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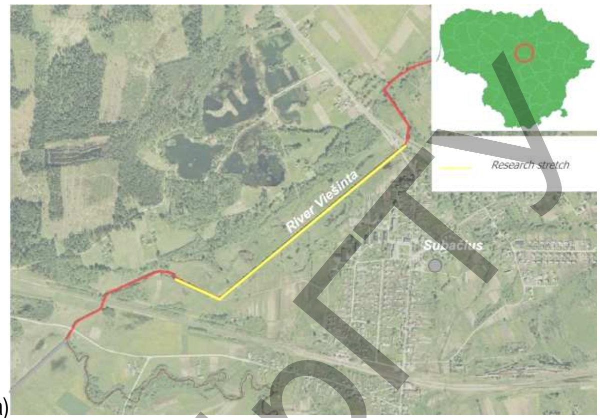
THE RESEARCH OF RIVERS RESTORATION IN LITHUANIA

Introduction. The channelized rivers and streams currently make up 82.6%, while natural watercourses make up 17.4% of the overall network of rivers in Lithuania (Gailiusis et al. 2007). Due to the effect of flow regulation significant changes occur in the shape of the riverbed, and they can affect flow energy distribution in the transversal and longitudinal stream profiles as well as relationships between hydromorphometric and ecological parameters of the river. That caused alterations in streams morphometry including changes of furrow line, forms of the shoreline, the bottom substrate and changes of flow hydrodynamic. The riverbed straightening increased flow velocity, sediment transport and longitudinal gradients. Therefore, straightened streams with monotonous, fast currents and silty bed caused water ecosystems with poor conditions for fishes and invertebrates. Due to these modifications, the regulation of the rivers was named as one of the greatest threats to wildlife biodiversity and ecosystems (Rosenberg *et al.,* 2000; Nakamura, Yamada, 2005; Horsák *et al*., 2009; Dave *et al*., 2003).

The restoration of morphometric, hydraulic and especially ecological conditions can return streams close to natural which is much more favourable for the natural flora and fauna. Therefore restoration of channelized streams is a prerequisite for more favourable water ecosystems. A good practice of stream restoration already exists in many countries and restoration projects are very popular over some decades in Europe and other continents (The river..., 1998; Ecological…, 2007; Morten, 2007; Maatalousalueiden..., 2006; Jormola, 2006, 2008; Aulaskari, 2008; Conservation..., 2003, 2006, 2007; Living..., 2006; Meine..., 2001; Guideline…, 2005). The main purpose of river restoration projects is to restore the disturbed natural balance, increase natural biodiversity and improve water quality in the channelized streams.

The aim of the article is to estimate the effectiveness of river restoration tools on river bed changes.



a)

b)

Figure 1 – The investigated sections of Viešinta and Vašuoka streams

Materials and Methods. The identification of channelized and natural stream parts was carried out on the basis of GIS database – 'GDB10LT' and database of orthorectified images 'ORT10LT' for controlled process. The recognition was done using automated data processing by standard tools of ArcGIS and visual image analysis. Finally, all streams were separated into natural and channelized/straightened reaches and straightened stream sections divided into 7 groups, which were identified by stream catchment area, bed slope and river surrounding areas (forest, urban area or arable land).

Two streams were selected for this study – Viešinta and Vašuoka. These streams belong to the fifth group of identified streams. The main characteristics of selected streams are presented in table 1.

The location of Viešinta and Vašuoka streams straightened stretches are presented in figure 1.

In both selected stream sections by restoration project are foreseen to install artificial obstacles and is expected to achieve the start of stream meandering. The purpose was to verify that the threshold velocity will be reached. For that purpose 1D numeric model was developed using HEC-RAS software. The simulation of obstructions was performed modelling steady state flow for selected stream section. Geometrical characteristics for the model were obtained by field surveying. Using ArcGIS tools digital terrain model was created. Latter by user interface Hec-GeoRas all data transferred to HEC-RAS. Model was calibrated under natural channel conditions for boundary conditions using measured flow rate, water level etc. An acoustic device 'Stream-Pro ADCP' was used for discharge, bed depth and velocity measurements. Topography was surveyed with the Trimble GPS/RTK. The shear stress coefficients were estimated visually in the field and latter corrected by calibration procedure. After calibration procedure, the channel geometry was corrected allocating artificial barriers along the stream. Model with modified channel geometry is continuously used simulating different stream flow and analysing distribution of velocities along the stream.

The differences of velocities with natural channel geometry and modified enables to estimate the effect of obstructions for initiating stream bed erosion of the opposite side and the starting of meandering process. Threshold velocities depend on type of soil that is in a particular place. Composition of soil particles was found in each of the relevant section using data of 4 geological wells.

Table 1 – The main characteristics of streams Viešinta and Vašuoka

Stream name	Main river name	Length of stream L, km	Stream catchment area A, km^2	Average discharge Q, m^3 s^{-1}	Total natural length of stream L_n, km	Total regulated length of stream L_r, km	Average flow velocity v, m s^{-1}	The gradient of section i, m km^{-1}
Viešinta	Lėvuo	24	235,5	1,16	8,5	15,5	0,6	0,87
Vašuoka	Viešinta	34	128	0,66	4	30	0,46	2,25

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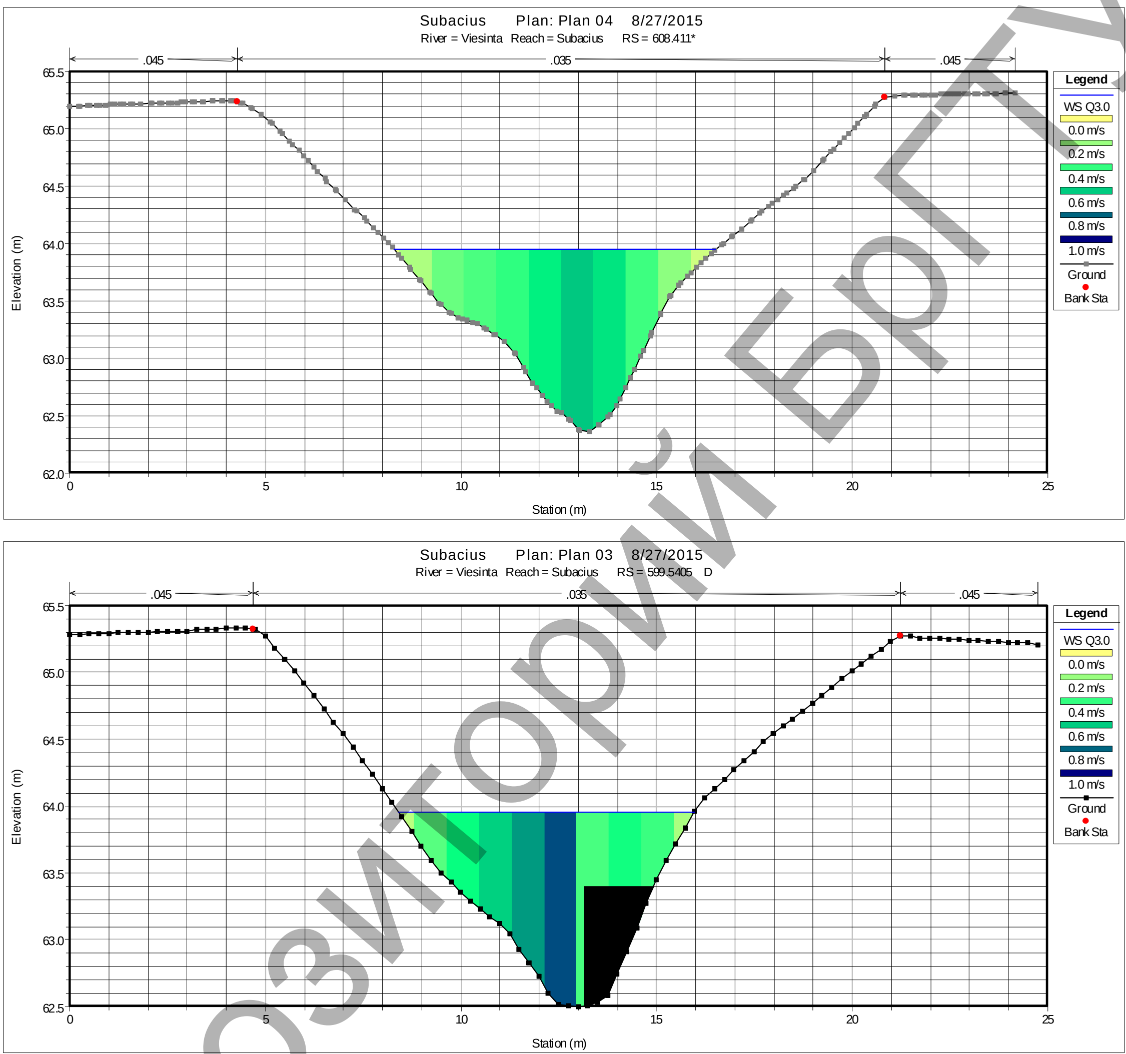
Table 2 **–** Groups of straightened streams sections in Lithuania

Group	The type of river	The environment of biodiversity	Gradient, m km^{-1}	Area of catchment A, km^2	The absolute height, m
1	1	-	-	<100	<200
2	2	forest	<0,7	100-1000	<200
3	2	field	<0,7	100-1000	<200
4	2	outskirts	<0,7	100-1000	<200
5	3	field	>0,7	100-1000	<200
6	3	forest	>0,7	100-1000	<200
7	3	outskirts	>0,7	100-1000	<200



a) b)

Figure 2 **–** The distribution of velocity in profiles No. 608 (no barrier) (a) and No. 599 (installed barrier) (b), when the flow rate 0.65 m^3 s^{-1}

Results and Discussion. Lithuanian water bodies are divided into separate types. Each type is described by such natural factors that have the greatest impact on the aquatic communities structure (Nemuno..., 2010). Three main factors that describe the types of rivers and lead to the major differences in aquatic communities are: the absolute height, the catchment area and the river bed slope. As presented in methodology channelized streams also are divided into 7 groups according to the natural environment. Table 2 presents the groups of regulated streams considering on different microclimatic and natural biodiversity conditions.

The allocation of straightened sections into groups takes into account the fact that restoration of streams with regulated segments are associated with the emission-cleaning function along the way to larger bodies of water. It was decided that in order to achieve good ecological status regulated streams with catchments area less than 100 km^2 can be restored without engineering tools (Nemuno..., 2010). Natural instability, periodic drying, light vulnerability and a very high percentage of straightening are the main factors to leave regulated streams and their ecosystems for self-naturalisation with the proper protective bands. So all streams sections of the first type are assigned to the first group.

For better ecological conditions restoration engineering tools are suggested to use only in water bodies with catchments area bigger than 100 km^2. To evaluate the restoration tools effectiveness two straightened streams – Viešinta and Vašuoka – have been selected as the biggest fifth group streams for pilot project. The investigated segments of streams are located in agricultural lands. Channel bed slope of along selected segments are greater than 0.7 m km^{-1}. That makes it possible to expect more rapid and effective impact of applicable restoration tools.

The numerical simulation using 1D model was performed for two scenarios: with obstacles and without obstacles. The purpose was to find out the difference of flow velocities in the absence of obstacles and installing them. The differences of velocities enabled to estimate the effect of obstructions for channel bed erosion and the beginning of meanders formation. Threshold velocities depend on type of ground is in particular place. The distribution of velocity in cross sections is presented in figure 2.

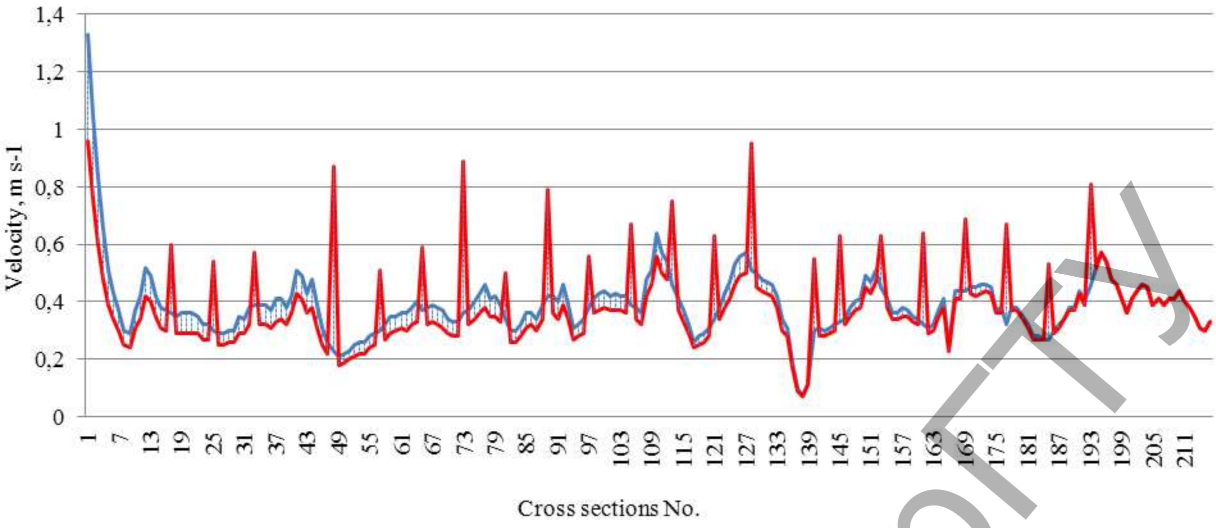


Figure 3 – Comparison of velocities with barriers and without at flow rate 1.5 $m^3 s^{-1}$

After installation of obstructions the highest differences of velocities in these cross-sections are at the flow rate, when water level reaches the height of obstructions. The average flow rate when water level becomes equal to top of obstruction was 0.65 $m^3 s^{-1}$. The changes of velocity vary in the range from 15 to 50 %. Increasing flow rate over 0,65 $m^3 s^{-1}$ water level is overtopping the barriers. The average flow velocity in cross-section increase, but the difference between velocities with obstructions and without decrease. It means that overall effect of obstructions on channel erodibility gradually decreases. To avoid large distribution of velocities along the channel bed, the parameters of barriers should be similar and any cross-sectional configuration should be taken in to account.

Each implemented barrier must be designed in such a way as to reduce one-third of the flow cross-section. However, if it is not reached, barriers should have the same dimensions. At this case the efficiency can be insignificant in the deeper and wider areas of stream bed. The changes of velocity occur not only in places where obstacles were installed. This takes place in intermediate cross sections, because hydrodynamic changes taking place throughout the flow after installation of barriers. The changes of water level due to installed obstructions are insignificant and fluctuate in range of 3–7 cm. This means that implemented measures will not have significant impact on flood risk. The highlights of the flow velocity distribution in the river bed with barriers and without it at 1.5 $m^3 s^{-1}$ flow are presented in figure 3.

Figure 3 shows that the effect of barriers is significant. High-speed curve peaks indicate changes of the flow velocity around them. Velocities between the barriers slightly reduce after the installation of barriers and this enables to accumulate washed silt.

The impact of the installed barriers to the channel bed formation can be assessed by the flow rates and prevailing soils. According to the soils of Viešinta river (gravel sand, fine sand with gravel impurities, and dust) and the table of threshold velocities, it was found that gravel sand is washed when stream velocity is 0.70-0.75 $m s^{-1}$ and fine sand is washed when stream velocity is 0.35–0.45 $m s^{-1}$ (flow velocities are taken at 1–2 m water depth of the bed). Figure 3 shows that some barriers are ineffective and do not reach the threshold velocities. If the velocities are ineffective the settings of barriers parameters are changed until the desired velocity is obtained. In order to determine the long-term impact of the barriers, it is necessary to carry out the hydrological calculations and to determine the selected flow pattern within a year. This remains an actual topic of future research.

The obtained geological data from straightened part of Vašuoka stream showed that the loam dominates with threshold velocities from 1.30 to 1.40 $m s^{-1}$. Flow velocities may exceed 1 $m s^{-1}$ in the selected stream after removing the existed thresholds and implementing restoration tools. That results only a theoretical possibility of the bed erosion processes remains. However, only minimal washouts are expected due to the loam soil with grass and bushes along the riversides.

In conclusion it can be noted that it is possible to achieve such a flow velocity variation that cause the primary deformations of channel and initiate the stream meandering if the proposed methodology of artificial barriers is properly implemented along the river bed. One dimensional model of steady flow cannot evaluate the future development of the process, but the results show that this methodology proposes fast and low cost for streams restorations.

Conclusions

1. The stretches of straightened streams were divided into 7 groups depending on river type, bed gradient and type of environment (forest, outskirts and field).
2. The first type of river sections assigned to the first group of straightened streams (A<100 km^2). Self-naturalization method is proposed to the first group of streams.
3. Depending on the different microclimatic conditions and biodiversity, large straightened streams (A>100 km^2) were divided into 2–7 groups. Good ecological status (biological, chemical) could be achieved by using bioengineered means for mentioned groups.
4. The implementation of obstructions indicates the largest distribution of velocities during the minimum flow discharge (0.65 $m^3 s^{-1}$). At these cases the distribution of velocities varies from 15 to 50 %.
5. The changes of water level due to installed obstructions are insignificant and fluctuate in range of 3–7 cm. This means that implemented measures will not have significant impact on flood risk.
6. The fluctuation of flow velocities will increase the initial bed deformations depending on the dominated types of soil, what initiate the formation of meanders. According to the calculations and visual assessment of the current situation it is very likely that the river bed meanders will form in the area of river floodplain.

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BAUBLYS R., DUMBRAUSKAS A., GEGUŽIS R. The research of rivers restoration in Lithuania

The main purpose of this article is to choose the appropriate restoration measures and evaluate their effectiveness for channelized streams in Lithuania. The results of different scenarios revealed, that installed obstructions can accelerates deformations processes initiate the meandering process and at the same time it will not have any significant effect on the agricultural land along restored stream.