The International Awards for Livable Communities 2008

Environmentally Sustainable Project Awards

IMPROVEMENT OF WATER QUALITY BY BIO-MANIPULATION IN VELKÝ BOLEVECKÝ POND

The City of Pilsen, Czech Republic

Contents:

Prepared by Pavlína Červená and Jindřich Duras
Source by Josef Čihák and Oldřich Hysek
Photography by Miroslav Kopecký and Jindřich Duras, Bolevec Archive, Museum of West Bohemia – K. L. Soběhrad and Jiří Berger

City of Pilsen, 2008
Náměstí Republiky 1, 306 32 Pilsen, Czech Republic
http://info.plzen-city.cz

1. The City of Pilsen and the Bolevec Ponds Development Strategy

The Bolevec Ponds recreational area lies in the Bolevec Stream drainage basin, covering around 1,622 hectares. The pond system dates from the Middle Ages (around 1460) and is one of the oldest such systems in the country. At present, it consists of a total of 14 ponds.

Wider links to the area

The basin, with its pond system and adjacent woodland, lies at the edge of the Northern Suburb residential area and has good links to public transport termini. It is a natural and traditional recreational area for the residents of Pilsen. It is enjoyed on a daily basis primarily by the residents of the Northern Suburbs, but its accessibility means it also attracts visitors from other parts of the city. The area is criss-crossed by a dense network of marked footpaths. The circular Sigmond nature trail runs through the centre of the area. The Ostende campsite attracts regular visitors from abroad.

Recreation

Bolevec Ponds is – and, given its exceptionally good natural environment, will remain – the most important recreational area in Pilsen, attracting large numbers of visitors. It is situated close to residential areas with high population densities and inadequate recreational facilities of their own. It offers a wide range of recreational opportunities, most notably bathing in the summer and skating in the winter. The woods are used all year round for walking, cycling and other sporting and recreational activities.

However, the area's recreational facilities and woodland need to be organised, operated and maintained to a standard commensurate with its natural potential, recreational significance and high visitor numbers.

The aim of the development of the recreational area is to preserve a high-quality natural environment and to upgrade the recreational facilities sensitively so that visitors can enjoy the area at the necessary level, while protecting the valuable woodland and ponds.

City of Pilsen Recreation Development Strategy and public involvement

The most important recreational area in the city must be managed in accordance with a strategic document approved by the city authorities and consulted with experts and the public. Therefore, one of the priority projects of the Pilsen Development Programme in 2005 was a feasibility study for the development of the Bolevec Ponds recreational area. The subsequent project documentation for individual actions is based on the principles contained in this document.

In 2004, the following preparatory work took place to acquire source materials for the study specification:

- a workshop with six invited teams of architects, landscape designers and ecologists, who drew up one of the sets of source materials for the specification of related documentation;
- a public opinion poll published in the City of Pilsen official newsletter;
- an opinion poll conducted by the Department of Anthropology at the University of West Bohemia;

- a conference attended by 34 politicians, experts and representatives of non-profit organisations.

The study for the development of the recreational area was drawn up in 2005 and its principles were approved in 2006.

2. The Ponds

History

The City of Pilsen prepared the grand plan to establish the Bolevec pond system back in the mid-15th century. Along with brewing, fish farming was one of the most profitable businesses at the time. In 1460, the city bought the village of Bolevec and began building the dam of the Large Pond on former agricultural land. From the technical and landscaping perspective, the system is a unique late-Gothic work warranting comprehensive care and protection.

More sources on the history of the pond survive from the mid-17th century. At that time, there were 30 ponds on the entire Pilsen estate. Between 1881 and 1917 city brewery was the tenant of the ponds. It was interested primarily in using them as a source of ice. From the 1870s onwards, it had an ice-drawing area on the dam of the Large Pond, which was in service until 1987. In the 1880s, a separate railway line and loading ramp were built to transport the ice. In the 1920s and 1930s, up to 600 wagons of ice were being consumed each year. In 1942 a special iron conveyor was installed on the dam to convey ice from the pond to the railway line. It was not removed until 1994. The other ponds in the system were also used for ice to a lesser extent.

For centuries, the ponds were used for low-intensity fish farming and were harvested regularly. The harvesting of fish from the Large Pond was an interesting spectacle for the residents of Pilsen and the surrounding area. In 1929, for instance, the pond was emptied over the course of six weeks and more than 8,000 kg of carp and 400 kg of pike were harvested. The following harsh winter of that year was a disaster for the fishery, as half of all the fish in the Pilsen ponds froze to death.

Interest in recreational bathing started growing at the start of the 20th century. In a decree dated 3 September 1920, Pilsen City Council gave over part of the Large Pond and the adjoining shoreline “for the establishment of a bathing area and ice rink and for the construction of buildings necessary therefor”. In 1921, a restaurant fashionably called Ostende was established on the sandy north-east shore.

The ponds’ recreational and landscape functions currently prevail over their commercial significance. The ponds were given over to the development of water recreation in 1981. The quality of the water in the system has always been fairly good and suitable for bathing, thanks to its relatively clean inflow, low intensity fishery and mostly forested drainage basin.

A valuable natural ecosystem

The natural environment of the recreational area may be a result of centuries of human intervention, but thanks to the sensitive fish farming methods that have long been applied it forms a comparatively balanced system that is rightly appreciated by visitors. During the drafting of the development document, the sustainability of this environment for expanding recreational use was assessed, and principles and measures were defined to support it.
Biologically important habitats have also been preserved in the area (special conservation areas – nature reserves and natural monuments, important botanical and zoological localities,

important trees). These habitats maintain the area's high degree of ecological stability and biodiversity. The Bolevec Ponds area also plays a very important role in the territorial system

1. Fishing competition on Large Bolevec Pond in 1965

2. Ostende Restaurant by Large Bolevec

of ecological stability. The woods, ponds and water flows in the area are defined as important landscape features under the Czech environmental and landscape protection legislation.

Hydrology of the area

The entire area of the Bolevec system is drained by Bolevec Stream. The area of the hydrological basin is 19.5 km^2 (average rainfall 504 mm, average total drainage including evaporation 21 $l.s^{-1}$, specific drainage 1.08 $l.s^{-1}.km^2$).

A major hydrological intervention was the building of a large housing estate in the 1970s and 1980s, which encroaches into the drainage basin of the Bolevec Stream. All the estate's surface water is drained through a single sewer to a central waste water treatment plant, giving rise to a sizeable deficit in the hydrological balance of the Bolevec ponds. This has made it very difficult to use the ponds for commercial fishing, and in particular to empty them (for the purposes of fishing or repairs), because it cannot be taken for granted that they can be refilled in time. This applies particularly to the Large Pond, which was last emptied 45 years ago. No one has had the courage to do so since then, as it could take several years to fill it again.

3. Large Bolevec Pond Bio-Manipulation Project

The water quality in the Bolevec pond is traditionally good – 95% of the drainage basin area is forested, with no pollution sources. The low-intensity fish farming on the pond involved no added nutrients or feeding. The turning point came in 1999/2000, when the water became more turbid and waterblooms of blue-green algae appeared. This had negative consequences for recreation. The worsening water quality and public interest moved the local authorities to solve the problem.

During 2000–2005, systematic monitoring of water quality, sediments and biocenoses was carried out. It was found that the key factor responsible for the worsening water quality was the introduction of grass carp *(Ctenopharyngodon idella)* in 1998. In two years, these fish had consumed all the submersed vegetation, causing a change in the basic character of the water ecosystem: a "pelagic trophic" system was established. This ecosystem was dominated by plankton-eating fish that dramatically speeded up the turnover of phosphorus – the most important nutrient – with a clear result: strong enhancement of phytoplankton populations, especially cyanobacteria.

The principle of the Water Quality Improvement Project is to change the character of Bolevec Pond back to the "littoral" ecosystem native to our region. In littoral ecosystems, the phosphorus cycle is slowed down markedly by aquatic macrophytes, which have a structuring role across all parts of the system: sedimentation, phytoplankton (including blue-green algae), zooplankton, the fish stock, etc. Shallow lakes in the littoral stage typically have clear water and a low level of cyanobacteria. These water bodies are usually not only very suitable for bathing, but also ecologically important localities.

Although both the aim and the principle of the project were clear enough, its implementation was significantly complicated by the fact that the former pelagic state was very stable and kept in position by many interactions. It was decided to affect all the three most important components of the pond system intensively: (i) the fish stock, (ii) aquatic plants, and (iii) the phosphorus cycle directly, including sediments. The implementation of the project started at the beginning of the vegetation period in 2006.

The fish stock had to be changed towards a low biomass of "undesirable" plankton- and benthos-eating fish such as common carp *(Cyprinus carpio)*, bream *(Abramis brama)*, roach

4. Application of Fe and Al coagulants helped to control the key nutrient – phosphorus

5. Reduction of the fish stock by night seining

(Rutilus rutilus) and partly also perch *(Perca fluviatilis)*. Of course, the grass carp had to be eliminated as efficiently as possible. Undesirable fish were systematically removed by sport fishing (carp), night seining and electrofishing. Special interest was paid to the spring spawning season of cyprinids. During this time, seining and electrofishing (booming boat) were highly efficient. Moreover, artificial substrates were installed in the shallows and after spawning the substrates were removed complete with the roes. In parallel, predator fish populations were supported – pike *(Esox lucius)*, zander *(Lucioperca lucioperca)* and catfish *(Silurus glanis)* – and asp *(Aspius aspius)* was introduced. When the aquatic plants regenerate, the predators will have a suitable habitat to keep their population abundant and populations of undesirable fish low.

Results: By summer 2008, around 8,700 kg of undesirable fish had been harvested, representing around 80–85% of the whole fish stock.

Aquatic vegetation had been eliminated by the feeding activities of fish and by increased water turbidity caused by phytoplankton and by particles re-suspended by the fish (carp, bream). Because the natural seed bank in the sediments was found to be very poor, more than ten species of plants were collected from suitable habitats in neighbouring localities and planted out in an enclosure situated in a shallow part of the Bolevec Pond. Attention was focused on native species of pondweed *(Potamogeton sp. div.)*, cattail *(Ceratophyllum demersum)*, millefoil *(Myriophyllum spicatum)*, pond lily *(Nuphar luteum)*, *Sagittaria*, *Batrachium* and especially stonewort *(Chara sp.)*. After initial experience in 2006, when the planted vegetation did not grow very successfully, intensive planting took place in 2007.

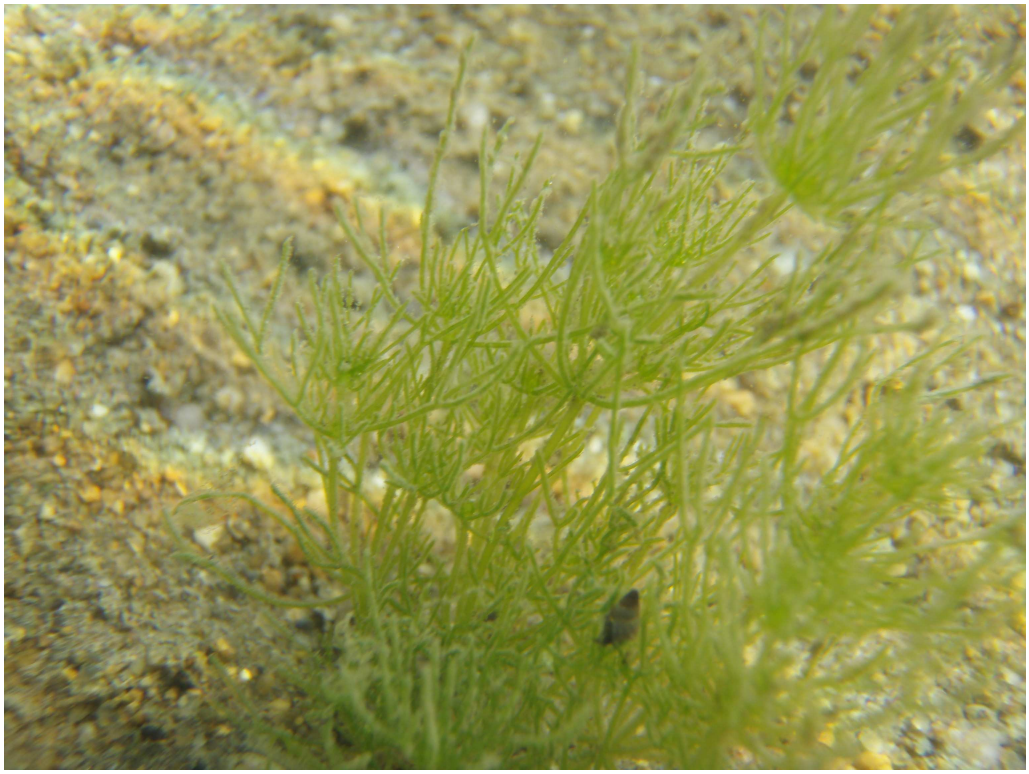
Results: In early spring 2007, Chara *appeared for the first time and colonised some parts of the bottom. Its spread was supported by high winter water clarity. In 2008,* Chara *has expanded and has overgrown the bottom between 0.5 m and 2.0 m to cover 50–70% of the colonised substrate.* Chara *has retreated in the summer, but other species of macrophytes (especially millefoil) have started to grow intensively. In 2008, aquatic macrophytes have overcome the first vulnerable stage and their populations are proliferating independently. Only slight intervention towards a wider spectrum of species is now needed.*

The phosphorus cycle was strongly influenced by two key factors: (i) due to its digestive activity the fish community returned phosphorus into the water column, where it was used for cyanobacterial growth; (ii) the sediment had no capacity to bind phosphorus effectively during the summer, so phosphorus released by mineralisation of newly settled material was returned to the water column. Moreover, mud at the deepest sites of the bottom released considerable amounts of phosphorus under anoxic conditions. It was necessary to reduce substantially the amounts of phosphorus available for phytoplankton. In parallel with the fish stock reduction, the application of chemical coagulants was inevitable, too.

Results: Aluminium sulphate (2006), ferrous chloride (2007) and polyaluminium chloride (2008) were used to remove phosphorus from the water column and to lock the phosphorus supply in sediments. Application of aluminium-containing solutions improved water transparency. Although this improvement was only temporary, it was important for the growth of aquatic vegetation and was appreciated by the public.

Concurrently with the remediation efforts focused on the pond ecosystem, other activities directed at the terrestrial parts of the locality are under way. Of great importance are measures to counter shore erosion by runoff, including retention of material that used to enter the pond (plant debris, litter, etc.). The local public recreation conditions are also being improved intensively. Some parts of the shore have been redesigned and numerous chemical toilets have been installed.

6. Several species of aquatic vegetation spread from the enclosure and supported positive changes in the ecosystem



7. *The recovery of stonewort (Chara sp.) was very important for the successful progress of the project*

The first remarkable positive effects appeared two years after the project started, by which time (i) the fish stock reduction had reached more than 80%, (ii) aquatic macrophytes *(Chara sp.)* had colonised wide parts of the bottom, and (iii) the phosphorus-binding capacity of the sediment had been enhanced by the addition of Fe and Al salts. During spring and early summer, the water transparency exhibited values of 2–4 meters, yielding favourable conditions for the growth of submersed vegetation and for public recreation, too. We expect that along with the progress of aquatic vegetation the season of excellent water quality will be well stabilised and will last longer, providing water transparency of about 2 meters until the end of September. We foresee intensive intervention in the fish community for the next two years. Application of Al coagulants supporting stabilisation of the ecosystem will be useful over the next 1–2 years. Continual intervention in the plant community will be needed – during the next 1–2 years still focused on the introduction of more plant species. A systematic effort to regulate plant growth will be required – the extent of aquatic macrophytes will need to be balanced with the recreational use of the pond by swimmers and sailors. The maintenance of the whole ecosystem will include setting new detailed rules for angling.

We consider the project to be useful in the field of ecological education, too. Articles have been published in local newspapers explaining the principles of the project (i.e. basic information on the functioning of water ecosystems) and providing details about the individual actions. Several information boards are installed each year in the locality, and many short reports have been broadcast by radio and TV stations. Moreover, Bolevec Pond is very good example of "sustainable exploitation". The pond is a natural ecosystem used by people for recreation – and these recreational activities must not exceed the ability of the ecosystem to withstand them. This means that swimmers, rowers and sailors must tolerate some plants previously considered pestilent. They must understand that some parts of "their" water body will contain aquatic vegetation and some parts of the shore will have a natural character – for example reed-beds. Also, fishermen have to accept changes in the fish stock – the traditional catch of carp will be substituted by limited angling of predator fish: pike, perch, zander and asp. This type of angling is much more attractive, less widely available and also more expensive. On the other hand, water macrophytes will need reasonable and sensitive regulation to maintain an optimal balance between good ecological status (i.e. good water quality) and multilateral recreational use.

4. Plan for the Further Development of the Large Pond Recreational Area

A wide-ranging plan for further development activity was set out in the aforementioned 2005 study, which also takes on board the main opinions of the Pilsen public. On the one hand, it contains the foundations of a long-term conceptual solution and, on the other hand, it sets out sub-actions to improve the current situation. The most important projects of a conceptual focus are: (1) Ostende Woodland Park and (2) Change in the Use of the Large Pond Shorelines. The sub-actions include, for instance, minor changes to the recreational shores and technical facilities, the implementation of more anti-erosion measures on the shores and the addition of more information boards for the public. A key prerequisite for the favourable development of recreation will be the introduction of a new approach to maintaining the Large Pond focused primarily on regulating the growth of aquatic plants and on managing the fish stock.

8. Water sports on Large Bolevec Pond

9. Sunbathing and swimming on the redesigned shore of Bolevec Pond

Ostende Woodland Park

The aim of preparing the Ostende Woodland Park project was to propose the gradual sustainable development of an important recreational area of the city while preserving a high-quality natural environment. Ostende Woodland Park is intended to be part of the "buffer zone" between the built-up area of the city and the fish pond system and woodland in the Bolevec Ponds Recreational Area. The primary function of this zone is to absorb the growing human pressure to exploit the woodland for recreational purposes. The parkland modifications must therefore be aimed at gradually restoring the existing degraded wooded areas to a near-natural or natural state with high ecological stability to compensate for the high human pressure, i.e. the presence of large numbers of holidaymakers and visitors.

The gradual repairs relate to the network of paths, in particular cycle paths, viewpoints and rest areas. The tree species composition will be changed, with the planting of predominantly deciduous trees. Water absorption and retention will be increased. The former ponds will be renewed, water flows revitalised, anti-erosion measures implemented, and so on.

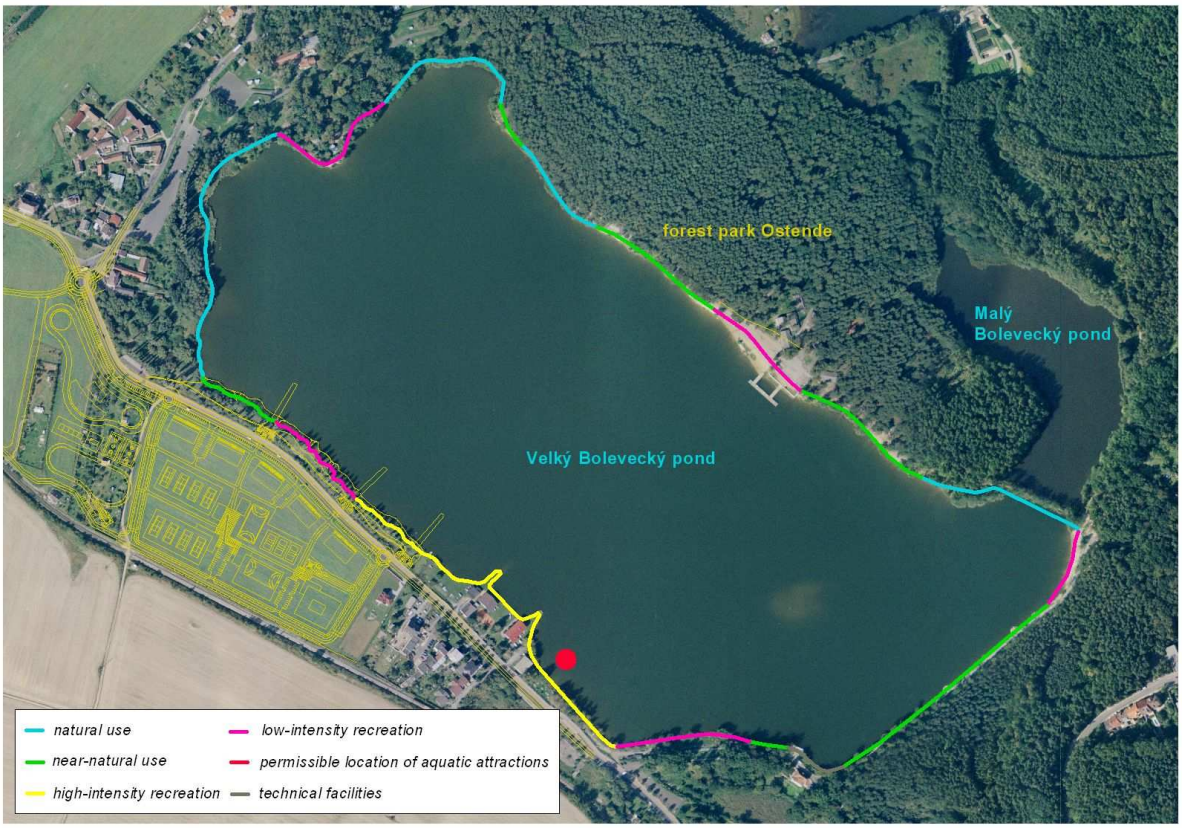
Change in the Strategy of Use of the Large Pond Shorelines

The change in the strategy of use of the Large Bolevec Pond consists in a proposal for high-intensity recreational use of the south shore of the pond. The plan hinges on calming the traffic in U Velkého Rybníka Street. This will be done by re-routing through traffic along a new I/20 highway running south alongside the existing railway line. The basic idea underlying the proposal is to make the nearest part of the recreational area directly accessible and to immediately intercept the traffic heading into the area along the main route from the city.

The north shores of the Large Pond, including Ostende and the area between Košinář and the Large Pond, will be left in a calmed natural state. The area will be protected against the adverse impacts of traffic and mass tourism and will be freely accessible to walkers and cyclists. On the site of the former Ostende restaurant the plan envisages the construction of a small multifunctional amenities building with limited transport access and no car park for visitors. The study envisages a modern Nordic-style wooden building that fits in with the natural surroundings and builds on the traditional of the original restaurant erected by the City of Pilsen in 1921, which stood on the site for more than 60 years.

The backbone of the urbanised recreational area to the south of the pond will be the traffic-calmed *U Velkého Rybníka* Street, which will become a pedestrian boulevard. The road – with limited traffic access – will be equipped with parking spaces, wide pavements, cycle paths and avenues of trees along both sides. The re-designed south shore lies to the west of the existing yachting club and to the north alongside this road. Its advantages compared to the north shore include its location at the centre of visitors' interest, easier transport access, easier connection to utility lines, the possibility of providing a wider range of recreational amenities, and the gentle slope of the beach into the pond. Basic amenities will be located on the beaches (WCs and changing rooms). Higher-level recreational amenities (snack bars, restaurants, accommodation, play areas, sports equipment rental shops, etc.) will be situated between the road and the railway line. To the south along this road, the plan is to locate small-scale recreational buildings (guesthouses, hotels, restaurants, coffee bars) with views over the pond. The higher-level recreational amenities, which will also serve as amenities for nearby residential areas, requiring larger-scale constructions with no direct links to the Large Pond (sports and tennis halls, gyms, car parks), are planned along the railway line and may also serve as a noise barrier for the railway and the I/20 highway.

The commercial benefit of locating the recreational amenities on the south shore of the pond is that it allows year-round operation of some facilities visited by the residents of surrounding residential areas.



10. Proposed future use of the shores of Large Bolevec Pond