Technical note about the monitoring of hydromorphological restoration/management of the Talvera River in Italy

Project: HyMoCARES
Work package: WPT3 - Effects of hydromorphological management and restoration measures
Activity: A.T3.1 - Monitoring physical and ecological (habitat/biota) effects of stream management/restoration measures at pilot sites
Deliverable: D.T3.1.1. - Technical notes on monitoring protocols implemented on river management/restoration pilot sites
Status: Final Version
Date: 15-03-2019
Authors: Nicola Marangoni, Silvia Simoni, Francesca Minute
Revision: APC_PAB

List of involved PPs:
APC_PAB

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space programme

www.alpine-space.eu/hymocares

CONTENTS

1 General presentation of the study site

1.1 The Talvera River

The Talvera River has a length of 46 km and a catchment area of 429 km²; it drains the Sarentino Valley and it is the second largest tributary basin of the Isarco River (*Figure* **1**). The highest point within the Talvera catchment is at 2781 m a.s.l. (Cervina Peak), while the lowest one corresponds to the confluence with the Isarco River (260 m a.s.l.). Just upstream Bolzano, the Talvera enter a deep gorge, named Sill, flanked by rocky walls, then downstream of it flows over its fan. Due to the lack of glaciers on the upper part of the catchment, it shows a nivo-pluvial hydrological regime.

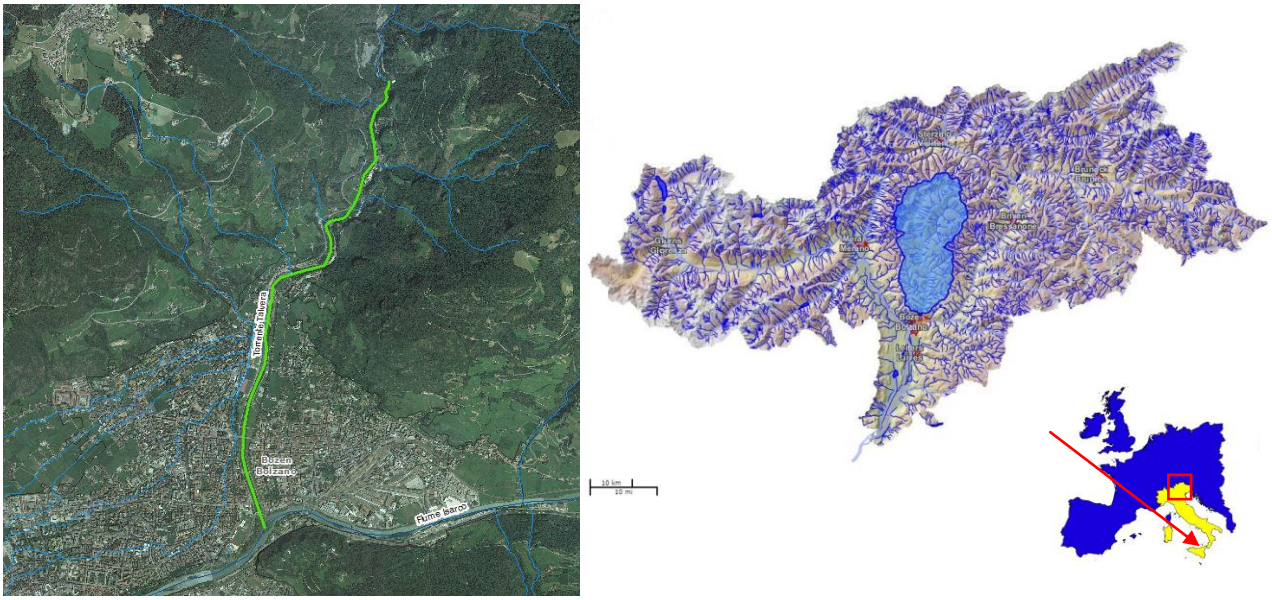

Figure 1 - *Talvera River reach (left) and Talvera River basin (right)*

Along its course, the Talvera is diverted several times, thus presenting a reduced flow rate until where the diverted water is returned to the river in Bolzano (St. Antonio hydropower plant). In addition, many tributaries of the Talvera are also highly impacted by diversions for hydroelectric purposes. The Talvera has been channelized and confined during the years mainly for hydroelectric reasons, modifying the natural ecological conditions.

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space programme
www.alpine-space.eu/projects/hymocares

Table **1** summarizes the main physical features of the pilot site.

Table 1 - *Main physical features of the pilot site*

Pilot Site	**TALVERA**
Drainage area (km²)	429
Minimum elevation (m a.s.l.)	260
Maximum elevation (m a.s.l.)	2781
Start coordinates (East, North)	681402.524, 5155581.475
End coordinates (East, North)	680244.098, 5151556.126
Length of the study reach (km)	5
Active channel width (m)	20-50
Channel slope (%)	2
Planform morphology	Single thread

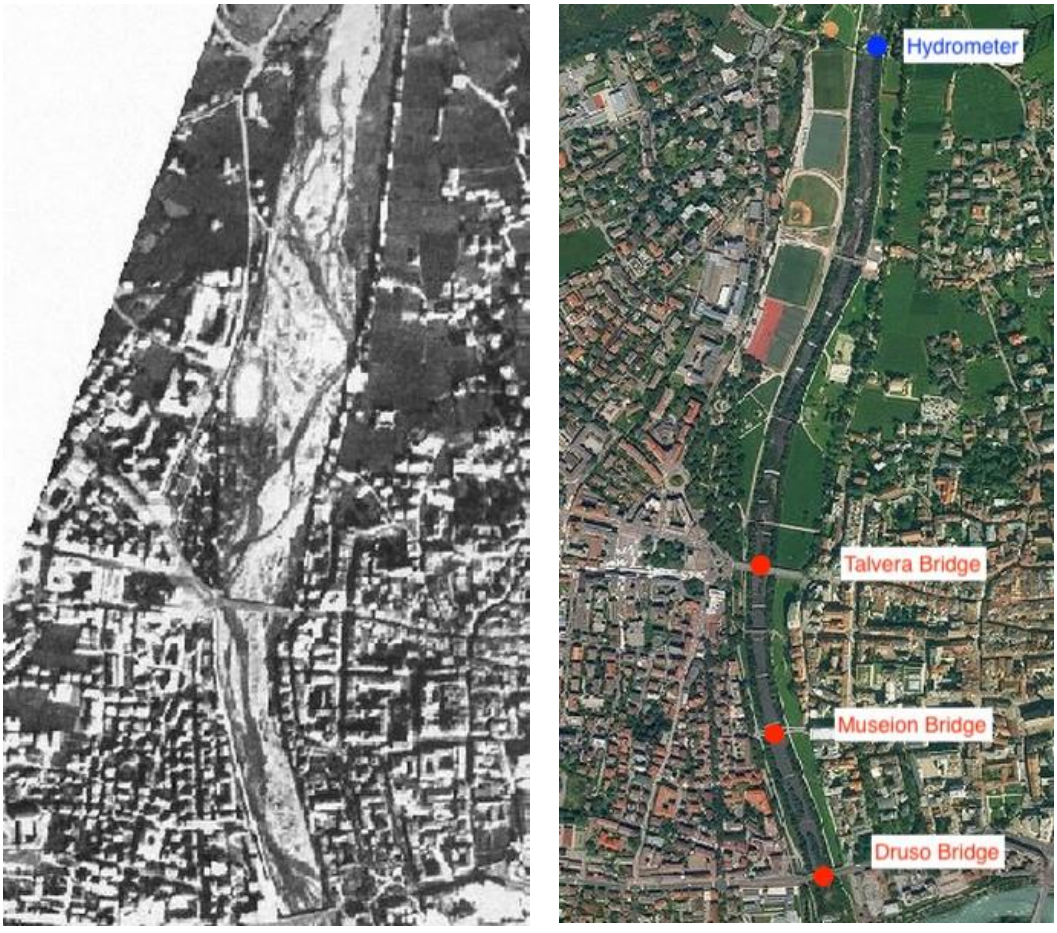

Figure 2 - Talvera River in 1954 (left) and 2014 (right)

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space programme
www.alpine-space.eu/projects/hymocares

Figure 3 - *Planimetric view of the Talvera Torrent before the confluence with the Isarco River*

In addition, due to the river high transport capacity, several check dams were built in the past in order to foster sediment and woody debris deposition and retention and thus to protect Bolzano from flood.

The stream reach target of the restoration within the HyMoCARES project includes the last 5 kilometres of the Talvera before the confluence with the Isarco River. Before the restoration, the average stream width along the studied reach ranges between 20 m to 50 m. However, originally the Talvera river cross sections used to be twice its actual size (breadth). *Figure* **2** shows a comparison between the Talvera in 2014, characterized by a single-channel-shape, and a braided stream in 1954. The channel slope ranges between 1.8 and 2.4% with a prevalence of cobble-size sediment. The widespread presence of reinforced embankments reduces the river's capacity to erode and move freely, contributing to a static equilibrium of the watercourse. The presence of check dams determines a significant alteration of morphological forms and inhibits forming processes, typical of the original morphological configuration. The recovery from this situation was one of the major goals of the restoration project, which aims at promoting sediment continuity by the removal of man-made cross sectional structure and at enhancing longitudinal connectivity for the fish population. Figure 3 shows a sketch of the Talvera reach before the confluence with the Isarco River. The series of check dams is clearly visible and their opening will enhance fish passage upstream the river, and therefore its ecological quality. Riparian vegetation is also affected by anthropogenic pressures, especially in terms of reduced width of the perifluvial zone; as a consequence the

presence of woody material in the riverbed is deficient. The overall morphological state of the described stretches is between Poor and Very Poor.

2 Hydro-morphological restoration project

2.1 Human alterations

The main human alterations affecting the restored river reach of the Talvera are river channelization, hydropeaking due to the hydropower plan activities and hydro-morphological alteration due to a series of check dams and bank protection. The channelization of the Talvera occurred between the 60s and the 80s, when the cross section, up to 180 m wide (*Figure* **4**), was confined to a roughly constant width of 20 to 50 m.; in addition, this brought about a stronger river bed incision due to higher flow velocity.

Figure 4 - *Aerial image of the Talvera at the Talvera bridge in 1935/1936*

Figure 5 – *Upper Talvera river-reach pre-restoration. Series of weirs and a consolidation check dam impeding fish passage. On the orographic left, the S. Antonio hydropower plant.*

The reduction of the stream velocity was achieved by building a series of 43 transversal structures whose height ranged between 0.40 m to 6 m (*Figure* 5). These check dams cut the longitudinal connectivity of aquatic populations along the river reach; as a consequence a loss of habitat occurred, which contributed to a decrease in the number of individuals. Moreover, a selection of fish species occurred according to the check dams height, since some of them are less skilled to jump obstacles: for example, the common barbell (*Barbus barbus*), the European bullhead (*Cottus gobio*) and all the juveniles individuals cannot overcome obstacles higher than 80 cm.

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space programme
www.alpine-space.eu/projects/hymocares

Since the construction of those check dams, sediment transport and supply have been deeply reduced; this brought about a loss of gravel areas, which used to provide habitats for several fish species. One of those check dam, downstream the Sill gorge, has already been removed and replaced by a retention check dam with a filter permeable to small size cobble and gravel (*Figure* **9**). However, sediments tend still to be retained within the Sill gorge (which corresponds to the area upstream of the studied stretch) by a large retaining dam, planned to be removed in 2019. Another one is located upstream the Sill gorge. Further projects might concern the removal of this last check dam leading to even higher longitudinal connectivity.

The hydropower plant along the Talvera in Bolzano relies on three storage reservoirs, two are located in the Community of Sarentino and the third in Renon. Depending on the price of electricity and production, there are sharp and abrupt fluctuations in discharge downstream the S. Antonio power plant (hydropeaking effect). The fluctuation between high and low discharge values brings an additional burden to the aquatic life, especially in the spawning period and during the juveniles development. In addition the hydropeaking, due to shear stress along the river bed, has an effect also on bed armouring and vegetation removal. *Figure* **6**, *Figure* **7** and *Figure* **8** show how the hydropeaking affects the discharge fluctuations in different seasons. Generally, the Talvera discharge varies between 1 and 20 $m^3 s^{-1}$ at least a couple of times per day.

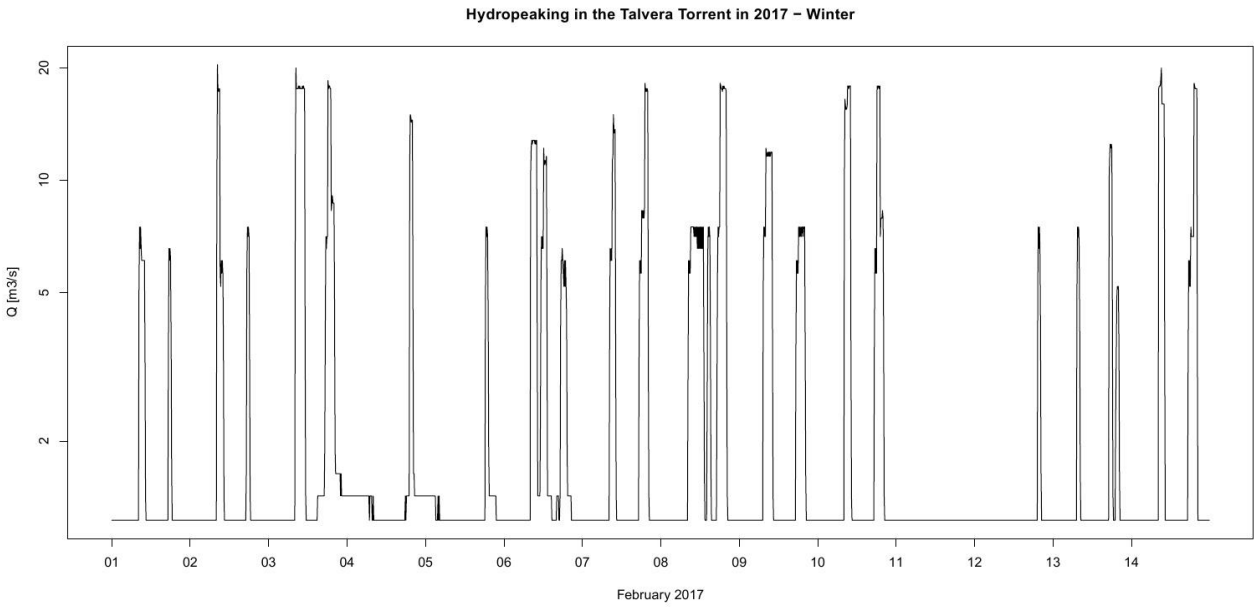

Figure 6 - *Discharge fluctuations recorded at the beginning of February 2017*

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space programme
www.alpine-space.eu/projects/hymocares

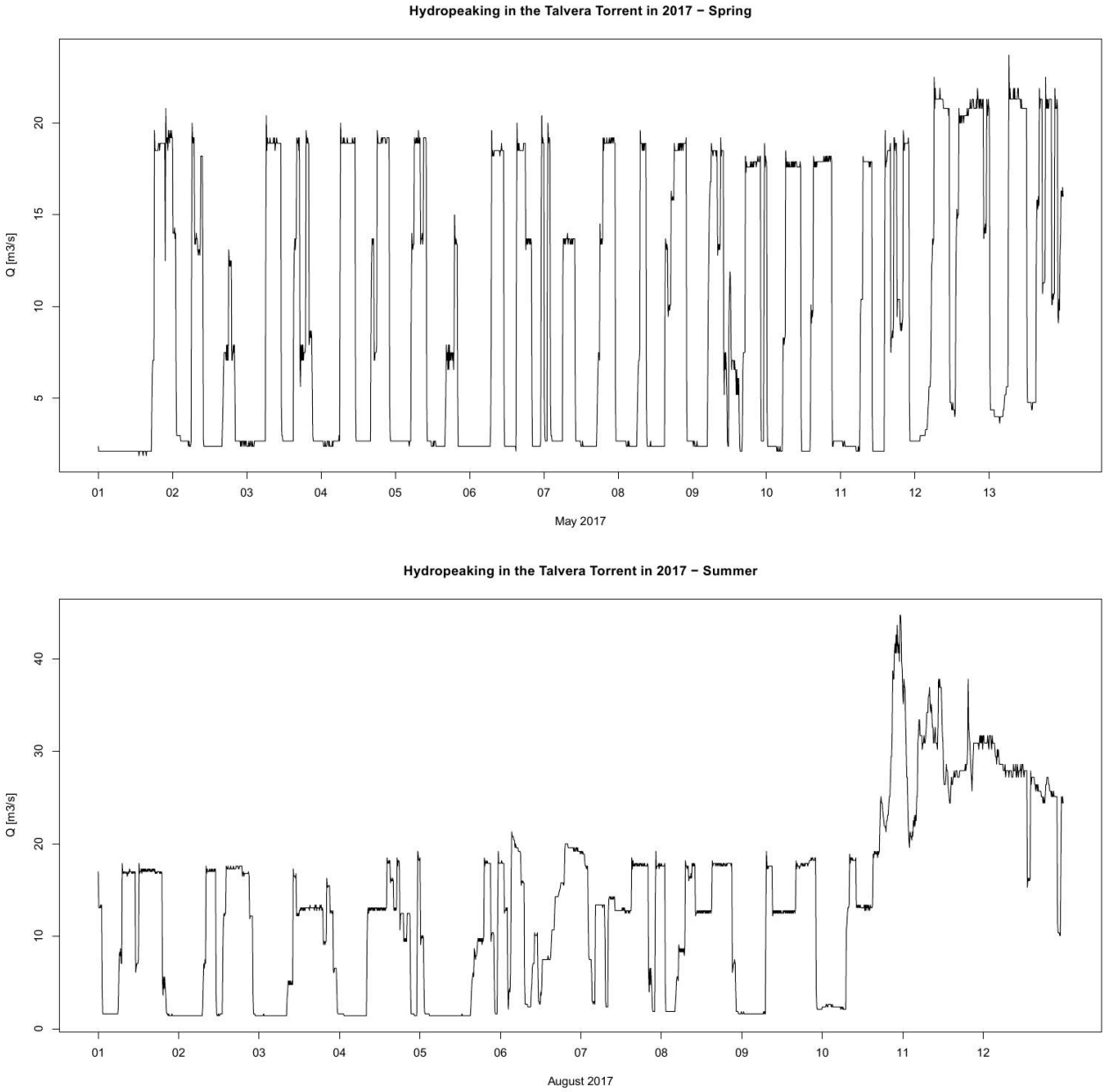

Figure 7 - Discharge fluctuations recorded at the beginning of May (top) and August (bottom) 2017

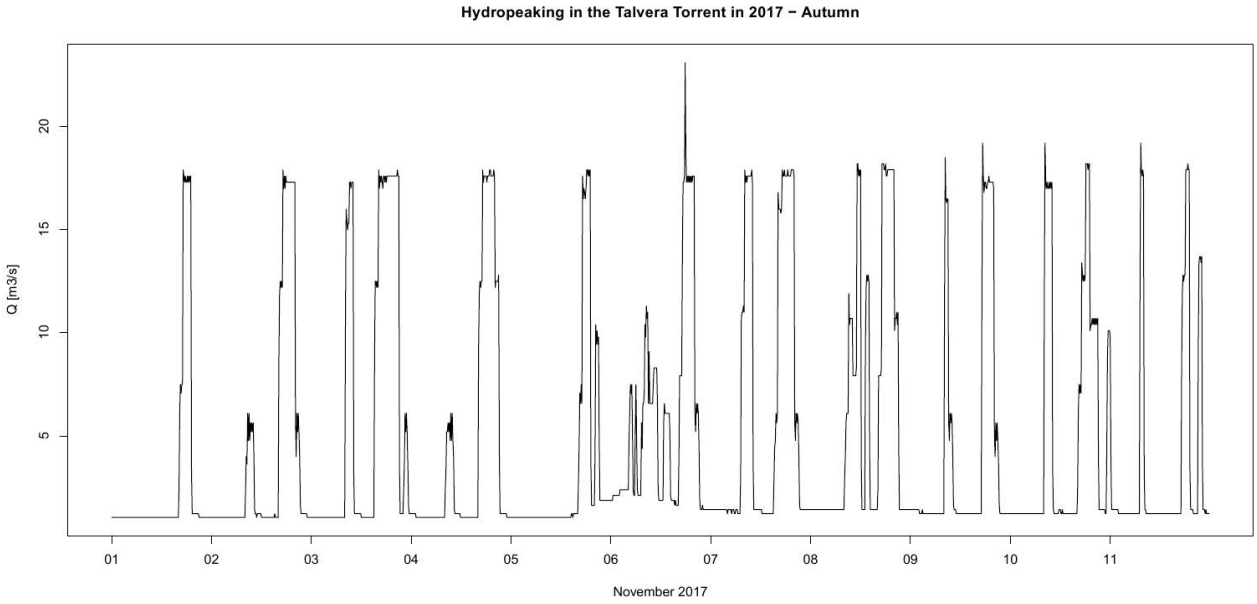

Figure 8 - Discharge fluctuations recorded at the beginning of November 2017

2.2 The restoration project

The Talvera in the area of the S. Antonio power plant has a huge ecological potential providing spawning areas and good habitat for the juveniles of like grayling (*Thymallus thymallus*), common barbell (*Barbus barbus*) and m (*Salmo trutta marmoratus*).

The main goals of the restoration project are the improvement of the longitudinal connectivity for the fish population, the increase of the number of habitats, the enhancement of stream physical heterogeneity and of flow variability.

The restoration works started in 2014 and went on up to spring 2019; the revitalization measures aim at:

- The removal or partial opening of the check dams all along the stretch, in order to allow longitudinal connectivity. The openings were obtained by alternating right- and left-openings to provide a sinuous pattern to the watercourse. This measure brings advantages for both aquatic populations and river morphology (higher sediment connectivity and diversity) avoiding sediment or wood accumulation and dangerous areas formation.

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space programme
www.alpine-space.eu/projects/hymocares

- The establishment of a medium water profile to solve problems due to low water level (hydropeaking).
- Dead wood introduction and recreation of natural macroforms (e.g. flow deflectors, bars, pools).
- Identification of a target species, the European bullhead (*Cottus gobio*), whose spread can be used to evaluate the efficiency of the restoration measures.
- Removal of a consolidation check dams in the upper reach, which was substitute with a retention check dam (*Figure* **9**), where fish migration is ensured also in low water regime. A retention basin was build upstream guarantying sediment entertainment. Further measures are planned to be deployed during the winter 2018/spring 2019 regarding the demolition of a dam at the Sill ice rink area. The 5 m jump will be retrieved by means of an ascending fish ramp.
- The recreational value of the Talvera is enhanced by the described restoration action. The longitudinal connectivity of the stretch allow recreational activities such as kayaking and fishing.

Due to the natural redesign of the streambed and the removal of anthropic obstacles, the good state of the water body should be achieved from a water-morphological point of view, according to the EU-WFD. Additional temporal measures involves the hydropower plants management, which should limit discharge fluctuations during the most sensitive periods of the year (spawning and juveniles months).

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space programme
www.alpine-space.eu/projects/hymocares

Figure 9 - Retention check dam constructed within the HyMoCARES project, sited 4.1 km upstream from the Isarco confluence. View from downstream to upstream

3 Monitoring activities

3.1 General objectives of the monitoring program

The main objectives of the monitoring program are to analyze, understand and quantify morphological and biological responses of the river reach after the restoration. Within the HyMoCARES project, the redesign of the riverbed by removing and opening the check dams and enhancing the longitudinal connectivity aims at improving and maintaining the ecological and morphological status of the water body in the long run. The achievement of this main objective will be checked through two types of monitoring actions: physical and ecological. As to physical monitoring a DoD (DEMs of Differencing) analysis and grain size characterizations will be performed, while as to the ecological monitoring fish electrofishing will be carried out (Figure 10). Habitat conditions in the Talvera and its surrounding waters should be improved and ensured in a sustainable manner having in mind the importance of structural and habitat biodiversity. The long-term

objective is to contribute to achieve good ecological and morphological state, according to the EU Water Framework Directive or to come as close as possible to it.

Restoration action	Restoration objectives	Monitoring actions
Check dam removal	Enhancing sediment connectivity	DoD Grain size characterization
	Enhancing fish passage	Fish electrofishing

Figure 10 – The main objectives of the restoration project and relative monitoring actions that will be performed to understand the achievement of the restoration objectives

The improvement in sediment supply is expected to enhance the morphological variability of the watercourse and its sinuosity, to reestablish a dynamic equilibrium, to reduce channel incision and to create new habitats for the aquatic species. Moreover, sediment supply together with channel widening, riverbanks renaturalization and recreation of natural macroforms (e.g. flow deflectors, bars, pools) will create reaches or areas where water flows slowly, alternated to areas of faster flow. Spawning gravel zones suitable for trout reproduction will be therefore re-established and fish populations are expected to grow.

A greener and more sustainable way to operate hydroelectric power plans would bring about a decrease in discharge fluctuations, which will have a positive impact on the river ecology. The actual manager of S. Antonio power plant is building a 90,000 m^3-buried reservoir to minimize the impact of the hydropeaking on the river ecology. This will allow for a more constant discharge to be released in the water body so that the negative impact of fluctuations on the aquatic life can be minimized.

3.2 Physical monitoring

The physical monitoring will mainly focus on the analysis of topographical changes, induced by the restoration on local morphology, and on hydraulic data, in order to characterize hydrological regimes and to assess the impact of hydropower pressure.

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space programme
www.alpine-space.eu/projects/hymocares

Topographic and LiDAR surveys will allow to assess channel and floodplain morphological changes. This monitoring technique results particularly efficient in this case study because the shallow water depth of the Talvera allows a fairly good identification of morphological changes. DTMs (Digital Terrain Models) before the restoration are available as well as detailed post-restoration data. Within the project a bathymetric LiDAR survey was carried out on December 14th, 2016. Another bathymetric LiDAR survey took place during November 2018. A geomorphological change detection analysis will be performed through a DEM (Digital Elevation Model) of Difference (DoD) approach which allows assessing elevation changes in time by comparing pre- and post-restoration DTMs. The morphological pattern and its variations will also be roughly estimated by visual inspection by comparing ortophotos or photos taken at different time. Photos pre- and post- restoration are available and the effects of the restoration works are already visible when comparing the situation in 2004, 2015 and later in 2018 (*Figure* **10**). In particular, orthophotos from 1945 (taken by the Royal Air Force) are available and a historical reconstruction of the Talvera dynamics will be performed. A quantitative analysis of the river hydro-morphological status will be evaluated by the Morphological Quality Index (MQI), developed for the hydro-morphological classification required by the European Water Framework Directive 2000/60/EC (WFD) and by the Monitoring Morphological Quality Index (mMQI).

Monitoring the hydrological variables includes also the analysis of data such as flow discharge. A hydrological station is located in a Talvera cross section about 2 km upstream the confluence with the Isarco River. Flow depth and discharge data are collected at this station with a sampling rate of 10 minutes; the available time series is 7-year long. From the analysis of discharge fluctuations will be extracted the IARI (Hydrological Regime Alteration Index) index that provides a measure of the deviation between the observed hydrological regime and the natural regime in the absence of human pressure.

Regarding future data collection, despite their cost, LiDAR surveys are an effective mean to monitoring the effect of restoration projects. Future topographic surveys are planned to evaluate the morphological changes over years, as well as grain size distribution at the scale of the restored reach. The collection of data regarding transported sediments is planned in order to understand the grain size distribution and which diameters are missing according to the Talvera discharge (Wolman count, Bunte & Abt 2011).

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space programme
www.alpine-space.eu/projects/hymocares

To assess the effectiveness of restoration measures not only in time but also in space, a morphological comparison between data collected within the restored reach and data collected within an unrestored reach will be carried out.

Figure **10** displays a comparison, for a reach of the Talvera, before restoration measures took place, during the restoration (2015) and at the end.

Table **2** summarizes all the available data for the physical monitoring.

Table 2 - Data for the physical monitoring. Data provided by the Autonomous Province of Bolzano or available in the Geocatalogo, Geobrowser of the Autonomous Province of Bolzano

	AVAILABLE DATA	
	PRE	POST
DTM	2006, 2013	2016, 2018, 2019
Topographic survey	2013	-
Ortophoto	1992/97, 2000, 2003, 2006, 2008, 2011	2014/2015
Q - discharge	2011 - 2014	2015 - 2018
h – water stage	2011 - 2014	2015 - 2018

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space programme

www.alpine-space.eu/projects/hymocares

Figure 10 - *Talvera River upstream Talvera bridge in 2004 (top-left), 2015 (top-right) and 2018 (bottom)*

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space programme

www.alpine-space.eu/projects/hymocares

3.3 Ecological monitoing

The ecological monitoring of the restored river reach is a crucial point to understand how and to what extent the biota responds to the habitat rehabilitation.

The Environmental Agency of the Autonomous Province of Bolzano collects monthly data to assess the chemical quality of the water. In particular, the chemical status of the river is estimated by using the LIMeco Index (Livello di inquinamento da Macrodescrittori per lo stato ecologico – pollution level from macro-descriptors for the ecological state), which was introduced by the D.M. 260/2010. The index is devised to describe the chemical-physical quality of the water, combining values of dissolved oxygen and other three nutrients (NH_4^+, NO_3, P_{tot}). The ecological status of the river reach is determined by assessing the main biological groups according to the Water Framework Directive. Biological sampling are carried out once every three years and three times per year of sampling. In particular, macroinvertebrates are used to calculate the STAR_ICMi index which is the official tool to assess the quality class (ISPRA, 2014). Besides macroinvertebrates and according to the EU legislation, the Environmental Agency collect samples also of diatoms. They are unicellular algae which are indicators of the water quality; even if they are not the more meaningful, since data are available, Diatoms data will be evaluated anyway to get a better picture. The national index used to assess the quality class is the ICMi (Intercalibration Common Metric index), which combines the Indice de Polluosensibilité Spécifique, IPS (Cemagref 1982) and the trophic index of Rott (TrophieIndikation, TI, Rott et al. 1999).

The fish populations were also monitored mainly by using electrofishing. The Office for hunting and fishing of the Province, is collecting data not only in the restored reach before and after the intervention but also in reference sites. Data are assessed both considering species structure and abundance, but also calculating the official index called ISECI (Ecological Status of the Fish Communities), now updated to a new improved version known as NISECI (ISPRA, 2017). *Table* 3 reports the available chemical and biological data used for the monitoring.

A study concerning the characterization of fluvial habitats will be performed. The method Caravaggio has already been applied to the Talvera (2009 and 2011) as well as the CasiMir's ones (Valorzi's master thesis, 2012). The Mesohabsim method seemes the most suitable to evaluate the hydropeaking effects; given, the lack of past applications (before restoration), it will be here applied with the aim of evaluating the effect of

the hydropeaking reduction on the habitat availability and the population number. With this purpose data will be collected in collaboration with the hydroelectric power plant, which will release fixed discharges to simulate 4 different flow conditions.

Table **3** *- Data for the ecological monitoring. Data provided by the Environmental Agency and the Office for hunting and fishery of the Autonomous Province of Bolzano*

	AVAILABLE DATA	
	PRE	POST
Chemical analysis	2005, 2006, 2007, 2008, 2010,2013	2015, 2018
Star_ICMi	2008, 2010, 2013	2015, 2018
ICMi	2008, 2010, 2013	2015, 2018
Fish species	2010	2015

This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space programme

www.alpine-space.eu/projects/hymocares

4 References

Bunte K & Abt SR (2011). Sampling surface and subsurface particle-size distributions in wadable gravel- and cobble-bed streams for analyses in sediment transport, hydraulics, and streambed monitoring. - U.S. Dept. of Agriculture, Forest Service, Rocky Mountain Research Station https://books.google.it/books?id=I9WZ54gwYMEC

Cémagref (1982). Etude des méthodes biologiques d'appréciation quantitative de la qualité des eaux.

D.M. 260/2010. Decreto Ministero Ambiente 8 novembre 2010, n. 260 (D.M. 260/10) - Regolamento recante i criteri tecnici per la classificazione dello stato dei corpi idrici superficiali, per la modifica delle norme tecniche del decreto legislativo 3 aprile 2006, n. 152 predisposto ai sensi dell'articolo 75, comma 3, del medesimo decreto legislativo

EU-WFD (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

ISPRA (2014). Manuali e linee guida – Linee guida per la valutazione della componente macrobentonica fluviale ai sensi del DM 260/2010. 107/2014

ISPRA (2017). Manuali e linee guida – Nuovo indice dello stato ecologico delle comunità ittiche (NISECI). 159/2017

Provincia Autonoma di Bolzano (2017). PGUAP - Piano generale di Utilizzazione delle Acque Pubbliche - approvato il 22 giugno 2017 con D.P.R.

Valorzi C (2012). Ökomorphologische und zoozönotische Erfolgskontrolle der Renaturierung der Talfer in Bozen