Sediment and woody debris transport regulation in torrential catchments: case study of an Alpine torrent

Argentine (Savoie – France), June 7th to 9th, 2017

Final Report

Context

Following on from the implementation of WGII activities and in compliance with Phase 2017-2018 Workplan, the 3rd workshop addressed the issue of solid transport regulation (bedload, debris flows and woody debris) in torrent catchments. Based on a case study, participants discussed about strategy of intervention, methodology and technical solutions to implement in order to maintain the dynamics of sediment transport and, in the same time, retain massive sediment transportation/woody debris to prevent damages during flood/debris flows events.

Objective

Build knowledge of practitioners on torrent control methods related to sediment and woody debris transport regulation.

Specific objectives

- Put into practice general and technical recommendations elaborated during Salzburg Workshop (2016)
- Compare approaches, methodologies and structures implemented by the countries for the addressed issue
- Develop a common proposal on a case study
Day 1 (June 7th)

Arrival of participants at Lyon Airport and route to Chamousset

14:00 – Workshop opening
   ▪ Welcoming message by David Binet, Head of ONF RTM Service of Savoy
   ▪ Introduction
   ▪ Presentation of the detailed program and objectives of the workshop
   ▪ General presentation of the region and overview of the studied watersheds
   ▪ Introduction to the visit (Arvan river structure)

15:00 Visit of a recent structure designed to control sediment transport and woody debris deposit on Arvan River, upstream of the confluence with the Arc River. Here.

Day 2 (June 8th)

8:00 - National presentations of Albania and Turkey
9:00 - Introduction to the case study:
   ▪ Presentation of the characteristics of the “Torrent de la Balme” catchment
   ▪ Results of achieved studies on the catchment (hazard analysis, hazard mapping, modelling...)
10:00 - Setting up of the groups and departure for the field work (Argentine)
10:30 - 12:00 - Visit of the catchment
14:00 - Field work, in groups
15:30 - Return to the hotel
16:00 - Debriefing – by group – and preparation of the proposal of intervention on La Balme torrent

Day 3 (June 9th)

8:00 - Presentation of technical measures/studies developed in similar contexts (Austria, Bavaria)
9:30 - Presentation of the proposals of technical measures for La Balme Torrent (each group)
10:30 - Presentation of the proposal developed by ONF RTM
11:00 - Discussion and elaboration of common recommendations
11:30 – Discussion on the means of valorization/diffusion of the results, next steps for the working group
12:00 - Closing of the workshop
<table>
<thead>
<tr>
<th>#</th>
<th>Name</th>
<th>Country</th>
<th>Institution</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Mr. Ylli Hoxha</td>
<td>Albania</td>
<td>Ministry of Environment</td>
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<tr>
<td>2</td>
<td>Miss Eneida Rabdishta</td>
<td>Albania</td>
<td>Ministry of Environment</td>
</tr>
<tr>
<td>3</td>
<td>Miss Albora Kacani</td>
<td>Albania</td>
<td>National Federation of Communal Forest and Pasture of Albania</td>
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<tr>
<td>4</td>
<td>Mr. Janaq Male</td>
<td>Albania</td>
<td>CNVP (NGO)</td>
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<tr>
<td>5</td>
<td>Mr. Thomas Fink</td>
<td>Austria</td>
<td>Austrian Service for Torrent and Avalanche Control</td>
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<td>6</td>
<td>Mr. Andreas Drexel</td>
<td>Austria</td>
<td>Austrian Service for Torrent and Avalanche Control, District Vorarlberg</td>
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<tr>
<td>7</td>
<td>Mr. Christof Seymann</td>
<td>Austria</td>
<td>Austrian Service for Torrent and Avalanche Control, District Carinthia</td>
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<tr>
<td>8</td>
<td>Miss Alison Evans</td>
<td>France</td>
<td>ONF RTM 74</td>
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<td>9</td>
<td>Mr. Bruno Demolis</td>
<td>France</td>
<td>ONF RTM 74</td>
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<tr>
<td>10</td>
<td>Mr. Romain Paulhe</td>
<td>France</td>
<td>ONF RTM 73</td>
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<tr>
<td>11</td>
<td>Mr. Anthony Dubois</td>
<td>France</td>
<td>ONF International</td>
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<tr>
<td>12</td>
<td>Mr. Peter Wagner</td>
<td>Germany</td>
<td>Bavarian State Office for the Environment</td>
</tr>
<tr>
<td>13</td>
<td>Mr. Bilal Gunes</td>
<td>Turkey</td>
<td>OGM - Department of Soil Conservation and Watershed Reclamation</td>
</tr>
<tr>
<td>14</td>
<td>Mr Senol Oktay Keten</td>
<td>Turkey</td>
<td>OGM - Department of Soil Conservation and Watershed Reclamation</td>
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</tbody>
</table>

*Group photo in front of the catchment of the torrent of La Balme*
The Maurienne Valley

The Maurienne is a 125 km long Alpine valley located in Savoie. The main river, the “Arc”, drains the valley with numerous short tributaries. The watershed has a strong natural hazards activity, in particular the main debris flows torrents of the French Alps. Altitude ranges between 290 m (confluence with Isère River) and 3855 m (Grande Casse). It’s an important way of communication between France and Italy with the tunnel of Frejus. The Valley has a relevant industrial activity (mine, hydropower and aluminium) and tourism activity (skiing, trekking and cycling).
As an introduction to the workshop, the group visited a recent structure designed to regulate sediment transport and trap woody debris on the Arvan River, upstream of the confluence with the Arc River (Commune of St Jean de Maurienne).

A small scale model was run, in order to design the structure (CNR¹ and ETRM²) with different scenarios tested.

Details on the watershed, the conducted studies and the structure, are presented in Annex 2.

Discussions focused on technical aspects of the structure such as the shape of the piles with different experiences according to the countries, the needs of maintenance for such structures, the management of residual risks and fish fauna issues (downstream).

¹ CNR : « Compagnie Nationale du Rhône »
² ETRM : « Eaux Torrents Et Rivières De Montagne » (Consultancy firm)
National presentations

Albania

Since Albania participated for the first time at WG2 workshop, the Albanian participants were asked to present a general overview of the national context related to natural hazards, especially about torrent risk.

Albania is facing important flood events and sedimentation of hydropower plant reservoirs largely affect power supply. Ylli Hoxha, Head of the Forestry Service, presented the ongoing actions which are being implemented to control soil erosion and stabilize torrents. Discussions focused notably on the techniques for check dam construction.

Turkey

M. Gunes and M. Keoten from Turkey presented an overview of the mountainous and forest context of the country, the challenges due to natural hazards and the actions being implemented (afforestation/reforestation, structures to control erosion and torrent, woody debris management).

The participants discussed about the huge programmes of soil reclamation/afforestation implemented by OGM\(^3\) (species, water supply, human resources...).

Austria

For the Austrian delegation, Thomas Fink presented a recent implemented structure that aims at solid transport regulation and woody debris trapping and which proved to be efficient during a major event that occurred one year after the construction was finished.

Austria has experimented with different design of check dam/woody traps structures. Often the aim is to maintain a permeability of the structure for some grain fractions of the solids during a flood event and to let pass the solids and just filter the wood of smaller events. This kind of structure can be built only when there is no risk of sediment deposition close to settlements downstream due to the fraction of solids led pass. The inclined grid/structure enables the floating of trapped wood. This type of structure has the advantage of limiting the phenomena of scouring/erosion downstreams and to keep the maintenance costs low. Another important aspect is to design the structure to withstand events bigger events than the design event (overflow). For this purpose, the structure must be provided with rising wings, high enough to concentrate the flow in case of overflow to avoid lateral erosion.

Germany (Bavaria)

Peter Wagner presented a recent study held in Bavaria to assess the functioning of different structures of woody debris trap/bedload transport regulation. The feedback of the study started an interesting discussion on technical aspects to consider for the structures (nets, shape of screen dam, location of the wood trap...).

N.B.: Country presentations are available in Annex 6 to 9.

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\(^3\) OGM : General Directorate of Forestry
Case study of La Balme Torrent

ONF RTM introduced the torrent of La Balme (tributary of the Arc River).
A risk analysis was conducted by ONF RTM in the catchment, in 2014, with proposals of technical measures in order to preserve the municipality of Argentine, from torrential disasters.

In brief: Argentine is exposed to flood events with bedload transport and debris flows. Several structures have been constructed in the past, mainly for riverbed and bank stabilization. Since a few years, an important amount of material is stored in the riverbed due to active rockslides in the catchment.

Objectives of the exercise

Based on the existing information (events record, torrent characteristics, risk analysis, modelling) and on field visits, the exercise aimed at:

- Describing the best adapted methodology to study the torrential catchment
- Proposing a project to manage sediments and woody debris transport
- Discussing and sharing experiences around this case study

Detailed presentation of the catchment and of the case study is available in Annex 3.

The watershed of La Balme torrent

- Municipality of Argentine (Savoie)
- Little watershed of 6.6 km²
- Altitude range 340 m – 2696 m
- Tributary of the Arc river
- Largely wooded (Communal and State owned forest)
- Active rock slides
- Flood with bedload transport and debris flows
- Problematic of woody debris transport during floods
- Main stakes: Village of Argentine, water pipe, railway, bridges, main road (RD72)
Development of the case study

Morning: visit of the catchment from the lower zone to the upper part:

Stop 1: Panorama on the catchment and view on the channel leading to the confluence
⇒ narrow channel and 90° curve
⇒ not able to transport sediments, only clear water
⇒ risk of clear water overflow in case of flood (Q100=17m³/s)

Stop 2: downstream bridge (secondary road)
⇒ Deposition area (slope 5%)
⇒ Section of the bridge reduced
⇒ Risk of overflow

Stop 3: Village of Argentine (main bridge)
⇒ Artificial channel (concrete and stone)
⇒ No deposition – slope of 10 to 15%
⇒ Risk of damage/clogging in case of debris flows and/or woody debris transport

Stop 4: hydropower station (470m)
⇒ Evidence of old debris flows deposit
⇒ Old dike on the left bank no more in function

Stop 5: Old forest road on the left bank removed due to overflow risk (the road lead to the village). Earthwork has been realized to concentrate the flow into the bed in case of flood/debris flows.

Stop 6: Right bank of the torrent. Upper check dams. On the opposite bank, an active rockslide on a cliff brings a lot of materials and woody debris into the torrent bed.
⇒ One of the check dams is totally buried due to the substantial provision of materials
⇒ Woody debris are cut in small segments when possible.

Location of the stops during the visit of the catchment

(Background map: © IGN)
**Afternoon**: Three groups were composed for the fieldwork. Each group was free to move within the catchment to evaluate the possibilities of intervention. Then all the participants came back to the hotel to work on a technical proposal.

### Proposals of the groups

- **For references to structures/stakes, see profile map of the torrent in Annex 1**

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main difficulty is to store 40,000 m³ of materials:</strong></td>
<td>The 2007 hazard map identifies potentially flooded area, larger than the hazard map determined with modelling. The proposal takes that situation into account.</td>
<td>No major event since 50 years. Situation could be not as bad as expected due to reforestation.</td>
<td></td>
</tr>
<tr>
<td>- Not enough space</td>
<td>Forest measures may not have an effective effect on the risk. Should mainly be considered in the neighbourhood of the structures.</td>
<td>Financial limitation prevents the possibility of controlling effectively DB/flood events.</td>
<td></td>
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<tr>
<td>- Scouring problems downstream with sediment entrapment in structure</td>
<td></td>
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<td>- Steep slope (necessity of a high dam)</td>
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<td>- Extraction of deposits</td>
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<td>- High cost of such structure</td>
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<td>Problems with transit of debris flows (especially at the bridge)</td>
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<table>
<thead>
<tr>
<th>Proposal</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
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<tbody>
<tr>
<td><strong>Forestry strategy:</strong></td>
<td>3 solutions:</td>
<td><strong>Optimum technical solution:</strong></td>
<td><strong>Optimum technical solution:</strong></td>
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<tr>
<td>- Extract dead wood and mature trees in the catchment</td>
<td><em>Optimum</em>: 2 check dams below the landslide (A + B) + improve the “old” deflection dam (C) (making dike higher)</td>
<td>- 1 big check dam designed for WD retention</td>
<td><em>Optimum</em>: 2 check dams below the landslide (A + B) + improve the “old” deflection dam (C) (making dike higher)</td>
</tr>
<tr>
<td>- Create small structures in sub basins</td>
<td><em>Medium</em>: only 1 dam (A) below the landslide + improving the “old” deflection dam (C) by a concrete core, for example.</td>
<td>- series of check dams to stabilize the riverbed</td>
<td><em>Medium</em>: only 1 dam (A) below the landslide + improving the “old” deflection dam (C) by a concrete core, for example.</td>
</tr>
<tr>
<td>- No structure in the main channel</td>
<td><em>Minimum</em>: only improving the “old” deflection dam (C) and reinforced communication with stakeholders on the residual risk</td>
<td><em>Very expensive</em> (2 to 3 million €) not affordable in this case</td>
<td><em>Minimum</em>: only improving the “old” deflection dam (C) and reinforced communication with stakeholders on the residual risk</td>
</tr>
<tr>
<td><strong>Hydraulic strategy:</strong></td>
<td></td>
<td><strong>“Realistic” solution:</strong></td>
<td></td>
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<tr>
<td>- One check dam to dissipate energy of DF and to hold back the first wave of debris flows including majority of DW. (4-5 meters high structure to dissipate energy and catch first part of drift wood)</td>
<td>Designed for medium event. Combination of:</td>
<td>Designed for medium event. Combination of:</td>
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<tr>
<td>- Improving the flow conditions above the bridge building a ramp (with steeper slope)</td>
<td>- Improve the old dike</td>
<td>- Improve the old dike</td>
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<td></td>
<td>- Awareness with stakeholder</td>
<td>- Awareness with stakeholder</td>
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<td></td>
<td>- Emergency plan (including excavators at bridges during events)</td>
<td>- Emergency plan (including excavators at bridges during events)</td>
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<td></td>
<td><em>Cheaper solution</em> (200-300.000 €)</td>
<td><em>Cheaper solution</em> (200-300.000 €)</td>
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<td></td>
<td>For WD management, cut in small pieces remains the less expensive way.</td>
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Presentation of ONF RTM proposals

Proposition 1

Build a 20 000 m³ check dam at hydropower station (COT1)

Objectives:
- stopping and storing the debris flow
- trapping the woody debris
- stopping or regulating the sediment transport
- blocking the river wandering on the left bank

Estimated cost: 600 000 € to 800 000 €

Localisation of the check dam

Proposition 2

Re-establishment of the old dike and enlargement of the riverbed

Objectives of check dam
- trapping the woody debris
- optional steel piles
- stopping the biggest rocks coming during debris flows events
- blocking the river wandering on the left bank

Estimated cost: 300 000 € to 400 000 €

Cross-section view of the structure:
Discussion

Diagnosis
- A 40,000 m³ design event as estimated in the ONF/RTM study was considered as relevant by all groups (regarding the geology and torrent characteristics)
- No major issues of bedload transport during small events ⇨ keep the focus on major events
- Proposal has to be fitted with financial possibility
- Positive impact of an adapted solution, even though we know that it could be not sufficient for the designed event

Technical solutions
- An adapted solution could be to build a 20,000 m³ check dam
- In ONF proposal #2: steel piles could be unnecessary because the structure is sized for a medium event and woody debris would be an issue in the case of the design event.
- In all cases something has to be done for the road on the left bank (before the settlement), to avoid potential overflow to take this way.
  ⇨ Optimizing old dike (at COT1) seems to be the best solution
- An additional measure could be to build a ramp between the Argentine bridge and the 1 m high step (check dam) before the stream to speed up the flow and to reduce flow high under the bridge (at CB4).

Forestry measures
Relevance of forestry measures has been widely discussed within the groups and during the discussion with divergent points of view/experiences among the participants.

Discussed forest measures:
- Preventive forest management and extraction of deadwood and trees at risk
  ⇨ Difficult to implement because of different owners and specific management plans of the catchment forests catchment.
  ⇨ High costs of such operations and largely wooded catchment
  ⇨ Efficiency of such actions has been questioned (impossible to avoid all trees at risk)
- A cheaper and effective solution can be a regular inspection of the torrent and the extraction of wood when possible, or to cut wood in 1m pieces when it is not accessible with machinery. This solution was already highlighted during the Salzburg workshop.

No intervention
The possibility of no intervention for this project has been expressed. Arguments could be the limited stakes at risk, the limited financial means which prevent an optimum solution, and the reforestation of the catchment with no significant events since 50 years.

Communication/awareness
- Only technical measures will not be sufficient for the “adapted solution” to be implemented. A long term communication plan has to be set up to raise the awareness of local authorities and inhabitants of the residual risk.
- Raise awareness and explain the risk, the possibilities of intervention and to share responsibilities on decisions with local authorities.
Conclusion

General discussion on natural hazards management

*Forestry measures: Can they have a function for this kind of catchment?*
Divergent points of view on the role and efficiency of forestry measures were raised on this case study. Participants from alpine countries are not used to indicate forestry measures in similar contexts (too costly, limited effect) or consider these measures to be part of routine forest management (which may be a mistake according to the participants), when participants from Albania or Turkey would indicate preventive forest management.

*Financial means vs strategy of intervention*
The discussions underlined that divergences on strategy of intervention are also related to availability of funds for disaster risk management. For instance, the “optimum solution” would be certainly chosen in a similar case in Austria.

*Natural hazards acceptance*
A discussion on risk acceptance suggested that some countries are more aware that big natural catastrophes cannot be managed, when in other countries, torrent/natural hazards prevention services are supposed to protect against all events. Another point is that in forested catchments like La Balme, it can be difficult to make understand the needs of investment on protective structures, as there is not so much natural hazards activity (irregular activity of torrent, with long periods without events)

*Further financial question discussed*
- All countries experience financial limitations for protective measures.
- How to raise awareness of decision makers on the needs of investment for NHM?
- Could the European Union be a financial body for these investments (such as for agriculture/transport)?

Working group 2 progress

*Feedback from the participants*
- The participants expressed their satisfaction with the workshop in terms of acquired knowledge, exchanges and confrontation of experience in a different context
- Case studies are a good format to address a topic in an international workshop and help to encourage discussions between participants.

*Products*
- The main output of the workshop is the experience shared between participants during the workshop, which is not easy to transcribe in the report
- Additionally to the workshop report, the workshop achievement will be presented at the 31th Working Party session in Prague (September 2017)
- A reflection is ongoing on how to enhance the results of the practitioners workshops with a publication

*Next workshops*
Topic/place/date of the next workshop will be announced at the 31th Session.
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Annex 7: Presentation Turkey (B. Gunes /O. Keten)
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Annex 1: Longitudinal section of the torrent of La Balme (profile map)

### Profile
- Channel
- Bridges
- Check dams

### Torrent de la Balme - commune d'Argentine

Longitudinal section (profile map)

<table>
<thead>
<tr>
<th>Distance to the Arc confluence (m)</th>
<th>Altitude (m)</th>
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<tbody>
<tr>
<td>0</td>
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<tr>
<td>500</td>
<td>370</td>
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<tr>
<td>1000</td>
<td>420</td>
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<td>1500</td>
<td>470</td>
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<tr>
<td>2000</td>
<td>520</td>
</tr>
<tr>
<td>2500</td>
<td>570</td>
</tr>
<tr>
<td>3000</td>
<td>620</td>
</tr>
</tbody>
</table>

- $i_{moy} = 1\%$  
- $i_{moy} = 4,1\%$   
- $i_{moy} = 7,7\%$  
- $i_{moy} = 10,9\%$  
- $i_{moy} = 12,9\%$   
- $i_{moy} = 15,6\%$  
- $i_{moy} = 17,3\%$   
- $i_{moy} = 24,3\%$