BASEMENT 2-D APPLICATION IN THE TERRITORIAL PLANNING OF MOUNTAINOUS AREAS - FROM THE DESIGN OF HYDRAULIC DEFENCE WORKS TO THE DEFINITION OF HAZARD MAPS

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Gaspare Andreella / Marika Righetto

BASEMENT users meeting 2024

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HOME LO STUDIO SERVIZI PORTFOLIO APPROFONDIMENTI CONTATTI

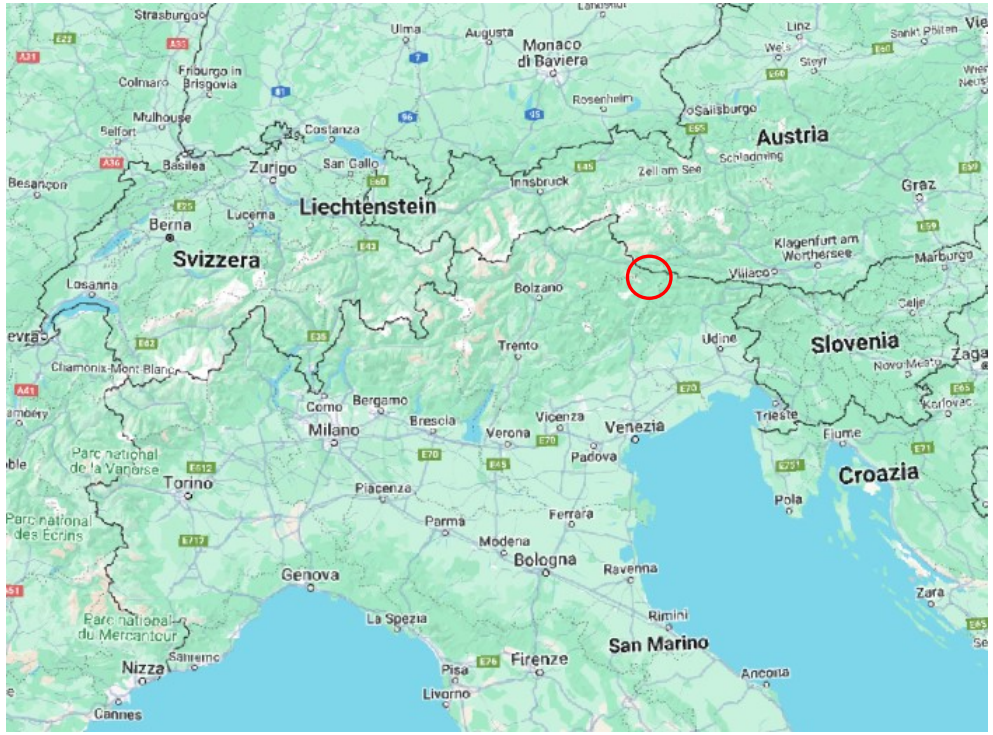
MORPHODYNAMIC –INLINE STRUCTURES

HYDRAULIC - DEFENCE WORKS

MORPHODYNAMIC –LATERAL STRUCTURES

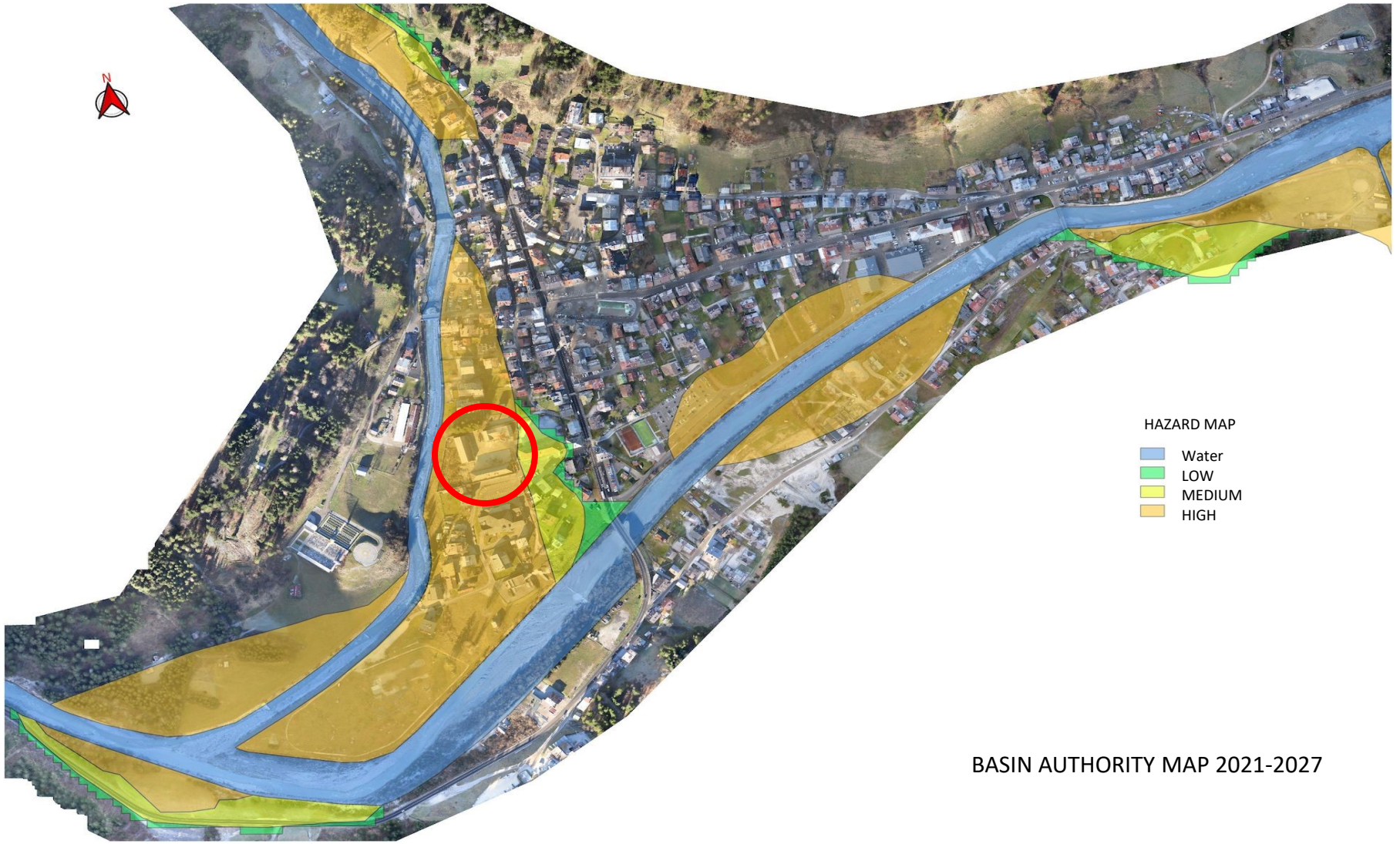
MORPHODYNAMIC – DEFENCE WORKS

SEDIMENT TRANSPORT



Santo Stefano di Cadore – Dolomiti UNESCO

CURRENT HAZARD MAP



BASIN AUTHORITY MAP 2021-2027

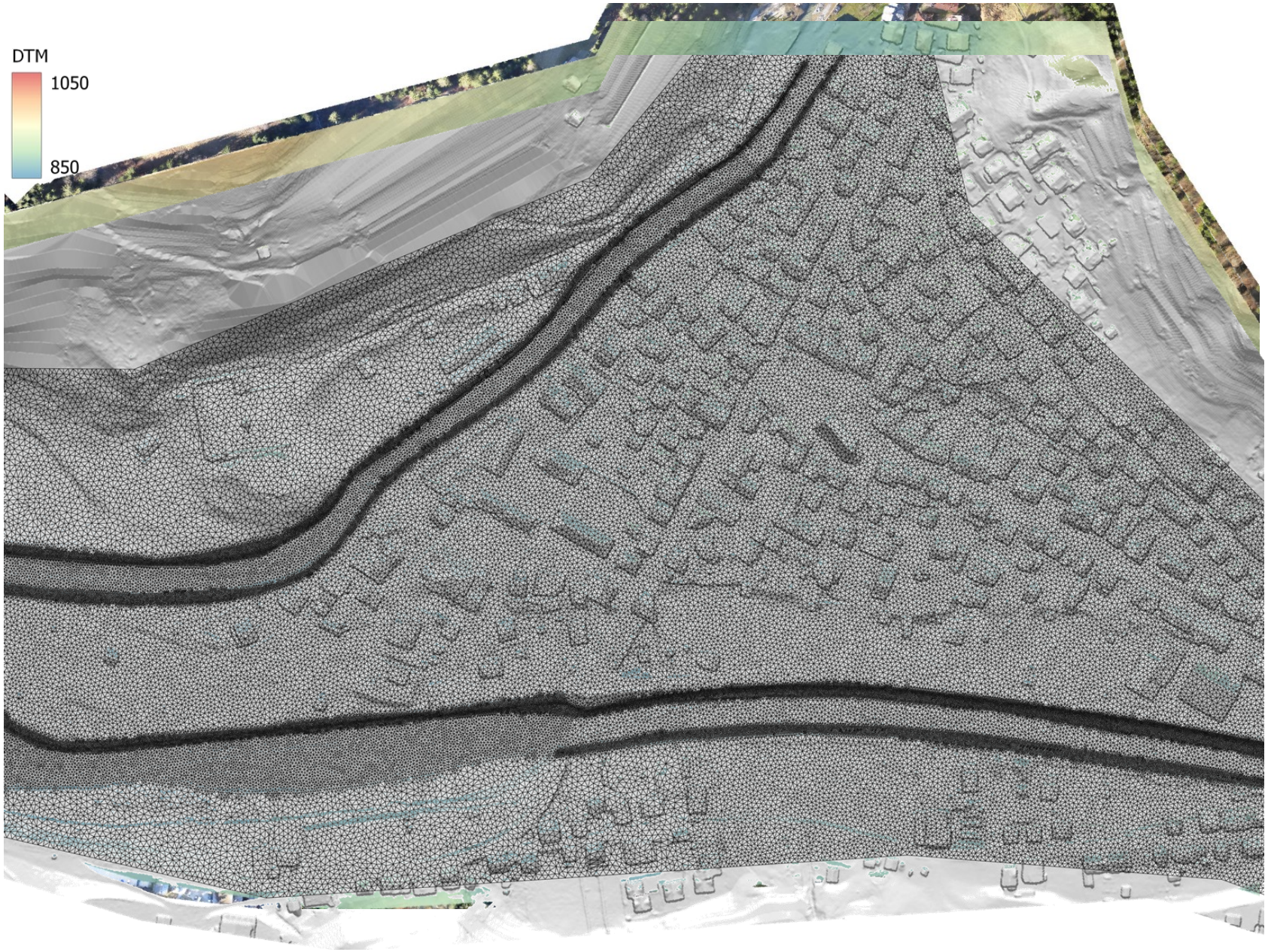
The AIM OF THE STUDY is to redefine the floodable areas and obtain a change in the current hazard maps through the design of mitigation works in order to build a new fire station

PROBLEMS

- We did not have recorded data for calibration
- It is a very complex area (large but with very small linear works such as retaining walls, it's a built-up area with complex hydraulic and morphological processes at the confluence of rivers)
- it is a mountainous area dealing with torrential watercourses where the hydrodynamic processes must be considered together with the morphodynamical processes, if we hadn't evaluated the erosion/sedimentation process correctly, we could have made errors in sizing the mitigation works
- We have to simulate the effect of the obstruction of bridges
- We have to manage a huge amount of data

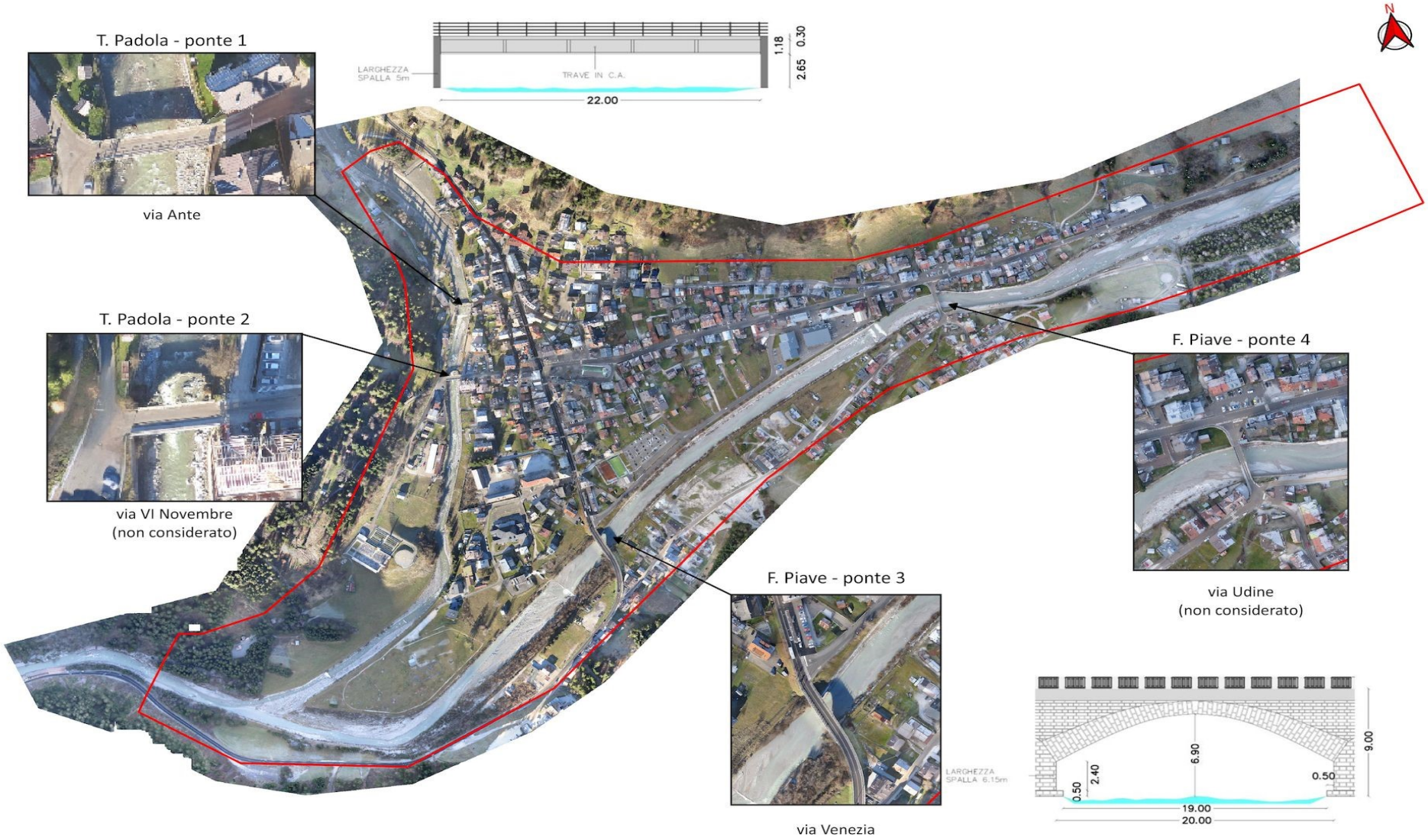
GOALS

- The model application allows to reduce the hydraulic hazard in urban area
- It made possible the realization of strategic public works that were not permitted with stakeholders' satisfaction (mountain community, municipalities in the neighbourhood, citizens,…)
- this project led us to implement a GIS tool for the hazard definition from Basement Mesh (.2dm file and .xdmf file) following the Basin Authority mapping procedure



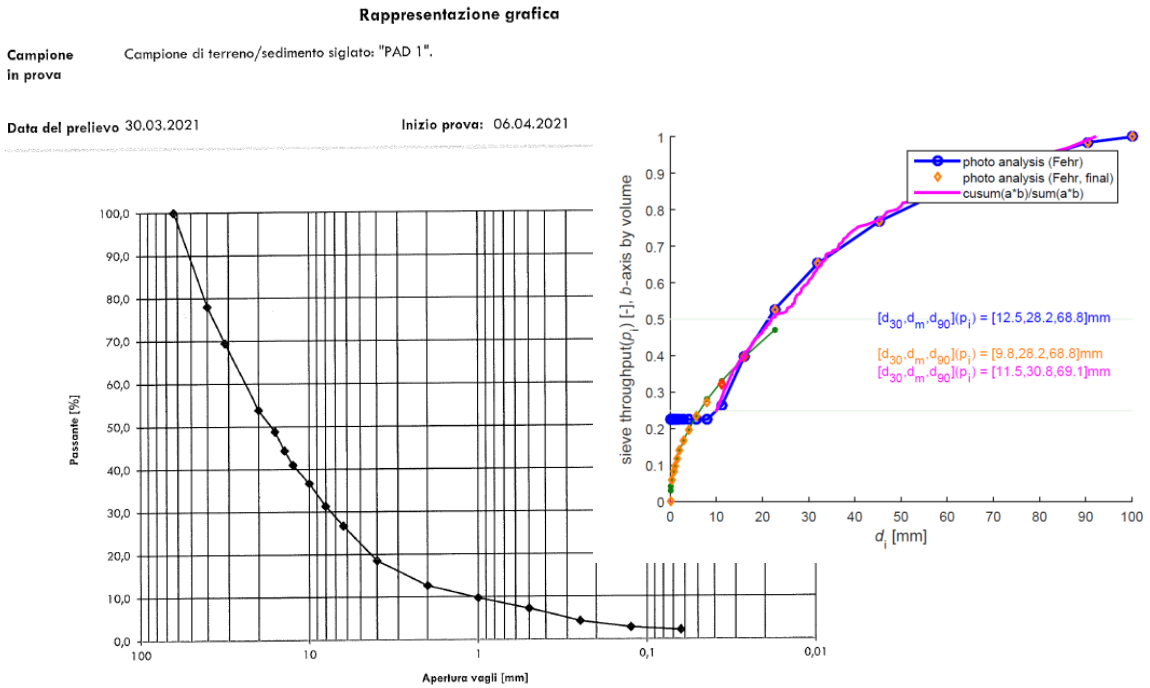
Elevation data by Airborne Laser Scanning (Lidar)

Domain area = 80 ha
Cells (Riverbed) 3 m²
Cells (Banks and walls) 0.2 m²
Cells (Floodplain) 5 m²


T. Padola - ponte 1
via Ante
T. Padola - ponte 2
via VI Novembre
(non considerato)
F. Piave - ponte 4
via Udine
(non considerato)
F. Piave - ponte 3
via Venezia
LARGHEZZA SPALLA 5m
TRAVE IN C.A.
1.18
0.30
2.65
22.00
LARGHEZZA SPALLA 6.15m
6.90
9.00
2.40
0.50
0.50
19.00
20.00
N

BOUNDARY CONDITIONS

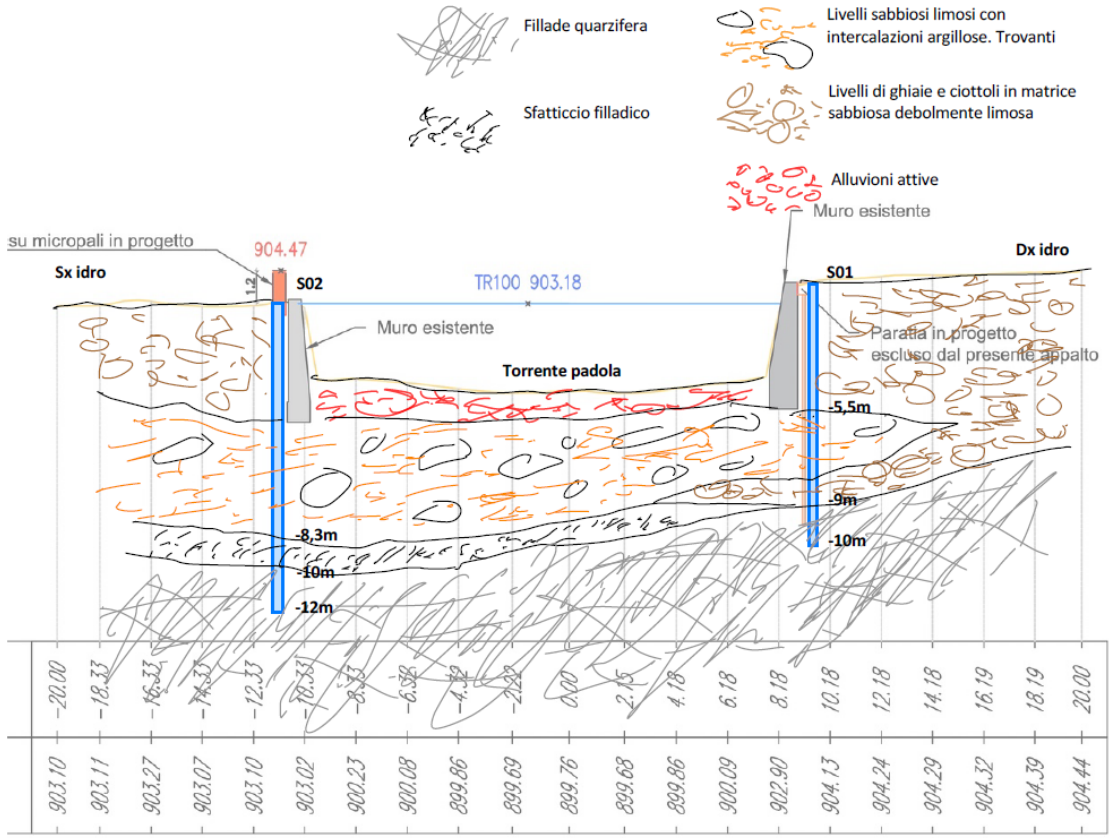
- **Morphology**: single-grain bedload transport (mean grain diameter: 20 mm) derived from the granulometric analysis and BASE-Grain application
- **Soil stratigraphy**: Depth of possible erosion limits



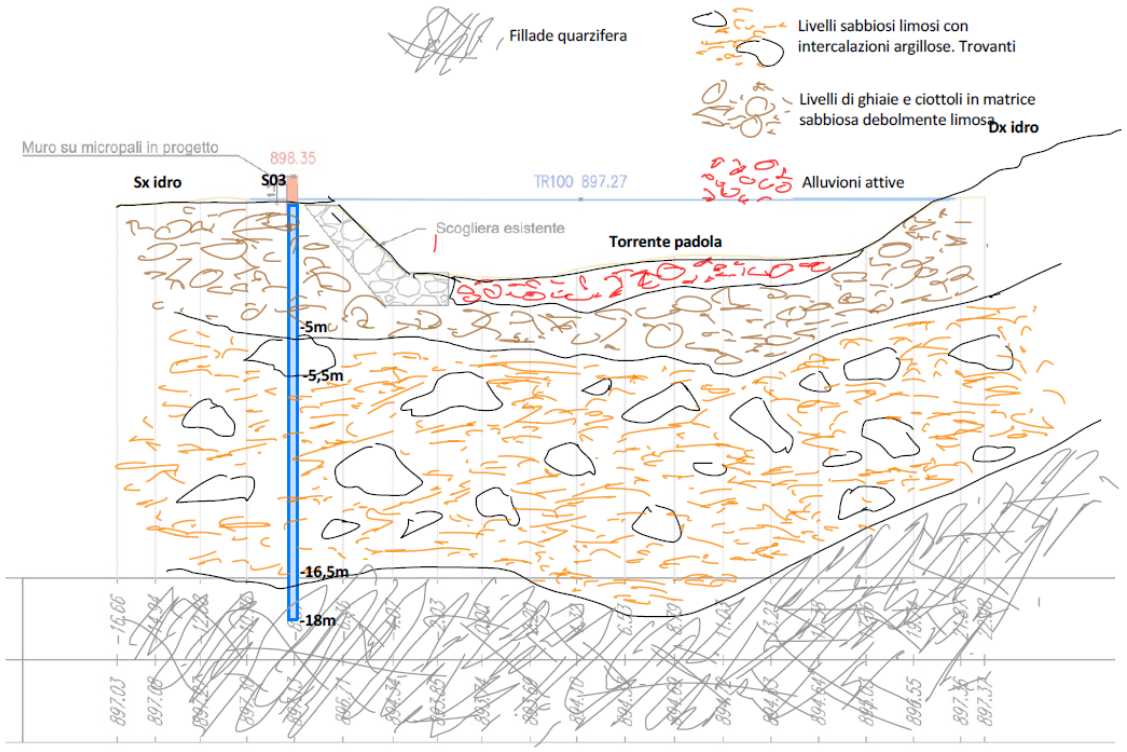
BOUNDARY CONDITIONS

- **Morphology**: single-grain bedload transport (mean grain diameter: 20 mm) derived from the granulometric analysis and BASE-Grain application
- **Soil stratigraphy**: Depth of possible erosion limits

SEZIONE GEOLOGICA A



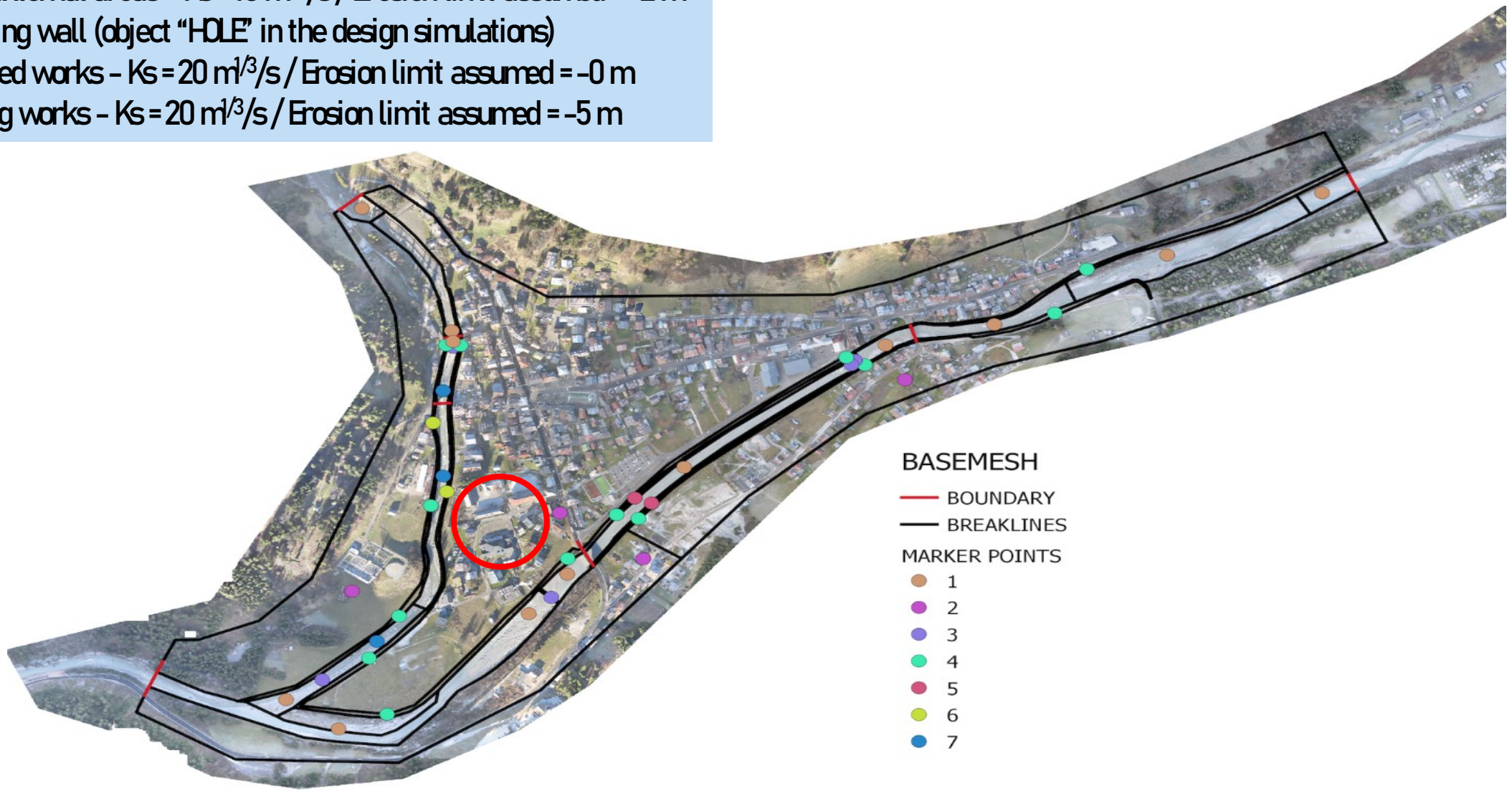
SEZIONE GEOLOGICA B




MESH
Material ID
1
2
3
4
5
6
7

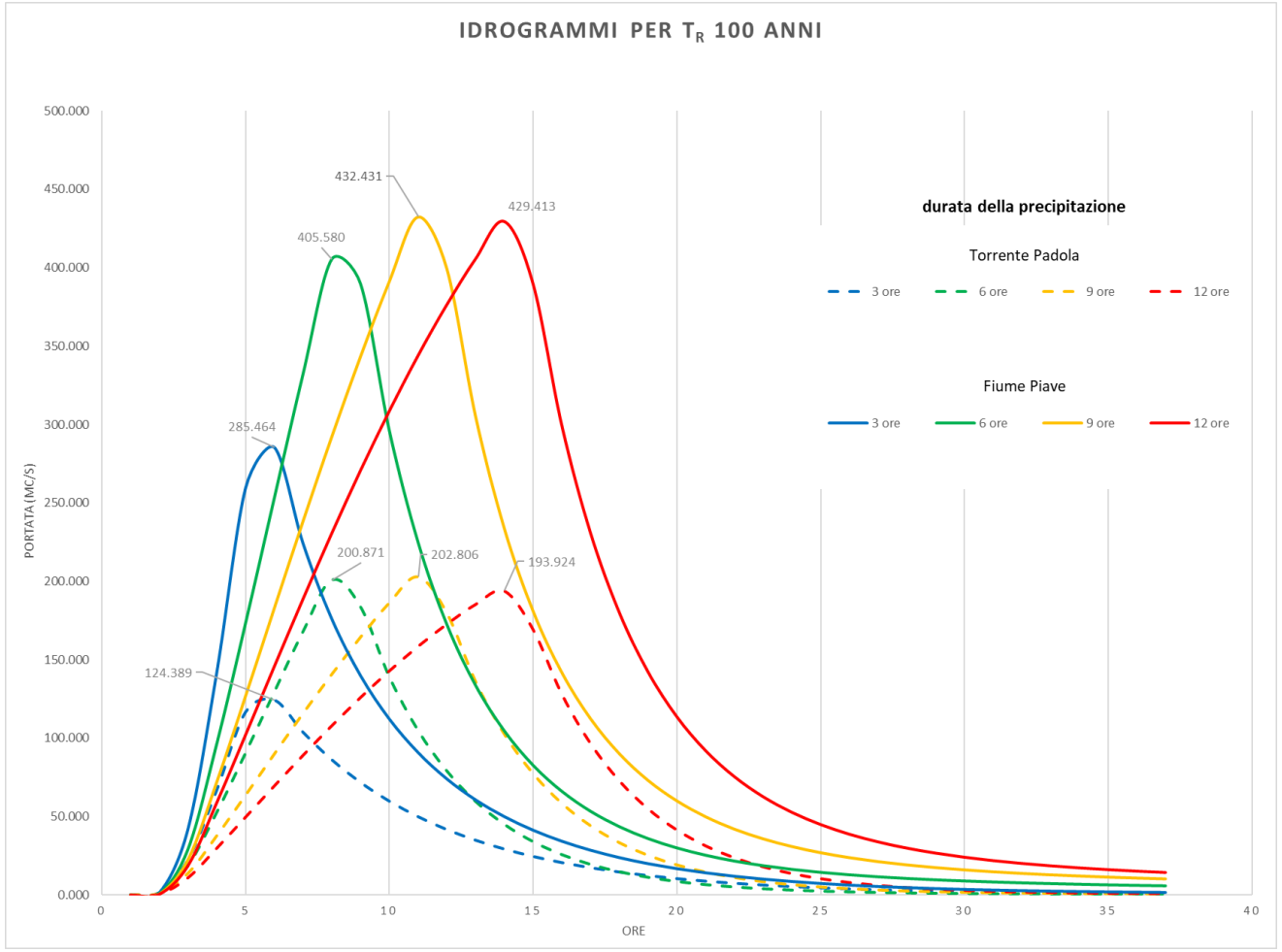

MESH
Material ID
1
2
3
4
5
6
7

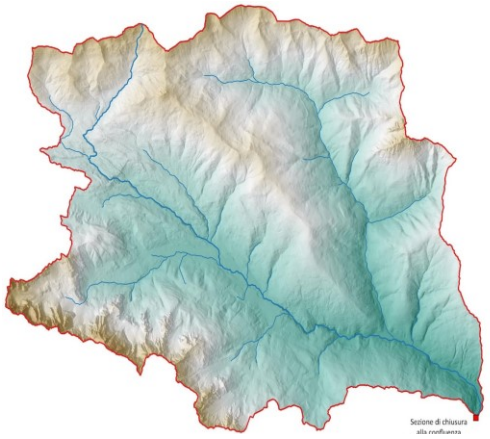
- Active river bed – Ks = 15 $m^{1/3}/s$ / Erosion limit assumed = -5 m
- non erodibile areas – Ks = 20 $m^{1/3}/s$ / Erosion limit assumed = -0 m
- Flood external areas – Ks = 10 $m^{1/3}/s$ / Erosion limit assumed = -2 m
- Retaining wall (object "HOLE" in the design simulations)
- Designed works – Ks = 20 $m^{1/3}/s$ / Erosion limit assumed = -0 m
- Existing works – Ks = 20 $m^{1/3}/s$ / Erosion limit assumed = -5 m



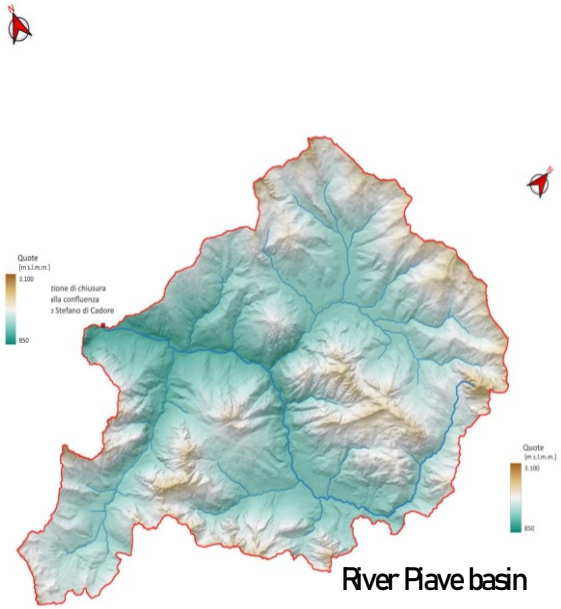
BOUNDARY CONDITIONS

- **Hydraulics**: Input hydrograph and output average slope, Ks
- **Bed Load**: Mayer Peter Muller equation, boundary equilibrium conditions





Padola stream basin

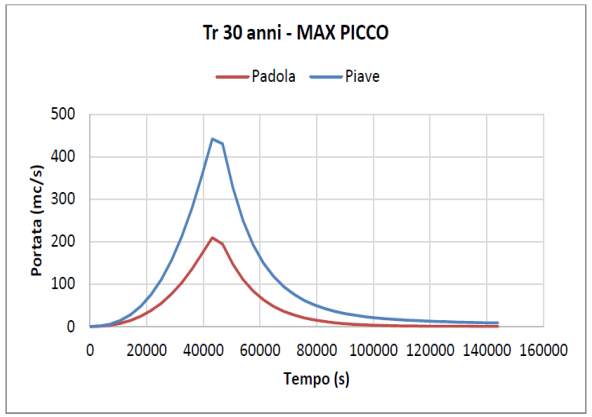


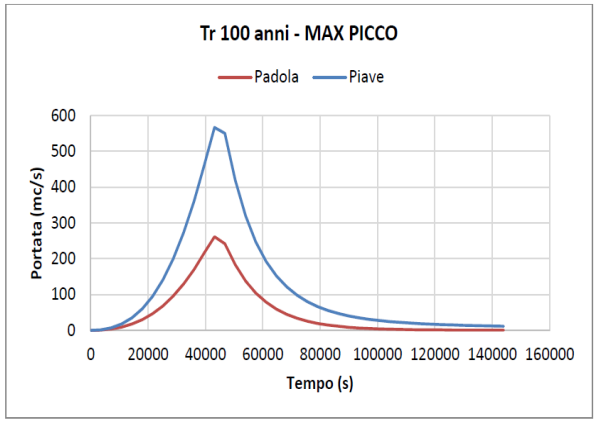
River Piave basin

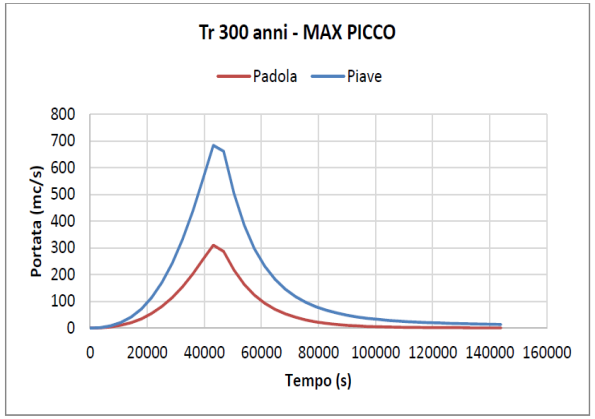
30, 100, 300 years return periods
Different precipitation duration
Different precipitation distribution

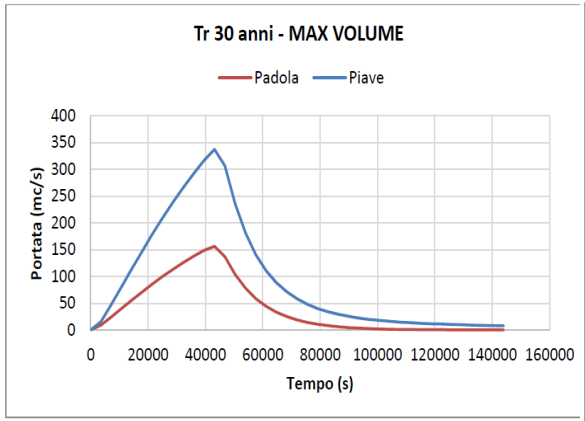
BOUNDARY CONDITIONS

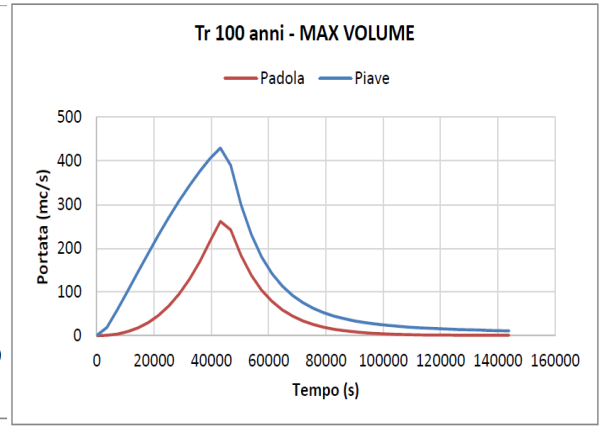
1. the hydrograph that maximizes the peak of the liquid discharge (pmax hydrograph);
2. the hydrograph that maximizes the volume of the associated sediment discharge (vmax hydrograph).

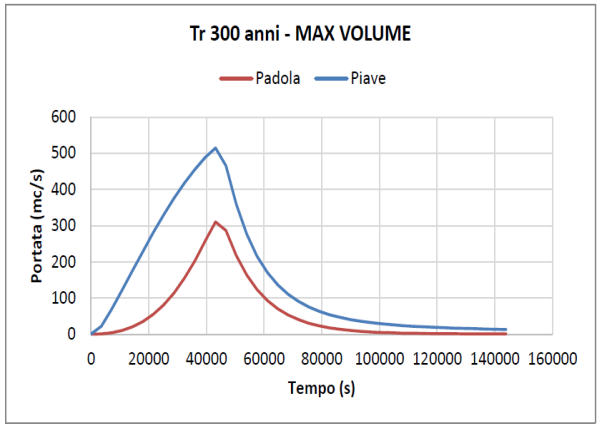












SCENARIOS DEFINITION

10 Scenarios for model calibration trying different grain sizes, roughness and boundary conditions

6 Scenarios for preliminary simulations (pmax 30,100,300 and vmax30,100,300)

For the mapping procedure the current EU Directive says that we must consider the possibility of **collapse of structures** or **obstruction of bridges** as well as to assign a "status" of functionality for each existing work

- 6 simulations without obstruction, fully erodible domain
- 6 simulations without obstruction with non-erodible domain
- 5 simulations with obstruction of the bridge over the Padola stream at present (no obstruction occurs for maximum volume Tr30)
- 5 simulations with obstruction of the bridge over the river Piave in the current state (no obstruction occurs for maximum volume Tr30)

Total 22 simulations, 44 raster (max depth – max velocity)

BRIDGE OBSTRUCTION SCENARIOS

In torrential watercourses we are supposed to evaluate the reduction of the section under a bridge caused by the deposit of vegetation

We follow procedure and methods of the "System for stream hydro morphological assessment, analysis, and monitoring" named IDRAIM (Flood Directive 2007/60/CE)

1. SURVEY: To verify the presence of vegetation in the riverbed and on the banks, at least 2 km upstream of the bridge, and to estimate the height of plants and the tendency for vegetation deposit or transport
2. GIS DATA PROCESSING: Spatial analysis to calculate the length of the banks and the surface of riverbed with vegetation or without vegetation
3. PARAMETERS SETTING:

   P_0: Obstruction probability depending on to the geometry of the bridge (C), the availability of vegetation (K) and the probability that vegetation arrives under the bridge (T)

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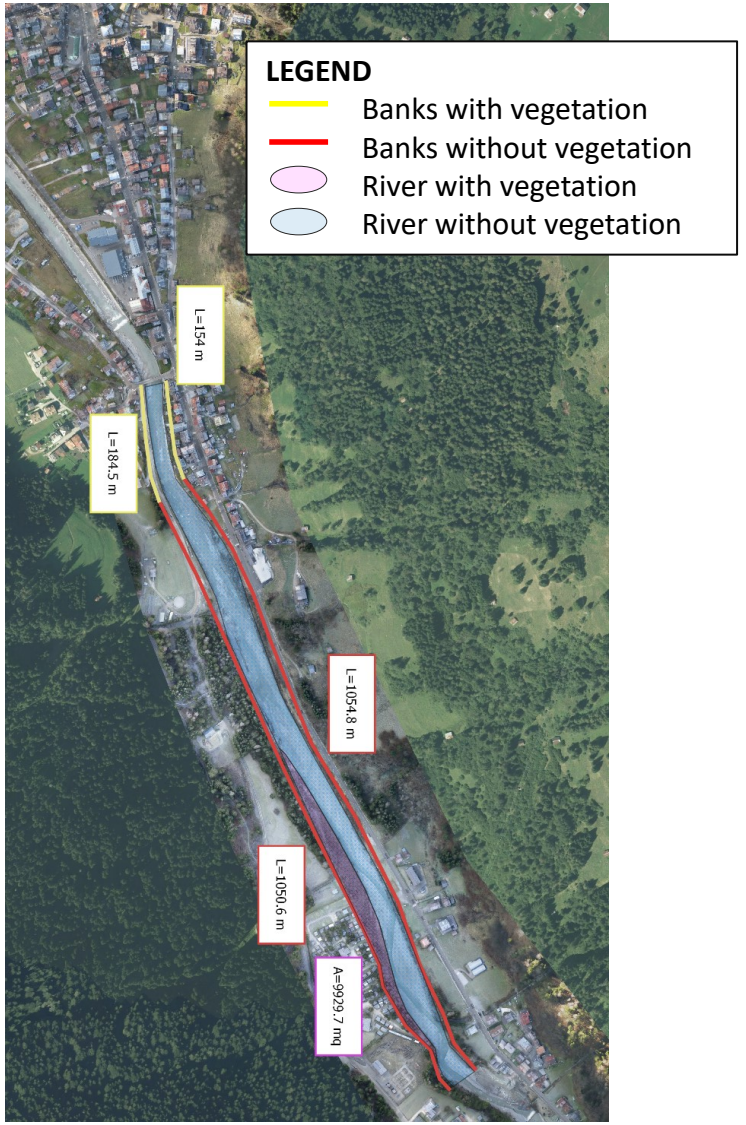

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2. **GIS DATA PROCESSING**: Spatial analysis to calculate the length of the banks and the surface of riverbed with vegetation or without vegetation
3. **PARAMETERS SETTING**: P_0=C*K*T

   P_0: Obstruction probability depending on to the geometry of the bridge (C), the availability of vegetation (K) and the probability that vegetation arrives under the bridge (T)

$P_0 = 1$	→	$F_R = 0.4$
$1 < P_0 \leq 0.75$	→	$F_R = 0.5$
$0.75 < P_0 \leq 0.5$	→	$F_R = 0.6$
$0.5 < P_0 \leq 0.25$	→	$F_R = 0.8$
$0.25 < P_0 < 0$	→	$F_R = 0.9$
$P_0 = 0$	→	$F_R = 1$

BRIDGE OBSTRUCTION SCENARIOS

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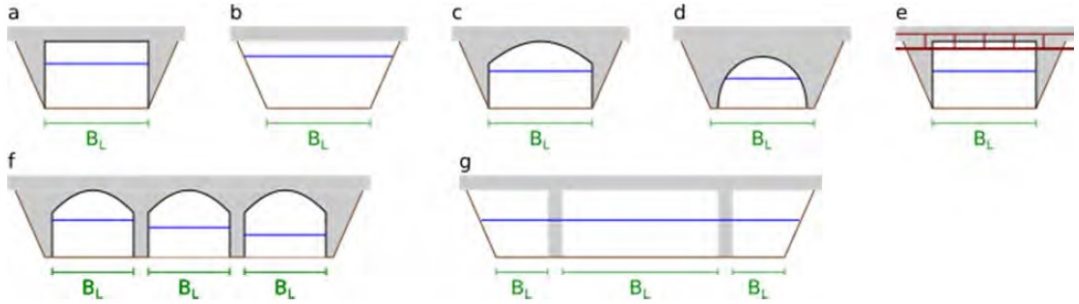
2. **GIS DATA PROCESSING**: Spatial analysis to calculate the length of the banks and the surface of riverbed with vegetation or without vegetation
3. **PARAMETERS SETTING**:
   P_0: Obstruction probability depending on to the geometry of the bridge (C), the availability of vegetation (K) and the probability that vegetation arrives under the bridge (T) – **Reduction Factor (F_R) and Effective Area (A_R)**

$$A_R = A_L F_R$$



Identification of the time of occlusion T_0

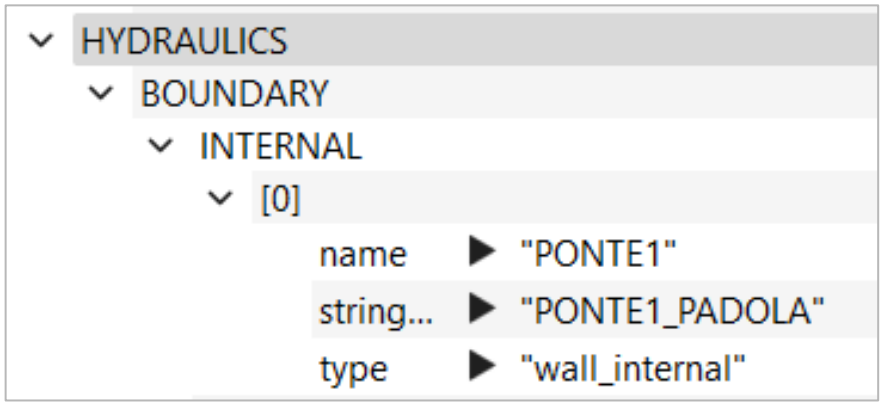
1. A "standard" simulation without bridge obstruction
2. The results of the simulation are extracted by the «BM3NbdestringResults.py» tool
3. The time of obstruction T_0 is defined (time in which the wetted area is equal to or greater than the effective area A_R)

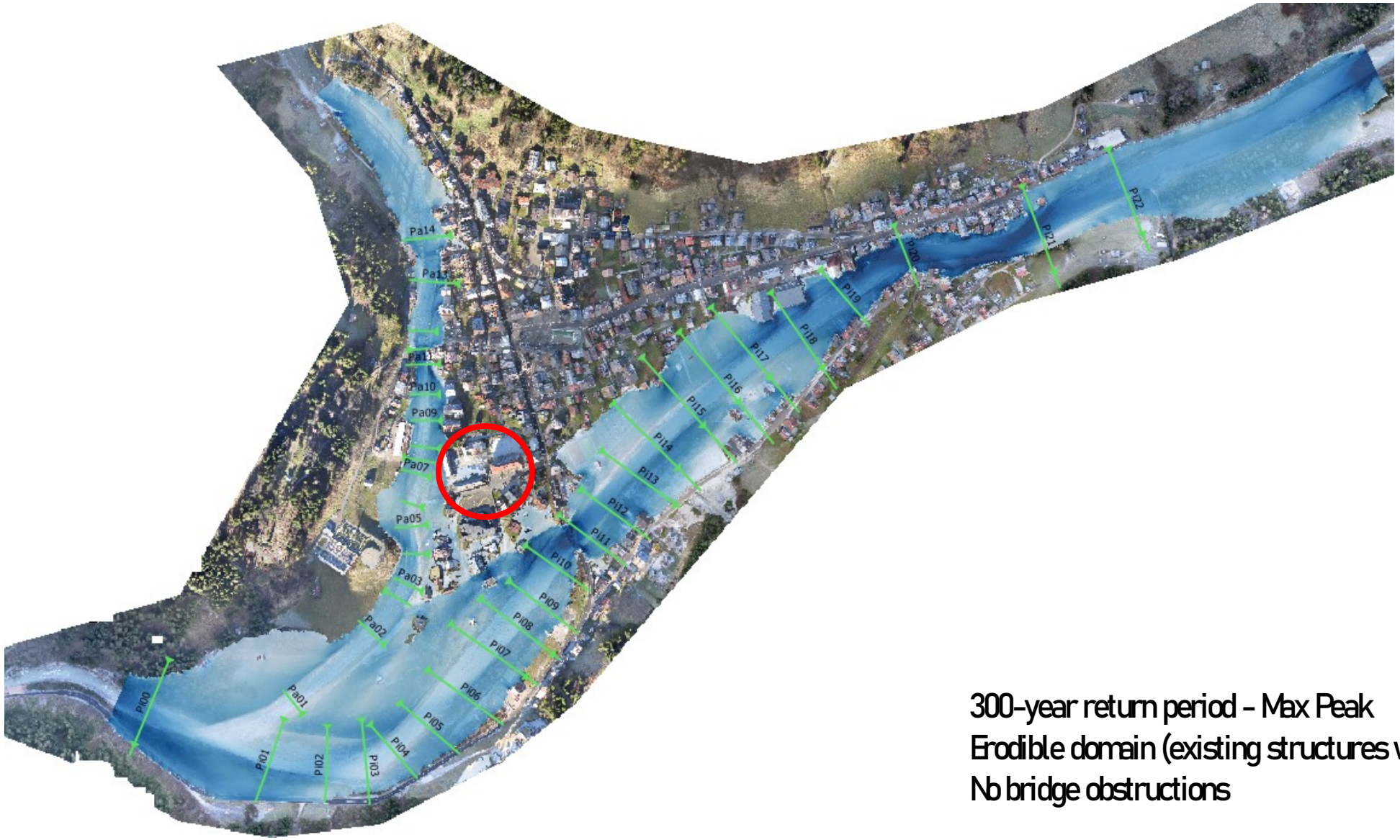
$$\text{Wetted Area} \geq A_R \rightarrow \text{Time of occlusion } (T_0)$$

Simulation of the bridge obstruction

- A RESTART SIMULATION is performed
- In the *Model.json* file the internal boundary condition named «*wall_internal*» is added at the bridge cross section;
- In the *Simulation.json* file the «*start time*» is set equal to the time of occlusion T_0

Model.json

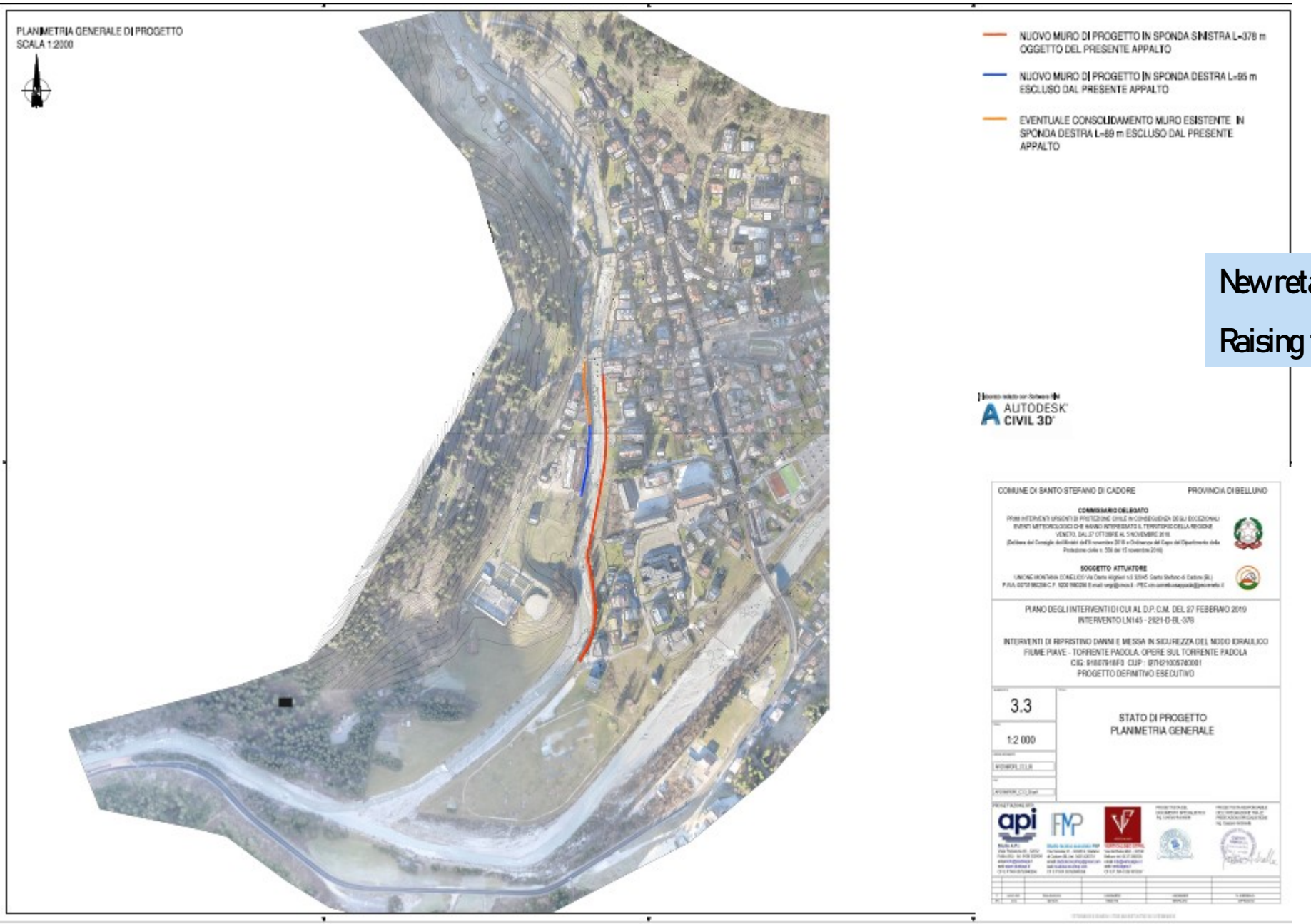




300-year return period – Max Peak
Erodible domain (existing structures with poor functionality)
No bridge obstructions

.. if we protect the retaining wall from erosion, stabilizing the riverbed, we will raise the water levels and we worsen the hydraulic conditions.

...it is important to define **a set of interventions** aimed both at hydraulic protection and at river stabilization.



DEFINITION OF INTERVENTION

New retaining wall

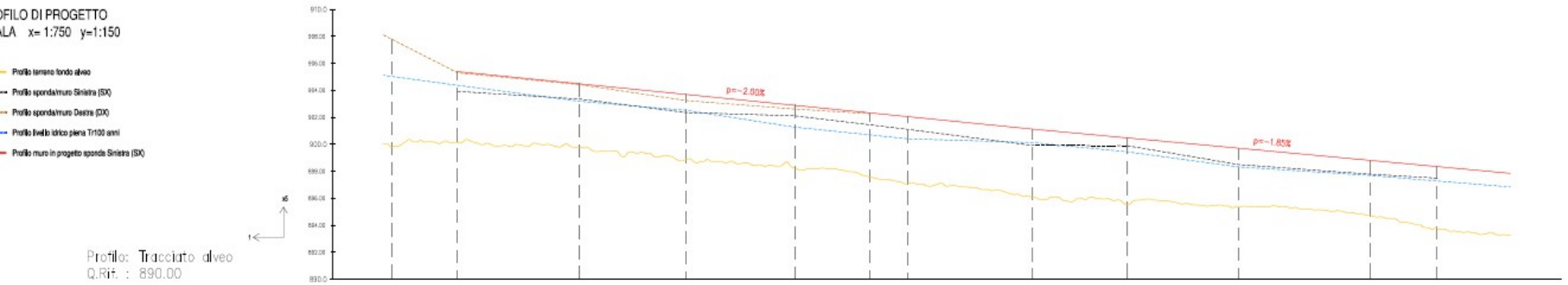
Raising the level behind the existing riprap

DEFINITION OF INTERVENTION

LEGENDA

- NUOVO MURO IN PROGETTO OGGETTO DEL PRESENTE APPALTO L=378 m
- NUOVO MURO DI PROGETTO IN SPONDA DESTRA L=95 m ESCLUSO DAL PRESENTE APPALTO
- EVENTUALE CONSOLIDAMENTO MURO ESISTENTE IN SPONDA DESTRA L=69 m ESCLUSO DAL PRESENTE APPALTO

Elaborato redatto con Software BIM
AUTODESK CIVIL 3D



NUMERO SEZIONE	PA11bis	PA11	PA10	PA09	PA08	PA07bis	PA07	PA06	PA05	PA04	PA03	PA02bis
DISTANZE PROGRESSIVE												
DISTANZE PARZIALI		24,42	45,39	39,26	40,33	27,99	13,79	46,51	35,12	41,10	48,75	24,99
QUOTE TERRENO												
QUOTE MURO ES SX												
QUOTE MURO ES DX												
QUOTE PIENA												

COMUNE DI SANTO STEFANO DI CADORE — PROVINCIA DI BELLUNO

COMMISSARIO DELEGATO

PRIMI INTERVENTI URGENTI DI PROTEZIONE CIVILE IN CONSEGUENZA DEGLI ECCEZIONALI EVENTI METEOROLOGICI CHE HANNO INTERESSATO IL TERRITORIO DELLA REGIONE VENETO, DAL 27 OTTOBRE AL 5 NOVEMBRE 2018.
(Delibera del Consiglio dei Ministri del 15 novembre 2018 e Ordinanza del Capo del Dipartimento della Protezione civile n. 558 del 15 novembre 2018)

SOGGETTO ATTUATORE

UNIONE MONTANA COMELICO Via Dante Alighieri n.3 32045 Santo Stefano di Cadore (BL)
P.IVA: 00731980256 C.F.: 92001980256 E-mail: segr@cmcs.it - PEC cm.comelicosp.pada@pecveneto.it

PIANO DEGLI INTERVENTI DI CUI AL D.P.C.M. DEL 27 FEBBRAIO 2019
INTERVENTO LN145 - 2021-D-BL-378

INTERVENTI DI RIPRISTINO DANNI E MESSA IN SICUREZZA DEL NODO IDRAULICO FIUME PIAVE - TORRENTE PADOLA. OPERE SUL TORRENTE PADOLA
CIG: 91807918F0 CUP : I27H21005740001
PROGETTO DEFINITIVO ESECUTIVO

3.4

VARIE

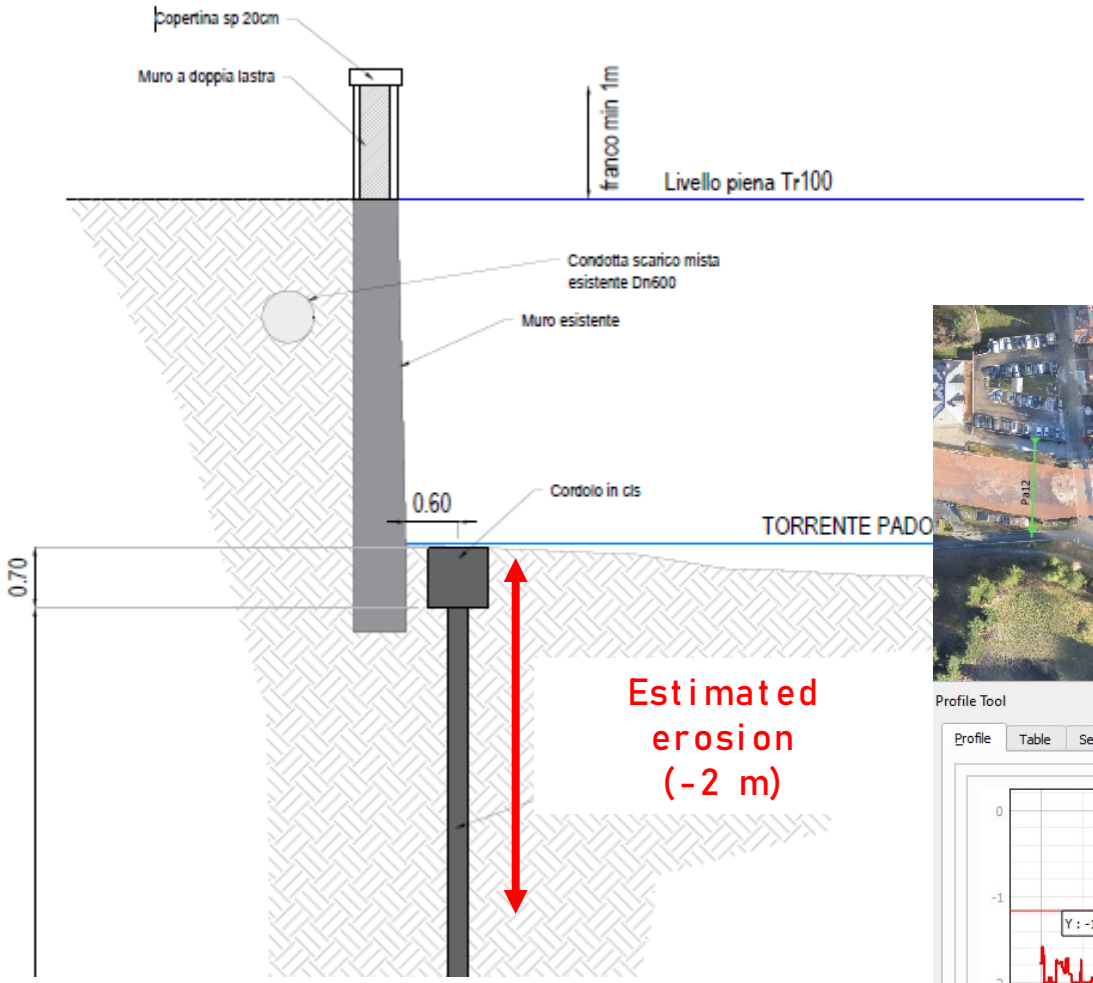
STATO DI PROGETTO
PLANIMETRIA PARTICOLARE E PROFILO LONGITUDINALE

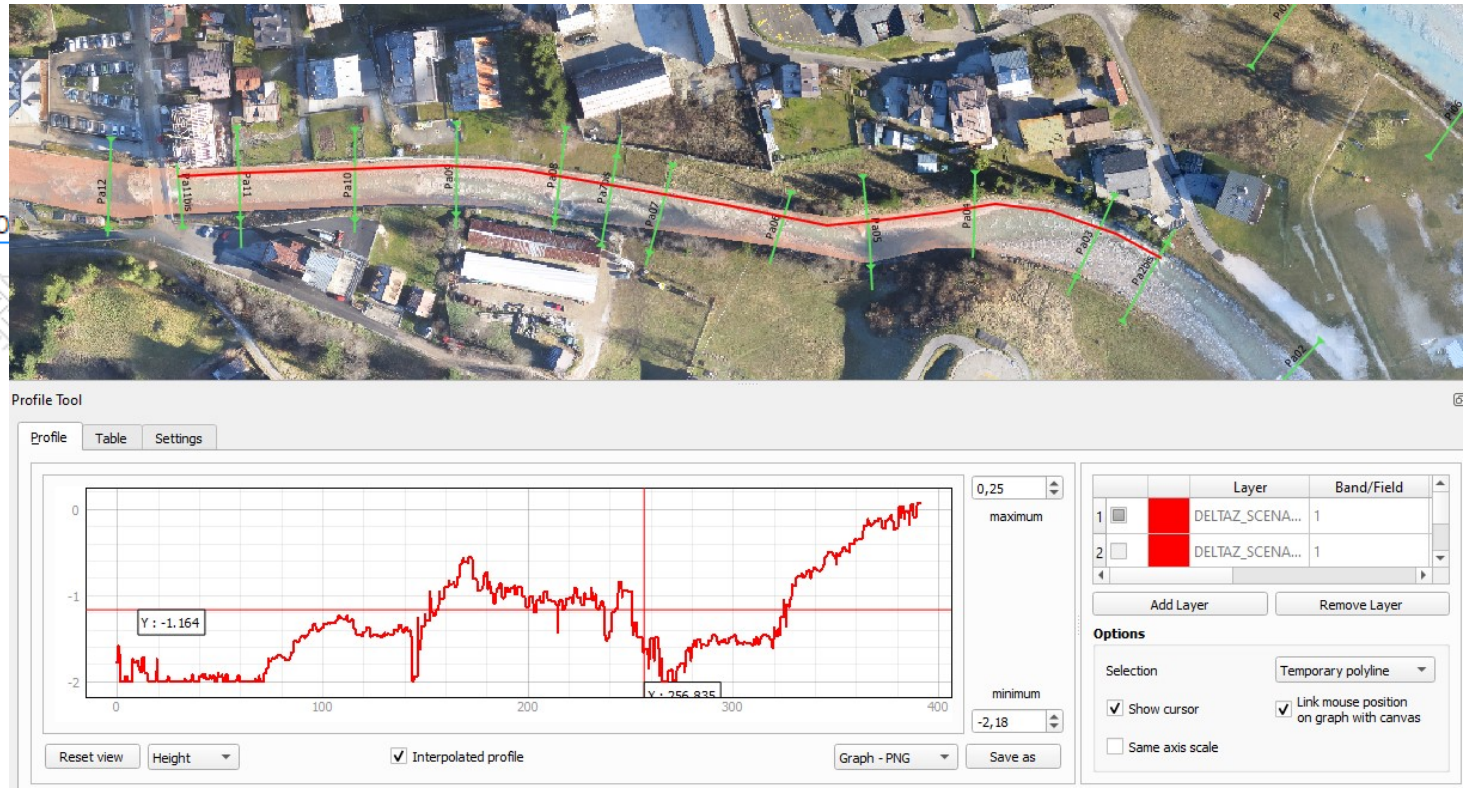
PROGETTAZIONE RTP

SEZIONE TIPO1

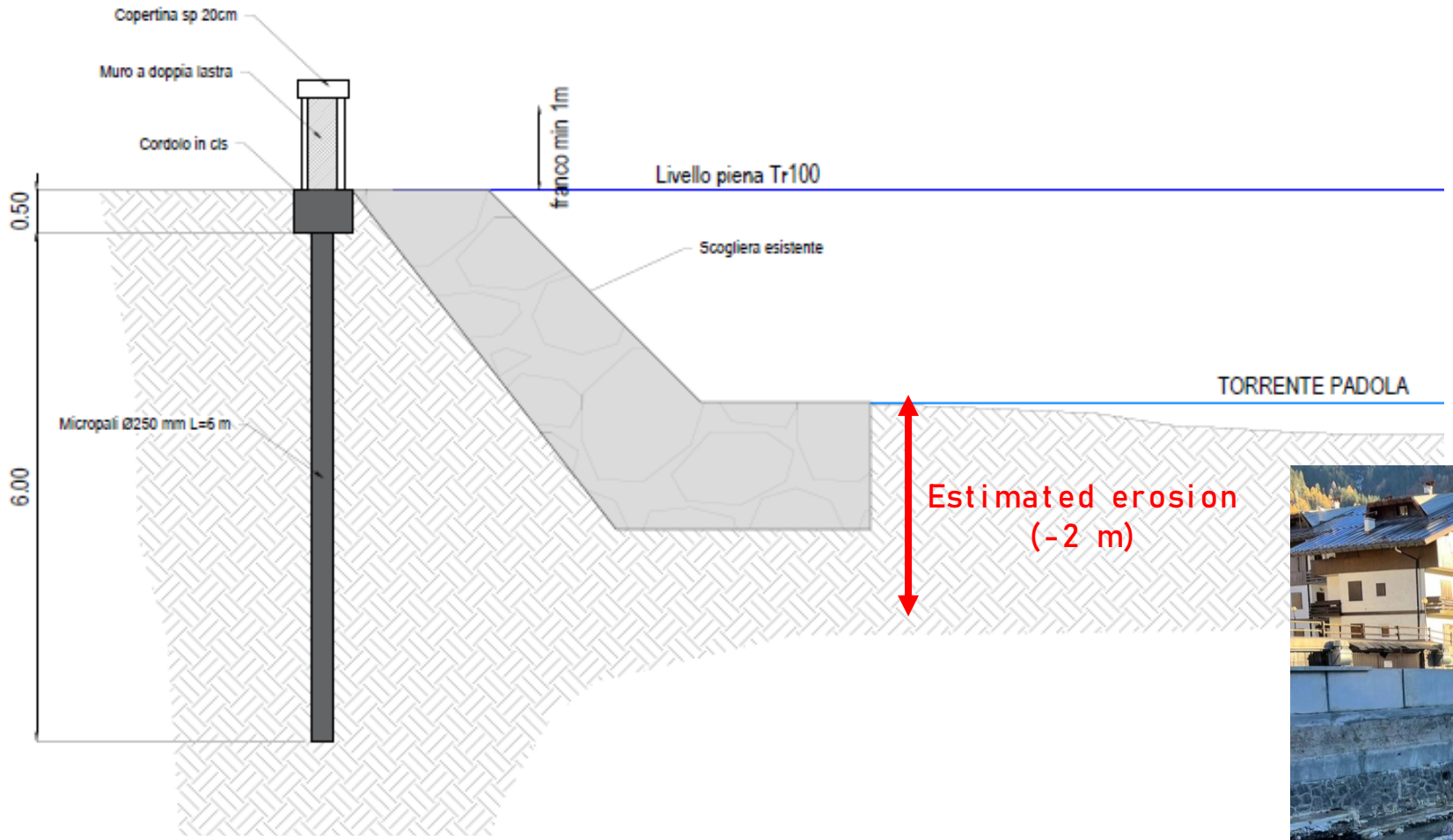
Sopraelevazione muro esistente e cordolo su micropali al piede del muro

Scala 1:50

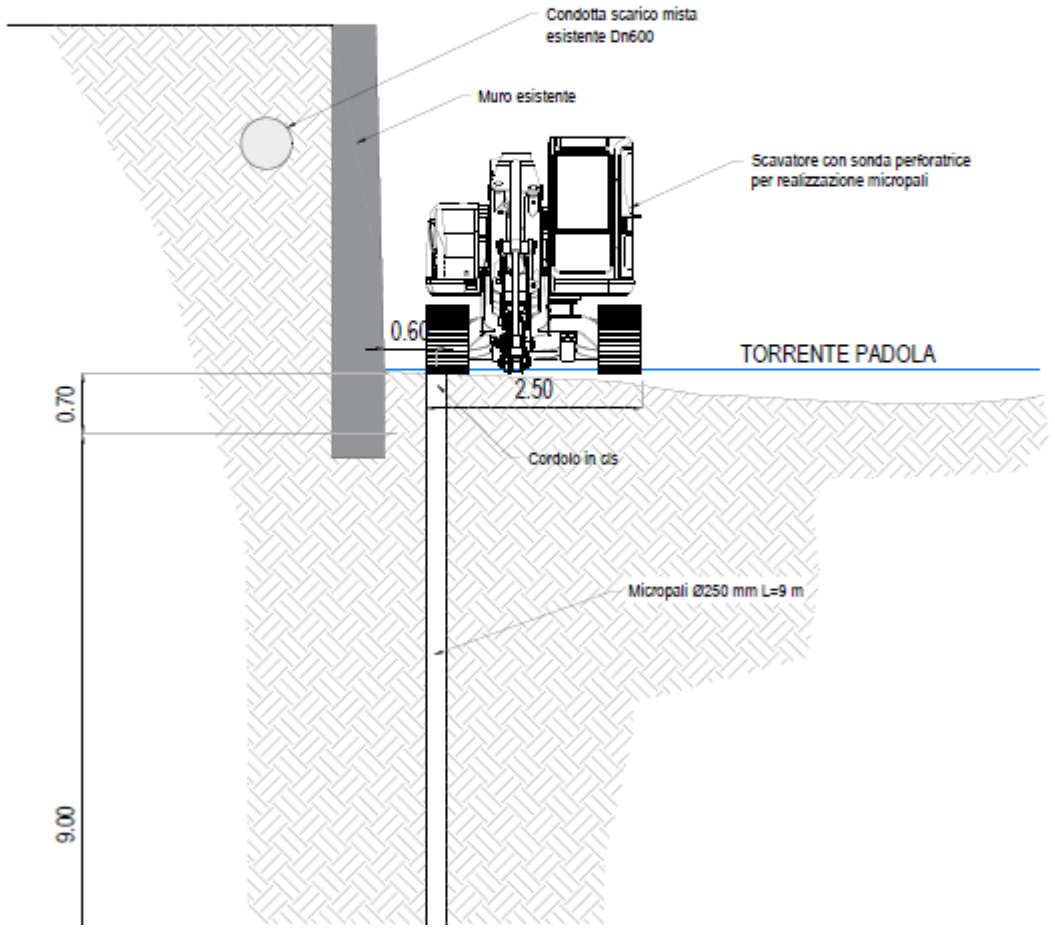




SEZIONE TIPO4
Muro su micropali a tergo scogliera esistente
Scala 1:50



SEZIONE TIPO1, 2 E 3 - FASE DI CANTIERE
Sopraelevazione muro esistente e cordolo su micropali al piede del muro
Scala 1:50




Pa14
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Pa11
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Pa08
Pa7bis
Pa07
Pa06
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Pa03
Pa2bis


Pa14
Pa13
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Pa07
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Pa05
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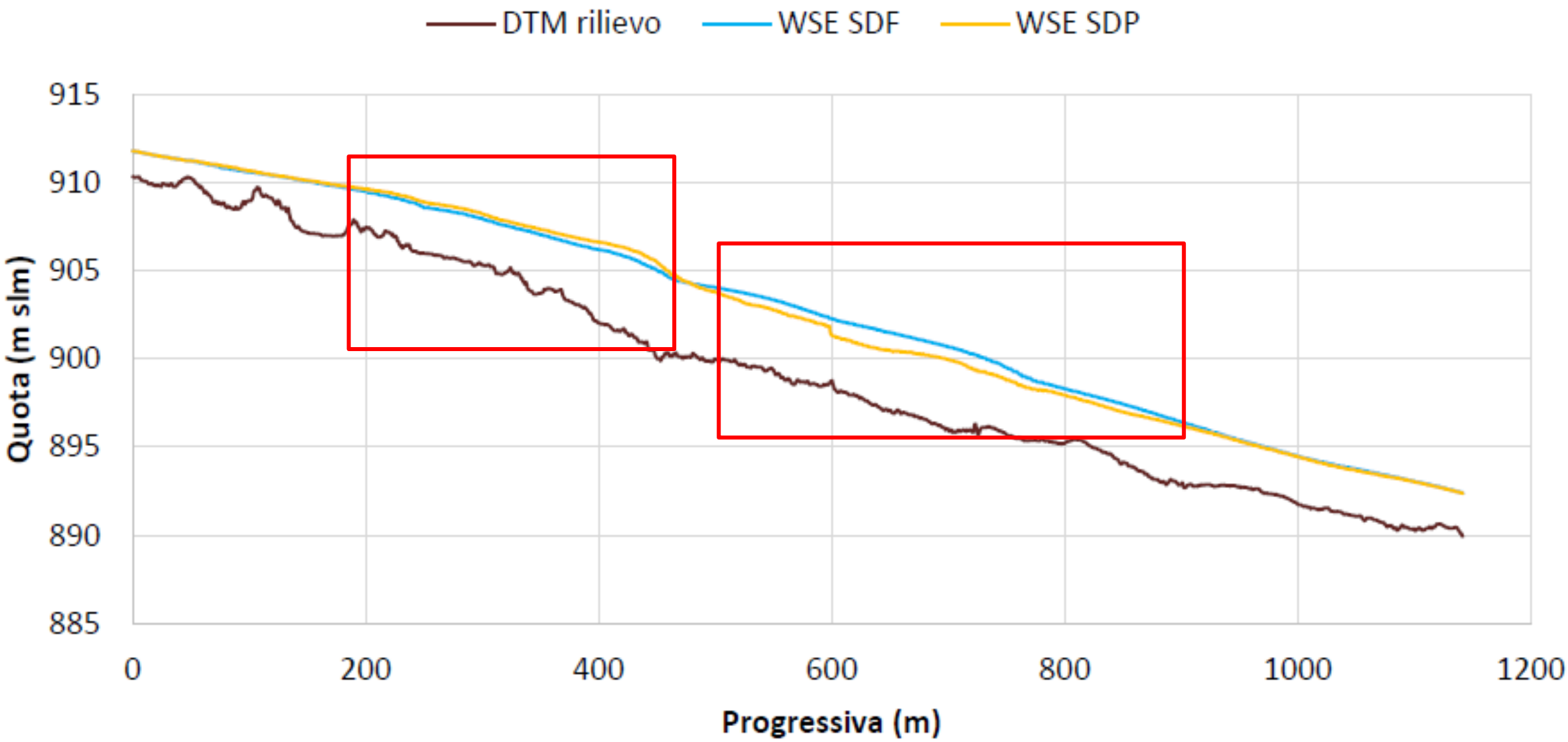
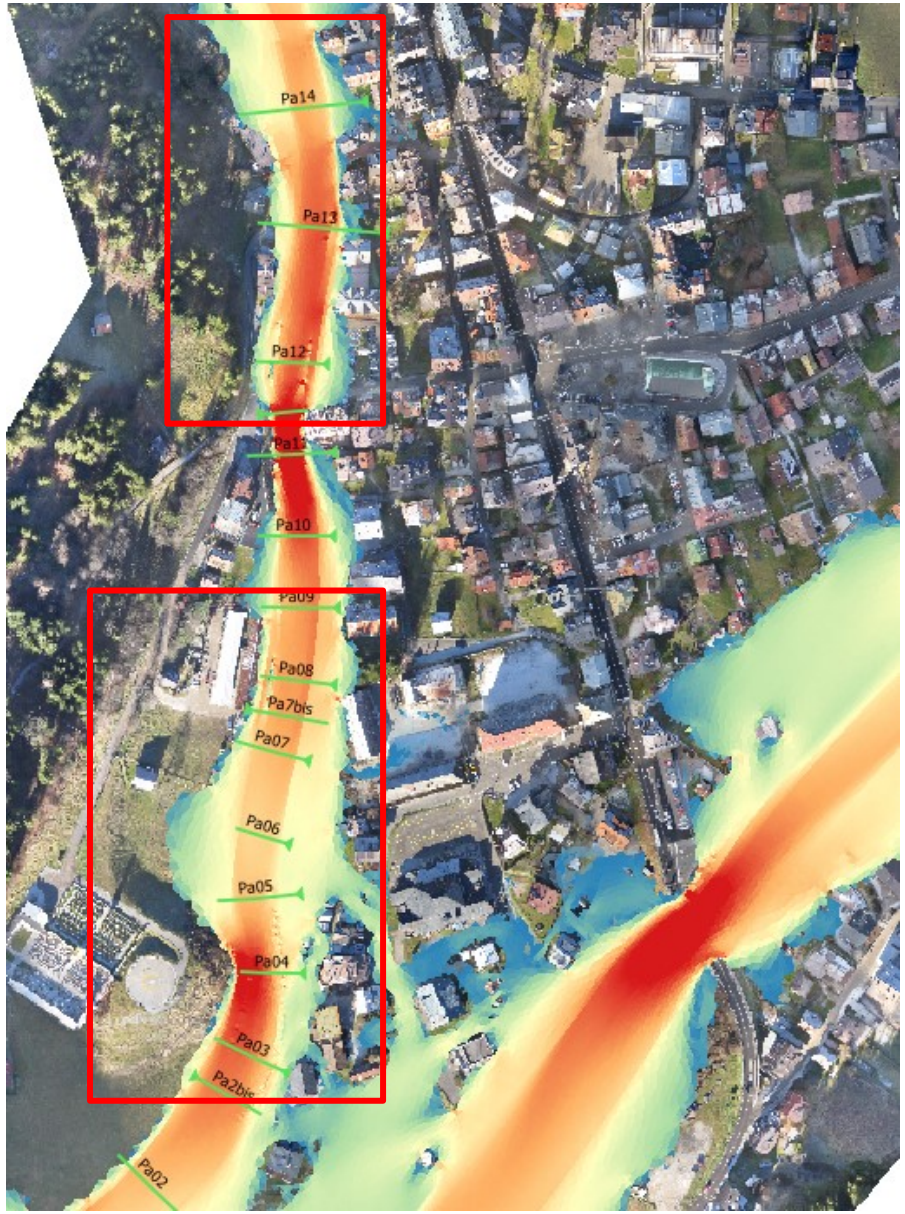
Pa03
Pa2bis
Pa02


Padola - Tr 100 anni - massimo picco
DTM rilievo
WSE SDF
WSE SDP
915
910
905
900
895
890
885
Quota (m slm)
0
200
400
600
800
1000
1200
Progressiva (m)


Pa14
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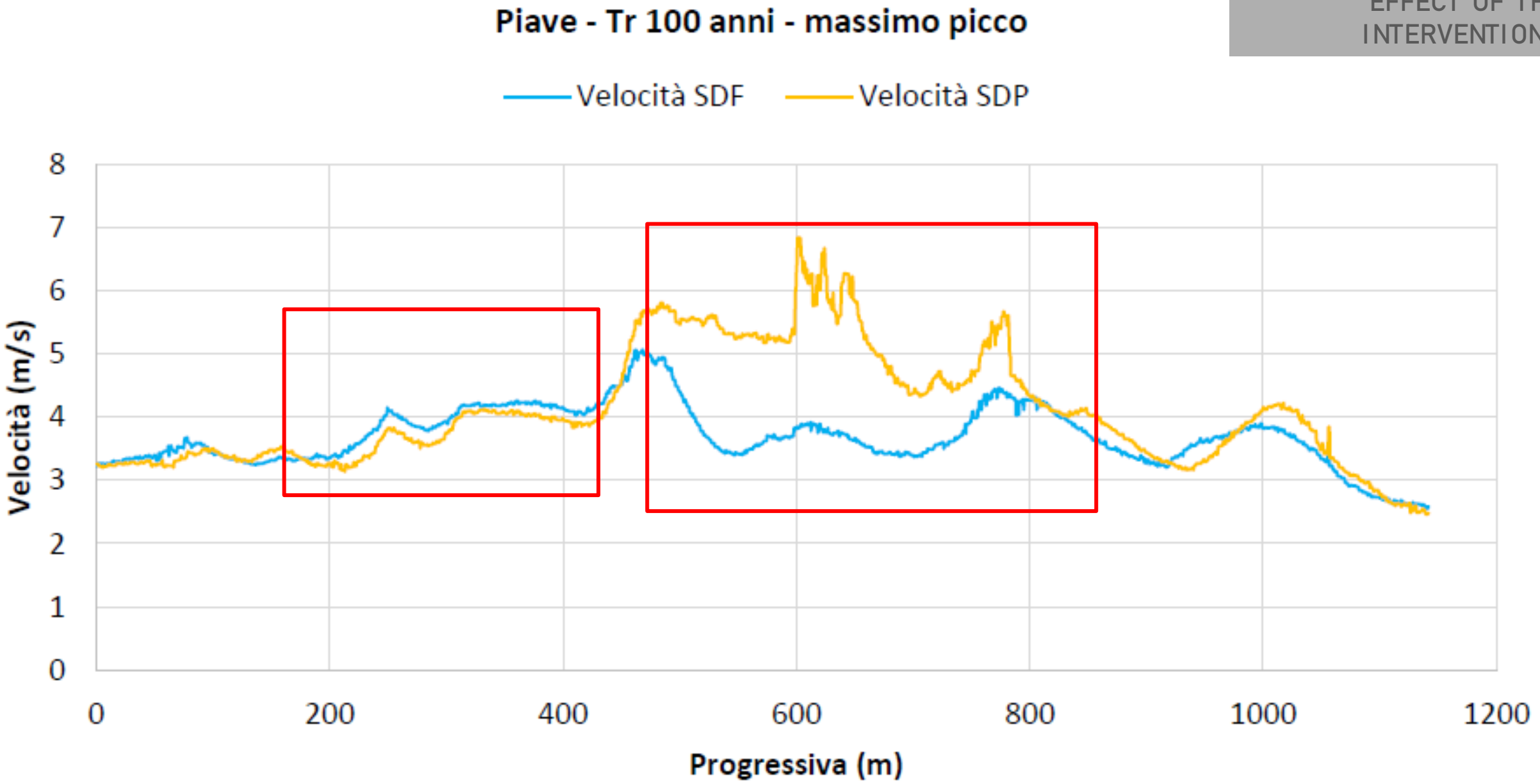
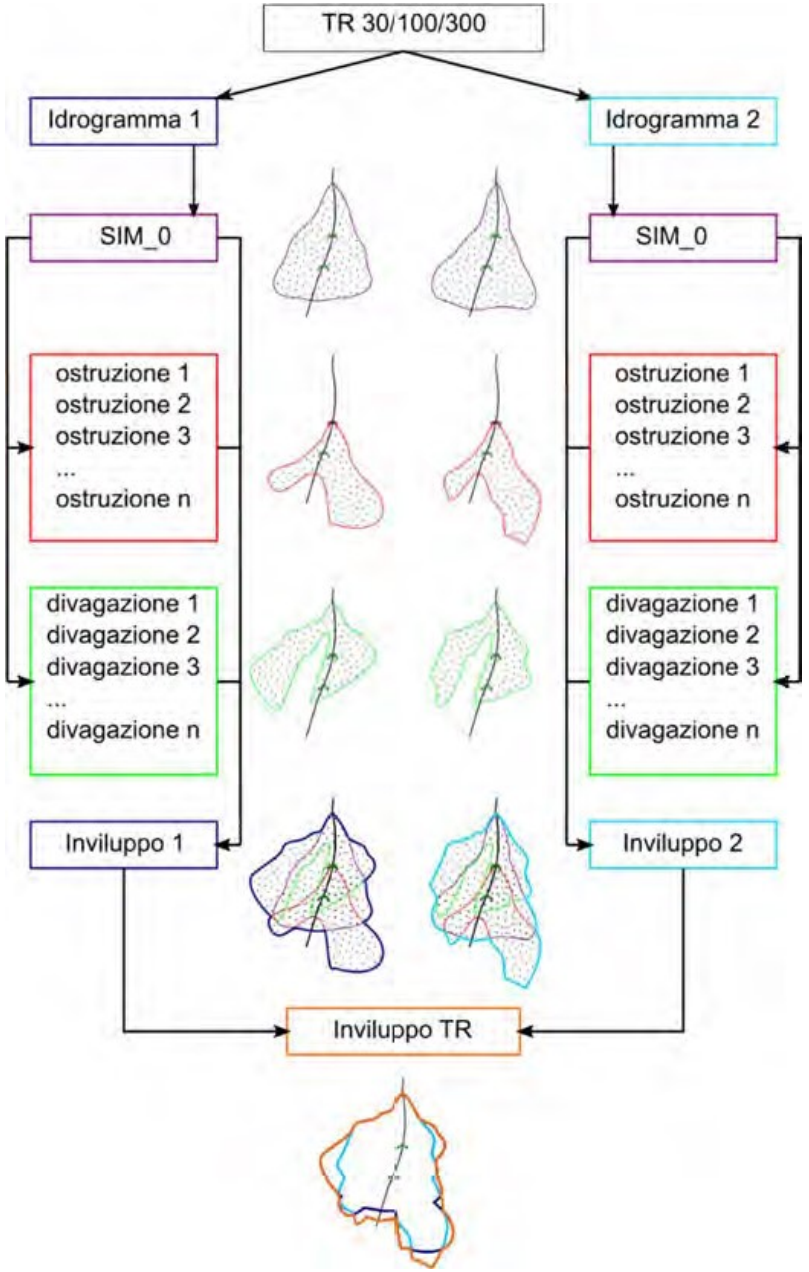

Piave - Tr 100 anni - massimo picco
Velocità SDF
Velocità SDP
Velocità (m/s)
0
1
2
3
4
5
6
7
8
0
200
400
600
800
1000
1200
Progressiva (m)

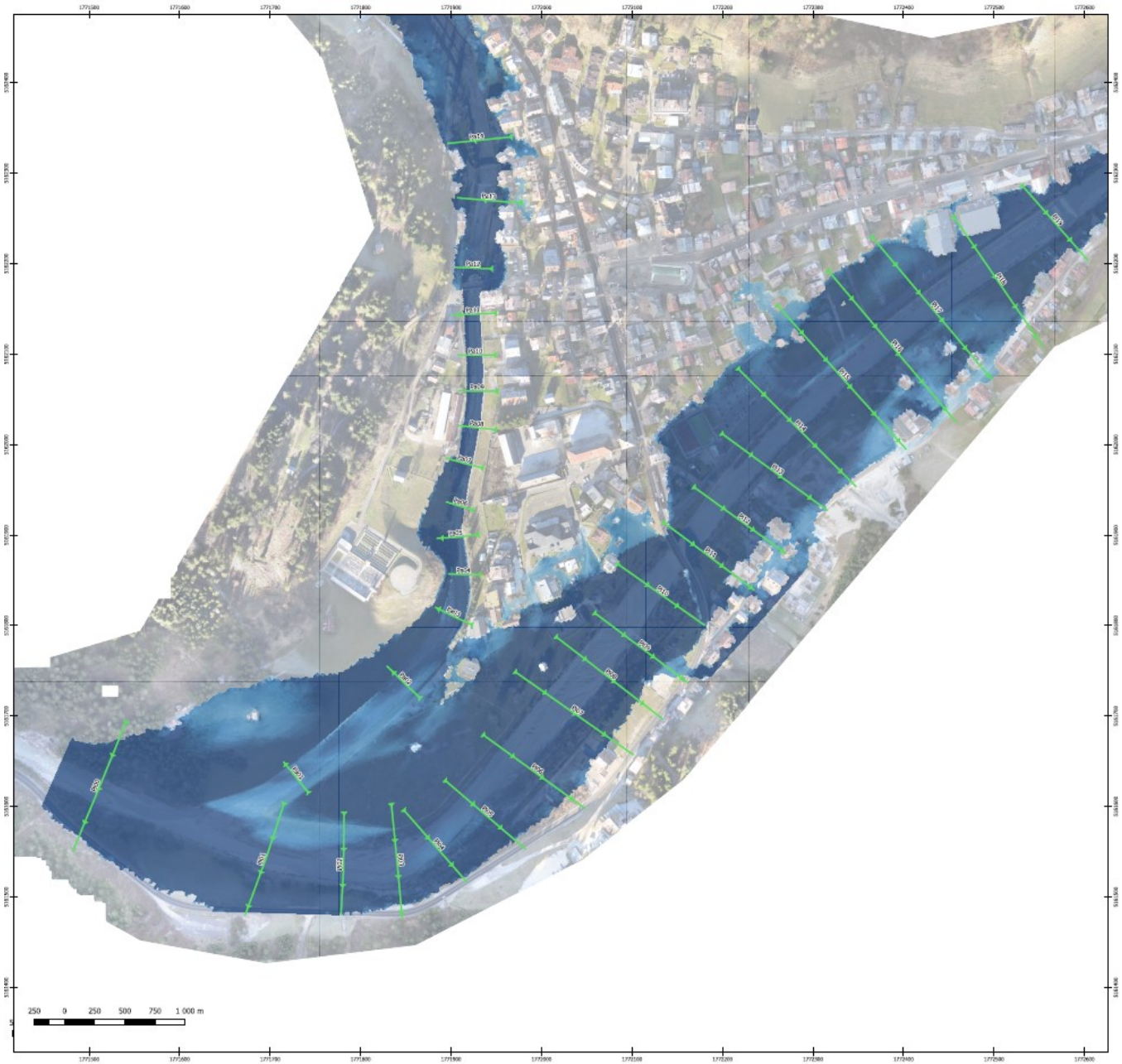

Pa13
Pa12
Pa11
Pa10
Pa09
Pa08
Pa2bis
Pa07
Pa06
Pa05
Pa04
Pa03
Pa2bis
Pa02
Pa01



For each return time the maximum flooding area is defined as the envelope of the areas obtained with all the scenarios implemented.

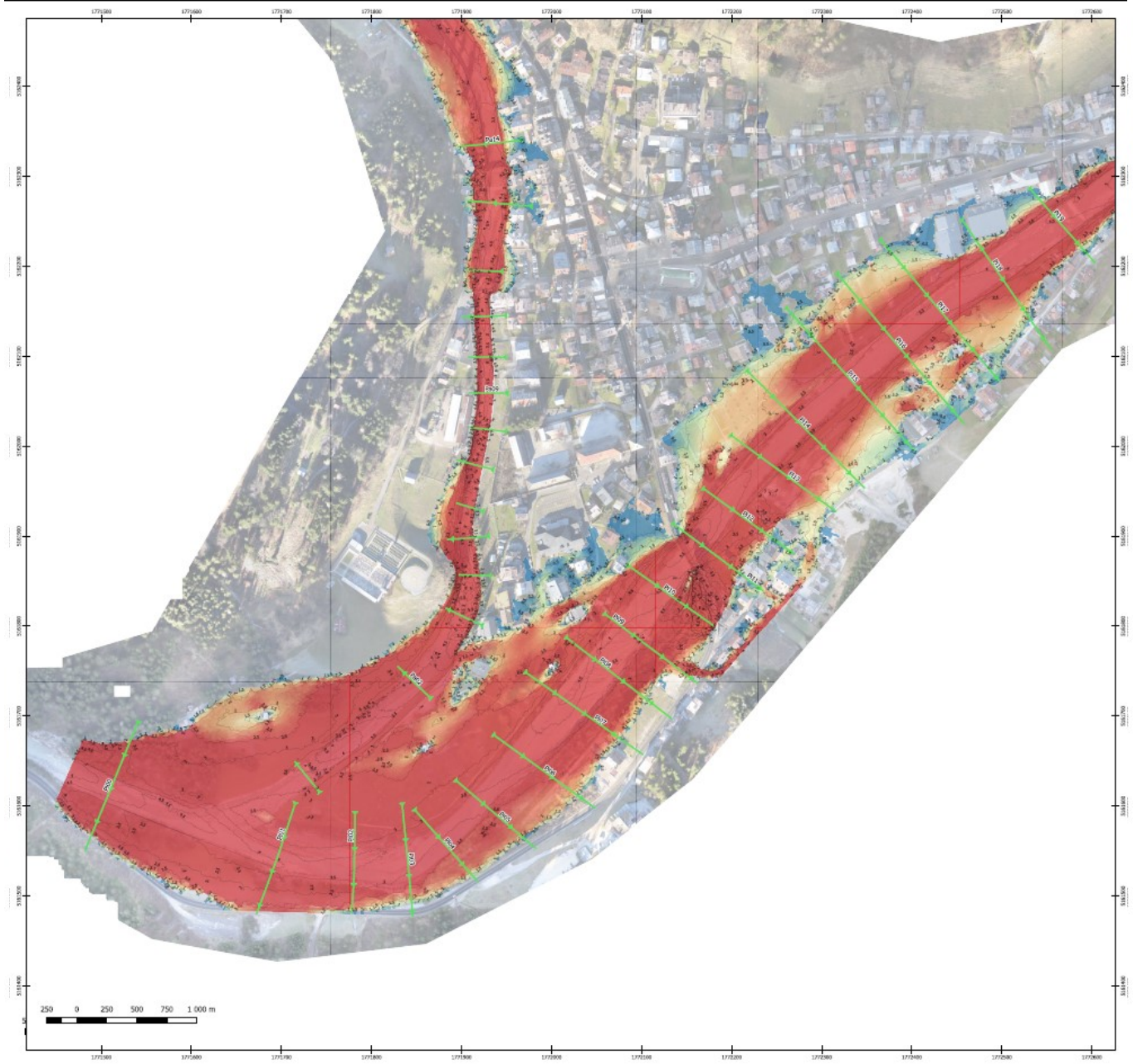
The map relating to the single return time was therefore obtained as an envelope of the maps relating to the two hydrographs max DISCHARGE and max VOLUME

WORKS VERIFICATION WITH BRIDGE OBSTRUCTIONS

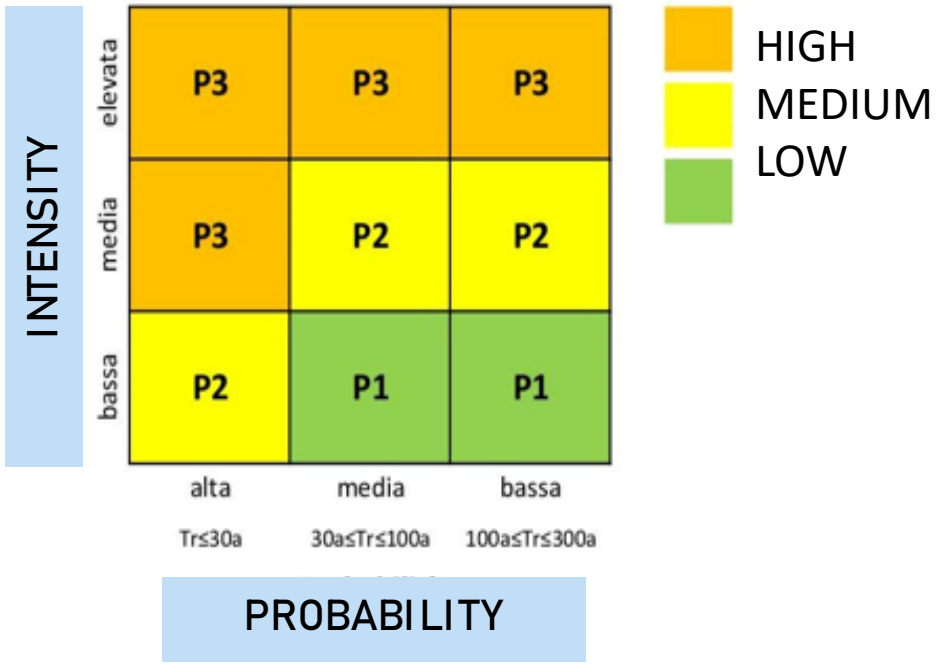


Envelope of Max Depth for 30 yr
Envelope of Max Depth for 100 yr
Envelope of Max Depth for 300 yr

WORKS VERIFICATION WITH BRIDGE OBSTRUCTIONS



Envelope of Max Velocity for 30 yr
Envelope of Max Velocity for 100 yr
Envelope of Max Velocity for 300 yr



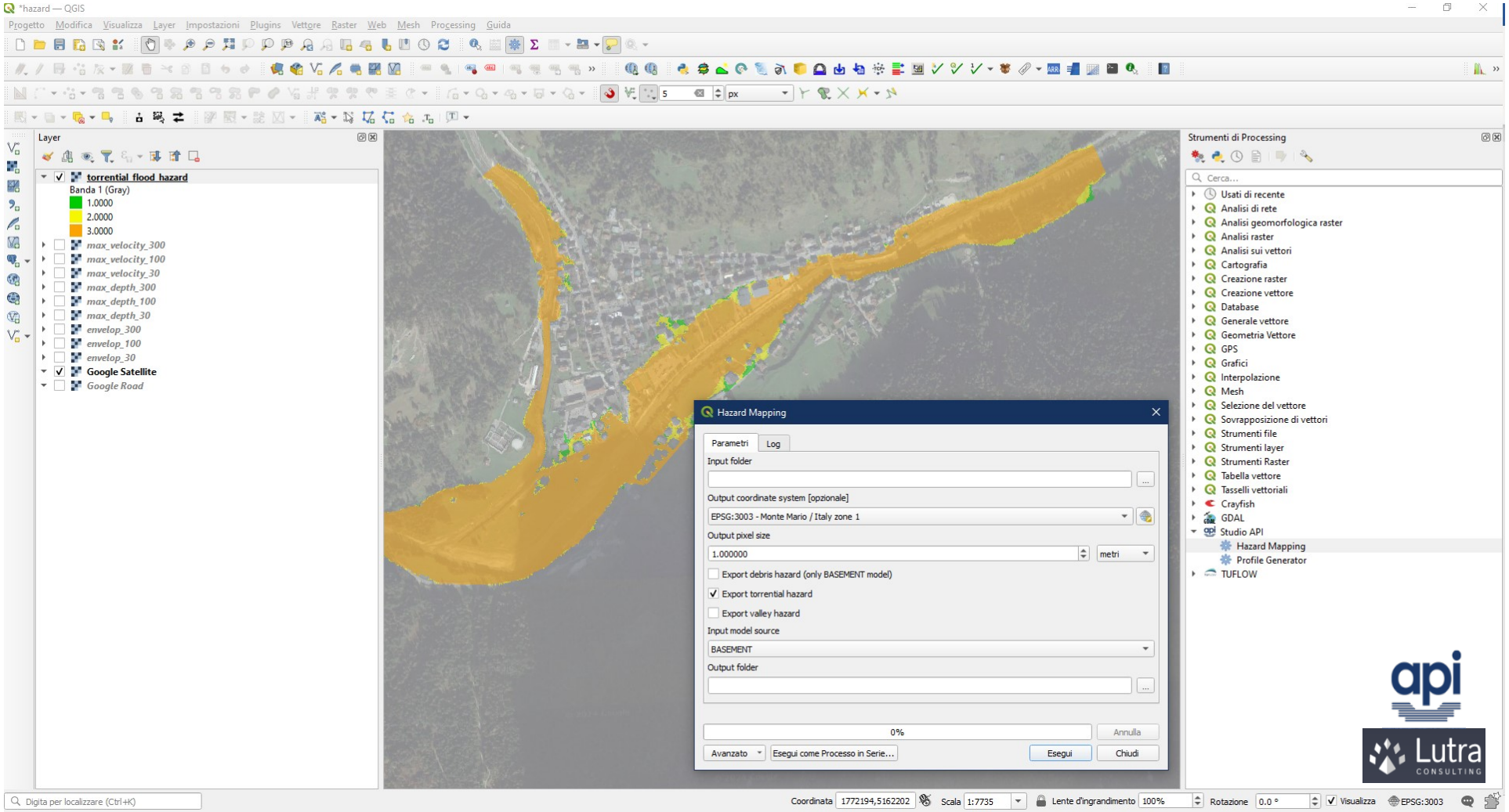
PROBABILITY

- high probability: Tr ≤ 30 years.
- medium probability: 30 <Tr ≤ 100 years.
- low probability: 100 <Tr ≤ 300 years.

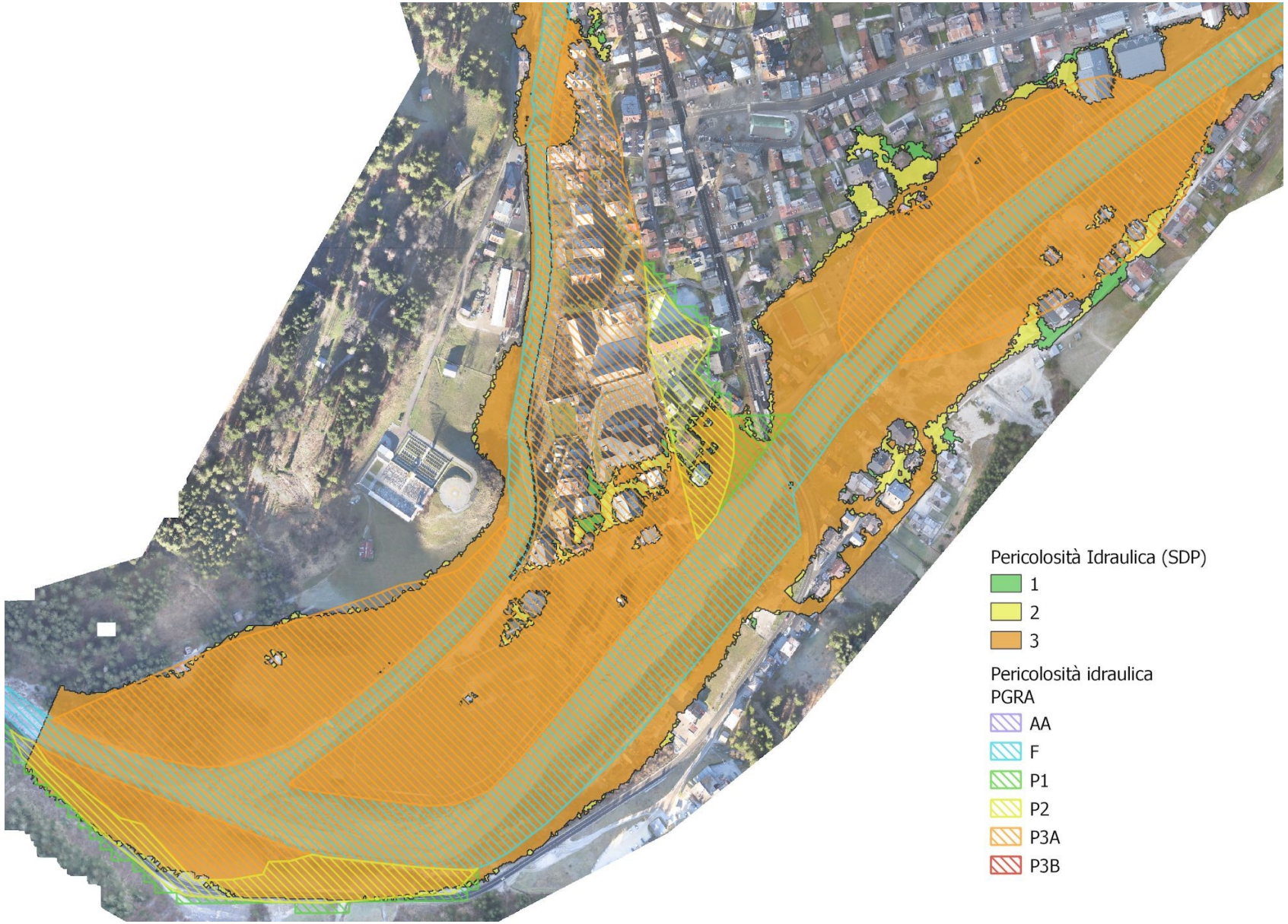
INTENSITY

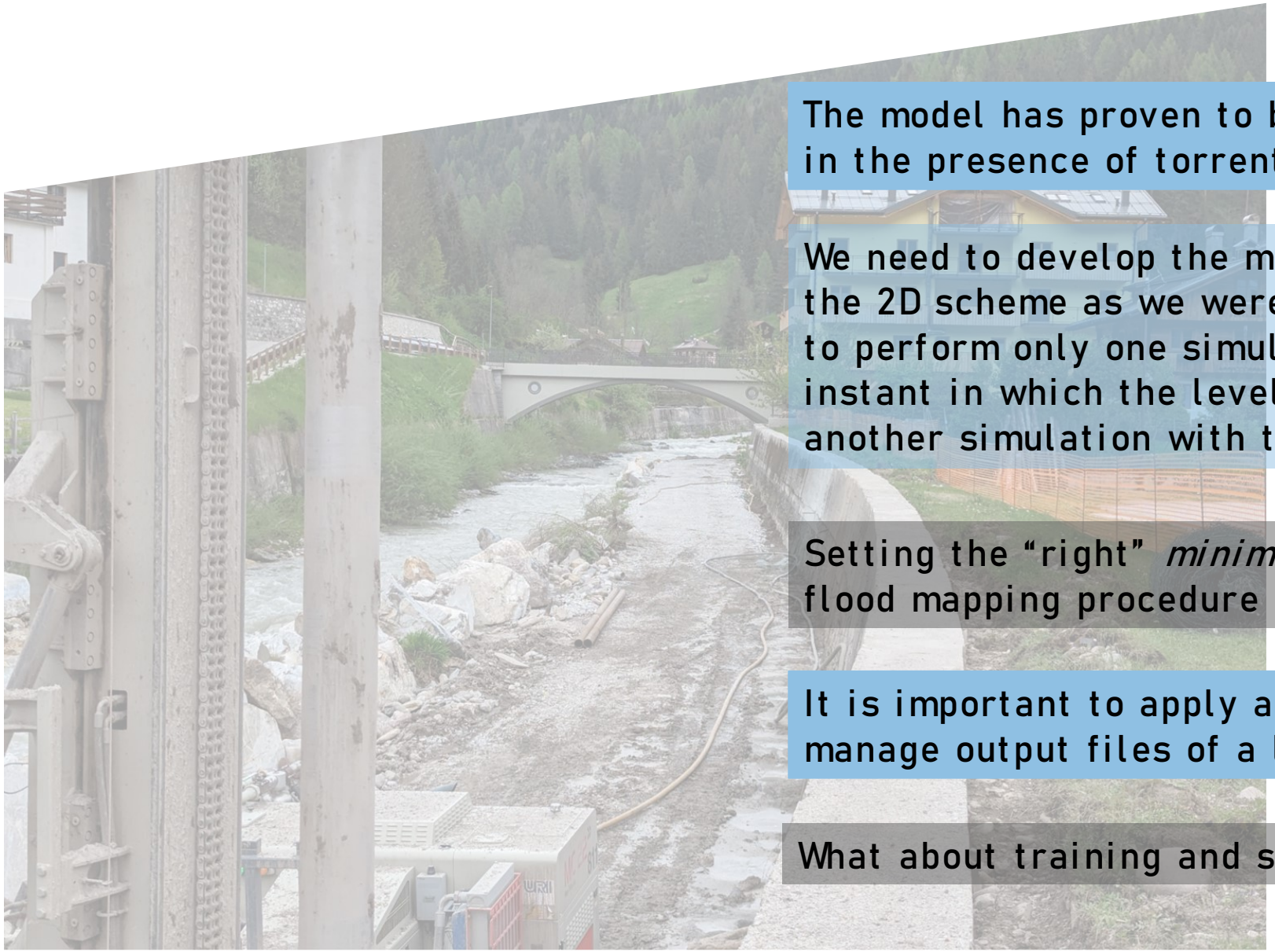
- high intensity: h > 2 OR h*v > 2;
- medium intensity: remaining cases
- low intensity: h < 0.5 AND h*v < 0.5;

GIS POST PROCESSING




Pericolosità idraulica SDP
P1
P2
P3


Pericolosità Idraulica (SDP)
1
2
3
Pericolosità idraulica
PGRA
AA
F
P1
P2
P3A
P3B



The model has proven to be adequate to hazard mapping even in the presence of torrential phenomena

We need to develop the methodology of bridge obstruction in the 2D scheme as we were unable to insert a level rule and to perform only one simulation, but we need to calculate the instant in which the level is reached and then perform another simulation with the restart file

Setting the “right” *minimum water depth* is important in flood mapping procedure

It is important to apply a standard methodology when you manage output files of a large number of simulations

What about training and sharing experiences ..?

Thank you for your attention

Marika Righetto
BASEMENT users meeting 2024