

RESTORATION OF AN ALLUVIAL MATTRESS USING ARTIFICIAL ARMOUR LAYER



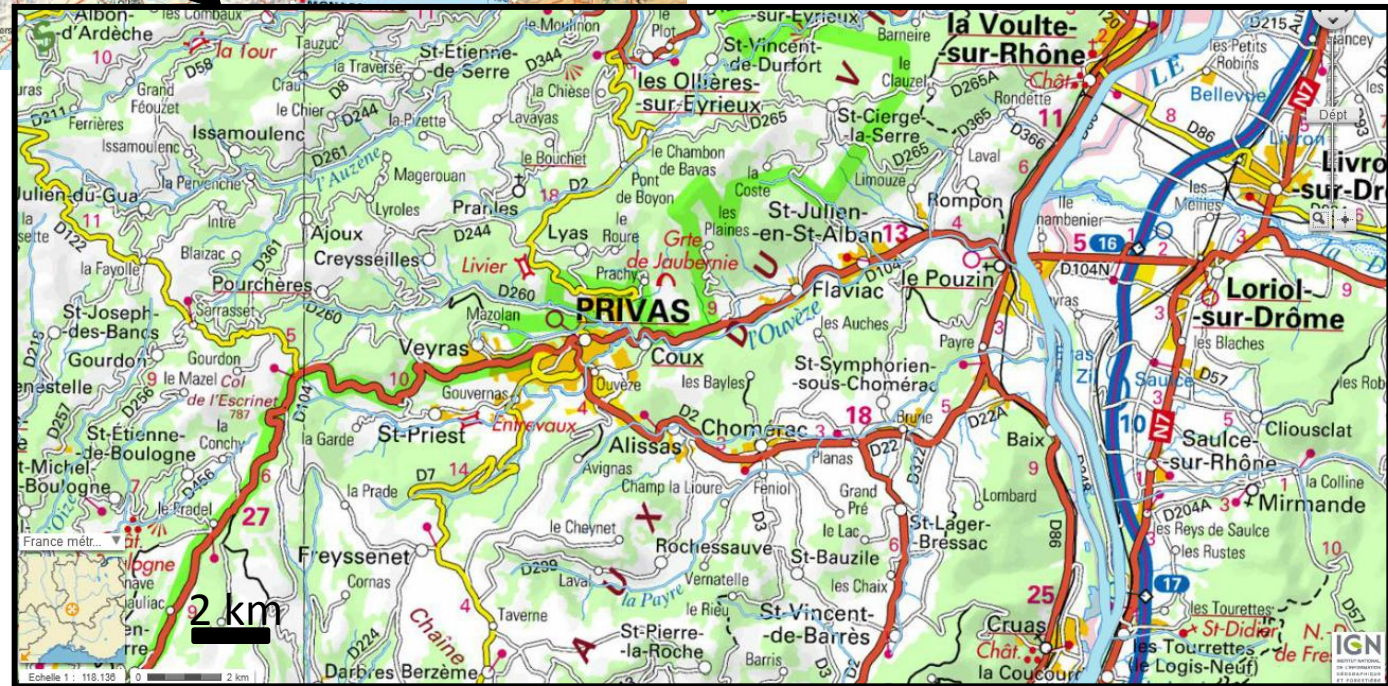
Experimental study on the River Ouvèze (France)

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1. Geography



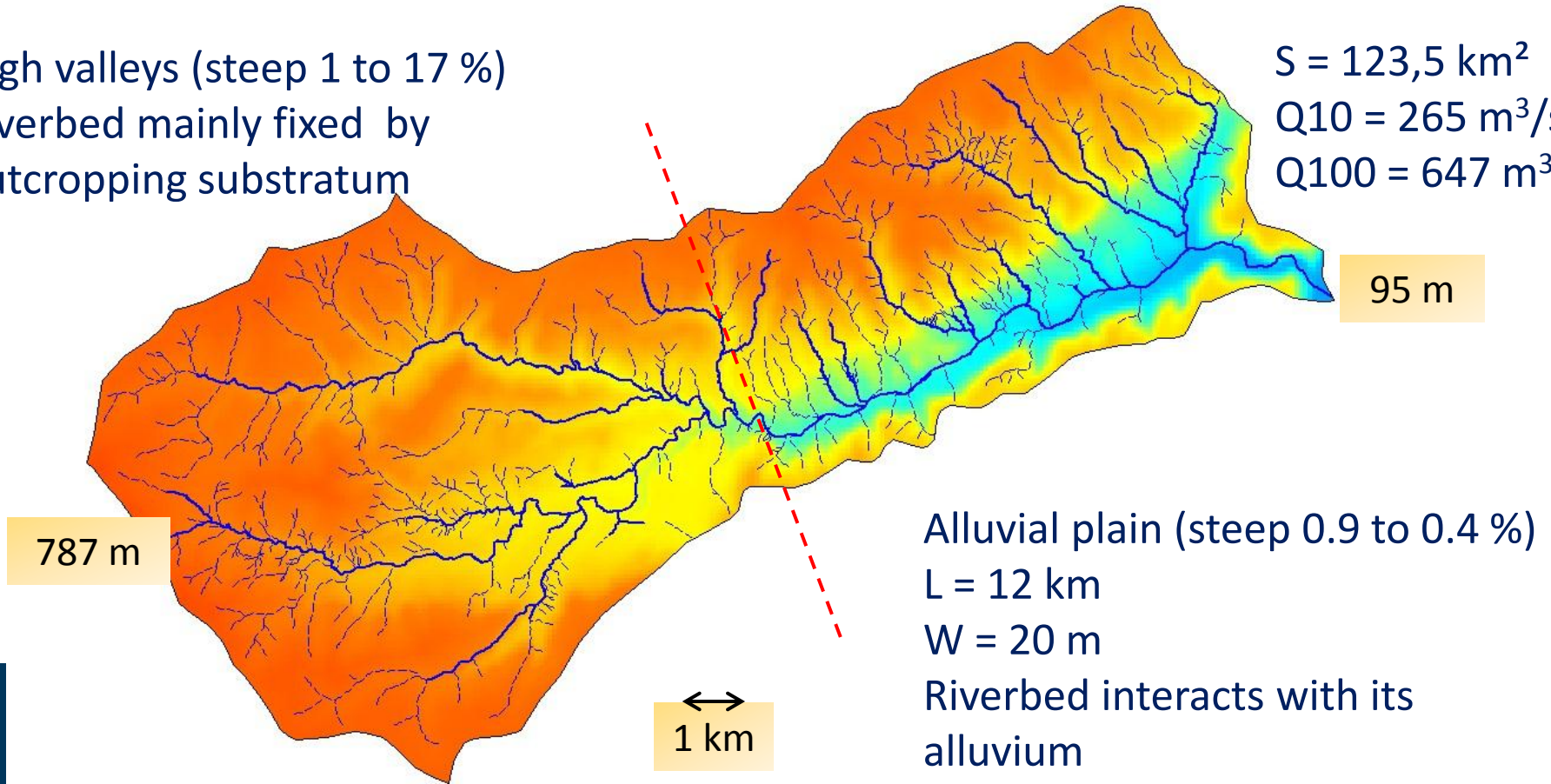
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2. Geomorphological context

High valleys (steep 1 to 17 %)
Riverbed mainly fixed by
outcropping substratum

$S = 123,5 \text{ km}^2$
 $Q_{10} = 265 \text{ m}^3/\text{s}$
 $Q_{100} = 647 \text{ m}^3/\text{s}$



In the alluvial plain (subject of this study) generalised incisions have led to a riverbed fixed by substratum. **The alluvial mattress has disappeared on a very large part.**



4

■ 1st reason : Low level of morphological activity

- ✓ Substratum (marl) always been close to the riverbed
- ✓ Thin alluvial mattress : 1 to 2 m at the beg. of the 20th century (limestone, mainly granite)
- ✓ The constant supply of bedload material protects the vulnerable substratum

Natural transport has been estimated at 4 000 m³/year (30 m³/km²/year)

■ 2nd reason : **The action of man**

- ✓ River training with extraction (after dramatic flooding of 1967-1968)
- ✓ Extraction of alluvial material for valorisation : **Total volume of extraction since 1970 is estimated at 400 000 m³ = a century of solid transport**
- ✓ Destruction of weirs
- ✓ Reforestation of hillslopes



■ **Outcropping of the substratum**

- ✓ Alluvial mattress has disappeared revealing the outcropping rocky substratum

■ Irreversible incision of the friable marly substratum

- ✓ Under water flow, shoks, frost, drying conditions
- ✓ River bed has found a new equilibrium at between 1 to 2 m below its natural level



■ Harmful to the environmental quality of the riverbed

- ✓ Substrate is less welcoming for aquatic wildlife
- ✓ Reduction of the river's self-cleaning capacity
- ✓ Disconnection of the riverbank vegetation

■ Principles

- ✓ Deficit of material transport+ risk of substratum irreversible incision



all cleaning operations should be halted

✓ Program :

- Protective measures : restoration of an alluvial mattress
- Measures to restore the river morphodynamics by promoting mobility
- Measures to restore ecological continuity (analysis of weirs)
- Measures to restore the riverbank vegetation and its ecological continuity
- A system to monitor and oversee the operations to be carried out

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4. Artificial riverbed armouring for protection

■ Method most frequently used : creation of weirs

- ✓ Capture of alluvium creating a deficit downstream
- ✓ Lengthy weir sedimentation
- ✓ Increased risk of flooding
- ✓ Fish movement impeded
- ✓ High cost...

■ In this case :

- ✓ Main problem : loose of alluvial mattress
- ✓ Minor problem : lower level of riverbed
- ✓ River bed has regained its equilibrium, with a profile parallel to the original one, 1 or 2 m below



Recreate a pebble mattress in the areas most at risk of substratum outcropping

4. Artificial riverbed armouring for protection

■ Principles :

- ✓ **Protect substratum with artificial riverbed armouring**
- ✓ **Use coarse alluvium (largest 10% of the alluvium particle size range)**

■ Difficulties :

- ✓ **local populations prefer material extraction (against flooding)**
Projects are designed to avoid increase flooding
- ✓ **Scepticism of technicians regarding long-term durability**
Localised mobility isn't excluded in the event of major flooding
- ✓ **Length, cost and supply**
Experimental study, running pilot schemes before generalising the process (if positive results)

4. Artificial riverbed armouring for protection

■ Choice of 4 pilot sites :

- ✓ River sections where substratum has been entirely exposed and most fragile River with outcropping substratum is too long
- ✓ Different configurations to have a better feedback Limit singularities impacts + Test different types of mattress structures
- ✓ Close to material sources Different sources → different sites + Availability of different size of pebbles + large quantity of material of large size

11 ■ Dimensional design criteria :

- ✓ Minimum particle size corresponds to the largest 10% of the alluvium particle size range and of at least 8 or 10 cm
- ✓ Riprap bottom slab to mechanically block alluvium (it is not a weir, no resulting head loss in the event of morphologic floods)
- ✓ Thickness of the mattress : 30 – 50 cm

4. Artificial riverbed armouring for protection

■ Material supply sources :

- ✓ 1 – alluvial deposits



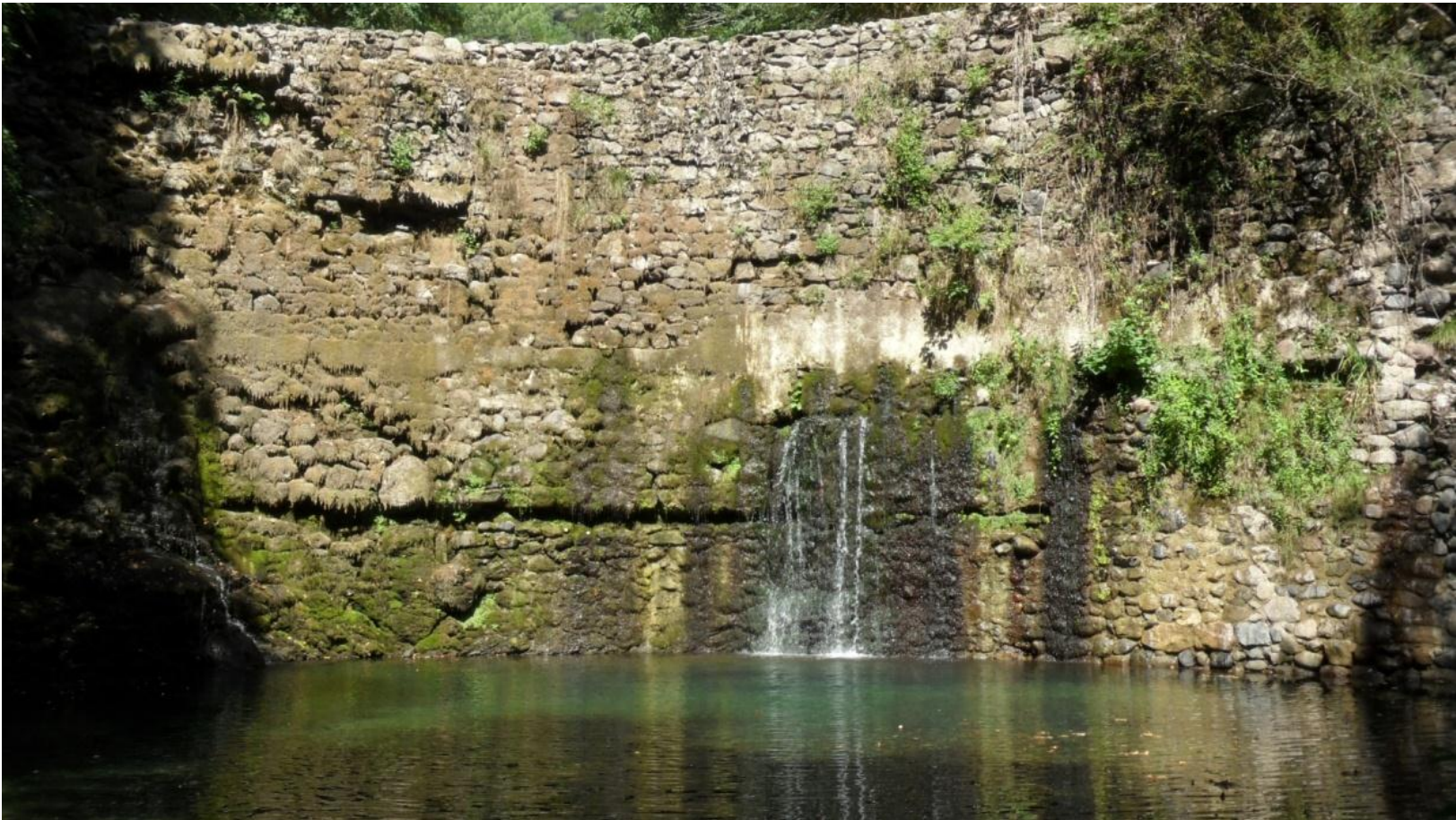
■ Material supply sources :

- ✓ 2 – extraction by the Compagnie Nationale du Rhône in the area influenced by the Pouzin Dam



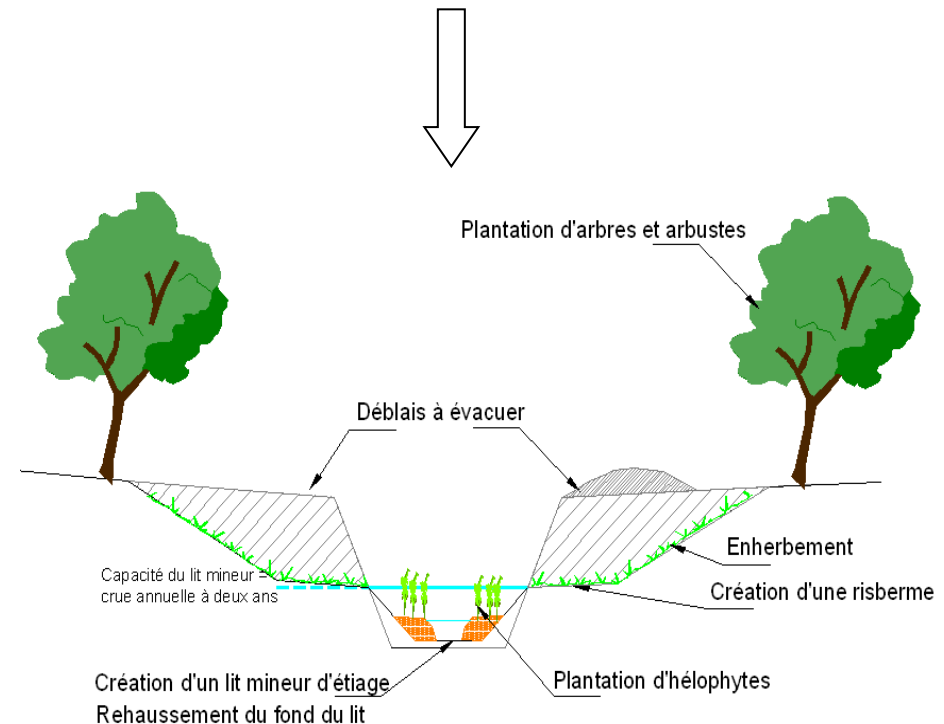
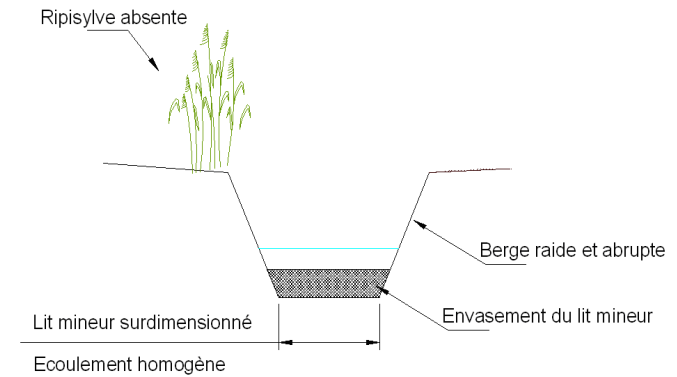
■ Material supply sources :

- ✓ 3 – large quantity of material behind the high weirs (weirs in poor conditions, not used anymore, with no risk of profile destabilisation)

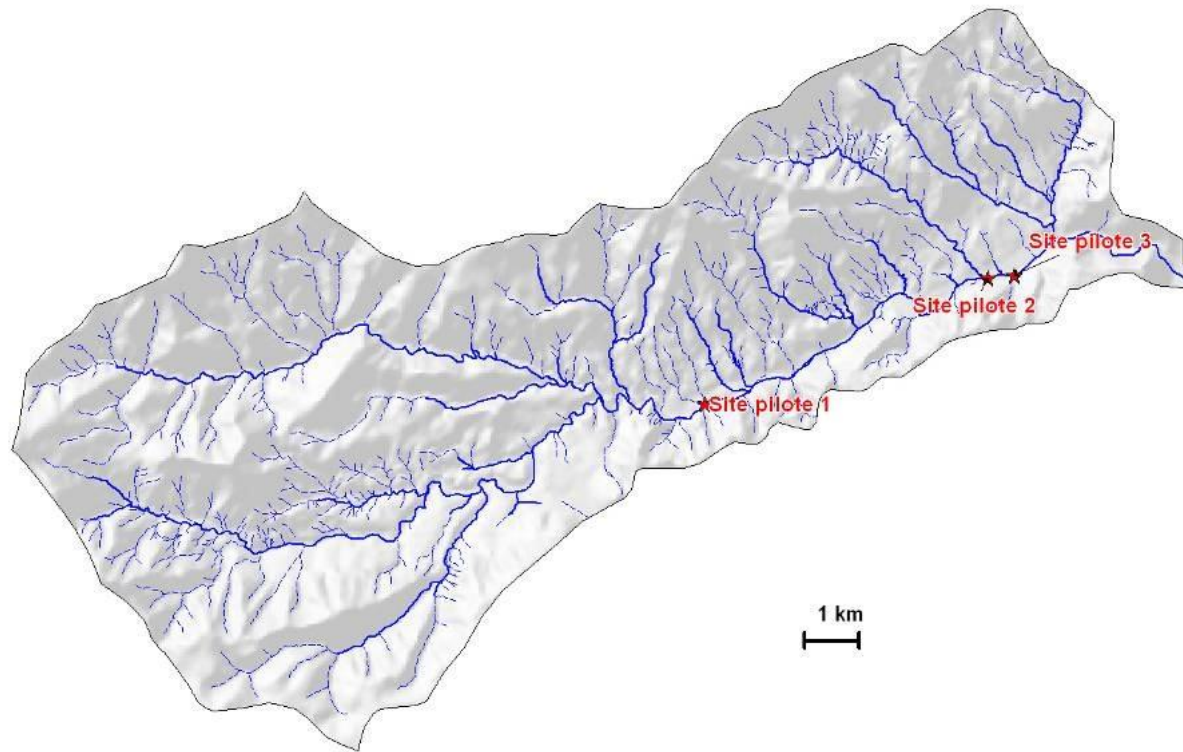


■ Material supply sources :

- ✓ 4 – recovery of material from riverbanks



- Proposed managed plan study 3 pilot sites, detailed in the article





Thanks for your attention