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The reactivation of Warsaw oxbow lakes as a leitmotiv of urban design

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Abstract

Oxbow lakes occurring in floodplains are those natural elements that are subject to rapid changes, which may lead to their disappearance. These are extremely valuable ecosystems and landscape components, as well as water management units. However, they quickly disappear if they are not periodically fed with river water, which takes place especially when rivers are embanked. Such a situation occurs, among others in Warsaw, in the Vistula valley. There are many opportunities for the reactivation of oxbow lakes, including through technical activities. It is not always possible to restore the natural values of the valley in urbanized areas, however, oxbow lakes can then also play a recreational role and they can fulfill an important task in improving the quality of life, being also an important element of the public space system. The author has carried out research related to land development projects of the new district located in the Vistula River valley in Warsaw (the Siekierkowski Arc). Many different design solutions have been proposed, taking as a leitmotiv the restoration of oxbow lakes, for example: (1) reconstruction of the water channel in the former watercourse with the boulevard along its fragment and with the public park in another part, (2) water supplying of the existing oxbow lake through the green and blue infrastructure system. The author presents few urban designs carried out under her direction for this area and shows that creative reactivation of oxbow lakes can improve water conditions, and be beneficial for the introduction of a new, attractive development.

Key words: *extreme daily precipitation, GEV distribution, homogeneous regions, L-moments, regional frequency analysis*

INTRODUCTION

Oxbow lakes present in floodplains are natural elements which are subject to rapid changes, especially: shallowing, drying up, and overgrowing, which can eventually lead to their obsolescence. Leaving them in their natural state does not require any interventionist measures, and the tasks of the planners are limited to the introduction of construction bans and hardening of the ground in the river valleys. The situation is different, however, when the drying up or the already dried up oxbow lakes are situated in the areas behind the flood embankments, especially in large cities and areas subject to strong urban pressures. This study presents and supports the thesis that in the cases as described above, the relics are worth being preserved or recreated by means of an appropriate inclusion in the urban design and in the water management system as the elements of green and blue infrastructure. In such a case, spatial decisions – expressed in spatial development plans of various status and in design solutions – acquire key importance. For this reason, research aiming at the selection of optimal and creative approaches to the treatment of oxbow lakes in urban planning, which would also be beneficial for urban ecosystems, also gain in importance.

Scientific research on the broadly understood integrated water management and the contemporary methods of the shaping of rivers and their valleys as well as other reservoirs and waterways have been widely described. The subject of the relation between water management and land development has been discussed in numerous publications [ADLER, TANNER 2013; ANDERSON, IYADURI 2003; DREISEITL, GRAU (ed.) 2005], also in Poland [JANUCHTA-SZOSTAK 2011; JANUCHTA-SZOSTAK (ed.) 2009; SOLAREK *et al.* 2016; STAŃCZYK 2015; WOLSKI 2013]. Most of the authors of publications concerning urbanism, spatial planning and landscape architecture focus on the use of an integrated management of water systems on different levels of planning and design – in various scales and with the use of dif-

ferent tools. It is recommended to choose the solutions incorporating the green and blue infrastructure because the traditional methods and the "grey infrastructure" do not always allow for the suppression of the adverse hydrological phenomena progressing along with the climate change [NAUMANN *et al.* 2011; SZULCZEWSKA 2018].

Some issues relating to water management in rivers valleys have been thoroughly studied in different disciplines and specialties, including urbanism and spatial planning, but mostly in hydrogeology, water engineering and environmental protection. This especially concerns the issue of restoration and renaturation of rivers [ŻELAZO, POPEK 2014]. The discussion on this subject started along with an increase in awareness of the human influence on ecosystems and in answer to the emerging legal acts, reports and declarations which put emphasis on the restoration and recultivation of rivers and floodplains, such as: the Water Framework Directive [Directive 2000/60/EC], the Habitats Directive [Council Directive 92/43/EEC] and Report of the European Environment Agency [EEA 2016]. Numerous authors describe case studies based on the evaluation of realized investments of this type [ADAMS, PERROW (ed.) 1999; CLIFFORD 2007; MOSS, MONSTADT 2008]. On the basis of scientific publications, guides have been published which allow for the implementation of the research results by the local authorities and planners, e.g. Urban rivers – vital spaces [REURIS Project Team 2012]. Another often discussed and well-researched subject concerns the creation of wetland habitats, including artificial wetlands, examined, among others, by JÓŹWIAKOWSKI *et al*. [2016] and HAMMER [1997]. Compilations and guides are of high value for the implementation of that knowledge, for example: "Guidance document for constructed treatment wetlands" [ITRC 2003], or: "A guide to wetland functional design" [MARBLE 1992].

The issues relating to the recreation of oxbow lakes are present in the research on the restoration of rivers. One of the methods for the elongation of the river course and the restoration of its meandering course is the use of oxbow lakes and their reintegration in the course of the river. The research on this subject has been done, among others, by OBOLEWSKI *et al*. [2013]. This method has its critics – including FLOREK [2008], whose research has shown that by use of this method polluted river water flows into the oxbow lakes and the valuable animal and plant communities previously present in the oxbow lakes are completely destroyed. This scientific discussion shows that the issue under debate is difficult and multi-faceted, and for that reason it requires interdisciplinary research, while a complete lack of research on the purposefulness, meaning and methods for the reactivation of oxbow lakes in cities, especially in relation to the issues of spatial development and urban design, is visible. This article presents results of the research concerning the possibility to reactivate the oxbow lakes of the Vistula River, conducted in Warsaw in the region of the so-called Siekierkowski Arc (Pol. Łuk Siekierkowski).

The aim of this research is to recognize the conditions justifying the reactivation of oxbow lakes in urban areas and to determine examples of such interventions. The general idea is that it is necessary to undertake actions for the benefit of the active support and enrichment of water systems and – as far as the requirements of the ecosystems and the capacities of the local authorities are concerned – their partial or full recreation. In areas in which, according to the urban policy and the investment trends, development is permissible and which are situated in river valleys, it is of vital importance to preserve and protect the existing water reservoirs along with the accompanying flora and fauna, as well as to utilize the former riverbeds for the support of retention systems and the increase of biodiversity. Also, the functional and landscape aspects as well as the role of the former riverbeds are significant in the shaping of public spaces. The most important functions which the preserved or recreated oxbow lakes can perform are related to the ecosystem services in a broader sense [KRONENBERG 2016], such as:

- support of the water retention systems;
- support of flood protection;
- increase in biodiversity;
- favourable impact on local climate;
- creation of recreation areas;
- shaping of public spaces.

STUDY MATERIALS AND METHODS

A part of the Vistula Valley in Warsaw has been chosen for the study – Siekierkowski Arc. It is 600 hectares of land, situated in the Mokotów city district, on the left bank of the river, on the lower fluvial terrace, South of the Siekierkowska Route (Al. J. Becka). For almost 100 years this vast field has been indicated as the area reserved for new development and designated for development in formal planning documents[1)]. There have been many reasons for this situation, i.a. the fact that the vast majority of the land was in private hands and the owners expected to invest in it. Moreover, the area is situated within a 3 km distance from the Warsaw city center. The studied area encompasses a lot of undeveloped land, mostly wastelands, some detached houses with small services points, a large amount of substandard buildings of various, often burdensome functions which do not match the character of the area, e.g. a concrete plant, warehouses for building materials, halls, landfills, and a large Siekierki CHP plant. The area is crossed by high voltage overhead lines and a heating and a sewer collector.

On the other hand, there are also valuable natural elements, the most important of which are: Lake Czerniakowskie (Pol. Jeziorko Czerniakowskie) – an oxbow lake falling under the legal protection of the reserve with a buffer zone established around it, and the Vistula River itself along with the waterfront, the part of which is situated between the embankments belongs to the Natura 2000 site. The impoverishment and simplification of the structures of plant communities in the studied area – due to the change in the water conditions – is strictly connected to human activity conducted in the region of the Siekierkowski Arc.

[1)] However, the development suggestions for the Siekierkowski Arc are also subject to public criticism.

At the turn of the 19th and the 20th century the hydrographic structure of the discussed area was different from the current one. Almost the whole of the floodplain was covered by floodmeadows, the Siekierkowska Sandband (former watercourse) was connected to the Vistula River and, during the spring flooding, its waters reached the Lake Czerniakowskie. Over time these areas began to be used for agriculture. Today, due to the cessation of such form of use, the cropland and floodmeadow vegetation is disappearing and in its place ruderal vegetation appears. The interference with the water conditions of the area in which the Siekierki CHP plant was built, the construction of residential towers on the fluvial terrace and the Siekierkowska Route led to the drainage of the wetlands and the loss of some open bodies of water. In consequence, also the plant communities connected to those habitats have disappeared.

This area was joined to Warsaw in 1918, and not long after that the urbanization trend for this area emerged – the existing owners of the land transferred the land transactions to seven lotting companies which legally divided the real estates and led the sale. One of them was the organisation, founded in 1920, on behalf of which a new settlement Miasto-Ogród Czerniaków (Garden-City Czerniaków), was designed and approved in 1923. The architects Oskar Sosnowski and Antoni Jawornicki designed here a district for 15 thous. inhabitants. The buildings were planned to be situated almost at the lake shore and stretched in a narrow lane up to the Vistula River, but the design was only partially realized [KOTASZEWICZ 2004]. After World War II, numerous other ideas arose regarding the development of the Siekierkowski Arc: first it was supposed to be an Olympic stadium location, then an exhibition site, a scientific center, a residential area, and finally the area was considered again for the large sports center, but in the local development plan from 1992 the area was designated to fulfill the central functions of Warsaw. The urban workshops Warsaw of Our Dreams, organized in 2001, the subject of which was the development of the Siekierkowski Arc, proved that there are different views on the development of this area, even though all of the works indicated the legitimacy of building in the area [SOLAREK 2004]. The conclusions of the workshops served as guidelines for the acceptance of the General Plan for Warsaw in 2006 and for the local designs which are gradually adopted for this area.

Different types of oxbow lakes have been distinguished in the studied area. They have been divided in terms of the current development status – land cover and manner of use, with regard to legal aspects, including the established protection rules. This division was based on research conducted at the direction of Michał Fic in the context of the eco-physiographic study for the Siekierkowski Arc [FIC (ed.) 2004] and the study of the factual state, as of July 2018. Particular objects were characterized and variant ways for the reactivation of each of them were suggested. The adopted method was research by design, i.e. urban concepts were developed which presented the possibility for the incorporation of the reactivated oxbow lakes in the urban spatial structure. Then, the solutions were assessed regarding the social, economic, functional and spatial as well as ecological aspects. Planning record methods were suggested for the indicated concepts.

RESULTS AND DISCUSSION

CLASSIFICATION OF OXBOW LAKES

Until the beginning of the 20th century, the fluvial flows on the Siekierkowski Arc were strongly developed. The Lake Czerniakowskie was connected into one system with the reservoirs located more to the South – the Lake Wilanowskie and the Lake Powsinkowskie as well as the Lake Sielanka (by the currently inactive W-Ditch), and its outflow led to the North-East through the currently inactive Siekierkowski Channel and to the west through the currently inactive Czerniakowski Channel. A younger oxbow lake was situated closer to the Vistula River – it is locally preserved in the form of so-called thick valleys of the Vistula waters, mostly disappearing and hard to discern. The western part, arched to the West and North, the so-called Siekierkowska Sandback, was partly used to receive the rain water from the new road – the Siekierkowska Route. The remains of the historic moat and an interfortress dyke of the 19th century Augustówka Fortress were also incorporated into the system after some reconstruction and adjustment works. These reservoirs are filled with water and, except for their retention and landscape function, they also play an important role in the system of the green and recreation areas. The midden and eastern part of the oxbow lake – the Czerniakowska Sandback – is a former watercourse in the final state of the water reservoir development, currently degraded. It appears as a depression, stretching from where the Wilanówka flows into the Vistula River all the way to the Augustówka Fortress. This streak is currently overgrown with vegetation in the eastern part, while the predominant section is covered with soil and construction remains (Fig. 1).

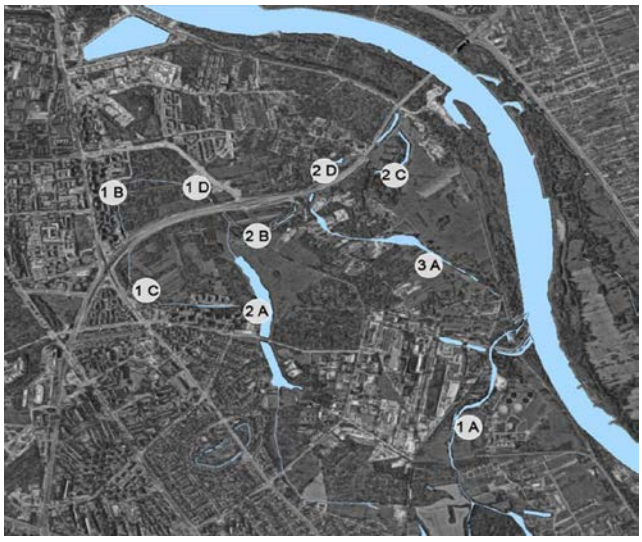

Fig. 1. Hydrological conditions at the area of Siekierkowski Arc in Warsaw: *1* = waterways, *2* = standing water bodies (2A. Lake Czerniakowskie), *3* = non-existent waterways (3A. Czerniakowska Sandbank); source: own study

The only "salvation" for these reservoirs is the implementation of the project of the recreation of water resources through their restoration and supply with rainwater which has been adequately purified; these activities can be seen as a creative reconstruction. They require the use of urban design for the optimal integration of the reconstructed oxbow lakes into the functional and spatial structure of the area. Within the research area, three types of intervention for the benefit of the oxbow lake reactivation have been selected:

– the Lake Czerniakowskie – protection, water supply;
– the Czerniakowska Sandbank – partial recreation, preservation of the existing vegetation, creation of wetland habitats.

TRANSFORMATION DESIGN

The concepts, which were proposed, provide the multifunctional, diverse district at the area. An expressive macrospatial arrangement was designed, preserving the connections to the surroundings, multiple public spaces and a rich road network. Concurrently, incorporation of the oxbow lakes into the park greenery system was provided for with a high (90%) participation of biologically active areas along with their restoration and recreation. This will lead to the reinforcement of the natural connection of the Vistula River bed to the preserved, currently isolated fragments of oxbow lakes and single ponds.

Losses in the water balance of the area, which have occurred as a result of the increase in the number of sealed areas, will be compensated for thanks to the creation of a coherent small-scale retention system. Through the preservation of all natural water reservoirs, recreation or restoration of the degraded oxbow lakes and, additionally, the construction of artificial channels and reservoirs, as well as the creation of depressions in the green areas where the water could infiltrate the ground and the underground waters or flow to the water reservoir instead of directly to the sewage system, can to some degree reduce and slow down the water drainage from the studied area.

- The Lake Czerniakowskie – protection, water supply

The Lake Czerniakowskie and its surroundings belong to the so-called South Czerniaków for which an urban development project is being prepared at the direction of the author. The urban transformations which will be conducted in the area situated in the buffer zone will directly translate onto the functioning of the Lake Czerniakowskie. For this reason, the great majority of the planning solutions in the development design is directed towards the protection of the lake and even its reinforcement against the danger of drying up, i.a. through the creation of a supply system with water collected in the studied area. To this end, a "green horseshoe" has been designed in the project, constituting a series of parks with chains of infiltration niches, stretching along the arch from the main park situated in a depression and equipped with a water reservoir along the dyke and a small slope, surrounded by the urban development area, sports or educational sites and back to the slope and the dyke. The "green horseshoe" will be connected through a main alley with the channels and complementary pipelines, leading the purified rainwater in a pump system from the studied area to the lake (Fig. 2).

Fig. 2. A diagram of the planned rainwater collection system in Czerniaków Południowy area and supplying Lake Czerniakowskie with water – a "green horseshoe"; the arrows indicate the direction of water flow; source: own study

In the local plan for this area a development order for the chain of infiltration, bioswales and raingardens in the designated areas has been introduced, which need to be built in advance before the realization of the new buildings in the areas not yet invested in. It has been assumed that these pans will interconnect in a cascade so that any excess water flows by gravity from one niche to the other situated below it and (after purification of the water to the degree required by separate legislation) to the Lake Czerniakowskie.

Additionally, apart from the "green horseshoe" supplying the oxbow lake of the Lake Czerniakowskie, the spatial design proposed for the whole area will emphasize the natural, scenic and climatic connections between the lane of the open areas.

- The Czerniakowska Sandbank – partial recreation, preservation of the existing vegetation, creation of wetland habitats

The Czerniakowska Sandband requires a radical intervention in order to at least partially use its potential resulting from the hydrogeological conditions and to recultivate the area. The recreation of this former oxbow lake has been provided for both in the General Plan for Warsaw of 2006 and in the local plan from 2018. The local plan, conducted at the direction of the author, introduces concepts which will allow for a diversified approach to the particular fragments of the area in this region. Green areas with the use of water are proposed here and can be realized taking into account the current state of the area, e.g., in the eastern part where slight depressions and breeding vegetation prevailed, it is possible to create smaller ponds or artificial

wetlands. There where it is necessary to perform excavation works in the section of a completely degraded oxbow lake, it is worth forming a water channel. This would be beneficial for the building of a waterfront at the South side where a more intensive development is allowed, as well as beaches and swamps in the North. From this side, closer to the Vistula River, sports and recreational sites have been planned. Thanks to this form of development an area can be created which will support the supply of the natural system characterized by a more favourable topo-climate influencing the intensification of the vertical air exchange. The water management system has been reinforced through the project of a linear park with the chain of channels and a larger water reservoir in the vicinity of the historic fortress. The urban design provides for the preservation of a renovated moat and an inter-fortress dyke, incorporating them into the functional and spatial system.

CONCLUSIONS

An important effect of the designed reactivation will be the reinforcement of the natural connections network. The chains of riverside reservoirs, such as the Lake Czerniakowskie, fortress moats, the Czerniakowska Sandbank with Siekierkowska Sandbank, preserved in a relatively natural state or recreated and surrounded by greenery, will fulfil a very important role in the urban area as elements supporting the ecological corridor in the Vistula River Valley.

The proposed system of the hydrographic network consisting of a restored oxbow lake, the Lake Czerniakowskie, planned retention reservoirs and a chain of niches and depressions, creating dry-rivers in the so-called green horseshoe along with the existing channels, will allow for the retention of rainwater and maintenance of an appropriate level of the ground water table, as well as a periodical supply of clean water to the Lake Czerniakowskie what will be beneficial to other natural elements.

The creative reactivation of oxbow lakes can be beneficial for the introduction of a new, attractive development in the areas which are determined in the urban development policy, with their simultaneous protection and even the reinforcement of the status of water reservoirs. The drying up oxbow lakes can serve as elements of the system of green and blue infrastructure, which can be a main design leitmotiv in the urban design. Through the use of the oxbow lakes, attractive public spaces, compositional axes, parks and squares can be created. They can also play a recreation role and constitute storage for clean air and simultaneously enrich natural systems. And finally, what today seems to be most essential – they can help retain rain- and meltwater in the area of rainfall without nuisance and danger for the users. In the context of adaptive actions it is recommended to concentrate on the decrease of rainwater drainage and the increase of its retention in open areas, green areas, as well as developed plots of land and investment land. The adopted solutions should allow for the maximal decrease in the quantity of water discharged into the sewage system, water management in the place of rainfall, improvement of water balance and lower water usage. The presented suggestions can at the same time increase the resistance of the area to flooding, overflow and rise of water from the Vistula River. The discussed propositions have been implemented into the local plans and this is the first step towards their realization; however, it still requires an interdisciplinary cooperation and further research.

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