THE INFLUENCE OF HYDROTECHNICAL STRUCTURES ON THE MINOR RIVERBED MORPHOLOGY OF THE DANUBE, IN THE BALA BRANCH - OLD DANUBE BIFURCATION AREA

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Abstract:*The morphological and hydrological phenomena that occurred in the Bala Branch - Old Danube bifurcation area led to the worsening of navigation conditions on Danube. Thus, it was necessary the execution of hydrotechnical structures allowing the navigation to be unfolded under optimum conditions on the Old Danube branch, throughout the year. In the present paper is analyzed the morphological dynamics of the Danube's minor riverbed in the mentioned area, taking into consideration the evolution of anthropogenic interventions. This analysis is based on the informational volume obtained after bathymetric, flow and velocity measurements, in the periods of preconstruction and construction of the hydrotechnical works. This study is of significant importance in achieving the correlation between the execution dynamics of hydrotechnical works and the optimization of navigation conditions as recommended by the Danube Commission, in accordance with environmental parameters.*

Keywords: *Bathymetry, Morphology, Riverbed.*

1. Introduction

The Danube sector located between Calarasi and Braila (km 375 - km 175) is of particular importance, providing a connection between the Danube River, the Danube - Black Sea navigable channel and the maritime Danube (downstream of Braila) [1].

In the presentpaper is analyzed the influence of hydrotechnical structures started on Bala Branch in order to improve navigation conditions on the morphological evolution of the Danube riverbed.

According to the previous studies, the adversely situations for navigation are primarily due to the morphological and hydrological phenomena that occur at the bifurcation area of the Bala Branch (346 km) [1].

The area of study is located on the the Bala Branch - Old Danube bifurcation (Fig. 1).

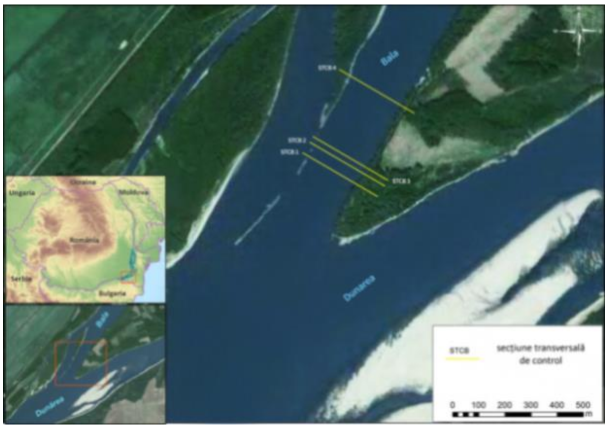

Figure 1. *Location of the Bala branch*

Bala Branch emerges from the Old Danube at 346 km and discharges in Borcea Branch at

68 km (on Borcea). Bala Branch has a length of 11 km and an average width of about 200 m in the construction area[1]. At a distance of about 600 m from the new construction, on

the Bala Branch are remains of an bottom sill executed in the ’90s.

2. Materials and Methods

In order to ensure the navigation conditions recommended by the Danube Commission, namely a fairway with a minimum depth of 2.5 m and a width of 150.0 - 180.0 m [2], throughout the year, on the Bala Banch it began the construction of the hydrotechnical structures. They consist in achieving a bottom sill with a crest level approximately equal to the one built in the '90’s (with a crest level of 0.22 m MNS, approximately 3.5 - 4.0 m above the riverbed and a crest width of 7.4 m), a guiding dam on the left bank (with a crest level of 11.28 m MNS and a length of 2200 m) and a bank protection - Turcescu [3] (Fig. 2). The bottom sill construction was started in July 2013.

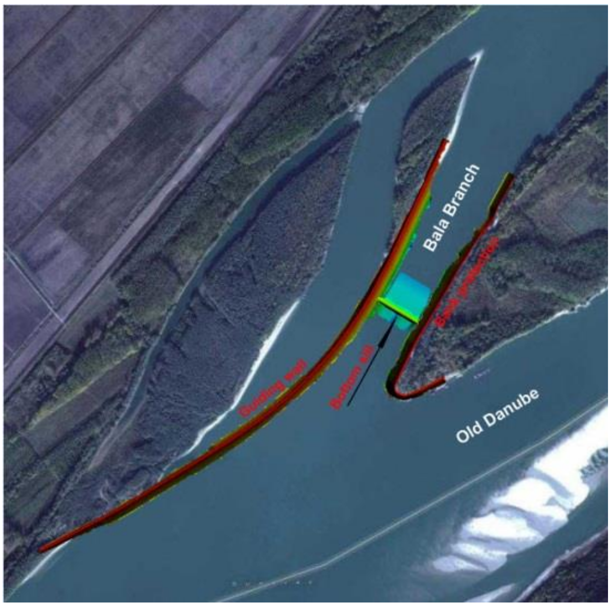

Figure 2. *Designed structures on the Bala branch*

For the achievement of bathymetric and velocitiy measurements and for the determination of flows, the ADCP technique (Acoustic Doppler Current Profiler) by RiverSurveyor S5/M9system was used. The measurements were performed by using a moving vessel. The system used is provided with eight sensors with different orientation, that are generating a sound beam which determine the water velocity rate. The software allows both the acquisition and the primary processing of data. Figure 3 shows, for a cross section, the riverbed geometry, the water velocity and direction, and the velocities distribution on the corss section [4].

For the monitoring of the minor riverbed evolution in time, INCDPM experts have established four cross sections on Bala Branch., where were performed bathymetric and velocity measurements by using the ADCP technique, in the pre-construction and construction period [5].

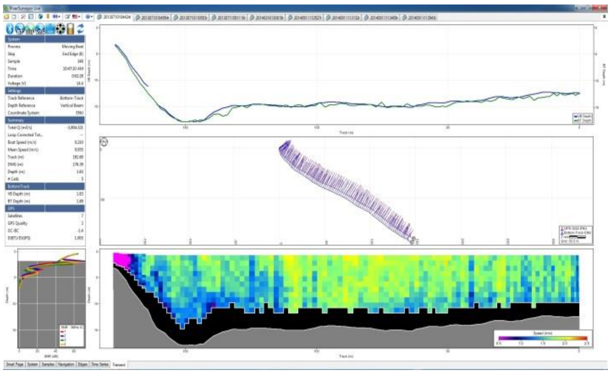

Figure 3. *Data view -Transect Tab*

In order to highlight the bottom sill influence, these monitoring sections were selected as follows: section 1, upstream the bottom sill, section 2, above the bottom sill crest, section 3, at the downstream foot of the bottom sill slope and section 4, at a distance of about 200 m downstream the bottom sill [5] (Fig.1).

3. Results and Discussion

At the cross section level were selected bathymetrical and velocity measurements during the pre-construction and construction period in similar flow conditions (values recorded at Calarasi hydrometric station belonging to the interval of 6970-7200 mc/s) and were achieved histograms of the velocities recorded for each section (Fig. 4) and comparative charts of the cross sections geometry (Figs. 5.1, 5.2, 5.3, 5.4).

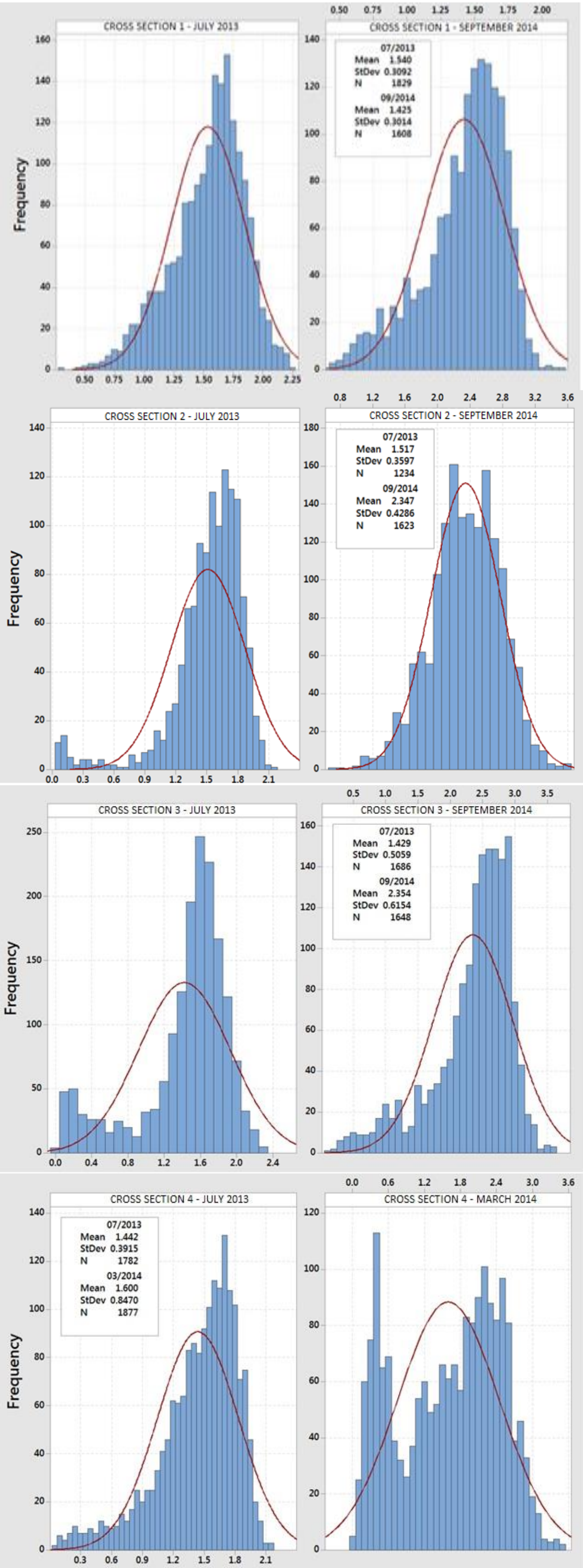

Figure 4. *Distribution of the velocities (m/s) recorded in cross sections1,2,3 and 4, in 2013 and 2014*

Both in terms of average water velocities rates (Fig. 4 - Cross Section 1) and in terms of bathymetry (Fig. 5.1.), in September~~,~~ 2014 were not recorded large differences compared to July~~,~~ 2013 on the upstream section of the bottom sill (Section 1).

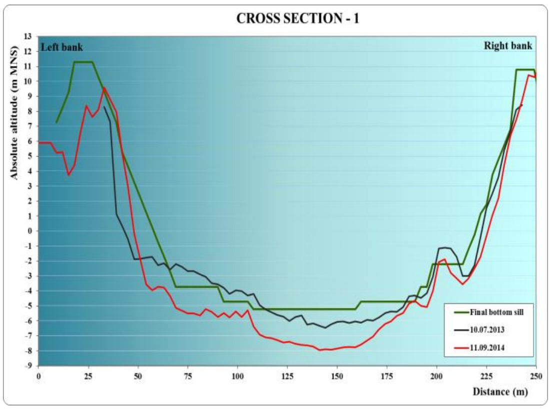

Figure 5.1. *Cross section 1 representing the Danube riverbed of 2013 and 2014 and the designed bottom sill (Petrescu&Deak)*

In cross-section 2 chart (Fig. 5.2.) located on the bottom sill crest, is highlighted the construction progress in the period of July 2013 - September 2014. During this time, the riverbed was elevated, on average with about 3.88 m. The measurements performed in September 2014 were conducted on an intermediate period of the project, thus the bottom sill geometry being irregular and showing differences from its projected geometry.

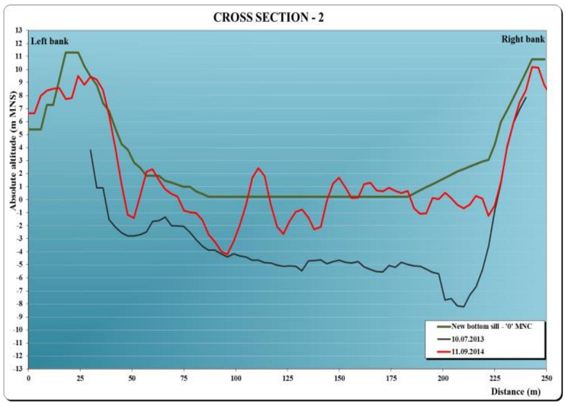

Figure 5.2. *Cross section 2 representing the Danube riverbed in 2013 and 2014 and the designed bottom sill (Petrescu&Deak)*

Due to the reduction of water flow section and to the irregular geometry of the bottom sill, the average of velocities on this section increased by about 55%.

In section 3 (Fig. 5.3.) the form and depths values are strictly influenced by the evolution of the bottom sill constructions. Thus, after construction, the cavity from the right bank, which was determined after the measurements performed in 2013, at a flow rate of 7200 mc/s, has been filled with material. Also, towards the left bank, on a length of about 50 m, the bottom sill was elevated to the projected level. According to measurements performed in September 2014, at a flow rate of 7070 mc/s and a water average velocity of 2.23 m/s, on central side, it was measured a maximum depth of 9.7 m, due to the execution of the work.

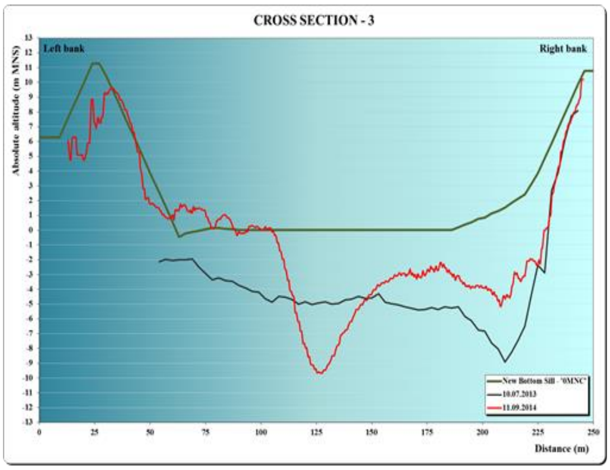

Figure 5.3. *Cross section 3 representing the Danube riverbed in 2013 and 2014 and the designed bottom sill (Petrescu&Deak)*

According to the measurements from March 2014 at a flow of 6970 mc/s (average water velocity of 1.26 m/s), in cross section 4, maximum depthwas 19.87 m,in contrast with the maximum depth of 8.75 m registered in July 2013 at a flow of 7200 mc/s (average water velocity of 1.38 m/s) (Fig. 5.4). Also,the riverbed form was deepened by an average of about 10 m onthe central part,on a length of approximately 100 m.

The scour hole determined in July 2013, appeared on a length of approximately 100 m, on the central side andhad an average depth of about 10 m from the baseline.

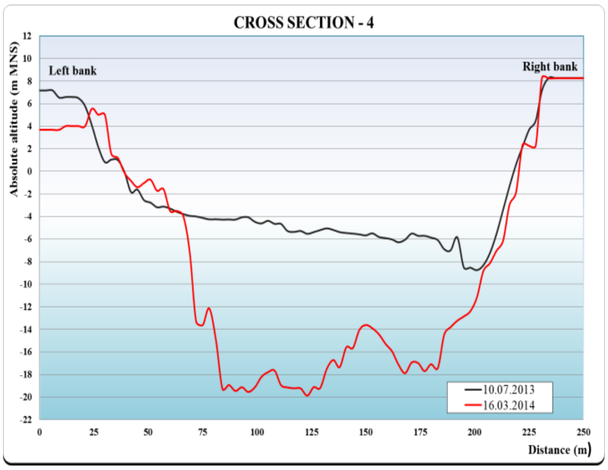

Figure 5.4. *Cross section 4 representing the Danube riverbed in 2013 and 2014 (Petrescu&Deak)*

4. Conclusions

The comparison of velocity and bathymetric measurements developed in 2013 to those developed in 2014, under similar values of flows, have shown that the execution of hydrotechnical structures has a significant influence on the Danube riverbed, downstream the bottom sill.

The graphs resulted from processing bathymetric measurements reveals the deepening of the scour hole formed behind the bottom sill of Bala Branch.

Thus, there are recommended protection measures against riverbed erosion. Also it is necessary the monitoring, in terms of bathymetry both of the works and the areas located upstream and downstrean the bottom sill.

Also it is necessary to be performed numerical simulations based on the DKRControl method principles [6] in order to develop preventive solutions to reduce the environmental impact.

5. Acknowledgements

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beneficiary: River Administration of the Lower Danube Galati.

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