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THE PROCESS OF REVITALIZATION OF THE RIVER BRANCHES OF THE ŽITAVA RIVER NEAR THE WETLAND ŽITAVSKÝ LUH

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Abstract. In the last century, many modifications of rivers were implemented on the territory of Slovakia, the current state of which does not meet modern ecological criteria. Historical modified corridors acting with technical elements such as trapezoidal profiles, concrete bank fortifications, complete felling of the stream's accompanying vegetation, protective levees on both watersides, elimination of meanders with the aim of straightening of the channel, the deepening of the riverbed are rarely proposed anymore. Modifications with the aim of channelization of the riverbank and quickly diverting the flow from the territory as part of flood protection and management with flood water. This process constitutes counter-production with modern aim of maintaining water in nature, its use and manipulation. The modern effort is to restore or preserve the existing ecosystems that are in the inundation of the river. One of the priorities is the ichthyological point of view, the task of which is to preserve the diversity of the flow, not to create migration obstacles and, on the contrary, to ensure constant minimum flows for animals and fish, especially during droughts. The riverbed itself can be helped by planting screening elements (whether vegetal or structural) to minimize the heating and evaporation of water. The perception of new proposals is more and more linked to nature and natural elements, a step back to nature is also positively perceived by the wider public, especially if the original required functions of the treatment such as flood protection can also be fulfilled. Even concrete constructions of protective walls can be supplemented with shelters for birds, in the form of holes or protrusions. The restoration of old and historical river branches, whose water-holding volume or flow cross-section profile can, on the contrary, help in the transfer of flood flows, is one of the modern processes. A system of such branches can also be used to create a larger retention space or create a wetland, with a regulated water surface elevation regime. One of the rivers affected by these technical solutions is the Žitava river. In the past, there was an effort to revitalize part of the given branches, but only a short section of the total length of the river underwent technical modification. However, the branches are still visible from satellite images in the form of terrain depressions or accompanying vegetation of dried riverbeds.

Keywords: flood protection measures, revitalization, wetlands, Slovakia

1 INTRODUCTION

Although minor interventions in Slovakia's waterways have been documented since the Middle Ages, the beds of larger rivers in Slovakia began to be more systematically influenced only from the 17th century. However, key morphological changes of the riverbeds are only associated with the straightening of meandering streams in the 18th and 19th centuries, and various other types of interventions that were implemented mainly in the 20th century - primarily by fortification banks and construction of water reservoirs. The morphological response of riverbeds to hydrotechnical interventions is good is known and has been considered for several centuries in the design of regulatory modifications of rivers (Raplík et al. 1989). Naturally, the river Žitava is no exception. The peak of man's expansion into the river flow is the drastic interventions in the 20th century, especially during the totalitarian regime, where, in addition to straightening and lowering the riverbed, Žitava

river was relocated in new corridor as "New" Žitava. (Harčár 1981). A part of the original riverbed named "Old" Žitava has been preserved and a wetland has been created in its part, which is declared as protected bird territory Žitavský Luh since 2008. Channelization of fluvial systems includes widening and deepening the stream channel, which increases the channel capacity, shortening the stream channel length, and increasing the stream gradient. These factors combine to typically move greater volumes of water through the system at a much more rapid rate compared to pre-channelization conditions. As a result of increased channel capacities and increased transport efficiency, channelization of streams causes the channels to be hydrologically disconnected from the adjacent floodplain and alters functional processes of fluvial systems (Kroes and Hupp, 2010). The goal of the article is to explain status of parts of the Žitava river, where is room for improvement and show proposals which will be implemented. The proposals are aimed at increasing the ability to regulate and maintain water in the Žitavský Luh wetland, either during drought or during floods (Tinák, 2010). Similar revitalization is designed to the branches of Klátovské Rameno stream. The project is aimed at the revitalization of the wetland biotopes of the Klátovské rameno and its associated branches Čótfá and Soliari. The area of revitalization was declared a National Nature Reserve and subsequently also a Territory of European Importance with V. to III. degree of protection (Tárník, 2022). Another situation is focused on the design of technical measures for the revitalization the Medzibodrožie region, which is located between the Latorica River on the north, the Tisa River on the south, the Bodrog River on the west, and the Slovak-Ukraine border on the east. The construction of protective dykes on the Latorica and Tisa rivers and the consequent decrease in the groundwater level in the region between these two rivers due to the decreased recharge of groundwater from the surface flows caused the drying out of the rivers. (Šoltész et al. 2018). This is one of the many examples of the negative consequences of anthropogenic activity on the environment in the wetland Čéne on the Slovak-Ukrainian border (Repel, A. 2021).

2 METHODS

This section will be devoted to the description of the Žitava river, its past and the modifications that still affect it today.

2.1 History of the River

Back in 1606, when the Treaty of Žitava was signed, the "Old" Žitava, specifically one of its main branches at the time, entered the Danube river near the settlement of Žitavská Tôň (Figure 1. on left). The remnant of the river from those times is currently Lake Virt. Of course, today's mouth of "Old" Žitava to Nitra river near Martovce city is well known. The peak of man's expansion into the river flow is the drastic interventions in the 20th century, especially during the totalitarian regime. In addition to straightening the channel, the so-called the "New" Žitava branch starting south of Hul city, the channel that diverts part of the Žitava water through the new, artificial estuary to the Nitra river, located already east of Šurany City (Figure 1. on right - without artificial estuary).



Figure 1. Historical map of the Žitava River (1938).

Even the mouth of the “Old” Žitava river, or the remnant of the historical river after the division, has changed no longer entering the Danube river directly.

2.2 Study area

The area of interest is a wetland formed by a part of the branches of the “Old” Žitava. The *Žitavský Luh* Nature Reserve is an area located in the floodplain of the Žitava River (Figure 2. point A). The area of the reservation is 74.69 ha. Average altitude is 133.00 m.a.s.l. From the point of view of physiognomy, it is for the most part herbaceous vegetation formation, to a lesser extent forest and water formation. It is semi-natural ecosystems that from a biogeographic point of view, these are azonal communities, which existence is conditioned by high soil moisture. The new riverbed bypasses the nearby villages (Michal nad Žitavou, Kmeťovo, Maňa and Vlka). Part of the “New” Žitava is also a double-sided protective levee (Figure 2. point B). Between villages Žitavce and *Veľká Maňa*, part of the original old branch of Žitava has also been preserved. The old riverbed meanders on right bank and flows through the town of Michal nad Žitavou, and it is called Maňa-Martinová channel (Figure 2. point C). It then crosses the riverbed of “New” Žitava (an inverted siphon) and passes through the territory of the Žitavský Luh with well-preserved banks vegetation along the transverse of the levee (Figure 2. point D). It continues below the outlet structure and thru Kmeťovo, near the village of *Veľká Maňa*, and it flows into “New” Žitava. The outflow from the wetland is partially regulated by an outlet structure in the lateral levee (Figure 2. point E). In the period from March to November, the water regime of the “Old” Žitava is artificially filled from the “New” Žitava near Martinová for the purpose of subsidizing the wetland area (Figure 2. point F).

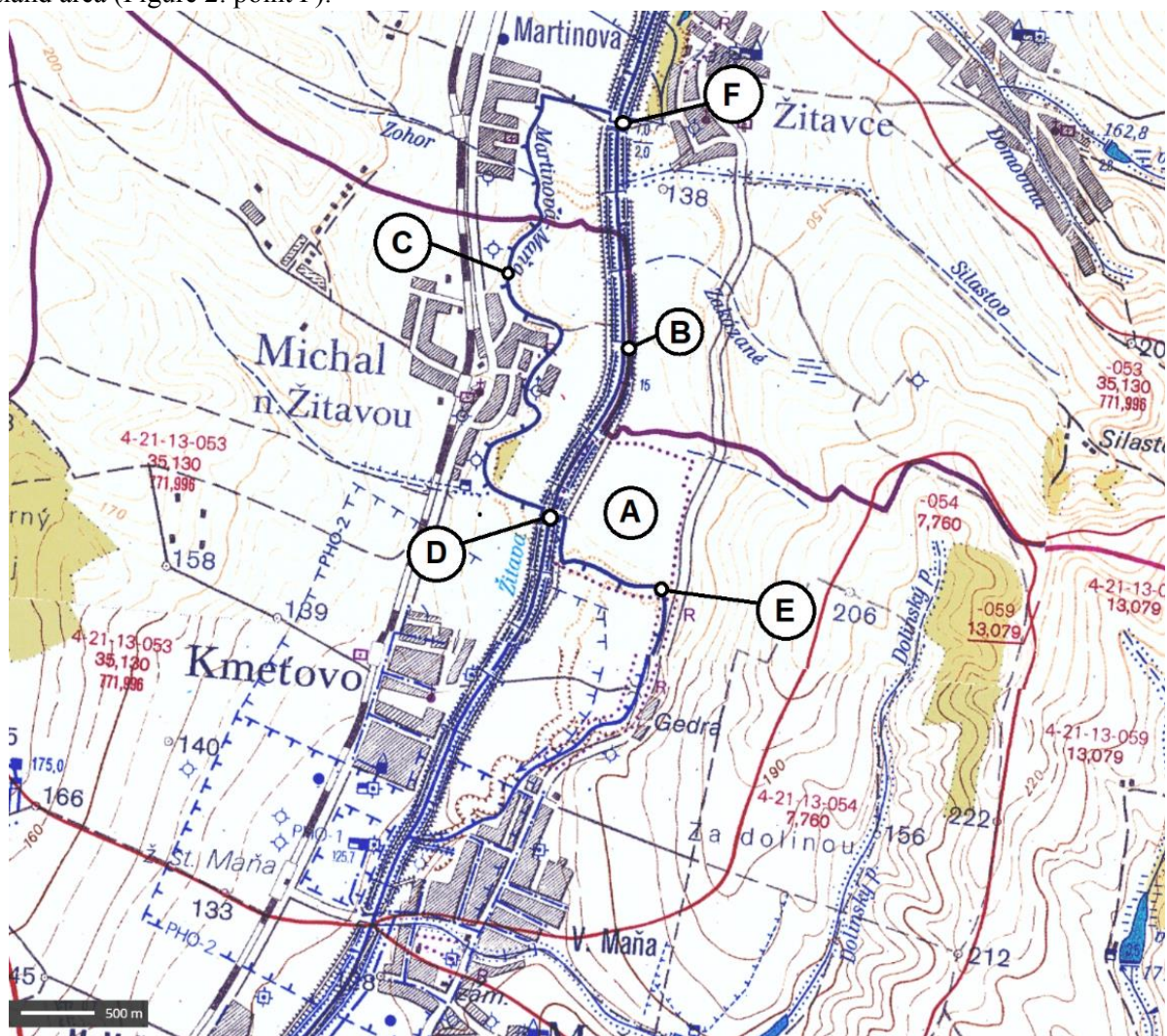


Figure 2. Map of water management of study area (2023).

The currently existing protective levees do not meet the requirements of flood protection. Complex studies focusing on the entire basin of the Žitava river and tributaries were also solved, but the implementation of modifications on the stream is slow and only partially solved. The possibility of using the retention volume of the wetland was not initially considered until the potential of the area was demonstrated.

3 RESULT AND DISCUSSION

Next part is focused on explaining the water level regime in the wetland area of the Žitavský Luh, what improvements were made, denied or are in process of future realisation.

3.1 Existing Improvements

Parts of construction objects that belong to the modification of the riverbed were reconstructed and modified in the past. An example is the modification of the inverted siphon, to which an outlet structure was built with the possibility of discharging water directly into the “New” Žitava. The solution of the suggested connection enabled the discharge of *Žitavský Luh* after the transition of the flood wave directly into the “New” Žitava river without the effect of impoundment of the water level and affecting the old branch.

3.2 Rejected Proposals

Currently, the wetland area is filled with water only from the old branch of the Žitava, which is designed for a maximum river flow of $3 \text{ m}^3\text{s}^{-1}$ (from the point of the possible flow at the intake structure, part of distribution facility, near village Martinová shown in Figure 2. point F. and the inverted siphon shown in Figure 2. point D), but the average flow in the “Old” Žitava is only $1.5 \text{ m}^3\text{s}^{-1}$. The wetland is subsidized from the given flow by partially closing the sluice gate in the outlet structure in the lateral levee and setting the water level regime in the treated area of the *Žitavský Luh*. To increase the flow subsidy for the wetland, either in the dry season or during the flood, in the form of relief from the flood wave, the construction of a new corridor was considered in the past. The given corridor would be located on the land side of the left-side protective levee of “New” Žitava, it would start at the distribution facility near Martinová, and it would flow into the branch of “Old” Žitava in the territory of *Žitavské Luh* with a total length of 2.6 km. The problem arose at crossings with melioration channels in the field, which flow into the “New” Žitava through outlet structures in the left-side protective levee. These collisions would have to be solved with additional inverted siphons, the implementation and functionality of which would be complicated with a minimum slope of the territory of up to 0.1%.

3.3 Proposals For Improving Water Surface Elevation Regulation

The technical solution of the modification was based on the following requirements:

- A. Restoration of branches in the *Žitavské Luh* wetland area without significant disruption of the land cover (formed sediments of the “Old” Žitava river).
- B. Construction of a lateral structure to ensure the necessary impoundment of the water level for enabling subsidization of restored branches of the “Old” Žitava with water.
- C. Construction of a new intake structure for inflow and outflow regulation of the wetland area.
- D. Repair of the crown of the lateral levee of *Žitavský Luh*, which had reduced the original level of the crown by natural sitting, movement or damaged by overflowing during the flood. Part of the levee is also outlet structure where construction of a new sluice gate is needed for regulation of the wetland area.
- E. Increase of protective levees in the extent of impoundment of the water level, due to non-reduction of existing flood protection level or maintaining the existing level of flood protection. Creation of an overflow edge on the left-side levee (lowering the crown of the levee), to enable relief when the water level rises due to the increase flow rates, increasing the roughness of the relief or reducing the flow area.

The points mentioned above are illustrated in Figure 3.

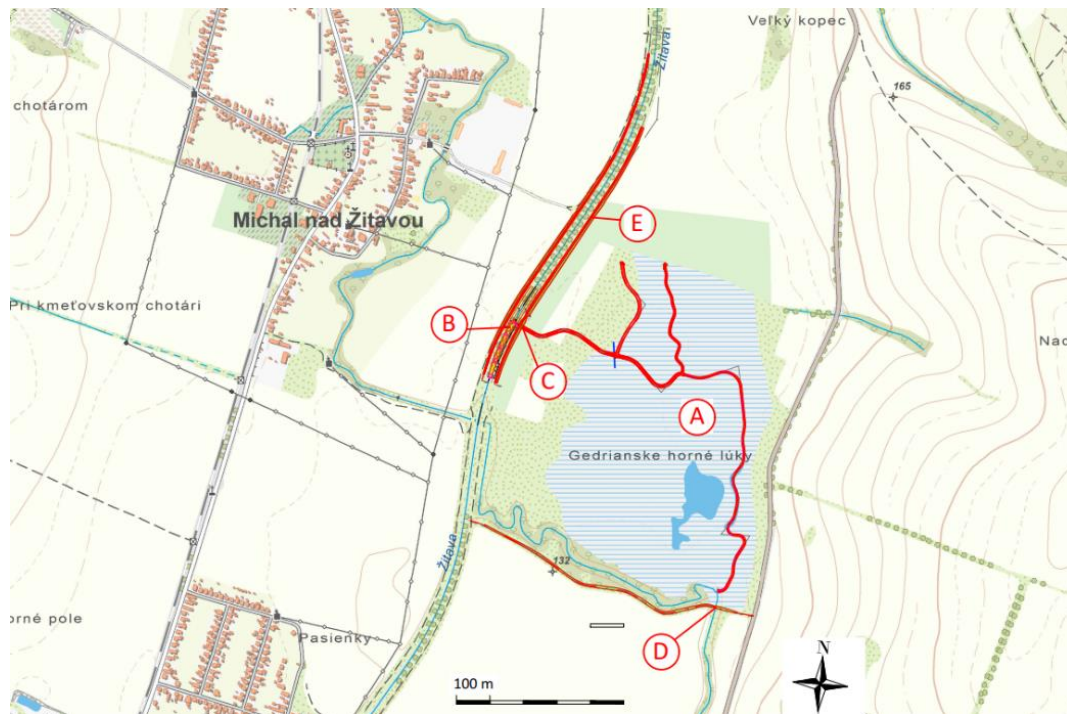


Figure 3. Map of technical solution of modification.

The subject of landscaping in the *Žitavský Luh* will be the restoration of the original ones (A) and addition of new branches (Figure 4). The proposed modifications will ensure revitalization of the main branch between the new intake structure, where it will be subsidized with water directly from “New” Žitava, and the outlet structure in lateral levee. The nature of the revitalization consists in the restoration of two visible terrain depressions (remains of old branches) and the connection of these branches with the main one. The given main branch will have width at the bottom 3 m, slopes of the bank 1:2 at a depth of 0.4 to 1 m. The total length of the revitalization of the branches is 2.105 km. As a result of landscaping, there will be no violation of the land cover and thereby influencing the groundwater levels in the vicinity.



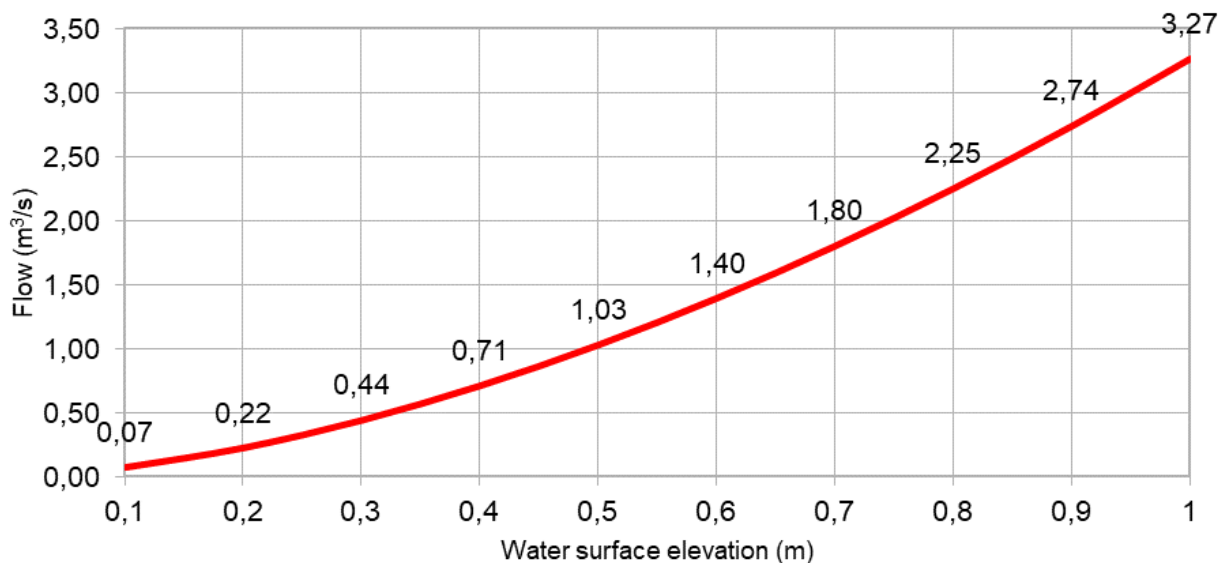
Figure 4. Aerial photo of partially visible existing branches of “Old” Žitava in wetland area.

The impoundment of the water level (B) for the intake structure will be ensured by the whole channel chute with an overflow edge at an elevation of 132.00 m.a.s.l. with a V-shaped transverse profile. The chute (ramp fishway) consists of four separate sections that are partitioned and stabilized reinforced concrete partitions. The ramp fishway is designed to meet the required parameters for the local fish zone. The length of

the proposed fishway is 185 m. Surface of the fishway is designed from heavy quarried stone resistant at increased speeds flowing water.

The intake structure (C) is designed as a reinforced concrete one, which consists of an inlet and a culvert, and an outlet cover shaft. Inlet with overflow edge at elevation 132.25 m.a.s.l., allows flowing only when ensuring the required biological flow necessary for fishway (shown in Graph 1).

Rating curve for inlet (1x1 m)



Graph 1. Rating curve for the inlet

During the flood in 2010, the lateral levee (D) of the *Žitavský Luh* was overflowed and at the same time the existing outlet structure was partially damaged. The subject of the proposal is the complete replacement of the closing shaft with the sluice gate, which is part of the outlet structure and repair of the levee's damaged crown.

The structure serves to maintain a constant water level in the territory of the wetland and for drainage of water after short-term flooding during extreme flows in the *Žitava* river. At minimum flow rates, the object is only used to transfer permanent flow, or to maintain a constant water surface elevation.

As a result of impoundment of water, the safety clearance above the Q_{100yr} water level is reduced and thus also, to a reduction in the level of flood protection for the current state. For the stated reason it is proposed to raise the levee in the entire section affected by the impoundment. This is an increase of homogeneous levee from 0.0 to 0.8 m. From a safety point of view, in case of an increase in the water level at the flow Q_{100yr} , e.g., because of reduction of flow due to clogging or increase in roughness, is in the left-side levee designed lateral spillway in the form of a lowered crown of the levee, which will be fortified with a quarry stone (E). At maximal of water level at Q_{100yr} by 0.5 m, lateral overflow will ensure a reduction to $7 \text{ m}^3 \cdot \text{s}^{-1}$. Given the overflow capacity and the shape of the peak of the flood wave, there will be a relief of about 530000 m^3 . In the case of using the entire volume of wetland area at level 133.00 m.a.s.l. (crown of the lateral levee is at 133.55 m.a.s.l.) it is a volume of 560000 m^3 .

4 CONCLUSIONS

From the point of view of the overall basin of the *Žitava* river, this adjustment is only one of many. If larger water retention and anti-flood measures (dams, polders) were to be implemented, the raising of the existing levee and the lateral overflow would completely lose their function. From the point of view of flooding the wetland, only the intake structure would fulfil this function of ensuring the flooding. However, an important contribution is the water subsidy itself for the Protected Bird Territory in the *Žitavský Luh* wetland area. So far, 216 species of avifauna have been found here, of which 70 species also nest here. The complex of alluvial meadows and marshes is of great importance for the migration and nesting of species bound to low herb flooded

stands and waterlogged meadows, which is why regulating the water level regime in the given area has a high priority. Which parts of construction objects and the sequence of implementation will show the overall impact on the addressed territory.

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