Data Collection, hydraulic and morphological modelling of the Danube River and the Sava River in the Republic of Serbia
Lot 1: Integrated Study

Stakeholders' Forum Meeting No. 17

16/07/2025

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hidrozavod dtd
AD za studije,istraživanja,projektovanje i inženjering NOVI SAD

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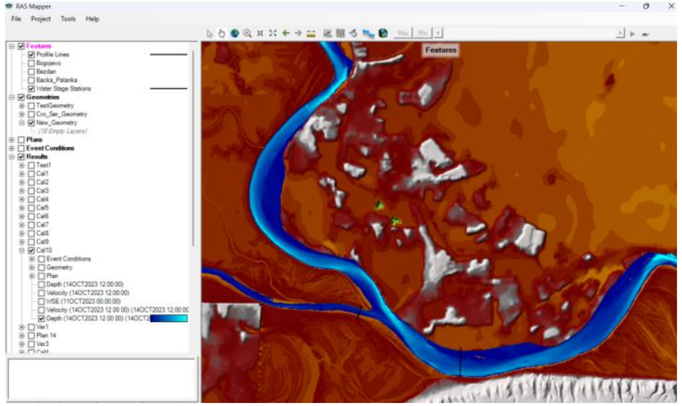
Act. 01 1D Hydraulic Modeling

Act. 01	1D Hydraulic Modeling
Task 01-01	Data Collection
Task 01-02	Hydrological Study
Task 01-03	Model Setup
Task 01-04	Model Calibration
Task 01-05	Model Simulation
Task 01-06	Analysis and Results
Task 01-07	Update of ENRs

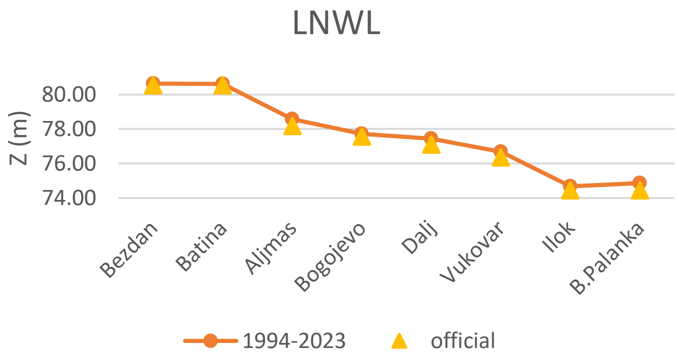
Act. 01 1D Hydraulic Modeling – Outcomes

- Hydrologic Study
- Calibrated and Verified 2D model of the common Serbian-Croatian stretch between km 1433.1 to km 1295.5

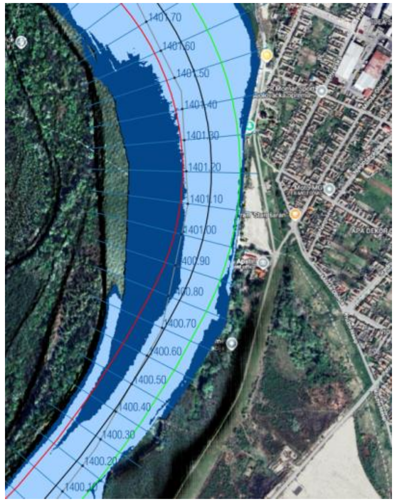
Station	Q94% (m³/s)			Q1% (m³/s)		
	Before adjustment	After adjustment	Adopted	Before adjustment	After adjustment	Adopted
Bezdan	1344	–	1344	4920	–	4920
Batina	1316	1349	1349	4817	4940	4940
Aljmas	1735	1719	1707	5290	5430	5395
Bogojevo	1707	–	1707	5395	–	5395
Dalj	1791	1768	1768	5252	5392	5395
Vukovar	1774	1769	1769	5266	5391	5395
Ilok	1821	1813	1778	5292	5449	5449
Backa Palanka	1897	1778	1778	4835	5173	5449



- Updated Low Navigation Water Levels (LNWLs) - **Output 1.2**



- Visual presentation of the bottlenecks and shallow zones along the observed stretch



Act. 02 Redefinition and Prioritization of Navigational Bottlenecks – Outcomes

Act. 02	Redefinition and Prioritization of Navigational Bottlenecks
Task 02-01	Update of the bottleneck catalogue
Task 02-02	Prioritize bottlenecks for which 2D models will be developed

- Updated catalogue of bottlenecks - **Output 2.1**

No.	Sector	Chainage (from km to km)	Quantity of sediment within the fairway of 2.5m depth &			
			Width 100m	Width 120m	Width 150m	Width 200m
1	Bezdan	1,429.0 – 1,425.0	0	0	0	4,745
2	Siga Kazuk	1,424.2 – 1,414.4	0	0	0	1,106
3	Apatin	1,408.2 – 1,400.0	7,035	14,635	26,821	54,311
4	Civutski Rukavac	1,397.2 – 1,389.0	343	1,494	8,164	52,977
5	Drava Confluence	1,388.8 – 1,382.0	0	441	4,221	22,013
7	Staklar	1,376.8 – 1,373.4	733	1,571	3,823	14,781
9	Bogojevo	1,366.2 – 1,361.4	0	0	0	330
10	Dalj	1,357.0 – 1,351.0	0	0	0	344
11	Borovo 1	1,348.6 – 1,343.6	0	415	5,431	26,555
12	Borovo 2	1,340.6 – 1,338.0	0	346	6,863	40,353
14	Sotin	1,324.0 – 1,320.0	0	0	0	85
15	Opatovac	1,315.4 – 1,314.6	0	0	0	37
16	Mohovo	1,311.4 – 1,307.6	93	177	368	748

- The List of prioritized navigation bottlenecks – **Output 2.2**

No.	Sector	Chainage (from km to km)	Quantity of sediment within the fairway of 2.5m depth &			
			Width 100m	Width 120m	Width 150m	Width 200m
3	Apatin	1,408.2 – 1,400.0	7,035	14,635	26,821	54,311
4	Civutski Rukavac	1,397.2 – 1,389.0	343	1,494	8,164	52,977
5	Drava Confluence	1,388.8 – 1,382.0	0	441	4,221	22,013
7	Staklar	1,376.8 – 1,373.4	733	1,571	3,823	14,781

Act. 03 Definition of Criteria for the Multi-criteria Analysis

Act. 03	Definition of criteria for the multi-criteria analysis	M04-M05
Task 03-01	**Definition of MCA**	**M04**
Sub-Task 03-01-01	Definition of criteria for MCA	M04
Sub-Task 03-01-02	Definition of ponders for criteria for MCA	M04
Sub-Task 03-01-03	Definition of sub-criteria	M04
Sub-Task 03-01-04	Definition of ponders for sub-criteria	M04
Sub-Task 03-01-05	Definition of minimum thresholds	M04
Sub-Task 03-01-06	Definition of evaluation scales	M04
Task 03-02	**Elaboration of Technical Report on the Definition of the MCA**	**M04-M05**
Sub-Task 03-02-01	Elaboration of the draft Technical report on the definition of the MCA	M04-M05
Sub-Task 03-02-02	Obtaining feedback from stakeholders on the draft Technical report on the definition of the MCA	M04-M05
Sub-Task 03-02-03	Elaboration of the final Technical report on the definition of the MCA	M04-M05

Act. 03 Definition of Criteria for the Multi-criteria Analysis - outcomes

- MCA Criteria
- Technical report on the definition of the MCA – **Output 3.1**

Code	Criteria	Indicators	Acceptable Score	Weighting coefficient
N_1	Maximal DC recommendations	Quantitative - Water depth ratio (width of 200 m used as reference value), Width ratio (water depth of 2.5 m used as reference value), Curve radius ratio	1.5 - 2	0.30
N_2	Maneuverability	Quantitative - Velocity ratio Qualitative - Hindrance	0.25 - 2	0.05
N_3	Safety	Qualitative - Visibility of the structures	0.25 - 1	0.05

Code	Criteria	Indicators	Acceptable Score	Weighting coefficient
E_1	Hydro-morphology	Quantitative - Riverbed volume ratio, SHDi ratio, Length of low flow channels ratio, Bankfull discharge water level difference, Near bank velocity ratio, bank erosion length ratio	0.25 - 2	0.15
E_2	Physical naturalness of solution	Quantitative - Number of structures difference and level of nature protection	0.25 - 2	0.05
E_3	Sediment and water quality	Quantitative - Dredging volume Qualitative - Effects on physical, chemical and biological parameters of water quality	0.25 - 2	0.05
E_4	Bird population	Qualitative - Aspects of nesting, wintering and foraging	1 - 2	0.05
E_5	Fish population	Qualitative - Aspects of spawning, migration, wintering habitats, growing and living	1 - 2	0.05
E_6	Flora	Qualitative - Creation of new areas for distribution	1 - 2	0.05

Code	Criteria	Indicators	Acceptable Score	Weighting coefficient
F_1	Technical aspects	Quantitative - Execution of works and Response time	0.25 - 1	0.05
F_2	Financial aspects	Quantitative - Investment and maintenance costs/avoided users costs as benefit	0.25 - 2	0.10

Code	Criteria	Indicators	Acceptable Score	Weighting coefficient
C	Climate change vulnerability	Qualitative - Aspects of exposure, sensitivity and resilience	0.25 - 2	0.05

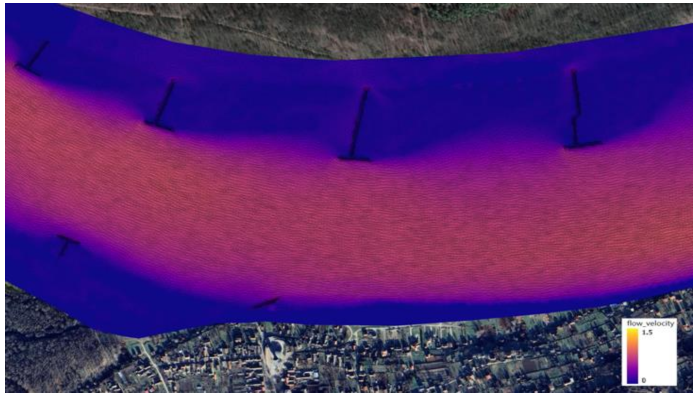
The quantitative indicators have continual scoring from 0.0 to 2.0. Qualitative indicators have discrete scoring 0 (unacceptable), 0.5 (slightly worse compared to the do-nothing scenario), 1 (approximately the same compared to the do-nothing scenario), 1.5 (moderately better) and 2 (significantly better).

Act. 04 2D Hydrodynamic and Morphological Modelling

Act. 04	2D Hydrodynamic and Morphological Modeling
Task 04-01	Data Collection
Task 04-02	Model Setup
Task 04-03	Model Calibration
Task 04-04	Model Verification
Task 04-05	Definition of Variants for each Bottleneck
Task 04-06	Preparation of Model for Considered Variants
Task 04-07	Analysis of Results
Task 04-08	Application of MCA
Task 04-09	Elaboration of Technical Report on 2D Modeling and Application of MCA

Act. 04 2D Hydrodynamic and Morphological Modelling - outcomes

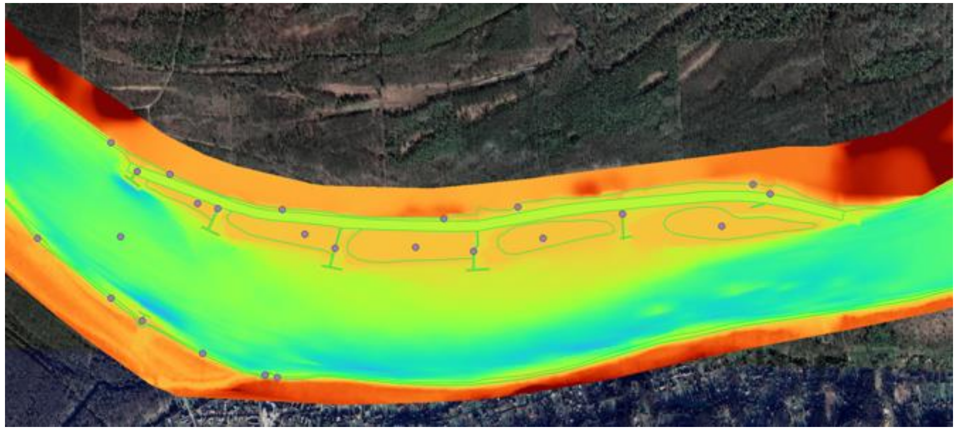
- 2D Hydraulic model including suspended and bedload transport model – calibrated and validated



Scenario	Sector				
	Apatin	Čivutski rukavac	Drava Confluence	Aljmaš	Staklar
Scenario 1 (S1) - Do nothing-	-	-	-	-	-
Scenario 2 (S2) - Structural and revitalization measures -	2 Chevrons, 2 sills		Sidearm channel	Sidearm channel	
Scenario 3 (S3) - Fairway realignment-	-	-	-	-	-
Scenario 4 (S4) - Only structural measures-	2 Chevrons, 2 sills	1 Groyne	2 sills		2 sills

- Bottlenecks variants defined - **Output 4.2**

- Technical report on 2D modelling and application of MCA - **Output 4.3**



	Group score for navigation	Group score for environment	Group score for feasibility	Group score for climate change	Total Score
S1	1.000	1.000	1.000	1.000	**1.000**
S2	1.026	1.144	0.901	0.966	**1.022**
S3	1.075	1.020	1.072	1.000	**1.176**
S4	1.137	1.036	1.035	0.966	**1.177**

Output 5.1

- Integrated study on alternative solutions
    - 1D Modeling
    - Update of Low Navigaton Water Levels (LNWLs)
    - Bottlenecks catalogue
    - Prioritization of navigational bottlenecks
    - Definition of MCA (Multi Criteria Analysis)
    - Definition of bottlenecks variants
    - Application of MCA
    - Summary

Communication with stakeholders and beneficiaries

✓Comprehensive record of comments and responses regarding Output 4.2, Output 4.3, and Output 5.1

	A	B	C	D
1	Output 4.3			
2	Comments on Output 4.3 Technical report on 2D modelling and application of MCA			
3	Comment	No. of page	Comments (Georg Rast)	Answers (Consultants)
4	1	Page 6	the discharge according the rating curve?	Exactly. The mistake will be corrected.
5	2	Page 9	A translation to English for Puzv and Pniz would be helpful If Pniz is the total flow downstream (Puzv + PDrava) it would be helpful to explain why there is a difference in flow figures	The consultant will follow the recommendations and explain the symbols and the difference in flow values.
6	3		The table in the report on bottleneck variants on the different scenarios which are quite difficult to separate should be included here as well	Thank you for the suggestion.
7	4		? please explain at least once, though most of the text is quite technical	The explanation will be added to the revised version of the text: In short, the dominant discharge is the flow that has the greatest (dominant) influence on the formation of the riverbed geometry. According to this concept, if the riverbed is subjected to a constant dominant discharge over a certain period, it will result in riverbed deformation that corresponds to the long-term effects of varying flow and sediment transport characteristic of the natural water and sediment regime.
8	5	Page 10	Attention, there may be also negative effects as morpho-dynamics of the technically undesired sandbar are diminished And natural sanbars have much smoother gradients favorable for benthic zone fauna	Based on historical profiles from Plovput, it can be concluded that the existing sandbar is undergoing significant shape changes and is unstable. The idea behind the chevrons is to stabilize the sandbar and create a channel fow low-flow condition also, which would contribute to a more diverse channel morphology.
9	6	Page 12	To delineate the proposed structures (chevrons and sills) in black color might better visualize the cause-effect situation, like in figure 12 Now it is almost unvisible, and just one bottom sill (?)	The consultant thanks you for the suggestion.
10	7		There is also a significant decrease in riverbed in scenario 1 not as significant compared to scenario 2 and 4 Cross-sections might help to visualize and explain differences	The consultant agrees with the comment and the suggestion.

Key findings

Key findings 1/2

- Developed a comprehensive **hybrid 2D hydraulic model;**
- Revised **Low Navigation Water Levels** (LNWLs) and **High Navigation Water Levels** (HNWLs);
- The hybrid model demonstrated satisfactory agreement between simulated and observed water surface levels within the low-flow domain;
- The need to enhance the quality of hydrological data;
- To improve data harmonization between Serbian and Croatian gauging stations;
- All newly observed **LNWLs for the period 1994–2023 are higher and** all newly observed **HNWLs for the period 1994–2023 are lower** compared to those previously reported to the Danube Commission.

Key findings 2/2

- Identified **4 most critical navigation bottlenecks (Apatin, Čivutski/Židovski Rukavac, Drava Confluence and Staklar);**
- A Multi-Criteria Analysis (MCA) introduced, the Weighted Product Model and discrete scoring thresholds used;
- Identified key problematic areas where sediment accumulation and unstable morphology compromise the fairway;
- A nature-inclusive structures (chevrons, detached groynes, sills, and opening of the sidearm channels) proposed;
- The scenario proposing new river training structures is considered optimal (Scenario 4 which includes 2 chevrons, 1 detached groyne and 6 sills).

Limitations

Limitations

1. Technical Limitations
    - Incomplete floodplain data
    - Modeling constraints
    - Infrastructure data gaps
2. Organizational Limitations
    - Fragmented stakeholder coordination
    - The lack of a holistic approach
3. Data-Related Limitations
    - Missing historical datasets
    - Missing geospatial and bathymetric data
    - Inconsistent metadata standards

Technical characteristics of the finally proposed variants

Technical characteristics of the finally proposed variants 1/2

Scenario 1 (Baseline) serves as a benchmark "do nothing" approach;

Scenario 2 (Structural and Revitalization) introduces non-traditional structural measures;

Scenario 3 (Minimal Intervention) represents a business-as-usual approach;

Scenario 4 (Comprehensive Measures) combines traditional structural measures with nature-inclusive solutions.

Technical characteristics of the finally proposed variants 2/2

The final design variants for river training structures along the Danube River comprise five types of solutions:

1. Chevron Structures;
2. Sill Structures;
3. Detached T-Groyne Structure;
4. Sidearm Channel Systems;
5. Fairway Realignment Specifications.

Recommendations

Recommendations 1/4

General:

1. Holistic Development of Inland Navigation;
2. Tailored Adaptive Measures;
3. Integrated River Management;
4. Alignment with EU standards;
5. Cross-Border Administrative Cooperation.

Recommendations 2/4

Specific:

I. Short-Term Actions (0–2 years)

- The calculated LNWLs and HNWLs data to be forwarded to the:
  1. Croatian river administration;
  2. Danube Commission,
- To regularly update adopted Bottleneck Catalogue;
- To provide technical justification and full documentation of selected modeling software;
- To provide targeted training on 1D and 2D hydrodynamic modelling to Serbian river administration staff and to Croatian counterparts;
- To explore opportunities to develop potential sustainable solutions for addressing navigational challenges in prioritized bottlenecks;
- To adopt the MCA approach in the planning process;
- Application of the 2D model to serve as a capacity-building exercise and be integrated into regular planning operations for both administrations;
- Use environmental assessments and zero-state analysis to support preparation of the Environmental Impact Assessment (EIA).

Recommendations 3/4

Specific:

II. Medium-Term Actions (2–5 years)

- Coordination and cooperation of hydrometeorological services of Serbia and Croatia;
- Future studies assessing reference water levels should rely on hydrological stations with at least 30 years of continuous data records, in line with international best practices;
- Design and propose an environmental monitoring Programme aligned with EU environmental directives.

Recommendations 4/4

Specific:

III. Long-Term Actions (5+ years and beyond)

- Develop long-term maintenance and adaptation plans based on 2D model outcomes and MCA prioritization;
- Embed climate resilience criteria into future infrastructure designs;
- Evaluate performance of nature-inclusive structures (if any established) (e.g., chevrons, sidearms) by establishing key monitoring indicators and benchmarks.

The next steps for future investments

The next steps for future investments 1/3

1. Consolidation of Strategic Inputs
   - Review of outcomes of available documentation and modeling analyses.
   - Confirm scenario selection through stakeholder endorsement or governing body decisions.
   - Clarify regulatory context—particularly permitting frameworks, cross-border coordination, and environmental obligations
2. Technical Scoping and Design Parameters
   - Define the technical scope of interventions, including boundaries of works, performance objectives, and integration with existing infrastructure.
   - Lock in design criteria, such as reference water levels (e.g., LNWL, HNWL), vessel classes, fairway dimensions, and roughness coefficients, with traceable justifications.
   - Incorporate site-specific constraints, e.g., erosion-prone zones, ecological sensitivities, or navigational bottlenecks.

The next steps for future investments 2/3

3. Data and Documentation Readiness

- Ensure geospatial and topographic datasets are accurate, complete, and quality-assured.
- Check hydrological and hydraulic modeling outputs to serve as design baselines.
- Secure all supporting reports and approvals from earlier project phases (e.g., stakeholder consultations, MCA results, environmental screening).

4. Institutional and Procedural Coordination

- Establish clear ownership of tasks, with identified technical leads, oversight bodies, and communication protocols.
- Coordinate with regulatory authorities to identify technical requirements for permitting (including environmental and navigational authorities).
- Validate compliance requirements, including national standards, Danube Commission guidelines, and EU directives (e.g., WFD, EIA, Birds & Habitats Directives).

The next steps for future investments 3/3

5. Outline Documentation Structure

- Draft the structure and content map for the technical documentation (e.g., general design report, detailed design drawings, bill of quantities).
- Plan integration of complementary documents, such as risk assessments, cost estimations, and environmental mitigation strategies.
- Schedule internal reviews and agree on quality control checkpoints during preparation.

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Lot 1: **Integrated Study**

Thank you for your kind attention

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