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RESTORATION OF WETLAND ČIČKY IN SLOVAKIA

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ABSTRACT

Wetlands occupy only a small area on most watershed landscape but their hydrologic role in terms of storage as well as their influence on sediment and water quality is often essential. It can be crucial to the hydrologic functioning of the watershed. Wetlands are areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted to saturated soil condition. Locally important wetland – Čičky is situated near the Košice city in the eastern part of Slovakia. Geological structure of the surrounding area of wetland is not very complicated and predetermined its morphological character, which reflected in the current form of the relief. This area was deforested by humans many years ago which affected hydrological regime of Čičky stream nearby Čičky wetlands. Suitable design of methods of wetland restoration/revitalization is therefore very important for this stressed area. To maintain ecological stability of a given zone wetland Čičky, also the alternatives as removal of invasive plants or purifying the Čičky stream were considered, but it is not presented in this paper. Some of technical measurements of restoration are the core of this manuscript. The first technical solution is Čičky stream regulation in the area. The next is the design of the weir and the design of the dike. The dike is designed in two variants; green one with the respect of capture of required amount of water. Red variant is following the same aim, but using enlargement the area of the existing wetland. The paper points the attention to the existing wetland as ecosystem in degraded habitats. The result is a project for the restoration using technical measurements in two alternatives with respect to preservation of ecological stability. Both technical solutions are described in paper in detail.

Keywords: Čičky, technical measures, wetland

1 INTRODUCTION

Wetlands have unique plant communities that provide valuable wildlife habitat that is result of prevalent water. Because of hydrologic characteristics, water quality, habitat and biodiversity values of wetlands, efforts to manage, protect, and restore them have become paramount today.
Wetlands are areas inundated or saturated by surface of groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted to saturated soil conditions. The hydrologic functions of wetlands include (Brooks et al., 2013): intercepting and reducing the transport of sediment and other pollutants to downstream water bodies; attenuating storm flow peaks; supporting hydric plants not found elsewhere on a watershed, thereby providing enriched biodiversity; and providing habitats for many organisms from microbes to migrating waterflow - which has led to wetland preservation programs.

In the paper the suitable design of selected methods of wetland restoration are described. There were designed in more alternatives; one is focused on the preservation status of wetlands with the proposition of necessary measurements (removal of invasive plants and purifying stream Čičky), another alternative is aimed on complex reconstruction of the wetland and third alternative is focused on the design of technical measurements to ensure the necessary amount of water in wetlands. Design of technical measurements - Čičky water stream regulation, design of the weir and design of the dike in two variants is included and is described in details in the paper.

2 METHODS

Proposals for a site relate to improved management of creation should contain the following sections (Hawke and Jose 1996): site description, site evaluation and rationale behind site proposals and objectives. Wetlands can be developed in dryland regions, where water collects in depression and maintains persistent, saturated soil condition.

Wetlands are most often situated in low-lying areas where are connected to ground water. In some cases, wetlands are maintained by their own water table, which is a perched groundwater system. Perched refers to limited downward water percolation and, therefore, limited connections to regional groundwater. In any case, the water table of wetlands is normally above, at, or near the ground surface throughout the year (Valkova 2006).

2.1 Study area

Geological structure of the surrounding area of wetland is not very complicated and predetermined its morphological character, which is reflected in the current form of relief. In terms of regional geological division of the Western Carpathians (Vass 2006), our area of interest is incorporated into the Eastern Slovakia lowland. It is a geologically heterogeneous region consisted of earlier paleozoic rocks, tertiary deposits of neogene and quaternary age diluvial deposits (Kalinciak et al., 1996).

The wetland is situated in the western part of Kosice city, rounded by the road connecting two big settlements. In the east it is adjacent to the block of flats and family houses and in the north with gardening village and mining area of Bankov mine. In the west it borders with the block of flats of the other settlement and in the south it borders with family houses. Area is valuable by its immediate links to the natural environment (forest park in Bankov hill) as well as the location between two housing estates with infrastructure, amenities and good transport links to the city center (Figure 1).

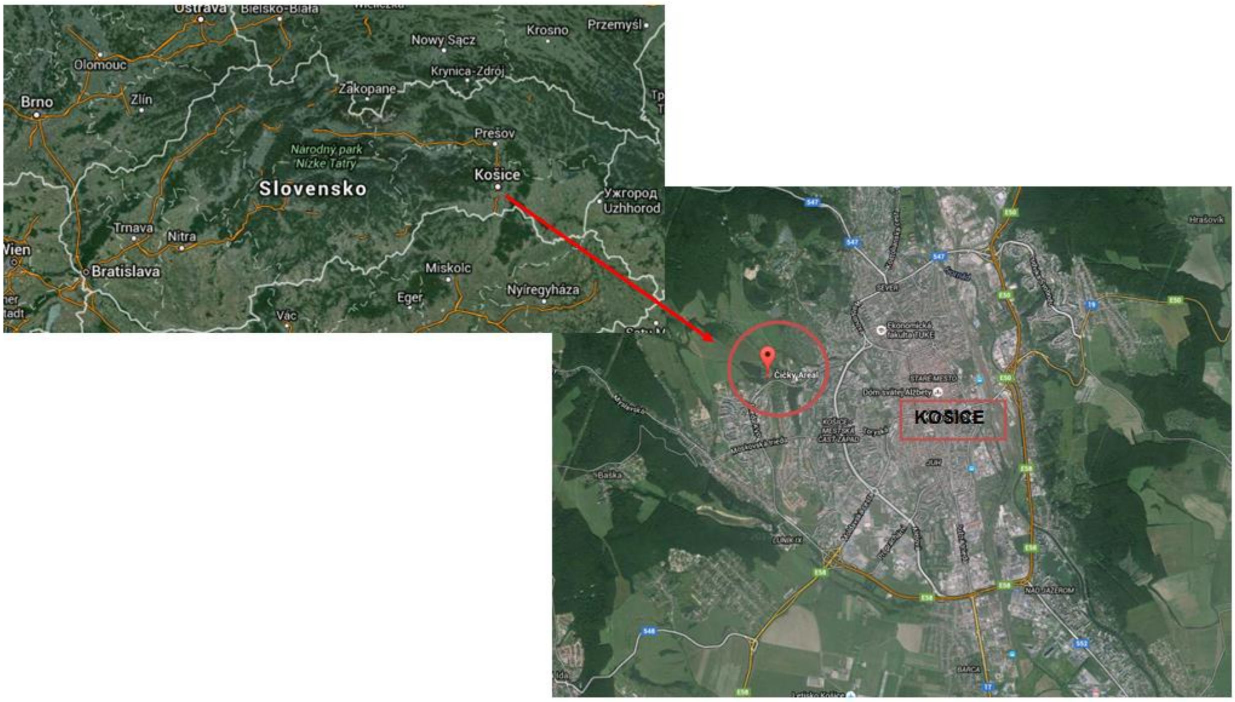

Figure 1. Locality of Čičky area

Southeastern slopes are in elevation 513 m asl. and are formed by age the oldest rocks. It is a rock complex, which under the structural-tectonic scheme (Kalinciak 1996) can be divided in gemerikum tectonic units, which form the bedrock of neogene basin. On the surface of the slopes mentioned above appears mainly the so-called rock of Dobšinská and Čermeľská groups of carbon age (according to (Kalinciak et al., 1996): earlier paleozic and carbon. In the Figure 2 the view from the south is depicted.

Figure 2. South view to the Čičky wetland

The water sources in the area are two springs whose water is running northerneast of Čičky at an elevation of 318 m asl.. Čičky stream is left tributary of Myslava creek that flows directly to Hornád river from the west side and belongs to Donau river basin. The elevation difference between the wetland Čičky (291 m asl.) and spring of Čičky stream is 82 m (in the west side); 107 m (in the east side) respectively. Čičky stream is not regulated, has a balanced slope, but very unbalanced flow due to human activities - deforestation and management of the surrounding slopes (Valkova 2006).

From landscape point of view the following types of habitat in the vertical direction can be defined here:

- water saturated and inundated areas,
- stands of trees in the alluvium,
- man-made habitats of extensively farmed land (gardens and orchards),
- grassland habitats on the slopes,
- man-made habitats of intensively farmed fields,
- shrub habitats and potholes.

3 RESULTS

To maintain ecological stability of a given zone wetland Čičky, we propose the following three alternatives:

1. Alternative is focused on the preservation status of wetlands with the proposition of necessary measurements. Design a solution for this alternative requires:
   a) Removal of invasive plants,
   b) Purifying stream Čičky.
2. Alternative is aimed on complex reconstruction of the wetland. Design of this alternative includes more steps and operating procedures. This option is one of the biggest changes in the wetland environment, but it wills gradually, stage by stage brings the return and settlement of fauna and flora. Reconstruction process can be classified into these following steps: removal of wetland vegetation, cleanup of wetland bottom, stream regulation in wetland, construction of dike, shaping the terrain, construction of collecting channels, cane plantations.
3. Alternative is focused on the design of technical measurements to ensure the necessary amount of water in wetlands. Design a solution for this alternative includes:
   a) Čičky stream regulation
   b) Design of the weir
   c) Design of the dike in two variants

Calculation and design of the last alternative form with Čičky stream regulation, design of weir and dikes in 2 variants are describe in detail in the next part of the paper.

3.1 Čičky stream regulation

For the calculation of the water stream regulation formulas (1) – (7) were used and then based on results presented in Table 1 and next the discharge diagram was prepared with the aim to determine the maximum water level during maximum discharge of the stream ($Q_{max} = 2$ m^3.s^{-1}) .

Channel top width of the free water surface *B* (m):

$$B = b + 2.m.h \tag{1}$$

where *h* is height of water level, *m* is inclination of slope and *b* is width of riverbed in the bottom.

Cross-section area *A* (m^2):

$$A = \frac{b+B}{2}.h \tag{2}$$

Hydraulic radius *R* (m):

$$R = \frac{A}{O} \tag{3}$$

Wetted perimeter *O* (m):

$$O = b + 2.h.\sqrt{1+m^2} \tag{4}$$

Chezy cefficient *C* (m$^{0.5}$.s^{-1}):

$$C = \frac{1}{n}.R^{1/6} \tag{5}$$

where *n* is Manning´s roughness coefficient (-).

The Chezy equation describes the mean flow velocity v (6) of steady turbulent open channel flow:

$$v = C.\sqrt{R.i} \tag{6}$$

where i is bottom slope (-).

Discharge Q ($m^3.s^{-1}$) is than calculated using formula (7):

$$Q = A.v \tag{7}$$

Table 1. Discharge diagram

h [m]	*b* [m]	*B* [m]	*A* [m²]	*O* [m]	*R* [m]	*c* [m0.5.s-1]	*v* [m.s-1]	*i* [‰]	*Q* [m3.s-1]
0	0.5	0.5	0	0.5	0	0	0	0.017	0
0.09	0.5	0.716	0.0547	0.781	0.07	21.4016	0.7385	0.017	0.04041
0.1	0.5	0.9	0.062	0.812	0.076	21.7094	0.782	0.017	0.04848
0.2	0.5	1.3	0.148	1.125	0.132	23.7725	1.1243	0.017	0.1664
0.3	0.5	1.7	0.258	1.437	0.18	25.0358	1.383	0.017	0.35682
0.4	0.5	2.1	0.392	1.75	0.224	25.9778	1.6032	0.017	0.62846
0.5	0.5	2.5	0.55	2.062	0.267	26.7438	1.8009	0.017	0.99047
0.6	0.5	1.94	0.732	2.375	0.308	27.397	1.9834	0.017	1.45182
0.65	0.5	2.06	0.832	2.531	0.329	27.6924	2.0703	0.017	1.72247
0.7	0.5	2.18	0.938	2.687	0.349	27.9708	2.1548	0.017	2.0212

The beginnig of the stream regulation is in rkm 1.09 from its confluence with the Račí stream, and end at rkm 1.108, in the place of weir, in length of 18 m. The longitudinal inclination of the bottom is 17 ‰ and stream bed is designed for maximum flow rate $Q_{max} = 2\ m^3.s^{-1}$. The stream flow rates are not monitored so data were obtained analogously from Myslavský stream in profile no. 5 - below the intake. Area under the bridge, which is part of the pavement in rkm 0.00 m is designed as trapezoidal profile of the stream bed in width of 0.5 m, slope inclination of 1:1.2 and height of the stream bed 0.7 m (Figure 3). For stabilization of slopes were designed natural rocks of fractions 20 cm, laid on fine gravel of thickness 10-15 cm.

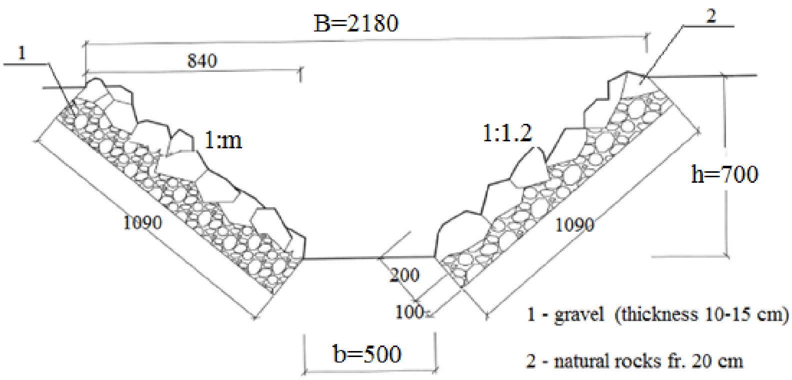

Figure 3. Cross section of the stream bed

3.2 Design of the weir

After this stream regulation of 18 m the weir will be constructed. Its foundations will extend to a depth of 0.2 m. The width of the weir is 0.3 m, length 0.3 as well as its height. Object is composed of gabion baskets. Behind the object will be area of the wetland with original terrain. Engineering structures thus ensure the water level increase and retain the necessary amount of water for wetlands biota existence.

3.3 Design of the dike - two variants

The dike was designed in two variants.

Green variant

One of the steps necessary to restrain the amount of water in the wetlands is construction of dike. The beginning of this construction we suggest in the southern part of the wetland at a distance of about 15 meters from the trail, which is a part of the bridge. There will be the 0.00 meters of river length in the eastwards. In about 40 m of river length is built the dike with a length of 1 m. Dike will continue further along the edge of wetlands, while its overall length is designed at 97.5 meters. In about 66 m of river length starts gardening area that ends at 98.5 meters of river length (Figure 4 – green variant).

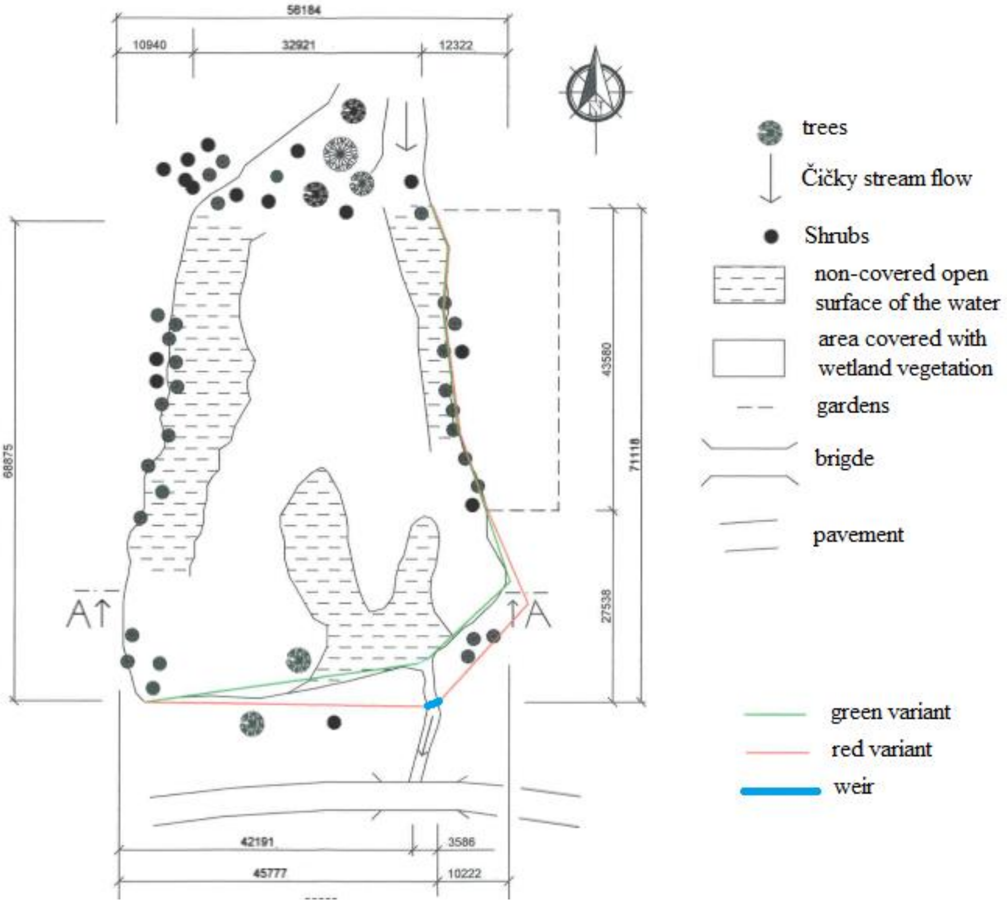

Figure 4. Top view of the designed area

The dike is designed from local materials (soil) with the width in the crest 0.4 m, the slope of the upstream 1:4 (in order to ensure migration of migrant animals in wetlands), the slope of the upstream 1:7 which end in the terrain, 1.0 meters from the original ground of the wetlands.
Figure 5 and Figure 6 presents the longitudinal cross section of the proposed dike.

Red variant

This solution considers enlargement of the area of wetland of about 425 m^2 (Figure 4 - red variant). The part of the stream channel with a length of about 6 m will be integrated into wetlands and enlarged area will be naturally flooded with water. The beginning is in the same river length as already is described in green variant, where 42 m river length the weir will be built, at 75.5 meters river length the gardening area begins and ends at river l length 113 m, in a same point like green variant. Shape of dike with its progressive grassing allows integration into the surrounding landscape.

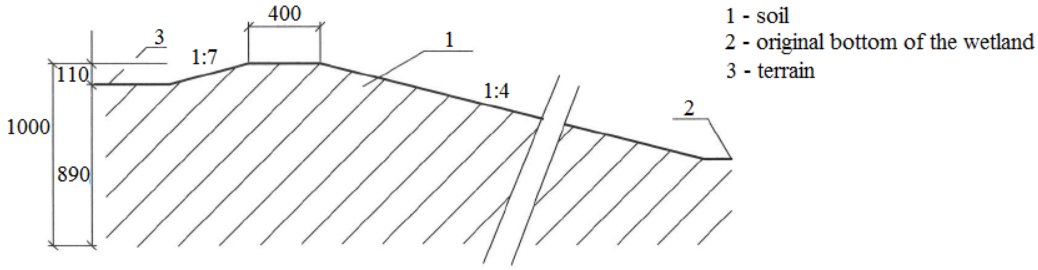

Figure 5. Longitudinal section of the dike

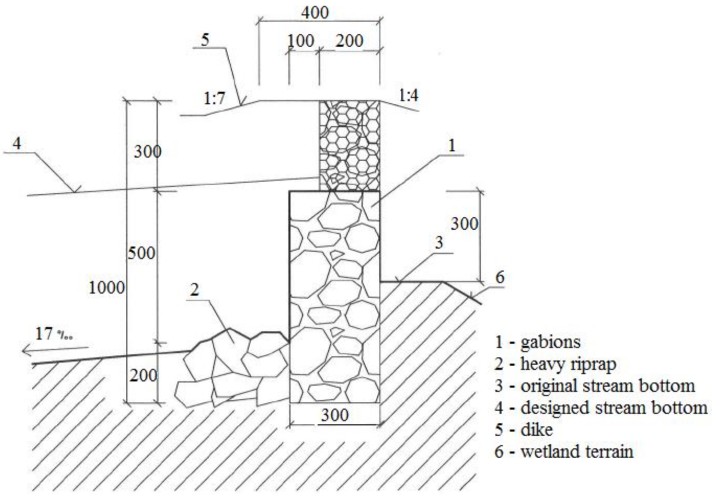

Figure 6. Cross section of the dike

5 CONCLUSION

Wetlands are important biological and hydrologic features of watersheds. In addition to supporting unique plant and animal communities, wetlands can reduce stream flow volumes and peak discharges to receiving stream channels through their storage function. They can also reduce the sediment delivery to receiving waters and improve the quality of water that is discharged to streams and rivers.

First and second alternatives represent the minimum interference with the natural environment of wetlands, but it sets only a temporary solution of the situation. In the third alternative, complex reconstruction of wetland is proposed, but it is the largest intervention to the environment. Wetland after the final planting will be able to provide the conditions for reeds and animals, which over the time can inhabit the area. The best solution of wetland restoration is the alternative focused on the design of technical measurements to ensure the necessary amount of water in wetlands in red variant.

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