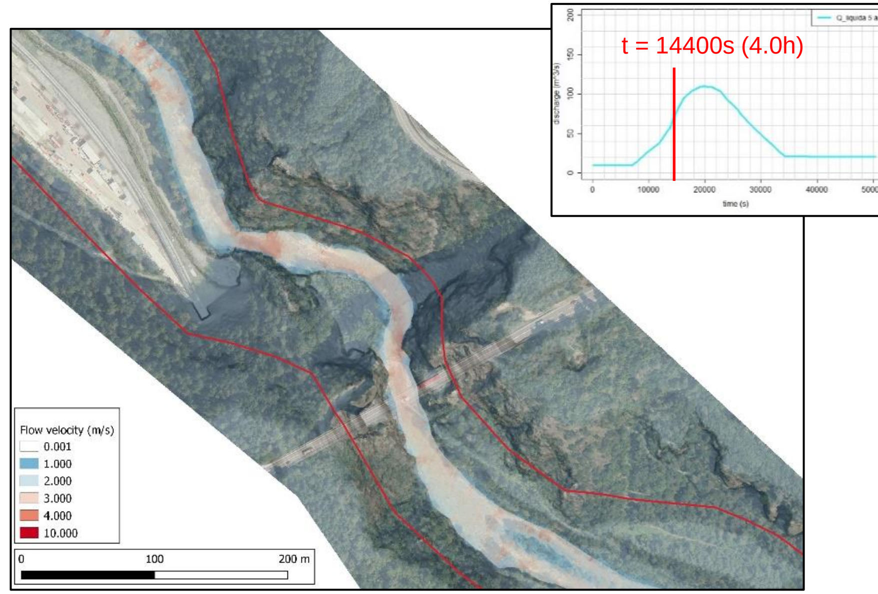
- **Rising phase of the hydrograph:** gravel is gradually mobilized and mostly tend to be trapped in the reach where there are two consecutive sudden contractions of the cross section

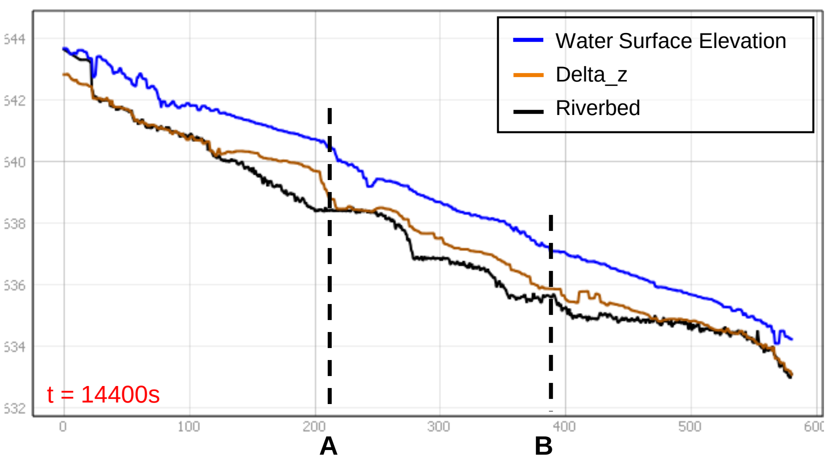


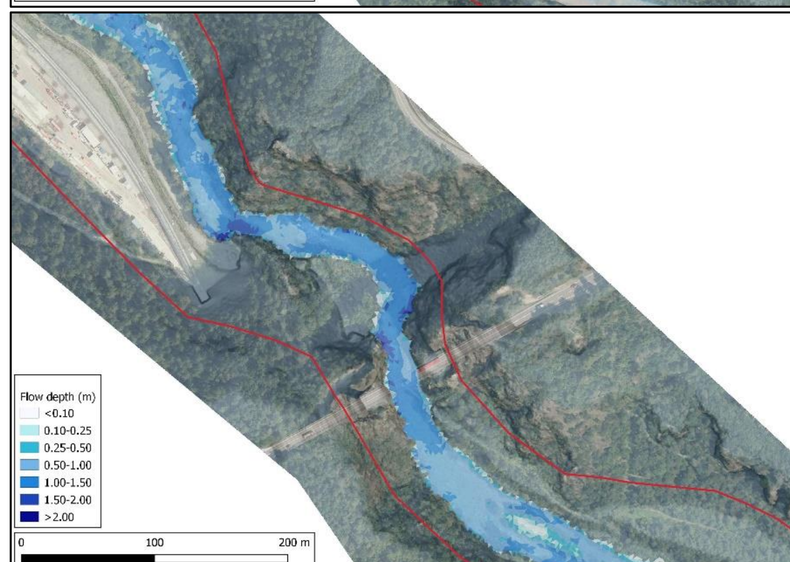


Results


Deposit thickness (m)
< 0.10
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.20
1.40
1.60
1.80
2.00
> 2.00
Sudden contractions
A
A
B
B
0
100
200 m

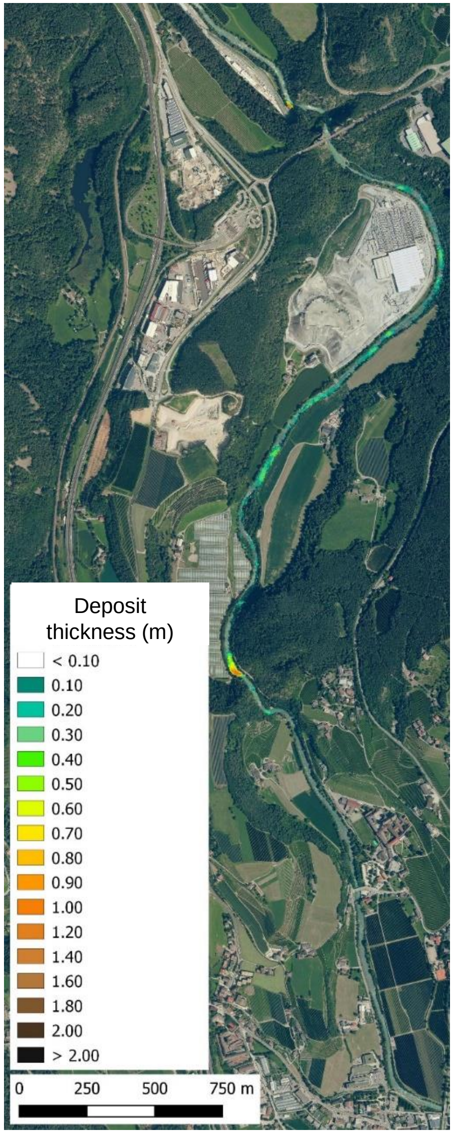

t = 14400s (4.0h)
Flow velocity (m/s)
0.001
1.000
2.000
3.000
4.000
10.000
0
100
200 m

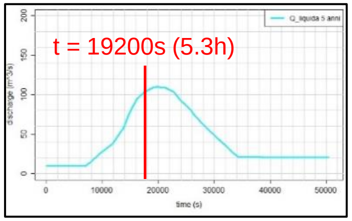

Water Surface Elevation
Delta_z
Riverbed
t = 14400s
544
542
540
538
536
534
532
0
100
200
300
400
500
600
A
B


Flow depth (m)
<0.10
0.10-0.25
0.25-0.50
0.50-1.00
1.00-1.50
1.50-2.00
>2.00
0
100
200 m

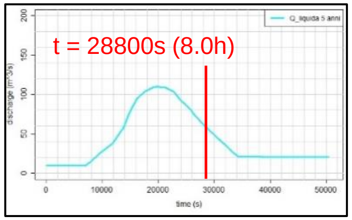
Results

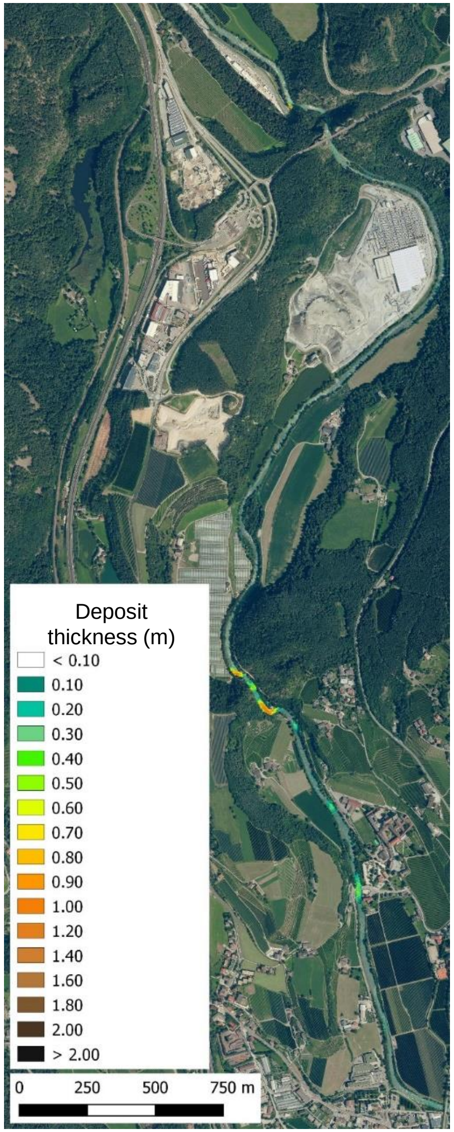
Peak phase: gravel almost completely transferred from the upstream sector and distributed along the downstream sector of the river reach

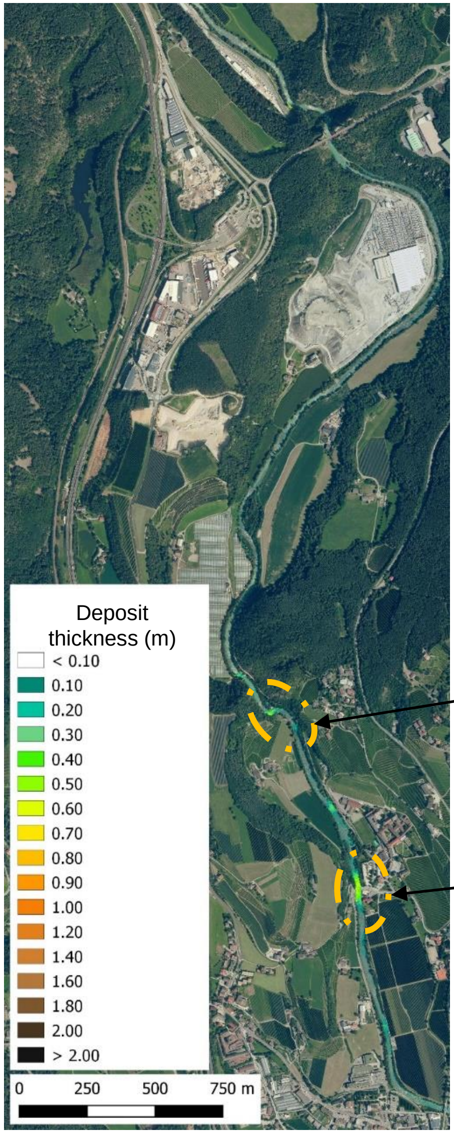


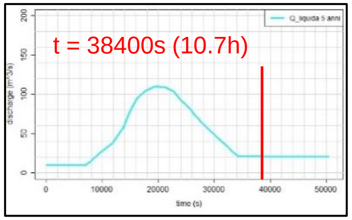


Results









Sudden section contraction

Bedslope reduction

Decreasing phase: sediments are mostly distributed in the second half of the analysed river reach and are concentrated in specific sectors.

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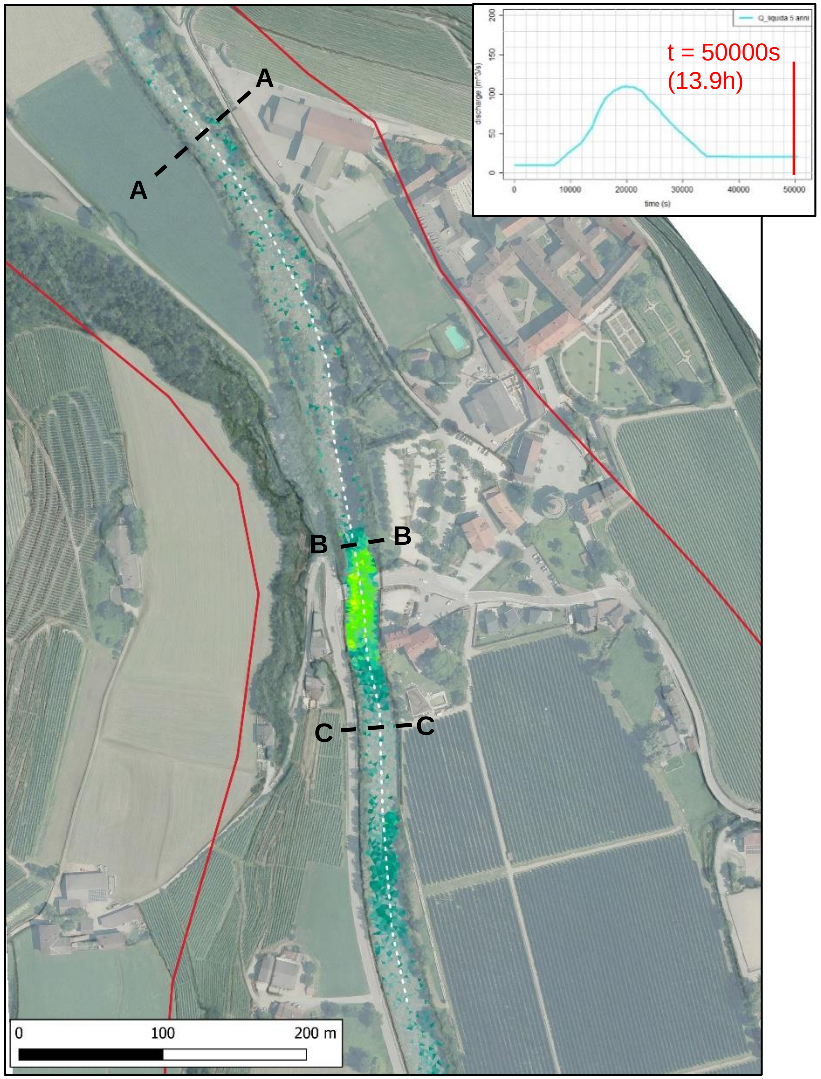
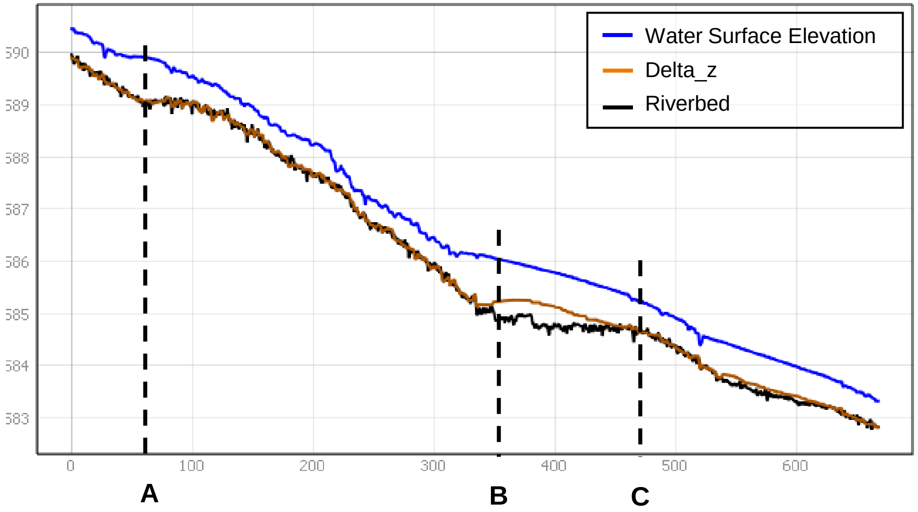
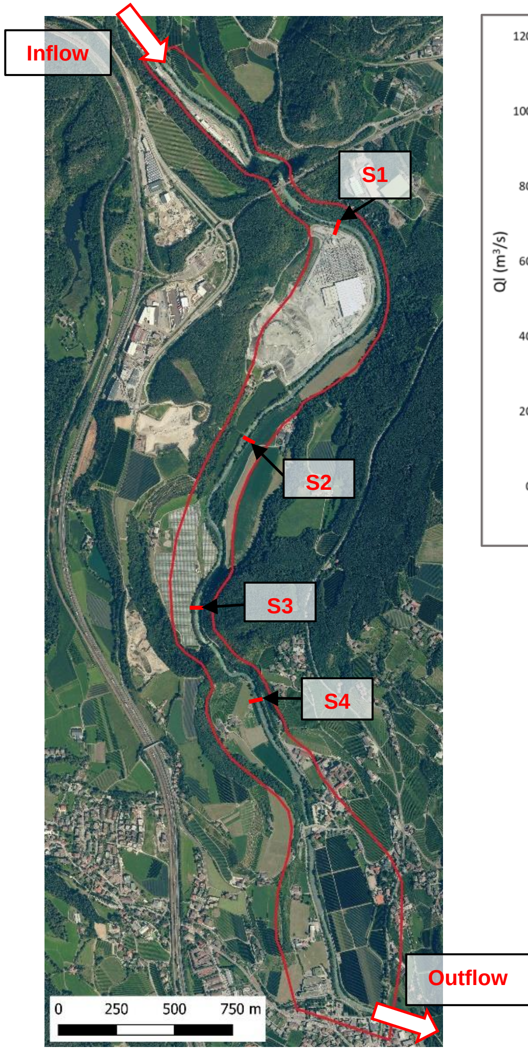
Results

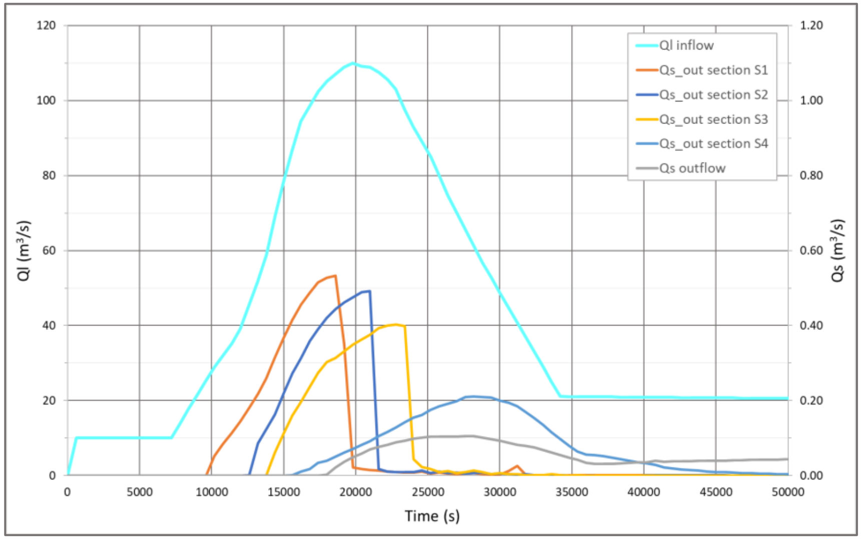




Results

- **Considerations on mobilized and deposited gravel volumes**





Sector	V_in (m^3)	V_out (m^3)	V_sed (m^3)
Inflow – S1	5500	4825	675
S1 – S2	4825	4485	340
S2 – S3	4485	4470	15
S3 – S4	4470	4415	55
S4 - outflow	4415	2990	1425
Total deposited volume			**2510**

Conclusions

The model showed that frequent flood events (5 years return period) mobilitate the whole volume of gravel fed in the river, gradually transfer the sediments downstream and distribute them in various sectors of the river reach.

The model allowed to identify the sectors of the simulated river reach where sediments mostly tend to deposit.

The model simulates well the effect of sudden contractions of the cross section and sudden slope reductions which cause a bigger tendency in sediment deposition.

The model allowed to calculate the volume of gravel deposited along the simulated river reach.

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Thank you for your attention

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