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# VERIFICATION OF THE PEAK FLOW RATES OF THE JULY 1997 FLOOD IN THE UPPER AND MIDDLE ODRA RIVER

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**ABSTRACT**

**Aim of the study**

This paper presents a verification of peak discharges (maximum flow) of the great flood that took place in July 1997 on the Odra (Oder) river, for the section between Racibórz and Słubice.

**Material and methods**

The carried out analysis included a review of hydrological and morphological data, GIS analysis, extensive hydrodynamic two-dimensional modelling, and determination of rating curves for gauging stations.

**Results and conclusions**

It has been found that previously published peak discharges for the 1997 flood need to be altered to a significant extent. For instance, the maximum discharge in Wrocław is estimated to have reached ca. 3900 $m^3 \cdot s^{-1}$ versus 3640 $m^3 \cdot s^{-1}$ as previously believed, while for the upstream Nysa Kłodzka station, the maximum discharge estimate had to be raised from 3530 $m^3 \cdot s^{-1}$ to 4300 $m^3 \cdot s^{-1}$. On the other hand, for the section below Ścinawa station, the peak discharges were significantly overestimated, even by 1000 $m^3 \cdot s^{-1}$, which is up to 50% of the actual flow. The determined values are hydrologically and hydraulically consistent, i.e. following the law of flow continuity, considering tributary supplies, flood bank breaches, and retention capacity of the river valley.

**Keywords:** the Odra river, the July 1997 flood, peak discharge, rating curve, 2-D hydrodynamic modelling

## INTRODUCTION

The catastrophic flood in July 1997 in the Odra river basin, referred to as the 1000-year flood, was the single most important and most dangerous flood event in this region of Poland in the last century. Reliable quantitative data on this flood constitute a particularly important element of hydrological knowledge. They are the basis and a reference point in water planning and water management, especially in terms of flood risk management and in view to making decisions about investment solutions in this area.

After the flood, there were various estimates – with significant differences – as to the value of its maximum flows, especially in relation to the Wrocław Floodway System (WWW). Later on, it was this particular location that focused the majority of the researchers' attention, along with significant financial resources invested in flood protection (under the Odra River Basin Flood Protection Project). The Institute of Meteorology and Water Management (IMGW) in the Monograph of July 1997 Flood (hereinafter referred to as the Monograph, Dubicki et al., 1999) determined the maximum flow ($Q_{max}$) in the Trestno gauging station

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at the value of 3640 $m^3 \cdot s^{-1}$, and in the Brzeg gauging section, which is located more upstream, at the value of 3530 $m^3 \cdot s^{-1}$. Similar values were reported earlier also by Radczuk et al. (1998). On the other hand, according to Czaban et al. (1998), the maximum flow at the WWW entry could have amounted to as much as 4500 $m^3 \cdot s^{-1}$. Some doubts about the values of peak flows assumed in the Monograph arose during the work that this author conducted, including hydraulic modelling, pertaining to the development of flood risk maps for the Odra River during the project "IT System of the Country's Protection against extreme hazards" (ISOK). Further doubts were raised by the Polish Hydrologists Association during the assessment of peak annual flows and designated flows with a given probability of occurrence for the Central Odra river, as part of the update of flood risk maps in 2017–2020 (Wałęga et al., 2017).

Immediately after the flood in July 1997, the possibilities to determine the exact peak flows were limited. This was simply due to the scale of the flood. The water exceeded the previously observed levels, and there have been numerous breaks in the flood banks or water overflowing them, causing the flow to take place across the entire, extensive valley of the Odra river. Water level readings on some water gauging stations during the flood wave's peak have become impossible due to their flooding, destruction, or lack of access. The flow rate measurement was even more difficult (Wdowikowski, 2017). A number of measurements were made using traditional current meters, but not during the peak of the wave. The subsequent determination of $Q_{max}$ had to be based on estimates and extrapolations. While using extrapolation of the water level-flow correlations presented by means of flow rate curves (KNP) for water gauging stations, it was not possible to obtain certain and reliable results for the ranges going far beyond the existing measurements. Furthermore, in the case of the flow passing through the whole river valley, such correlations are extremely difficult to determine. Along with a substantial increase in the flow rate, the increase in the ordinate of the water table may be small; the ordinate can even decrease as a result of the break in flood banks. Good examples of such situations include observations in the water gauging stations at Koźle, Brzeg, Trestno, and Brzeg Dolny.

Since then, however, circumstances occurred that allowed for a renewed analysis of the flow of flood waters in the Odra river valley, and one that was based on better foundations. Firstly, in May 2010, another great flood occurred on the Odra river. This flood event had been relatively well documented, and it provided many valuable hydrological and hydraulic data on the channel capacity and flood propagation. These data are all the more valuable as they fill the large gap between the flood in 1997 and the previous data. Secondly, as part of the ISOK project, in 2012, a numerical terrain model (NMT) was designed to detail the shape of the river valley. The new topographic data and the GIS tools made it possible to construct new numerical tools, i.e. hydrodynamic one- and two-dimensional models, covering the entire Odra river valley. Combined with the IT technologies development, these models enable a more time-efficient and more accurate flow simulation and determination of the state-flow correlation for particular water gauging stations and beyond.

The present study started with the analysis of flood flow in the Wrocław Floodway System (WWW), beginning with the verification of the distribution of flows during the flood in May 2010, along with the calibration of two-dimensional models necessary to elaborate flood risk maps in Wrocław (Banasiak, 2017). As a result, simulation tools were obtained – two-dimensional models for the WWW, in two versions: before modernization and after modernization. As a result of these works, it was determined, *inter alia*, that the peak flood flow in 1997 in the Trestno water gauging station should be verified, as well as the flows on the Odra river sections above and below it.

## THE BASIS FOR THE VERIFICATION OF PEAK FLOWS

In order to verify the peak flood flows in July 1997, the following information, data and tools were used:

- The General Strategy ... (IMGW, 1998), Flood Monograph (Dubicki et al., 1999), other publications;
- Results of hydrometric measurements of flood flows (IMGW, Hydrological Forecasting Office – BPH);

- Hydrographs of water levels for water gauging stations (same source as above);
- Relationships of the water level and flow rate (rating curves) for water gauging stations (same source as above);
- Inundation areas, photographic documentation, including materials from the press and the Internet;
- Levee breach locations (source: The General Strategy, 1998, a report being part of the Preliminary Flood Risk Assessment, IMGW, 2011);
- Numerical terrain model;
- ArcGIS geospatial analysis computer environment;
- Two-dimensional (2-D) hydrodynamic models.

An important element of the analyses were the hydrodynamic calculations of two-dimensional models implemented using the MIKE21 software. These models are based on a regular computational grid with a single cell size of 5 m × 5 m. Individual models include 20–30 km long sections of the river, forming a continuous cascade for the entire analysed Odra river, where neighbouring models overlap to a certain extent. It is important for the analysis that the water gauging stations in these models are positioned far from the boundaries of the model, i.e. outside the influence of boundary conditions. An example of such a model is presented in Figure 1 in the form of a resultant water depth raster for the river section including the water gauging station at Krapkowice.

Roughness coefficients have been defined on a grid identical to that of computational bathymetry, and their spatial distribution, i.e. land cover, was imported from topographic databases. Individual classes, such as forests, meadows, arable land, shrubby areas, and so forth, have been assigned specific values. For the main channel of the Odra river, the Manning roughness coefficient value was adopted in the range 0.026–0.029 $m^{-1/3} \cdot s$. This range is based on field studies of the flow resistance of the Odra river during floods (Banasiak and Krzyżanowski, 2015a).

All models underwent the calibration stage, in which the assumptions of roughness coefficients and geometric mapping of the riverbed were verified. The correctness of calculations made using the two-dimensional model – at least for the section below the water gauge – and that model's predictive value is deduced here on the basis of the comparison and compliance of the results of calculations with the results of flow intensity measurements during particular flood events (see: Fig. 2–4). Based on the simulation, rating curve was obtained, which together with the results of hydrometric measurements, in particular the verified results for the flood in May 2010 (Banasiak and Krzyżanowski, 2015b), and the approximate flow rate curve, makes it possible to determine the flow for the maximum level $H_{max}$ during the floods in July 1997 for selected cross-sections.

In order to determine or verify the KNP in the water gauging stations, various calculation scenarios were implemented, both for the steady and the unsteady flow, i.e. for flood waves with a given peak flow and duration. The calculations for the actual flood of July 1997 have not been carried out because that would be computationally very time-consuming and difficult, due to the resulting breaches in the flood banks and subsequent modernization thereof. In addition, it is impossible to provide enough accurate flow hydrographs for this particular flood, the duration of which was extremely long.

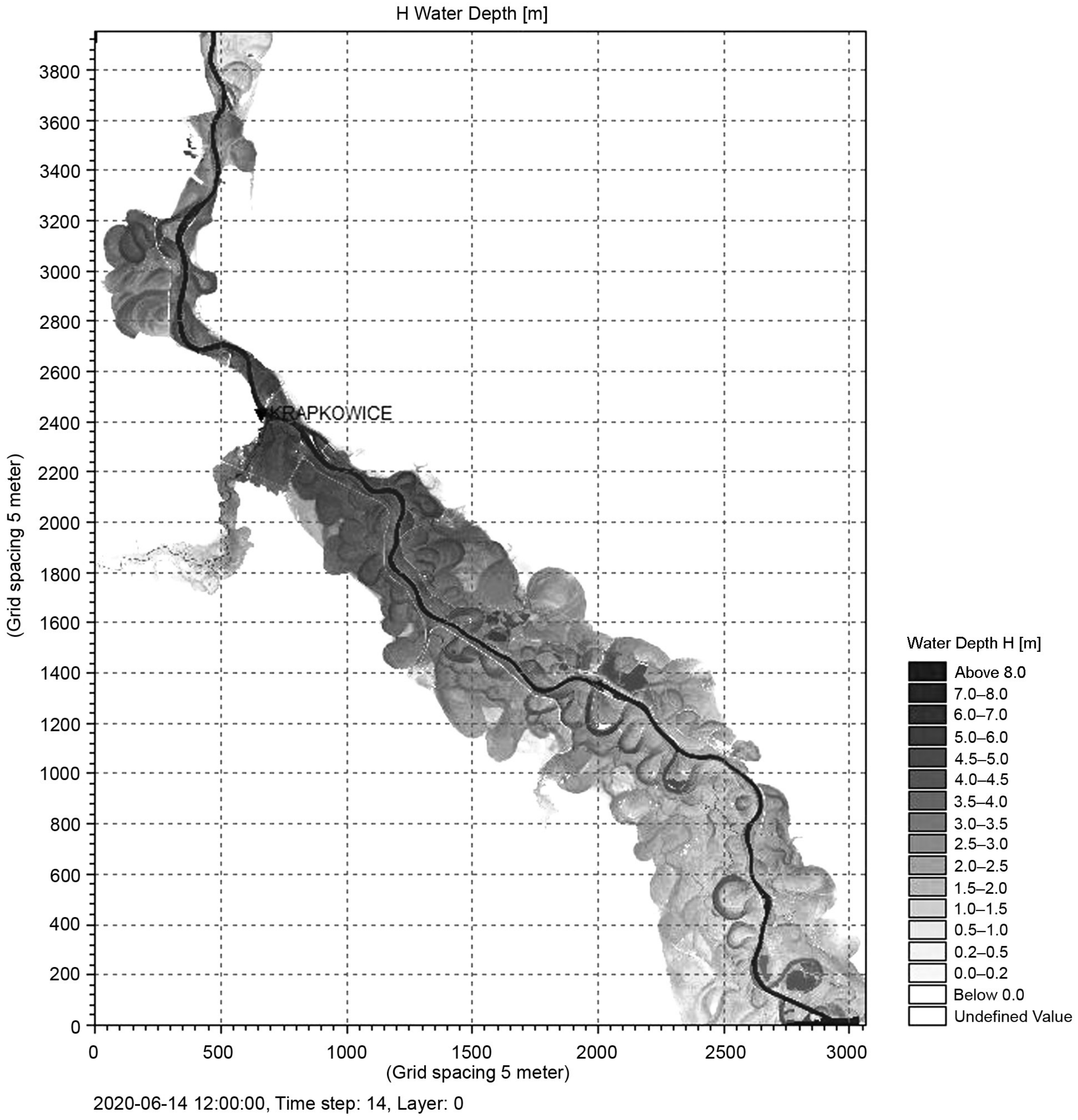


**Fig. 1.** A 2-D simulation result for the Odra river near Krapkowice gauging station, $Q_{max} = 3500 \text{ m}^3 \cdot \text{s}^{-1}$

## PEAK FLOWS IN GAUGING STATIONS

The verification of peak flood flows in 1997 for the Odra river, from the border with the Czech Republic to the city of Wrocław, can be best performed for two gauging stations, namely Racibórz and Krapkowice. In these particular gauging sections, the flood water was spatially limited. In the case of Racibórz, the barrier for the flood zone was the right-side flood banks, which was not drowned or breached. In turn, the Krapkowice gauging station is located on a section of a river with a naturally narrowed valley. For these cross-sections, the KNP can be determined relatively accurately and reliably. In other cases, that is in water gauging stations at Chałupki, Krzyżanowice, Koźle, Opole, mouth of the Nysa Kłodzka river, Brzeg, Oława, and Trestno, this is very difficult – as already mentioned, due to their location in relation to the complex development and nature of water flow in the wide valley, and compounded by numerous breaches of the flood banks. The correctness of determining these curves for the 1997 event could easily be called into question here.

Figure 2 presents the rating curve for Racibórz and Krapkowice water gauging stations in the form of: hydrometric measurements, a curve approximated by the Office of Hydrological Forecasts IMGW-PIB, and simulation results using the 2-D model. For these particular water gauges, the approximation of KNP in the upper discharge zone is not correct. Approximation and extrapolation in this, as well as in many other rivers, is problematic in the absence of the results of hydrometric measurements, or significant discrepancies therein, as they are sometimes inaccurate or incorrectly described. In the case of Racibórz, extrapolation of this curve to the ordinate of $H_{max}$ = 1045 cm produces an exceedingly high value of $Q_{max}$, above 3600 $m^3 \cdot s^{-1}$. The relationship between the water level and discharge can be better represented here by the results of numerical calculations, which indicate

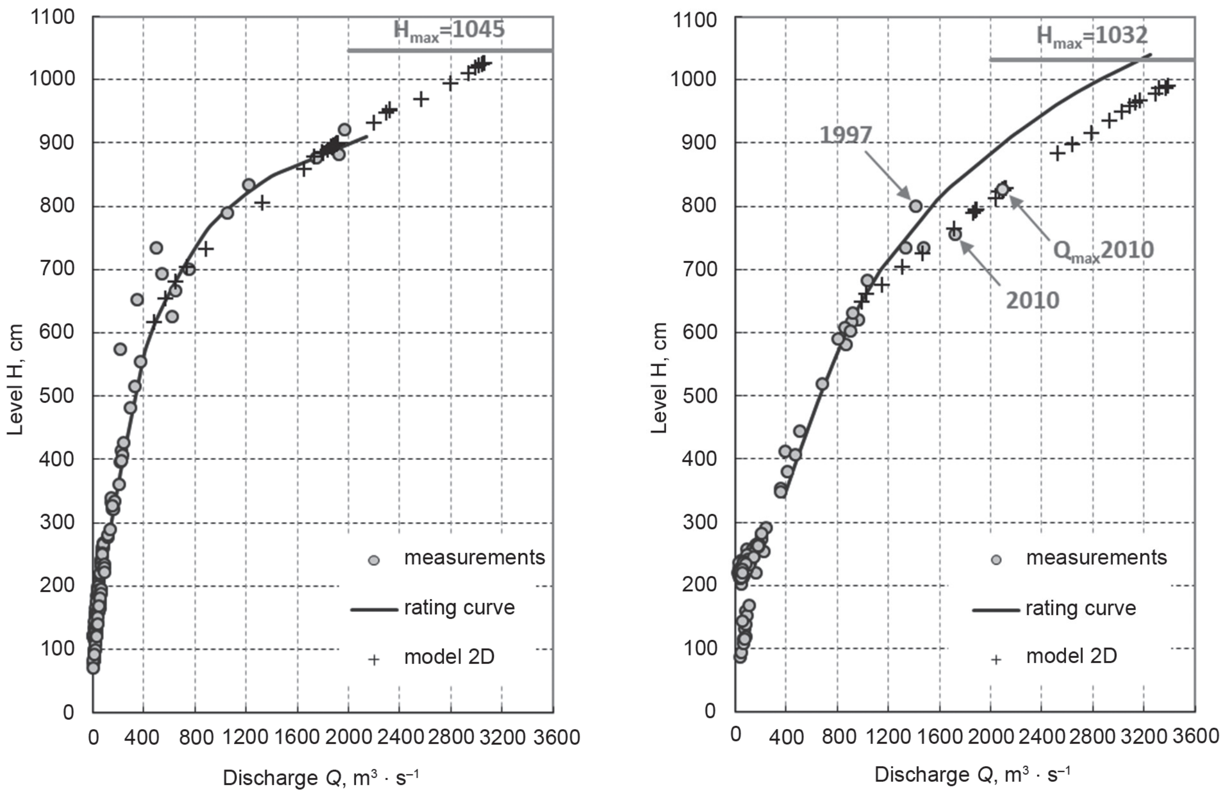


**Fig. 2.** Water level – discharge relation for gauging stations: a) Racibórz-Miedonia, b) Krapkowice

that the flow at $H_{max}$ was about 3200 $m^3 \cdot s^{-1}$, which basically confirms the previously published value of 3120 $m^3 \cdot s^{-1}$. In turn, in the case of Krapkowice (see: Fig. 2b), the measurement result in 1997 significantly differs from the actual trend; this particular measurement probably did not include the total discharge in this gauging station. Similar conclusions were reached (after consultation with the PSHM measuring team) in the measurement of floods in 2010, resulting from the lack of measurement of a part of the discharge over the road flood bank on the right-side flood terrace (Banasiak and Krzyżanowski, 2015b). The verified flood flows in 2010, that is the measured discharge and peak discharge in this and the neighbouring water gauging stations in Opole and Koźle, confirm the KNP for Krapkowice obtained from the 2-D model calculations. The almost straight-line nature of the curve in the upper range results from the narrowing of the river valley, and from the presence of a relatively short railway bridge along with the embankment crossing the valley at a distance of 1500 m below the water gauge. This bridge is damming up the flood waters. Therefore, for the Krapkowice section, $Q_{max}$ is set at approx. 3500 $m^3 \cdot s^{-1}$.

As can be seen in this example, in the assessment of flood $Q_{max}$ one should comprehensively take into account a number of factors conditioning the water level and the discharge (flow). It is worth adding that just above the Krapkowice water gauging station, the left tributary of Osobłoga is incoming, which along with other tributaries in this section significantly contributed to the formation of the Odra river flood wave (Strońska and Dubicki, 2001). This explains the significant $Q_{max}$ increase between Racibórz and Krapkowice. It is also worth noting that for Osobłoga, $Q_{max}$ equal to 141 $m^3 \cdot s^{-1}$ was quoted in the Racławice Śląskie water gauging station (at kilometre 29.85), but the preliminary assessment by the author of the KNP for this water level and of discharge conditions – for the flood zone that was almost 1 km wide, with a depth of 1–1.5 m – indicates that the discharge has been severely underestimated. This is also indicated by the fact that only the Prudnik river alone, a tributary of Osobłoga above Racławice Śląskie, in the Prudnik water gauge (just above the entrance of the tributary), showed close to 200 $m^3 \cdot s^{-1}$ (BPH data). Thus it can be concluded that flood discharges from the Osobłoga basin, as an important tributary of the Odra, require separate tests and verification.

Another section of the Odra river, which was subject to direct verification, is the Wrocław Floodway System (WWW) area, where measurements of the flow rate were carried during the flood. These were conducted by both the IMGW and the Institute of Environmental Engineering of the Wrocław University of Environmental and Life Sciences (Czaban et al., 1998). As mentioned in the introduction, in the scope of determination of $Q_{max}$ in the WWW area, particularly thorough research was conducted using a set of two-dimensional models. Their detailed description is quite extensive due to the complexity of the system, and it was included in the works of Banasiak (2017) and Banasiak (2018). The findings from these works, as to the value of the total maximum flow rate (peak discharge) and its distribution in individual elements of the Wrocław Floodway System, are given in Table 1. The results of earlier studies by other authors are also presented. It can be concluded that on July 12–13, 1997, $Q_{max}$ in Wrocław amounted ca. 3900 $m^3 \cdot s^{-1}$.

**Table 1.** Peak discharges of the flood in July 1997 in Wrocław Floodway System ($m^3 \cdot s^{-1}$)

| Cross-section | Czaban et al., 1998) | Radczuk et al., 1999* | After verification |
|---|---|---|---|
| Footbridge near the Zoo | 2270 (2240) | 2084 | 2270 |
| Most Pokoju (bridge) | 1350 (1430) | 1226 | 1300 |
| Most Zwierzyniecki (bridge) | 920 (1010) | 858 | 970 |
| Mosty Jagiellońskie (bridges) | 1450 (1360) | 1409 | 1360 |
| Odra–Widawa Canal | 185 (270) | 160 | 220–330 |
| Total | 3950 (4070) | 3640 | 3850–3960 |

* 1-D simulation for a given discharge of $Q$ = 3640 $m^3 \cdot s^{-1}$.

The values of maximum discharge in the remaining water gauging stations above Wrocław can be estimated based on data from the gauging stations discussed previously as well as other hydrological data, including those concerning supply of tributaries, above all, of the Nysa Kłodzka river. The impact of water retention in the valley is also important, and the 2-D model simulations also provide information about that. Since the $Q_{max}$ in Wrocław amounted to almost 4000 $m^3 \cdot s^{-1}$, it must have been even higher above the city, because along the way there was extensive flooding of the Odra river valley (Dubicki, 2012). $Q_{max}$ in the gauging station at the entrance of Nysa Kłodzka tributary is determined here as 4300 $m^3 \cdot s^{-1}$. In this particular gauging station, the waves of Odra and Nysa Kłodzka overlapped, which can be concluded from the established hydrograms of water levels (Dubicki et al., 1998, MKOO, 1999). The culmination of the wave from Nysa Kłodzka only slightly preceded the peak of the Odra river, and its $Q_{max}$ at the mouth of the Odra river was determined as 1200 $m^3 \cdot s^{-1}$ (with a maximum discharge of 1500 $m^3 \cdot s^{-1}$ from the Nysa reservoir) (MKOO, 1999; Kosierb, 2017). The passage of flood wave through Brzeg, which is located downstream, proceeded not only through a hydraulically complex gauging station, but also due to the breaches of the right-side banks, through the extensive valley of the Odra and Stobrawa rivers, and then Smortawa river (tributaries). Further down the river, most of the waters flowed around the water gauging station in Oława via the Lipki-Oława polder, whereby based on numerical simulations, it was established that a maximum of 1200–1250 $m^3 \cdot s^{-1}$ could have passed through the town of Oława. Then, the left-side embankments were breached around the town of Siechnica, which led to the extensive flooding of the Odra and Oława river valleys as well as the flooding of the city of Wrocław from the south-east. It is therefore assumed that the values of $Q_{max}$ from the inlet of Nysa Kłodzka to Wrocław were gradually reduced, and amounted to 4200 $m^3 \cdot s^{-1}$ and 4100 $m^3 \cdot s^{-1}$ respectively in Brzeg and Oława.

Further analysis concerns the Odra river section below Wrocław. Figures 3 and 4 present KNP for subsequent gauging stations, starting from Brzeg Dolny. At the height of this gauging station, flowing waters were contained within the inter-flood bank. In the case of the water level-discharge relationship at this gauging station, the results of measurements in the range of high water levels, the approximated curve, and the numerical simulation results are rather consistent, and they all indicate a discharge of approx. 3200 $m^3 \cdot s^{-1}$ at $H_{max}$. However, before the flood wave peak, not far below the gauge station, the flood bank was breached, which resulted in lowering of the water level upstream, also observed at the gauge (Dubicki et al., 1999). Two-dimensional model simulations confirm the impact of these breaches on the water levels at gauging station, that is, the reduction of the said levels, with a constant discharge causing their break. Ultimately, this leads to the conclusion that $Q_{max}$ should be adjusted to the value of approximately 3500 $m^3 \cdot s^{-1}$ (see: Fig. 3a).

Further along with the course of the river, due to the flooding of a vast valley, there was a strong reduction in the $Q_{max}$. In the gauging stations of Malczyce and Ścinawa, the probable values of $Q_{max}$ were 3300 $m^3 \cdot s^{-1}$ and 3000 $m^3 \cdot s^{-1}$, respectively. On the inter-flood bank area of Ścinawa water gauging station, 2800 $m^3 \cdot s^{-1}$ was recorded, and an additional discharge of about 200 $m^3 \cdot s^{-1}$, descending on the valley outside the right-side flood bank, that had been breached above. The diagrams for these gauging stations (see: Fig. 3b, c) also show the results for the part of the simulation of wave falling in unsteady flow, in which the hysteresis effect is marked.

In Głogów, importantly the flood flow was again contained within the inter-flood bank. On the basis of the measurements of the flow rate (discharge) and the results of the calculations, it can be concluded that $Q_{max}$ here amounted to approx. 2200 $m^3 \cdot s^{-1}$. In the additional numerical simulation, lower coefficients of roughness were assumed, that is, 10% lower in the main channel, and 30% lower in the flood plain, thus creating very good flow conditions. In that case, the $Q_{max}$ would be about 2400 $m^3 \cdot s^{-1}$, which is still acceptable, but in this case the results differ slightly from the highest measured flows in this gauging station (see: Fig. 3d). This additional simulation also sheds light on the impact of changing the coefficient of roughness on the calculated water level-discharge relationship. The calculated $Q_{max}$ in this case is much lower than the previously determined value of 3040 $m^3 \cdot s^{-1}$. Such a substantial reduction in $Q_{max}$ compared to the Ścinawa gauging station (at kilometre 332) finds its justification in the breach of the flood bank followed by extensive flooding of the valley up to the inlet of Barycz river (at kilometre 378).

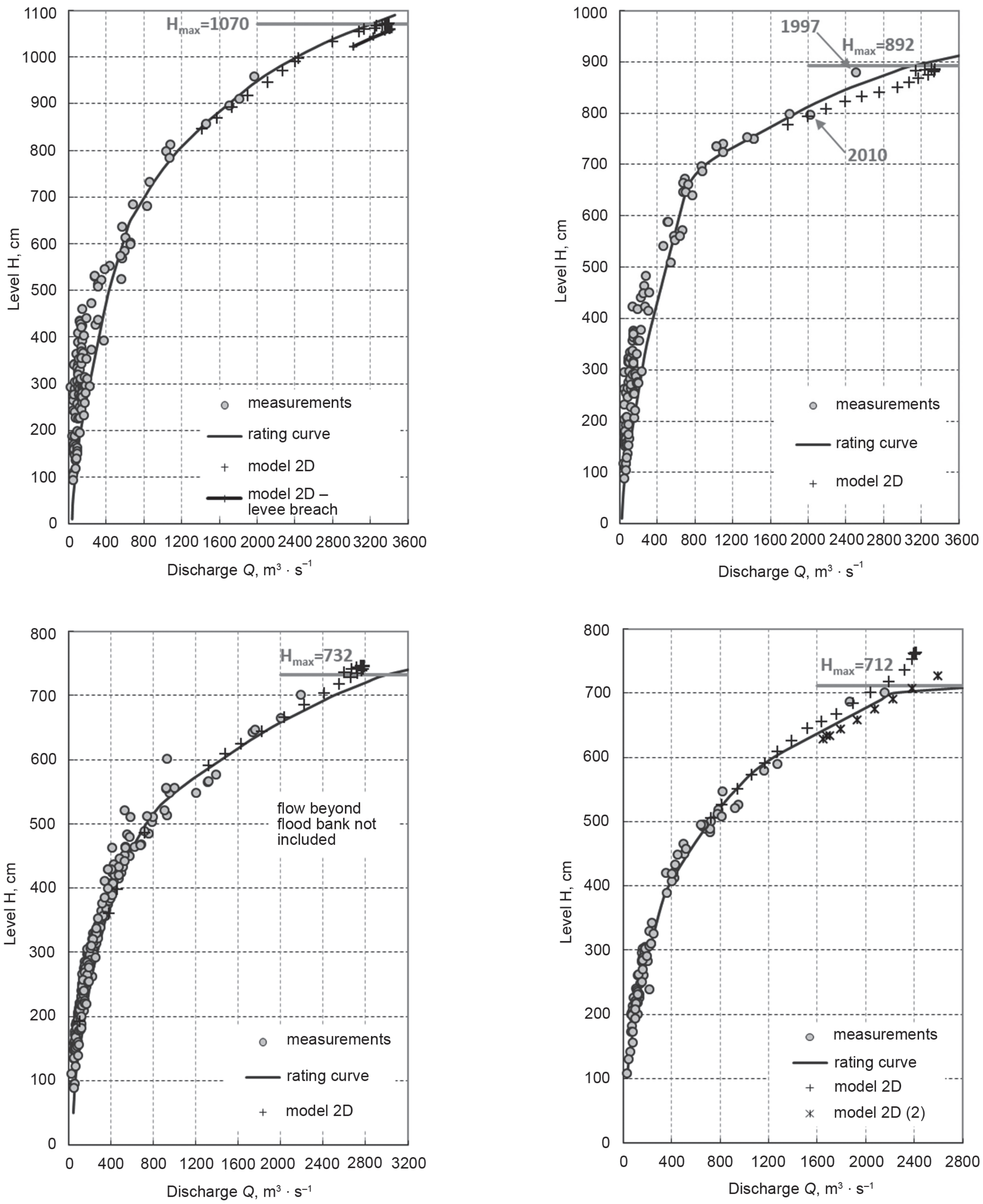


**Fig. 3.** Water level – discharge relation for gauging stations: a) Brzeg Dolny b) Malczyce, c) Ścinawa, d) Głogów (two-dimensional model (2) – roughness coefficients reduced by 10–30%)

Further, it is worth analysing the KNP for the Nowa Sól gauging station (see: Fig. 4a). In this section of the river, there are specific and complex conditions for the flood flow. Some of the water overflowed through the road-side flood bank along the national road No. 315 on the right bank of the river (upstream the gauging station) and headed directly to the valley downstream the gauging station (where the river takes a sharp turn to the right). In 2010, this flood bank was breached while conducting measurement at the cross-section of a road bridge in Nowa Sól (Wdowikowski M., PSHM, personal communication). The flow going through the resulting breach was not included in the measurement, and this deficiency is clearly marked in the figure. Unfortunately, these incomplete measurements were used to approximate the KNP. Calculation using the two-dimensional model again produces a more reliable course of the KNP, and for $Q$ > 1800 $m^3 \cdot s^{-1}$ it reveals the effect of damming the flood banks with a relatively narrow spacing on the section below the gauge.

The KNP for further water gauges do not raise much controversy. To determine the $Q_{max}$ in Cigacice and Nietków, some flow outside the embanked channel should be considered. The flooding behind the flood banks was no longer so deep, and its share in the discharge was not so significant. In Połęcko, the KNP already accounts for the total inter-flood bank discharge with a $Q_{max}$ value of approximately 2250 $m^3 \cdot s^{-1}$, with the incoming of the Bóbr tributary (at kilometre 516.2). $H_{max}$ in this section was recorded on July 24, 1997. The flow measurements carried out by the German services a dozen kilometres below, near Eisenhuttenstadt on the border section of the Odra (Oder) river on July 22–26 produced results in the range of 1823–2193 $m^3 \cdot s^{-1}$, while during the culmination in Słubice, a maximum of 2525 $m^3 \cdot s^{-1}$ (27 July) was recorded, which, taking into account the entrance of Nysa Łużycka tributary (km 542.4), corresponds to the results of the verification as carried out and summarized in Table 2. It should be added that, in principle, the error of determining $Q_{max}$ in this analysis should not exceed 100–200 $m^3 \cdot s^{-1}$.

**Table 2.** Peak discharges of the Flood in July 1997 on the Odra river ($m^3 \cdot s^{-1}$)

| Gauging station | Km Chainage | Radczuk et al., 1998 | The monograph of the flood, 1998 | After verification |
|---|---|---|---|---|
| Chałupki | 20.7 | 2160 | 2160 | |
| Krzyżanowice | 33.6 | 2600 | 2880 | |
| Miedonia | 55.5 | 3100 | 3120 | 3120 |
| Koźle | 97.2 | 3290 | 3060 | 3200 |
| Krapkowice | 123.7 | 3430 | 3170 | 3500 |
| Opole | 152.2 | 3500 | 3100 | 3400 |
| Ujście Nysy | 180.5 | 3500 | – | 4300 |
| Brzeg | 199.1 | 3530 | 3530 | 4200 |
| Oława | 216.5 | 3550 | 3550 | 4100 |
| Trestno | 242.1 | 3640 | 3640 | 3960 |
| Brzeg Dolny | 284.7 | 3200 | 3200 | 3500 |
| Malczyce | 304.8 | 3100 | 3100 | 3300 |
| Ścinawa | 331.9 | 3000 | 3000 | 3000 |
| Głogów | 392.9 | 3040 | 3040 | 2200 |
| Nowa Sól | 429.8 | 3040 | 3040 | 2180 |
| Cigacice | 470.7 | 3050 | 3050 | 2150 |
| Nietków | 490.5 | 3200 | 3200 | 2100 |
| Połęcko | 530.3 | 3200 | 3200 | 2250 |
| Słubice | 584.1 | 2500 | 2500 | |

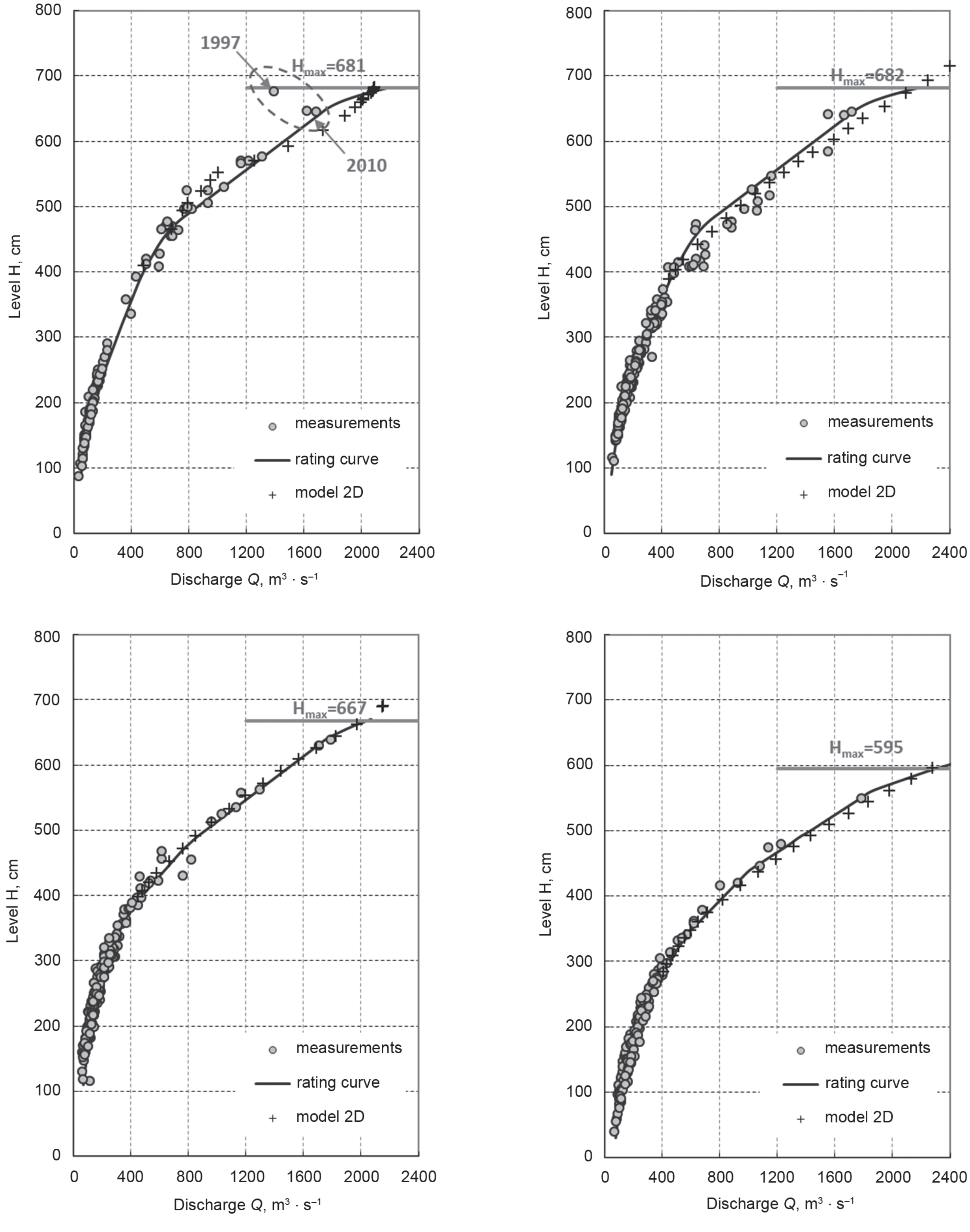


**Fig. 4.** Water level – discharge relation for gauging stations: a) Nowa Sól, b) Cigacice, c) Nietków, d) Połęcko

## CONCLUSIONS

In recent years, methods and tools of geospacial, hydrological and hydraulic analyses have been developed and improved, thus allowing a new, comprehensive approach to determining the maximum historical flood flows, including those in the Odra (Oder) river in July 1997. The results of 2-D modelling show that these methods can be successfully used in order to determine or verify the KNP in terms of high water levels, and that they are more reliable than the traditional approximation and extrapolation of measurement data, which is often highly speculative. The result of the conducted analysis indicates that the maximum discharge for the Odra river from Racibórz to Ścinawa should be adjusted to higher values; particularly on the section from the entry of Nysa Kłodzka tributary all the way to Wrocław – for instance, in the gauging station at Brzeg, it should be corrected from 3530 $m^3 \cdot s^{-1}$ to about 4.200 $m^3 \cdot s^{-1}$. However, for the section from Ścinawa to Połęcko, the peak discharge should be reduced by as much as 1000 $m^3 \cdot s^{-1}$. The results of the calculations also make it possible to assess the impact of valley retention, that is, the area protected by flood banks, on the reduction of maximum flood flows, whereas the flood caused numerous breaches of the flood banks. The average reduction amounted to approximately 10 $m^3 \cdot s^{-1}$ per 1 km of the river's length.

The results obtained should be taken into account in the assessment of flood risk from the Odra river, especially in the context of the ostensible climate change. They should be used for statistical calculations of flows with a given probability of exceedance. These calculations should also include hydro-technical structures development and the Racibórz reservoir currently under construction.

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## WERYFIKACJA PRZEPŁYWÓW MAKSYMALNYCH POWODZI W LIPCU 1997 R. NA GÓRNEJ I ŚRODKOWEJ ODRZE

**Cel pracy**

Praca przedstawia wyniki weryfikacji przepływów maksymalnych powodzi w lipcu 1997 r. na rzece Odrze na odcinku od Raciborza do Słubic.

**Materiał i metody**

Weryfikację oparto na przeglądzie i ocenie danych hydrologicznych, uwarunkowań propagacji i transformacji fali z wykorzystaniem GIS oraz na obliczeniach dwuwymiarowymi modelami hydrodynamicznymi i wyznaczeniu związków stan-przepływ dla przekrojów wodowskazowych.

**Wyniki i wnioski**

Zweryfikowane przepływy znacząco różnią się od dotąd publikowanych. We Wrocławiu przepływ maksymalny wyniósł ok. 3900 $m^3 \cdot s^{-1}$ wobec 3640 $m^3 \cdot s^{-1}$, natomiast powyżej, w przekroju ujścia Nysy Kłodzkiej, ok. 4300 $m^3 \cdot s^{-1}$ wobec 3500 $m^3 \cdot s^{-1}$. Z kolei na odcinku Odry poniżej Wrocławia przepływy maksymalne mocno zmalały i na odcinku od Głogowa do Połęcka należy je zweryfikować w dół, do zakresu 2100–2250 $m^3 \cdot s^{-1}$, nawet o 1000 $m^3 \cdot s^{-1}$ mniej od wartości dotychczasowych. Zweryfikowane przepływy maksymalne są hydrologicznie i hydraulicznie spójne i uzasadnione, tzn. uwzględniają zasilanie dopływami, zasadę ciągłości przepływu oraz wpływ przerwań wałów i retencji dolinowej.

**Słowa kluczowe:** przepływ maksymalny, rzeka Odra, powódź w lipcu 1997 r, hydrodynamiczny model 2D, krzywa natężenia przepływu