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SYSTEM FOR FLOOD PROTECTION IN ODRA RIVER BASIN - ITS EFFICIENCY DURING THE FLOOD OF 1997

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A b s t r a c t. The efficiency of the system for flood protection in Odra river basin during the flood of 1997 is shown.

K e y w o r d s: flood protection, Odra river basin

INTRODUCTION

Flood wave formation depends on basin parameters as topographical conditions, hydrographical and geological conditions and also on human activities in the watershed (reservoirs, polders, embankments, canals, changes in forestation and land use).

The magnitude and scale of flood depends, above all, on the precipitation intensity and its spatial distribution.

The total area of the Odra basin is 118.861 km^2, of which 89% belongs to Poland, 5% to Germany and 6% to the Czech Republic.

The Odra basin is very asymmetrical. Three main types of landscape can be distinguished in the Odra basin: mountain, highland and lowland. This differentiation of the environment has an effect not only on the amount of precipitation but also on the runoff and storage possibilities of the catchment. The left-sided tributaries are mountain type rivers with headwaters in the Sudety Mountain, Przedgórze Sudeckie and Beskid Śląski. The main left -sided tributaries are Osobłoga, Nysa Kłodzka, Oława, Ślęza, Bystrzyca, Kaczawa, Bóbr, Nysa Łużycka.

The right-sided tributaries such as Kłodnica, Mała Panew, Widawa and Barycz are lowland type rivers. The length and catchment area of the Warta river nearly equals the length and area of the upper and middle Odra catchment, and has a significant influence on the lower Odra river.

Although the Odra rivers course was winding it has been shorten by the excavation of many meanders over the last 200 years. The general shortening of the Odra can be estimated at 160 km and the present landscape is rich in old riverbeds. Typically Odra river valley passes through proglacial stream valleys: Wrocławsko-Magdeburska, Barycko-Głogowska, Warszawsko-Berlińska, and Toruńsko-Kostrzyńska (Fig. 1). Existing embankmets and dykes often pass through old riverbeds that considerably weaken their strength.

The continental and marine climate encountered over the Odra basin causes a large variability of weather. Among European rivers the Odra belongs to the least abundant in water. The average annual sum of precipitation is 600 mm. Months with the highest rain are July and August.

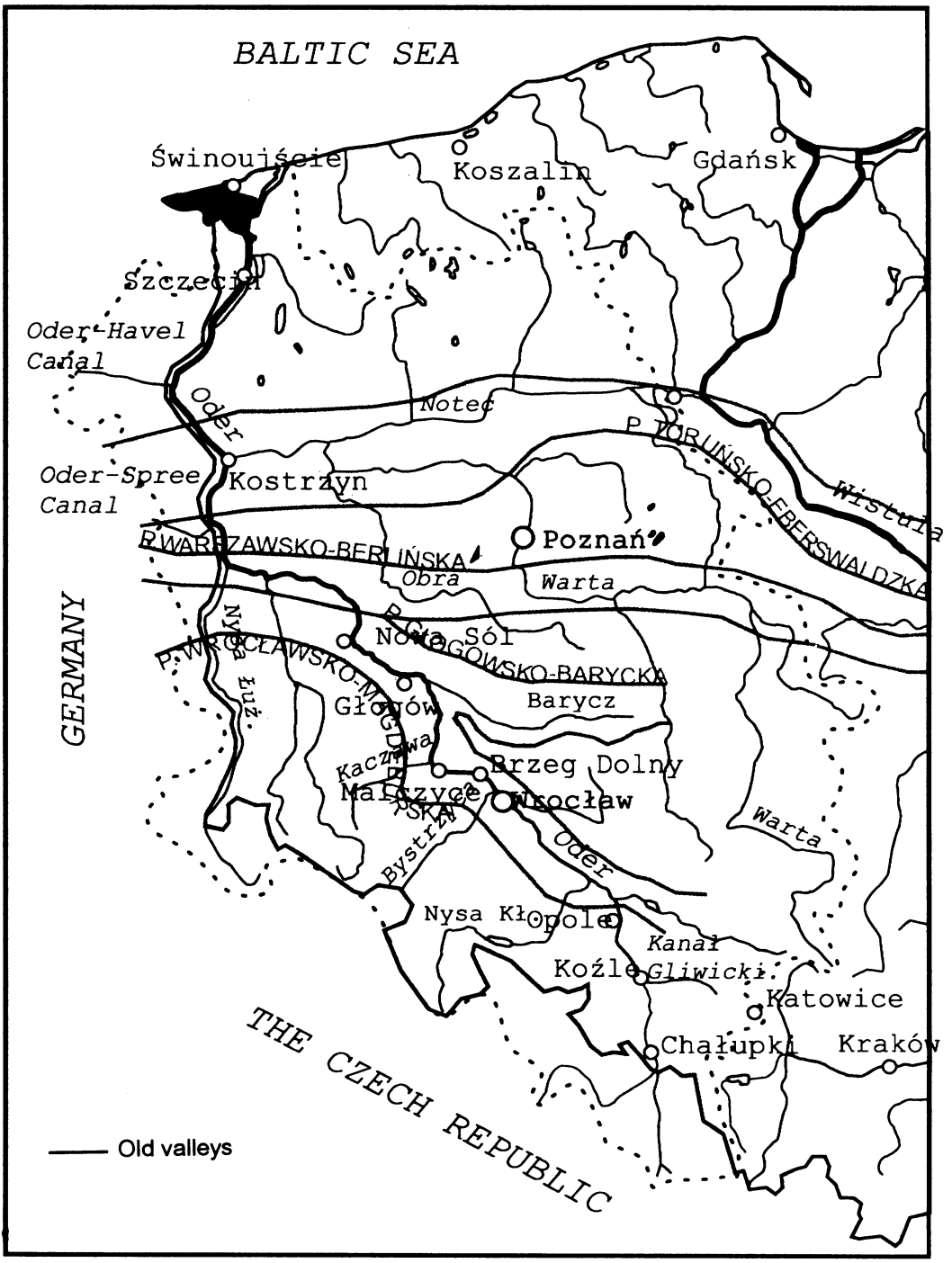

Fig. 1. The proglacial stream valleys in the Odra river basin.

According to the historical documents floods occurred at the watershed relatively often. From 988 to 1774 about 36 large scale floods were recorded. In the 19th century disastrous floods occurred in 1813, 1854, 1855 and 1888. In the 20th century floods were observed in 1903, 1915, 1924, 1938, 1940, 1947, 1958, 1960, 1963, 1964, 1965, 1970, 1972, 1977, 1980, 1985 and 1997. The flood of July 1903 was considered as the highest flood in the 20th century until July1997. The nodes that decide the magnitude of waves in the Odra are the mouth of Olza and the mouth of Nysa Kłodzka.

SYSTEM FOR FLOOD PROTECTION IN ODRA RIVER BASIN

The present system for flood protection was designed and constructed after 1903 and consists of the following elements:

- embankments,
- polders,
- artificial canals,
- storage reservoirs,
- dry storage reservoirs.

At present there are 21 storage reservoirs in the Polish part of the Odra basin with a total capacity 968.48 mln m^3 and total flood reserves of 328.9 mln m^3. They were constructed for different purposes: water supply, river alimentation for navigation, power engineering, for agriculture, recreation, and to reduce the flood wave peak. In the Czech Republic territory there are 8 storage reservoirs with total capacity of 386.4 mln m^3 and with a flood reserve of 56.0 mln m^3.

In total there is 1354.88 mln m^3 in storage reservoirs of which 384.9 mln m^3 is given for flood reserve.

In 1905-1929 14 "dry" storage reservoirs were built with a total capacity of 28.57 mln m^3. These reservoirs are only of local significance in the system of flood protection and preserve the urban areas of valley of rivers where they are located.

Polders were designed as reservoirs located behind the dykes with the main task of reducing the level of flood wave in Odra river. During flood the water overflows through weirs in dykes and the polder is filled with water from river. There are 8 polders in the upper and middle Odra basin with a total capacity of 140 mln m^3. Between the floods polders are usually used as arable lands and grasslands. Till 1985 many of them were protected from surrounding water. In 1997 all polders were flooded. According to specialist opinion the system of polders is in effective due to its small possibility of lowering the wave peak.

Artificial canals were designed to relieve the Odra river bed that pass through the cities Racibórz, Opole and Wrocław. The channel capacity is 600 m^3/s. The length of the artificial channel in Wrocław is equal to 6 km and its capacity is 870 m^3/s.

The first dykes were built in the 17th and 18th centuries with the purpose to protect only the local areas. Nowadays there are many kilometres of embankment along the Odra river and its tributaries. The total length of embankments at the Chałupki-Wrocław section is 320 km.

METEOROLOGICAL CONDITIONS IN JULY 1997

The flood in 1997 by its scale exceeded all previous floods. Precipitation, that was the direct reason of flood, started in the upper Odra basin on 5th of July 1997 between 4 and 7 p.m. and in the Nysa Kłodzka basin between 8 and 10 p.m. and lasted continuously 60-70 h. The precipitation core was located in the upper Odra basin (Lysa Hora from 5 to 9.07.97-586 mm; Praded, Jesenik and Zlate Hory - 5 days sum of precipitation varied from 458.9 mm to 513 mm) and in the eastern part of the Nysa Kłodzka basin (the precipitation recorded during 65-75 h on the stations: Międzygórze - was 454.8 mm, Kamienica - 484.3 mm (strong storms) (Fig. 2). Compared with the multi-annual mean precipitation in the Odra basin and in the Nysa Kłodzka and Biała Głuchołaska catchments, precipitation attained 20-40 % of the multi-annual mean value, and in Jesenik Mountains - 50 %. A rise in water in the upper section of the Odra river

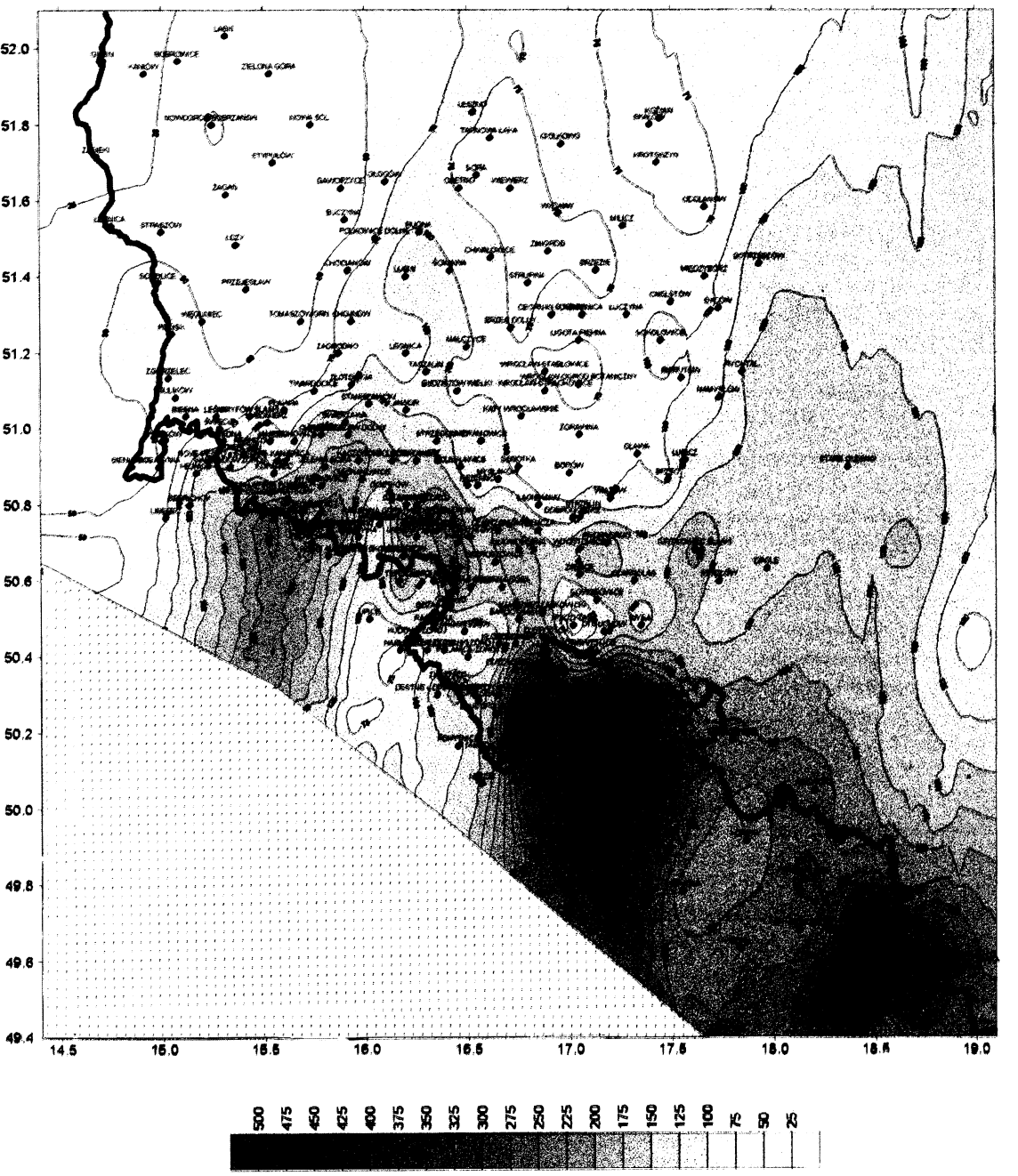

Fig. 2. Spatial distribution of daily sum of precipitation in period 4/5 - 8/9.07.1997, Branch of the Institute of Meteorology and Water Management, Wrocław.

and in its mountain tributaries in the Czech Republic and in Poland started several hours after the precipitation began.

The concentric system of tributaries in the upper part of the Odra river caused the superposition of waves. The sudden rise of water level (the water level between Bohumin and Miedonia cross - sections during 12 h increased by 400 cm and at the peak 850 cm) devastated hydrotechnical structures and gauging stations (all gauge stations situated on the Odra river from Chałupki to the inflow of the Nysa Kłodzka river were under water). Because of high flows of the rising wave in the Odra river and the high peak flow of the Nysa Kłodzka river (where the outflow from the Nysa reservoir was 1500 m^3/s) a 3640 m^3/s flow entered the Wrocław Hydrotechnical System. A second precipitation occurred during the period from 17/18 of July to 21/22 of July producing another rise of water level in the Odra river as in its tributaries. The highest maximum levels were exceeded by 80 to 221 cm. High precipitation in Nysa Kłodzka catchment and the superposition of high waves from the Wilczka and Biała Lądecka rivers caused the development of a wave of unprecedented dimension in the Nysa Kłodzka river. The volume of precipitation in the Odra basin up to the Słubice cross-section was estimated at about 12 billions m^3 of water.

In the Table 1 the sums of the flood precipitation from July 1903, August 1972 and July 1997 from several stations in the upper and middle Odra River are given. The discharge of the floods that occurred in 1903, 1965, 1977, 1985 and 1997 in the Odra River basin from several gauging stations are given in the Table 2.

Table 1. Sum of precipitation from July 1903, August 1972 and July 1997

Name of station	Sum of precipitation (mm)		
	9.07-10.07.1903	20.08-22.08.1972	5.07-9.07.1997
Šance	-	-	616.9
Lysa Hora	263.5	412.4	586.0
Ostrawa	188.2	65.6	262.8
Cieszyn	82.0	277.5	220.0
Praded	150.0	144.3	459.0
Jarnołtówek	220.0	163.7	313.0
Prudnik	152.2	85.9	190.0
Głubczyce	125.0	67.9	240.0
Racibórz	70.0	28.2	249.0
Bielice	243.2	75.1	366.0
Lądek Zdrój	180.0	22.2	332.0
Kłodzko	40.0	3.9	119.0

Institute of Meteorology and Water Management. On the basis of "The flood in August 1972" - Komunikacja i Łączność, Warszawa, 1975.

THE EFFICIENCY OF SYSTEM FOR FLOOD PROTECTION IN JULY 1997

The scale and size of flood in the Odra river and its tributaries were so large that with the condition of flood protection system the disaster was unavoidable.

The amount and distribution of the precipitation from 3/4 - 8/9 July 1997 in the upper and middle Odra show that the precipitation in the Czech Republic was unfavourable for Poland. The peak of the flood wave exceeded the highest water level hitherto recorded at the upper and middle Odra and Nysa Kłodzka with its right -sided tributaries.

Analysis of the magnitude of precipitation in July 1997 showed that they were catastrophic and in the entire upper and middle Odra they exceeded by 200 - 400% the usual sum of rain for July. Such precipitation can be classified as the Maximum Possible Precipitation (MPP).

The tragic consequences of the flood are the result of careless water management, lack of funds for remedial works, preservation and maintenance. The floods of 1972, 1985 and 1997 showed that many kilometres, of embankments are too low to protect urban and industrial districts. Heightening of dykes should be planned simultaneously with new reservoir construction and modernisation of polders that can store a big capacity of water.

The flood of July 1997 showed the unsatisfactory efficiency in system functioning and a lack of proper protection for cities, towns, settlements, industrial districts and large arable areas located both in the Odra river valley and it tributary valleys. The technical conditions of flood barriers and their operation have a big contribution in safely carrying away large volumes of flood water.

Table 2. Maximum discharges for the floods in the 20th century in the Odra river watershed

Gauging station	Catchment area (km^2)	Maximum discharges (m^3/s)				
		1903*	1965	1977	1985	1997
Chałupki	4666.2	-	519	738	1050	2160
Krzyżanowice	5874.8	-	854	930	1321	-
Miedonia	6744.0	2000	885	960	1337	3100
Koźle	9173.6	-	827	886	1287	3290
Krapkowice	10720.6	-	890	974	1307	3430
Opole	10989.2	-	891	1014	1306	3500
Ujście Nysy	13454.9	2500	925	1191	1233	-
Brzeg Most	19731.6	-	936	1300	1350	3530
Oława Most	19981.1	-	1040	1250	1380	3550
Trestno	20561.2	-	1210	1650	1480	3640
Brzeg Dolny	26428.0	-	1330	1580	1440	3200
Malczyce	26812.4	-	1330	1470	1510	3100
Ścinawa	29583.8	2200	1200	1490	1230	3000
Głogów	36393.8	-	1240	1430	1260	3040
Nowa Sól	36780.3	1975	1200	1500	1270	3040
Cigacice	39887.6	-	1170	1540	1280	3050
Mietków	40396.7	-	1200	1350	1280	3200
Połęcko	47152.0	1740	1379	1670	1384	3200
Słubice	53382.0	1740	-	-	1612	3100
Hohensaaten	109938.2	2040	-	-	-	-

*On the basis of "Sommerhochwasser der Oder von 1813 bis 1903", Dr Karl Fischer, Berlin, 1907.

In general on the basis of the data and the progress of flooding in the Odra it can be concluded that weak elements in the system of flood protection are choked canals, polders under use, leaky and disrupted dykes.

As a result of neglect a lot areas were flooded. The flood brought a lot of damage to hydrotechnical structures.

CONCLUSIONS

The disastrous consequences of the 1997 flood showed that there is a need to verify all existing and future design projects. More emphasis should be put on small storage capacity in the Odra river basin. The Institute of Environmental Engineering was involved in the 1994 project "Regional programme of realisation of small storage capacity in the upper and middle Odra River basin". 221 locations of planned and designed storage reservoirs in the main tributaries of Odra River were subject to analysis.

A new study programme should start in co-operation with partners from Czech Republic and Germany.

REFERENCES

1. **Michalczewski J.** (Ed.): Monography of inland waterways in Poland. Komunikacja i Łączność, Warsaw, 1985.
2. **Ichnatowicz S.** (Ed.): Flood in August 1972. Komunikacja i Łączność, Warsaw, 1975.