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Restoration of the Old Drava Riverbed at the Čakovec Hydropower Plant

Ladislav Grđan, Zdenko Kereša

SUMMARY: The paper examines some aspects of environmental impact caused by hydropower plants built on the Drava River from the Slovenian border to the Mura River mouth. It presents both a possible mitigation of the negative impacts on the areas along the river as well as the problems arising from the implementation of such measures. Regardless of the availability of hydrological, environmental and socio-economic data, there are still unsolved water management issues, particularly in the field of protection against adverse effects of water. The paper describes the use of available water resources and mineral raw materials (gravel and sand) in the period of intense economic pressures and their incorporation in the process of sustainable development.

KEYWORDS: water regime, high water wave, riverbed maintenance, hydropower plant maintenance, sill, use of mineral raw materials (gravel), the Drava River

Introduction

The Drava River starts in the Dolomite Alps, Italy, and flows in the length of 426 km to the Croatian border, and has a catchment area which covers 15,600 km^2. The Drava has pluvial-glacial (rainy-glacial) water regime, characterized by small amounts of water in winter and large water amounts in the second half of spring and early summer.

The Drava used to flood quite frequently in the past. Historical data record big floods and comprehensive public works on dike construction near the city of Varaždin as early as the 17th century.

The September 1965 flood has been the largest flood wave on the Drava upstream of the Mura River mouth in the last 120 years. The estimated water flow equalled 2800 m^3/s. Due to considerable damages caused by the flood, dike construction was intensified in the following years.

It must be noted that the dike construction defined the still existing border between the areas set aside for agriculture and other anthropogenic activities and the areas "*reserved for water and natural processes*".

The attempts to use the large hydropower potential of the Drava resulted in the construction of several hydropower plants in the upper and middle course of the river. At present, upstream of Donja Dubrava a total of 22 hydropower plants (HPPs) has been constructed, of which 11 in Austria, 8 in Slovenia and 3 in Croatia: the HPP Varaždin (1975), the HPP Čakovec (1982) and the HPP Dubrava (1989). The natural river flow from Donja Dubrava to the Croatian-Slovenian border equalled **80.8 km**. Today **26.7** km are within reservoirs, and as many as **54.1** km are old riverbeds (Figure 1).

After the hydropower plants construction almost all water was redirected to power generation facilities. The flow in the old riverbed at the HPP Čakovec is approximately 12-

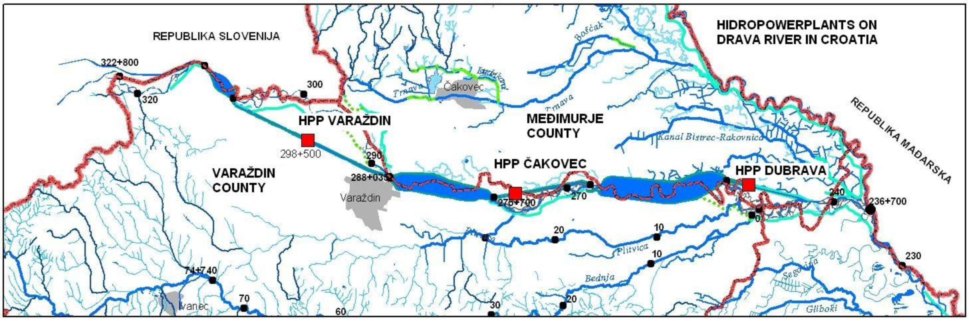

Figure 1: Hydropower plants on the Drava River in Croatia

14 m³/s (8 m³/s at the dam generator, 4-6 m³/s in the right drainage canal and a small quantity in the Plitvica canal). This is the situation for the most part of the year, i.e. more than 90% of the time.

On the other hand, there are still periods of high water levels, which hydropower facilities cannot fully absorb. These are flows of 1500 - 2000 m³/s or above, which appear 1, 2 or 3 times per year, last for several days and then pass through the old riverbeds.

Furthermore, hydropower plant construction practically interrupted the transport of bed load, primarily gravel.

The comparison of the old riverbed before and after hydropower plant construction reveals that before construction (Figures 2, 6 and 8)

- the flow was medium (335 m³/s);
- there were considerable quantities of bed load, which were constantly replaced by deposits from the upstream stretches of the Drava;
- the width of the main riverbed (including sandbanks) equalled 100 – 350 m;
- the hydrograph was 1.5 – 2.5 km.

After construction (Figures 7 and 9):

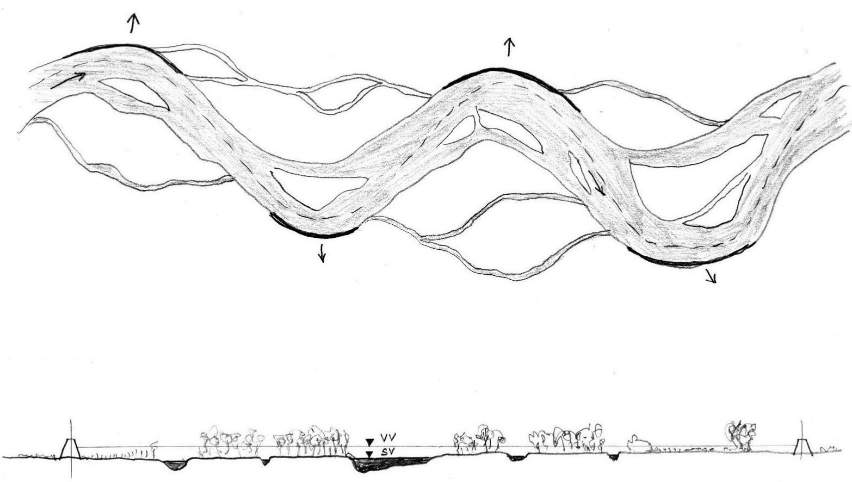

Figure 2: River course before the construction of the hydropower plant

- the Drava has either the minimum flow of 12 m^3/s or above 500 m^3/s (up to 2,000 m^3/s or more);
- water levels in the riverbed are lower (due to a lower flow);
- there is no replacement of bed load from the upstream stretches of the Drava; the existing bed load comes form the old riverbed itself (downstream of the dam), caused by erosion of the bottom and banks of the old riverbed, which results in the further lowering of water levels in the riverbed;
- the width of the riverbed is 15 – 50 m;
- vegetation has significantly overgrown parts of the riverbed, which have been rendered waterless in the new conditions;
- the hydrograph equals 0.3 – 1.0 km.

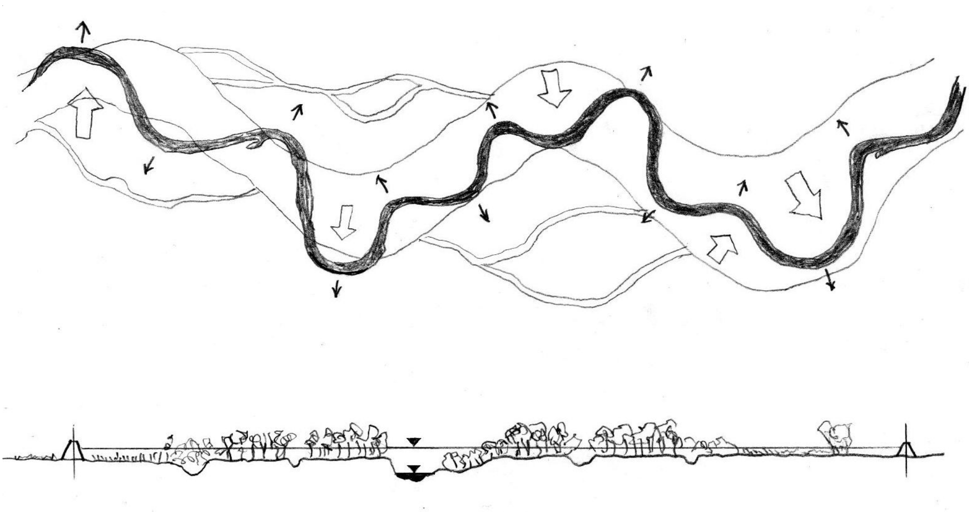

Figure 3: River course after the construction of the hydropower plant

Figures 4, 5: Former main riverbed of the Drava River

As described above, it is evident that hydropower plant construction caused problems that are sufficiently evident and require a solution.

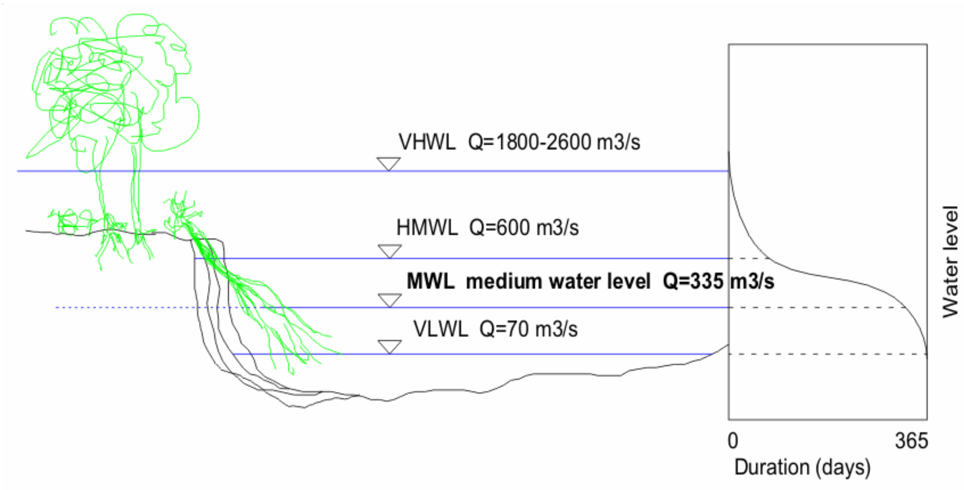

Figure 6: Cross-section of a bank and the riverbed of the Drava before the construction of the hydropower plant, including water levels, with regard to duration

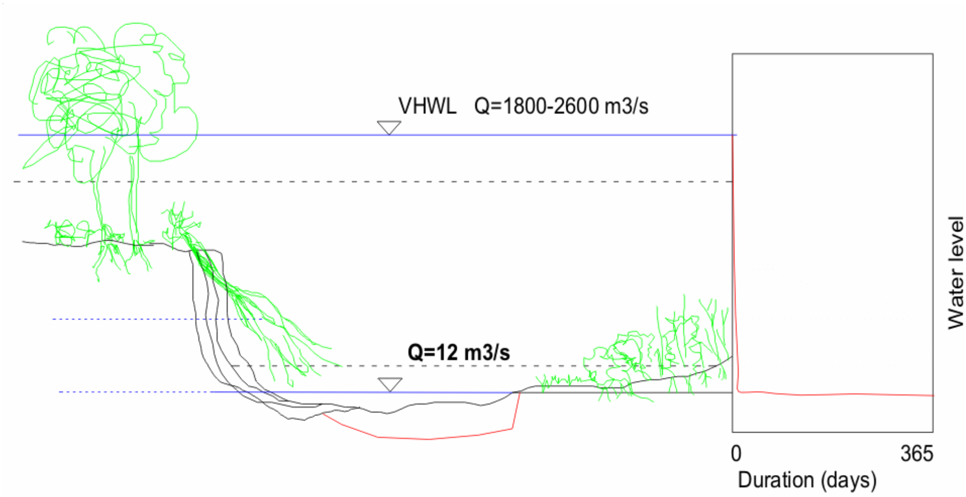

Figure 7: Cross-section of a bank and the riverbed of the Drava after the construction of the hydropower plant, including water levels, with regard to duration

The first issue

The minimum flow (12-14 m^3/s) forms a concentrated flow the size of a bigger stream, which deepens its own riverbed and further results in the lowering of water table. This minimum flow forms its own bed load (local erosion), which does not get replaced, since the constructed hydropower facility interrupts deposit transport. As the majority of the terrain is composed almost only of gravel, the lowering of water table in the old riverbed increases the drainage of inundation and bank areas, which then results in the gradual lowering of groundwater levels in the lowlands as well (Figures 3, 7 and 9).

The described process also leaves many former river arms waterless and the majority of inundation area without any water as well (Figures 2 and 3).

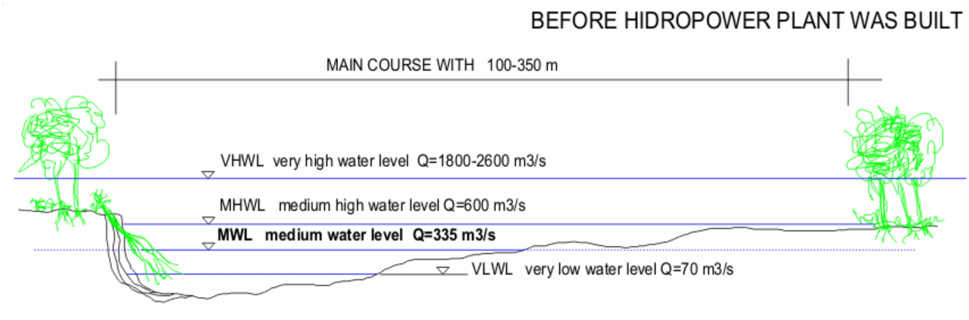

Figure 8: Cross-section of the main channel of a Drava's bend before the construction of the hydropower plant, including the position of vegetation and water levels

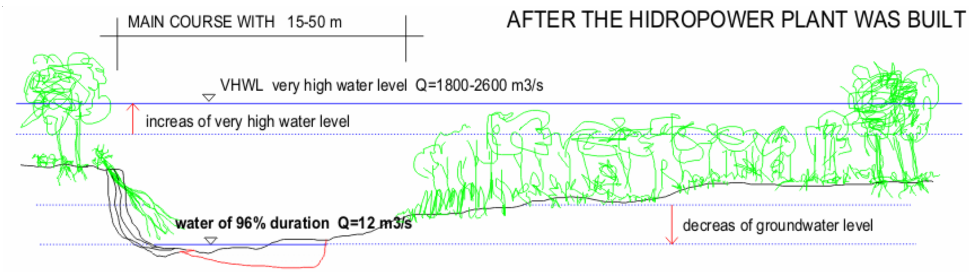

Figure 9: Cross-section of the main channel of a Drava's bend after the construction of the hydropower plant, including the position of vegetation and water levels

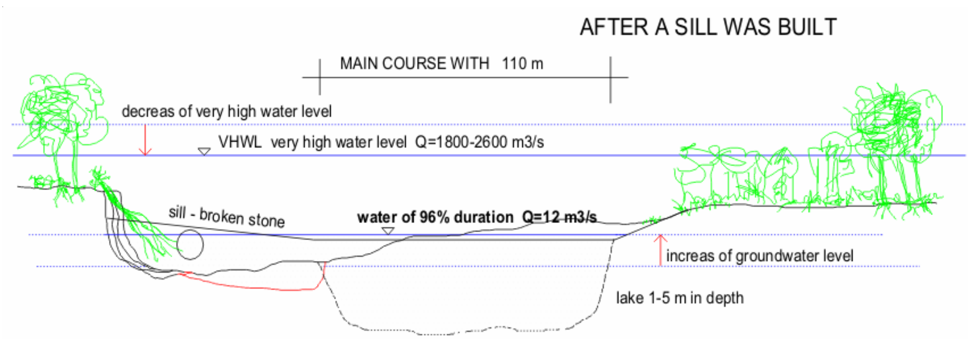

Figure 10: Cross-section of the main channel of the Drava at the sill position after the construction of the hydropower plant, including the position of vegetation and water levels

The second issue

It is evident from the introduction that the occurrence of high water levels is a reality, which must be taken into consideration. In the period since the construction of the hydropower plants, it has become evident that high water levels show a rising tendency. There are many reasons for the occurrence of high water levels, the most apparent being that the regulation of upstream basins significantly reduced former flood storages (areas flooded by the river prior to hydropower plant construction).

On the other hand, the permeability of the old riverbed is constantly declining due to a very strong vegetation growth (Figures 3 and 9).

The solution

Respecting the corridor formed by the river, a regulation line was set through the old riverbed which horizontally defined the desired flow path. The regulation width, adopted from earlier studies and projects, equalled a 110 m wide riverbed for the whole stretch of the Drava River upstream of the Mura River mouth to the Slovenian border.

By comparing the longitudinal profile of the condition zero (surveyed immediately after the start-up of the hydropower plant), and the longitudinal profile surveyed afterwards, a deepening of the riverbed was determined. In order to re-establish the original water levels in the old riverbed, the building of sills is planned (Figures 10 and 11).

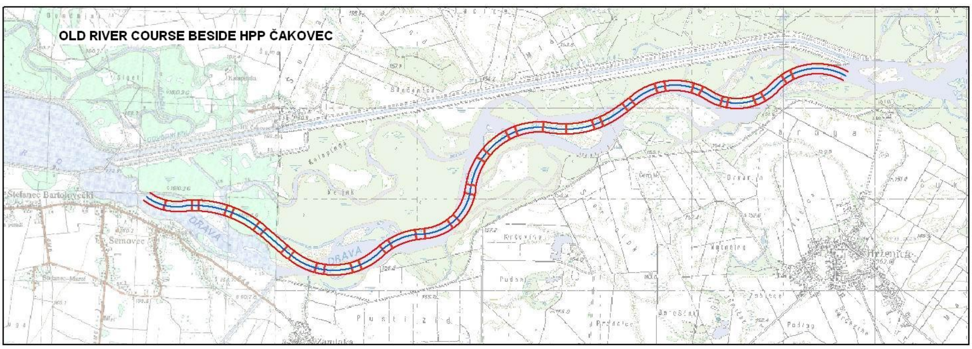

Figure 11: Position of sills and the regulation line

The average lowering of the Drava water table equals 0.9 ‰. Since the flow is generally only 12-14 m^3/s, sills in the riverbed would form a series of cascades, where upstream «lakes» would have a practically horizontal surface. Since the increase in the height of cascades results in increased tensile forces which pull the material used in sill construction, bulkier material must be used for higher sills. At the same time, since the old riverbeds are part of a lowland river, high sills are not desirable. These considerations resulted in determining a sill spacing of 400 m, which means that the height difference between the upper and lower water level of the sill equals approximately 35 cm.

A further element of the old riverbed regulation is the prevention of vegetation growth in the areas intended for flow of higher or high water levels. For that purpose, the excavation of material (gravel) is planned inside the designed regulation line, thereby forming the sills and «lakes». The «lakes» are water surfaces with minimum water depth of 1 m (a guarantee that there will be no growth of terrestrial vegetation), but on


Figures 12, 13: Constructed sills 2 and 5 in the Drava riverbed at the HPP Čakovec

average 3-4 m deep. The forming of «lakes» is planned in the direction of the flow - a sill presents 100 m of the riverbed bottom, followed by a newly formed «lake» at the length of 300 m.

The exposure to erosion of the cascade's downstream edge is the strongest; therefore it is necessary to build such edges by using a material that can withstand the projected tensile forces. In this case, the final sill layer should be made of bulky broken stone.

The cascades should not be an obstacle to the movements of aquatic organisms; therefore, they should be built in a manner that the minimum depth of water on the overflow equals approximately 25 cm, which can be achieved by local lowering of the overflow position in the middle of the sill.

The sills should be built vertically to water flow in all parts of the old waterbed (former oxbows) that are lower than the planned sill position. A special attention should be paid to lateral sill edges, where erosion occurs as well, due to significant change in roughness. Sill lining should therefore always end on the high bank, or a bank stabilized by growth. (Figure 10)

The solution in practice

Several years ago intensive building of the Zagreb-Goričan highway commenced. Due to extremely high demands for gravel, the pressures on the river area became very strong. This resulted in works carried out on the implementation of the regulation of the old Drava riverbed at the HPP Čakovec according to earlier described principles.

Based on the current situation, the predictions are fully realized. The water levels in the surrounding areas have risen, and high water levels in the riverbed are lower than before the intervention.

The primary effects of these works are: a free-flowing profile for high water levels, the raising of groundwater levels in the lowlands, riverbed and inundation area for minimum flow. This means than many oxbows, which were dry before, now have water. The water also enters other old oxbows more frequently, even at small overflows at the dam of the hydropower plant.

Also evident is the increased number of different bird species (divers, blue-grey and white herons, swans, ducks, water-hens, etc.), some of which by their sheer number (cormorants) indicate an obvious increase in fish quantities.

Figure 14 The HPP Čakovec dam – the beginning of the old riverbed
Figure 15 Old structures protruding from the dry bottom

The Conclusion

The Drava riverbed, whose flow was for the most part redirected during the construction of the hydropower plants, is still perceived as it used to be before the construction. People remember the Drava more than 200 m wide, with shifting sandbanks. This has irreversibly changed. There is no flow anymore that could move the sandbanks and fill the riverbed.

From the technical viewpoint, the old Drava riverbed is a relief channel, but one of a great ecological value.

Figures 16, 17: After the sill was built

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Authors:

Ladislav Grđan, Croatian Water, Regional Office Osijek, Department Varaždin, lgrdjan@voda.hr
Zdenko Kereša, Croatian Water, Regional Office Osijek, Department Varaždin, zkeresa@voda.hr