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Editorial

River Channel Hydraulics, Fluvial Dynamics and Re-Opening Floodplains

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1. Introduction

The management of river systems is currently undergoing a fundamental paradigm shift. For decades, traditional river engineering focused primarily on flood defence through channelization and bank stabilization involving the use of hydraulic structures. Over the past centuries, numerous flood protection arrangements have been built across the landscape. In modern history, Central Europe experienced extreme flood events in 1997, 2002, 2009, 2010, 2013 and 2024. These events highlighted the need for more systematic flood protection, as reflected in the Flood Directive 2007/60/EC [1], which was followed by the construction of thousands of kilometres of new flood barriers. This approach often led to the disconnection of rivers from their natural floodplains. While these measures provided immediate protection and reclaimed land for agriculture and urban development, they left a legacy of degraded aquatic ecosystems, accelerated downstream flood peaks, and severely disrupted sediment regimes. Today, in the face of climate change and accelerating biodiversity loss, the scientific community and river managers are increasingly turning towards nature-based solutions. Among these, the re-opening and restoration of floodplains have emerged as key strategies for sustainable river basin management [2].

2. River Channel Hydraulics, Fluvial Dynamics and Re-Opening Floodplains

This Special Issue, entitled "River Channel Hydraulics, Fluvial Dynamics and Re-Opening Floodplains", brings together a collection of cutting-edge research papers that bridge the gap between fundamental fluvial hydraulics and practical river restoration. The volume addresses the complex physical, ecological, and morphological feedback loops that occur when rivers are reconnected with their alluvial valleys.

The contributions in this Special Issue can be broadly categorized into the following interconnected themes:

- Advanced hydrodynamic modelling provides insight into the hydraulic behaviour of reconnected floodplains. This requires highly accurate predictive tools. [Contribution 3] demonstrates the application of multi-dimensional hydrodynamic models to simulate complex flow patterns and lateral connectivity within the floodplain. [Contribution 2] examines the relationship between SSP and whitewater class ratings on the Deschutes River.
- The accuracy of flood inundation modelling is critically dependent on the precision of Digital Terrain Models, which provide the topographic foundation for hydraulic simulations [3,4]. [Contributions 2 and 3] highlight how the accuracy of Digital Terrain Models (DTMs) directly influences the reliability of hydrodynamic modelling results and flood hazard assessments. To improve information about terrain configuration, unmanned aerial vehicle (UAV) photogrammetry is recommended.

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- Fluvial Sediment Dynamics and Morphological Evolution is a topic addressed in [Contributions 1, 4 and 5]. Reconnecting floodplains dramatically alters shear stress distributions, initiating sediment deposition on the floodplain and triggering channel migration or bed aggradation/degradation. The aforementioned contributions use both field monitoring and numerical sediment transport models to predict long-term morphological changes, ensuring that restored reaches achieve dynamic equilibrium rather than structural failure.

2.1. Floodplain Re-Opening

Many existing flood protection measures, including set-back levees, farmer dikes and corresponding hydraulic structures, have been designed using older hydrologic data and less precise terrain elevation data. At the same time, the relevance of hydrologic data and the accuracy of terrain levels significantly influence the reliability of hydraulic modelling results. The Biodiversity Strategy (2030) [2] calls for the removal of existing redundant levees along the streams, with their possible substitution by set-back levees and floodwalls located at the edge of the floodplain, close to the built-up areas. In this context, the accuracy of floodplain water-level determination is crucial.

2.2. The Impact of Digital Terrain Model Accuracy

In hydraulic open channel and floodplain flow modelling [5–7], DTMs are used to define the terrain surface, which directly influences flow routing, water depth calculations, and the spatial extent of inundation [8]. The integration of DTMs into 2D models allows for the simulation of complex flow dynamics, including overland flow, channel–floodplain interactions, and the representation of topographic features such as levees, roads, and buildings. In these models, even minor and local inaccuracies in DTM can lead to significant deviations in predicted flood extents and water levels [Contribution 3]. To assess uncertainty in DTM data and their impact on flood modelling, recent studies employed advanced methods such as surrogate models and stochastic approaches [9].

For mid-scale problems, unmanned aerial vehicle (UAV) photogrammetry may be useful [Contribution 2]. UAVs can cover large areas more quickly than ground-based measurements, thus reducing fieldwork time [3,10]. Mapping and image analysis applications are widely used; over small areas, UAVs can provide data of sufficient quality at relatively low cost when compared to satellite imagery or aircraft-mounted sensors [10].

For 3D-modelling applications, light detection and ranging (LiDAR) is an appropriate technology for data acquisition. High-resolution DTMs derived from LiDAR or photogrammetry are preferred for their ability to capture fine-scale topographic features. Advancements in remote sensing and computational hydrology have expanded the range of available DTM datasets, from global open-access models (SRTM, ALOS World 3D) to locally derived, high-resolution products, e.g., DTM5G in the Czech Republic [Contribution 3]. Global models offer broad coverage but often lack the precision required for local flood studies, while high-resolution models may be computationally demanding or limited in spatial extent.

[Contribution 3] contains a comprehensive analysis of the impact of DTM accuracy on the results of 2D hydraulic flood modelling for discharges corresponding to return periods of 1, 5, 20 and 100 years. It was found that the differences in water levels obtained from hydraulic modelling due to DTM inaccuracy decrease as flood discharge increases, and that even minor local DTM differences can significantly affect the flow and influence upstream backwater effects over a large area. At the same time, missing terrain elevations may cause an underestimation of water levels in upstream areas.

2.3. Sediment Dynamics

A river cannot be separated from its sediment. Re-opening the main channel to floodplains causes water inundation, which results in changes in velocity and shear stress distributions. During floods affecting wider inundation areas, sediment deposition on the floodplain can be expected. At the same time, changes in sediment transport along the river can affect the rate of sedimentation of reservoirs located downstream. Both floodplain and reservoir geometry directly influence the distribution and sedimentation of transported solids [Contribution 4]. The influence of the geological and hydrodynamic characteristics of the region, including floodplains, on the distribution of sediments within the reservoir is evident. Studying sedimentary distribution in water reservoirs based on the morphology and hydrodynamic characteristics of the upstream river is essential to understand the depositional processes and develop sustainable environmental management strategies [Contributions 1, 3]. The management scenarios must be compared based on the simulated spatial patterns of erosion and deposition, with particular attention to the critical backwater zone. In this context, erosion hazard maps are useful tools [Contribution 5].

The papers presented here utilize both field monitoring and numerical sediment transport models to predict long-term morphological changes, ensuring that restored river reaches and reservoir deltas achieve dynamic equilibrium rather than experiencing excessive sediment accumulation.

3. Conclusions

The research compiled in this Special Issue underscores that successful floodplain reopening cannot rely on structural engineering alone. It requires a holistic, interdisciplinary approach in which river channel hydraulics and fluvial dynamics are used to forecast and guide ecological recovery. By restoring lateral connectivity, not only can flood risks for downstream communities be mitigated, but vital habitats can also be recreated, enhancing nutrient cycling and building resilient landscapes capable of buffering extreme droughts and deluges. Here, hydraulic and sediment transport analyses based on reliable and accurate representations of terrain morphology are essential.

The five studies highlight a shift in modern water resources engineering: the transition from static, empirical observations to high-resolution, physics-based numerical modelling and remote sensing. The papers collectively address how water interacts with its boundaries—whether causing erosion, depositing unwanted silt, or creating turbulent energy—and emphasize that the accuracy of engineering solutions depends heavily on the precision of the input data used.

The following table compares the core objectives, geographical focus, modelling tools, and primary outcomes of all five contributions, which focus on five rivers in five different countries.

Paper & Region	Research Objective	Technical Methodology & Tools	Key Practical Finding/Solution
Síňava Reservoir (Slovakia)	Mitigate reservoir storage loss due to heavy siltation.	2D numerical modelling and optical photographic granulometry.	Localized maintenance dredging is the most viable long-term solution.
Deschutes River (USA)	Objectively quantify whitewater rapid difficulty levels.	UAV photogrammetry, aerial LiDAR, and Specific Stream Power.	Both average and peak site SSP correlate strongly with whitewater grades.

Paper & Region	Research Objective	Technical Methodology & Tools	Key Practical Finding/Solution
Morava River (Czech Republic)	Evaluate how terrain model errors affect flood routing.	Comparison of three DTMs using 2D hydraulic models across return periods (Q_1 to Q_{100}).	DTM inaccuracies may distort results, such as during smaller flood discharges (Q_1).
Espora Reservoir (Brazil)	Track siltation dynamics threatening a hydroelectric plant.	29 sediment core samples, particle-size distribution, and depositional facies identification.	Sand deposition due to agricultural runoff is higher upstream, while fine silt and clay are deposited farther downstream.
Selška Sora River (Slovenia)	Standardize and improve floodplain erosion hazard mapping.	Integrated 2D hydraulic-sediment transport modelling via HEC-RAS software (version 6.4.1).	Coupling hydraulic variables with soil profiles removes empirical bias from erosion maps.

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Conflicts of Interest: The author declares no conflicts of interest.

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