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## ESTIMATION OF COVERAGE OF WATER REQUIREMENTS FOR FISH (CARP) PONDS IN THE RIVER MAŁA WEŁNA CATCHMENT

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**ABSTRACT.** The paper presents water budget in 1997 and 1998 for 14 carp ponds of area 235 ha located at Kiszkowo. Water supply is provided from the river Mała Wełna. Quality of water was appropriate but due to high seepage losses and low river flows a full impoundment of the ponds was not possible.

**Key words:** fish (carp) ponds, water requirements, coverage, water quality

### Introduction

Exploitation of fish ponds may significantly influence river runoff, particularly in small river catchments intensively used by agriculture (Drabiński 1991). Investigations on detailed water budgets of fish ponds are important from both scientific and practical points of view, especially for regions of water deficits. The paper presents results of estimation of requirements for fish ponds located in Kiszkowo and their impact on runoff of the river Mała Wełna.

### Materials and methods

The investigations of water balance were carried out in the catchment of the River Mała Wełna down to the gauging station at Kiszkowo (Fig. 1) in the years

1997-1998. Physiographical catchment characteristics and technical parameters of ponds were determined. Hydrometric characteristics of the river Mała Welna were measured at three cross-sections (upstream and downstream of ponds at Kiszkowo). Water flow rates were measured using rectangular weirs installed at drop inlet to the ponds. Water requirements for ponds' filling were calculated according to the **Wieniawski and Drabiński (1989)** guidelines. They include saturation of the bottom soil, ponds' filling pool and seepage losses during impoundment. Ground water levels were related to free surface water levels in inner

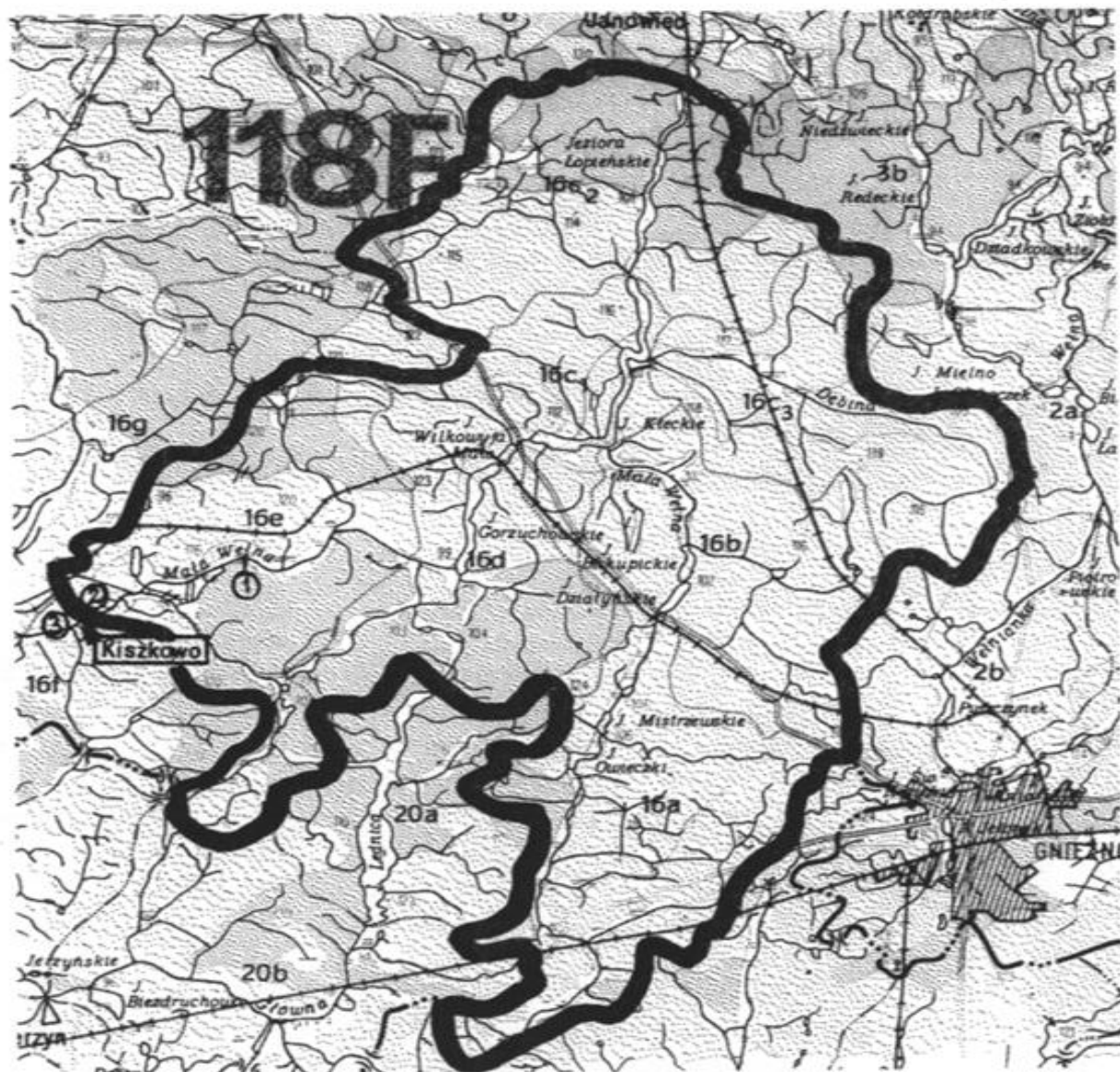


Fig. 1. Catchment of the river Mała Welna down to Kiszkowo (Podział... 1980)  
Ryc. 1. Zlewnia Małej Welny do przekroju Kiszkowo (Podział... 1980)

and outer drainage ditches. In February 1998 ground water level laid between 0.6 m and 1.8 m. Water content in the soil was highly differentiated: in calculations field capacity was taken into account.

Technical parameters of the fish ponds were established on the basis of available technical materials (drawings) and own field measurements. The degree of coverage of water requirements was estimated by comparison of the water demand by fish ponds and flow rates available from the river intake. To determine quality of the influent water, samples were taken at the intake cross-section once a month. Water quality analyses encountered physical parameters (pH, temperature), oxygen conditions (DO, BOD<sub>5</sub>, COD) and concentrations of nutrients (N and P compounds). All analytical procedures were in agreement with those officially recommended by Polish guidelines (**Wykaz...** 1993).

### Catchment characteristics

The catchment of the river Mała Wełna lies in the middle part of the Great Poland Lake District. The investigated catchment area down to Kiszkowo is equal to 330.3 km<sup>2</sup>. It comprises 2.1% lakes (including ponds) and only 7.5% forests. Other parameters are more typical for lowland catchment in the central-west Poland: mean longitudinal slope – 0.11%, and density of river network – 1.3 km/km<sup>2</sup>. Transverse slopes of the river valley vary within 0.5-3.0%, reaching locally 8.0%. The river Mała Wełna flows through nine tunnel-valley lakes of total area 362 ha.

According to the Polish Hydrographical Division (**Podział...** 1980) the river Mała Wełna has its source in boggy valley near Falkowo at elevation of 120 m above sea level. The water level at mean low flow at the Kiszkowo gauge is 99.55 m a.s.l. The river valley is typically post-glacial. The 15 m thick valley cover is built of holocene and pleistocene sediments. The rest of the catchment consists of outwash sands and boulder-clays of a ground moraine.

### Ponds' characteristics

There are 14 carp ponds of total area 235 ha (Fig. 2). They were built in 1986-1989 in Kiszkowo commune and recently were owned by the State Agency of Agricultural Property. The ponds are filled with water from the river Mała Wełna. The river between 40.7 km and 46.8 km of its length (measured from its mouth) flows in a newly constructed channel close to the right-hand side of its valley. There is a weir (No. 1) at 44.325 km which dams up the river till water level of 97.8 m

a.s.l. From that intake 12 ponds of total area 115 ha are filled by gravity. The second weir (No. 2) is located 1.75 km below the first one. Thanks to a nominal dammed water level 97.3 m it allows filling two next ponds of area 120.3 ha. These are earth ponds with independent inflows and outflows. Levees' crests are 3.0 m wide, the wet side slopes 1 on 2 and the dry ones 1 on 3. The levees are made of clayey sands.

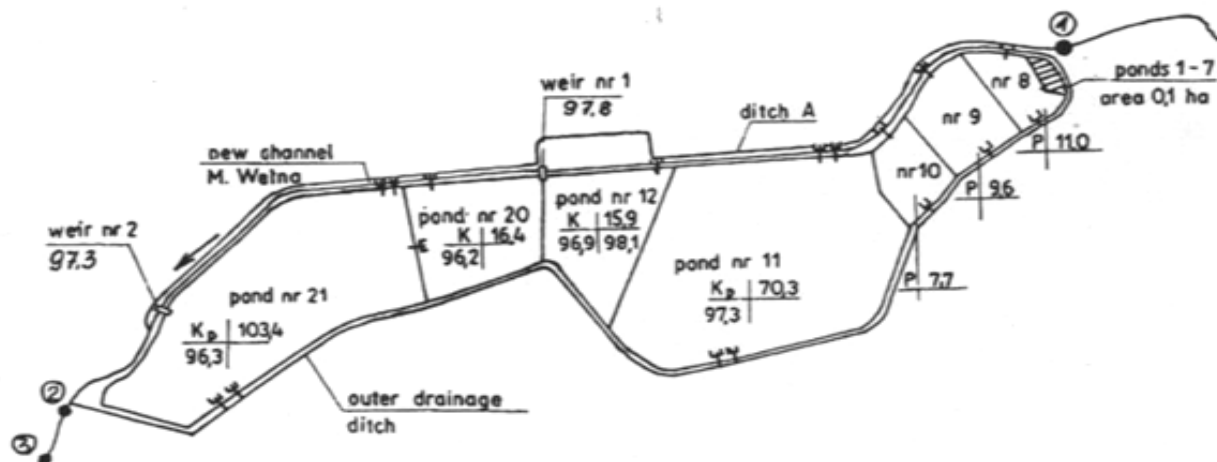


Fig. 2. Layout and area of fish ponds at Kiskowo  
Ryc. 2. Rozmieszczenie i powierzchnie stawów rybnych w Kiskowie

The bottom of ponds consists of bed sediments in the form of a fertile soil of depth 0.8 m. Below there are boggy sediments, peat and organic muds of thickness 8 m, then holocene and pleistocene sediments in the form of non-uniform sands with interbeddings up to 6 m thick. In every pond a network of drain ditches exists. The ditches are 0.6 m deep. Their mean longitudinal slope is approximately equal to 0.5%, bottom width varies from 1.0 to 2.0 m, side slopes 1 on 3 are not lined.

## Hydrometeorological conditions

Weather conditions were determined on the basis of records from the IMGW (Institute of Meteorology and Water Management) meteorological stations: Rogoźno (precipitation) and Gniezno (air temperatures). Mean yearly precipitation in the period 1989-1998 was equal to 451 mm and the half-yearly (May-October) – 161 mm. Correspondent air temperatures equalled 8.3°C and 14.4°C, respectively. Figure 3 depicts deviations of yearly and half-yearly sums of precipitation and deviation of mean half-year air temperatures from multi-yearly means. An analysis of the Figure shows that the hydrological year 1997 can be assessed as average concerning precipitation and cold, and the year 1998 – as dry and warm. In the latter year the yearly precipitation was 95 mm lesser than on average. That was



one of main reasons of occurrence of water shortages at the investigated site. Flow rates measured during spring, summer and autumn in 1997 and 1998 divided by the catchment area gave low values of  $2.7 \text{ dm}^3/\text{s}\cdot\text{km}^2$ . They were lower than the mean values given in the "Polish hydrological atlas" (Atlas... 1987) equalled to  $3.5 \text{ dm}^3/\text{s}\cdot\text{km}^2$ . Runoff variability was low due to storage and routing in lakes and reservoirs.

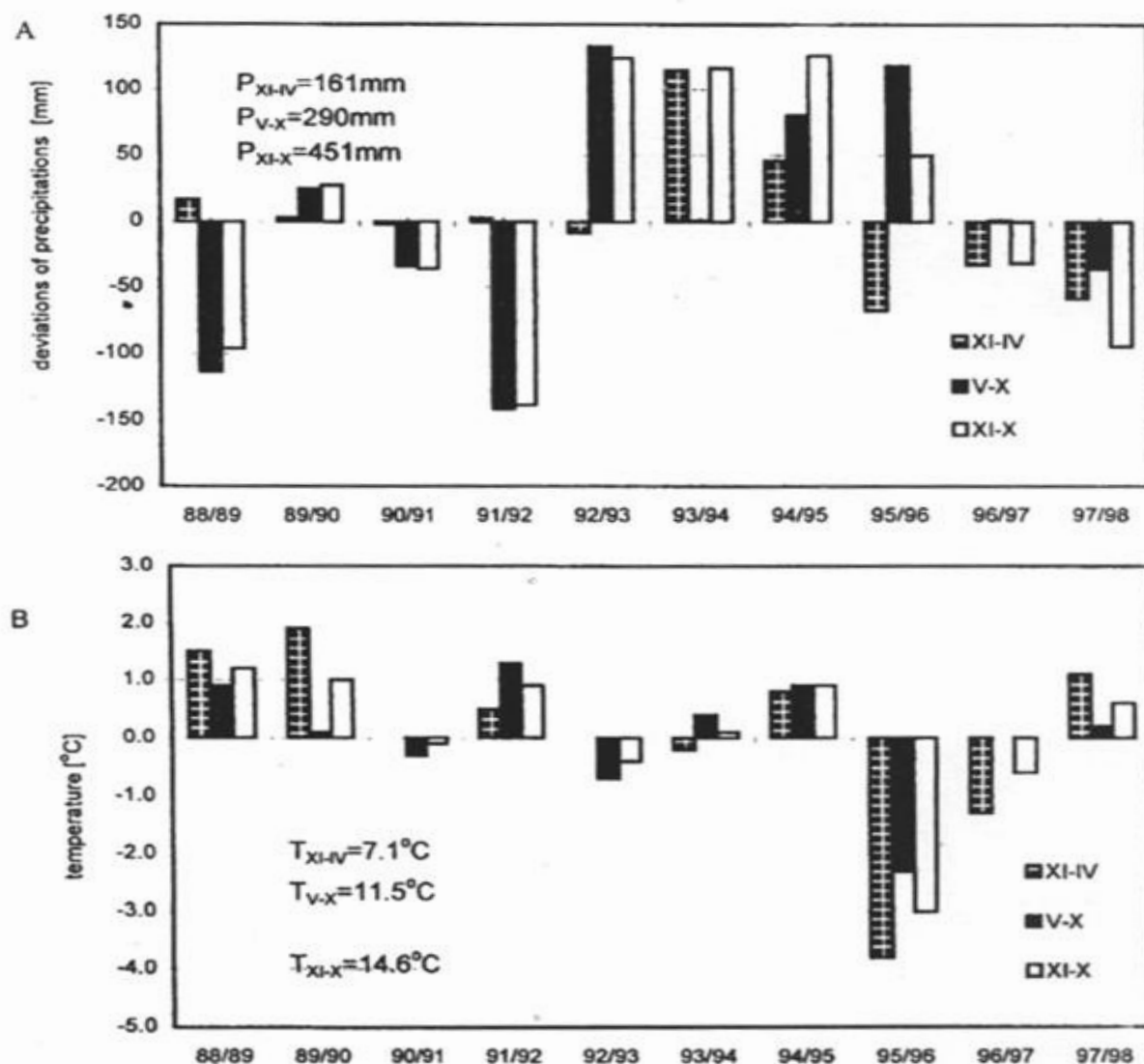


Fig. 3. A. Deviations of yearly and half-yearly sums of precipitation from long-term mean sum (IMGW data for station Rogoźno). B. Deviations of yearly and half-yearly temperatures from long-term mean (IMGW data for station Gniezno)

Ryc. 3. A. Odchylenia rocznych i półrocznych sum opadów od średnich z wielolecia (dane IMGW dla stacji Rogoźno). B. Odchylenia rocznych i półrocznych temperatur powietrza od średnich z wielolecia (dane IMGW dla stacji Gniezno)

## Water quality

Water quality was estimated on the samples taken at the water intake (cross-section No. 1) during period 1997-1998. The results of chemical analyses were compared with consents of Ministry of Environmental Protection, Natural Resources and Forestry (**Rozporządzenie...** 1991). Table 1 shows minimum, mean and maximum values of the measured quality parameters. The lowest row in the Table 1 depicts the required values for the second (II) class of inland surface water quality.

The riverine water was slightly alkaline (pH 7.3-8.4) with low to medium concentrations of nutrients. Concentration of ammoniacal nitrogen varied from 0.1 to 2.0 mg N in 1 l, fortunately in non-gaseous form thanks to medium values of pH. High concentration of dissolved oxygen (mean value from day-time samples – 8.9 mg O<sub>2</sub> in 1 l) confirmed good oxygenation conditions at the water intake. As a whole the quality of water was rather good (I and II class), rarely poor (III class). That was guaranteed by lakes located upstream as well as biogeochemical (tree) barriers along the river banks.

## Water management in fish ponds

The main objective of water management in the carp ponds is to fill them during the period from February to May and then to maintain the impoundment till autumn. The most critical period is naturally the former one. Table 2 shows the results of calculations of the water requirements for ponds in this period.

To determine disposable water resources at the section 1 actual mean monthly flows were diminished by biological flows. The latter ones were established on the basis of hydrobiological criteria as  $Q_n = 0,243 \text{ m}^3/\text{s}$  (**Kostrzewa** 1977).

Comparing monthly water requirements with monthly flow volumes (Fig. 4) one may state water shortages, particularly in the dry year 1998. The coverage of monthly requirements varied from 53% to 68% in the average year 1997 and from 50% to 75% in the dry and warm year 1998. The shortages made it impossible to fill up fully ponds No. 11 and 12. Two next ponds (No. 20 and 21) of area 120.3 ha remained dry due to lack of water.

From the analysis of water budget one may conclude that the beginning of ponding should be shifted to the autumn of the previous year.

Table 1

Minimum, mean and maximum values of chosen parameters of water at intake (section No. 1) in years 1997\* and 1998

Minimalne, średnie i maksymalne wartości wybranych wskaźników jakości wody w dopływie (przekrój pomiarowo-kontrolny nr 1) w latach 1997\* i 1998

Parameter Parametr	Water temperature Temperatura wody (°C)	Dissolved oxygen O <sub>2</sub> Tlen rozpuszczony O <sub>2</sub> (mg/l)	Ammoniacal nitrogen N Azot amonyowy N (mg/l)	Nitrite nitrogen N Azot azotynowy N (mg/l)	Nitrate nitrogen N Azot azotanowy N (mg/l)	Phosphates PO <sub>4</sub> Fosforany PO <sub>4</sub> (mg/l)	pH
Number of samples Liczba prób	15	15	15	15	15	14	15
Min. - Min.	0.5	3.2	0.1	0.01	0.14	0.05	7.3
Mean - Śr.	9.8	8.9	0.76	0.032	0.94	0.35	7.9
Max. - Maks.	22.0	16.2	2.0	0.09	1.63	0.88	8.4
Norm II class Norma II klasy		5	3.0		7.0	0.5	7.0-8.0

\*The author's data were supplemented by data obtained from the Provincial Inspectorate of Environmental Protection in Poznań.

\*Dane własne uzupełniono danymi udostępnionymi przez Wojewódzki Inspektorat Ochrony Środowiska w Poznaniu.



Table 2

Water requirements for fish ponds in Kiszkowo  
Zapotrzebowanie dopływu wody do napełniania stawów rybnych w Kiszkanie

No. Nr	Pond type Kategoria stawu	Symbol	Area Powierzchnia (ha)	Mean depth Średnia głębokość $h_1$ (mm)	Thickness of aquifer Zbiornik podz. $h_2$ (mm)	$h = h_1 + h_2$ (mm)	Date of ponding Termin zalewu	Ponding time $T$ (day) Czas zalewu $T$ (doba)	Demand Zapotrzebowanie	
									unit jedn. (1/s/ha)	total całk. (1/s)
1-6	spawning tarliska	T	0.1	1 200	102	1 302	V	2	75.5	7.6
7	warning-up ogrzewalnik	O	0.1	1 600	102	1 702	V	2	98.7	9.9
8	nursery I przesadka I	P <sub>I</sub>	11.0	1 200	107	1 302	V	14	10.8	118.8
9	nursery I przesadka I	P <sub>I</sub>	9.6	1 200	102	1 302	V	12	12.6	120.8
10	nursery I przesadka I	P <sub>I</sub>	7.6	1 200	102	1 302	V	10	15.1	114.8
11	market towarowy	K <sub>p.</sub>	70.3	2 100	75	2 175	III-IV	30	8.4	591.3
12	fattening kroczkowy	K	15.9	2 150	75	2 225	III-IV	20	12.9	205.2
20	fattening kroczkowy	K	16.9	1 850	75	1 925	III-IV	20	11.2	188.7
21	market towarowy	K <sub>p.</sub>	103.4	2 200	75	2 275	II-III-IV	89	4.4	454.8
	Σ		235.9							

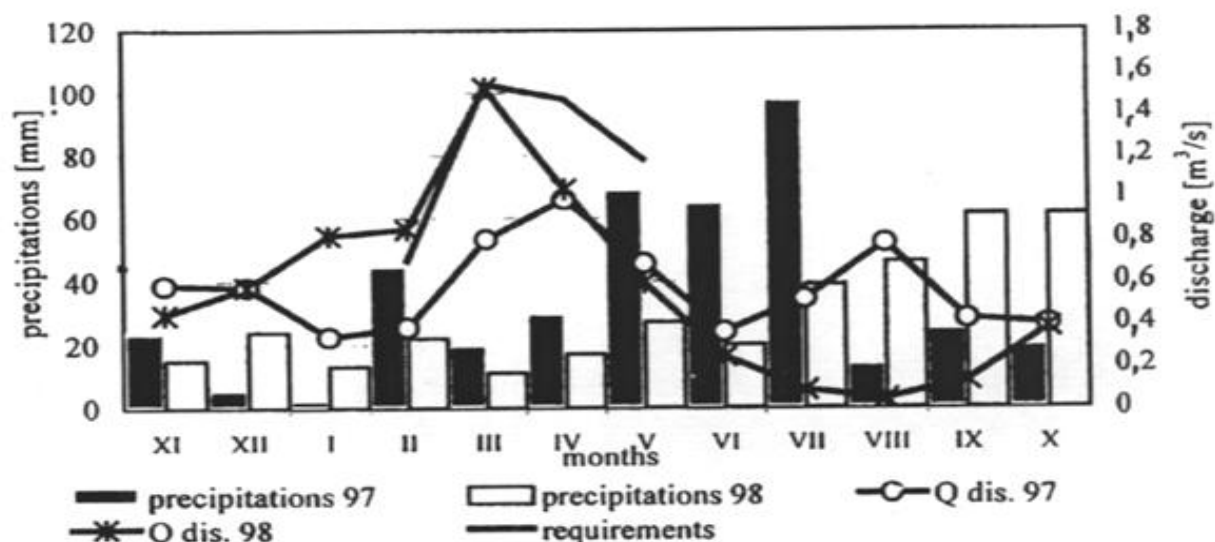


Fig. 4. Water requirements for ponds at Kiszkowo and disposable resources at section Myszki on the river Mała Węlna related to monthly precipitations (IMGW data for station Rogoźno) in years 1997 and 1998

Ryc. 4. Zapotrzebowanie stawów rybnych w Kiszkowej na wodę a zasoby dyspozycyjne w przekroju Myszki na Małej Węlnie na tle miesięcznych opadów (dane IMGW dla stacji Rogoźno) w latach hydrologicznych 1997 i 1998

## Conclusions

1. Water quality was not a critical factor in supply of the analysed fish ponds.
2. Water quantity was not sufficient for full impoundment of the ponds due to high seepage losses and low river flows, particularly in the dry year 1998 when only 50-75% of monthly water requirements were fulfilled.

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## OCENA POKRYCIA POTRZEB WODNYCH STAWÓW RYBNYCH (KARPIOWYCH) W ZLEWNI MAŁEJ WEŁNY

### Streszczenie

W pracy przedstawiono wyniki badań terenowych prowadzonych w latach 1997-1998 na stawach rybnych w Kiszkanie, położonych w zlewni Małej Wełny. Kompleks składający się z 14 stawów karpionych, o łącznej powierzchni 235 ha wybudowano w latach 1986-1989. Małe zasoby wód dyspozycyjnych Małej Wełny spowodowały, że pokrycie potrzeb wodnych stawów w kolejnych miesiącach ich napełniania zmieniało się w granicach od 53% do 68% w 1997 roku i od 50% do 75% w 1998 roku.