European Commission

NWRM

Natural Water Retention Measures

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Case Study

River restoration lower Aurino

Environment

This report was prepared by the NWRM project, led by Office International de l'Eau (OIEau), in consortium with Actéon Environment (France), AMEC Foster Wheeler (United Kingdom), BEF (Baltic States), ENVECO (Sweden), IACO (Cyprus/Greece), IMDEA Water (Spain), REC (Hungary/Central & Eastern Europe), REKK inc. (Hungary), SLU (Sweden) and SRUC (UK) under contract 07.0330/2013/659147/SER/ENV.C1 for the Directorate-General for Environment of the European Commission. The information and views set out in this report represent NWRM project's views on the subject matter and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in this report. Neither the Commission nor any person acting on the Commission's behalf may be held Key words: Biophysical impact, runoff, water retention, effectiveness - Please consult the NWRM glossary for more information.

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I. Basic Information

Application ID	*Italy_01*			
Application Name	**River Restoration_lowerAurino**			
Application Location	Country:	Italy	Country 2:	
	NUTS2 Code		*ITH1*	
	River Basin District Code		*ITA*	
	WFD Water Body Code		*IT03SS3N*	
	Description		*Restoration interventions in four different sites in the lower course of the Aurino stream: Molini di Tures/ Gais; Gatzaue/ Gais; gatzaue downstream; S. Giorgio- Brunico.*	
Application Site Coordinates	Latitude (site Molini di Tures): *- WGS84: 46°53'6.80"N*		Longitude (site Molini di Tures): *- WGS84: 11°56'51.28"E*	
	Latitude (site Gatzaue/ Gais): *- WGS84: 46°50'56.14"N*		Longitude (site Gatzaue/ Gais): *- WGS84: 11°57'21.78"E*	
	Latitude (site S. Giorgio-Brunico): *- WGS84: 46°48'10.56"N*		Longitude (site S. Giorgio-Brunico): *- WGS84: 11°55'33.30"E*	
Target Sector(s)	Primary:	Hydromorphology		
	Secondary:			
Implemented NWRM(s)	Measure #1:	*N8 Riverbed*		
	Measure #2:	*N3 Floodplain*		
Application short description	River restoration measures were implemented along the Aurino stream as part of the Aurino management plan. Interventions were grouped in Work Packages and were implemented in different moments within the years 2003-2011. The objectives were flood protection and, secondarily, the improvement of the natural environment. Different interventions were implemented to widen the river bed, such as for example: (i) forests were cleared in the relevant areas, to add space to the river bed; (ii) (artificial) river banks were lowered and enlarged; (iii) re-activation or creation of lateral river branches; (iv) measures to raise the river bed's level. Specific measures implemented in all three sites: • Enlargement and re-meandering of the river bed; • Clearing of degraded riparian woodland (mainly alder trees) • Removal and temporary stocking of the first soil layer, rich in organic matter. This soil was then used to cover new surfaces obtained with the measures • Excavation and creation (depending on the sites) of lateral river branches, dead river branches or small lakes; • Banks and river bed sections structured in a natural-like and irregular way (including vertical banks to favor nesting of kingfishers) • The river bed was structured by using large rocks and dead woods • Creation of islands and gravel areas The river bed was brought to a higher level by using fixed (Gatzaue Lot I) or dynamic (S. Giorgio and Gatzaue Lot II) ramps. Overall, interventions concerned the following areas: • Molini di Tures site: intervention on a 390-m river stretch, enlargement			

	from 30 to 60 m; • Gatzaue lot I & II: interventions on 12 000 m^2, average enlargement 35 m ; • Gatzaue lot III : intervention on 6000 m^2; • San Giorgio di Brunico: intervention on a 700-m river stretch.

II. Policy context and design targets

Brief description of the problem to be tackled	The main objective of the interventions is flood protection, coupled with the improvement of riparian natural environments. More in detail, the interventions were aimed at tackling: (i) almost total disappearance of islands and gravel areas; (ii) dramatic reduction of flooding areas. Another major objective is to raise the groundwater level, which has significantly reduced over time. As a result of the former (i) the river has damaged longitudinal hydraulic works, especially near bridges; (ii) riparian forests are now rarely flooded, and this disturbs ecological dynamics. However, a lower groundwater table allowed the expansion of agricultural areas, and this had to be taken into account when designing and implementing the measures –i.e. bringing back the ground water level back to the original level would not have been a desirable outcome for farmers. The issue described above are due to (i) hydromorphological interventions on Aurino's effluents, and on 40% of the Aurino stream: this led to the reduction of solid transport; and (ii) intense gravel mining along the lower stream course (in the 70's).		
What were the primary & secondary targets when designing this application?	Primary target #1:	Buffering and attenuation of mass flow	
	Primary target #2:	Biodiversity and gene-pool conservation in riparian areas	
	Remarks	*Primary target #3: raise the ground water level*	
Which specific types of pressures did you aim at mitigating?	Pressure #1:	WFD identified pressure	*4.1.1 Physical alteration of channel/bed/riparian area/shore of water body for flood protection*
	Remarks	As mentioned below, in this case study NWRMs were not connected to WFD or FD implementation. However, they respond to a WFD-related pressure.	
Which specific types of adverse impacts did you aim at mitigating?	Impact #1:	WFD identified impact	*Altered habitats due to morphological changes*
	Impact #2:	Floods Directive identified impact	*Property*
	Remarks	As mentioned below, in this case study NWRMs were not connected to WFD or FD implementation. However, they aim to tackle WFD- and FD-related pressures.	
Which EU requirements and EU Directives were aimed at being addressed?	Requirement #1:		
	Intervention not linked to the WFD or other Directives		
Which national and/or regional policy	All interventions are part of the Lower Aurino Management Plan, and they are also included in the project "River Basin Agenda" (Alpine Space – Interreg		

challenges and/or requirements aimed to be addressed?	IIIB) aimed at addressing common challenges of alpine river basins. Essential functions and use of river basins are flood protection und flood retention, extensive agriculture and forestry, recreational use, groundwater protection and nature conservation. Modern river basin management therefore means conciliating these requirements at the best possible way. River basin management as it is understood within the project group of the RBA, deals with coordination of procedures regarding flood protection and land use planning in Alpine valley floors. The river basin management plays particularly a crucial role in the spatial development of endangered, intensively used valley sites. In the frame of the planning process it is important to integrate as many participants as possible, e.g. municipalities, departments, interested and concerned people, etc. At the regional level, the interventions aimed at addressing both flood control and the enhancement of riparian environments.

III. Site characteristics

Dominant Land Use type(s)	Dominant land use	*313 – Mixed forest*
	Secondary land use	*321 – Natural grasslands*
	Other important land use	*Type in the relevant Code Level3*
	Remarks	
Climate zone	cool temperate moist	
Soil type	*A detailed soil map is not available – The national map indicates some options:* • Phaeozem • Leptosols • Cambisols	
Average Slope	very gentle (1-2%)	
Mean Annual Rainfall	600 - 900 mm	
Mean Annual Runoff		
Average Runoff coefficient (or % imperviousness on site)		
	Not available/ not applicable	
Characterization of water quality status (prior to the implementation of the NWRMs)	The first RBMP for the Eastern Alps RBD classifies the Aurino stream in good (2003) and high (2004) ecological status (NWRM implementation in the period 2003-2004).	
Comment on any specific site characteristic that influences the effectiveness of the applied NWRM(s) in a positive or negative way	*Positive way:* Although the river bed is incised, the lower Aurino course still kept its meanders, and even before interventions it could have been considered one of the best conserved river stretches in the Bozen province.	
	Negative way: The Aurino is an alpine stream, and thus it flows in a very narrow valley with high competition over land use by the different sectors (agriculture, industry, residential). As a consequence, land prices are amongst the highest in Italy. This means that these interventions, which reclaim land to the river bed, are necessarily confronted with these limiting issues: (i) interventions are limited in the sense that they cannot bring the ground	

	water level back to its original level, as this would imply a loss of agricultural land; and (ii) due to land prices, interventions were mostly implemented on public land.

IV. Design & implementation parameters

Project scale	Medium (eg. public park, new development district)	*Lower Aurino water course*
Time frame	Date of installation/construction (MM.YYYY)	*2003-2014* *Six interventions over the indicated time span – IMPORTANT: the last intervention was just completed, so data and information are not available.*
	Expected average lifespan (life expectancy) of the application in years	*As the measures are aimed at restoring the natural characteristics of the river (or at least to give back some river stretches a natural character, to some extent) they are expected to last over the years.*
Responsible authority and other stakeholders involved	*Name of responsible authority/ stakeholder*	*Role, responsibilities*
	1. Provincia Autonoma di Bolzano – Ripartizione Opere Idrauliche, Azienda Speciale per la regolazione e la difesa del suolo (Autonomous Province of Bozen – Hydraulic engineering department)	In charge of planning, designing and implementing the measures. Although the project was carried out in the context of the INTERREG IIIB Programme Alpine Space, the Autonomous Province of Bozen was the only authority involved in the implementation of measures.
	2. Private landowner – Gatzaue site	NWRM implementation in the Gatzaue site mostly concerned a privately owned area. Such area became part of State-owned property. The landowner was compensated with a piece of land nearby, of equivalent size, originally belonging to State property.
	3. Municipalities, farmers, fishermen associations, local communities	External stakeholders All measures were extensively presented to them and discussed with them well before implementation.
The application was initiated and financed by	The application was initiated, financed and implemented by the Special Enterprise for River Regulation and Land Protection, which is a body of the Autonomous Province of Bozen. The Province allocates funds to the Special Enterprise for the protection and safety of residential areas, and in turn the Special enterprise allocates part of these funds to restoration interventions.	
What were specific principles that were	The selection of sites and the design of the application were based, first of all, on the study of the historical maps of the Aurino stream, so that	

<table>
<tr><td>followed in the design of this application?</td><td colspan="3">the application could intervene in those sites where modifications of the river bed were made. However, it was not possible to recreate the original conditions, due to many factors (see other relevant fields).
Other principles included:
• Functionality
• Habitat recreation (including a targeted selection of plant species)
• Impact on public perception and acceptability: the implementation of NWRMs was coupled with several communication and participative activities with the local communities and relevant stakeholders. Nevertheless, in one case the original design had to be modified for acceptability issues. In addition, the measures were designed according to the outcomes of negotiations with farmers.</td></tr>
<tr><td rowspan="2">Area (ha)</td><td colspan="2">Number of hectares treated by the NWRM(s).</td><td>4.3 ha</td></tr>
<tr><td colspan="3">The values reported refer to the additional riverbed areas = additional areas now occupied by the stream
Total area: 4.3 ha
Area per intervention site:
Molini di Tures: 0.5 ha
Gatzaue/ Gais (all three lots): 2.8 ha
S. Giorgio/ Brunico: 1 ha</td></tr>
<tr><td>Design capacity</td><td colspan="3">The preliminary study (1999) identified the maximum flow rates of the river with respect to different return times (10, 30, 100 and 150 years). The hydraulic model allowed for the identification of areas more vulnerable to floods up to a return time of 150 years.</td></tr>
<tr><td rowspan="6">Reference to existing engineering standards, guidelines and manuals that have been used during the design phase</td><td colspan="2">Reference</td><td>URL</td></tr>
<tr><td>1.</td><td></td><td></td></tr>
<tr><td>2.</td><td></td><td></td></tr>
<tr><td>3.</td><td></td><td></td></tr>
<tr><td>4.</td><td></td><td></td></tr>
<tr><td>5.</td><td></td><td></td></tr>
<tr><td>Main factors and/or constraints that influenced the selection and design of the NWRM(s) in this application?</td><td colspan="3">The availability of land was the main constraining factor: most of the measures were implemented on public land (state or municipal land). Only in the case of Gatzauer/ Gais Lot III measures were implemented mostly on private land, but this required compensation (see dedicated cell).
In the S. Giorgio/ Brunico site, the original project included a larger intervention (widening of the river bed + reactivation of an old branch of the Aurino stream). This would have implied clearing a large area of riparian forest (0.5 ha, 1/3 of the total forest area). Despite the fact that the riparian forest was classified as irreversibly degraded, such a massive forest clearing in a sensitive and densely populated area would not have been accepted. Therefore the reactivation of the old branch was substituted with the creation of a smaller dead branch, which is only 100 m long.
Due to human modifications to the water body and consequent riverbed incision, in the previous decades the ground water table had lowered. However, a lower groundwater table allowed the expansion of agricultural</td></tr>
</table>

	areas, and this had to be taken into account when designing and implementing the measures –i.e. bringing back the ground water level back to the original level would not have been a desirable outcome for farmers. Therefore the capacity of the applications was constrained by negotiations with local farmers.

V. Biophysical impacts

Impact category (short name) Select from the **drop-down menu** below: ⇩	**Impact description** (Text, approx. 200 words) The measures give a large contribution to the reduction of peak flows. However, such interventions alone cannot be considered enough to protect downstream populated areas from flood, due to the presence of other human-made infrastructures (e.g. many bridges have narrow sections, so in case of peakflows the river is very likely to flood surrounding areas). Other technical measures ("traditional" infrastructures) are then recommended. Improvement of channel pattern/planform Improvement of structure and condition of riparian shore zones Improvement of connection to groundwater The measures improved the river bed structure, created differentiated habitats and created areas with different flow speed. As a result, the fish population improved considerably, both in terms of size and ratios among main species. Unfortunately, quantitative information on impacts was not available.	**Impact quantification** (specifying units)	
		Parameter value; units	% change in parameter value as compared to the state prior to the implementation of the NWRM(s)
Runoff attenuation / control			
Peak flow rate reduction			
Impact on groundwater			
Impact on soil moisture and soil storage capacity			
Restoring hydraulic connection			
Water quality Improvements			
WFD Ecological Status and objectives			
Reducing flood risks (Floods			

Directive)			
Mitigation of other biophysical impacts in relation to other EU Directives (e.g. Habitats, UWWT, etc.)			
Soil Quality Improvements			
Other			

VI. Socio-Economic Information

What are the benefits and co-benefits of NWRMs in this application?	Information on benefits is closely linked to observed impacts. As impacts have not been measured so far, no information on benefits is available.		
Financial costs	***Total:***	*427,000 €*	*Costs per site:* *Molini di Tures: 100,000 €* *Gatzaue/ Gais (all three lots): 195,000 €* *S. Giorgio/ Brunico: 132,000 €* *As the Province was fully in charge of implementation, and no activity was contracted or sub-contracted to external enterprises, these costs include all components (design, actual implementation, communication activities, a few monitoring activities)*
	Capital:		
	Land acquisition and value:		
	Operational:		
	Maintenance:		
	Other:		
Were financial compensations required? What amount?	*Was financial compensation required: No*		
	Total amount of money paid (in €):		
	Compensation schema:		
	In most cases, the measures were implemented on public land (property of the state or the municipality). *In Gatzaue/ Gais Lot III most of the land (0.6 ha) was privately owned. Once the measures were implemented, the landowner received in exchange other parcels. Some parcels on the old Aurino river bed were in fact still inventorized as "demanio idraulico" (state hydraulic property), but they cannot be considered anymore as part of the hydraulic private property as they are completely covered by woodland. These parcels were given to the private landowner as an exchange, whereas the formerly private parcels used for implementing the measures passed onto the hydraulic public property as they are now occupied by the river.*		
Economic costs	*Actual income loss:*		
	Additional costs:		
	Other opportunity costs:		
	No data are available on the economic costs – However, such costs can be considered negligible for the following reasons: • *Measures implemented mostly on public land or, in one case, on unproductive private land;* • *The measures were designed to avoid that the ground water table rises to the point where agricultural land is lost; and* • *Measures are also aimed at protecting residential areas from floods*		
Which link can be made	- Amenities (associated to habitat protection)		

to the ecosystem services approach?	- Flood security and protection - Habitat services - Food supply (the fish population in the river has increased)

VII. Monitoring & maintenance requirements

Monitoring requirements	No specific monitoring plan was developed. Overall, the Special Enterprise of the Autonomous Province of Bozen is not undertaking any monitoring, because they only have funds to implement the measures –they do not have the legal status of research institution. The Special Enterprise is collaborating with some Universities (Bozen, Trento and Innsbruck) which are undertaking some monitoring/research activities on their own, using their own budget. The only monitoring they are undertaking is the measurement of the groundwater level, as this is a major concerns of local farmers: prior to implementing the measures, the Province and the farmers agreed upon a maximum ground water level. If the aquifer gets higher than this threshold, then the Special Enterprise committed to implement additional measure to bring down groundwater level below this threshold. However, information on this was not available. In addition, some (little) monitoring activities took place (monitoring data not available). Monitoring changed slightly from one site to the other. Please find below a summary of monitoring activities carried out in the three sites: • Channel pattern/ Planform (more often only after measure implementation – both quantitative and qualitative monitoring • Connection to groundwaters: monitoring in one site, before and after measure implementation – quantitative monitoring • Structure and condition of riparian shore zones: after measure implementation, quantitative monitoring • Regular check of piezometer levels • Monitoring of invertebrates populations (quantitative monitoring after measure implementation • Monitoring of fish and bird populations
Maintenance requirements	Ideally, these interventions do not need maintenance, as measures restored (or mimicked) the natural hydrological and ecological processes and dynamics of the Aurino river. However, some maintenance might be required on the medium term, but a maintenance plan was not developed –however, more detailed and/or clearer information on possible maintenance requirements was not provided. The Special Enterprise of the Autonomous Province of Bozen is not undertaking any monitoring, because they only have funds to implement the measures –they do not have the legal status of research institution. The Special Enterprise is collaborating with some Universities (Bozen, Trento and Innsbruck) which are undertaking some monitoring/research activities on their own, using their own budget.
What are the administrative costs?	No information

VIII. Performance metrics and assessment criteria

Which assessment methods and practices are used for assessing the biophysical impacts?	Impacts were not measured.
Which methods are used to assess costs, benefits and cost-effectiveness of measures?	Economic costs, benefits and cost-effectiveness were not assessed.
How cost-effective are NWRM's compared to "traditional / structural" measures?	In terms of flood protection, the measures give a large contribution to the reduction of peak flows. However, such interventions alone cannot be considered enough to protect downstream populated areas from flood, due to the presence of other human-made infrastructures (e.g. many bridges have narrow sections, so in case of peakflows the river is very likely to flood surrounding areas). Other technical measures ("traditional" infrastructures) are then recommended.
How do (if applicable) specific basin characteristics influence the effectiveness of measures?	Although the river bed is incised, the lower Aurino course still kept its meanders, and even before interventions it could have been considered one of the best conserved river stretches in the Bozen province.
What is the standard time delay for measuring the effects of the measures?	No information.

IX. Main risks, implications, enabling factors and preconditions

What were the main implementation barriers?	The availability of land was the main constraining factor: most of the measures were implemented on public land (state or municipal land). Only in the case of Gatzauer/ Gais Lot III measures were implemented mostly on private land, but this required compensation (see dedicated cell). Due to human modifications to the water body and consequent riverbed incision, in the previous decades the ground water table had lowered. However, a lower groundwater table allowed the expansion of agricultural areas, and this had to be taken into account when designing and implementing the measures –i.e. bringing back the ground water level back to the original level would not have been a desirable outcome for farmers. Therefore the capacity of the applications were constrained by negotiations with local farmers. In one case, the original plan had to be modified for acceptability issues. In the S. Giorgio/ Brunico site, the original project included a larger intervention (widening of the river bed + reactivation of an old branch of the Aurino stream). This would have implied clearing a large area of riparian forest (0.5 ha, 1/3 of the total forest area). Despite the fact that the riparian forest was classified as irreversibly degraded, such a massive forest clearing in a sensitive and densely populated area would not have been accepted. Therefore the reactivation of the old branch was substituted with the creation of a smaller dead branch, which is only 100 m long.
What were the main enabling	Two main success factors were identified:

and success factors?	- Participatory planning and communication activities: informing and involving local communities and key stakeholders was the key to successful implementation (see e.g; negotiations with farmers); - The Autonomous Province of Bozen has, as its name suggests, almost full autonomy when it comes to land and river management. This means that it has full responsibility and control over its territory and water bodies, so it can autonomously plan and implement interventions. In addition, it is one of the richest local administrations in Italy, and thus it has funds available. The measures were fully implemented by the Province, which has all the necessary equipment, and nothing was externally contracted or subcontracted: this allowed for keeping the costs down. Interventions were managed by a "strong" coordinator, who had everything under control.
Financing	The application was initiated, financed and implemented by the Special Enterprise for River Regulation and Land Protection, which is a body of the Autonomous Province of Bozen. The Province allocates funds to the Special Enterprise for the protection and safety of residential areas, and in turn the Special enterprise allocates part of these funds to restoration interventions.
Flexibility & Adaptability	Measures restored (or mimicked) the natural hydrological and ecological processes and dynamics of the Aurino river, so in principle they should be able to adapt to (changing) natural conditions.
Transferability	In principle, river restoration measures can be applied everywhere. However, their design must be tailored on the specific site conditions. In addition, implementation is influenced by several other factors, such as for example: (i) land tenure and land prices; (ii) land use; (iii) perception and acceptability of local communities and stakeholders; (iv)….etc.

X. Lessons learned

Key lessons	• Participatory planning and communication activities are the key to successful implementation (see e.g. negotiations with farmers, communication with local communities and other stakeholders). • When implementing NWRMs, interventions must seek a balance between the desired outcome and the economic activities in the area of intervention. In this case, for example, bringing back the ground water level back to the original level would not have been a desirable outcome for farmers. Negotiations with farmers led, on the one hand, to a reduced ambition of the interventions, but on the other hand it also led to acceptance of the measures and, ultimately, contributed to the success of implementation. • Most of interventions were carried out on public land, and this made implementation easier (and less costly). In one case, interventions were planned on (unproductive) private land, but a least-cost solution could be found. In fact, land tenure is an important issue to consider when implementing NWRMs, as

	land purchase can become an important cost item, and land availability is often a constraining factor to NWRM implementation. • In the case of flood protection, the presence of other man-made infrastructures (e.g. bridges with narrow sections) limits the potential of NWRM to effectively prevent flood damages.

XI. References

Source Type	*Project Report*		
Source Author(s)	Caterina Ghiraldo		
Source Title	*Piano di Gestione Basso Aurino – Relazione sintetica degli interventi realizzati in località Rienzfield, Gatzaue e Molini di Tures (2002-2011)*		
Year of publication	2011		
Editor/Publisher	*Provincia Autonoma di Bolzano – Alto Adige*		
Source Weblink			
Key People		*Name / affiliation*	*Contact details*
	1.	*Caterina Ghiraldo*	*caterina.ghiraldo@provinz.bz.it*

Source Type	*Interview*		
Source Author(s)	Andrea Goltara – CIRF (Centro Italiano per la Riqualificazione Fluviale – Member of RESTORE consortium)		
Source Title	Text		
Year of publication	Date of the interview: April 16th, 2014		
Editor/Publisher	Text		
Source Weblink	Weblink		
Key People		*Name / affiliation*	*Contact details*
	1.	*Andrea Goltara - CIRF*	*a.goltara@cirf.org*

Source Type	*Website*
Source Author(s)	Caterina Ghiraldo
Source Title	RESTORE Database
Year of publication	2013

Editor/Publisher	RESTORE project		
Source Weblink	http://restorerivers.eu/wiki/index.php?title=Case_study%3ALower_Aurino_river%3A_Gatzaue_riverbed_widening http://restorerivers.eu/wiki/index.php?title=Case_study%3ALower_Aurino_river%3A_San_Giorgio_di_Brunico_riverbed_widening http://restorerivers.eu/wiki/index.php?title=Case_study%3ALower_Aurino_river%3A_Molini_di_Tures_riverbed_widening http://restorerivers.eu/wiki/index.php?title=Case_study%3ALower_Aurino_master_plan		
Key People		*Name / affiliation*	*Contact details*
	1.		
	2.		
	3.		
	4.		

XII. Photos Gallery

Source of the pictures: Ghiraldo, C., 2009. "Rinaturalizzazione dei corsi d'acqua in Alto Adige – Gli interventi sul torrente Aurino". Powerpoint presentation given in Sarzana, June 18-19 2009, Autonomous Province of Bozen.

Site: Molini di Tures/ Gais

Figure 1 The riverbed before interventions

Figure 2 The riverbed after the interventions

Site: Gatzaue/ Gais

Figure 3 The riverbed before interventions

Figure 4 The riverbed after interventions (both Lot I and Lot II)

Site: S. Giorgio-Brunico

Figure 5 The riverbed before interventions

Figure 6 The riverbed after interventions

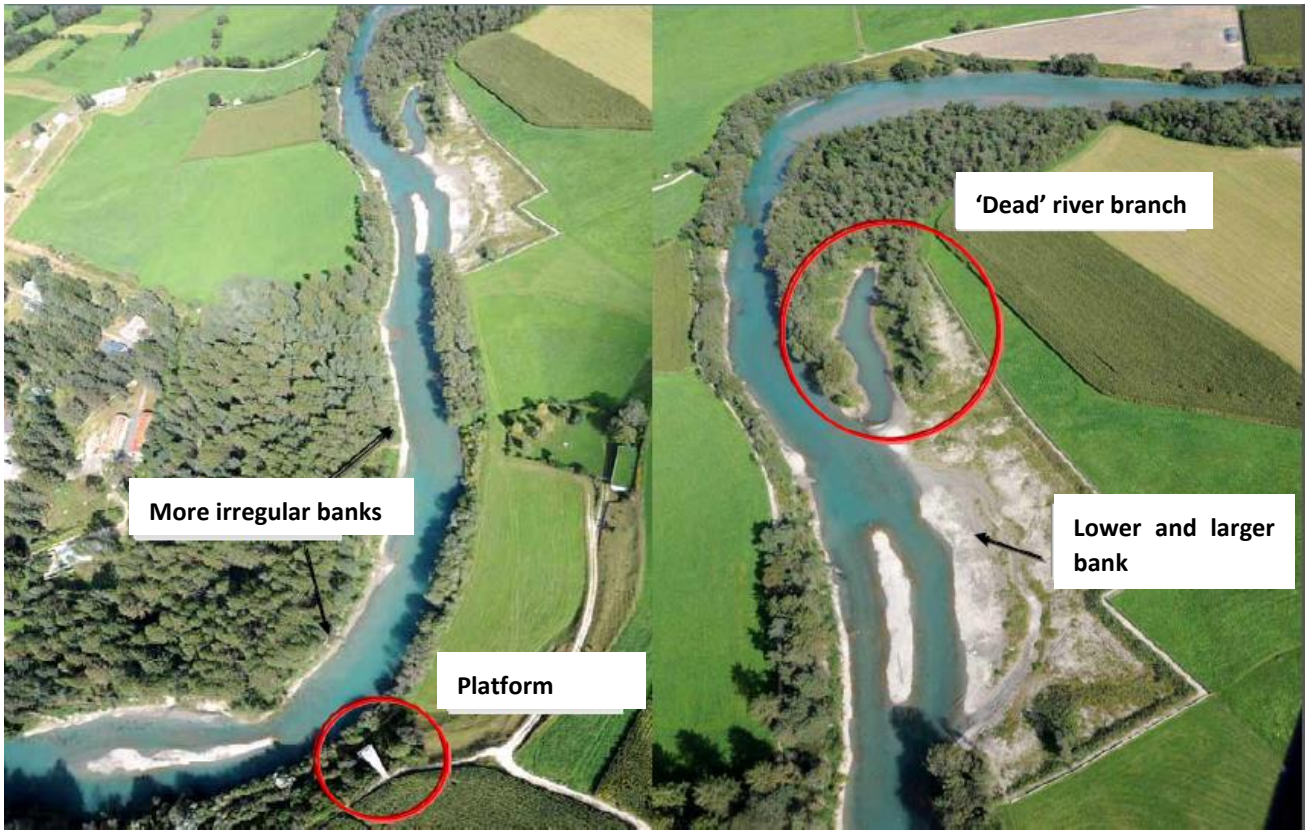

Figure 7 Zoom on the river bed after the interventions