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Analysis of the flood events in the upper Biała Lądecka basin 2024 up to the town of Lądek Zdrój

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Presentation outline

- Introduction
- Hydrological models
- Data
- Model set-up
- Results
- Summary, conclusions and further research

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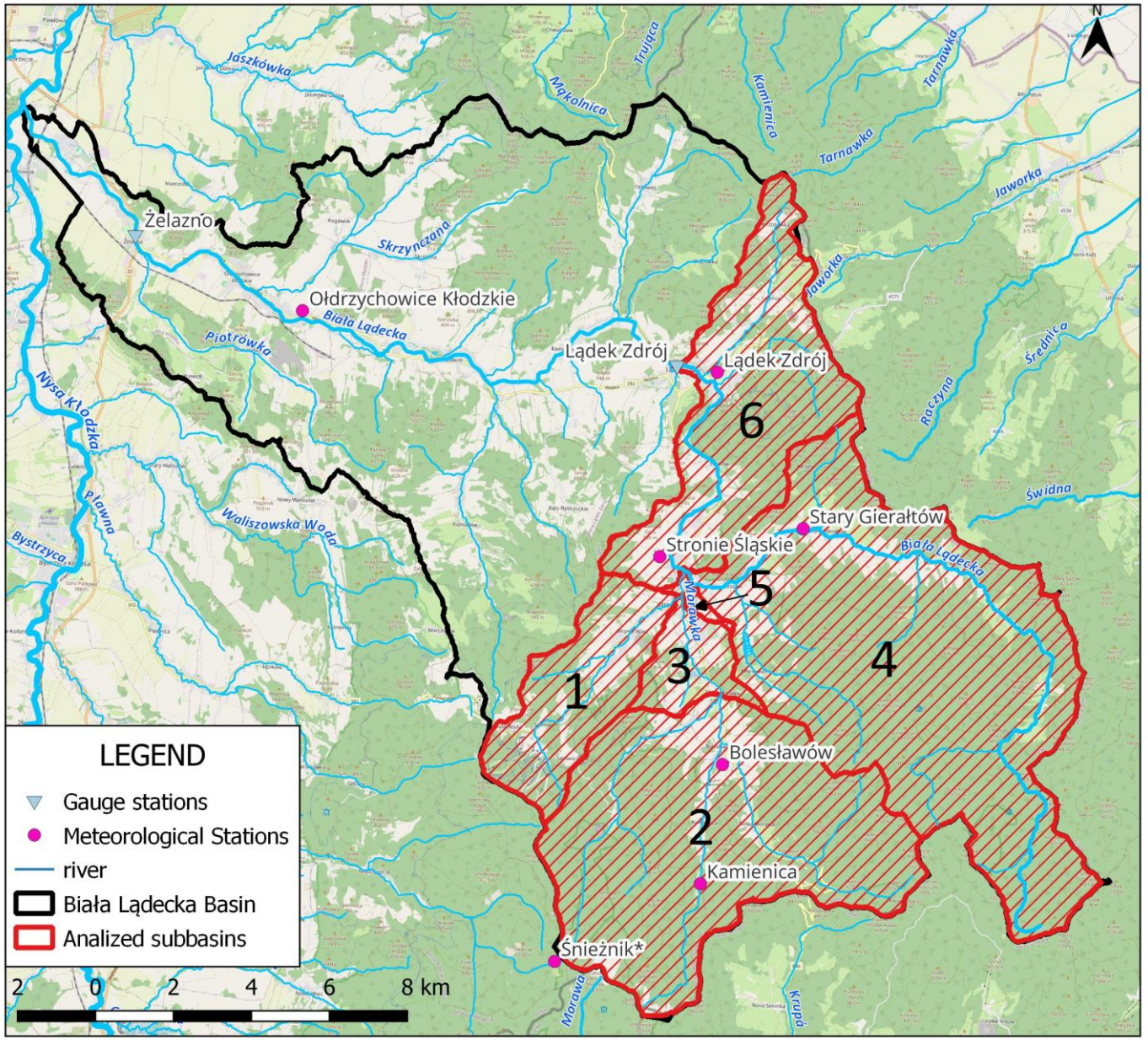

Biała Lądecka basin and the location of the analysed subbasins (in red).

Biała Lądecka river during the flood in September 2024.
Source: https://radio.rzeszow.pl/

Lądek Zdrój town after the 2024 flood. Source: https://www.reuters.com/

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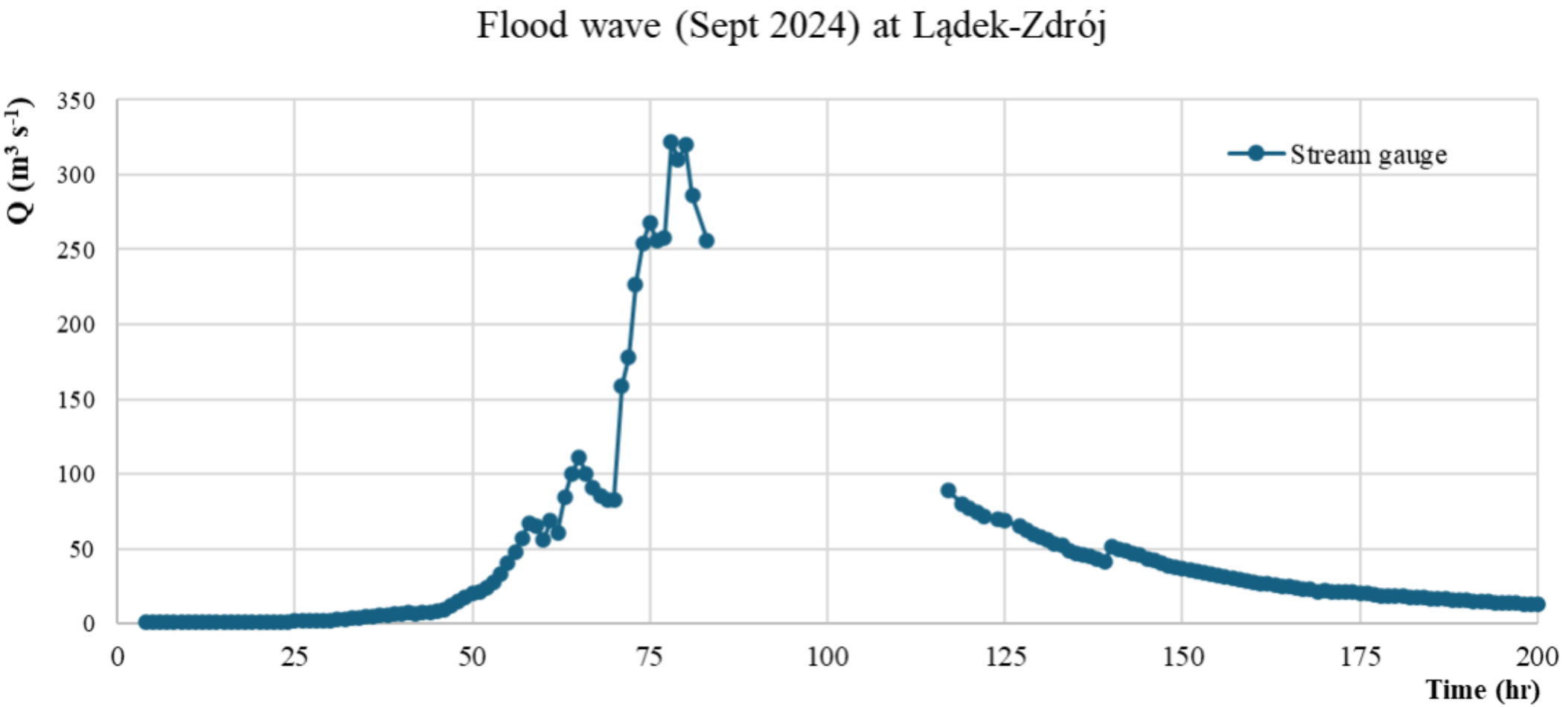

Hydrograph registered at the Lądek Zdrój gauge station during September 2024 (source: hydro.IMGW.pl)

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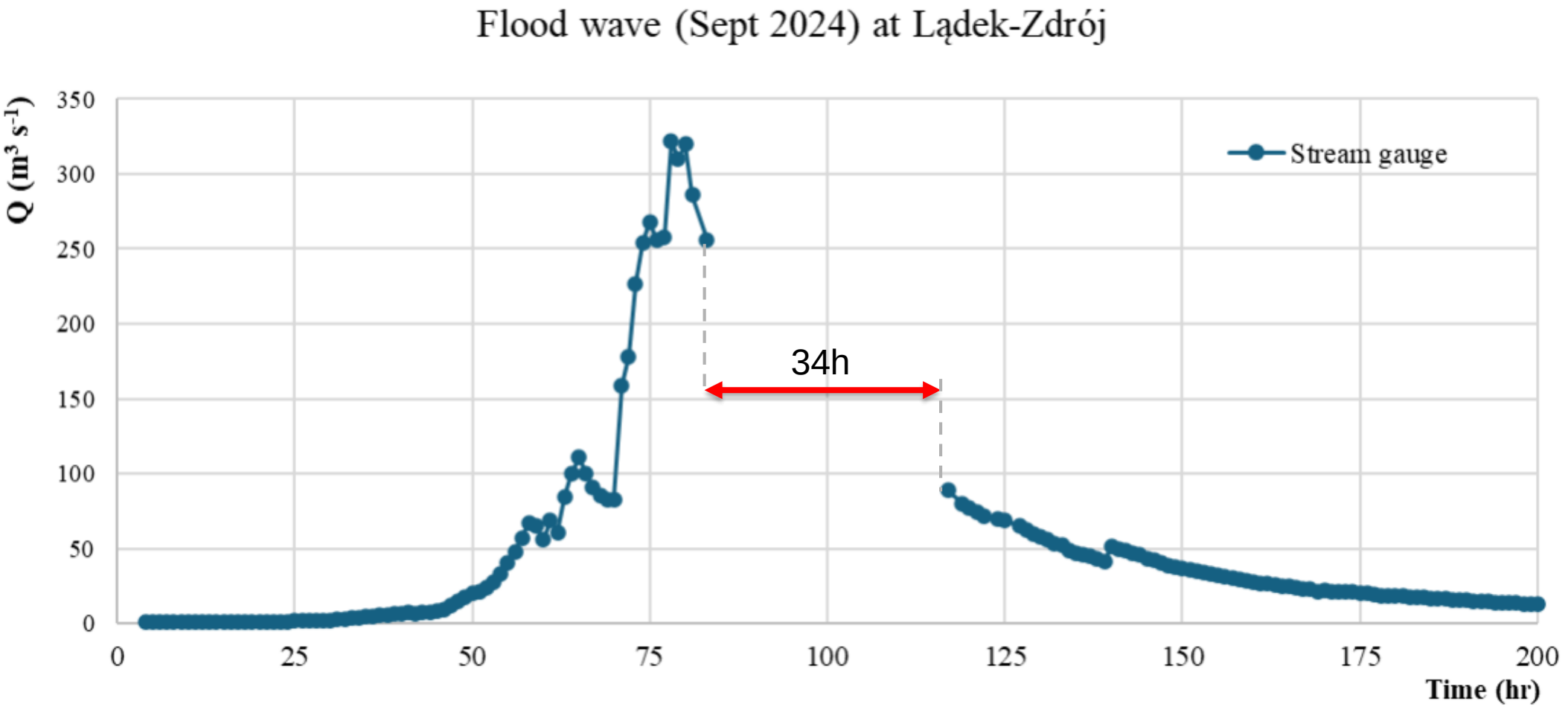

Hydrograph registered at the Lądek Zdrój gauge station during September 2024 (source: hydro.IMGW.pl)

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Hydrological models: rainfall-runoff model

$$P = I_a + F + Q \tag{1}$$

where: P is the total rainfall; I_a – initial precipitation loss before the onset of runoff; F – cumulative infiltration including I_a; Q – direct runoff. The initial precipitation can be estimated using equation 2:

$$I_a = \lambda \cdot S \tag{2}$$

where: λ is a regional parameter dependent on geological and climatic factors ($\lambda \in (0; 0.2 \div 0.3)$); S – potential maximum retention or infiltration. The latter parameter was determined by the SCS-CN model (eq. 3).

$$S = \frac{1000}{CN} - 10 \tag{3}$$

where: CN – (Curve Number) represent a numerical factor reflecting the soil's ability to retain water ($CN \in (0 \text{ to } 100)$). It depends on soil type, type of vegetation cover, land use ore treatment, hydrologic condition, antecedent moisture condition and climate of the watershed (Mishra and Singh, 2013).

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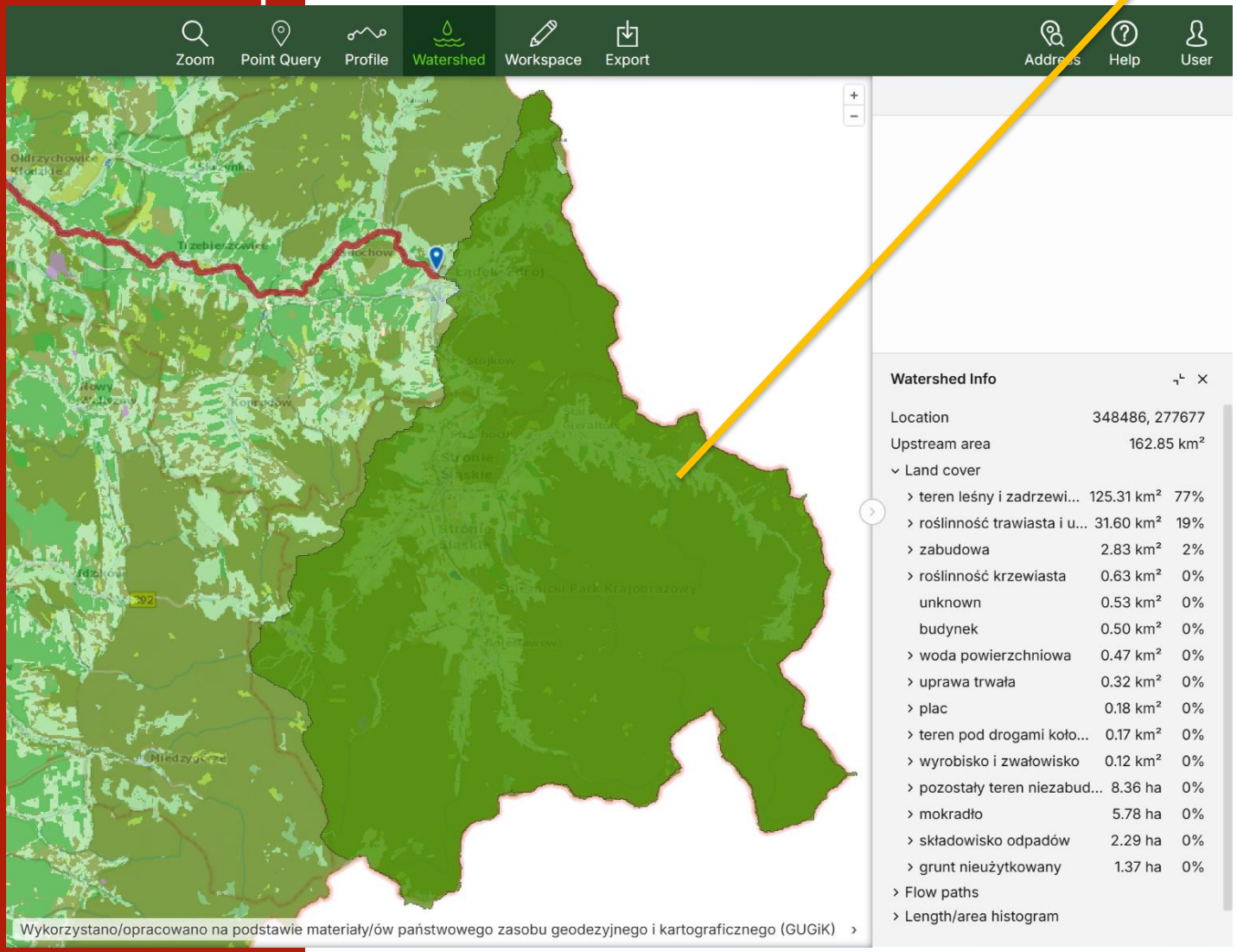
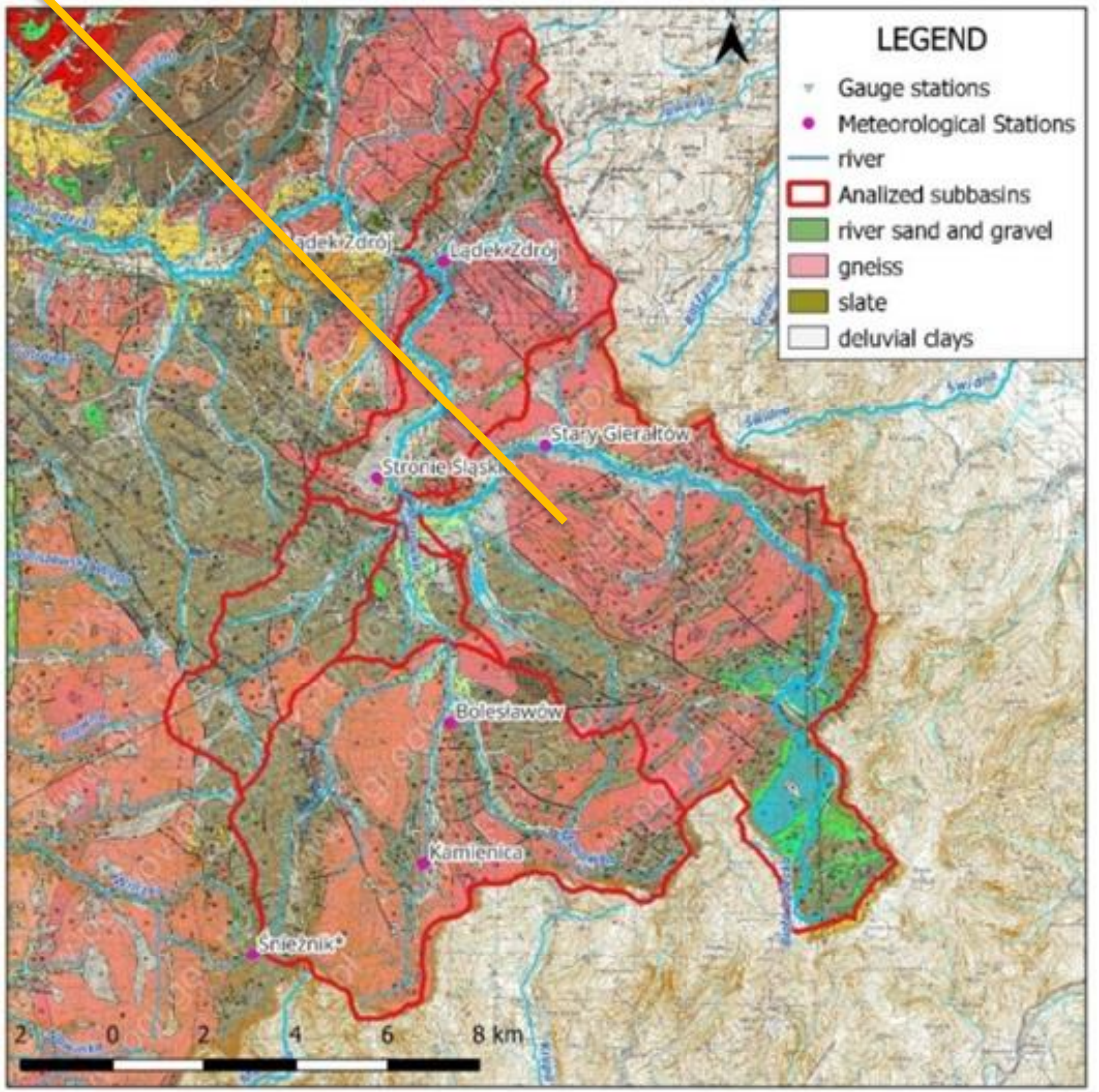
Curve Number (CN)





Land Cover map from BDOT10k and Geological map of the Biała Lądecka basin

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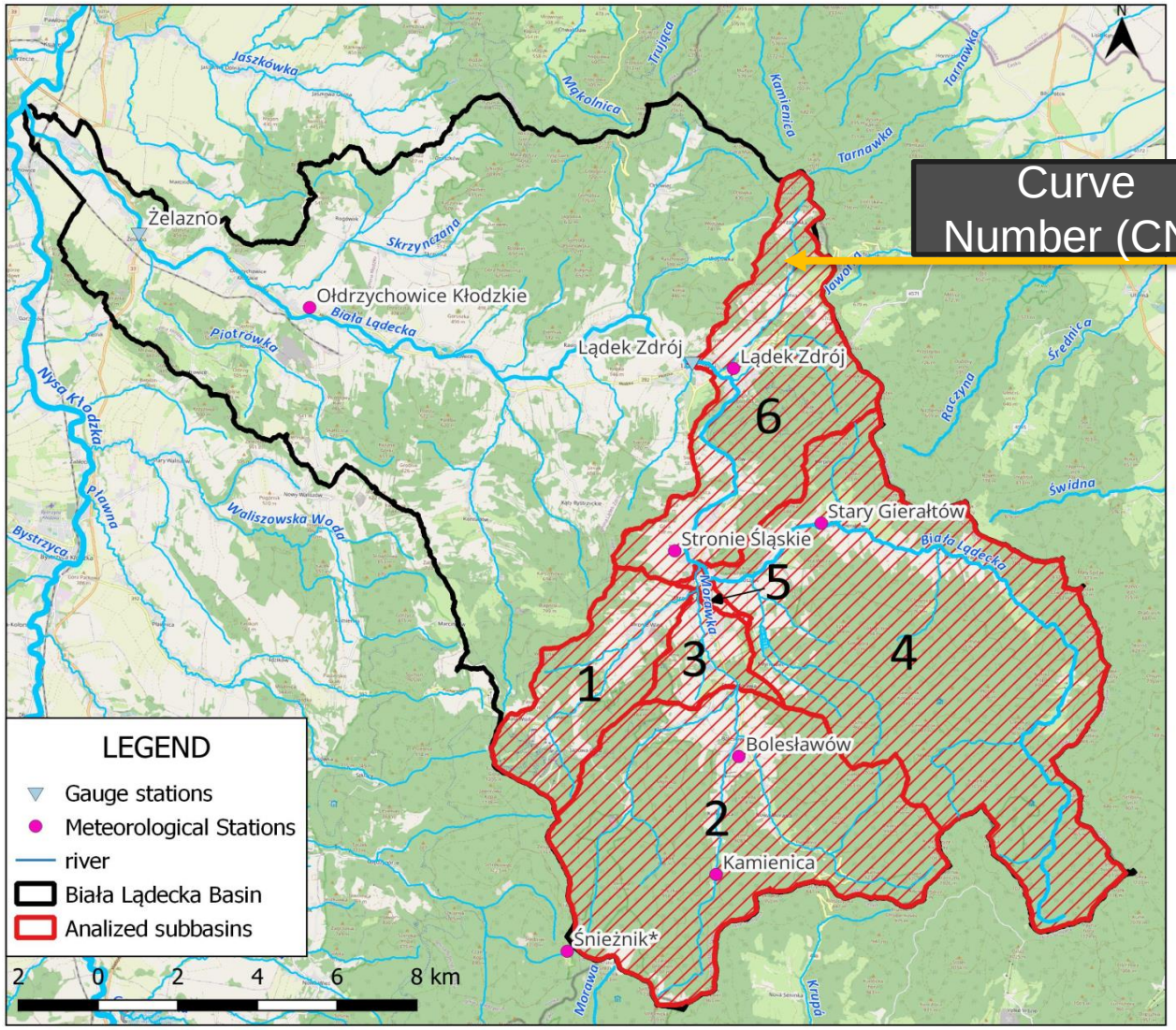

Table 1 Land use coverage according to SCALGO (2024) and CN estimation for subbasin 6

Landuse/Land cover	Hydrologic condition	Surface (km^2)	Surface (%)	Weighted CN (%)
Buildings		0.208	0.747	0.6874
Bush/shrubbery	Good	0.051	0.184	0.1566
Forest	Good	17.295	62.112	47.8260
Allotment	Good	0.116	0.415	0.3321
Squares		0.0516	0.185	0.1815
Other constructions		0.256	0.919	0.9007
Grass	Good	7.709	27.686	21.5953
Orchard	Good	0.0129	0.046	0.0366
Terrain as 'wheels type road'		0.0813	0.292	0.2861
Ground under technical ob.		0.030	0.109	0.1014
Wetlands		0.010	0.035	0.0344
Industrial/storage area		0.027	0.096	0.0893
unknown		0.012	0.043	0.0426
Cultivated land	Poor	0.604	21.692	1.9306
Flowing water		0.103	0.371	0.3639
Standing water		0.020	0.073	0.0712
Exploitation hollow, mines		0.048	0.172	0.1682
Shopping & service buildings		0.016	0.059	0.0557
Single-family buildings		0.605	2.172	1.9981
Industrial-storage buildings		0.073	0.263	0.2498
Multi-family buildings		0.111	0.400	0.3678
Coppices	Fair	0.209	0.751	0.4731
Woodlet	Fair	0.195	0.701	0.5540

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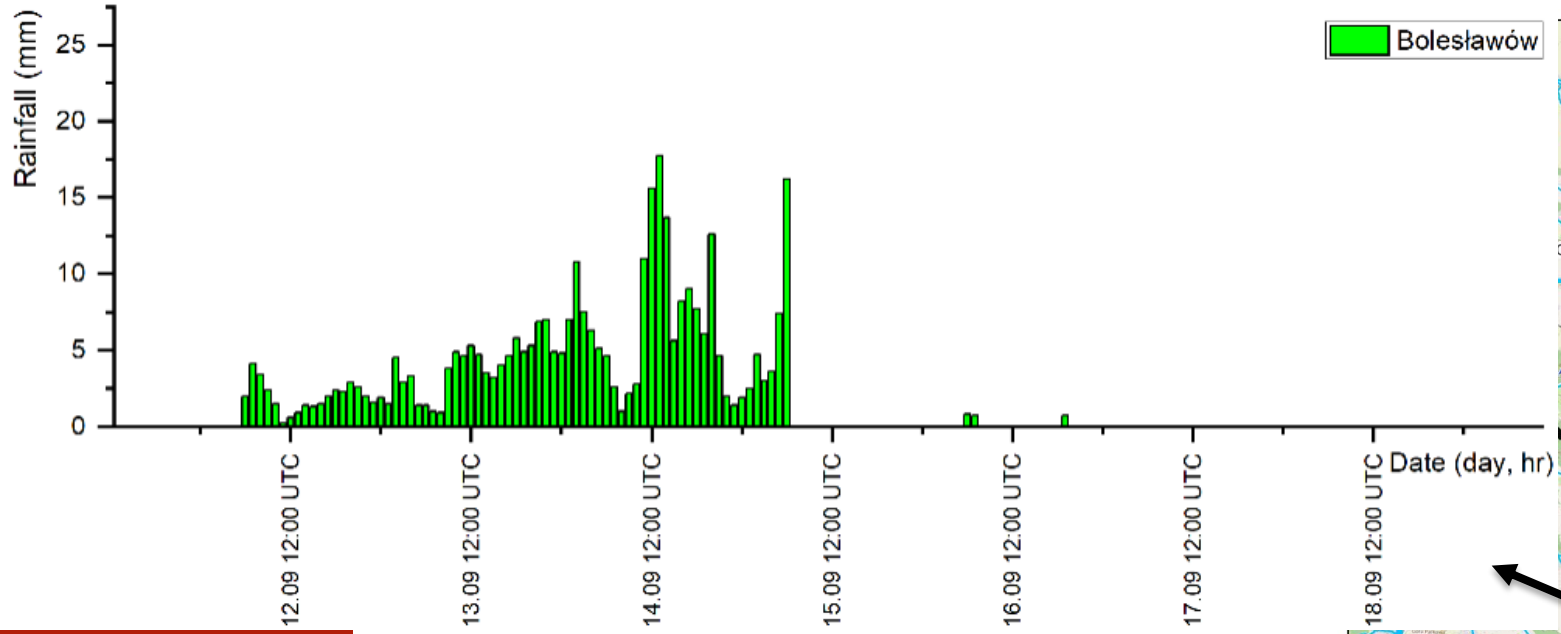
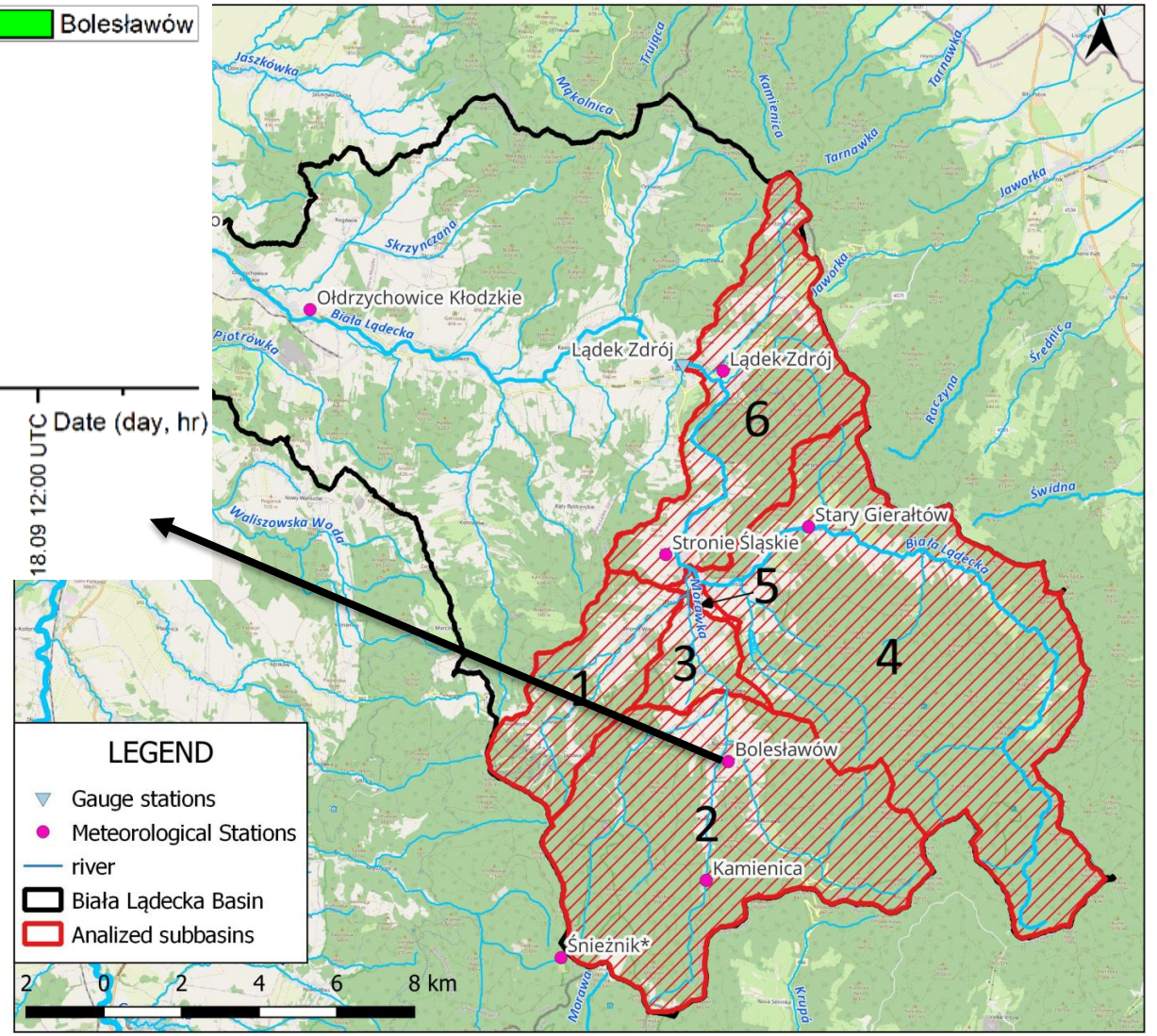
Registered hyetograph at Bolesławów during September 2024 (source: meteo.imgw.pl)





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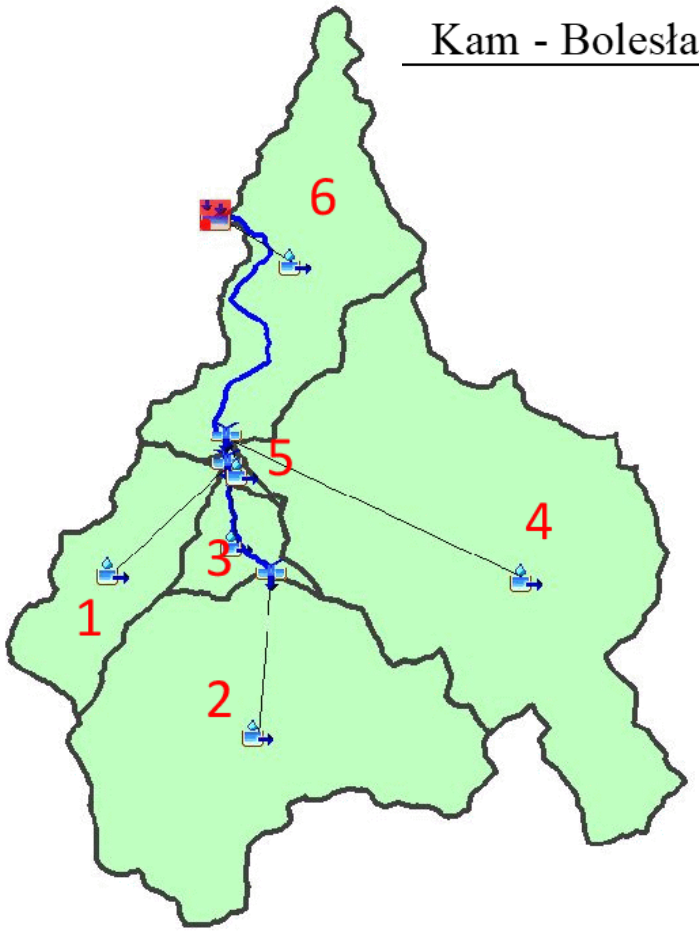
Subbasin name (ID)	Longest path (m)	Estimated CN value (-)	Average slope (%)	Y - Average slope (m/m)	Lag tim (min)
Lądek Zdrój (6)	10017.91	78.50	20.56	0.2056	71.98
Stary Gierałtów (4)	27497.63	70.82	25.69	0.2569	180.01
Outlet Morawka (5)	930.64	72.40	8.20	0.0820	20.33
Western Morawka (1)	9958.46	78.10	24.43	0.2443	66.52
Stronie Śląskie Res. (3)	3590.32	72.60	17.43	0.1743	40.82
Kam - Bolesławów (2)	12315.85	77.56	30.38	0.3038	71.87



Lag time

$$t_1 = \frac{\ell^{0.8}(2540 - 22.86CN)^{0.7}}{14104CN^{0.7}Y^{0.5}} \quad (4)$$

where: t_1 – catchment lag time [h]; ℓ - longest runoff path [m]; Y – average catchment slope [m·m^{-1}]. In Table 2, these parameters are summarized for the six subbasins. These parameters were determined using GIS.

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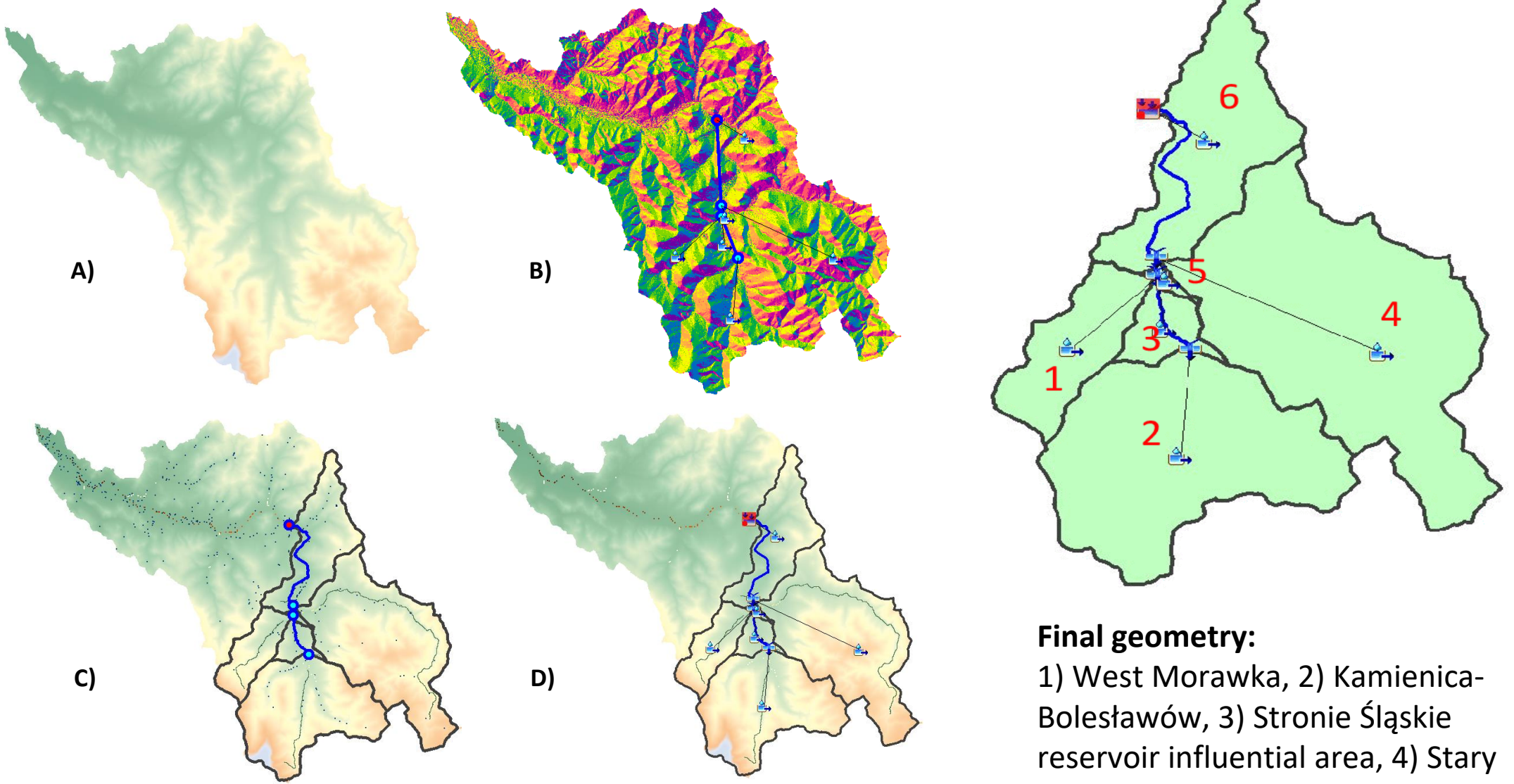
Geometry set-up in the numerical model using GIS data.



A) Biała Lądecka Digital Elevation Model; B) Flow direction calculated using GIS; C) GIS identified sinks and D) Preliminary geometry.

Final geometry:

1) West Morawka, 2) Kamienica-Bolesławów, 3) Stronie Śląskie reservoir influential area, 4) Stary Gierałtów, 5) River Morawka outlet, 6) Lądek Zdrój upper basin

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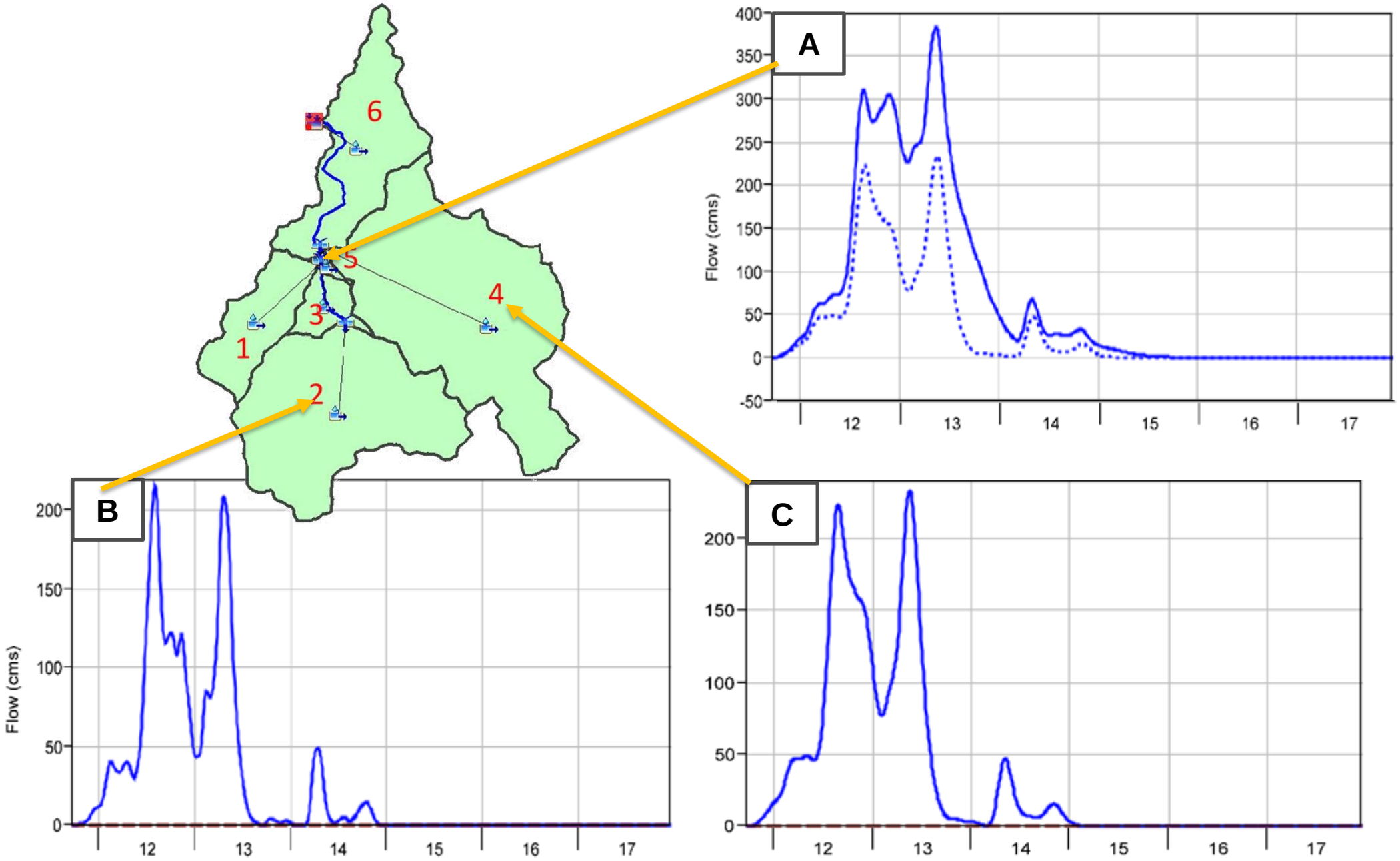

Simulated hydrographs: A) Morawka river outlet; B) Subbasin 2 “Kamienica – Bolesławów” and C) Subbasin 4 “Stary Gierałtów”.

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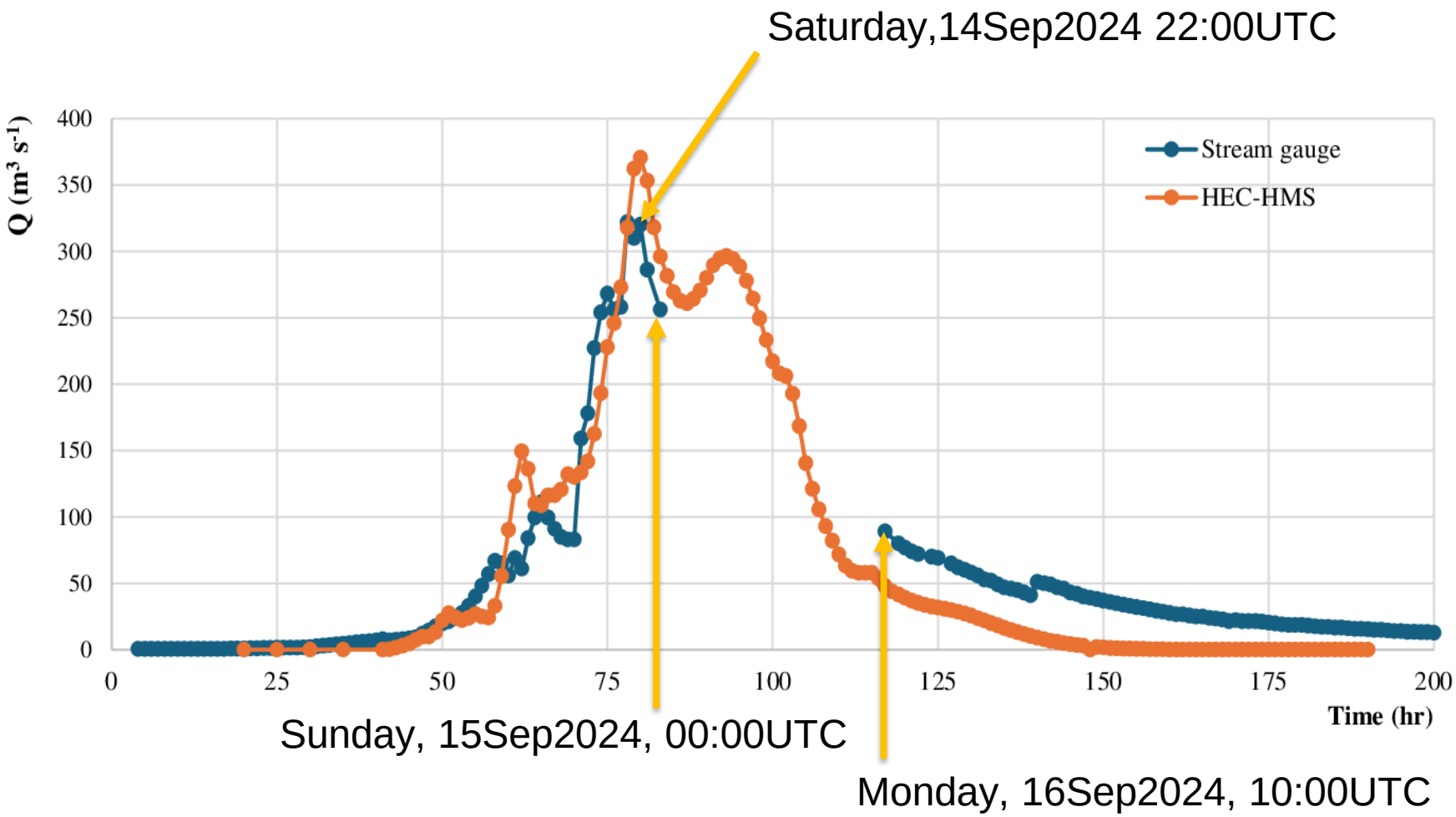

Comparison of the recorded data with the numerical model output

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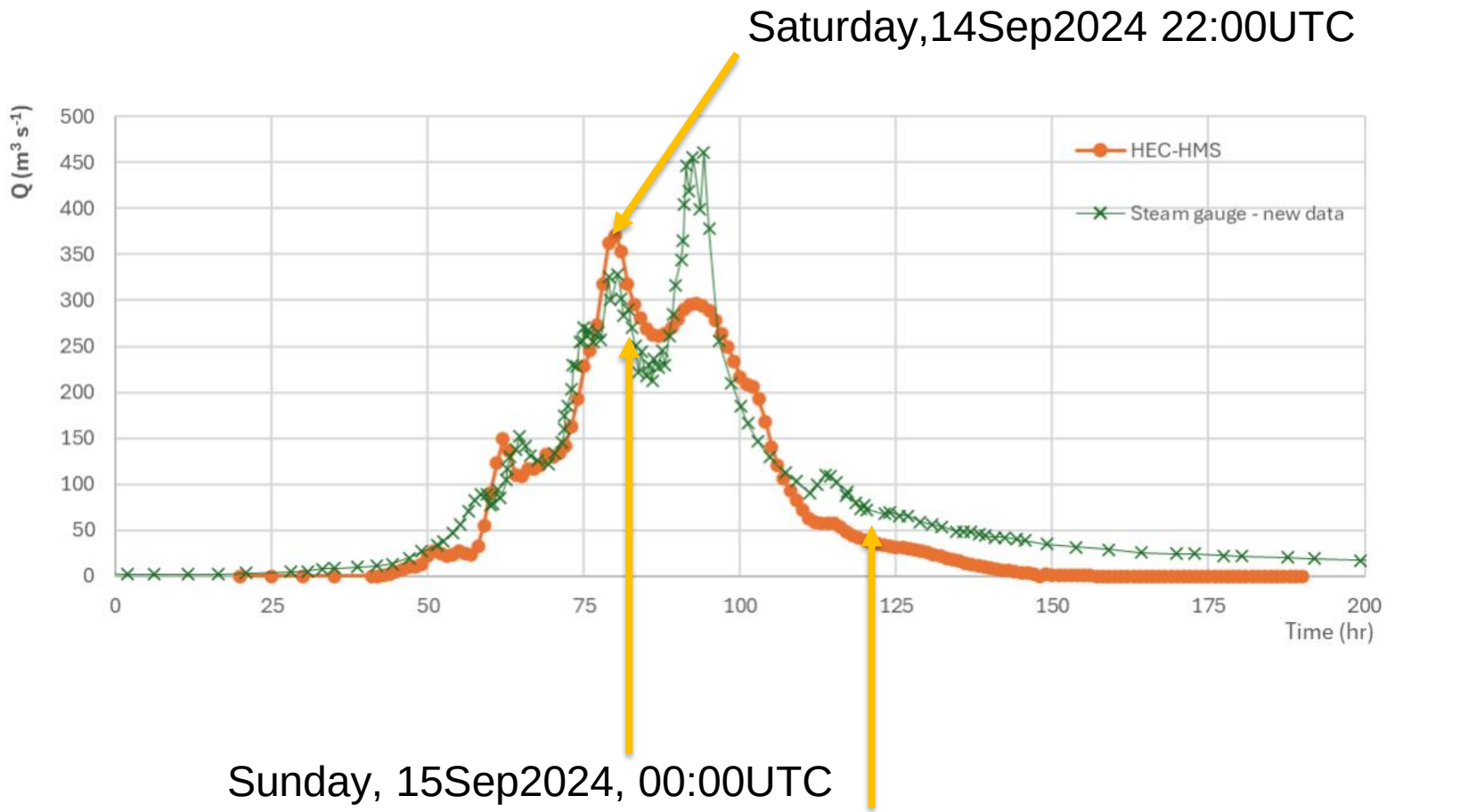

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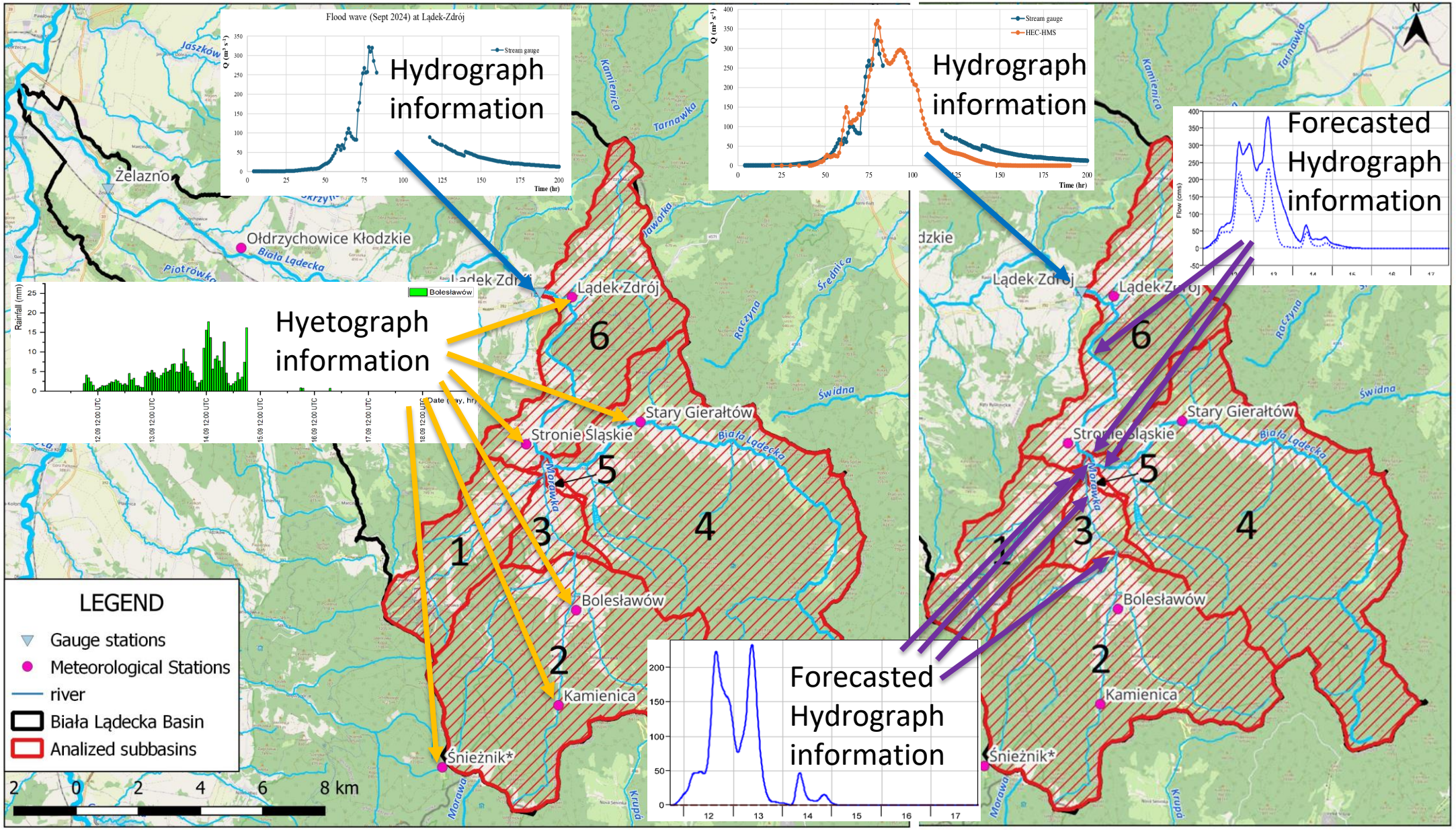
Summary & Conclusions



Biała Lądecka subbasin (before modelling) and after modelling.

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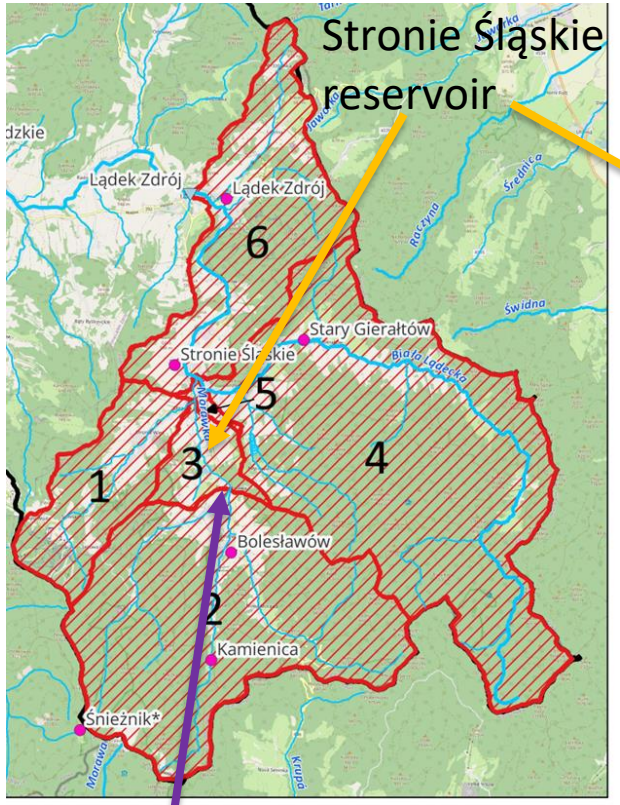
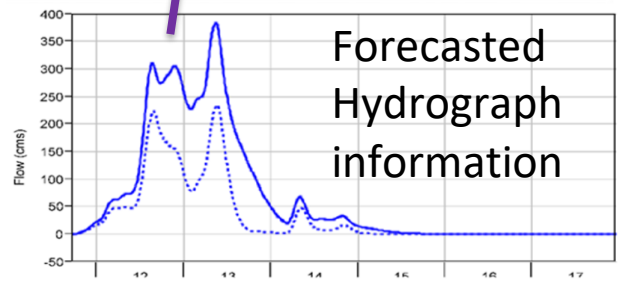
Further Research

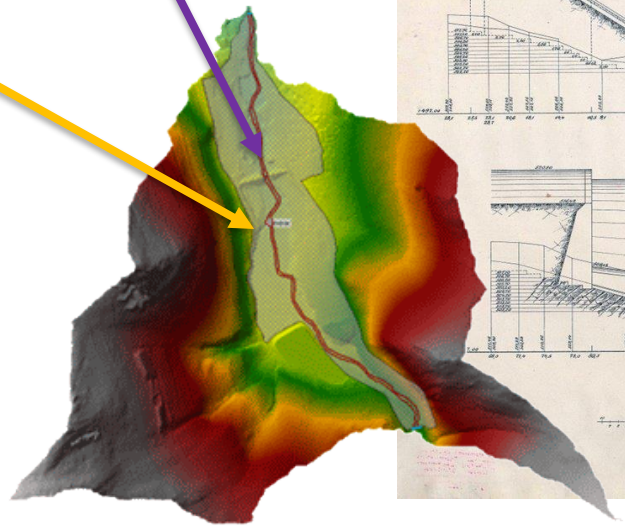


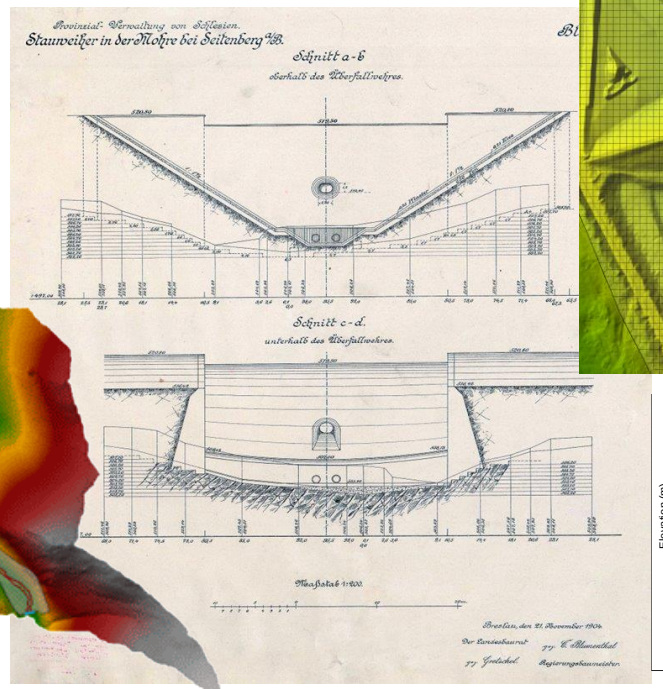


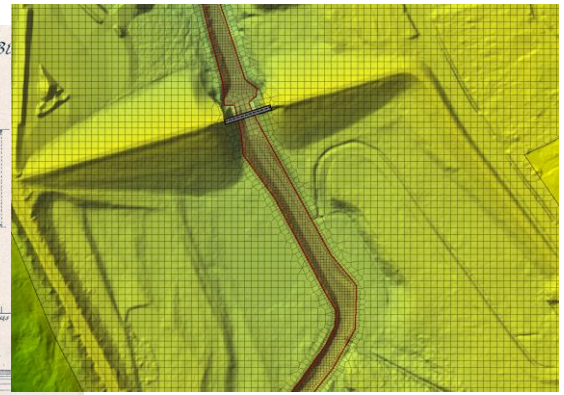
Forecasted Hydrograph information

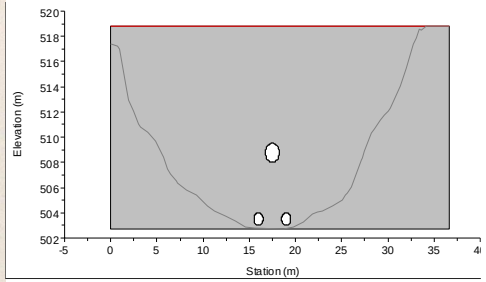
Information for hydraulic routing analysis (2D modelling)

Expected hydraulic routing analysis



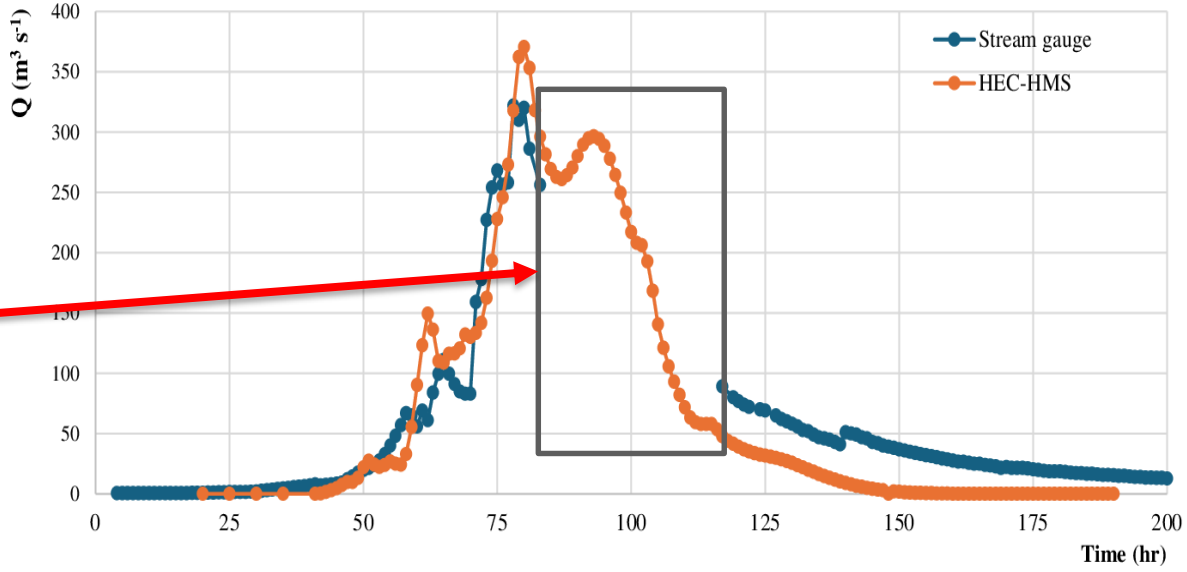






Could the 2D model solve our main research doubt (slides 5, 13 & 14)?

We are working on it!!



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Summary, Conclusions & Further Research

- forecasted hydrograph of flood wave in Lądek Zdrój
- second peak in the forecasted flood wave
- plan of examine the impact of the reservoir
- more complex hydraulic routing methods
- check another hydrological models
- carry out more accurate rainfall simulation

AI generated with Copilot

Source: www.willamarianna.pl/(left); Fot. Michał Ryniak / Agencja Wyborcza.pl (right)

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Thank you for your attention

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