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ECOLOGICAL ASPECTS OF FLOOD DEFENCES

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(Prepared by Ms. Joanna Filip and Ms. Magdalena Dybalska,
Institute of Meteorology and Water Management)

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Flood control dates as far back as the dawn of civilization. It has undergone a series of stages and changes along with the development of new methods and technologies. The areas, previously left intact, have been transformed as a result of urbanization and the development of agriculture.

The following are used, among other things, for the purpose of flood control and protection:

- river regulation
- the construction of storage reservoirs
- the construction of flood embankments
- the construction of polders.

The transformation of river beds for the purpose of a more efficient water intake, protection against the effects of extreme phenomena, improved navigability of waterways, etc. has been applied since the beginning of time. However, such enterprises have been undertaken at the most intensive scale since mid-1850's. In this period the biggest water management systems have been created, regulation works have been conducted on the largest scale, and the biggest number of storage reservoirs has been constructed.

Flood control has many aspects. Its main task is to protect people and land against flooding. However, while realizing various flood control projects we may not forget about the consequences for the natural environment. Regulation works conducted on river beds, consisting in the construction of stages of fall, dams and storage reservoirs, the cut-off of old river beds and the construction of embankments lead to enormous changes in the ecosystems of rivers and inundation areas, which results in reduced biodiversity.

The impact of flood defences on aquatic environment consists primarily in the transverse and longitudinal fragmentation of the river valley. The transverse fragmentation of the river valley disrupts its continuity as a result of the construction of water dams, whereas the longitudinal fragmentation does so because of the construction of embankments along the river bed.

The longitudinal fragmentation of the river valley is caused primarily by flood embankments, which cut off the river from its original inundation areas.

In order to improve the hydraulic properties of the river valley to accelerate the water runoff, the original variety in their spatial arrangement was eliminated in river valleys, which had previously included areas with various moisture contents in the soil, old river beds, seasonally flooded areas, forests of various types, which were connected with diverse water conditions. In the valley each of these elements was connected with different communities of plants, animals and avifauna.

In order to improve their hydraulic properties, rivers were regulated, as a result of which the natural and semi-natural conditions of water flow in the river bed and in the inundation terrace were altered. This regulation includes e.g. channel straightening, the narrowing and deepening of the channel, the creation of a uniform transverse and longitudinal section of the river bed, and the removal of the riverside vegetation. Water structures used to realize the above mentioned tasks include stone and concrete walls, groins and narrowing dams. The standardization of river gradients and the shape of river channels is combined with the elimination of shoals, deep places and islands. Frequently regulation works include the cutting of whole riverside forests, the levelling of the terrace using heavy machinery and quite often also land reclamation works draining the river valley.

River regulation may cause changes in hydrological parameters of the stream channel and the major bed, and results in the changes in the hydrological regime of the watercourse.

The course and intensity of extreme phenomena are altered, the transport of debris in the watercourse is changed, the river bank constructions sometimes built using materials harmful for the natural environment and the elimination of riverside vegetation have an adverse effect on the development of aquatic flora and fauna, losing their natural niches. A change in the watercourse flow velocity and other characteristic hydrological phenomena also have an adverse effect on the natural environment. As a result of works conducted in the major bed, in the opinion of hydraulic engineers necessary for flood control, the processes of autopurification of are hindered in the rivers.

The elimination of islands and bars prevents breeding of numerous bird species, the biology of which is connected with river beds.

While constructing engineering structures on the river bank, the usual practice is to remove vegetation covering it. This in turn results in the elimination of breeding sites of rare bird species, frequently endangered throughout Europe. Osier bushes found in the river bank zone, along with the grassy patches and small old river beds which they cover, are breeding grounds for numerous bird species (Tomialojc L. 1993).

The levelling of the bottom in river beds leads to a decrease in the population of ichthyofauna. As a result of such works deeper and calmer river fragments, habitats with bigger depths and slower flow disappear. Generally all the works conducted within the river bed, together with the removal of river bank vegetation with their roots immersed in water, have an adverse effect on the size of the population of fish which require these habitats for shelter, as resting places and spawning sites. The populations of spikes, roaches, rudds and breams in regulated rivers are by 28% smaller than those in unregulated watercourses (Witkowski J. 1995).

The levelling of the inundation terrace in practice means the destruction of still more habitats of valuable plants and animals. Riverside forests are then almost completely cleared, small water bodies and old river beds are filled. The clearance of large forest areas on river banks concerns at present first of all the embankment areas. As a result other potential nesting grounds for birds disappear.

The effects of the drainage, levelling and filling of old river beds and small water bodies are felt especially severely by amphibians, which are far less mobile than birds. Small surface water bodies are for them breeding grounds for adult forms and the sites for the development of larvae. A lack of old river beds and small water bodies results in the extinction of amphibians. According to herpetologists, the number of anurans, especially toads, drops – depending on the species – from several to about a dozen times 10 years after the completion of a land reclamation project in the river valley (Witkowski J. 1995).

Unregulated river beds remain in the state of dynamic equilibrium, supported by the floating and deposited stone debris (Raichholf J. 1998). In the upper course of rivers water carries away material from the bottom and deep erosion predominates. In the middle course of rivers lateral erosion begins to dominate, whereas in the lower courses the accumulation of dragged material is already predominant (Dynowska I., Tlalka A., 1976). Engineering structures on the banks and the construction of dams and stages of fall disrupt these processes.

Many segments of river valleys have undergone severe changes as a result of human activity.

Losses accumulate with the increasing human interference in river valleys. Embankments situated close to the river bed cause a rise in the level of flood water. Structures constructed close to the river and intensively managed areas, in spite of attempts at their protection, are probably going to be destroyed during the high water stage.

As a consequence of cutting a segment of the river valley off the natural inundation areas, soil-forming processes are frequently inhibited, ground is over-dried and most old river beds dry out. In Europe it results in the disappearance of some plant associations typical for river valleys connected with water-logged areas, and the drying out of riverside forests and alder carrs. The composition of fauna has also changed in these areas. The construction of flood embankments limits the water-retaining capacity of river valleys, thus increasing flood hazard in the lower river.

A completely new problem in the recent years is chemical hazard caused by waste rock used for the construction and modernization of embankments. It is a waste material of coal mining. When exposed to the action of rainwater, ground and river waters, it causes salinification of soil as a result of leached chlorides and acidification as a result of leached sulphates. An additional load of heavy metals accompanying ferric sulphates, such as e.g. zinc, molybdenum and selenium, is released to the environment in the course of acidification processes. At the same time radioactive elements are released as well. As a result riverside ecosystems are degraded (Wawrety R.).

The construction of man-made reservoirs results in the disruption of river continuity, as the so-called transverse fragmentation takes place. The ecological barrier, which is impossible for fish to cross, is formed. The effects of the construction of dams and stages of fall is felt especially severely by these species which spawn in the upper river segments, e.g. the Roznów dam on the Dunajec along with the compensation reservoir in Czchów had a clearly adverse effect on the populations of salmon and brown trout, which in spite of fish ladders were not able to cross them to reach the previously observed spawning grounds above Roznów (Backiel T. 1993).

Changes in ecosystems caused by the construction of storage reservoirs depend on the location of the ecosystem in relation to the reservoir. Ecosystems situated above the reservoir are threatened with modifications of the thermal regime, the accumulation of sediment in the reservoir, changes in water quality and changes in groundwater around the reservoir. These changes affect plankton and periphyton, the growth of aquatic macrophytes and riparian vegetation, resulting in the changes in the populations of invertebrates, fish, birds and mammals. On the other hand, ecosystems below storage reservoirs are threatened with daily, seasonal and annual flows, changes in water quality, reduced sediment flows, changes to the channel, floodplain and coastal delta morphology, changes in groundwater in the riparian zone, water temperature (thermal pollution), and ice formation. The above mentioned changes have a considerable effect on plankton, periphyton, the growth of aquatic macrophytes, riparian vegetation, as well as carbon flows and cycle distortions. As a result the lives of fauna and flora in these ecosystems are completely altered.

The construction of reservoirs affects considerably the natural hydrological regime of the river, which causes a prolonged low-water period, thus decreasing the frequency of flooding the terrace, leading to the drying out of the valley.

Quite often the construction of water dams causes changes in the size of bird populations. Such a case was observed after the creation of Wloclawskie Lake, where the populations of rare and endangered species dropped (Kowalczewski A. 2001).

Another negative effect of the construction of artificial water reservoirs are groundwater fluctuations, which may be as high as 20 m. They result in the dying out of spawn and fish fry. Aquatic plants of the deeper zones are exposed to the action of sunlight, whereas plants in the surface layers dry out (Engelhardt W. 1975).

An advantageous situation is observed in case of the preservation of barely changed, semi-natural rivers and their valleys. The protection of such ecological corridors as rivers with their valleys, unoccupied by industry, housing, technical infrastructure, arable land, with

no embankments, or with embankments located far from the river and close to the valley sides, ensures not only proper functioning of plant associations and animal systems, but also promotes better flood control of areas located in river valleys. It also assists in the protection of river waters against agricultural pollution and in autopurification processes. Moreover, it not only enhances the purification of water during seasonal inundation into the valley, but also limits the soil erosion in the valley, thus preventing its sedimentation in the rivers. A natural river and its valley is conducive to the development of ichthyofauna, promotes angling, enhances the tourist and recreational assets of the area, but also aids soil fertilization.

In order to prevent the negative effects of water engineering structures designed for the purpose of flood control, numerous steps may be taken, such as e.g. the location of embankments as far from the river beds as possible, in which case they may be lower, and thanks to the bigger water-retaining capacity of the area between embankments the high water stage is lowered, the flow velocity of flood waters decreases, and the river banks and their vegetation undergo less flood damage. Moreover, river valley storage is increased and the risk of floods in the lower river is lower. Another measure is to construct locally depressions and culverts in the embankments to increase the water-retaining capacity of the valley and the irrigation of the areas behind the embankments at higher water stages in the river. It would be advisable to build additional polders for the purpose of flood control in the river valleys and in the valleys of its tributaries, especially in the areas requiring high moistening by constructing embankments around peatmoors, other open wetlands and riparian forests. Instead of “straightening” the course of the river and clearing the forests in the river bends creating flood hazard, it would be preferable to build relief channels connecting the beginning and end of such a river segment.

Flood control measures may serve as an example of attempts to retain biodiversity and the development of existing species of fauna and flora.

Effective flood control is first of all appropriate land use planning.

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