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STUDYING THE INFLUENCE OF FUTURE URBAN DEVELOPMENT ON THE ATTENUATION VOLUME OF A RESERVOIR

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Abstract: The paper presents a 1D numerical modelling of Dumbrăviţa reservoir on Behela water course, in Dumbrăviţa village, in Timis County, aiming to establish if its attenuation water volume is influenced by future urban development, with respect to the enforced specific national regulations. The numerical simulations are to support the study of water volumes and levels on both the reservoir and left bank, near the future urban development location. The modeled river section will have to allow the pass of the maximum design flow needed to be considered for the hydraulic structure, according to its importance class and given by a synthetic high waters curve.

Keywords: 1D numerical model, volume of attenuation, hydrodynamic modelling, water catchment.

1. GENERAL DESCRIPTION, LOCATION AND HYDROLOGICAL DATA

The studied area covered by this documentation is near the dam lake in Dumbrăviţa, about 7 km from Timisoara, at the exit of Dumbrăviţa on the right side, near the Green Forest. The lake stretches over an area of approximately 13 hectares and was refurbished in 2009. Access is made on the county road 691 Timisoara - Lipova, at the exit from Dumbrăviţa. In order to establish the „Influence of future urban development on attenuation water volume" investment planed by a local developer [4], a hydrodynamic study which is to establish the allowed amount of water volume in accordance with the enforced regulations concerning this specific water engagement had to be developed.

Dumbrăviţa accumulation is in hydrographic catchment Bega, on Behela water course (code V-1.20) at hm. 150, upstream of the Green Forest and Dumbrăvita-Giarmata Vii Road from Timiş County.

The front dam is transversely located on the Behela water course, it is a trapezoidal weighted dam and has homogeneous embankment.

All operational system of the Dumbrăviţa establishment was considered for this case study.

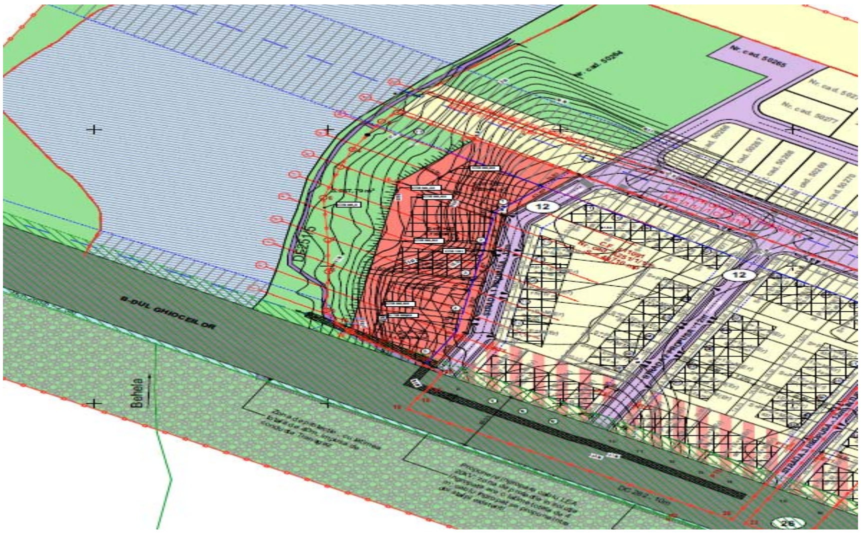

Figure 1.1 Urban development plan view [4]

The flood protection (297 ha of agricultural land) is achieved by regulating the outflow, according to the Hydrological Study communicated by the Hydrological Bureau of ABA Banat, according to the calculators of the technical expertise of the work done by the expert in 2014, to the 0.1% A.E.P. the inflow is 37.8 mc / s, the outflow decreasing to 10.2 mc/s downstream of the accumulation. For the 1% A.E.P. 1%, the maximum inflow is 21,1 cm/s, the outflow

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decreasing to 9.25 mc / s downstream of the accumulation.

Total flood protected area by Dumbrăvița establishment is 297ha.

The maximum discharge flow values are 21.50cm/s for 0.1% A.E.P, 15.30cm/s for 1% A.E.P, 9.25cm/s for 5% A.E.P.

The maximum evacuation capacities at the maximum verification level are: - bottom draining pipe Dn = 1500 mm. (Q = 10.20 cm/s); upper discharger: Q = 12.30 cm/s. (the transport flow capacity of the upper discharger is limited by the flow transport capacity of the bottom discharger, which at the maximum water level, transports just 10.20 cm/s); lower discharger: Q = 8.00 cm/s.

The transport capacity of the downstream river reach (in normal operation condition) is 8.00 cm/s

The most important parameters of high flow regime are: maximum inflow of 37.80 cm/s for a minimum level of 96.30 maBSL, with a volume of 300 cm and for a maximum level of 97.40 maBSL, with a water volume of 1,320 cm.

A high waters typical curve was than artificially developed by the help of HEC-RAS v5.03 dedicated software [3]. Probable curves were than scaled as reaching the mentioned maximum flow values of different overrunning probabilities.

The profiles are numbered individually getting the corresponding "*-left*" or "*-right*" indication.

Figure 1.2 Upstream view of dam, to the interest proposed site by developer [4]

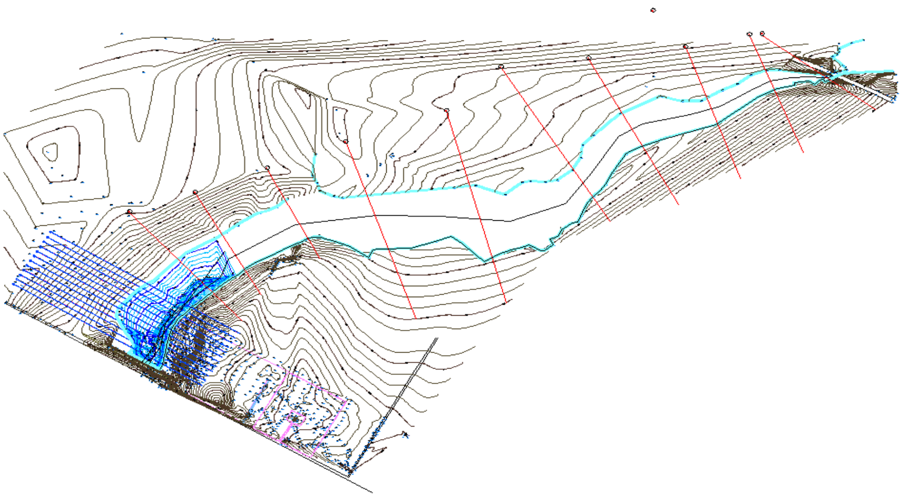

Figure 1.3 Modeled layout with the topographical data [4]

Photos 1.1 View to and from the area of interest, towards accumulation Dumbrăvița

Photos 1.2 View upstream of the dam towards the reservoir and the area of interest

2. NUMERICAL SIMULATION

For the realization of the numerical model, the whole area of interest, with the length of the 2194.5m shore and the 2082m length of river bed, known as the shape from the topographic elevation, was considered.

The profiles identification in the model [1, 3] employs a “milestone” kind of labeling (fig.2.1) which facilitates the generation of new interleaved cross-views by automatic interpolation, useful for calculations refinement.

This section was divided by 22 cross sections obtained according to the actual topographic elevations and additionally by interpolation sections (34 sections) taking into account the spatial representation of the interpolation shown in Fig.2.1.

For cross section interpolation, a 3D model was used, “frame” type, which is a grid type file - dumbravita.grd (obtained with coordinates points x, y, z from the topographical survey, file “csv”).

Automatically interpolation (34 interpolated cross sections, intermediary, on an even distance of 47m) was achieved within the specialized software HEC-RAS 5.0, knowing the spatial representation “shape 3D” type.

The supplementary cross sections are also created through the reservoir bed and left river bank, with a starting point at dams ‘top elevation level, and ending point at the end edge of the reservoir left bank.

Therefore, in the numerical model simulation of water flow in a unsteady or steady flow regime, HEC-RAS version 5.0 software was used.

Regarding the profiles identification in the model, is good to mention that the distance between to cross section measured at the bed level can be identified in its name (for example: station name is 10.340, meaning 340 is the distance between current station and the one downstream).

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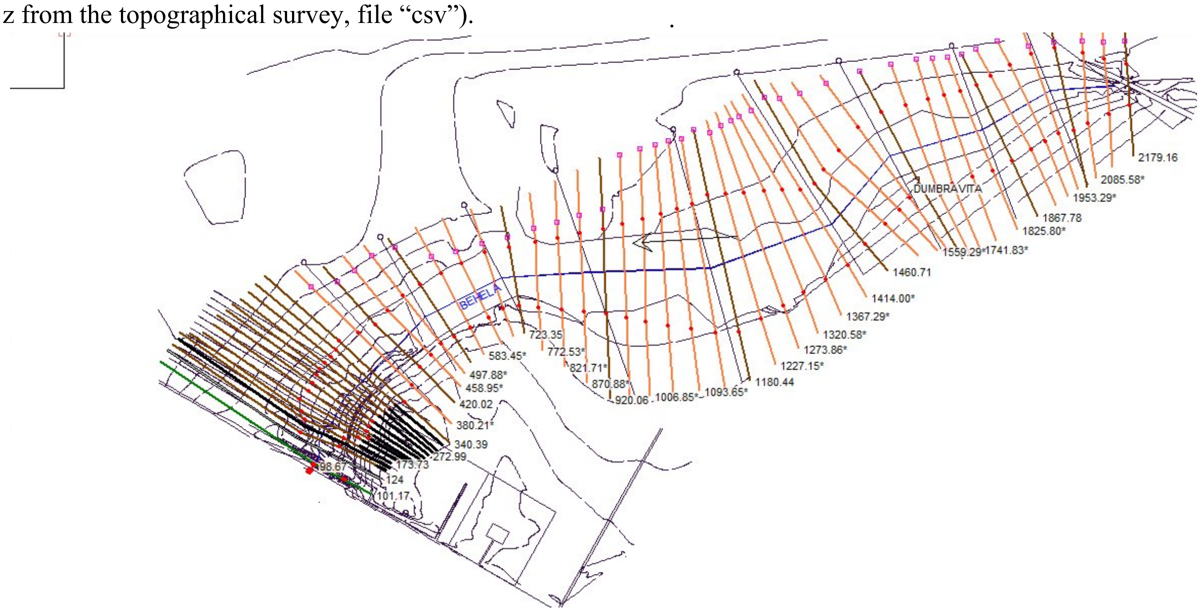

Figure 2.1 Layout of the numerical model with the profiles in HEC-RAS [5]

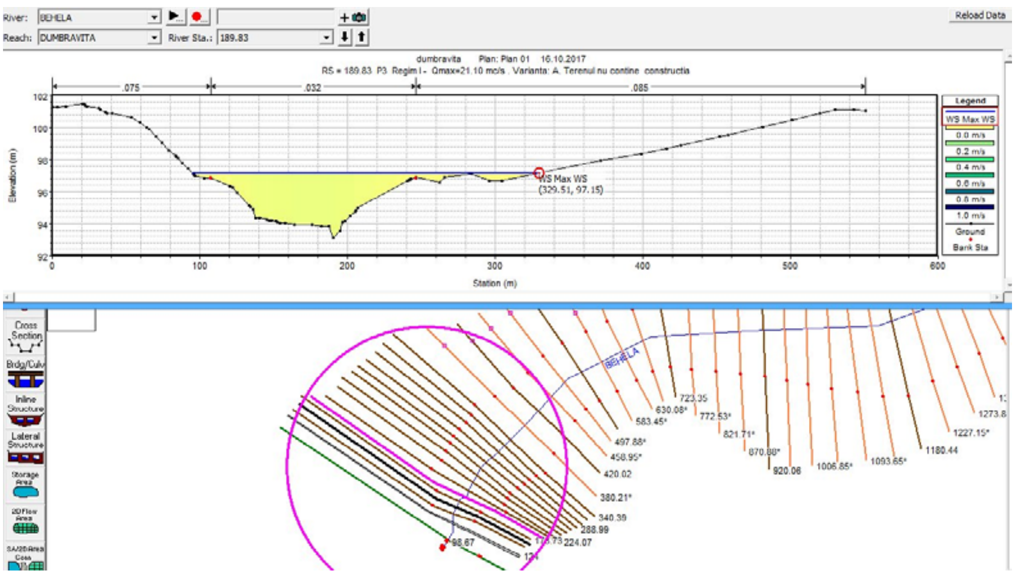

Figure 2.2 Model characteristic cross section, in a natural flow regime (without proposed development)

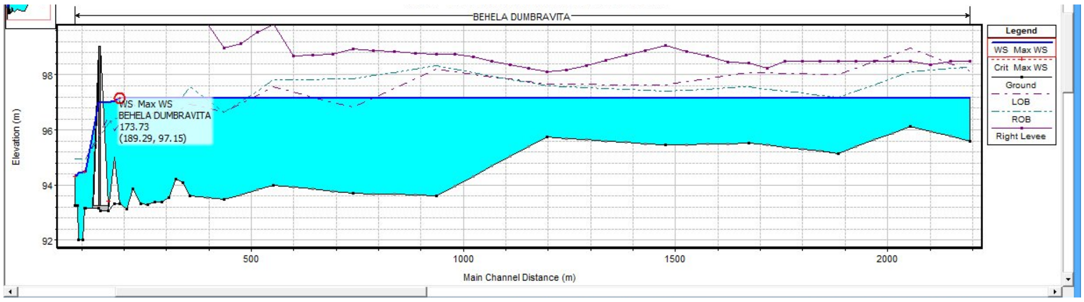

Figure 2.3 Long section through the resrvoir

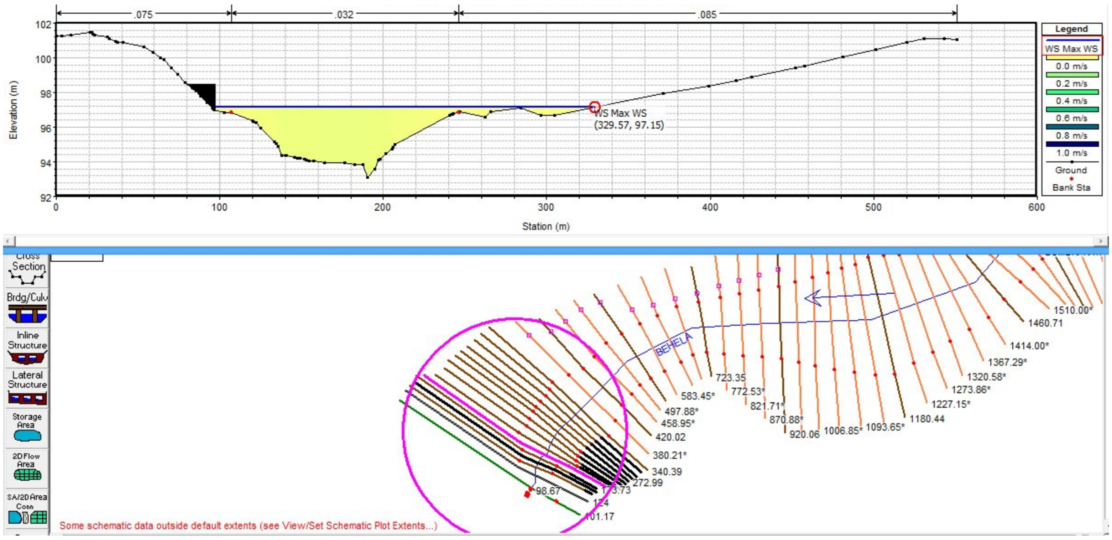

Figure 2.4 Model characteristic cross section, in the scenario with the proposed development included

In figure Fig. 2.1 is illustrated the plan view of interest area with the profiles represented in AutoCAD and HEC-RAS software ver. 5.0 and 4.1.

It can be seen that the model profiles are in the same position as from the topographical survey, and in figure Fig.2.2 is showed a characteristic cross section with panel markers, respectively in figure Fig.2.3 is presented the long section of the entire reach, including the dam structure. In figure Fig2.4 is illustrated the left river bank obstructed, considering the proposed development include in the model.

On the upper part, in characteristic cross section illustrated in Fig2.2, which roughness coefficients were used in the model, for the numerical simulation, in both river channel and floodplains. The roughness coefficient distribution is variable within a cross section and from one cross section to another. Those values are within the following limits: n=0.075 for the left floodplain area, n=0.085 for the right floodplain area, and for the river bed n=0.032.

For this study case, on the analyzed river reach, 4 scenario simulations were created, in order to simulate the open channel flow, in to flow regimes: initial situation, with the proposed development not included (natural river flow), and another one with the proposed development included in the model. This scenario are described as it follows:

- Flow regime I: Scenario A.

Flow simulation in the natural state of left bank, without the proposed development included in the model, unsteady flow, the synthetical flow hydrograph for high peak flow of $Q_{1\%}$ = 21.10cm/s was used as a boundary;

Scenario B. flow simulation in the case with the proposed development included in the model. This was represented by blocking the left side of the river/reservoir with a volume of ground soil, creating by this a wall which narrows the river's cross section. The synthetical flow hydrograph for high peak flow of $Q_{1\%}$ = 21.10cm/s was used as a boundary.

In this scenario each cross section between P1 to P12 form the model, were blocked with this "wall" – area related with the PUZ requirements, respectively compliance with imposed bordering limits, on the left river/reservoir bank, nearby the embankment, as it can be seen in figure Fig. 2.4.

- Flow regime II: Scenario A.

Flow simulation in the natural state of left bank, without the proposed development included in the model, unsteady flow, the synthetical flow hydrograph for high peak flow of $Q_{0.1\%}$ = 37.80cm/s was used as a boundary;

Scenario B. flow simulation in the case with the proposed development included in the model. This was represented by blocking the left side of the river/reservoir with a volume of ground soil, creating by this a wall which narrows the river's cross section. The synthetical flow hydrograph for high peak flow of $Q_{0.1\%}$ = 37.80cm/s was used as a boundary.

In this scenario each cross section between P1 to P12 form the model, were blocked with this "wall" – area related with the PUZ requirements, respectively compliance with imposed bordering limits, on the left river/reservoir bank, nearby the embankment.

3. RUNNING THE NUMERICAL MODEL AND RESULTS PRESENTATION

As a result of the numerical simulations, all the constant or variable time parameters were obtained in terms of: levels, flows and speeds in all cross-sectional numerical models for all four flow scenarios.

The results obtained after the model simulations are showed in the following part.

Flow Regime I: high water peak of Q_{max}= 21.10 cm/s. At the inlet zone through, a cross section was used to calibrate the model.

Scenario A: the flood plain terrain has no proposed development included (river Behela, at the embankment Dumbrăvita). It reaches the maximum flow value through the high-water outlet of the dam of 8.98 cm/s and a maximum water level in each one of the cross sections from P1 to P12 of 97.15 m.a.B.S.L.

Scenario B: the proposed development is included in the left flood plain zone (river Behela, embankment Dumbrăvita). For this scenario, a zone of left flood plain area from each one of cross sections from P1 to P11 was obstructed, related with the property limit of the construction. The obtained peak flow through the high-water outlet is 8.98 cm/s, and at a maximum water level of 97.15 m.a.B.S.L, in each profile from P1 to P12.

Flow Regime II: high water peak of Q_{max}= 37.80 cm/s. At the inlet zone through, the same cross section was used to calibrate the model.

Scenario A: the flood plain terrain has no proposed development included (river Behela, at the embankment Dumbrăvita). It reaches the maximum flow value through the high-water outlet of the dam of 10.68 cm/s and a maximum water level in each one of the cross sections from P1 to P12 of 98.12 m.a.B.S.L.

Scenario B: the proposed development is included in the left flood plain zone (river Behela, embankment Dumbrăvita). For this scenario, a zone of left flood plain area from each one of cross sections from P1 to P11 was obstructed, related with the property limit of the construction. The obtained peak flow through the high-water outlet is 10.69 cm/s, and at a maximum water level of 98.12 m.a.B.S.L, in each profile from P1 to P12.

It can be seen, therefore, that the obstruction of the major bed according to the ownership limit of the building does not influence the attenuation of the flood waves. The designer has to take account of the flood water levels, when designing the future buildings development.

As a common approach, the actual running of the model goes for specific boundary conditions consisting from the following two hydraulic parameters: the passing flow of a given overrunning probability considered by the synthetic high waters curve attached to the most upstream cross section (P1), and the watercourse hydrodynamic grade as given for the downstream cross section (P21) respectively.

All the fixed or time depending parameters regarding levels or water flow and velocity related to each cross section were obtained by running the model numerical simulation. Subsequent to the post processing graphic operation, the results were structured as follows:

- the piezometric line (the water level as maBSL) and water velocity development (in m/s) characterizing significant cross sections on the left bank side, in natural flow regime (fig.3.1), and fig.3.2 – with the constructions included in the model;
- the longitudinal view comprising the given geometry (thalweg, left/right banks, modeled structures) and presenting the piezometric line expansion (fig.3.4), for both flow regimes, scenario B;
- water flow and piezometric line time development presented for the embankment cross section (fig.3.5a)

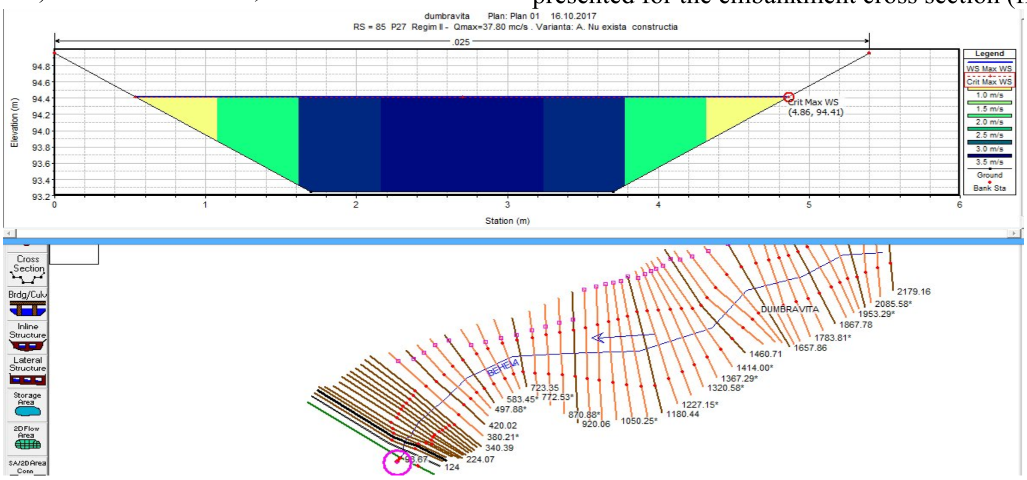

Figure 3.1 Flow Regime II, scenario A: water level and velocity in cross sections P27

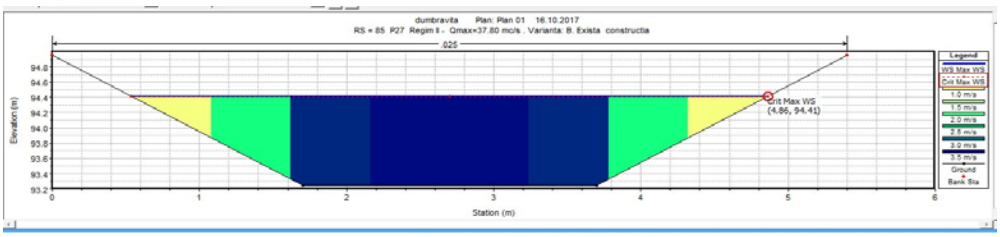

Figure 3.2 Flow Regime II, scenario B: water level and velocity in cross sections P27

The fixed and time depending river flowing parameters reached by running the numerical model were graphically organized following at large the same approach as for the previous scenario:

- piezometric line (water level as maBSL) at the embankment cross section (fig.3.5 b);
- the longitudinal view comprising the given geometry of the modeled river sector and presenting the piezometric line expansion (fig.3.6).
- the longitudinal 3D view of the reservoir/river reach in both flow regimes for scenario B, with the future development included in the model, showing the influence upon the attenuation water volume (fig.3.6).

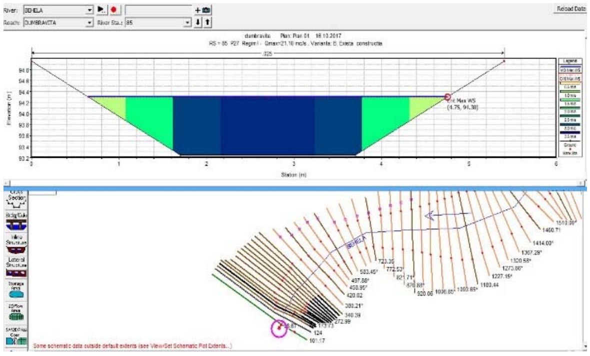

Figure 3.3 Flow Regime I, ScenarioB: water level and velocity in cross sections P27

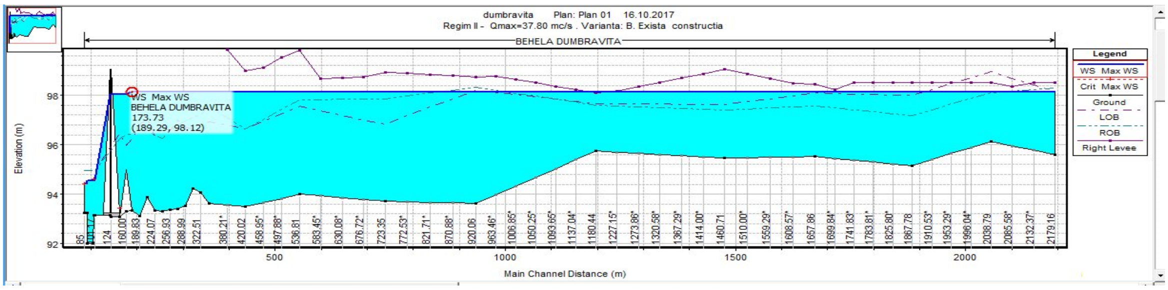

Figure 3.4.a Flow Regime II, scenario B, longitudinal views (at the hour 16):

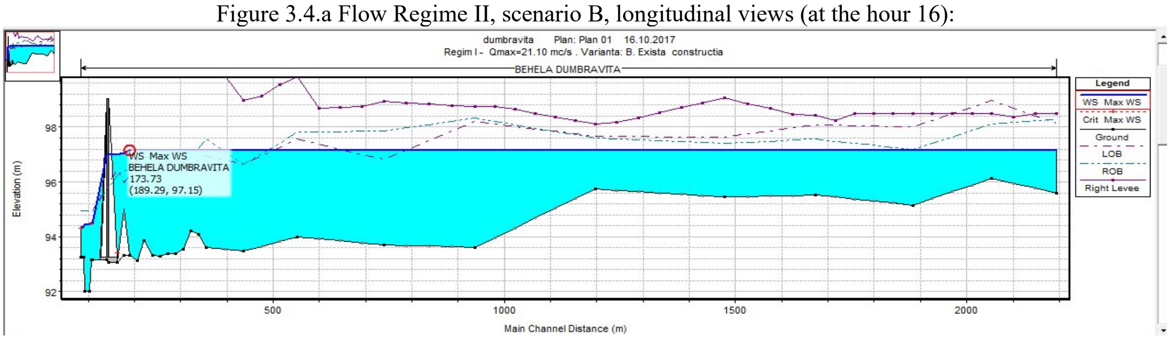

Figure 3.4.b Flow Regime I, scenario B, longitudinal views (at the hour 16):

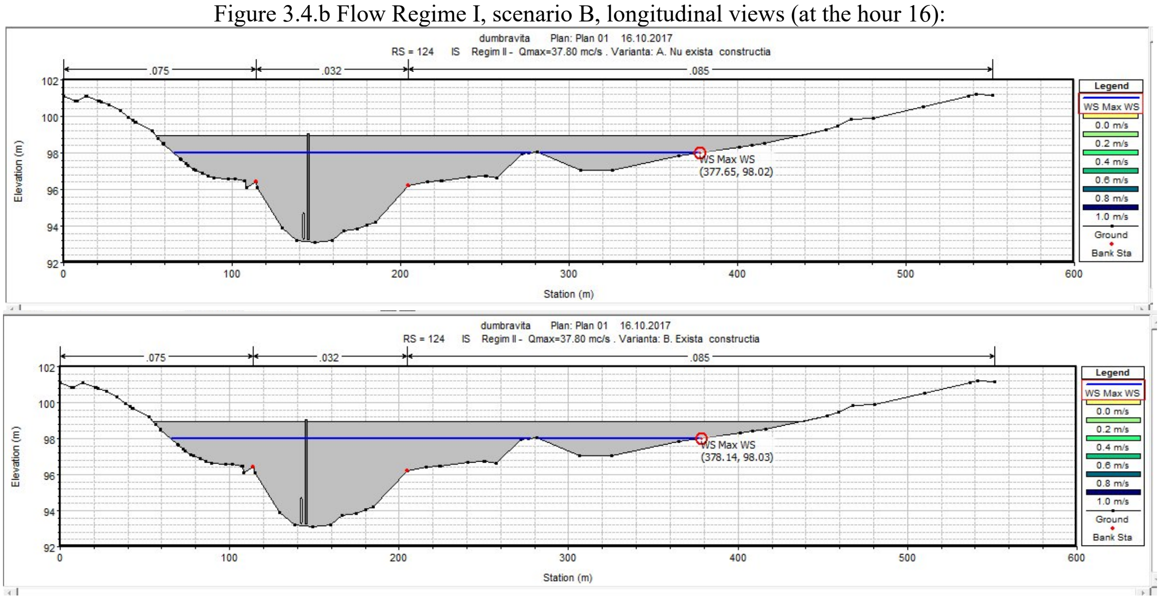

Figure 3.5a Flow Regime II, scenario A (up) and B (down): water level at the embankment cross section

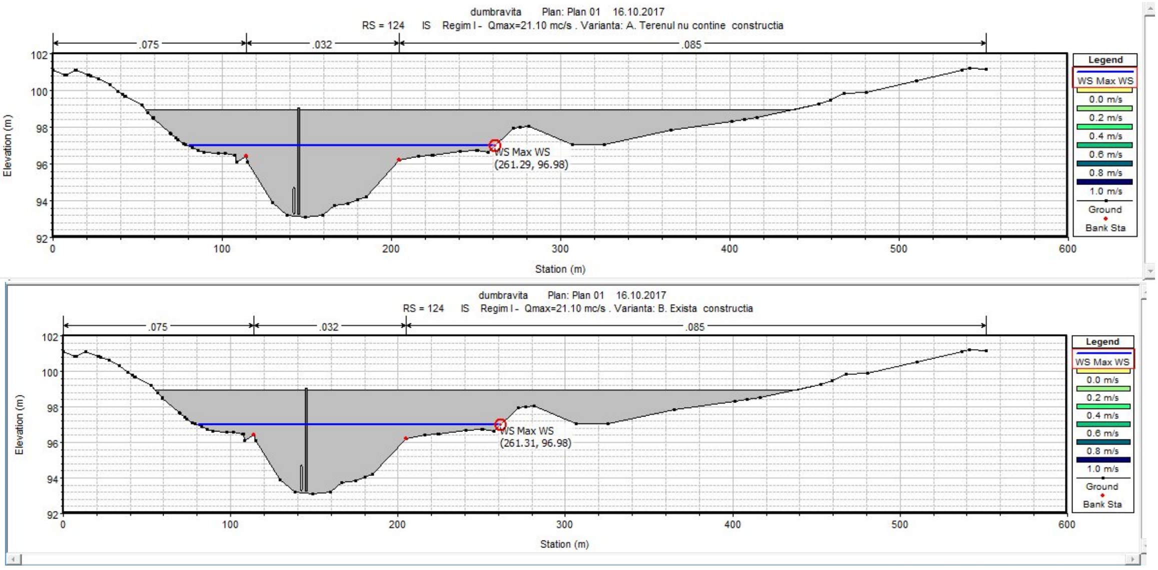

Figure 3.5b Flow Regime I, scenario A (up) and B (down): water level at the embankment cross section

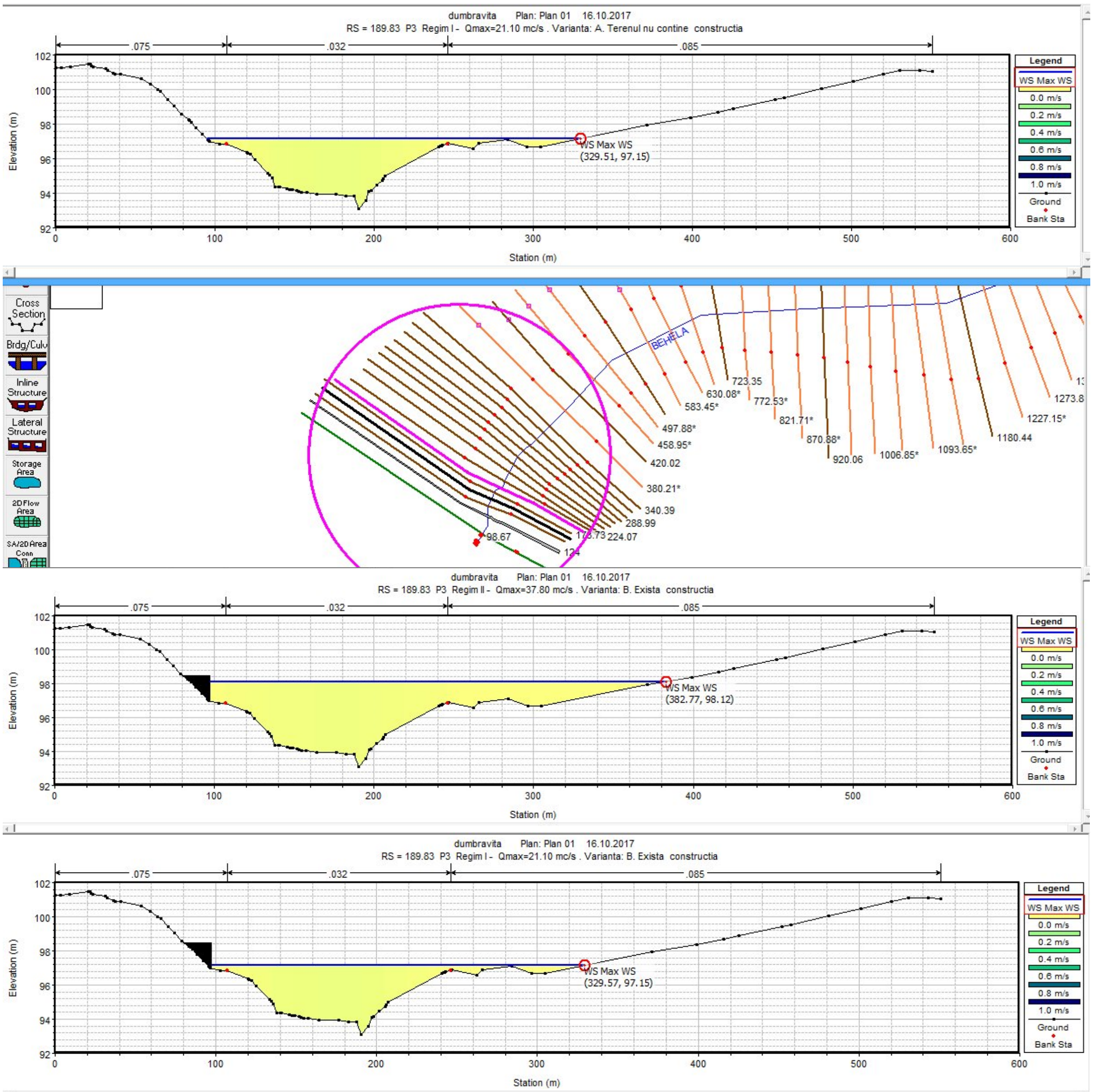

Figure 3.6 Flow Regime I (up) and II (down), scenario B - water level – blocked representative cross section

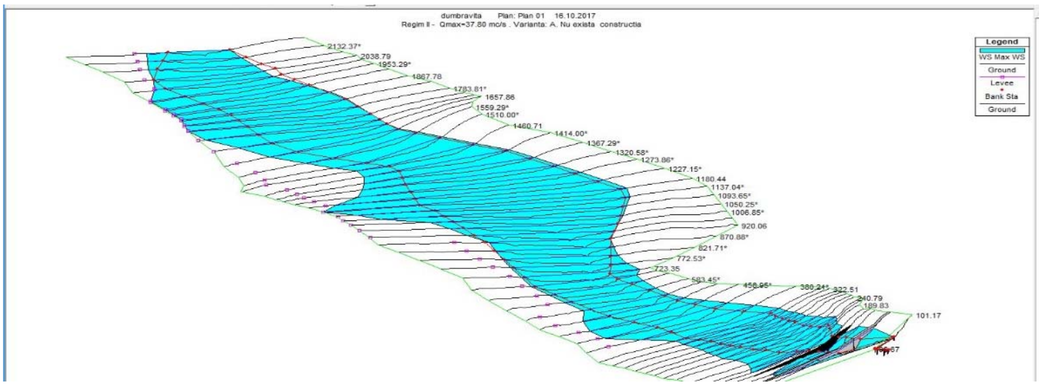

Figure 3.7 Flow Regime II scenario A – long section profile with water levels ("3D" view)

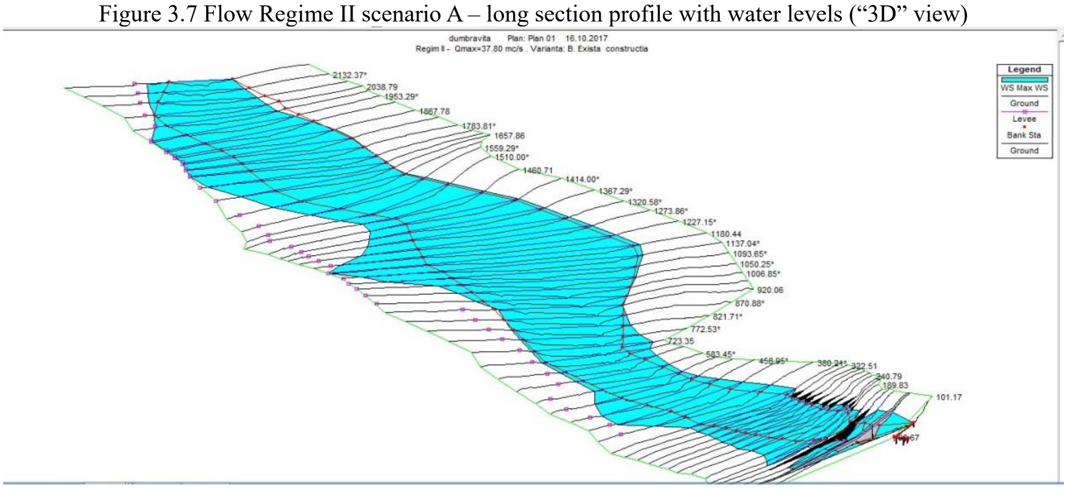

Figure 3.7b Flow Regime II scenario B – long section profile with water levels ("3D" view)

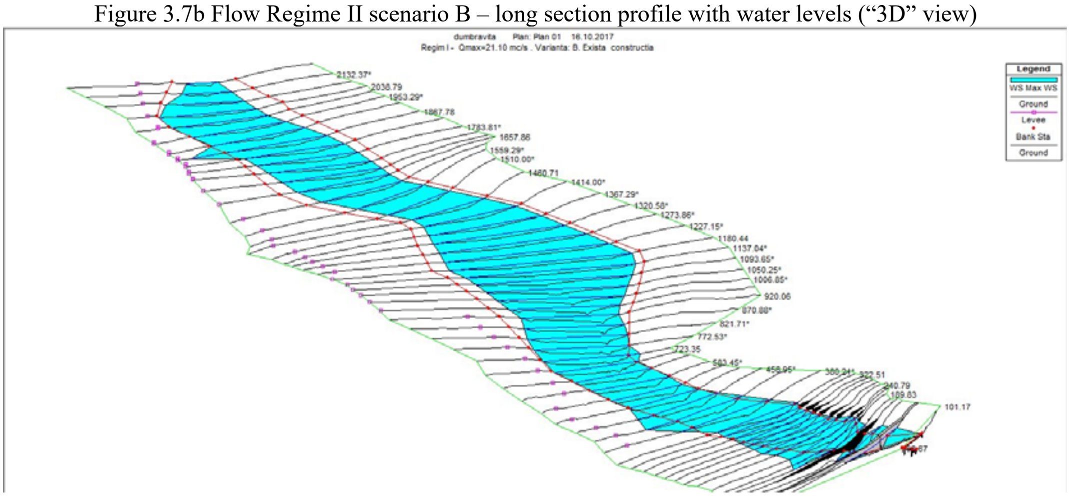

Figure 3.7c Flow Regime II scenario B – long section profile with water levels ("3D" view)

4. CONCLUSIONS

From the cross-sectional profiles provided by the beneficiary through the topography company, it is found that the left bank restoration, according to the desired requirements (h_{max} filling 0,72m, volume 844c.m. filling, volume of excavation 37c.m) does not in any way influence the volume attenuation of accumulation.

However, it is advisable, as far as possible, that the beneficiary of the PUZ parcels indicated, to ensure the volume of soil fillings in the area of the lagoon, within the limits of its propensity, between the quotas: 96.80 m.a.BS.L. (97.13 m.a.BS.L) and 97.80 m.a.BS.L. (98.13 m.a.BS.L).

REFERENCES

[1] BRUNNER G.W., HEC–RAS 4.1, River Analysis System, Hydraulic Reference Manual, USACE, November 2002.

[2] BRUNNER G.W., Combined 1D and 2D Modeling with HEC–RAS, USACE, October 2014

[3] BRUNNER G.W., HEC–RAS 5.03, River Analysis System, Hydraulic Reference Manual, USACE, September 2016

*[4] ***** Studiu privind influența lucrărilor cuprinse in PUZ (CF Nr.407992, CF411091 Extravilan Dumbrăvița) asupra volumului de atenuare a acumulării Dumbrăvița - Contract BC 83/29.09.2017, UPT - Octombrie 2017*

*4] ***** Documentație ridicari topografice si profile caracteristice SC BIOS & CO SRL Timişoara 2017*

*[5] ***** A.N. APELE ROMÂNE- ADMINISTRAȚIA BAZINALĂ DE APĂ BANAT, Regulament de Exploatare Acumularea Dumbrăvița, Timişoara, 2016.*

[6] LAZAR Gh.I., Modelarea numerică asistată de calculator a curenților cu nivel liber în regim amenajat, Ed.Politehnica, Timişoara