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EFFECTIVENESS OF ASSESSING FLOOD HAZARDSALONG THE LUBUSKI SECTION OF THE ODER

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One of the major problems connected with the management of the Oder river-basin is an effective protection against floods. In the region of Środkowe Nadodrze (Middle Oder Land) it has been done, among others, by means of constructing flood banks.

Flood banks in this region were built already in the prehistoric times, but they used to be constructed in an arbitrary way which did not guarantee their proper technical condition [Kołodziejczyk, Kowalski 2001]. Their quality and condition were additionally weakened by numerous floods, and also by erosion processes and incorrect use of the flood banks.

With higher and higher as well as more frequent occurrence of flood waves, which endangered permanent human settlements originally located in safe places, their inhabitants used to defend themselves by building up flood banks. Unfortunately, however, the work of building them up was carried out when the flood was already approaching and in a great haste, and thus materials in the immediate vicinity, those at hand were used. The height of the flood bank was connected inseparably with the width of its base and the gradient of the slope, which always approximated the gradient of natural slope of the built-up material. The gradient changes under the surface of the water, i.e. after the flood has approached, as it has been found out by observing the sapping and washing of the flood banks during flooding.

From the middle of the Holocene epoch, higher and higher flood occurred in individual sections of the river valleys of the East Mid-European Lowland.The first flood banks, which were built, with time proved to be too low. They had to be raised, and also their bases had to be widened. As a rule this was done in the conditions of an impending threat of flooding, and the material for building the flood bank was collected from the area behind the bank, and not from inter-bank area. Thus the possibility of the occurrence of overflowing and paludification increased which was due not only to infiltration of water from the inter-bank area through the flood bank to the area behind the bank, but also to damming up of the ground water in the area behind the bank . Neither was a proper technique of building up the flood banks always used due to the hurry and urgency of the situation. As a result, it turned out that raising up, widening and lengthening of the flood banks could not secure safety in particular sections of a valley. Successive floods followed, when the bulk of the flowing water destroyed the flood banks, or overflowed their crown if it could not be held in the inter-bank area.

A number of floods in the middle part of the Oder were recorded in chronicles, for instance among others the floods which took place in 1565, 1736, 1785, 1813, 1902, 1903, 1930, 1947 and 1982. However, the catastrophic flood of the year 1997, called the flood of the century, had the greatest range (fig. 1).

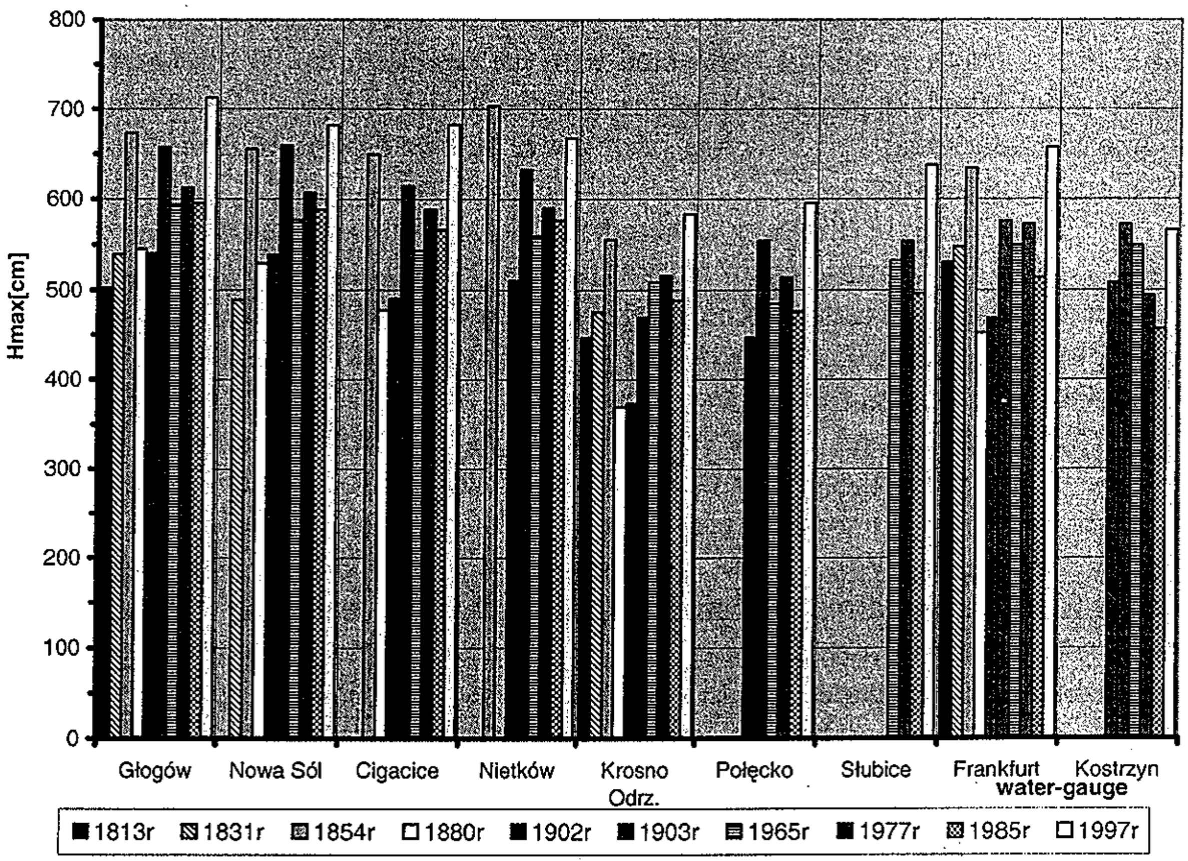

Fig. 1. The biggest floods on the middle part of the Oder

Negligence of many years' in operating anti-flood constructions and structures was distinctly and dramatically revealed then [Dubicki, Słota, Zielinski (red) 1999].

The distressing balance of the results of the 1997 flood triggered off a number of both national and international initiatives and projects, aiming at improving flood protection in the whole Oder river-basin. As an example of the above may serve the complex investigations into the condition of the flood banks in the Lubuski province, which were localized along 409,0 – 614,2 km down the river. The objective of the study was to analyse the parameters and engineering-geological phenomena in the flood bank body and subsoil and then to evaluate and assess the technical condition of the flood banks and determine the possible methods of their improvement [Kołodziejczyk 2002].

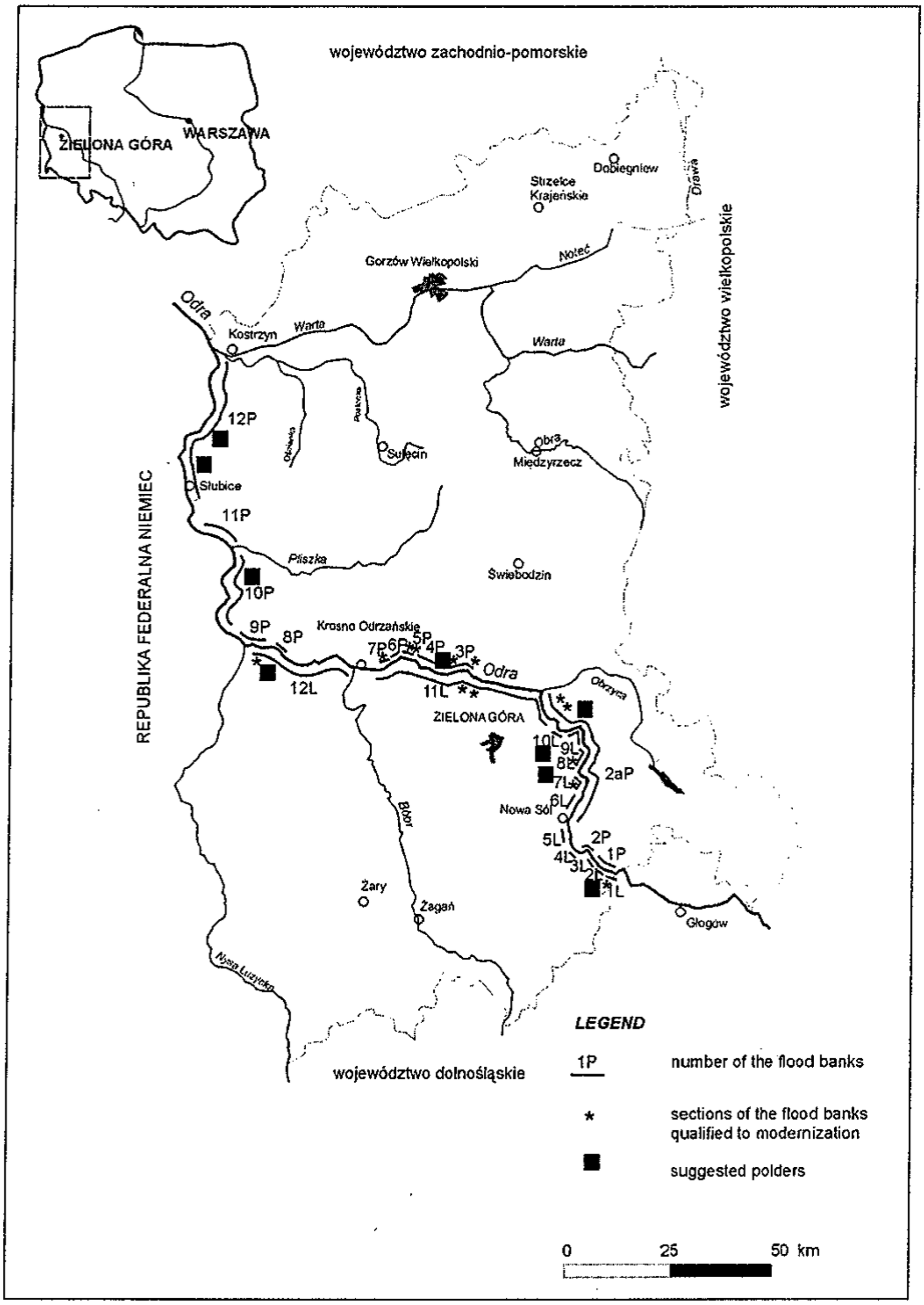

Fig. 2. The Lubuski section of the Oder river

Table 1. The results of the laboratory analysis' concerning the Grodnu in the body of the flood banks

BODY OF THE FLOOD BANKS			volume density of the soil ρ [t/m-3]	specific density of the soil skeleton ρs [t/m-3]	natural water content wn [%]	porosity n [%]	degree of plasticity IL [-]	plasticity index IP [-]	plasticity limit wP [%]	liquid limit wL [%]	degree of density ID [-]	filtration coefficient k [m/d]
SOILS		type of soil										
Mineral soils	cohesion soils	clays	1,74-1,93	2,63-2,70	20,0-42,7	20,2-51,2	0,02-0,27	23,0-59,6	17,5-35,0	51,0-93,7	-	n.b.
		boulder clays	1,80-2,01	2,60-2,69	10,7-34,,2	33,2-47,6	-0,05-0,40	14,0-30,3	12,0-26,9	18,3-54,6	-	0,001-0,21
		loams	1,71-2,18	2,59-2,67	9,5-38,2	28,1-50,2	-0,12-0,61	6,6-40,8	9,4-33,3	14,1-72,4	-	0,0001-15,6
		loamy sands	1,90-2,11	2,61-2,67	5,3-24,6	-	-0,07-0,41	5,2-9,8	9,4-23,3	16,7-29,5	-	0,001-2,11
	coheion less soils	coarse-grained sands	1,71-1,98	2,63-2,67	6,6-22,6	-	-	-	-	-	0,19-0,62	0,001-79,4
		fine-grained sands	1,72-1,73	2,64-2,65	7,1-25,0	-	-	-	-	-	0,10-0,50	0,005-13,48
Organic soils		clay agradations	1,91-1,76	2,58-2,62	12,8-12,9	-	0,08-0,22	111,1-11,3	10,3-12,0	21,4-23,3	-	0,007-0,254
		sand agradations	1,75-1,82	2,60-2,65	8,8-27,5	-	-	-	-	-	0,24-0,30	0,0025-0,0384

Tabele 2. The results of the laboratory analysis' concerning the ground in the subsoil of the flood banks

BODY OF THE FLOOD BANKS											
SOILS		type of soil	volume density of the soil ρ [t/m-3]	specific density of the soil skeleton ρs [t/m-3]	natural water content wn [%]	porosity n [%]	degree of plasticity IL [-]	plasticity index IP [-]	plasticity limit wP [%]	liquid limit wL [%]	degree of density ID [-]	filtration coefficient k [m/d]
Mineral soils	cohesion soils	clays	1,69-2,04	2,51-2,71	19,9-52,0	37,1-58,8	0,02-0,44	24,3-70,0	16,8-44,6	23,9-106,5	-	n.b.
		boulder clays	1,73-2,07	1,92-2,69	14,7-43,6	13,9-52,9	0,05-0,95	0,22-40,3	8,0-33,8	16,1-62,2	-	0,0001-0,0012
		loams	1,79-2,18	2,58-2,68	8,3-38,9	28,6-47,0	0,06-0,99	7,9-19,8	10,4-19,9	18,5-49,6	-	0,0001-0,1287
		loamy sands	1,90-2,10	2,60-2,68	6,2-23,9	n.b.	0,24-0,43	6,3-6,5	12,4-16,2	18,9-22,5	-	0,005-2,63
	coheion less soils	coarse-grained sands	1,88-2,0	2,64-2,75	15,0-18,0	n.b.	-	-	-	-	0,37-0,61	2,39-73,18
		fine-grained sands	1,83-1,87	2,62-2,68	10,1-24,7	n.b.	-	-	-	-	0,20-0,75	1,351-146,8
Organic soils		clay agradations	-	1,81-1,87	2,62-2,66	9,0-32,1	n.b.	-	-	-	-	0,20-0,71
		sand agradations	-	1,45-1,82	2,30-2,57	34,2-73,2	47,5-63,5	0,29-0,46	12,3-52,8	21,6-55,9	23,4-105,6	-

The paper presents results of detailed geological and engineering investigations into the flood banks along the Lubuski section of the Oder (fig. 2), which were made in 720 cross-sections. The cross-sections were selected after having analysed the results of geological cartography, bioindication and geophysical examinations. Within each cross-section probes were located and drill-holes made, where macroscopic assessment of the soil was made and samples for laboratory testing taken.

Altogether 1345 samples of soil were laboratory tested. The following was determined: grain-size distribution, type of soil, organic matter content (I_{om}), specific density of the soil skeleton [ρ_s], volume density of the soil [ρ] porosity [n], natural water content [w_n], degree of plasticity [I_L], plasticity index [I_S], plasticity limit [W_P], liquid limit [W_L] and filtration coefficient [k] – Tab. 1, Tab. 2.

The values of individual engineering-geological parameters of the soils making up the flood banks and their subsoil were compared with the Polish standard PN-81/B-03020 "Building grounds. Direct Foundation".

It follows from the research carried out that the condition of the flood banks is to a considerable extent determined by the condition of the subsoil, which is differentiated with respect to its facies, lithological and geotechnological aspect. The subsoil is mainly made up of low bearing capacity soils, greatly permeable, and greatly varied in terms of ground-settlement. They are characterized by low shear strength, great deformability under loads, normal or slight preconsolidation , plastic and soft-plastic consistence and high water-saturation.

Also the body of the flood banks is characterized by weak engineering-geological parameters. This is due to the way of constructing the flood banks, which used to be formed using random and odd building materials - differentiated with respect to their grain-size distribution and density; taken from the neighbourhood and built into the flood banks in a completely random fashion.

The flood banks located along the Lubuski section of the Oder river were also broadly studied and assessed with respect to geotechnical hazards by analysing the following possibilities: loss of slope stability, filtration hazards due to the flow (filtration) of water through permeable soils occurring in the flood bank body or the bank subsoil as well as to piping through the layer of impermeable soils in the subsoil of the flood bank.

A detailed investigation into the engineering-geological conditions and geotechnical hazards rendered it possible to make a synthetic assessment of the current condition of the flood banks of the Lubuski section of the Oder and to separate flood bank fragments representing: 1. good condition – securing a safe operation of the flood banks during freshet, 2. average condition – corresponding to insecure flood banks, which are likely to break down, 3. bad condition –

comprising fragments of flood banks endangered by break-downs and not satisfying the technical and constructional requirements.

The engineering-geological studies carried out, as well as the synthetic assessment of the condition of individual flood bank fragments, the analysis of bank classes treated as hydrotechnical structures and their role in flood prevention strategy resulted in indicating the methods of improving the technical condition of the flood banks (modernization, repair, maintenance).

On the basis of statistical analysis it was proved that despite the emergency repairs of gaps made directly after the flood in the sections of the total length of 6.9 km, still only 38,9% of the Lubuski flood banks are in good technical condition, whereas the remaining 37,8% - in average condition, and 23,3% - in bad condition.

Taking into account the total length of the flood banks located along the Lubuski section of the Oder, as well as the number of endangered flood banks, i.e. those in average and bad condition (61,1%), it must be borne in mind that at least 146,9 km of the flood banks require to be repaired or modernized. After publication of brief, intensive modernization work has been started. The work was carried out in the space of years from 1998 to 2001 in many sections of the flood banks of the total length of 68,4 km.

The analysis of the condition and stability of the flood banks and their subsoil was used to work out the prognosis of flood hazards in particular sections of the flood banks.

The efficiency of flood protection was also assessed with respect to other parameters favouring the occurrence of floods, which – apart from geotechnical parameters – included the following: uneven permeability of the subsoil and body of the flood banks, the condition of the flood bank body (geometry and technical condition), location of the flood banks (flood terrace, old river-bed), condition of the inter-bank area (its capacity, roughness, susceptibility to erosion), condition of the area before the bank (water basins, excavations and workings, pot-holes), condition of the river-bed (meanders, destroyed river banks) and others.

As it follows from the investigations and research carried out the efficiency of the flood banks is first of all determined by their localization (in the old river-bed or the flood terrace) and the permeability of the subsoil; therefore by the factors which cannot be removed or eliminated by modernizing the flood banks. In the thesis an attempt has been made at pointing out effective solutions, as for instance formation of additional polders, widening of the inter-bank area, displacement of the population of a given locality, or the most effective one – re-naturalisation of the river valley.

Over Lubuski section of the Oder the following sections of the flood banks were qualified to urgent modernization (Fig. 2):

- part of the section 2P protecting Głuchów Village and Kargowa Valley,
- part of the section 3P protecting Pomorsko Village and Brody Village,
- part of the section 5P protecting Nietkowice Village and Railway Track Zielona Góra – Czerwieńsk,
- part of the section 7P protecting Będów Village,
- section 1L of the flood banks protecting Drogomil Village,
- part of the section 7L (where water overflew in the direction to Otyń),
- part of the section 8L protecting Tarnawa Village,
- part of the section 11L protecting arable land and surroundings of Czerwieńsk Town,
- part of the section 12L protecting Kosarzyn Village.

Aforementioned studies revealed in addiction that it is necessary to create inundation polders: Urad, Słubice – Górzyca, Ługi Górzyckie, Głęboka-Głuchów and above Otyń. In the light of the studies there is serious need to reconsider the issue of rehausing the inhabitants of small villages like Będów (496 km of Oder down-stream), Kosarzyn (541 km of Oder down-stream), Drogomil (413 km of Oder down-stream) and Tarnawa (445 km of Oder down-stream). The rest of towns will be protected with flood blanks until their inhabitants convince themselves about detrimentally of the further settlement on the inundation grounds. Although it needs many years of ecological education.

CONCLUSION

Flood banks used to be built as constructions which were aimed at counteracting the harmful impact of flood waves – particularly those high ones. It is also possible to decrease the height, i.e. flatten the flood wave in a given cross-section of the river valley by means of a rational and integrated management of rain water and surface water in the river basin above the cross-section [Chojnacki 2002, Mitchell 1990, Mikulski 1998]. This calls for creating flood control reservoirs, which will render it possible to stop the excess of rain and surface waters in periods of intensive rainfalls and to supplement the deficit of water in periods of drought. In such a case, the flow of waters in the inter-bank area can be equalised, i.e. it will not reach extreme values, and then the flood banks can fulfil their protective functions.

Observations of river waters overflowing higher and higher flood banks crowns [Kaczmarek 1998], which have been carried out for many years now, have led to the conclusion that it is impossible to build up flood banks of the height ensuring at all times successful protection against flood and its effects. [Cunnane 1989, Uhlemann 1999]. It was observed that the conclusive meteorologic and hydrologic factors conditioning the alternate occurrence of heavy rain and drought periods in a particular river section are in the majority of cases located in the upper section of the river. Equally, increasing rain fall and surface water retention in the upper basin through building up high-water dams [Cosse 1993] and polders in combination with proper water management in both natural and man-made retention reservoirs can, in a particular river section, prevent formation of destructive, high flood waves, or at least flatten them and in a period of drought direct the missing water amounts to the river bed [Mikulski 1998, Mitchell 1990]. Rational management of water resources in the basin of a big river is not easy. Apart from many diverse factors, which are not explicitly stated, there may also be a clash of interests between communities inhabiting the basins of each of the tributaries and particular sections of the main stream valley. Undoubtedly, the results of the catastrophic flood of 1997, which occurred in the Oder river valley and its side streams in Poland, as well as in the territory of the Czech Republic and Germany would have been less destructive, if, prior to the flood, there had been an agreement made by and between the communities dwelling in endangered areas and local authorities being in charge of water management [Dubicki, Słota, Zieliński 1999, Chojnacki 2000, Greinert H., Kołodziejczyk, Greinert A. 1998, Ozga-Zielińska 1998]. In the same year of 1997, in the basin of the river Vistula, as the result of more efficient water management, the flood wave was flattened and did not cause such damages as in the neighbouring basin of the river Oder. Hence, flood banks should be built and incorporated into the whole water management system as hydrotechnical structures.

In the eastern part of the Mid-European Lowland the permanent monitoring of flood banks state and condition has been started only recently. Obviously, the process entails certain expenses. However, if we compare the costs of constant monitoring with the value of flood damages, we can prove that even lowering the level of the damages only by little will reimburse entirely the costs of long-term, well-organized and professionally run monitoring.

A good example of well-started and well-organized constant monitoring of flood banks are engineering - geological investigations into the state and condition of the flood banks in the Middle Oder Land (Fig. 2) which have been carried out regularly since the great flood of 1997.

Everyone has to be aware of the fact that all attempts at counteracting and fighting against floods shall always be only a sort of a search for substitutes or just a palliative measure. The river has to have its space. As men settled in river valleys and flood terraces, we have to learn how to live in this environment and how to cope with floods. It only remains to be hopeful that flood protection of the Middle Oder Land shall be successfully carried on and completed before it is forced by another flooding.

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SKUTECZNOŚĆ OCHRONY PRZECIWPOWODZIOWEJ NA LUBUSKIM ODCINKU ODRY

Streszczenie

Jednym z nadrzędnych problemów związanych z zagospodarowaniem dorzecza Odry jest skuteczna ochrona przeciwpowodziowa, prowadzona między innymi za pomocą wałów przeciwpowodziowych. Kompleksowe badania stanu wałów przeciwpowodziowych, zlokalizowanych na lubuskim odcinku Odry (409,0 - 614,2 km biegu rzeki), pozwoliły na zanalizowanie zjawisk geologiczno-inżynierskich zachodzących w korpusie oraz podłożu wałów przeciwpowodziowych, a następnie – na ocenę stanu technicznego tych obiektów. Rezultatem przeprowadzonych badań było ustalenie prognozy zagrożeń powodziowych w poszczególnych odcinkach wałów oraz wskazanie skutecznych sposobów poprawy bezpieczeństwa przeciwpowodziowego. Trzeba mieć jednak świadomość, że wszelkie podejmowane przez człowieka próby walki z żywiołem powodzi będą zawsze tylko szukaniem rozwiązań zastępczych. Rzeka bowiem musi mieć swoją przestrzeń, a skoro człowiek zasiedlił doliny rzeczne, a tym bardziej tereny zalewowe, musi nauczyć się żyć w tym środowisku i walczyć z żywiołem powodzi. Pozostaje nadzieja, że wyniki badań zaprezentowane w tej pracy posłużą modernizacji urządzeń przeciwpowodziowych i to zanim wymusi ją kolejna powódź.