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# Development and Calibration of a Hydrodynamic Model for Predicting Increases in the Height of the Water Column in an Urban River

Iubel, J.P.G.*, Braga, S.M.** and Braga, M.C.B.***

***Doutoranda – PPGERHA – UFPR. E-mail: julianapisag@gmail.com**
***** Professor Associado, DHS - PPGERHA – UFPR. E-mail: sergiombraga@ufpr.br**
**** Professora Titular Sênior, PPGERHA – UFPR. E-mail: crisbraga@ufpr.br**

**Highlights:**

- **In the Brazilian context, lacking rainfall data hinders flood forecasting.**
- **Site-specific models encompass the peculiarities of Brazilian hydrographic basins.**
- **The development and calibration of a site-specific hydrodynamic model can be an important tool in flood forecasting.**

**Keywords: Hydrodynamic modeling; Flood prediction model; Passaúna River –**

## INTRODUCTION

**Over the last decades, as a consequence of climate change, it has been observed an increase in the number and intensity of natural disasters related to flooding (Hirabayashi et al. ANO, Ionno et al., 2024). Another condition to emphasize is the intensification of flood events resulting from the occupation of riverbanks. It has been particularly evident in countries with tropical climate and high levels of social inequality, such as Brazil, as pointed out by Alcántara-Ayala (2002) and Leite et al. (2024). Furthermore, developing countries typically lack sufficient monitoring of precipitation and water levels in flood-prone areas, which are essential components of conventional flood monitoring (Degrossi et al., 2014).**

**Therefore, given the conditions described above, the development and calibration of models that require minimal data to predict water level increases in rivers prove to be important. According to Braga (2001), the development of site-specific mathematical models to represent the hydro-environmental characteristics of aquatic systems is fundamental for understanding the phenomena of the dynamics of these systems. The results obtained from water quality modeling provide conditions to understand specific characteristics of the river and facilitate the prediction of conditions associated with intense precipitation events.**

**As a result of this research a site-specific hydro-environmental mathematical model is presented, which was developed using an urban river basin in Paraná as a case study.**

## METHODOLOGY

**To develop this research, the Passauna River basin was chosen as a case study. This catchment occupies an area of 217 km2, and it is located in the state of Paraná, Brazil (SUDERHSA, 2002), as shown in Figure 1. To analyze water surface elevation in the Passaúna River, twelve upstream points of the Passaúna Reservoir were selected (Figure 1). Flow rates ranging from 1 to 3 $m^3/s$**

were selected to encompass precipitation events considered relevant for the research, based on prior knowledge of water level elevations in the Passaúna River (Grudzien, 2019).

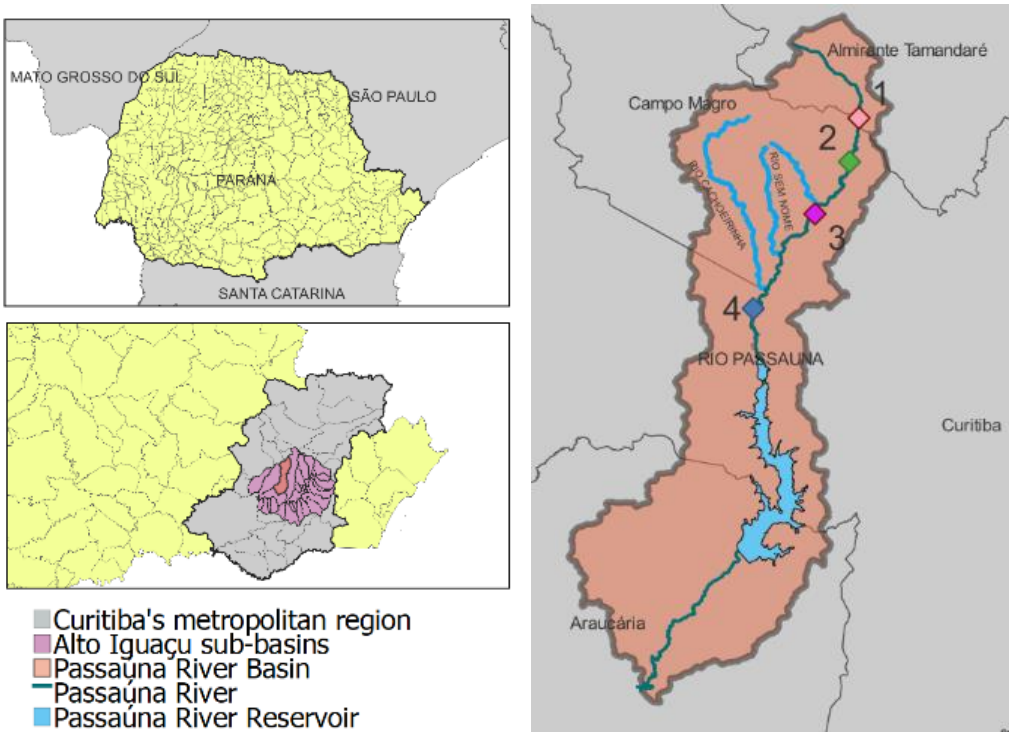


**Figure 1 – Passaúna River Basin showing the four monitoring points of IAT (2023)**

For the modelling exercise, a 1.82 km stretch of the river, located upstream of a water reservoir, was divided into 19 segments of 100 m each. The cross-sectional profiles of these segments were derived by interpolating bathymetric data from four monitoring points, provided by the Paraná Environmental Institute (IAT-PR) (as shown in Figure 1). This bathymetric data enabled the calculation of flow rates using the Manning equation, considering 8640 time-steps of 10 seconds each. Based on the mass balance, a new water volume was calculated for each segment after every time-step, resetting the calculation.

The resulting hydrodynamic model is one-dimensional, dynamic-deterministic, and grounded in mass balance principles. Model calibration was performed using data from stage-discharge rating curves from the four monitoring points.

## RESULTS AND CONCLUSIONS

After calibration of the Manning roughness coefficients, the model produced results aligned with those indicated by the IAT (2023) in the flow range, as depicted in Figure 2. This adherence to the rating curve defined by the IAT (2023) is an indicative of the hydraulic-hydrological model's well-

**functioning. Additionally, potential flood was observed at certain points along the Passaúna River's.**

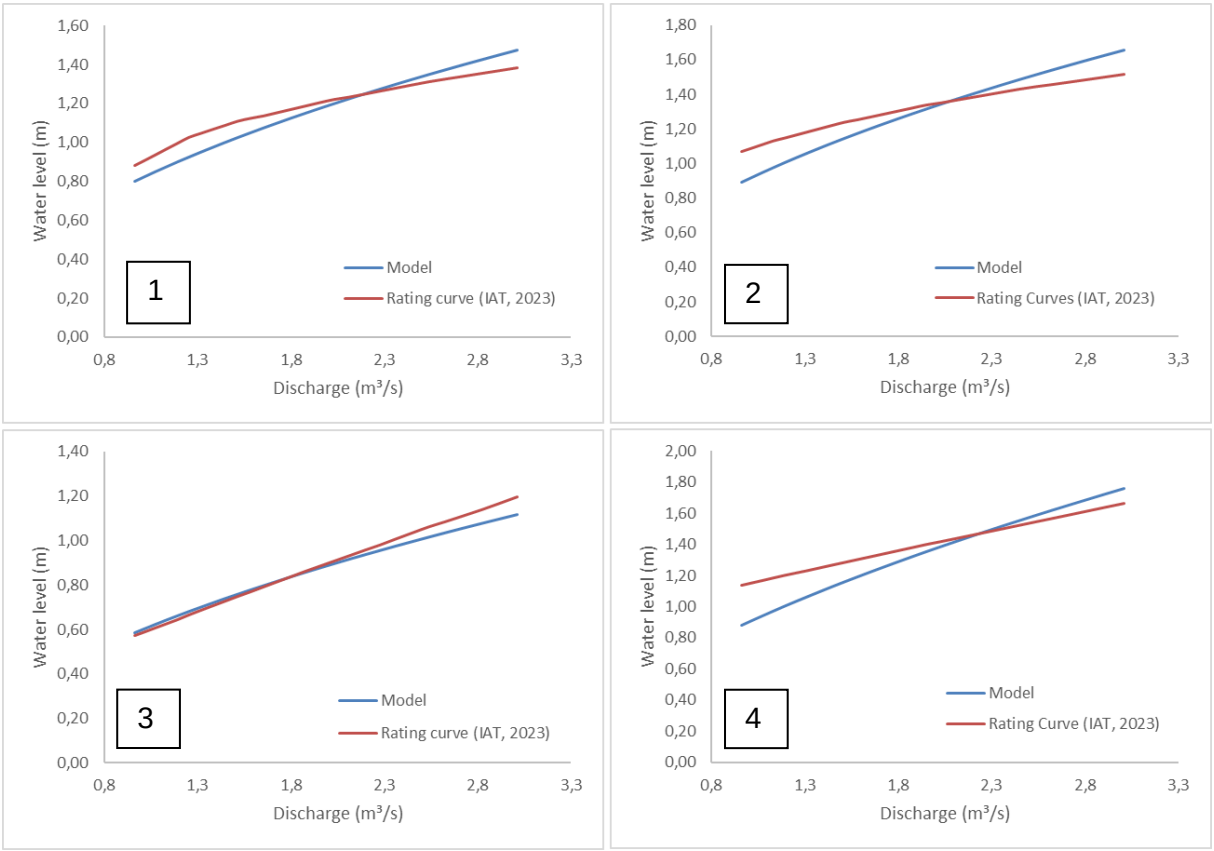


**Figure 2 – Comparison of model results and data by IAT (2023) for the four monitoring points**

**Thus, from the presented results, it is evident that the model produced values close to those provided by the IAT (2023), despite the considerable limitations in available data for model's development and calibration. Moreover, bathymetric data from cross-sectional profiles enabled the assessment of flood situations under different flow rates. Therefore, it is important to highlight that models specifically designed for Brazilian basins demonstrate promising outcomes, particularly when considering the country's unique characteristics in their development.**

**It is noteworthy that the obtained results suggest the developed model could serve as an effective tool for flood prediction in Brazil, not only in the Passaúna River. This is because model's adaptation is possible for various Brazilian rivers sharing similar hydraulic characteristics, relying solely on bathymetric, terrain topography, and key-curve information.**

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