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MEASURES FOR IMPROVING THE AQUATIC BIODIVERSITY ON THE LOWER SECTOR OF BEGA VECHE RIVER

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ABSTRACT. Measures for Improving the Aquatic Biodiversity on the Lower Sector of Bega Veche River. For surface water bodies, the main environmental objectives set out in the Water Framework Directive are aimed at achieving the good ecological status, respectively the good potential for heavily modified and artificial water bodies. The Banat River Basin Management Plan 2016-2021 identified several significant pressures at watercourses level, such as Bega Veche, which lead to the failure to achieve these objectives. This paper presents the proposed green measures which have a beneficial role from a biological and ecological point of view, which involve natural water retention measures and renaturation of water streams banks, including measures to improve the retention capacity at catchment level.

Keywords: Water Framework Directive, Banat, Biodiversity, Green measures.

1. INTRODUCTION

This paper highlights the results of "Enhancement of aquatic and riparian habitat biodiversity by increasing the water body's lateral connectivity and wetlands establishment on the lower Bega Veche River" study, and implicitly the working method/methodology that was the basis for selection of optimal measures to enhance aquatic and riparian habitat biodiversity on lower Bega Veche River. The study was aimed at laying the scientific grounds for a following up project, targeting the Large Infrastructure Operational Programme 2014-2020's objectives, Priority Axis 4 - "Environmental protection through biodiversity conservation measures, air quality monitoring and remediation of historically polluted sites", Specific Objective 4.1 - "Increased protection and conservation of biodiversity and restoration of degraded ecosystems". The study had, as main goal, the improvement of hydro-morphological, physical-chemical, and implicit biological indicators, which was required for increasing the aquatic and riparian ecosystems' biodiversity, the water body's reshaping as a long-term environmental objective, the natural water reserve's increase, but also watercourse's quality improvement. The study was also focused

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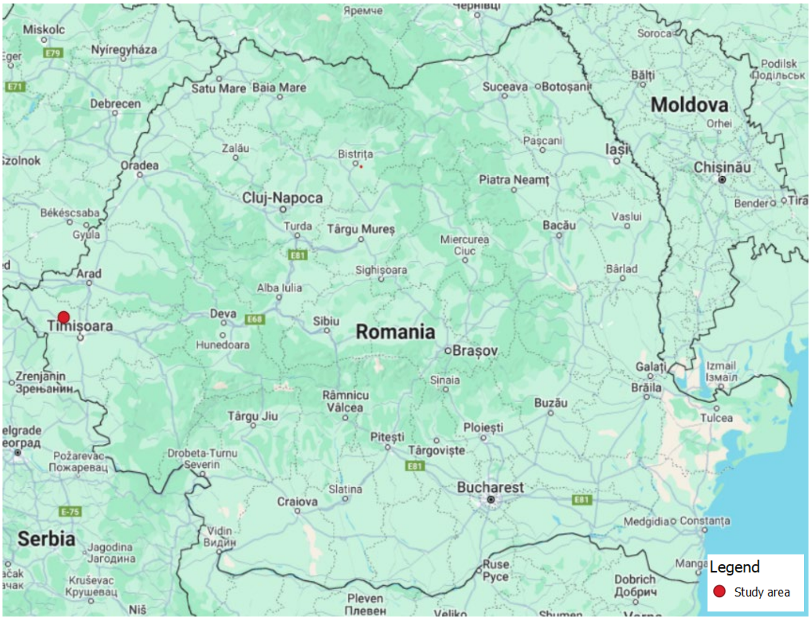
on promoting growth and development of flora and fauna by creating wetlands and providing new food and habitats for many bird species.

2. METHODS

2.1. The study area description

The study area is in south-west Romania, near the city of Timisoara.



The area of interest covers the lower sector of Bega Veche water body, mainly Bega Veche River (Beregsău, Niraj) – downstream of junction with Valea Dosului and its tributaries (RORW5.1.21. B2). This area was chosen due to the risk of not achieving environmental objectives.

Bega Veche River (Figure 1) is the Bega River's main tributary (cadastral code V.1.), formed by the union of Ier River, Niarad River and Beregsău stream, after Bega Canal construction. The Bega Veche River has a 107 km length and a drainage catchment area of 2050 km^2, with 39 km of embankments' length. From a hydrological point of view, Bega Veche drains together with its tributaries, including: Niarad or Măgherăuș and Ier or Apa Mare an area of 2110 km^2. Bega Veche is, in fact, an old route of Bega River, and is basically an extension of Beregsău stream.

Figure 1. Map of surface water bodies in the Banat RBA with indication of the area of interest (source: Updated Management Plan of the Banat RBA 2016-2021)

The study area included several local administrative units in Timiș County, namely: Beregsău Mare, Beregsău Mic, Cenei, Bobda and Uivar. (Figure 2).

Figure 2. Study area description (source: Google Maps, March 2022)

From a biological perspective, the following species are found in Bega Veche water body: *Alburnus alburnus* (common bleak), *Carassius auratus gibelio* (carp), *Cobitis taenia* (pike), *Esox lucius* (pike), *Misgurnus fossilis* (eel), *Rutilus rutilus* (burbot), *Sabanejewia balcanica* (caper), *Abramis brama* (bream), *Ameiurus nebulosus* (dwarf catfish), *Cyprinus carpio* (carp), *Lepomis gibbosus* (sun bass), *Rhodeus sericeus* (red sea bass), *Scardinius erythrophthalmus* (redfish), *Perca fluviatilis* (perch), *Abramis sapa* (flatnose seabream) and *Abka gymnotrachelus syn.*, *Neogobio gymnotrachelus* (mudskipper). One species is predominant in terms of individuals' numbers in all the analyses carried out, namely *Carassius auratus gibelio (carp)*. It is considered as an invasive species, having a negative impact on the native species, *Carassius carassius*, to the point of extinction of the second one. Other highly invasive species identified by field surveys include *Babka gymnotrachelus syn.*, *Neogobio gymnotrachelus* (mudskipper), *Ameiurus nebulosus* (dwarf catfish) and *Lepomis gibbosus* (sun perch) (source: Technical documentation for obtaining the Water Management Permit, 2022).

2.2. Description of the current situation. Main issues identified

In the analysed river basin, some of the hydrotechnical works are more than 250 years old. The longitudinal river works built on this water body are flood protection embankments. The three watercourses forming Bega Veche River have been strongly modified since the 18th century, and the historical maps (1769-1772) certify that the entire Banat Catchment had many wetlands, meanders and secondary watercourses that were lost due to hydrotechnical works (observed and attested in the historical maps from 1819-1869). Now, it can be observed that former watercourses incorporation into drainage systems, modifies to a significant extent the natural hydrographic network and creates a strongly modified water body.

Based on Banat River Basin Management Plan (RBMP) 2016 – 2021 (ABA Banat, 2015), it was possible to identify numerous and significant pressures on these watercourses, which are preventing the environmental objectives' achievement. These negative pressures are divided into point pollution sources, diffuse pollution sources and other pressures, such as those generated by hydrotechnical works (alterations or hydro-morphological pressures).

Regarding the first type of pressures on Bega Veche water body, were identified the potential point sources, because of agricultural and zootechnical activities. But their small number (1 source on Apa Mare River) and the technologies used established that they do not produce negative effects. The localities that have the potential to produce negative effects on the watercourse are: Cenei, Dudeștii Noi, Becicherecu Mic, Biled, Satchinez, Vinga, Sagu, Ortișoara, Iecea Mare, Variaș, as they do not have a wastewater collection system and produce diffuse organic load.

Among the hydro-morphological pressures analysed and identified in Banat Hydrographic Area, not all are present on Bega Veche water body. Those present and identified pressures on this analysis are the reservoirs (Murani Reservoir), the riverworks and the embankments (107.5 km of total embankments and regularisations on almost the entire watercourse).

Also, as a part of the study assessment and implicitly the technical documentation for obtaining the Water Management and Environmental Agreement, field studies were carried out to identify other sources, in addition to those mentioned above, which may exert significant pressures on Bega Veche water body. Thus, we can talk about household's waste accumulations, ruderal and invasive plants, the phenomenon of severe subsidence of land by herds of animals, the destruction of embankments with technical equipment, overgrazing and many embanked meadow sectors with anthropized aspect, surrounded by agricultural land and grazing land.

Bega Veche, although classified as a heavily modified water body and which does not meet the environmental objective for physical-chemical (nutrients and oxygenation) and biological (ichthyofauna) elements, the water body RORW 5.1. 21_B2 Bega Veche (Beregsău, Niraj) - downstream confluence with Valea Dosului and tributaries has been designated protected natural area (ROSCI0277 Becicherecu Mic and ROSCI0115 Satchinez Marsh), containing either aquatic species or community interest habitats (1530 Pannonian salt marshes and steppes, 92A0 *Salix alba* and *Populus alba* galleries), or species or habitats dependent on watercourses or wetlands (e.g. otter - *Lutra lutra*, red-bellied pondweed - *Bombina bombina*, great crested newt - *Triturus dobrogicus*, sandpiper - *Cobitis taenia*, eelgrass - *Misgurnus fossilis*, european freshwater pondweed - *Emys orbicularis*).

As a result of these changes which occurred over time, on the embankments sector, Bega Veche River does not reach the environmental objective related to physico-chemical (nutrients and oxygenation) and biological (ichthyofauna) elements, mentioned in Banat R.B.M.P. - cycle II (HG 859/2016). Thus, the ecological status considered for this study is, on one hand, the good ecological potential mentioned in R.B.M.P., and on the other hand that the parameters that determine the moderate ecological potential are: ichthyofauna, oxygenation conditions and nutrients. Achievement of the environmental objective for the water body represented by the lower sector of Bega Veche River can become possible / feasible through aquatic and riparian habitats' diversification, having beneficial effects on nutrient, oxygenation regime, on biological parameters, by reducing significant pressures effects.

3. RESULTS AND DISCUSSIONS WILL BE ADDED

4. PROPOSED MEASURES FOR IMPROVING AQUATIC AND RIPARIAN HABITATS' BIODIVERSITY

In order to identify viable measures, an Options Analysis was carried out, based on which were identified two options. Table 1 summarises these options, the baseline option *("Do nothing")* is numbered as Option 0.

The proposed green measures are:

- Reconnecting Bega Veche River with the floodplains by restoring / creating a wetland on the right bank, upstream of Beregsău Mic. This involves a wetland development in the area of some Bega Veche River's former meanders, by embankment relocation to create floodplain zones (wetland itself) Method presented in some of UK's practice guide(Scottish Environment Protection Agency, 2020).

- Reconnecting nine clogged river channel's branches (which have become inactive due to gradual sedimentation and silting) in Bega Veche Canal's minor bed. This will be done, inside the embanked area, by excavations, with no effect on the embankments' existing structure. This meanders reconnection is located between Beregsău Mic and downstream of Cenei and extends over 4.6 km length (McMahon, 2000).
- Reconnecting the historical river branches on the lower Bega Veche River (on historical river branches at Cenei and at Beregsău Mare), located in the floodplain of Bega Veche watercourse, behind the existing embankments. This measure implies the accomplishment of embankments 'culverts crossing and implicitly to control flooding on the area of interest (Scottish Environment Protection Agency, 2015).

Table 1. Description of the analysed options

<table>
<tr><th>PROPOSED MEASURE</th><th>OPTION 0</th><th>OPTION 1</th><th>OPTION 2</th></tr>
<tr><td>Lateral connectivity measures (7 areas)</td><td rowspan="3">Baseline option (without project) " Do nothing"</td><td>x</td><td></td></tr>
<tr><td>Embankments abandonment</td><td></td><td>x</td></tr>
<tr><td>Riparian corridor development, invasive and ruderal species removal</td><td>x</td><td>x</td></tr>
</table>

A Multi-Criteria Analysis (MCA) was carried out, and based on the options assessed in MCA, the first option was chosen. Option 1 involved measures to ensure lateral connectivity of Bega Veche River (for seven areas), riparian buffer strips implementation / invasive and ruderal species' removal.

Therefore, the chosen option involves the combined use of soft and green measures to produce positive hydro-morphological changes, by increasing locally the natural water supply. Also, these measures were chosen for improving the watercourse quality and for supporting flora and fauna characteristic's development or re-establishment on riparian ecosystem. The following paragraphs briefly describe Option 1's impact over the environmental factors (Benedict and McMahon, 2002).

- Impact on water - The historical branches reconnection ensures hydraulic continuity between the main watercourse and its floodplain, i.e. the water renewal (Coutts and Hahn, 2015). This favours improvement of physical-chemical and biological water indices, having a positive impact on both long and short term. Among the positive impacts of proposed works, we mention water quality improvement by increasing filtration capacity, decreasing temperature variation, increasing O_2 water concentration and stopping bank erosion process. Overall has a moderate positive impact and a high occurrence probability on short, medium and long term.

- Impact on air – For works execution, special equipment is required to handle soil movement, and from an air quality point of view, the preferred option's implementation implies a negative impact during this process. The negative impact on air is through atmospheric emissions associated with the transport and handling of raw and auxiliary materials required, as well as due to the operations carried out at the worksites (Mell, 2017). However, the negative effect of these sources is reversible and disappears once the works are completed. Thus, despite the above, new flora organisms (which punctually increase the concentration of atmospheric oxygen through the process of photosynthesis) appear through the improvement of water quality and planting process. The impact associated with this option is insignificant, completely reversible and manifested on the short term. On the medium to long term (after work's implementation and actual growth of riparian woody vegetation), the impact becomes positive, observed over riparian habitats and the project lifetime.
- Impact on soil - The chosen option also foresees actions to mitigate soil degradation, more specifically in areas where riverbanks are eroded, by filling the gaps. In addition, for historical river branch reconnection at Cenei area, two riverbank reinforcements have been proposed, made of hard stone prisms. Another positive impact on soil, comes from its water covering in wetland areas, a process carried out upstream of Beregsău Mic locality, as well as in all other locations where wetlands will be developed (along the watercourse current route). This will happen during flow excess periods. Covering these areas with water is a soil quality benefit, as the transported materials by water contribute to soil fertility increase, by enriching it with nutrients, with an increased biological diversity effect. Thus, the impact on the soil environmental factor associated with this option is estimated to be significant positive, with a high occurrence probability on the medium to long term.
- Impact on biodiversity - In terms of biodiversity, the preferred option's implementation is beneficial, as local flora and fauna feeling almost exclusively positive effects, with an increase over time. The wetlands development in all proposed locations provides important resting and breeding sites for waterbirds, and other wetland fauna as invertebrates, fishes, amphibians, reptiles or mammals. The specific types of aquatic and riparian vegetation, lost when Bega Veche River and its tributaries began to be regularised, are also developing again. In its current state, the vegetation identified, based on field studies, contains numerous allochthonous elements, with an invasive potential (*Ambrosia artemisiifolia*, *Robinia pseudoacacia*, *Populus x euroamericana*, *Fraxinus pennsylvanica*, *Morus alba*, *Xanthium spinosum*, *X. strumarium*). On this matter, it was proposed to remove these species, followed by woody species plantation. Thus, the impact of biodiversity environmental factor, associated with this option, is estimated to be significant positive, with a high occurrence probability on short, medium and long term.
- Impact on landscape - The chosen option implies certain changes in landscape, which occur both during the construction phase and once the works are completed. Thus, during the development phase, the landscape area's visual impact is affected by the open front works specific of construction sites. The proposed

project works are located outside urban areas, but some will correspond to areas with a current relatively high degradation degree of natural landscape. Therefore, until the proposed works are completed, a visual impact as assessed on the local landscape.

5. PREFERRED OPTION ASSESSMENT

The proposed measures were evaluated through the hydraulic modelling of Bega Veche Canal. A two-dimensional (2D) hydraulic model was built, including the sector between the upstream junction of Apa Mare - Beregsău Canal and downstream of Cenei locality. The simulations were done in unsteady flow regime, using HEC-RAS software.

The reconnection of the historical river branch requires construction of a gate control culvert in the embankment's structure, at the upstream end of the historical branch to allow water access, and the reprofiling / cleaning of the historical river branch channel to allow the water to flow along the entire branch (Figure 3). Potential design options were tested, and the efficiency was proved by modelling.

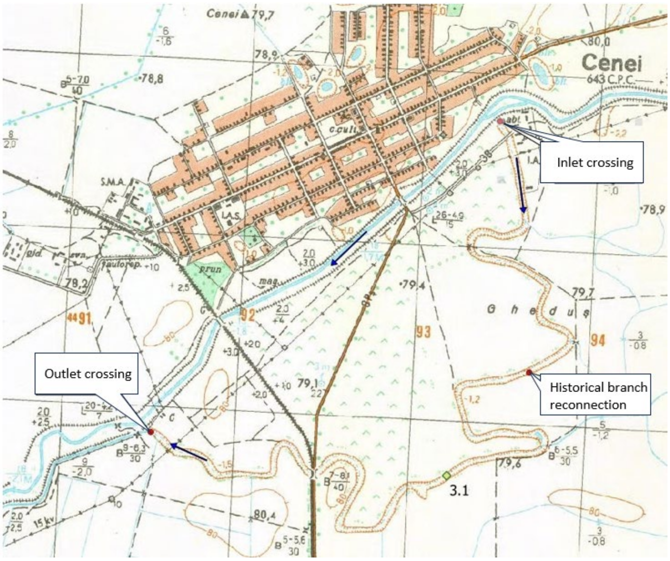


Figure 3. Cenei – Historical River branch reconnection (1:25.000 Topographic map)

The river channel reshaping measure involves a trapezoidal section. These measures were included in the 2D hydraulic model, and results showed that water will travel the entire branch and fill the channel to about half of its capacity in about 12 hours (Figure 4a). The model showed that the branch will get wet when the flow in Bega Veche Canal exceeds 10 m^3/s. The maximum flow within the culvert is 2 m^3/s. The historical branch at Cenei is crossed by a communal road which currently obstructs the flow. We can mention that, in the model, it was assumed that this obstruction would be eliminated post- project implementation, to ensure flow continuity and longitudinal connectivity along the entire branch. In case that during extreme floods such as 1%AEP the culvert gate remains open, the flow through the culvert can be conveyed by the reprofiled channel, without causing flooding in the agricultural area or adjacent properties (Figure 4b).

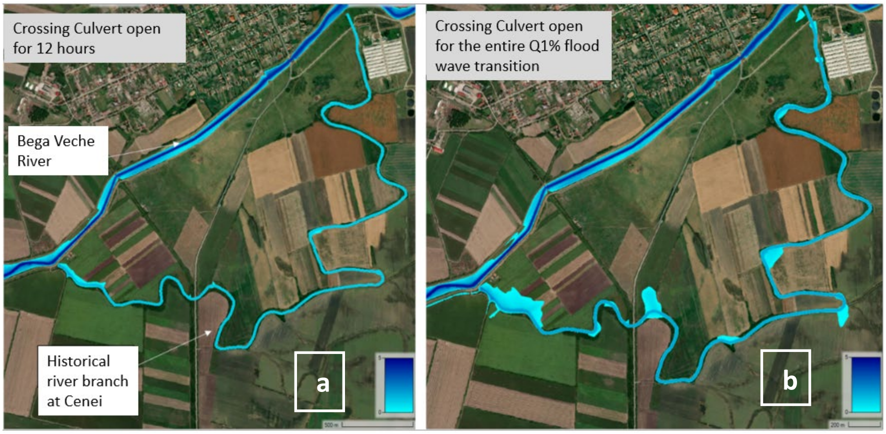


Figure 4 (a., b.) – Flood extent at Cenei historical river branch

Another proposed measure was the reconnection of Beregsău Mare River's historical branch (Figure 5) by constructing a crossing culvert through the embankment, immediately downstream of Beregsău Mare and reprofiling / cleaning the channel related with the historical branch.

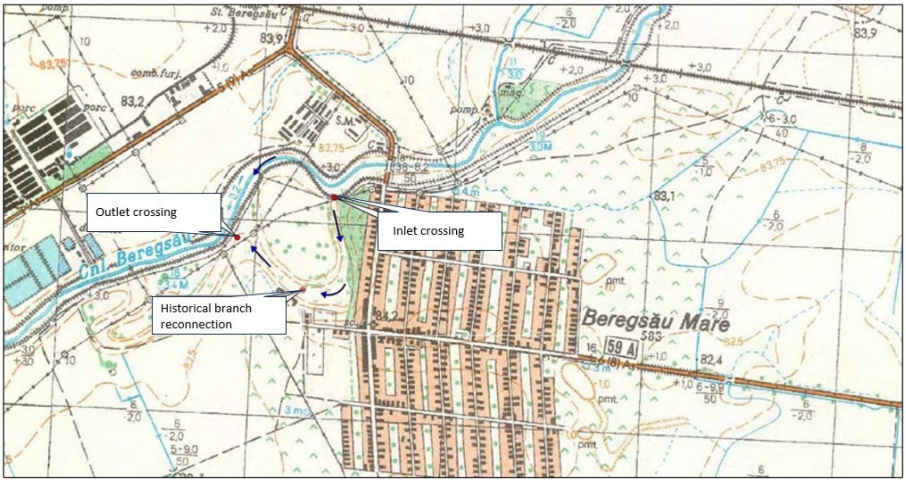


Figure 5. Beregsău Mare - Historical River branch reconnection

As in the historical river branch at Cenei case, the reprofiling involves a trapezoidal section with the same characteristics. By implementing this measure in the 2D hydraulic model, results showed that the water will travel the entire branch and fill the canal in about 7 hours. After this time, the crossing culvert's gate must be closed in order not to flood the adjacent lands or Beregsău Mare locality. (Figure 6). The historical river branch at Beregsău Mare starts flooding when the flow on Bega Veche Canal exceeds 10 m^3/s.

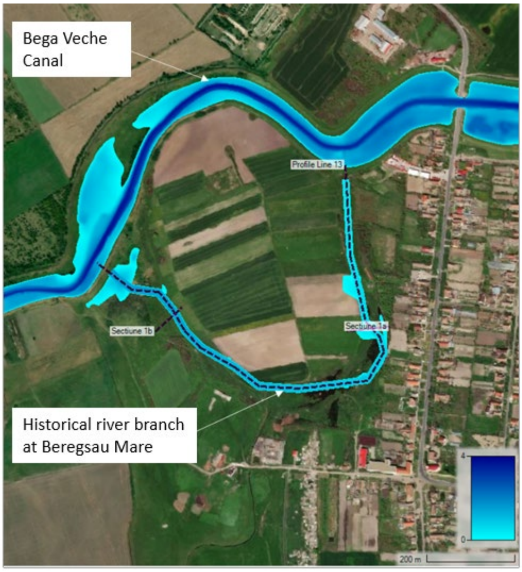


Figure 6 – Flood extent at Beregsău Mare historical river branch

In Figure 7, the results of hydrodynamic modelling are illustrated comparatively by flood outlines of Q1% for both, initial situation, and post-implementation of proposed measures situation.

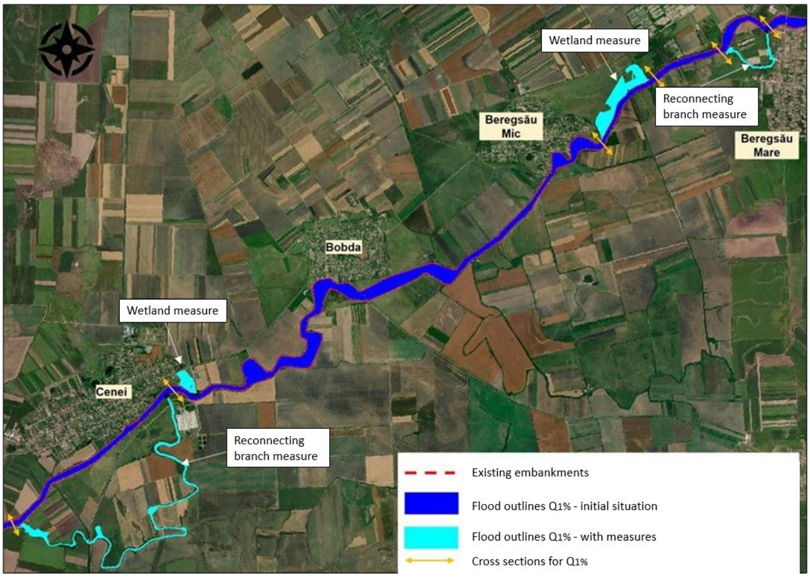


Figure 7 – Plan view of flood outlines results with proposed measure's location

Figure 8 presents the water level comparison for 1%AEP flow upstream and downstream of Cenei branch, for baseline and post-implementation of proposed measures which reveal a benefit in flood levels reduction.

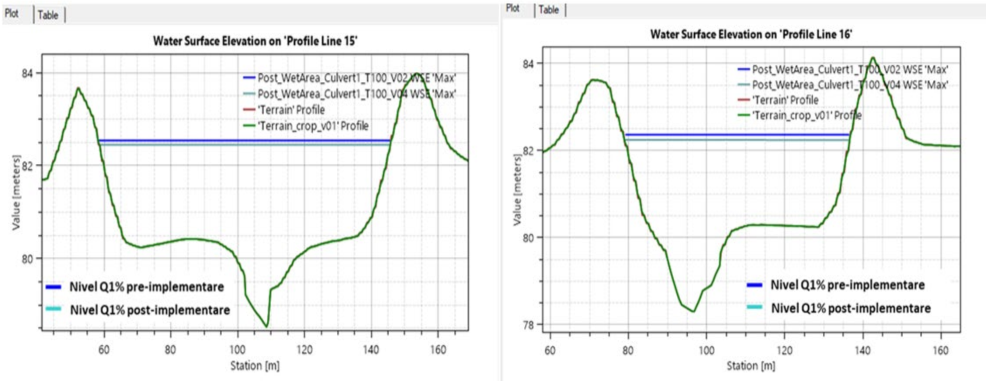


Figure 8 – Cross section upstream and downstream of proposed measure – reconnecting historical river branch at Cenei

6. CONCLUSIONS

This paper highlights how the chosen measures correspond to the project's objective, i.e. improving watercourses' quality and supporting flora and fauna characteristic's development or re-establish the riparian ecosystem. The aim of the study, presented in this paper, was to improve the moderate state of the physical-chemical, biological and hydro-morphological parameters, by focusing on oxygenation conditions, nutrient regime and ichthyofauna.

Considering all environmental, economic, technical, and social factors, the most suitable option for the development of River Bega Veche was represented by Option 1, with effects not only at works' site level, but along the river channel, riverbanks, upstream and downstream.

As a result of the implementation of lateral reconnection with meanders measure, wetlands are created. Wetlands can offer diverse habitats to aquatic fauna and, at the same time, host the bird species located in the neighbouring protected areas, in accordance with their biological functions.

The modelling process confirmed the hydraulic efficiency of all proposed measures under the recommended option, demonstrating and validating their overall effectiveness. At the same time, based on the analysis of all environmental, economic, technical, and social aspects, Option 1 was the most suitable for planning the course of Bega Veche River. This option involves the measures implementation, which ensure lateral connectivity of the water course, namely the creation of riparian curtains, elimination of invasive and ruderal species.

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