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TECHNICAL ASPECTS OF WETLAND RESTORATION: SELECTED EXAMPLES

E. Jędryka, M. Borys

Institute for Land Reclamation and Grassland Farming at Falenty, 05-090 Raszyn, Poland
e-mail: e.jedryka@imuz.edu.pl; e-mail: m.borys@imuz.edu.pl.

A b s t r a c t. This paper presents needs and technical possibilities of affecting reclaimed valleys and wetland habitats in order to restore them. Based on the past and present ecohydrological conditions, a possibility of restoring the status of three different objects to that from before reclamation has been presented. Technical concepts of restoration is presented in short. General guidelines for technical restoration were formulated.

K e y w o r d s: restoration, meandering river channel, ecological hydraulic structures

INTRODUCTION

According to a definition given by Okruszko [5], wetlands are ecosystems, which genesis is associated with wet habitats to a degree, which ensures the presence of hydrophilous vegetation and accumulation of hydrogenic soil formations. Recently, wetlands are also meant as ecosystems associated with hydrogenic sites transformed by draining, which underlines their origin, potential natural value and technical possibilities for their restoration [1].

Parts of wetlands, e.g., marshy meadows, has been subject of agricultural interest because of their high potential productivity. Agricultural utilization of wetlands was, however, possible only after draining, which was usually achieved by river regulation and drainage reclamation. River regulation was mostly accomplished through the reconstruction of the river channel with its straightening, shortening and deepening. Meandering rivers of well developed network of channels were most affected. Drainage reclamation was usually performed through a network of ditches supplemented with draining pipelines. As a result of human activity, most river valleys ceased to play their natural functions in the environment and were transformed into agricultural lands of different, often restricted, natural values.

Due to recent changes in the economic situation in Poland, agriculture often retreats from the formerly reclaimed areas. These areas quickly undergo "degradation" as there is no proper water management (restricted to draining only in the reclaimed areas), agrotechnical operations and fertilization are abandoned. One of the ways of using the above areas is their restoration, more the so as these are sites with natural hydrophilous vegetation around ditches and in the mid-field shrub "islands" which provide a pool for species dispersion. A complete restoration and recreation biocoenoses typical of river valleys with adequate habitat conditions is difficult. Therefore, actions are often restricted to a "partial restoration" consisting in the protection of some selected species of flora and fauna.

In order to specify the goals assumed for a given object, it is necessary:

- to recognize and delimit main habitat complexes,
- to recognize present status of soils and vegetation in the habitats so-distinguished,
- to estimate natural and anthropogenic successional trends,
- to analyze present water conditions.

Data collecting enables to estimate types of habitats, re-creation of which is possible on a given area. Understanding of the water requirements of plant associations allows to elaborate a technical concept of restoration.

EXAMPLES OF TECHNICAL RESTORATION CONCEPTS

Three technical concepts of restoration of wetlands situated in the upper Narew river valley are given in short. The objects differ in the set up of their hydrographic networks and the existing technical infrastructure but also in the availability of water resources and in the present status of vegetation.

The Rudnia object

As shown in field studies [2,6] and through analysis of the archive materials, the Rudnia was a meandering river. The riverside areas were fed by both flood waters and ground waters and shore areas by the inflow of side ground and surface waters. The valley – a concentration place for both ground and surface waters – was characterized by a high water saturation, which favored accumulation of hydrogenic formations and the development of hydrophilous plant associations. Due to reclamation works initiated in the sixties, the character of the river valley changed drastically. The river channel was straightened and widened and several side channels were constructed. As shown by field measurements taken in the regulated and non-regulated (immediately downstream of the former valley) parts of the river, the regulation widened the river bottom by about 0.65 m and an upper profile by about 2.5 m. Old meanders remained but lost their connection with the mainstream. The course of the present, regulated river channel and the old meandering one is presented in Fig. 1. The river regulation and construction of side channels decreased water table in the river. Now, ground water table in parts of the valley adjacent to the river channel, is at a depth of 0.10 – 2.10 m below ground. Such a deep water table together with agricultural utilization (mainly as meadows and pastures) forced an introduction of plant species characteristic of poor fresh meadows. Now only ox-bows are characterized by a diversity of plant associations with the most common rush communities represented by manna-grass and associations of acute sedge and beaked sedge.

In the concept elaborated [6], the aim of restoration was assumed as a recreation of the vegetation characteristic of the river valley and processes of silting by river floods. It was assumed that a belt of rush plants several to several dozen meters wide along the river and extended meadows in the area would develop as an restoration effect.

The technical concept for a 950 m long river section was based on the assumption that the changes desired might be achieved through meandering the river channel and constracting hydraulic structures. The course and longitudinal profile was designed so as to lead the channel along the main ox-bows and to ensure the bottom ordinates of the beginning and end of the section restored be the same as in the regulated channel. As a result of changing the river course, length of the section would increase from 950 to 1350 m and its mean slope would decrease from 0.69 to 0.34‰. To maintain water conditions typical of variable meadows, three hydraulic structures were planned in the river channel which would provide the following functions:

a) Forcing water flow through meanders. Structures will be localized in the crossings of the regulated and meandering river channel. They will not allow water flow (up to a given level) through the regulated channel but instead will direct it to the meander. An example of such a construction is given in Fig. 1b. It is a dyke, which can be constructed of local materials. At low waters it would operate as a "mini" embankment and at high waters – as a spillway. With such an embankments along the whole river, cut-off sections of regulated channel would form basins water, holes filled at the maximum flows but with no throughflow at the

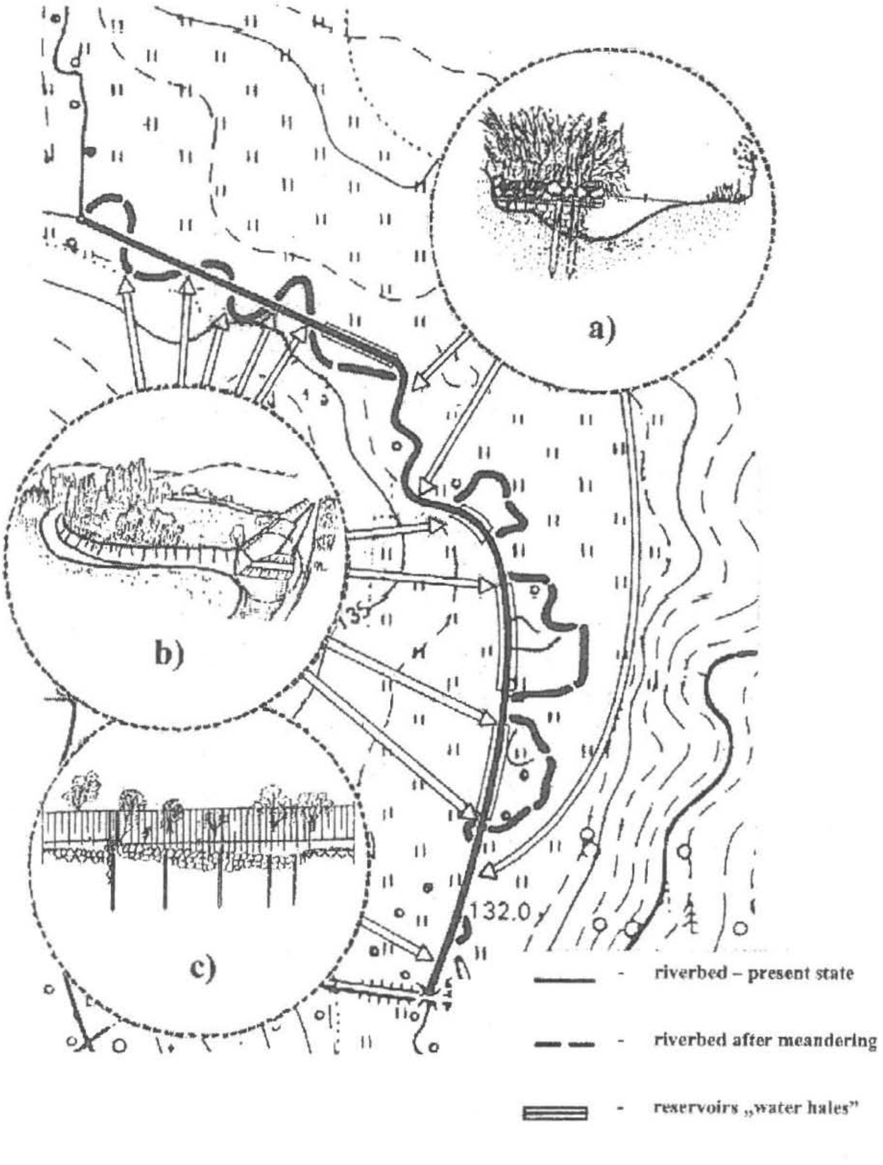


Fig. 1. The Rudnia's river valley segment of intendent for restoration, technical activities proposed: a) riverbed narrowing structures, b) dykes affecting water flow by meanders, c) stone spillway

lower water stages. For the reason of stability and protection against rodents, such an embankment should have a proper design, shape and size.

b) Narrowing the river channel. This is necessary in the sections where courses of a wider, regulated channel overlap with the narrower, meandering section. Bank constructions made of wooden logs and stones shown in Fig. 1a is perfectly fit for this purpose.

c) Closing the meandered section. This is a storage structure situated in the lowest profile of section of the channel designed for meandering. It is necessary to ensure: connection between the regulated and meandered channels, additional water rising in the channel at low flows, counteracting the unpredicted "river behaviour" after meandering (e.g., in the case of too low water tables in periods other than periods of low flows).

The Sumiackie Meadows object

The object is a part of the Tyniewicze peatland. Before reclamation, as a result of an inhibited outflow by various Narew channels and also due to the rising of ground waters by the valley waters, there were favorable conditions for peat accumulation in the object. Construction of a network of draining ditches resulted in faster water drainage and in the drying of the upper layer of peat deposits. The inhibited accumulation of organic matter and, then, its mineralization led in consequence to the disappearance of peat.

There are two main ditches, R-A and R-J, and a K-A channel in the object (Fig. 2). Ditch R-J runs along the eastern side of the object, the slope of its bottom varies from 0 to 6.7‰. Three concrete culverts are located along the ditch (P on Fig. 2). Ditch R-A runs through the central part of the object. The mean slope of its bottom varies from 0.35 to 3.36‰. There are 12 concrete constructions in the ditch (a step, 8 culverts and 3 weirs). Channel K-A runs along the western side of the object with a slope of 0.16 – 5.6‰. Five concrete hydraulic structures were made in the channel (2 weirs, 2 culverts and a step). Channel K-A is connected to R-A ditch with a side R-A_3 ditch [3].

Most of the area of the Sumiackie Meadows is now used as meadows and pastures. In the southern part, there are agriculturally valuable, regularly mowed meadows which supply good quality hay. Meadows in the middle part of the object are less valuable since this area is periodically flooded. This part is used less frequently. Then northern part is occupied by extensively grazed wet meadows and sedges. The lack of management practice (mowing, fertilization) resulted in

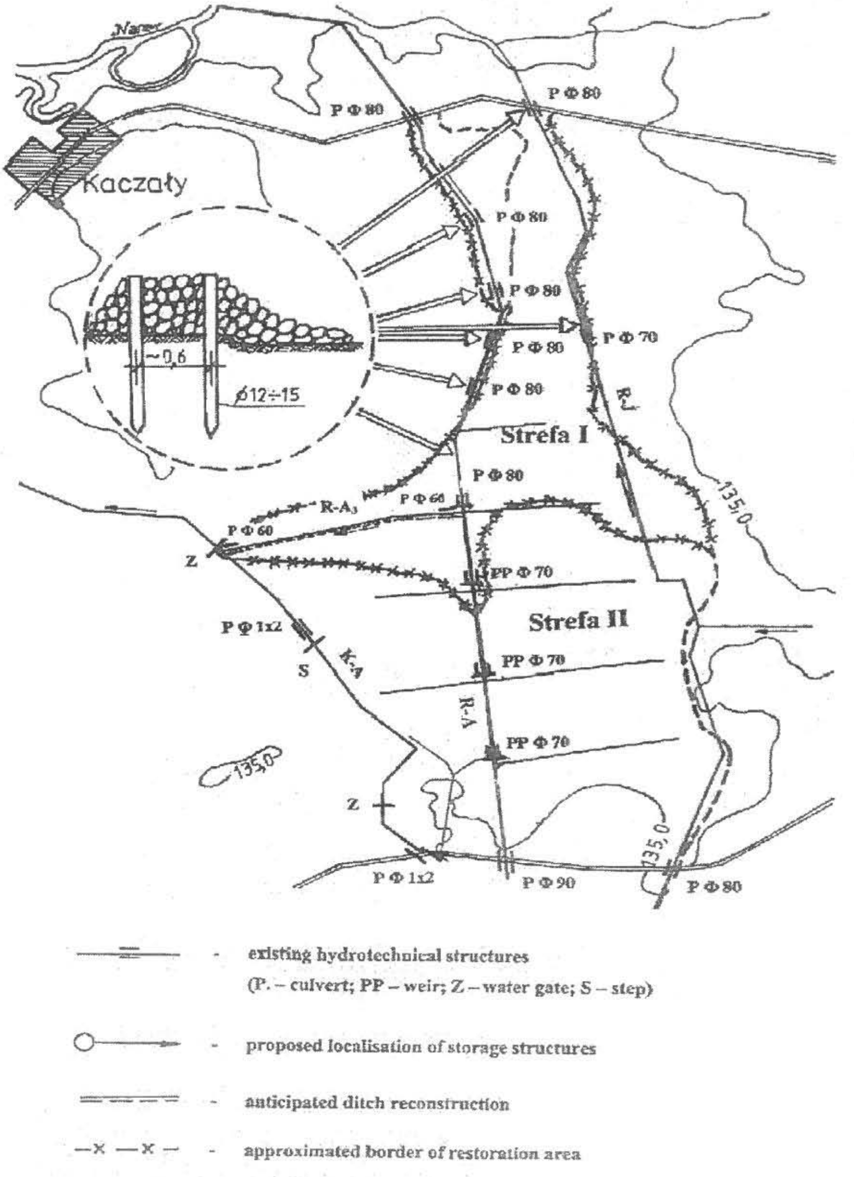


Fig. 2. The Sumiackie Meadows – hydrography, existing hydrotechnical structures and proposed technical solutions

the secondary succession, leading to the development of weeds, herbs with a high contribution of sedges and rushes.

Habitat, soil and floristic analyses allow for the conclusion to be drown that the best management on the Sumiackie Meadows is to restitute wet meadows with a typically high biodiversity in the southern and middle parts of the object and to maintain the existing marsh communities in the northern part.

Analyses of the stream network and situation of the surface and ground water tables showed that it is possible to restore the object by a minor enrichment of the technical infrastructure and conservation of the existing ditches and constructions. A preliminary concept of hydrotechnical solutions was elaborated on the assumption that:

- the object will be agriculturally used as meadows and pastures (in a way it is done now) only in its southern part;
- agricultural activity in the remaining area will be abandoned since the water table will be raised, it will result in a self-spreading of plant species characteristic of high moisture areas.

A technical concept of restoration was based on the assumption that water from R-A and R-J ditches but also water delivered by K-A channel would be used. This requires water raising in the northern part: at five cross-sections in ditch R-A and at two cross-section in R-J ditch. The concept requires also the clearing of the side R-A_3 ditch and making its slope adequate for the directing of water from K-A channel to R-A_3 ditch (in the past R-A_3 ditch was a draining ditch, now the slope of its bottom and that of the pipeline are reversed). Culverts connecting R-A_3 ditch with K-A channel and R-A ditch should also be repaired. The existing culverts should be equipped with storage devices at their inlets or new ecological constructions in a form of wooden palisades or stone steps should be constructed.

In the northern part of the object where agricultural production is planned, no additional constructions are needed. The required level of ground water can be obtained in this part with a help of the existing hydraulic structures.

The Małynka object

It consists of a part of the river valley, with a total length of 19 km and a catchment area of 50.3 km^2. A concept of restoration was elaborated for the middle 5.4 km long part of the river [4]. In the natural conditions, the Małynka was a meandering river. As an effect of regulation, the river channel was straightened and deepened and the valley cut with a network of draining ditches. Fragments of the natural river channel were filled up and only rare ox-bows usually with no connection with the mainstream remained. Now the width of the river bed varies from 0.5 m to 3.5 m, the upper cross-section – from 5 m to 8.6 m, depth – from 0.8 to 1.5 m and the longitudinal slope of the bottom varies from 0 to 3.6‰.

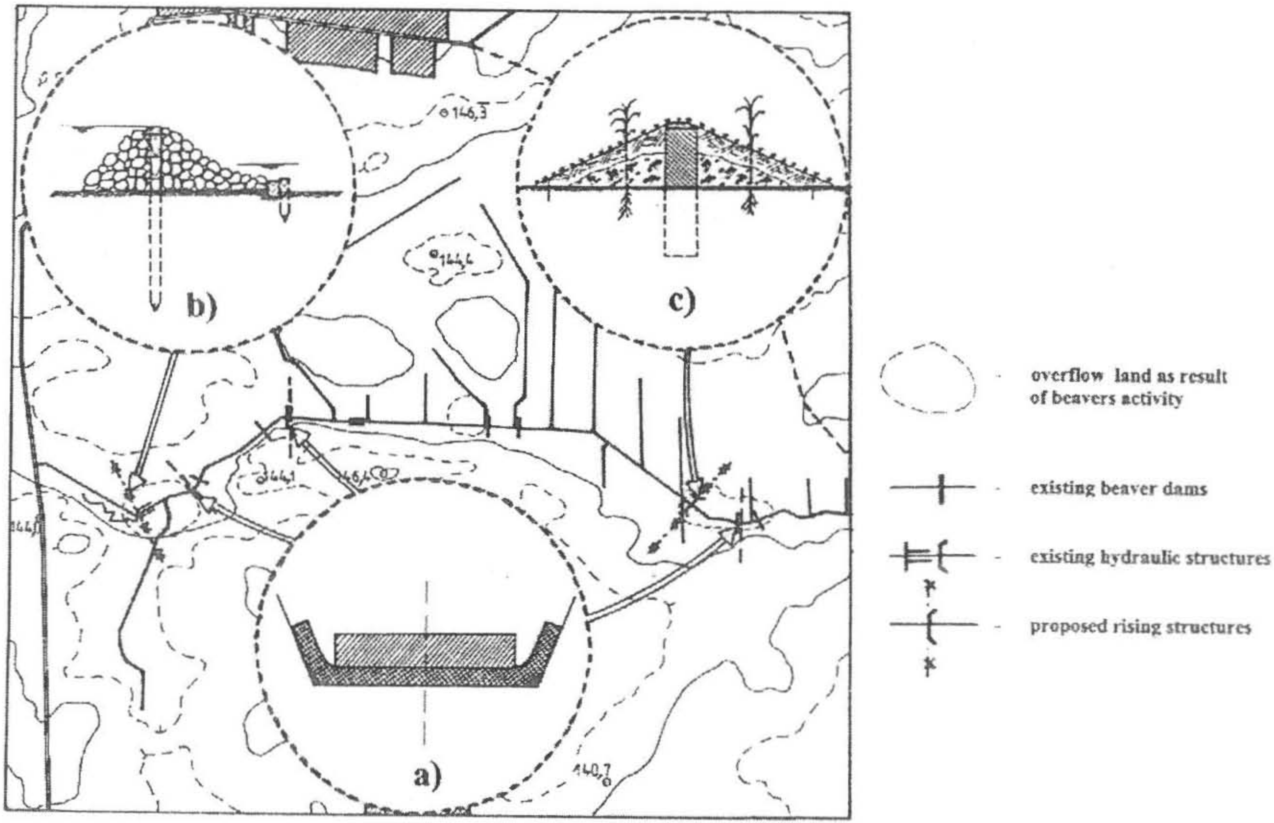
Ten structures were localized in the studied river section: 3 bridges, 5 weirs (2 seriously damaged) and 2 culverts. Additionally, there are numerous beaver dams along the river. Traces of ox-bows remained in the valley, 18 in the right shore 18 and 11 in the left river sections from before regulation. Twenty one draining ditches were made in the valley section studied during reclamation. Most of them are relatively short of a length between 150 and 300 m.

Three objectives were planned in a natural part of the restoration concept:

- to maintain the present direction of biocoenotic development through stabilizing habitat conditions in the relatively natural areas of the advanced secondary bog processes associated with beavers' activity;
- to increase soil moisture on valley stretches mostly transformed after regulation and draining. These actions would focus on the reversing soil degradation and on the creating conditions appropriate for the growth of hydrophylous vegetation;
- to re-create the landscape characteristic of a valley of a small stream. This goal should be achieved through the re-creation of an old river bed and, where possible, through the restoration of meanders cut off from the mainstream by regulation.

In the technical restoration concept, it was assumed that the recommended elevation of the water table would be combined with the following groups of constructions (Fig. 3):

a) existing hydraulic structures in a good technical state or after minor repairs;
b) existing beaver dams;
c) new water rising structures localized:
   - downstream beaver dams and therefore demanding special attention as to their design and construction. These requirements are fulfilled, e.g., by gabion steps (Fig. 3a);
   - in the remaining cross-sections. These constructions should be made of environmental-friendly materials (Fig. 3b);
d) structures existing in the river channel, which need modernization due to:
   - partial destruction or a need to fit them into a natural valley landscape (Fig. 3c);
   - a possibility for using them for water storage in the channel.



ig. 3. Hydrographic net and localisation of hydraulic structures at the section of the Małynka river valley predicted for restoration: a) gabion step, b) dam constructed from wood and stone covering, c) "camouflage of concrete gate

An accomplishment of this restoration variant requires: 5 constructions that would supplement beaver activity, 3 new environmental-friendly water rising structures, reparation or rebuilding of two partially destroyed weirs and the closing of one culvert.

Apart from the constructions needed to raise the water level in the river and its valley, changes of the river course were also planned. Changes would involve these river pasts where traces of the old course from before regulation are still visible. Small hydraulic structures in the draining ditches (fascine gates or dams of gabions) were planned as supplementary measures. These structures should be localized in the ditches within the range of backwaters caused by water storage in the river.

DISCUSSION AND CONCLUSIONS

After thorough analysis of wetland restoration concepts and data from literature, it was found that there are generally two possible situations when:

- there is a stream flowing into the valley which, depending on the needs, may be used to flood the valley or to raise ground water level;
- the valley is cut with a network of draining ditches and there is no stream with constant water flow.

As has been already mentioned, to re-create vegetation in the restored object, one has, first of all, to recover water regime appropriate for plants. This may be achieved by technical measures which bring about an effect reverse to that of draining. First, water outflow must be slowed down which, in the case of a regulated river, is associated with the recovery of former course, shape, size and natural roughness of the river channel. In the case when the surface is covered by a network of ditches, one has to stop water outflow or, if it is economically impossible (the adjacent area is used by agriculture), to delay the outflow with storage structures. One may also consider import of water.

Technical aspect of restoration often arises many objections among ecologists. Based on several-year-long experience, we may state that recovering water conditions without human intervention, relying on nature only, is almost impossible since we can hardly count on such a rapid intervention of natural forces as it has happened in some parts of the Małynka valley. Usually, we have to decide upon the type of hydrotechnical constructions, their number, location and material used. We must also decide, if changing the river course, or rather restoring its former route, must be done quickly, with the use of heavy equipment or rather by itself through forcing the water flow direction with shore constructions (heads).

The investigations carried on the objects presented in this paper enabled to formulate general conclusions on the technical restoration as follows:

1. The establishing of a new river course or rather recovering its way from before regulation, is relatively simple, if traces of old meanders remained in the field and when we have maps from which such a course can be re-constructed. Otherwise, the new river course should be formed according to the reference river sections. Such sections should, if possible, be selected from the natural parts of the same river or other hydrologic, topographic and geological conditions close to those in the restored section.

2. An additional obstacle in the designing of the river course in the restored section is the presence of the regulated channel with geometric and hydraulic parameters different from those of the natural one. This problem can be solved in three ways:

- the regulated channel is included in some sections to the new river course,
- the regulated channel is closed by a dam and forms water reservoir,
- the regulated channel is definitely liquidated by filling up.

3. The main principle we must adopt in the designing of the new river course is to re-construct the natural set up of the river bottom and particularly its slope. It appears that shape of the bottom and its variability along the river course are associated with the maintenance of the hydrodynamic and hydrobiological equilibrium. Data on the vertical profiles of the channel should thus be obtained based on observations and measurements made in the reference sections of the natural river.

4. To preserve the natural character of the river, it is necessary to differentiate shapes and sizes of the cross-section. In parts where the river flows in an old channel, this goal is achieved by the maintaining of the natural shore forms: heads, bays, peninsulas, islands and various slopes.

5. In the part where the new river course coincides with the regulated one (often deeper and wider), it is necessary to change geometry of the channel which can be done through:

- biological protection of the river bed, i.e., planting the bottom and slopes with aquatic vegetation. As has been shown in the studies carried out at the Institute for Land Reclamation and Grassland Farming [7], species appropriate for this purpose in small rivers are: water meadow-grass, reed canary-grass, acute sedge and sweet flag. Literature data suggest also using osier in such cases;

- the use of wooden, stone-wooden, fascine or fascine-stone constructions bound to the shore and narrow at the channel;
- the use of fences or small palisades leading to the self-elevation of the bottom (due to silting).

6. The very idea of restoration means that the introducing hydrotechnical constructions should be restricted to an absolute minimum but in many cases we can not get rid of them. These should be special constructions, least emerging above the water table and allowing free movement of aquatic organisms. The constructions need to be made of special materials "close" to natural ones such as wood, fascine, earth. The engineering practice knows such constructions as wooden or stone-wooden weirs, fascine palisades and fences, fascine and pile dams, stone steps and rapids, earth dams of reinforced crest which are perfect for the use in channels of the restored rivers.

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TECHNICZNE ASPEKTY RENATURALIZACJI OBIEKTÓW MOKRADŁOWYCH NA WYBRANYCH PRZYKŁADACH

E. Jędryka, M. Borys

Instytut Melioracji i Użytków Zielonych w Falentach; 05-090 Raszyn, Polska

S t r e s z c z e n i e. W artykule omówiono potrzeby i możliwości technicznego oddziaływania na zmeliorowane doliny małych rzek nizinnych, z siedliskami mokradłowymi, w celu ich renaturalizacji. Na tle istniejących w przeszłości i w chwili obecnej warunków hydroekologicznych, zaprezentowano możliwości przywrócenia do stanu z przed melioracji trzech różnych rodzajów obiektów. Pokrótce przedstawiono techniczne koncepcje przywrócenia ich do stanu naturalnego. Na tym tle sformułowano ogólne założenia w zakresie technicznych podstaw renaturalizacji.

S ł o w a k l u c z o w e: renaturalizacja, warunki hydroekologiczne, meandryzacja koryta rzeki, działania techniczne, ekologiczne budowle wodne