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European Topic Centre
Inland, coastal, marine waters

Rivers and lakes in European cities
Past and future challenges
Annex

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Case Study Overview Table

Case Study		River Aarhus	River Dâmbovița	River Luppe	Podutik reservoir	River Mayesbrook	River Dyle	River Sokolowka	River Quaggy	River Yzeron	River Guadiana	River Isar	River Waal	Water bodies of Oslo	River Emscher	Lake Trekanten, Igelbäcken stream	Lake Ülemiste	River Liesing, Wienfluss, Old Danube
Geographical Spread	NW	●		●		●	●		●	●		●	●	●	●	●		●
	E		●					●									●	
	S				●						●							
Themes of main report	Water availability/ supply		●													(●)	●	
	UWWT/ Water quality	●	●		●	●		●		●				(●)	●		●	●
	Bathing quality	●										●				●		●
	Stormwater management	●	●		●	●		●						●	●			
	Urban river/lake restoration	●		●		●	●	●	●	●	●	●		●	●	●		●
	Biodiversity enhancement			●	●	●		●	●	●			●	(●)	●	●		●
	Flood protection via restoration	●		●	●	●	●	●	●	●	●	●	●	●	●	(●)		●
	Natural water retention			●	●	●	●	●					●	●	●	(●)		
	Access and recreation	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Urban regeneration	●		●			●	●	●	●	●	●	●	●	●			

River Aarhus – Aarhus, Denmark

Name of initiative
Reopening the Aarhus river

General characterisation (short description of area / site)
The Aarhus River has a total length of 40 km, originating in the bogland of Astrup Mose and discharging into the Bay of Aarhus. Along its course the river crosses the city of Aarhus, Denmark's second-largest city, serving as a natural structure connecting the city centre with the port.
Location (city, town, neighbourhood): Aarhus
River/lake concerned: Aarhus river, Lake Braband
Setting [Main urban area; Peri-urban area]: Urban

Background (key water management issues, sources of degradation and challenges)
In the late 1920's the decision was made to cover the full stretch of the river that crossed the city. Recent efforts to reverse this action have reinstated the river as a local landmark and are enhancing its functional features for the city's population (Hvilshoj and Klee, 2013). Water pollution from sewage and general waste being deposited in the river has been an issue at least since the first decades of the 20th century. This, in combination with new traffic requirements and ambitions to develop the town into a modern city, led to the motion of culverting the Aarhus River into a concrete channel in the 1930s (Greenscom Project, n.d.-a). This not only prolonged the degradation of the water body but it disrupted the possibilities of direct interaction between urban dwellers and their river, further sinking the relevance of the latter in the collective outlook. According to Basso, in 2010 about half of the water in the Aarhus River was treated wastewater and around 55 Combined Sewage Overflow (CSO) systems discharged into the river (Basso, 2010).
Main trigger for action: A political campaign and a change in the local administration.

Objectives and description of the initiative
Type of measures implemented: In 1989 the city authorities laid out a plan to uncover the river as an initiative to enhance the aesthetics of the city, facilitate and promote recreational uses, adapt the city to climate change, protect it against flooding from rising-sea levels and

reduce the frequency of sewage overflows originating from extreme rainfall events. The measures implemented included the establishment of two upstream lakes to reduce nitrogen and phosphorus flows into the Bay of Aarhus (Stahl Olafsson et al., 2015), the construction of new rainwater retention basins and the implementation of an integrated real time control system to allow for coordinated operation of the sewer systems and wastewater treatment plants. Additionally an early warning system for water quality in Lake Braband, Aarhus River and the harbour was incorporated (Basso, 2010).
Key objectives: To enhance the aesthetics of the city, facilitate and promote recreational uses, adapt the city to climate change, protect it against flooding from rising-sea levels and reduce the frequency of sewage overflows originating from extreme rainfall events.
City strategy, scheme or project to which this initiative is linked to: It was a theme for improving the water quality in the Lake Brabrand, the river of Aarhus and the Harbour of Aarhus.
Links to WFD, Floods Directive or other policy/planning process: Bathing Water Directive
Start-date/end-date: 1989 - 2015
Status: Ongoing
Lead organisation(s): Municipality of Aarhus and Aarhus Water Ltd.
Key actors involved: Contractors

Achievements and negative effects
Main results and benefits of the measures (ecological, social and economic): So far, these measures have resulted in a significant change in the way citizens and visitors experience the blue corridor –now lined with new waterfront amenities and a lively atmosphere– and the harbour –where local and foreign visitors can bathe safely (Aarhus Municipality, 2008; Aarhus Municipality, 2014; Hvilshoj and Klee, 2013).
Negative side-effects identified: None reported.
Lessons learned (constraints and positive aspects)
Welfare benefits and improvements in quality of life for the public: It is now possible to use the lake, the river and the harbour of Aarhus in the daily life. **Links to river basin management planning:** According to the Greenscom project (Greenscom Project, n.d.-b):

- The case of the reopening of the Aarhus River demonstrates that natural elements can be included successfully into even dense urban environments as long as they support urban activities.
- It demonstrates that the formal planning system must be supplemented with ad hoc tools to fit a specific purpose. They are catalysts for the starting process as they may create the necessary public and political support.

Contacts

Claus Møller Pedersen, Aarhus Water

Inge H. Jensen, Aarhus Water

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River Dâmbovița – Bucharest, Romania

Name of initiative

Wastewater treatment in Bucharest

General characterisation (short description of area / site)
Bucharest is situated on the banks of the Dâmbovița River, which flows into the Argeș River, a tributary of the Danube.
Location (city, town, neighbourhood): Bucharest
River/lake concerned: Dambovita, Arges (Danube)
(Other) Main rivers and lakes of this city: Several lakes – the most important of which are Lake Herăstrău, Lake Floreasca, Lake Tei, and Lake Colentina – stretch across the northern parts of the city
Setting [Main urban area; Peri-urban area]: Main urban area

Background (key water management issues, sources of degradation and challenges)
Bucharest is supplied with water by three drinking water plants, located outside the city perimeter. The Arges river is the main source of raw water for two of the drinking water plants, while the Dambovita river supplies the third water plant (Vasile et al. 2012). All three plants are located upstream discharging point of the treated or no-treated water. Until 2011, Bucharest discharged wastewater from more than 2 million inhabitants without treatment into the river. These wastewaters (from both domestic and industrial use) had seriously deteriorated both the Dâmbovita and Arges Rivers. Bucharest was listed as major pollution hot-spot along the Danube and was one of few European capitals without wastewater treatment. The water quality of Dambovita sharply deteriorated between itsstretches upstream (class II) and stretches downstream (class V) of Bucharest. Concentrated sources of degradation in this urban region are represented mainly by the industrial and domestic discharges and relate to exceedances in the oxygen regime, nutrients and organic micro-pollutants. Both domestic and industrial wastewaters are collected by the sewerage network of Bucharest, and end up together with stormwater in the Glina Wastewater Treatment Plant (GWWTP) which is situated in the south - east of Bucharest, on the right bank of Dambovita (The Dambovita river is the discharging point of the treated water) (Morcotec et al. 2011).
Main trigger for action: The legal obligation to meet the UWWTD.

Objectives and description of the initiative
Type of measures implemented: The construction of the wastewater treatment plant in Bucharest began in 1985 (it was designed for treating 20 m^3/s of urban and industrial waste water) but was abandoned in 1996 because of lack of funds. By 2000, the need for an

operational wastewater treatment plant became increasingly obvious. Furthermore, Romania declared its whole territory a sensitive area according to the Urban Wastewater Treatment Directive, which requires all agglomerations of more than 10,000 population equivalents to have wastewater treatment plants with the highest degree of treatment, the removal of nitrogen and phosphorus.

In 2004, the European Commission and the Romanian government co-financed a project to finish the Bucharest wastewater treatment plant. The main objective of the project, 'Rehabilitation of wastewater treatment plant Bucharest', was to enlarge the urban wastewater treatment plant capacity (to about 2.2 million population equivalent) and to improve the technology using two lines built in two stages.

The first stage of the project (the treatment capacity is designed to operate at a flow rate of 10 m^3/s in mechanical stage and 5 m^3/s for biological treatment) began in 2007 and was completed in 2011. This included rehabilitating mechanical treatment and extending biological treatment to include nitrogen removal. A biological and chemical phosphorus treatment installation was built, and construction was completed on sludge anaerobic digesters as well as the necessary capacity for thickening and dewatering the sludge, including biogas reservoirs. In addition, the project included the construction of a drainage system and storm water storage capacities. The budget for the project, € 108.3 million, was financed through grants from the Instrument for Structural Policies for Pre-Accession (ISPA) programme, loans from the European Bank for Reconstruction and Development, the European Investment Bank and as well from state budget funds.

Line I of the wastewater treatment plant is operated by Apa Nova Bucureşti S.A. It ensures that 55% of the area's wastewater is treated in compliance with the standards of the EU Urban Wastewater Treatment Directive for discharge to sensitive water bodies. Rehabilitating and extending the wastewater treatment plant has reduced the amount of the pollutants – mainly organic, suspended solids and nutrients (total nitrogen and total phosphorus).

The second stage of the project is planned for 2016-2021(according to the 2nd River Basin Management Plan (RBMP)) and will build Line II of the wastewater treatment plant to increase the treatment capacity. The project aims also to increase the capacity of fermentation for sludge treatment, adding thickening and drying equipment. In addition, an incinerator will be built to ensure the entire process of sludge management. The investment value of the second stage of project is estimated at approximately €350 million, to be financed through Cohesion Funds.

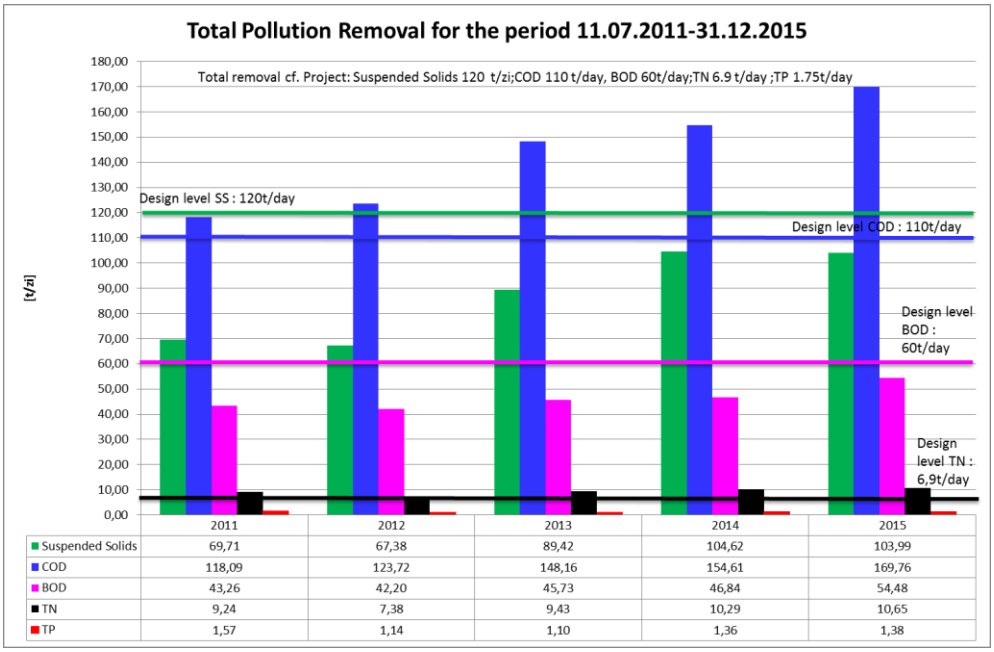
(http://www.icpdr.org/main/publications/hotspot-no-more-wastewater-treatment-plant-bucharest)

Key objectives: To reduce the impact of Bucharest's urban wastewater on surface water resources, mainly the Dambovita River, which flows into the Arges River. This will ultimately result in less pollution further downstream in the Danube river and the Black Sea.

After completing both stages of the project, the plant will ensure the treatment of the entire wastewater flow of the Bucharest urban area and will discharge an effluent which will meet the requirements of national and European legislation, thus eliminating one of the major pollution hotspots in the Danube River basin.

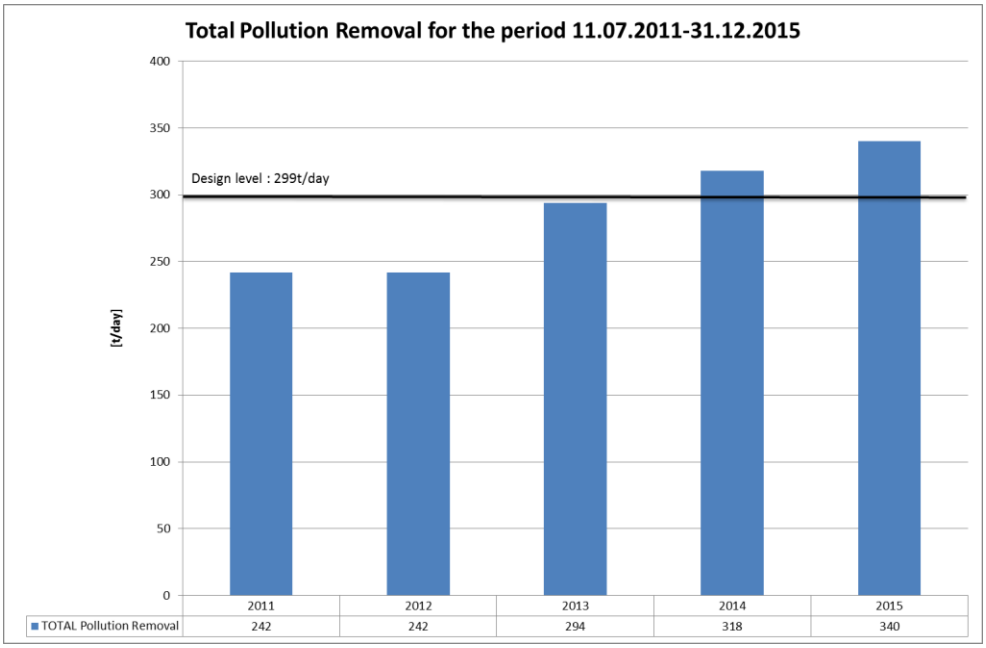
City strategy, scheme or project to which this initiative is linked: Sewerage Network Masterplan for the city of Bucharest (updated in 2013)
Links to WFD, Floods Directive or other policy/planning process: The urban wastewater treatment plant aims to increase compliance with the UWWTD and this is the major measure established in the 1st River Basin Management Plan for achievement of good potential / status of the Dambovita downstream water body.
Start-date/end-date: 2007–2011: 1ststage of the GWWTP. 2016-2021 : 2nd stage of the GWWTP.
Status: Ongoing.
Lead organisation(s): Apa Nova Bucureşti S.A. (Romanian branch of Veolia Water).
Key actors involved: Government of Romania, Bucharest City Hall, European Commission.

Achievements and negative effects
Main results and benefits of the measures (ecological, social and economic): The operation of the wastewater treatment plant can significantly reduce the impact of Bucharest's urban wastewater on surface water resources. As shown in the figures below, the total pollution removal from the wastewater by the treatment plant has steadily increased since 2011. Since 2014, the total pollution removal is even higher than the design level of the Glina WWTP. According to the WFD compliant monitoring results at the level of water bodies (WB) located on the Dambovita River (downstream of the Glina WWTP discharge) and on the Arges River (the last WB before discharging in the Danube River), the concentrations of organic and nutrient pollution indicators have significantly decreased for the last 5 years, leading to improving of the receiver water quality. It should be highlighted that in the receiving Dambovita WB the concentrations of organic substances (COD and BOD) have registered an about 50 % reduction, while total nitrogen and total phosphorous concentrations have decreased by aprox. 30% and respectively by about 60% (Source: National Administration "Romanian Waters"). The project has also contributed to increasing the public's awareness of the pollution effects of wastewater and the responsibility to protect river ecosystems.



	2011	2012	2013	2014	2015
Suspended Solids	69,71	67,38	89,42	104,62	103,99
COD	118,09	123,72	148,16	154,61	169,76
BOD	43,26	42,20	45,73	46,84	54,48
TN	9,24	7,38	9,43	10,29	10,65
TP	1,57	1,14	1,10	1,36	1,38

Source: Apa Nova Bucureşti S.A.



	2011	2012	2013	2014	2015
TOTAL Pollution Removal	242	242	294	318	340

Source: Apa Nova Bucureşti S.A.

Negative side-effects: None reported.

<u>Lessons Learned</u> (constraints and positive aspects)

The project serves as a model for implementation of measures in the Danube River Basin. The wastewater treatment plant was highlighted as a 'Lighthouse Project' in the ICPDR's Interim Report on the Implementation of the Joint Programme of Measures to provide

examples of projects of basin-wide relevance.

Welfare benefits and improvements in quality of life for the public: The UWWT project has contributed to increasing the public's awareness of the pollution effects of wastewater and the responsibility to protect river ecosystems.

Funding: European and national funding.

Links to river basin management planning: The urban wastewater treatment plant aims to increase compliance with the UWWTD and this is the major measure established in the 1st River Basin Management Plan for achievement of good potential / status of the Dambovita downstream water body.

Before and after photos

Before operation of the UWWTP

Source: photographer unknown, owner Bucharest City Hall

After operation of the UWWTP

Source: Razvan Alexandru, owner Apa Nova Bucureşti S.A.

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Doina Catrinoiu, Vice-president and State Under-secretary – Ministry of Environment, Waters and Forests, National Environmental Protection Agency

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River Luppe – Leipzig, Germany

Name of initiative
Revitalization project in Leipzig's urban floodplain forest – Living Luppe

General characterisation (short description of area / site)
As a "green belt", the city of Leipzig is crossed by the floodplain of the rivers Weiße Elster, Pleiße and Parthe, which is classified as a significant Central European floodplain ecosystem resulting from widespread floodplain forests. The most natural areas are part of the Natura 2000 network. Large parts of this floodplain forest are mixed stands with large structural diversity and a high diversity of flora and fauna. Its uniqueness lies in the comparatively large natural area, which has been preserved despite intensive anthropogenic interventions in the river and floodplain system and the immediate proximity to the city. The area of the project reflected in this factsheet is concentrating on the northwest floodplain of Leipzig, which has been formed by the Weiße Elster and its several side arms. The most important ones are the river sections of the old and new Luppe.
Location (city, town, neighbourhood): Leipzig and Schkeuditz
River/lake concerned: Luppe
(Other) Main rivers and lakes of this city: Weiße Elster, Pleisse, Parthe
Setting [Main urban area; Peri-urban area]: urban and peri-urban area

Background (key water management issues, sources of degradation and challenges)
Interventions such as river regulation measures, extensive diking and the drainage of agricultural and pasture fields have had significant impacts on the floodplain. Several impacts have been the result of the creation of the river section Neue Luppe (New Luppe) to serve flood protection in the 1930s and completed in the 1950s. Former river sections were cut off and could not provide the floodplain forest with water anymore. As a result, the formerly water-rich floodplain landscape suffers from massive drop of the groundwater table and is drying out. Today the area consists of many dry river beds without connectivity and a decrease of dynamic floodplain ponds and oxbow lakes. This is a threat among others also to the biodiversity of the floodplain forest and related ecosystem services Source: http://www.lebendige-luppe.de/). In the same time, the floodplain of Leipzig has an important function as recreational area and significantly contributes to life quality of the city residents. The floodplain is appreciated and intensively used by the Leipzig inhabitants especially for cycling, sports and walking. Especially the floodplain forest in the south of the city has a high density of visitors (Steuer,

2014).

Main trigger for action:

Several threats were identified, which led to action:

- Decrease of floodplain dynamic and groundwater table led to an increase of non-typical floodplain hardwood forest species (like Acer in most of the forest stands)
- Loss of the former typical rich floodplain habitats and species like amphibians; only remnant species and habitats survived
- Highly impacted river morphology and need for better flood retention areas

Large floods in 2002, 2011 and 2013 in the Elbe catchment showed the high potential for restoration of the area and improvement according to the WFD, Floods and Habitats Directives.

Objectives and description of the initiative

Type of measures implemented: The revitalization project "Lebendige Luppe" (Living Luppe) is one of the largest projects on floodplain and river restoration in Central Germany and started in 2012. The objective is the revitalization of more than 16 km of a former river course in Leipzig's floodplain ecosystems (Scholz et al., 2015; 2016). In the northwest floodplain of Leipzig, dried-up river arms of the former water-rich floodplain, especially of the river system Luppe, are to be filled and reconnected again with water and create a continuous water landscape. This activity, combined with the still existing Wildbett Luppe in Saxony-Anhalt, will lead to increased ecological continuity up to the River Saale further upstream. The aim is for significant floods to reach large areas of the floodplain via the new river course. It is planned to achieve inundation of at least 30% of the floodplain area via the new river. The groundwater table should be stabilised and raised by about 1 meter in most parts of the project area. Additionally in a former dredging area (Papitzer Lachen) inside the Weiße Elster floodplain (and today one of the most important amphibian habitats of the region) measures are planned to increase the floodplain typical water supply. The revitalisation of stretches of the Luppe should help counteract water shortage in the floodplain and enhance again the diversity of floodplain species.

The project (http://www.lebendige-luppe.de/) also places emphasis on communicating the importance of the floodplain for people and nature. The ecosystem services provided by an intact floodplain, such as oxygen supply, sequestration of carbon dioxide and the provision of space for recreation increase the life quality of city inhabitants.

The project is considered part of a mosaic of different measures needed to achieve more extended revitalisation of the floodplain in the future and is planned as a no-regret measure (Scholz et al. 2016).

Key objectives: The main objectives are to improve the floodplain dynamics, to increase the quality of the habitats for plants and animals and to maintain and increase its ecosystem functions and services for people.

City strategy, scheme or project to which this initiative is linked: The project idea is based on preparatory work of the Green Ring Leipzig, an initiative of Leipzig and the neighbouring municipalities for a number of projects to enhance the environmental character of the city. The Green Ring Leipzig defined the revitalisation of former river stretches south of the Neue Luppe as key project for its workplan and financed the first planning phase (feasibility studies) in 2006 and 2009 (Putkunz, 2012; Steuer, 2014; Vitzthtum & Riedel, 2014).

The City of Leipzig and its neighbouring municipalities have developed an integrated water body concept (integriertes Gewässerkonzept), which involves reopening former water courses, creation of continuous water bodies according to the WFD, enhancement of river morphology and management of the discharge in the water courses according to ecological and safety needs.

Links to WFD, Floods Directive or other policy/planning process: There are potentially strong links to the WFD objectives as the aim of the project Lebendige Luppe is to re-establish continuity in the river network between the city centre of Leipzig and the downstream areas, improve the ecological structure and achieve good water quality in the affected water bodies.

Start-date/end-date: 2012 - ongoing

Status: Ongoing, planning phase of the new river course

Lead organisation(s): The project is coordinated by the City of Leipzig.

Key actors involved: The technical measures are undertaken by the cities of Leipzig and Schkeuditz (both active in the Green Ring Leipzig) and the NGO NABU. Scientific monitoring to evaluate the effects of the communication process and the ecological effects is undertaken by the Centre for Environmental Research - UFZ together with the University of Leipzig. The Federal Agency for Nature Conservation and the State of Saxony is involved as funding organisation but also for streamlining the project with the aims of the national biodiversity programme.

Achievements and negative effects

Main results and benefits of the measures (ecological, social and economic): Major flood events in January 2011 and in June 2013 inundated most of the project area and showed that, as a result of the project Lebendige Luppe, the floodplain is being re-activated and still functioning when sufficient inundation is provided. As the project is still in development, the scientific monitoring has still to demonstrate the concrete effects on floodplain species and biodiversity.

In a first part of the project, which has already been realised, it has been achieved to restore the water supply of a former dredging area (Papitzer Lachen) and to increase the floodplain typical water supply in the most important Amphibian habitats in the area.

In addition, a large communication process has been established to show the extent to which the Lebendige Luppe project can mitigate negative effects of the loss of floodplain functioning in the Leipzig area. Due to interventions of NGOs, nature conservation experts and scientific expertise, the objectives of the project have been enlarged to restore more flood dynamics in the river than originally planned.

Negative side-effects identified: none

Lessons Learned (constraints and positive aspects)

Governance and multi-actor cooperation: The governance framework of the revitalisation project is highly challenging because of the multi-functionality of the floodplain in an urban context. There are many actors involved given that the river network in and around Leipzig is a heavily managed system. The planning phase has to bring together many actors responsible for flood and river management, nature conservation, forestry, agriculture, the neighbouring public, NGOs and politicians; different levels of local to regional authorities and agencies are involved.

Public involvement: Diverse communication activities of the project are undertaken via internet, regular public presentations and press work. A dedicated office for the project Lebendige Luppe is coordinating public relation work to inform the broader public as well as experts and press and is supporting environmental education. In parallel a **floodplain management forum** has been installed to bring forward future river and floodplain restoration measures in the Leipzig floodplain context. Once the planning phase for the new river is finished an official public participation process according to German regulation will be started.

Welfare benefits and improvements in quality of life for the public: The ecosystem services provided by an intact floodplain, such as flood retention, oxygen supply, sequestration of carbon dioxide, nutrient retention and the provision of space for recreation increase the life quality of city inhabitants.

Funding: The project presents one of the national "light house" projects funded by the Federal Programme for the Biological Diversity of the German Federal Ministry for Environment, Nature Conservation, Building and Nuclear Safety (75 %). 25 % has to be financed by all partners and the State of Saxony.

Availability of land to fulfil the measure: Large parts of the project area are already in public ownership, especially forest sites. Building activities in the floodplain area covered by the project are not allowed. However, the transformation of arable land into more floodplain-adapted land uses like grassland still remains a big challenge as compensation areas have to be found. This is an item of ongoing cooperation between the City of Leipzig and the Department of Agriculture.

Links to planning processes, incl. river basin management: There are still considerable planning challenges on the way to a full revitalisation of the Leipzig floodplain as the interests of other water users and owners must be taken into account. The river and floodplain network especially inside the city of Leipzig has been strongly modified in the past for technical flood protection. In addition, the water supply of the existing or new river arms especially during low or medium water discharge has to cope with small hydropower stations

along the Weiße Elster, the dilution of the sewage treatment plant water, the minimum environmental instream flow of all water courses and the requirements of urban sanitary environmental engineering.

It should be noted that a full floodplain dynamic cannot be achieved only via the measures of the project Lebendige Luppe. Wider processes, for example of sedimentation and sediment redistribution, are dependent on frequent large-scale inundations by spring flooding and the unregulated flow of sufficient water quantities of floodplain rivers. The overarching framework conditions set for flood protection and sanitary environmental engineering are decisive for the regulation of flow in and close to the urban area and cannot be influenced to a large extent yet by the actors of the project Lebendige Luppe (Scholz et al., 2016).

Before and after photos

Strongly modified river networks inside floodplain forest of Leipzig - aerial image of the Burgaue the floodplain forest and the New Luppe with the confluence with the Nahle (city of Leipzig in the background) (photo by Arne Weiß und Jan Baest, www.360bit.com)

Lebendige Luppe – Heuwegluppe (one of the disconnected Luppe river arms) in dry condition (photo by Maria Vitzthum).

Lebendige Luppe – Heuwegluppe inundated (photo by Maria Vitzthum).

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Podutik reservoir – Ljubljana, Slovenia

Name of initiative
Multi-functional flood reservoir Podutik in Ljubljana

General characterisation (short description of area / site)
Ljubljana (European Green Capital 2016) is vulnerable to destructive floods caused by a number of torrents, which are fed by intensive rainstorms or snowmelt in the upper catchment. The city region suffered six severe floods during the 20th century and particularly severe consequences in 2010 when heavy rainfall caused several fatalities and millions of Euro in damages. A flood reservoir (the Podutik reservoir) was constructed in 1986 on the Glinščica river in the west part of Ljubljana to protect nearby settlements from floods by storing floodwater (Grant, 2016). The Glinščica river joins the Gradaščica River in the Vič District of Ljubljana. Most of its lower course through Ljubljana is channelized.
Location (city, town, neighbourhood): Ljubljana
River/lake concerned: Glinščica River
(Other) Main rivers and lakes of this city: Rivers Ljubljanica, Sava, Gradaščica, Mali Graben, Iška and Iščica
Setting [Main urban area; Peri-urban area]: peri-urban area, west part of Ljubljana

Background (key water management issues, sources of degradation and challenges)
The Ljubljana Urban Region and the City of Ljubljana have been dealing with flooding of rivers for many years. However, the events of recent years (2010) made it evident that additional flood protection measures were necessary, especially because settlements are gradually spreading to areas of periodic flooding (http://www.turas-cities.org). The Podutik reservoir, constructed in 1986 to tackle the issue of floods at least in part of the Ljubljana Urban Region, receives water from the Glinščica River and stormwater from the nearby settlements. The reservoir is facing water quality problems, as it is affected by occasional overflows from leaking septic tanks, polluted tributaries and urban runoff from gardens, parking places, etc. (Griessler Bulc et al, 2015). In 2001, in the frame of monitoring financed by the City of Ljubljana, increased toxicity of the Glinščica River as a main recipient of the water from the flood reservoir III Podutik was demonstrated. The pollution of the Glinščica River at that time indicated the need for additional water treatment in the catchment area of the flood reservoir (http://www.turas-

cities.org).

Since 2006, the authorities have addressed the problem by using green infrastructure in the form of vegetated ditches to improve water quality (Grant, 2016).

Main trigger for action: Water quality problems became gradually evident via monitoring. In addition, the 2010 flood event made the need for additional flood protection measures obvious.

Objectives and description of the initiative

Type of measures implemented: Part of the flood reservoir Podutik has been redesigned into a multi-functional flood reservoir with enhanced ecosystem services via *ecosystem technologies (ET)* for stormwater management.[1] The reconstruction was carried out in the framework of the EU-funded project Turas (http://www.turas-cities.org/). The ecosystem technology was constructed within the flood reservoir consisting of **a constructed wetland** and **a new river bed with meanders** to provide several functions regarding environmental protection, namely a) Flood prevention, b) Water retention for irrigation purposes of nearby green areas; c) Water pollution mitigation from urban gardens and sewage overflows; d) Increased self-cleaning capacity of the ecosystem; e) Increased biodiversity; f) Establishment of recreation and education path.

Key objectives: Beside flood prevention, the recent activities targeting the flood reservoir Podutik aimed at offering water pollution mitigation by the usage of self-cleaning abilities, support of biodiversity, recreation, education, and as such several ecosystem services.

City strategy, scheme or project to which the initiative is linked: The Environmental Action Programme 2014-2020. This a local programme of the City of Ljubljana e.g.. a new city development plan impulsed by the local administration in the frame of European Green city award.

Links to WFD, Floods Directive or other policy/planning process: The multi-functional water reservoir Podutik is in accordance with both the WFD and the Floods Directive as it has two main functions a) improvement and maintenance of good ecological status of nearby watercourses and b) mitigation of floods for nearby settlements of City of Ljubljana. The Podutik reservoir is also in accordance with the Habitats Directive, as one of its functions is

[1] ET comprise a broad range of environmental engineering facilities such as vegetated drainage ditches, waste stabilization ponds, detention ponds, treatment wetlands, phytoremediation and revitalization measures etc. ET represent an innovative approach towards nature, space and environment protection based on a holistic approach.

enhancing biodiversity in the area.
Start-date/end-date: 2006 – ongoing.
Status: Ongoing activities; the re-design of the reservoir depends on the fund raising; H2020 SCC2 (Rainbow), structural funds, own budget etc. The activities planned: a learning path construction (necessary water permits are in procedure), optimisation of water gates.
Lead organisation(s): City of Ljubljana
Key actors involved: the Faculty of Civil and Geodetic Engineering and the Faculty of Health Sciences at the University of Ljubljana.

Achievements and negative effects
Main results and benefits of the measures (ecological, social and economic): The re-design of the Podutik reservoir into a multifunctional flood reservoir has improved its nature conservation value and also encouraged recreational and educational use (Grant 2016). At present, the flood reservoir Podutik with the ecosystem technology system established has mainly contributed to an enhancement of water treatment and biodiversity functions (Griessler Bulc et al, 2015). Concerning its function for **water pollution mitigation**, the flood reservoir is an ideal reservoir of suspended and settleable solids. Additionally, the constructed wetland connected to the reservoir treats the polluted water from the torrential tributary of the Glinščica River, and surface runoff from individual gardens prior inflow into a swamp. The water quality in the reservoir, also due to the ecosystem technology, has reached high to good ecological status (http://www.turas-cities.org/). Concerning the reservoir function of **enhancing biodiversity**, marsh vegetation in this area and algae species are extremely diverse. Also, the area of the flood reservoir is potentially a suitable habitat of endangered animal species and rare birds, like the green woodpecker (Picus viridis), the presence of which has been confirmed in the area (http://www.turas-cities.org/). In the future, maintenance work will be needed to **increase the retention capacity of the reservoir**. In 2014, the hydraulic retention capacity of the multifunctional flood reservoir Podutik was re-evaluated for 10- and 100-year events. The re-evaluation showed that the flood reservoir can retain 10-year events but not 100-year events. The hydraulic retention capacity of the reservoir has decreased in the last five years by approximately 500 m3 due to alluvial deposits and overgrowth of vegetation. Therefore, it is necessary to provide additional hydraulic retention capacity in the area. Additional measures for increasing flood protection include the establishment of safe operating conditions at the outflow and removal of overgrown vegetation and alluvial deposits (http://www.turas-cities.org/). With the appropriate arrangements, the flood reservoir can also become an interesting

educational path (bird observation points, observation of self-cleaning elements of wetland and the Glinščica River) **and recreational place** (walking) in dry periods. An upgrade of the existing educational trail displaying diverse habitats within the flood reservoir and their functions is in the planning. A recreational path for local residents, a playground for children and new information boards are also planned in the near future (Griessler Bulc et al, 2015).

Negative side-effects identified: None identified.

Lessons learned (constraints and positive aspects)

Based on the fact that the demonstration site Podutik is the first multi-functional flood reservoir in the Ljubljana Urban Region area, as well in Slovenia, it offers new perspectives for future developments in water management and flood prevention.

Public involvement: Each year, educational visits of different target groups are organised; pupils from primary schools, students from higher education institutions (Universities, VET), people living in vicinity, etc.

In addition, the flood reservoir was presented at the round table »From failure to sustainable investment« organized by the NGO-Umanotera to confront high level government representatives and professional public with the problem of the failure of large infrastructure projects and draw attention to good practices of small flexible infrastructure solutions, as green infrastructure (e.g. multi-purpose flood retention, nutrients recovery from waste water, etc.)

The purpose of such activities was communicating results to the local stakeholders, gaining acceptance and buy-in of the project.

Efforts to include civil society and to organise information events contributed to awareness on the multi-functionality of the reservoir, and countering lack of communication of different end users of the area of the flood reservoir especially regarding maintenance (e.g. Supplier of electricity, City of Ljubljana, Ministry of the environment and spatial planning of Republic of Slovenia, local people).

Welfare benefits and improvements in quality of life for the public: Relevant activities include: Connection of area with existing bike paths and foot paths. Connection of existing nature trail to the circular path around the reservoir. Construction of tourist infrastructure that includes parking, central information facility and other recreational and educational content related to the context of different educational and demonstration contents regarding multi-functional water reservoir Podutik.

This process is still ongoing; so numbers (e.g.visitors) cannot be reported. The learning and recreational path around the reservoir is planned to be constructed and connected to existing paths. The construction depends on financing possibilities in the next year. The feasibility project is already done.

Links to spatial and urban planning: The project is harmonized with the spatial plan which means that due to acceptability, all planned measures regarding flood reservoirs should not be hindered.

Links to river basin management planning: The multi-functional water reservoir Podutik is in accordance with the river basin management plan since it is enhancing the self-cleaning ability of water bodies and it addresses the main goal of the WFD, i.e. achieving good

ecological status of watercourses.

Before and after photos

Before intervention

Polluted riverbed of Glinščica watercourse (left) and natural swamp (right) before construction of the multi-functional water reservoir Podutik. Photo: Tjaša Griessler Bulc, 2005.

After intervention


Treatment ditch in 2006 (left). Photo: Tjaša Griessler Bulc, 2006; Treatment ditch in 2015 (right). Photo: Klara Jarni, UL ZF, 2015.

New river bed with meanders. Foto: Klara Jarni, UL ZF, 2015.

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River Mayesbrook – London, United Kingdom

Name of initiative
Restoring Mayesbrook, London

General characterisation (short description of area / site)
The Mayes Brook is an urban river located in the east London Borough of Barking and Dagenham. It is a tributary of the River Roding and it gives its name to the Mayesbrook Park, a 45ha urban landscape and public open space that recently became the UK's "first climate change park" (Natural England, 2013). The complex has become a good example of an integrated river and park restoration initiative in an urban environment which combines flood protection, biodiversity enhancement, amenity and aesthetic improvements and climate change adaptation (EA, 2011).
Location (city, town, neighbourhood): London, Upney
River/lake concerned: Mayes Brook
(Other) Main rivers and lakes of this city: Thames, Roding
Setting [Main urban area; Peri-urban area]: main urban area
Background (key water management issues, sources of degradation and challenges)
While it has been noted that the local community valued the park before its restoration, its former setup offered limited attractions both for people and for wildlife (London Borough of Barking and Dagenham, 2012). Run down sports facilities, two artificial lakes which were later polluted by diverted waters and a straightened, polluted, realigned and fenced river sunk into a deep concrete channel disconnected from its floodplain made up the landscape (Natural England, 2013). Many people consulted were not even aware there was a river there before the project.
Main trigger for action: The main driver for the restoration project was the identified need for revitalisation of the park and water quality improvements.

Objectives and description of the initiative
Type of measures implemented: The river itself has been restored with 500m of new sinuous water channels to help slow high flows and create habitat diversity, and 450m of re-graded banks to increase the capacity of the river and improve the riverside habitat. At the heart of the redesigned park is a new 1.5 ha floodplain that will safely store floodwater and slowly release it. The floodplain has been designed as a complex patchwork of gravel riffles, runs, seasonal ponds, reed beds, acid grassland and scrub vegetation, and now provides home

for a range of wildlife rarely seen in one of the most deprived boroughs in London. Freshwater fish, water birds, amphibians and bats call the park home, while the new visually attractive meandering channel slows water down during high flows and allows for safer access to the park for visitors who want to enjoy the waterside (Natural England, 2013).

The project was a springboard for water quality improvement work. The reed beds were installed to address one unresolved misconnection within the park and 225 properties rectified their misconnections as a result of the Thames Water's liaison. Some of the larger misconnections identified included a residential home with 5 misconnected sinks and 2 misconnected dishwashers. Huge amounts of fat, oil and grease had been entering the surface water system over a long period of time from this misconnection.

Key objectives: According to the local government, the main aim of the measures implemented at the Mayesbrook Park, including the restoration of the Mayes Brook, was to enhance the community space and achieve a more natural landscape that could become a model for climate change adaptation in a city environment (Greater London Authority, n.d.). More specifically, achieving improvements on the physical, chemical and ecological characteristics of the river and lakes; enhancing biodiversity and ecosystem services in the park; reducing flood risk to adjacent and downstream properties; improving the perception, safety and security in the area; providing a space for educational trips; and promoting better understanding of river restoration, adaptive management and natural approaches through demonstration of their effects were all key objectives of the initiative.

City strategy, scheme or project to which the initiative is linked: In 2009 the London Rivers Action Plan was adopted (Thames River Trust, 2016). The main aim of this Plan is to provide a forum for identifying stretches of river that can be brought back to life, by improving river channel or riparian habitats, by removing or modifying flood defence structures, or by reclaiming 'lost' rivers currently buried under the surface (LRAP Partnership, 2009).

Links to WFD, Floods Directive or other policy/planning process: According to the Thames River Trust, the Mayes Brook was one of the worse water bodies in the area as identified in the Thames River Basin Management Plan 2009-2015, failing to achieve Good Ecological Potential due to hydromorphological modifications, poor water quality and low ecology (Thames River Trust, 2015). In addition to the clear links to the WFD implementation evident from the objectives of the project, the Mayesbrook scheme is also linked to several other past and ongoing policy/planning processes for water, biodiversity and climate change adaptation at all administrative levels. A few of them include DEFRA's "Making Space for Water" programme of 2004; the EA's "Biodiversity Strategy and Action Plan (Thames region)"; and London's "Climate Change Adaptation Strategy" of 2011).

Start-date/end-date: Phase 1: 2008(planning) - 2011 (delivery); Phase 2: 2016 (planning) - ongoing

Status: Phase 1: Finished in 2011; Phase 2: ongoing (involves plans to restore lakes, introduce angling activities and construct a cafe for park users)

Lead organisation(s): London Borough of Barking and Dagenham (LBBD), the Environment Agency, Thames River Restoration Trust, Natural England.

Key actors involved: London Wildlife Trust and the Greater London Authority (Priority Parks fund via 'Help a London Park' competition), Design for London, River Restoration Centre, Thames Water, Olympics Development Association.

Significant funding was also provided by the insurance company RSA Ltd and the SITA Trust, London Tree and Woodland Grant Scheme, London Underground.

Achievements and negative effects

Main results and benefits of the measures (ecological, social and economic): After restoration, the river is showing rapid morphological recovery and improved ecological resilience, helping the water body **progress towards Good Ecological Potential**.

In addition to the ecological benefits, the restoration of the Mayesbrook has provided many additional benefits such as health benefits, and improvement in the quality of life and wellbeing of the local inhabitants, improved safety through greater park usage, socio-economic benefits to local sports clubs (football/ cricket, etc) as well as an educational resource for the local schools.

An assessment of the ecosystem services provided by the restored Mayes Brook published in 2011 estimated a substantial lifetime benefit-to-cost ratio of £7 of benefits for every £1 of investment (EA, 2011). The study highlighted the social and health aspects **improving the quality of life and wellbeing of local communities** as the more important benefits of the intervention.

Negative side-effects identified: None reported.

Lessons learned (constraints and positive aspects)

Governance and multi-actor cooperation: The partnership governance model adopted by the project depends heavily on the recognition of specific ecosystem services relevant to individual funding partners in order to meet conditions for delivery of key criteria. By piecing together a 'mosaic' of funding, multi-objective partnerships are able to bring forward integrated schemes to deliver diverse benefits. In such complex schemes, the effectiveness of the governance will depend upon effective leadership and facilitation, with adequate time for cross-disciplinary communications to enable and coordinate integrated decision making. PhD research investigating the partnership governance and 'mosaic' funding approach (Shuker, 2011) found that effective time allowance for multi-actor communications, 'key-player' facilitators, flexible leadership and fund sourcing support were essential to the successful outcomes for this project.

Public involvement: Due to the high public profile for the Mayes Brook restoration and Mayesbrook Park regeneration works, as well as the responsibilities of the lead partner to the social and economic outcomes of the scheme, considerable pre-project engagement was undertaken to raise awareness of the potential gains in natural capital and social benefits. In particular, work with local school groups, awareness raising and stakeholder engagement activities were led by key partners. Formal public meetings were held regularly to inform local residents and businesses at key planning stages. A formal consultation event in the park

was also delivered.
These efforts allowed ensuring good knowledge exchange with local residents and park users (e.g. in relation to potential changes to the existing landscape which carried significance to individuals or families) as well as allaying concerns and identifying the best available solution without compromising the scheme objectives. Furthermore, the involvement of a private sector funder added considerable value with respect to resourcing PR events.

Welfare benefits and improvements in quality of life for the public: Landscaping and public art installed within the park enhanced its aesthetics and cultural value for the nearby communities. Ecological enhancements resulted in increased biodiversity and visiting wildlife, while additional equipment and facilities for sports and recreation have increased the opportunities for engagement and activities within the park. A key element with immediate benefits to local community groups was the funding of a park ranger who delivered regular engagement activities within the park including nature walks, bush crafts and other wildlife observation activities.

Funding: The availability and time constraints of funding and effectiveness of communications were found to be major determining factors in driving project opportunities and schedules. Ten funding partners collaborated with lead project mangers the London Borough of Barking and Dagenham, to deliver multiple benefits via Phase 1 of the project(park restoration). Due to a shortfall in funding early on in the project, an alternative 'mosaic funding' model, which fitted together funding conditions for specific objectives, was adopted. This model was able to make up for overall shortfalls and enabled the successful delivery of an integrated and diverse multi-benefit project.

Additionally, during the planning phase a range of funding initiatives for environmental works became available, including a London-wide funding competition named 'Help a London Park' (Greater London Authority, 2011) which allowed local people to vote for their local scheme, and successfully provided the Mayesbrook scheme with both funding and social involvement.

Links to spatial and urban planning: The project planning entailed carefully selecting those natural characteristics of the area to be featured within the overall scheme; scoping the opportunities to build connectivity enhancements into the new park designs (via pedestrian and cycle routes); and prioritising safety and aesthetics in spatial and amenity design features.

Availability of land to fulfil the measure: Before restoration, the Mayes Brook channel had been confined to the west and southern perimeters of the park where it was partitioned behind a 2m high steel palisade fence and low embankment from historic dredgings. Due to spatial opportunities and constraints, the restoration works were organized and undertaken in four separate sections/river reaches (reach 3 is shown in the pictures below). In other parts of the park, the landscape designs ensured ample space for the four existing football pitches and cricket pitch.

Links to river basin management planning: Restoration of the Mayes Brook and Mayesbrook Park lakes was identified as a measure to improve hydromorphology and water quality in the first cycle of River Basin Planning for the Thames River Basin District (EA, 2009). The project has shown the potential of green infrastructure approaches against their traditional engineered counterparts (Natural England, 2013). Furthermore, the integrated monitoring strategy established to coordinate all evaluation activities related to water, land,

social and climate change issues as well as the public participation efforts are recognized as key lessons from the project (RESTORE, 2013).

Before and after photos

Reach 3 before, during and after restoration:

Picture 1: Reach 3 before restoration – March 2011: River is not visible, located behind the tall fence running around the park boundary. A footpath runs through the grassland where the new channel will be constructed. Source: Environment Agency.

Picture 2: Reach 3 immediately after restoration in Autumn 2011 and Spring 2013. Two views show rapid morphological recovery from a newly restored channel to vegetated banks with mid channel bar formation. Source: Environment Agency.

Picture 3: Reach 3 three years after restoration – March 2014, showing riffle development, flood plain recovery and colonisation by aquatic marginal vegetation. Source: Environment Agency.

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River Dyle – Leuven, Belgium

Name of initiative
Flood protection / restoration of the river Dyle, city of Leuven

General characterisation (short description of area / site)
The Dijle or Dyle river is 86 km long, rises in Wallonia and flows into Flanders south of the city of Leuven. It is part of the Dyle-Zenne river basin in the center of Flanders. The Dijle flows through Leuven city and then further on in the direction of the city Mechelen where it joins the Zenne river. The basin of the River Dijle upstream of Leuven is characterised by fairly steep slopes. The river basin used to be virtually fully wooded. However, these woods had to largely give way to agricultural land. This leads to faster drainage of rain water, resulting in erosion. The Dijle as such was never straightened or embanked upstream of Leuven. Up to the present, the Dijle retains its meandering pattern and is therefore unique in Flanders. Once entering Leuven the river is shut in by the city (VMM 2011).
Location (city, town, neighbourhood): Leuven and the larger Flanders area
River/lake concerned: Dyle river
(Other) Main rivers and lakes of this city: Ijse, Voer and Vunt river
Setting [Main urban area; Peri-urban area]: Peri-urban & urban

Background (key water management issues, sources of degradation and challenges)
The flooding of the Dyle has always been an issue in Leuven as the naturally-occurring steep slopes and historical deforestation upstream of Leuven easily lead to rapid increases in flow rate and water level during high precipitation. These floods occurred after heavy rainfall or after sudden thaws following cold winters, resulting in the rivers overflowing. The most extreme flooding event in its recorded history took place in 1891, which led to a third of the city being flooded, and it remains a reference point for the river's destructive potential. Since then, flooding events (e.g. in March 1947 leading to extensive flooding in the upstream municipality) have remained a regular occurrence and prompted a number of interventions. Within the city of Leuven, the Dijle and its tributaries are largely vaulted or lie deeply and shielded in between the houses of the city.
Main trigger for action: Persistent flooding events (see above)

Objectives and description of the initiative

Type of measures implemented:

Measures upstream of Leuven

In the seventies, the idea to protect the city of Leuven began with the design of traditional hydraulic solutions, in particular a large flood reservoir in Neerijse valley upstream of Leuven. The poor water quality, the agricultural land use (still very important in that period), made it a requirement that the flood reservoir would not take up more space than was absolutely necessary. During the design period of these traditional hydraulic solutions, growing environmental awareness led Leuven to explore more nature-based solutions that take the ecological health and landscape value of the river valley into consideration (La Rivière 2014).

Based on new modelling software and taking into account the ecological requirements, the protection measures worked out, include a controlled flood reservoir in Egenhoven and natural, uncontrolled flood zones in the Neerijse valley (La Rivière 2014.).

In this new approach, instead of a hard engineered solution with artificial flood reservoirs, the natural processes resulting in "wet" valley floors along the River Dyle upstream of Leuven have been restored. Infrastructure works are kept to a minimum and are intended to 'guide' for the river rather than to contain it (La Rivière 2014).

Additional measures are currently being considered under the Flood Risk Management Plan (FRMP) to implement the EU Floods directive, on the basis of work and stakeholder consultation taking place in the EU project Flood Resilient City (FRC). The following broad categories of measures were found to warrant implementation or further investigation: Protection against floods by upstream attenuation, flood prevention and damage avoidance (incl. integration of flood resistance and space for water in regeneration areas in the centre of Leuven), awareness and preparedness (communication campaigns, historic flood marks in the city), assistance before, during and after a flood.

Measures inside Leuven

Except for the provision of areas to store water upstream of Leuven, it may be possible to slowly enhance the capacity of the channel network within the city over the years, providing that there is sufficient support within Leuven. Although the capacity enhancements will be relatively small, when these are coupled with flood resistant and resilient constructions, they will help to reduce the amount of storage required upstream. A smaller amount of storage upstream can be realised in a more natural way and avoids the more technical solution of a new large flood reservoir that has a large impact on the ecologically valuable valley. In the EU project Flood Resilient City (FRC), the Flanders Environment Agency implemented a number of measures to enhance the capacity of the channel network within the city. The existing quay-walls were improved to maintain the discharge capacity in the city centre. This was done in close contact with the riparian owners. In that way they became more aware of the river flowing next to or close to their houses. At one location it was possible to build a terrace alongside the river and a small park for people to enjoy. During high water the steps can flood. This increases the capacity for the river in the city centre. Additionally the terrace helps to make more people in Leuven aware that the Dijle is a living river, and that there is an ongoing threat of flooding (Source: http://www.floodresiliencity.eu).

In addition, covered branches of the Dyle inside Leuven are opened up, e.g. in a former industrial area in north Leuven, as part of a bundle of activities of the city of Leuven and the Flanders Environment Agency to enhance the role of rivers in the urban fabric and live in close vicinity with the water (La Rivière, 2014).

Key objectives: Reduce the frequency and severity of flooding, adapt the city to climate change

City strategy, scheme or project to which this initiative is linked: The spatial development plan of the city of Leuven, treated the Dijle river as a separate structure with high importance to be a blue-green corridor throughout the city. The main aim was to enhance the way the watercourse is experienced. General principles as higher water storage, improved water quality and erosion measures are also integrated in this plan.

At this moment the city also works on a RainWaterPlan, this plan has to give better insight in how they should deal with pluvial flooding. Because next to the river, rainwater that falls on the sealed, hilly surfaces can, combined with often too small sewer systems, also cause a lot of water problems.

Links to WFD, Floods Directive or other policy/planning process: Much of the work carried out in the EU project FRC for flood alleviation in Leuven is now used as a basis for the planning of measures under the Floods Directive and the preparation of the first flood risk management plan (FRMP).

The flood risk management plan and the river basin management plan in Flanders are integrated, so next to measures for flooding, also measures to improve water quality, structure of the Dijle river are integrated in the RBMP.

Upstream of Leuven, a big part of the valley is designated as Natura 2000 area, so measures we take there for flood protections should always take into account the natural importance of the valley.

Start-date/end-date: 2006 - ongoing

Status: Ongoing

Lead organisation(s): Operational Water Department of the Flanders Environment Agency (VMM), City of Leuven

Key actors involved: Agency for Nature and Forest (ANB), Catholic University of Leuven, project developers (regeneration projects).

Achievements and negative effects

Main results and benefits of the measures (ecological, social and economic): The construction of a controlled flood plain (CFP) in Egenhoven and the restoration of the natural valley storage of the 'Doode Bemde' nature reserve in Neerijse ensured that Leuven is ‘flood

safe' until a theoretical return period of 100 years. During the winter of 2010-2011, many places in Flanders suffered from severe flood damage. In Leuven itself no floods occurred, but the CFP in Egenhoven was filled to the brim in November 2010. In the 'Doode Bemde' as well a great amount of water was stored in a natural way. At the same time the maximum allowable flow rate was discharged through Leuven. This demonstrates that, although various protective measures have been taken, we still have to be alert and assess whether additional measures are required in the future (VMM 2011).

Inner-city measures (improvement of quay-walls, terrace and small park next to the river, opening of covered river branches) made riparian owners and citizens more aware of the river flowing through the city, increased recreational value and the construction of residential complexes next to the water. New residential complexes are advised (via water assessment tool) to build in an adapted way, meaning that ground floors should be above the water level expected every 500years taking into account the high climate scenario.

Negative side-effects identified: Question remains whether the natural storage upstream of Leuven will be sufficient enough to protect the city.

The terraces in the city centre, can get flooded. This was the aim to make inhabitants aware that the Dyle river is a living river . But due to sediment transported by the river, it requires some maintenance, so it is important to select the right material to create these terraces close to the water.

Lessons Learned (constraints and positive aspects)

Governance and multi-actor cooperation: Cooperation with the city of Leuven, which aims at creating a blue green corridor in their city, ensures that river restauration is obliged in new developments.

Public involvement: By making the Dijle river more visible and accessible in the city centre, people are more aware of the fact that they live close to a river. By creating terraces that descend towards the water, but that also can get flooded when the river rises, people are also aware that this river is a fluctuating river, of which the water level can change in time.

Welfare benefits and improvements in quality of life for the public: Concerning the restoration of the Dyle and its branches inside the city of Leuven, the realisation that open watercourses in the city creates significant added value is gaining in importance, not only among public administrations, but also among private project developers (La Rivière, 2014).

Funding: In the city centre cooperating with project developers, makes it possible for the VMM to do more with less money. The project developers are responsible for opening up the river again, and working out the design of the blue-green corridor. VMM then participates in the river enhancements.

Links to spatial and urban planning: The River Dyle has provided an example of how water management practice can change from the outmoded view that the only solution lies in concrete to one that works with nature. This pioneering work leads the way in the development of modern management practice for the watercourses in Flanders.

Availability of land to fulfil the measure: By working together with the city of Leuven, they demand that project developers should take into account that the Dijle river should be

opened up and integrated in their projects. Upstream the city we are lucky that most of the land is property of government (Agency for Nature and Forest, Flanders Environment Agency,…). By combining our flood protection objectives with their nature protection objectives, the land could be used in multiple ways.

Links to river basin management planning: By choosing natural flood protection measures upstream the city of Leuven, we could integrate the objectives of the FD with those of the WFD. Within the city opening up the river and the creation of green river banks, improves the structural quality of the river and makes it more interesting for nature (even within the city).

Before and after photos

Before restoration (photos)

Source: Flanders Environment Agency (VMM)

After restoration (photos)

Source: Flanders Environment Agency (VMM)

Contacts
Ivo Terrens, Flanders Environment Agency Annelies Haesevoets, Flanders Environment Agency

References and further information
Publications: • La Rivière, J., 2014, “The River Dyle in Leuven - a blessing and a curse”, Flanders Environment Agency (VMM). • VMM (Flanders Environment Agency), 2011, “How to deal with flooding: Preparations for drafting the flood risk management plans for the river basins of the River Dijle upstream of Leuven and the River Woluwe in Flanders.”
Websites: https://en.vmm.be/publications/the-river-dyle-in-leuven-belgium-a-blessing-and-a-curse http://www.floodresiliencity.eu

River Sokołówka – Łódź, Poland

Name of initiative
Restoration of the Sokolowka River, Lodz

General characterisation (short description of area / site)
With a population ca 800,000 inhabitants the city of Lodz is the third largest city in Poland. It is located ca. 135 km southwest of Warsaw and is the capital of the region named after it. It lies on the border between the catchment areas of the Vistula and Odra rivers (Tönkő and Kronenberg, 2015). The catchments of 18 small streams divide the city's area. One of these small urban streams is the Sokolowka River, which runs across the northern part of the city and which has an overall flow of 0.17 m^3/s (Bartnik, A., Moniewski, P., Tomalski, P., 2008). The valley of the Sokolowka, besides of the typical urban development, has also numerous patches of natural vegetation and even agricultural land (Wagner, I. et al., 2008). In its upper reaches, the river is partially canalized by concrete slabs, straightened and deepened, and receives stormwater from about 50 stormwater outlets. Eight stormwater receiving reservoirs are located along its run.
Location (city, town, neighbourhood): Lodz
River/lake concerned: Sokolowka River
(Other) Main rivers and lakes of this city: The city area and its surroundings are source areas for 18 streams, which flow through the city. Most of them are channelized and included as part of the sewage system. The biggest river of the city is the Ner River (catchment area of the Odra River). Waters from Lodz treatment plant, water from combined overflows and about 60 % of town rain water are directed to this river.
Setting [Main urban area; Peri-urban area]: Urban

Background (key water management issues, sources of degradation and challenges)
The city of Lodz became a major manufacturing center in the 19th century. In the early 1930's hydraulic regulation measures were introduced in the city's rivers. In the case of the Sokolowka, the river course was straightened and the river bed was deepened and lined with concrete slabs. The main channel of the urban stream was converted into a collector for 50 stormwater outlets. These developments resulted in adverse effects on the urban and surrounding ecosystems, including reduced water retention capacity, a limited capacity of the river to reduce air temperatures in the urban area and increased nutrient levels in the stormwater leaving the city (Negussie et al., 2012; Loftus, 2011).

Main trigger for action: Most of Lodz rivers work as a part of a combined sewerage system of the city. During heavy rains rivers intercept waters from overflows and rain water. Waters from combined sewage overflows and stormwater outflows pollute rivers several times per year. Shortage of stormwater retention reservoirs is one of the reasons for pollution of the Ner river, which receives combined sewage from the entire city. The repeating problems related to pollution, overflows and ecological degradation made the city look for possibilities of stormwater retention, and for improving the ecological quality of the rivers, thus creating friendlier and healthier public space.

Objectives and description of the initiative

Type of measures implemented: After the decline of the manufacturing industry in the city and in response to the issues described above, urban regeneration efforts have started taking place in Lodz. The restoration of the Sokolowka River has been used as a demonstration case to gather up experience that can then be used for further replication on the other streams crossing the city. The measures implemented included inter alia (Wagner and Breil, 2013):

- design of a sequential stormwater sedimentation-biofiltration system which prevents the influx of pollutants into the river during high flows; (Zalewski, et al., 2012) the design and construction of three stormwater reservoirs with increased river retention and pollution absorption capacity, thanks to adjusted biotic structures and hydrodynamic adjustment; and
- the elaboration of development plans for further rehabilitation of the river valley.

Key objectives: Implementation of ecohydrological principles to the river restoration, to increase water retention and improve the quality of life in the city.

City strategy, scheme or project to which the initiative is linked: In 2012, the City of Lodz adopted the Integrated Development Strategy for the City of Lodz 2020+ . The restoration of the Sokolowka River is part of an urban development programme centred on water and river restoration in Lodz. Five retention reservoirs were built on the Sokolowka River. As the river has different land conditions (size of catchment area, topographical feature), each of the reservoirs has its own style. But all of them have two main functions - water retention and recreation. In 2001 the Łódź City Office developed a Small Retention Programme, which covers the whole city. There were more than 50 reservoirs within the administrative borders of Lodz, and the programme proposed the construction of an additional 30 reservoirs.

Links to the WFD, Floods Directive or another process Policy / Planning: The city will take all measures for the city rivers as a consequence of the Policy for Municipal Environmental Protection. This is part of the strategy of the city. Investments planned on rivers are included in the plans for water management (water management strategy) in accordance with the provisions of the Water Framework Directive.

Start-date/end-date: 2000-2012

Status: Finished. According to financial possibility, measures on the other rivers in Lodz will be undertaken in the nearest future.

Lead organisation(s): European Regional Centre for Ecohydrology u/a UNESCO; City Office Lodz

Achievements and negative effects

Main results and benefits of the measures (ecological, social and economic): The restored river and its valley have become an attractive residential area which is connected to the rapidly developing city center and which has contributed to the positive development of the economy in the area (Wagner, I. et al., 2008). The activities taken have "harmonized the existing hydrotechnical infrastructure with ecohydrological measures", raised awareness and increased the quality of life in the area by providing a healthier environment for the citizens.

Negative side-effects identified: None reported.

Lessons learned (constraints and positive aspects)

The experience gained on the Sokołówka River is being used to initiate activities in other areas of Lodz. One example is the LIFE+ project EHREK: Ecohydrologic rehabilitation of recreational reservoirs "Arturówek" (Łódź) as a model approach to the rehabilitation of urban reservoirs.

Public involvement: Stakeholder involvement through a Learning Alliance has driven the success of the initiative, and has created links strong enough to last beyond the lifetime of the initiative and to sustain the upscaling of research results. Because research foci remained flexible and responsive to stakeholder needs, stakeholders participating in the initiative were able to really take advantage of their involvement. The Learning Alliance provided a well-structured framework to identify needs, develop capacities, define common goals and align the efforts of multiple actors towards reaching them and communicate decisions and achievements. It also became clear that the success of a Learning Alliance cannot just be based on occasional meetings, but rather that it relies upon strong facilitation, frequent communication, and the commitment of stakeholders from all levels to regular and open involvement. A big part of the success of the Learning Alliance has been linked to the strong commitment of champions within the Alliance. Individuals, in particular a professor from the university, have been instrumental in the process (Loftus, 2011).

Welfare benefits and improvements in quality of life for the public: The creation of new green areas has had positive influence on the quality of the inhabitants' life and their health. Many people can now have attractive rest in recreational areas along the rivers.

Funding: Difficulties have arisen in attracting investment in general, and EU funding has played a vital role in the implementation of this initiative. Further, the lack of technical experts and scientists has been noted as a main challenge to replication of the restoration action in the Sokolowka River, together with the lack of finances (Loftus, 2011).

Links to spatial and urban planning:

- The valley of the Sokołowka river is to 80 % covered by local Town Plans (spatial development plans). These plans are basic tools for right investment - revitalization of the valley to achieve its natural form. The plans point location of investment goals, their kind and scope (green infrastructure, water retention, biologically active areas, ...).
- Lodz took a broader view of the wider links between the water cycle and other aspects of urban development instead of just focusing on water. The demonstration projects implemented by Lodz have played an important role in creating visibility, interest and cooperation, and as such have been vital in the scaling-up strategy of the project (Loftus, 2011).
- The ability to motivate urban developers "to consider innovations linked to stormwater management in their development projects" has been important. Unfortunately, the failure to obtain permits has delayed the practical application of these design principles (Loftus, 2011).

Availability of land to fulfil the measure: The investments are being implemented on land which belongs to the City of Lodz or other public owners, which makes the implementation process more efficient.

Before and after photos

Locations Zgierska (upper images) and Teresy (lower images) before and after restoration in the urban catchment of the Sokolowka River (left-hand side: before restoration; right-hand side: after restoration). Source: ©Anita Waack-Zając.

Contacts

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- Zalewski, M., Wagner, I., Fratczak, W., Mankiewicz-Boczek, J., Parniewki, P., 2012. Blue–Green city for compensating global climate change. The Parliament Magazine 350, 2–3., In: http://www.theparliament.com/ digimag/issue350.

Websites: https://processdocumentation.files.wordpress.com/2007/07/2007-gazeta-switch-learning-in-lodz2.pdf www.switchurbanwater,eu
Conference presentations: • There have been more than 100 different presentations at both national and international conferences, meetings, workshops, and congresses presenting the Sokołówka rehabilitation project in Lodz.

River Quaggy – London, United Kingdom

Name of initiative
Quaggy River in Sutcliffe Park, London

General characterisation (short description of area / site)
The Quaggy is a main tributary of the River Ravensbourne and lies within the London catchment. It is 5.6 km in length, flowing from its source at Mottingham to its confluence with the Ravensbourne at Lewisham. Sutcliffe Park is a large area of open parkland that is owned by the Greenwich Council and managed in conjunction with the Environment Agency. The Park covers an area of 21 hectares and contains a large wetland habitat area as well as a regionally important Athletics facility.
Location (city, town, neighbourhood): London, Sutcliffe Park
River/lake concerned: River Quaggy
(Other) Main rivers and lakes of this city: Thames, Lea
Setting [Main urban area; Peri-urban area]: main urban area

Background (key water management issues, sources of degradation and challenges)
For years the River Quaggy at Sutcliffe Park was lost underground in a culvert. Local residents only became aware that a river was there when their homes flooded more frequently as development increased. Rather than further deepening and widening the hidden channel, a decision was made to combine flood risk management with a strategy for river restoration to benefit the local community (LRAP 2009).
Main trigger for action: There have been considerable flooding problems along River Quaggy in previous years, most notably in 1968 when Lewisham town centre was flooded to a depth in excess of 1 metre, and a smaller flood in 1992. Historically, these have been caused by urban development in the river valley and the natural flood plain.

Objectives and description of the initiative
Type of measures implemented: A new 'low-flow' meandering channel was cut through the park, following its original alignment. The previous culvert was retained, enabling it to take excess water in times of extreme flood events. Flow is now regulated between the two watercourses by a sluice. To provide further flood water storage, the park itself was lowered and re-shaped to create a floodplain capable of storing a maximum of 85,000 cubic metres of

flood water. A network of boardwalks, pathways and viewing points were designed to encourage access to the river and ponds, all of which were an integral part of the scheme. (LRAP 2009).

Key objectives: Combine flood risk management with a strategy for river restoration to benefit the local community

City strategy, scheme or project to which this initiative is linked: The restoration of the River Quaggy is part of the London Rivers Action Plan (2009). For further information on the London Rivers Action Plan (2009), see template on the Mayesbrook restoration and the main part of the report.

Links to WFD, Floods Directive or other policy/planning process: Though the project pre dates the catchment plans which implement the River Basin Management Plan for the WFD, the scheme would be considered as a mitigation to the heavily modified nature of the water body.

Start-date/end-date: 2003/2007

Status: Finished

Lead organisation(s): Environment Agency; QWAG (Quaggy Waterways Action Group); Breheny Engineering; London Borough Greenwich; London Borough Lewisham

Achievements and negative effects

Main results and benefits of the measures (ecological, social and economic):

- Flood risk has been reduced for the surrounding area;
- The combination of the new open river, together with the old culverts, enables the regulation of flows for a range of environmental conditions associated with climate change impacts;
- People have been reconnected to nature and since opening the park visits have increased by 73%;
- The open watercourse and wetland pond areas sustain a range of native plant species which, together with the natural gravels found on site, provide a variety of habitats necessary for a more diverse wildlife.

(LRAP, 2009)

Negative side-effects identified: Levels of siltation have been greater than initially anticipated, this has led to the frequency of flooding of one of the footpaths being greater than originally thought.

Lessons Learned (constraints and positive aspects)

- The scheme is part of a wider catchment scheme; an advantage of this is that the storage created at Sutcliffe Park has enabled habitat mitigation measures in more constrained environments downstream to be implemented.
- Design was driven by a multi-disciplinary scheme, which enabled wider community and environmental benefits to be achieved.
- The project employed a community liaison officer. There was interaction with schools, colleges and local charities who also became actively involved in the delivery of the project. A "friends of the park" group was subsequently created.
- Some of the design details were not as successful as anticipated. The post project appraisal was not sufficient to identify this and implement remedial actions.
- Demonstrating multiple benefits has enabled a wider range of funding sources to be approached for future schemes.
- The scheme was able to demonstrate a link between river restoration and flood risk management, and subsequently informed policies in the London Rivers Action Plan.
- Through providing multiple benefits, the ecological improvement has been significantly greater than for a project purely focusing on ecology.

Before and after photos

Picture 1: Quaggy River before and after restoration. Source: @The Environment Agency

Contacts

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References and further information
Publications: London rivers action plan (LRAP), A tool to help restore rivers for people and nature, January 2009
Websites: http://www.landscapeinstitute.org/casestudies/casestudy.php?id=1 http://www.therrc.co.uk/projects/sutcliffe-park-river-quaggy-flood-alleviation-scheme

River Yzeron – Lyon, France

Name of initiative
Flood protection / restoration in the River Yzeron, city of Lyon

General characterisation (short description of area / site)
The River Yzeron (25.1 km) originates in Montromant, a small village in the foothills of the *département* of Loire and Rhone, west of the city of Lyon. The Yzeron is a tributary to the River Rhone and drains part of the urban area south-west of the center of Lyon. The watershed of Yzeron can be distinguished into an upstream zone which is steep and predominantly rural, a middle area which is less steep and peri-urban and a downstream area which is densely urbanised.
Location (city, town, neighbourhood): Oullins, close to Lyon
River/lake concerned: River Yzeron
Setting [Main urban area; Peri-urban area]: Urban, peri-urban

Background (key water management issues, sources of degradation and challenges)
The key issues historically plaguing the River Yzeron have been high variability in its flow and pollution. During heavy rainfall, the river is capable of producing extremely high flow rates and dangerous flooding in the urbanised downstream areas. During the dry summer season, low water levels and a dry riverbed have been a problem in the past, whereby wastewater discharge accumulates and presents a breeding ground for diseases and a health hazard for city residents, especially during the summer months. It was these public health concerns that came to a head at the beginning of the twentieth century, when the municipal government decided to canalize the river for the first time. The last canalization of the River Yzeron dates back to the 1960s, along with hydroelectric development on the Rhône river, increasing its slope, reducing its width to 6 meters and laying concrete slabs along 1,3km of the riverbed. At that time, the issues were also hydraulic. In addition, the Yzeron basin faces strong demographic pressure.
Main trigger for action: After two important floods in 1989 and 1993, the signing of the Yzeron river contract in 2002 was the first concerted planning and management action programme implemented in the watershed. SAGYRC (Syndicat d'Aménagement et de Gestion de l'Yzeron, du Ratier et du Charbonnières), an intercommunal Union, bringing together 20 member municipalities, has been responsible for the management and implementation of the river contract. The reference flood (the largest recorded flood) is now that of 2003 (30 year flood).

Objectives and description of the initiative
Type of measures implemented: Since the late 2000s, the Yzeron ecological restoration project has had several objectives and incorporates various sustainability elements (Cottet et al. 2014). The River Yzeron is being restored in several steps: a small section was restored in 2012, and a larger section has been under restoration since 2014. To increase channel capacity in the densely urbanized downstream reach, and to provide opportunities for ecological enhancement, the river's corridor will be expanded. Additional width for the channel will come from a combination of narrowing an adjacent road and selective removal of structures. The restoration project involves the removal of the concrete culverts and revegetation of the banks in order to foster a wildlife corridor with flora and fauna. The simultaneous widening of the river and construction of two dams aids in flood control during the wet seasons. Taking residents' feedback into account, the project also places high value on the landscape quality of the river, providing a social service to locals seeking to relax and enjoy (Flaminio et al., n.d.). Thus while the original project mainly addressed increasingly frequent flooding, it came to include interests in the river's ecological, social and recreational services. In parallel, works are being conducted by Lyon Métropole (formerly named Greater Lyon) on the combined sewer system, to reduce overflows and emissions during rainy weather.
Key objectives: On one hand, the specific objectives of the Yzeron river contract are to protect the city against flooding and restore the aquatic environment. On the other hand, they aim to enhance the aesthetics of the city, facilitate and promote recreational uses, and adapt the city to climate change.
City strategy, scheme or project to which this initiative is linked: The restoration scheme is linked to the Yzeron river contract but not to an overall water strategy of the city of Lyon. However, Lyon Metropole is one of the most important partners of the river contract, and identifies the project in its urban planning documents.
Links to WFD, Floods Directive or other policy/planning process: Several of the actions carried out under the Yzeron river contract are part of the SDAGE Rhône Mediterranean 2010-2015, which is the framework for river basin management planning and the programme of measures for this River Basin district under the WFD.
Start-date/end-date: 2012/ 2014 – ongoing
Status: Ongoing
Lead organisation(s): SAGYRC
Key actors involved: SAGYRC, Greater Lyon, the Compagnie Nationale du Rhone (CNR), the Federation of Fisheries of the Rhone, contractors

Achievements and negative effects

Main results and benefits of the measures (ecological, social and economic): As the project is still ongoing, the main results and benefits cannot be described in detail yet.

It is significant to note that the project began with essentially technical objectives yet acquired a multifunctional character as it incorporated ecological and landscape objectives. This was achieved by involving a wide variety of stakeholders, especially the public, in a high-density urban area (Flaminio et al., n.d.; Cottet et al., 2014).

Negative side-effects: None reported in the reviewed literature.

Lessons Learned (constraints and positive aspects)

Governance and multi-actor cooperation: This is one of the first projects combining partnerships (technical and financial) on shutters protection against floods and ecological restoration. For local officials, the living environment component in addition to the technical aspects was very important and interesting.

Public involvement: The project was led by managers and elected officials but included an inquiry and consultation process with the public. This has allowed for an approach that is both effective technically and has a positive social impact (Flaminio et al., n.d.). The project has placed high value on the social context of the project, namely the riverscape as an interface between nature and society (Cottet et al., 2014). This has been done through surveys, questionnaires and eye tracking data analysis.

Welfare benefits and improvements in quality of life for the public: Improving the ecological quality of the river has created social benefits through increased perceptions of naturalness and beauty (Cottet et al., 2014)

There are a lot of new visitors to the restored site dedicated to the protection against floods, which requires a lot of educational activities for citizens to explain the functions of the site. It is not intended to have very regular maintenance and street furniture etc., but rather for the site to remain rustic.

Funding: Part of the financing was provided by the water agency Rhone Mediterranean Corsica for the shutter restoration, and by the ministry and Lyon Metropole for the floods protection.

Links to spatial and urban planning: The project was integrated into the planning document "Agenda 21" of the town, with a continuous garden concept. It is also identified in the flood zoning of Greater Lyon and the prevention plan established by the state.

Availability of land to fulfil the measure: Under French law, the River Yzeron is "non-national", ie. there are several riparian owners involved. The project required many land acquisitions on private rights of way, as well as public infrastructure, which were mainly roads that had to be reduced in favor of waterways.

Links to river basin management planning: As mentioned above, this urban restoration

scheme is linked to the SDAGE Rhône Mediterranean, which implements the WFD.

Before and after photos

Before restoration (photos)

Site at Oullins before restoration in May 2014 (Source: SAGYRC).

After restoration (photos)

Site at Oullins after restoration in July 2015 (source: SAGYRC)

Contacts
Stéphane Guérin, river manager (responsible for the SAGYRC institution)

References and further information
Publications: • Cottet M., Augendre M., Bozonnet M., Brault V., Magnet D., Marchand J., Roux-Michollet D., Trémélo M.-L., Tronchère H., Vaudor L., 2014, « Traquer le regard : vers une caractérisation des bénéfices sociaux induits par les travaux de restauration écologique en territoire urbain », ZABR, Agence de l'eau, action 37, rapport final, 77 p. • Flaminio S., Cottet M., Le Lay Y., n.d. A la recherche de l'Yzeron perdu : quelle place pour le paysage dans la restauration des rivières urbaines?
Websites: http://www.riviere-yzeron.fr/

Guadiana River – Mérida, Spain

Name of initiative
Restoration of the Guadiana River in Mérida

General characterisation (short description of area / site)
Mérida is a city of 58,985 inhabitants (2014) and the capital of the region of Extremadura, in western Spain, bordering Portugal. Founded by the Romans, the city has a strong historical heritage as an important Roman city -*Augusta Emerita*-, capital of the Roman province of *Lusitania.* The Guadiana river, one of the main rivers in the Iberian Peninsula, runs through the city. The river has a length of 744km, crossing Spanish and Portuguese territory as it flows into the Atlantic.
Location (city, town, neighbourhood): Mérida, Extremadura, Spain
River/lake concerned: Guadiana River
(Other) Main rivers and lakes of this city: Guadiana river, Montijo lake (a reservoir in Guadiana river created by Montijo dam), *Proserpina* and *Cornalbo* lakes (reservoirs created by the Roman-origin *Proserpina* and *Cornalbo* dams), Albarregas stream (a small tributary to Guadiana in which an urban restoration Project has also been developed).
Setting [Main urban area; Peri-urban area]: The most important interventions are conducted in the urban area, but the project as a whole also addresses two peri-urban areas, upstream and downstream of the city of Mérida.
Background (key water management issues, sources of degradation and challenges)
The Project "Banks regeneration and protection against floods from the Guadiana River between the River Matachel and Montijo Dam" was developed on suburban sections upstream and downstream of Mérida, as well as on the urban section. The total length of the action is about 20 km, of which 2.4 km correspond to the urban section. The overall area was suffering a progressive environmental degradation caused by invasion of the river margins by the adjacent landowners, uncontrolled excavations for the extraction of gravel and sand, dumping of debris and rubbish and degradation of the natural vegetation. While the urban section of the river suffered from these problems to some extent, further issues were also prevalent. One of them was the presence of some parts of the city very close to the river, which called for their protection against floods. Furthermore, the Montijo dam (a dam constructed for irrigation purposes and located downstream of the city) caused frequent oscillations of the river's water level, subsequently resulting in dramatic visual impacts on the urban landscape. This became an issue because Mérida is a historic city with an important archaeological and monumental heritage (declared a UNESCO World Heritage site in 1993). Some elements of this heritage are closely related to the river, as the monumental Roman

bridge, the longest (ca. 800 m) Roman bridge that still stands today.

In the late 1980s the "Confederación Hidrográfica del Guadiana" (Spanish Water Authority in the Guadiana River basin area, a part of the Ministry of the Environment) decided to act in the area to solve, or at least reduce, the problems described above.

Main trigger for action: Apart from the aforementioned problems, no specific events are considered to have triggered the intervention.

Objectives and description of the initiative

Type of measures implemented: The urban section of the river in Merida concentrated the greatest effort of the project. The actions in this area can be summarized as follows:

- Digging in the bottom of the river of two large canals (about 60 m wide each) to increase the hydraulic section, to a hydraulic capacity of 4,000 m^3/s, corresponding to the flooding with a return period of 100 years

- Construction of a weir (small dam) at the downstream limit of the urban section to enable a stable water level in this section, and reduce the effects of the Montijo Dam

- Several actions to increase the flood protection of some quarters of the city close to the river

- Creation of a large urban park on the left bank, called "Parque de las Siete Sillas" around the unique monument of that name and whose construction was also performed as part of this initiative

- Action on the big island existing on the right bank, raising its level, reforesting it, improving the access to it and establishing sports facilities there

- Creation of linear parks on the right bank in the areas of "Alcazaba" (close to a castle from the Islamic period) and "Paseo de Roma"

- Creation of another large urban park on the right bank, the Park "Pancaliente" around the old mill that gives it its name, ("Molino de Pancaliente") and whose restoration has also been undertaken as part of the initiative

- Installation of lightning systems on the Roman bridge, one artistic and one for the pedestrians

Key objectives: In the urban areas the project aimed to properly integrate the riverbanks with the city, paying special attention to the aesthetic and archaeological aspects and taking advantage of them to provide the citizens with new green zones (parks) which in turn are compatible with occasional flooding and prevent the improper use of the areas adjacent to the river.

City strategy, scheme or project to which this activity is linked: On the one hand, the Project was linked to the Urban Plan of Mérida. On the other hand, the "Confederación Hidrográfica del Guadiana" has a policy to enhance flood prevention, environmental improvement and urban integration in the urban (and suburban) sections of rivers. The main projects developed within this strategy include measures on the Guadiana River in Mérida,

the Albarregas Stream in Mérida, the Guadiana River in Badajoz, and the Rivillas and Calamón Streams in Badajoz, all of them developed between 2000 and 2015.
Links to WFD, Floods Directive or other policy/planning process: This Project was included in the "Plan Hidrológico de la Cuenca del Guadiana" (Hydrological Plan of the Guadiana River basin area) of year 2000, which was developed with the principles of the European Water Framework Directive in mind, although the plan precedes the directive.
Start-date/end-date: 1999 – 2003
Status: Finished
Lead organisation(s): Confederación Hidrográfica del Guadiana (as a part of Spanish Ministry of the Environment)
Key actors involved: Confederación Hidrográfica del Guadiana and Ministry of the Environment, Junta de Extremadura (Regional Government of Extremadura), Ayuntamiento de Mérida (Merida Council), Consorcio de Mérida (the organization which manages the monumental and archeological heritage in Mérida) and some NGO´s, like vicinal, sport and ecologist associations.

Achievements and negative effects
Main results and benefits of the measures (ecological, social and economic): Given that the measures were undertaken more than ten years ago, a proper appraisal of results can be conducted for the medium-term. In general, the measures are considered very successful on the basis of the following results: • **Urban flood protection**: no serious damage to the city has been registered after the works, even in the important flooding episodes of March 2013, when the discharge rate of the river in Mérida was monitored at 3,000 m^3/s. • **Environmental improvement**: in terms of vegetation the state of the environment underwent a very notorious improvement. Most of the trees and bushes planted as part of the initiative have grown adequately together with new natural vegetation. • **Urban integration**: potentially the most important target of the project, which has been achieved to a high degree. Currently, most of the urban river banks have become parks or riverside promenades, allowing an adequate transition between the city and the river and embellishing the environment surrounding the existing monuments. • **Social aspects**: the measures were very well accepted by the citizens. Both the urban and suburban areas are widely used for sports and recreation (e.g., walking, trekking, cycling, fishing and kayaking).
Negative side-effects identified: The increased access to the river and transit of visitors has also resulted in some degradation of the restored areas, calling for proper maintenance action. In the urban areas this has been undertaken by the City Council, and in the suburbs it is the

"Confederación Hidrográfica del Guadiana" who is in charge of this. No further negative effects have been detected.

Lessons learned (constraints and positive aspects)

- **Governance and multi-actor cooperation:** Multi-actor cooperation among governmental organizations (State, Region, City) has been absolutely fundamental in this project due to the great number of aspects concerned. This approach has been replicated in similar projects.
- **Public involvement:** Has also been key to obtain good social results of the action, but often difficult as there are many groups and organizations involved.
- **Welfare benefits and improvements in quality of life for the public:** Flood protection benefits are clear, while granting people access to new recreational areas is also considered an important outcome of the project.
- **Funding:** Total investment was about 25 million Euros, and the Project was co-financed by European Cohesion Funds.
- **Links to spatial and urban planning:** The Project fit perfectly with the Urban Plan of the city and the relevant water policies (see above). Ensuring this fit was a conscious aim during the design of the measures. Summarizing and simplifying, the key issue that allowed this was that the Urban Plan´s spatial planning scheme considered the river banks and some adjacent zones as "green areas" that were to be transformed into parks in the future.
- **Availability of land to fulfil the measure:** One of the goals of the project was to increase the public domain areas on the riverbanks. Obtaining new areas close to the river to develop this action was necessary, and this was achieved by the means of expropriation (according to the Spanish Laws). However, no domestic dwellings were affected.
- **Links to river basin management planning:** This project was in the "Plan Hidrológico de la Cuenca del Guadiana" (see above).

Before and after photos

Images of the Guadiana River at Mérida before the restoration measures. Source: Confederación Hidrográfica del Guadiana.

Images of the Guadiana River at Mérida after the restoration measures. Source: Confederación Hidrográfica del Guadiana.

Contacts

María del Carmen Molina Moya

Nicolás Cifuentes y de la Cerra, Guadiana River Basin Authority

Fernando Aranda Gutiérrez, Guadiana River Basin Authority

References and further information

Publications:

ACTUACIONES HIDRÁULICAS, URBANÍSTICAS Y AMBIENTALES EN LOS RÍOS GUADIANA Y ALBARREGAS A SU PASO POR MÉRIDA. Revista de Obras Públicas, nº 3.461, diciembre 2005, pp. 155 a 158. ISSN: 0034-8619

INTEGRACIÓN URBANA DEL RÍO GUADIANA EN MÉRIDA Y BADAJOZ, USOS RECREATIVOS DEL RÍO. Cauce 2000, nº 143, 2008, pp. 56 a 63. ISSN: 0212-761X

Websites: Not currently. "Confederación Hidrográfica del Guadiana" has a website "http://www.chguadiana.es/" about general issues related to the Guadiana River.

News stories: Frequent news in local press (diario HOY Extremadura) during construction.

Conference presentations:

V JORNADAS SOBRE ENCAUZAMIENTOS FLUVIALES. Centro de Estudios Hidrográficos-CEDEX, Madrid, del 20 al 24 de noviembre de 2000.

JORNADAS TÉCNICAS SOBRE HIDRÁULICA FLUVIAL. Centro de Estudios Hidrográficos-CEDEX, Madrid, del 3 al 7 de marzo de 2008.

CONGRESO SOBRE GESTIÓN Y RESTAURACIÓN DE RÍOS Confederación Hidrográfica del Guadiana, Mérida, del 8 al 10 de abril de 2008.

River Isar – Munich, Germany

Name of initiative
Urban river restoration on the River Isar, city of Munich

General characterisation (short description of area / site)
The Isar is a transnational river crossing parts of Austria and Germany. The source of this 270 km long watercourse is located in the Alps of Tyrol, and its confluence into the Danube takes place at the German town of Deggendorf. Within the scope of the Isar-Plan, an integrated landscape design initiative by the State of Bavaria and the City of Munich, an 8km stretch of the river that cuts across the city of Munich has been renaturated. This renaturated section runs from the southern city border, at the Großhesseloher Bridge, to the inner city at the Deutsches Museum (Museuminsel) (Wulf and Schaufuß, 2013; Arzet and Joven, n.d.).
Location (city, town, neighbourhood): Munich
River/lake concerned: river Isar
Setting [Main urban area; Peri-urban area]: Main urban area

Background (key water management issues, sources of degradation and challenges)
Hydraulic regulation measures introduced in the 19th century resulted in a gradual degradation of the river's ecology, flow conditions and water quality. Furthermore, these modifications increased the risk of flooding and damage to properties located at lower altitudes, as well as limiting the public access to the river (Arzet and Joven, n.d.; RESTORE, 2013).
Main trigger for action: Heavy rain events in the Alps in the years of 1999, 2005 and 2013 led to major floods and substantial financial damage in the South of Germany. In the late 1980s, a survey (1D state of the art discharge flow measurement at the time) of the flood prevention measures that were in place back then showed that the measures were not up to the challenges ahead.

Objectives and description of the initiative
Type of measures implemented: In response to the issues described above, the Isar-Plan was launched in 1995 as an initiative that integrated the goals of flood-protection, ecological restoration, and recreational use (Arzet and Joven, n.d.; Reiss-Schmidt, 2014). The measures

implemented included inter alia the renaturation of river banks, the enhancement of accessibility and improving the flood defences by bringing the dykes to the latest state of the technology (reinforcing the core of the existing dyke, as well as improving surface sealing).

Key objectives:

The main aims of the Isar-Plan were:

- Improvement of flood control by increasing the water discharge capacity of the river stretch in Munich;
- Improvement of the habitats for wild species, considering issues related to: ecological upgrading of the river Isar, morphological processes, longitudinal and lateral continuity, natural habitats for animals and plants, biodiversity and water quality.
- Improvement of recreational quality due to the growing need for recreational space within a dense urban area, i.e. access to waterline, attractive landscape and views.

City strategy, scheme or project to which this initiative is linked: No, the Isar-Plan is not part of a broader strategy of the city of Munich for integrated water management.

Links to WFD, Floods Directive or other policy/planning process: The Isar-Plan preceded the adoption of the EU WFD and Floods Directive.

Start-date/end-date: The Isar-Plan started in 1995. Restoration work began in February 2000 and was finished in 2011.

Status: Finished. Construction work was completed in 2011. Maintenance work according to the law and monitoring of the ecological impact are still ongoing.

Lead organisation(s): State of Bavaria, City of Munich.

Key actors involved: State of Bavaria represented by the Regional Office for Water Management and the City of Munich represented by the building division of the municipal administration.

Achievements and negative effects

Main results and benefits of the measures (ecological, social and economic):

The results of the project have been dramatic, particularly considering its urban location: the risk of flooding has been reduced, the local ecology enhanced, water quality improved and public access to the area improved (RESTORE, 2013).

In detail, main benefits of the project include (http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=4901):

- **Flood protection**. The big flood of 2005 had a major impact in the whole catchment area of the Isar river. The restoration measures in Munich had a

significant effect on the extent of the damages caused by the flood, as, compared to other parts in the South of Germany, the flooding did not cause substantial damages in the city.

- **(Bathing) Water quality.** The Isar-Plan also contributed to the improvement of water quality in the Isar River in order to achieve bathing water quality. The degree of effort that went into achieving bathing-water quality for the Isar was unmatched in Europe. All communities situated on the river have completed the process of upgrading their waste-water treatment plants to include UV germicidal irradiation systems. These measures have considerably improved the quality of water and today swimming in the Isar is possible.
- **Water and land habitats**. The widening of the riverbed not only led to an improved flow of flood water, but also created room for development and design measures on the banks. The Isar River now has more room to move and reshape itself along this entire stretch.
- **Recreational quality**. The recreational quality has greatly improved, the restored Isar is, especially in summer, one of the favorite places for the citizens of Munich. The restored Isar is used as a public location for swimming and the adjacent land to the river as a public park during the summer season.

Negative side-effects: With the increasing number of people visiting the river, especially during the summer, waste management along the banks has become an increasing issue for the municipal authorities as well as smoke emission due to the massive amount of grills and bonfires that are lit in the area.

Lessons Learned (constraints and positive aspects)

According to Reiss-Schmidt (2014) and the RESTORE partnership (2013), the following lessons were learned from the initiative:

- Integrating flood protection measures with an attractive landscape design can allow for reductions in flood risk without reducing the appeal of the urban areas for citizens and visitors
- Planning and execution of measures in urban river restoration should not follow a top-down approach; public consultation increased the acceptability of the overall project
- On one hand, river banks in an urban setting are highly attractive for leisure activities; on the other, this presents a risk of privatization, over-development and overexploitation of these public areas
- Custom approaches and solutions are necessary to take into account the complex functions of the Isar in the urban setting

Regarding more specific aspects:

Governance and multi-actor cooperation: In 1995, an interdisciplinary working group "Isar-Plan" was initiated. Members were the State Office of Water Management Munich and the City of Munich (Department of Public Construction, Department of Urban Planning and

Building Regulation and Department of Health and Environment). The working group examined the flood-water situation, the need for recreational areas at the riverside, the area's flora and fauna and their habitat. Based on their findings, the development goals were defined. The City Council and the District Councils were involved during the progress of the project as well as the "Isar-Allianz" (an alliance of NGOs). Public participation was ensured through an internet platform, info-brochures, excursions, workshops, TV and press, round tables, info-points, and a service telephone.

The level of cooperation achieved between all stakeholders involved within the Isar-Plan was excellent and one key success factor for the project. (http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=4901)

Public involvement: From the start of the Isar-Plan in 1995 the public was asked to accompany the planning process. People were interviewed about the new river and their preferences. The results of these interviews formed the guidelines for the planning process, which included: (http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=4901)

• to ensure flood control
• to bring back the alpine character of the Isar into the city
• to enlarge the gravel banks along the river (especially wanted by the younger citizens)
• to keep the flood meadows (especially wanted by the older citizens)
• to keep the trees and the nature vegetation

Welfare benefits and improvements in quality of life for the public: Munich is now a city with an 8km bathing beach.

Funding: 55% of the funds were provided by the state of Bavaria and the remaining 45% was provided by the City of Munich.

Availability of land to fulfil the measure: In urban areas, where available space is limited, river restoration projects are frequently restricted. In Munich, the flood corridor offered some space and thus could be integrated in the restoration project (Binder, n.d.)

Before and after photos

Isar River before (left) and after (right) restoration. Source: Wasserwirtschaftsamt München.

Contacts

Project leader for the Isar-Plan: Stephan Kirner, Wasserwirtschaftsamt München

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- City of Munich DUPBR (2005) Shaping the future of Munich. PERSPECTIVE MUNICH – Strategies, Principles, Projects. Development Report 2005. Department of Urban Planning and Building Regulation.
- RESTORE (2013) Isar River, Munich. Case study in: Rivers by Design. Rethinking develop-ment and river restoration. A guide for planners, developers, architects and landscape archi-tects on maximising the benefits of river restoration.
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Websites:

http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=4901

http://www.wwa-m.bayern.de/fluesse_seen/massnahmen/isarplan/index.htm

River Waal – Nijmegen, The Netherlands

Name of initiative
Room for the River Waal, city of Nijmegen

General characterisation (short description of area / site)
Nijmegen is the oldest city in the Netherlands (celebrated 2000 years of existence in 2005) and the largest town in the province of Gelderland with an urban population of 168.840 inhabitants. The city sits on the River Waal at one of the narrowest river bends in the country. The Waal is the main tributary of the Rhine which flows through the Netherlands. It is also Europe's busiest river, and Nijmegen is Europe's largest inland port (Citiscope, 2015).
Location (city, town, neighbourhood): City of Nijmegen, eastern Netherlands
River/lake concerned: River Waal
Setting [Main urban area; Peri-urban area]: main urban area

Background (key water management issues, sources of degradation and challenges)
One of the narrowest bends in the Dutch river system is situated in the River Waal (a branch of the Rhine) at Nijmegen. On the south bank, opposite Nijmegen, is the village of Lent. There the width of the river is just 450 m while in other upstream stretches the river is 1,000 m wide. This creates a bottleneck which results in large volumes of water having to force their way through the narrow passage at periods of high water. The restriction at this bottleneck is so great that failure to take measures to manage the predicted increases in discharge resulting from climate change will cause a serious threat to safety (FRC, 2015) at a location with high population density.
Main trigger for action: Addressing the risk of flooding from the River Waal, particularly following flooding events in 1993 and 1995 (NWRM, n.d.).

Objectives and description of the initiative
Type of measures implemented: Two measures are being undertaken that will increase flood protection for the village (some 350 m inland). The dyke that prevents flooding from the River Waal is being moved back from the riverbank and a second river channel will be dug in the resulting new area of floodplain. This will create an artificial island in the Waal. The new channel is intended to always be filled with water, and will flow along with the River Waal in extreme weather conditions. The design capacity is such that the water level at that section of the River Waal will be 35 cm lower during flooding events than without the

measure. Together with this increase in flood protection, the intervention is expected to bring beneficial circumstances downstream without adversely impacting upstream water capacity. The flood protection measures are incorporated with urban development measures that will provide aesthetic and recreational benefits, together with an enhancement of the spatial quality in the area (NWRM, n.d.).
Key objectives: Flood control and flood risk mitigation in combination with urban development.
City strategy, scheme or project to which this initiative is linked: "Room for the River" programme of the national government (UNESCO IHE, 2013).
Links to WFD, Floods Directive or other policy/planning process: The new project area connects two bird and habitat area's Gelderse Poort and Uiterwaarden (Floodplains) Waal. No water quality improvements are foreseen. Hydraulic connection between the river and part of its floodplain is being restored by moving the dyke backwards by 350m, and developing a new channel within the floodplain that will always contain water and will provide additional flood capacity. On the island there will be a new development area for nature. No ecological valuable area was lost or altered during the intervention. (NWRM, n.d.).
Start-date/end-date: 2013- 2016
Status: Ongoing
Lead organisation(s): Gemeente Nijmegen
Key actors involved: Rijkswaterstaat, Ministerie van Infrastructuur en Milieu, Staatsbosbeheer

Achievements and negative effects
Main results and benefits of the measures (ecological, social and economic): The expected benefits of the measures include flood risk reduction in the lower Waal (lowering of the water level by max 34 cm in case of extreme high water level in the Waal (like the situation in 1993 and 1995), the creation of a new permanent aquatic habitat and urban development with a strong blue-green connection.
Negative side-effects identified: The relocation of the dike at Nijmegen is one of the most controversial measures in the Room for the River Programme, because the northern bank of the River Waal at Nijmegen has already been developed. The relocation of the dike will result in the demolition of fifty houses and the destruction of several business premises within the village of Lent. Because of this, the announcement of the river widening plans resulted in strong protests (FRC, 2015). Rural area in the space between the current dike and the town of Lent will be affected as the channel will be dug here and the area will be completely reformed, leaving no room for previous uses (NWRM, n.d.).

Lessons Learned (constraints and positive aspects)

Governance and multi-actor cooperation, public participation: The main challenge was to combine national (top-down) frameworks such as on water safety and nature development bound by strict directives regarding planning, budget and scope with regional and local (bottom-up) interests. Joint responsibility for sustainable river management was to be promoted in such a way that many interests are met and support increased but sacrifices regarding time and budget should be kept to the minimum. Initially, many of the regional partners and stakeholders were extremely critical of and opposed to the national Room for the River plans. At Nijmegen, for example, the proposal to move the dike into Lent provoked wide spread public opposition and demonstrations. The key to creating win-win solutions was to align the national goals and those of the regional stakeholder groups.

The main lessons learned from the public involvement process organized was that:

- It is important to plan **with** the public **not for** the public
- Involve inhabitants as early as possible and be clear about the influence they have;
- Organize a professional information campaign focusing on the benefits of the program (place making), as early as possible.
- Continue during realization phase

Welfare benefits and improvements in quality of life for the public: The new area created on the river Waal as a result of the interventions is a new public space (more than 200 acres) in the heart of the city, where people of Nijmegen and Lent can enjoy the presence of the water on a daily basis, do their running tour, experience the plains.

Links to spatial and urban planning: The main factor that influenced the choice for this intervention was the possibility to combine it in to a larger city redevelopment project. The creation of a district on the other shore of the Waal, together with a revitalization of the shore at the old city center made the creation of a river park possible. (NWRM, n.d.). The project has created a catalyst for an integral development of the area. The excavation will create an island between the Waal and the channel, and the plan is to build three new bridges to link to the 'mainland'. A unique new river park with space for nature and recreational activities will be developed, blended into a new residential neighborhood on the new island and on the north shore.

Before and after photos

Source: @Johan Roerink.

Source: @Municipality of Nijmegen

Contacts
Yvette Pas, Municipality of Nijmegen

References and further information
Publications: • NWRM (Natural Water Retention Measures) (n.d.) Case Study Room for the Waal. • UNESCO IHE (2013) Tailor made collaboration. A clever combination of process and content.
Websites: • Citiscope (2015) A Dutch city makes room for its river - and a new identity. http://citiscope.org/story/2015/dutch-city-makes-room-its-river-and-new-identity#sthash.B0bnllGL.dpuf. Last visited on 06.04.2016. • FRC (Flood Resilient City) (2015) The Room for the River Project at Nijmegen.

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Streams & rivers – Oslo, Norway

Name of initiative
Water in the City - the Oslo strategy for de-culverting its streams and rivers

General characterisation (short description of area / site)
Several streams pass through the city of Oslo, capital of Norway, towards the Oslo Fjord. Most of these streams were culverted since the 19th century. This factsheet reflects upon the de-culverting strategy adopted for streams in the City of Oslo.
Location (city, town, neighbourhood): Municipality Oslo
River/lake concerned: The de-culverting strategy for the City of Oslo, Water in the City, covers all the streams and rivers originating in the surrounding forests and eventually cross through the city down to the Oslo Fjord. Focus is placed on the major ones, but the strategy also covers the smaller tributaries.
(Other) Main rivers and lakes of this city: Akerselva River, Alna River
Setting [Main urban area; Peri-urban area]: Forest, Peri-urban area, Main urban area;

Background (key water management issues, sources of degradation and challenges)
The key water management issue dealt with in this case from Oslo is the negative consequences caused by culverted streams passing through the city towards the Oslo Fjord. The culverts were used from 1860 and onwards up to about year 2000 as the City of Oslo expanded geographically. The city is still expanding, yet lately mainly through densification. The streams emanating from the surrounding forest areas became culverted for large stretches in order to reduce water pollution as they entered into urbanized areas. Other purposes were to get the water flows under control, to increase the area of dry land, make it easier to build roads and housing projects, and due to fear that small children might fall and drown in the streams.

Main trigger for action: The politic determination to de-culvert the streams emerged as the public and political awareness of the value of natural streams in the cityscape for recreational value and for securing ecological values arose. More recently, their value in retaining and cleaning storm urban surface water increased related to climate adaptation and environmental awareness has reinforced the public and political awareness. It now forms an integral part of the Oslo City Urban Stormwater Strategy. Also, the increasing insight of the value of exploiting running waters for enhancing attractiveness of green areas with their blue landscape elements is another important driver. Finally, the EU Water Framework Directive and its strong perspective on restoring ecological aquatic status have furthermore added to the political will to allocate resources to a de-culverting program.

Objectives and description of the initiative

Type of measures implemented: The initiative is a strategy for de-culverting the streams of Oslo. It forms part of a more comprehensive strategy for urban storm water management and works as an inter-agency program coordinated by the Agency for Water and Sewerage Works, but with involvement of three other city agencies.

Key objectives: The Strategy for Urban Storm Water Management, in which the strategy for de-culverting streams is included, is designed to:

- Meet climate change challenges and minimize damage and inconvenience to people, buildings, property and infrastructure
- Protect the environment and ensure good ecological and chemical status in water bodies
- Use storm water as a resource in cityscapes

City strategy, scheme or project to which this initiative is linked: The initiative is linked to two major strategic city policy programs beyond the overarching Strategy for Urban Stormwater Management. These are -

- The City Ecological Program approved by the City Council in 2009, and
- the new Municipal Master Plan 2015 - Oslo 2030 “Smart - safe and green” adopted in 2015.

Links to WFD, Floods Directive or other policy/planning process: For the major streams in particular, defined as water bodies sensu WFD, the strategy is considered as a solid city contribution to ensure good ecological and chemical status in riverine water bodies. The strategy is included as a measure in the WFD program of measure for the water area Oslo.

Start-date/end-date: November 2013 - ongoing

Status: Ongoing.
Lead organisation(s): The Agency for Water and Sewerage Works, Oslo Municipality
Key actors involved: Several other agencies within the City of Oslo

Achievements and negative effects
Main results and benefits of the measures (ecological, social and economic): The de-culverting strategy has gradually led to formerly culverted parts of rivers and streams in Oslo being re-opened with several positive benefits. The primary justification and most obvious benefit has been the regained value of natural streams in retaining urban storm water. Further, the de-culverted streams have had some positive effect upon the cleaning of pollutants in the urban storm water and for the larger ones defined as water bodies sensu the EU Water Framework Directive this has led to improved water quality. When the de-culverting projects took place in public open spaces (often park like), substantial additional financial resources have in some cases been provided that allowed for developing landscape architectural blue green solutions with high aesthetical and functional value, sometimes associated with other multi-functional facilities. As an example, the Bjerkedalen Valley section of the Hovinbekken stream was awarded in 2015 the City of Oslo Architectural Prize for its high aesthetical and functional values. In the stream segment of Hovinbekken stream where the Bjerkedalen Valley is located, you can now find trout swimming.
Negative side-effects identified: None so far. Still in some de-culverted streams where small ponds/lakes have been created there have been unrealistic expectations when it concerns the water quality and its suitability for bathing. Due to relatively high concentrations of bacteria they are not fit for bathing, which of course might be difficult to appreciate by some.

Lessons Learned (constraints and positive aspects)

One important lesson learnt from the development and implementation of the Oslo City strategy for de-culverting its streams and rivers is that **multi-functionality** is very important to consider. Several ecosystem services have been considered and justified the de-culverting efforts throughout the last decades, as mentioned before. Improved urban stormwater handling justified by a combination of more intensive rainfalls and urban densification has become a key driver lately. Yet, there are several other services that require due attention in the implementation of such a strategy. One reason why this is important is to ensure a good and operational inter-agency cooperation within the city administration. The other agencies may have complementary justifications as to why they engage in such a strategy. For instance, the Urban Environment Agency is responsible for the implementation of the EU Water Framework Directive (WFD) and thus seeks synergy with WFD objectives in their engagement in the implementation of the strategy. Likewise, the Agency for Planning and Buildings, seek to maximise the usefulness and attractiveness of the green areas in which the de-culverted streams pass through.

Another important lesson learnt is to **engage the local communities** surrounding the stretches being de-culverted. This requires a proper stakeholder analysis prior to the start of the work and their subsequent engagement. Also, if different agencies are involved in public outreach, it is important to have a common position and information material so that the city speaks with one voice. To allow for bottom up ideas from stakeholders and the public is generally a good thing, as "one size fits all" solutions do not work everywhere. Also to give the public and stakeholders realistic expectations of what can be done is a good approach. Clearly, the de-culverting projects including complementary non-water related components may add substantial welfare benefits and improvements in quality of life to local residents with good participation and local participation. Conversely, they may result in conflict-ridden projects if not well received and without good participatory processes.

Before and after photos

The ten rivers of Oslo. Source: http://www.osloelveforum.org/. Copyright Oslo Elveforum. Reproduced with permission. Legend: Hovedløp = Main river/stream; Sidebekker = Tributaries; Åpen = Open; Lukket = Closed.

Bjerkedalen Valley of the Hovinbekken stream (photos: Tharan Fergus)

Contacts
Tharan Fergus, Program Developer 'Water in the city', Oslo municipality, Water and sewage works

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News stories: Dagsavisen 29/5 2015: Graver fram byelver til nytte og glede http://www.dagsavisen.no/oslo/graver-fram-byelver-til-nytte-og-glede-1.361480 Dagbladet 28/5 2015: Åpning av elver skal hindre flom i Oslo http://www.dagbladet.no/2015/05/28/nyheter/global_oppvarming/ver/klimaendringer/39387867/

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Kjetil Lønborg Jensen. Oslo Urban Environment Agency. 2013. Hovinbekken - fra Marka til fjorden www.vannforeningen.no/ikbViewer/Content/887738/10%20Jensen.pdf Presentation given at seminar: Restauration of streams, 19.11.2013

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https://portal.tekna.no/ikbViewer/Content/924638/3%20Fergus.pdf *Kan også henvise til artikkel i vann 3/2015*

River Emscher – Ruhrgebiet, Germany

Name of initiative
Emscher River re-conversion

General characterisation (short description of area / site)
The catchment of the Emscher River lies within Germany's most populated federal state, North-Rhine Westfalia. The population of the area is estimated at 2.2 M inhabitants. The catchment is also part of the so-called "Ruhrgebiet", a region that ranks amongst the most densely populated in Europe with 2775 inhab./km^2 (Gerner et al., 2016). The Emscher basin has temperate seasonal climate with maritime influence. In terms of the local economy, the area has transitioned from heavily industrial activity towards the services sector. Agricultural activity is very limited. Transport infrastructure in the area is well developed, with a shipping channel and a network of highways and roads. Approximately 50% of the area accounts to urban settlements, industrial areas, transport infrastructure and other artificial land cover, while agricultural use and natural areas amount to ca. 18% and 22% of the area, respectively (Gerner et al., 2016; Emschergenossenschaft 2009).
Location (city, town, neighbourhood): Different cities and towns in the Ruhr Area; including Duisburg, Essen, Bochum, Gelsenkirchen and Dortmund
River/lake concerned: main stream of the river Emscher
(Other) Main rivers and lakes of this city: tributaries of the Emscher (e.g. Läppkes Mühlenbach, Boye, Berne, Hüller Bach, Schwarzbach, Deininghauser Bach are large tributaries, Herrentheyer Bach and Dorneburger Mühlenbach small ones)
Setting [Main urban area; Peri-urban area]: Urban and Peri-urban areas; a polycentric metropolitan agglomeration.

Background (key water management issues, sources of degradation and challenges)
After year 1860 industrialization kicked off a transition of the Emscher region into an industrial conurbation with a rapidly growing population. This caused an intensification of effluent discharge into the river from urban and industrial settlements. This increase in development and pollution, combined with the regular flooding of the river's floodplains, resulted in frequent damages to infrastructure built close to the river as it also triggered disease and epidemics. As mining activities intensified in the area, soil subsidence made it unfeasible to use underground channels to transport the wastewater (Gerner et al., 2016). As a result, the Emscher was straightened and channelized, and together with its tributaries it became a system of open wastewater channels. Presently, the Emscher and most of the creeks in its catchment are considered heavily modified water bodies according to the Water

Framework Directive specifications (IWW Water Centre, 2014).

Main trigger for action: Decline of the mining industry and the conviction of the responsible authorities (Emschergenossenschaft/Lippeverband) to re-convert the river and its tributaries into natural waterways.

Objectives and description of the initiative

Type of measures implemented: The initiative is highly ambitious, with 264 km of sewers constructed so far and 400 km more to be completed by 2017. Similarly, 91 combined sewer overflow (CSO) structures have been built in the area until now and 290 more are planned until 2017. Towards 2020 the Emscher reconversion project aims at the ecological revitalization of 350 km of water courses in an area of 865 km² (IWW Water Centre, 2014).

Key objectives: The reconversion of the Emscher aims to enhance water resource management and river ecology, reconnecting the river system and its region, improving the open spaces along the river and opening paths that link urban and natural spaces in the area.

This is being done through:

- The creation of a sewer network including Combined Sewer Overflows to make the Emscher a wastewater-free river
- The conversion of the Emscher into a collector for pretreated runoff and rainwater
- The enhancement of the ecological connectivity of the river
- The provision of new spaces for recreation and enhanced urban dwelling, increasing the quality of life in the area

City strategy, scheme or project to which the initiative is linked: The restoration and renaturation measures are part of a regional strategy called the "Emscher Future" Master Plan. This plan has 8 general principles: standards for flood prevention, ecological development of the aquatic system, connection with the environment, clear and corporate design of constructions and the development of open spaces, quality of life enhancement, profit from economic potential, incorporating history of the region.

Start-date/end-date: 1989-2020

Status: Ongoing until 2020. Some stages already completed.

Lead organisation(s): Emschergenossenschaft/Lippeverband.

Key actors involved: Led by the regional water board "Emschergenossenschaft/Lippeverband", the Emscher Future Master Plan has been developed in continuous dialogue with neighbouring cities and districts, citizens, with industry and business, the relevant government authorities and many other organisations and institutions (www.eglv.de).

Achievements and negative effects

Main results and benefits of the measures (ecological, social and economic): The Emscher restoration project is reducing the sewage and rainwater loads reaching the combined sewer system serving the area. Measures like the flood retention basins constructed combine technical flood protection and groundwater management with ecological design. This has enhanced both urban development as well as the biodiversity of the area, connecting green and blue spaces and enhancing the quality of life of the inhabitants. The project has also caused a reduction in wastewater fees, which could be related to a wide range of measures implemented to increase the energy efficiency of wastewater treatment plants. With the recovery of a new post-industrial, ecologically developed river landscape, development possibilities are opened up for the improvement of the entire region, creating preconditions for new housing areas, working spaces, etc.

Negative side-effects identified: None reported.

Lessons learned (constraints and positive aspects)

Public involvement: The Emschergenossenschaft is involved in an international scientific cluster for water Competence. The exchange of opinions and ideas on water management does not take place behind closed doors. The water board has created an online water portal and a "Water transforming blog" to provide latest news on water management. The Emscher conversion with a total running time of 30 years is a blue print for other essential infrastructure modernisation. People are invited to participate in the process actively. In addition, the organisation is tied to a number of European Union promotion and research projects. Regarding regional cooperation, the Emschergenossenschaft has been implementing a comprehensive strategic Masterplan, the "Emscher-Future", in a collaborative process.

Welfare: The cooperation of the Emschergenossenschaft with the ministry of building, housing, urban development and traffic of the land North Rhine- Westphalia allows to align objectives and ensure benefits and improvements in the quality of life of the region's inhabitants.

Before and after photos

Before restoration

Source: @Emschergenossenchaft/Lippeverband

After restoration


Source: @Emschergenossenchaft/Lippeverband

Contacts

To be used for completing the case study (not for publishing)

Dr. Mario Sommerhäuser, Emschergenossenschaft/Lippeverband

Dr. Martina Oldengott, Emschergenossenschaft/Lippeverband

Maryna Humailo, Emschergenossenschaft/Lippeverband

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https://epub.wupperinst.org/frontdoor/index/index/docId/5070

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Lake Trekanten, Igelbäcken Stream – Stockholm, Sweden

Name of initiative
The Stockholm Water Programme for improved water quality and recreational value including the cases of the Lake Trekanten and the Igelbäcken Stream

General characterisation (short description of area / site)
Stockholm is blessed with much water, both freshwater lakes and brackish waters in the Baltic Sea. It builds much of its image upon a water profile and has the world renowned Stockholm International Water Institute, the World Water Week and the Headquarters of the Global Water Partnership based in the city. Thus, the City considers itself a world leader in water management and governance. 'The Venice of The North' is a term sometimes used about Stockholm. Ten per cent of the city's area is covered by water, and the many lakes are highly valued for recreational purposes. That is why the City Council adopted in 2006 an ambitious Water Protection Programme (2006 -2015) setting objectives for cleaner water and outlining methods to achieve this. This should be done in a way that preserves the recreational value of the lakes, and streams. Indeed progress has been made, both when it concerns water quality and increasing recreational value of many water bodies. The Water Programme was replaced in 2015 by an Action Plan for good water status. The Action Plan states how water management within the city has to develop to gain more focus on operational measures in order to reach the goals of the Water Framework Directive by latest 2027. To reach the ambitious targets, local programmes of measures have to be completed by latest 2018. Two cases, the Lake Trekanten (Triangle) and the stream Igelbäcken are highlighted in this factsheet to give concrete examples of restoration of water bodies in the urban area.
Location (city, town, neighbourhood): Stockholm City
River/lake concerned: Lake Trekanten and stream Igelbäcken.
(**Other) Main rivers and lakes of this city:** Lake Mälaren
Setting [Main urban area; Peri-urban area]: Combined peri-urban and urban areas, as well as some forested parts.

Background (key water management issues, sources of degradation and challenges)
As a capital city, Stockholm is confronted with many water related challenges related to high population density, much traffic, current and historic industry and other anthropogenic sources of pollutants. In addition, Stockholm city is growing with 140.000 new households

and 300.000 new inhabitants expected by year 2030.

The major sources of pressure for Stockholm's streams and lakes include contaminated stormwater from industrial land use, roads and urban land use, untreated wastewater from storm overflows and misconnections in the wastewater and stormwater system, "old sins" – mostly untreated urban wastewater, industrial wastewater and land use and morphological alterations due to exploitation in water and near the shoreline, culverts and other migration barriers.

The Lake Trekanten (Triangle) is a small but important recreational lake (13,5 ha) located in a very densely populated area close to Central Stockholm often suffering from eutrophication. The area closest to the lake is park like. Within its small catchment area (0,75 km2) there are residential areas, downtown area, light rail and two nationally important highways. The lake is extensively used for swimming and fishing by local residents. Fish restocking with rainbow trout is done regularly. Crayfishing is extensive. The main water environmental issues are excessive nutrient loads and heavy metals and hazardous substances. A large number of measures have been conducted. Several have been analytical in character, some have been of monitoring to support analysis while quite some have been of remedial character. Some prime examples are aluminium treatment of the sediments to keep phosphorous bound in sediments and treatment solution for stormwater emanating from the major highway.

As another contrasting example, the Igelbäcken stream is in a city context a relatively undisturbed stream and is considered one of the most ecologically valuable rivers and streams in the Stockholm area. It is an important part of the green wedge that connects the northern part of Järva outdoor field with the National City Park in the midst of densely populated sub-urban areas. Natural and recreational values are high because of good access to well-preserved cultural landscape and rich flora and fauna for a huge number of inhabitants in the Northwestern parts of Stockholm. The stream has a unique population of the (for Sweden) rare fish species stone loach, which has become an iconic indicator species of the stream and is widely used communicatively for stimulating restoration and other environmental measures. Stone loaches live amongst the gravel and stones of fast flowing water where they can search for food. The most distinctive feature of this small fish (that can become 14 cm long) is the presence of barbels around the bottom jaw, which they use to detect their prey. The body is a mixture of brown, green and yellow colours. Previously implanted signal crayfish is believed to impair the preconditions for stone loach. Other fish species encountered in Igelbäcken are trout, pike, perch, roach, tench and bream. Fishing is prohibited in the stream. Restoration efforts in River Igelbäcken have included re-meandering parts of its stretches and adding bottom substrates such as gravel and stone. The purpose of these measures was to increase the turbulence in the water and achieve better oxygenation. Trees and shrubs have been planted along the river to increase shadowing and lower water temperature during hot summer periods. In 2006, the City of Stockholm established the Igelbäcken Cultural Reserve. The nearby municipalities of Solna and Sundbyberg have formed reserves for their parts of Igelbäcken valley. Within the inter-municipal Igelbäck Group collaboration between municipalities, the County Administrative Board and several NGOs has been conducted over 15 years.

Main trigger for action: The trigger and initial driver for the Water Programme and the Action plan for good water status was the EU Water Framework Directive and its strong focus upon achieving good ecological and chemical status.

Objectives and description of the initiative
Type of measures implemented: The Stockholm Water Programme included a wide range of measures depending upon the environmental water challenge and the options available for measures. In the programme of measures (PoM) under the WFD, 52 measures were implemented, 27 were started, 7 were delayed or deregistered and 64 new complementary measures were proposed. The costs of these measures differed widely and the budget originally allocated for the measures in the 2006-2015 program was about 100.000.000 EUR. Within the new Action Plan for good water status, separate local programmes of measures (PoM) are planned for each waterbody. As an example, the PoM for the urban stream Bällstaån will be adopted by the city council during 2016. The costs of reaching good status regarding nutrients and some heavy metals has been calculated to 1.500.000 EUR annually. Early estimations have shown that the total cost of reaching good ecological status in all waterbodies will cost about 30.000.000 EUR annually. See above for brief information on the restoration of Lake Trekanten and stream Igelbäcken as exemplified in this factsheet.
Key objectives: The Stockholm Water Programme (2006 -2015) set objectives for cleaner water and outlined methods to achieve this. The Action Plan adopted in 2015 states how water management within the city has to develop to gain more focus on operational measures in order to reach the goals of the Water Framework Directive by latest 2027.
City strategy, scheme or project to which this initiative is linked: The Action Plan food good water status is factually *the* city strategy for integrated water management and the water backbone of the wider environmental program. The wider Environmental Program is currently under revision.
Links to WFD, Floods Directive or other policy/planning process: The Action Plan for good water status was initiated due to a political ambition to reinforce local efforts towards improved water quality, ecological and chemical, as demanded by the EU Water Framework Directive
Start-date/end-date: 2015-2027**.**
Status: Ongoing
Lead organisation(s): Stockholm Municipality

Achievements and negative effects
Main results and benefits of the measures (ecological, social and economic): Through the implementation of the wide array of measures in most water bodies within the Municipality of Stockholm during a 10 years period, the water quality in several of those has been

improved due to reduced pollution or through restauration efforts, while others have maintained the current status. At the same time the recreational value has been maintained or further developed, also by means of complimentary measures aimed to improve accessibility and services alongside the water bodies. Altogether, this has contributed to significantly maintain and strengthen Stockholm's reputation as a world leader capital city in water governance and management.

Negative side-effects identified: None

Lessons Learned (constraints and positive aspects)

The Stockholm City Water Programme and the Action Plan for good water status are best practice examples of what can be achieved if there is strong city political will to allocate funding for a major and long term water improvement program benefiting both aquatic ecosystems and the urban population in enjoying the water bodies and their ecosystems.

The trigger and initial driver for the Water Programme and the Action plan for good water status was the EU Water Framework Directive and its strong focus upon achieving good ecological and chemical status. The plans thus can be seen as the city's response to meet the objectives of the WFD.

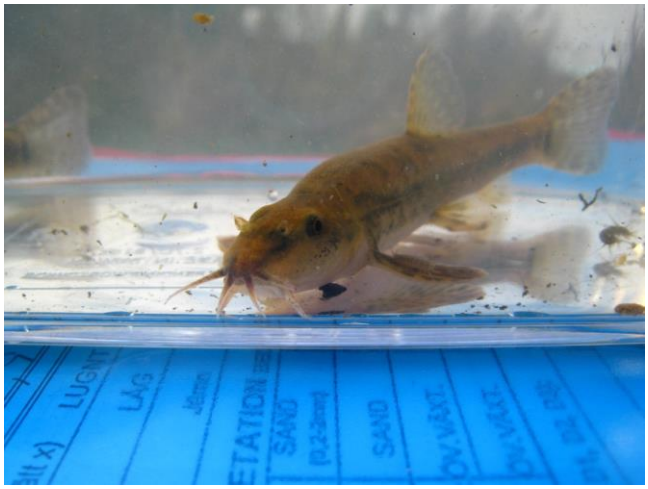
Governance-wise the Water Programme was led by the City administration but extensive co-operation with neighbouring municipalities such as for the Igelbäcken Stream and with the County Administrative Board was an important ingredient to respect the river basin principle. This will be done for the Action Plan for good water status as well. For several of the water bodies, including Lake Trekanten and Igelbäcken Stream, public involvement, often through NGOs such as environmental organisations, fishing clubs or others, formed important part of the activities.

Before and after photos

Lake Trekanten. Copyright: City of Stockholm.

Igelbäcken stream (restoration). Copyright: City of Stockholm.

Igelbäcken stream (stone loach). Copyright: City of Stockholm.



Contacts

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http://www.stockholm.se/OmStockholm/Stadens-klimat-och-miljoarbete/Vattenprogrammet/

Startsidan / Miljöbarometern / Vattenprogrammet

http://miljobarometern.stockholm.se/default.asp?mp=VP

Specific web sites on the two cases mentioned specifically

Trekanten:

http://www.miljobarometern.stockholm.se/sub.asp?mp=VP&mo=7&dm=2

Igelbäcken:

http://www.miljobarometern.stockholm.se/sub.asp?mp=VP&mo=10&dm=1"

Lake Ülemiste – Tallinn, Estonia

Name of initiative
Protection of Tallinn's drinking water resources: The case of Lake Ülemiste

General characterisation (short description of area / site)
Lake Ülemiste (975 ha) is a shallow eutrophic lake (mean depth 3,4 m), which has been the main reservoir of drinking water for Tallinn since the 14th century. The water level is controlled by a Water Treatment Plant. The catchment area of the lake has been enlarged from 70 km² to 1865 km² and it extracts water from three river systems by a complex interlinkage of reservoirs and canals (Panksep et al. 2009). Tallinn's surface water intake consists of Lake Ülemiste and the water intake systems that have been built on the Pirita, Jägala and Soodla rivers in order to direct water into Lake Ülemiste. Over 90% of the inhabitants of Tallinn are supplied with drinking water by the Ülemiste water treatment plant, while the rest are supplied from bore wells. (Tallin Environmental Strategy to 2030)
Location (city, town, neighbourhood): Tallinn
River/lake concerned: Lake Ülemiste
(Other) Main rivers and lakes of this city: Lake Harku, River Pirita
Setting [Main urban area; Peri-urban area]: urban

Background (key water management issues, sources of degradation and challenges)
The main problem of Lake Ülemiste is its high phytoplankton biomass, which increases the cost of water treatment (Panksep et al. 2009). A typical feature of Lake Ülemiste, and one which might intensify this problem, is the fine thick sediment that has accumulated for decades on the bottom. Re-suspended sediments might be a source of nutrients for phytoplankton (Tammeorg et al., 2013). In windy weather, wind-induced sediment re-suspension is favouring eutrophication, as it will lead to higher internal loading of nutrients. A potential source of contamination are also cases of emergency landings on water, as the Lennart Meri Tallinn Airport is located on the eastern shore of the lake. Emergency water landings have taken place in 1938, 1966 and 2010. In addition to water quality issues related to Tallinn's main source of drinking water, there have recently been initiatives to open up Lake Ülemiste for recreational purposes. Located only 2 kilometres from the city centre, Lake Ülemiste has since the Soviet times been closed to the public. Recently the restrictive zone that surrounds the lake was extended by a decision

of the Environmental Board, the main motivation being to protect Tallinn's drinking water reservoir (Pädam & Ehrlich, 2011). There have been citizens' requests to open up parts of the lake shore to recreational purposes (http://news.postimees.ee/1250712/peetri-town-folks-want-lake-ulemiste-partially-opened).

Main trigger for action: None reported.

Objectives and description of the initiative

Type of measures implemented: The main measures taken so far to protect Tallinn's drinking water reservoir and improve water quality include:

- The renewal and expansion of the sanitary protection zone of Lake Ülemiste was completed in 2009. Considering the importance of the surface water intake of the lake as a source of drinking water, expanding the sanitary protection zone by more than was required under the Water Act (i.e. 90 metres) was deemed to be necessary. The sanitary protection zone covers Lake Ülemiste, its water intake facilities, its shore protection facilities and the close surroundings of the lake, which must be preserved in their natural status and where the movement of people must be restricted. The sanitary protection zone is surrounded with a fence and is not in public use.
- The reconstruction and extension of the shore protection dam of Lake Ülemiste was completed from 2011-2012. Its goal was to increase the adjustable volume of the shallow lake, reduce the eutrophication of the water, stop the shore erosion caused by waves and guarantee a service path for the management and inspection of the lake.
- A biomanipulation project as a lake restoration tool, was also carried out to intensify the lake management. The aim of the project was to increase the abundance and size of herbivorous zooplankton in order to control phytoplankton biomass and therefore improve the water quality in the lake. Improved water quality helps to reduce the chemical and energy costs of treatment caused by high phytoplankton biomass in the water. For this purpose, approximately 180 metric tons of herbivorous in addition to demersal fish have been caught from lake Ülemiste. As goaled, the most caught species have been bream *Abramis brama* and roach *Rutilus rutilus*. In addition, piscivorous fish was introduced into the lake. (Panksep et al. 2009; Panksep, 2009).

Source: http://www.tallinn.ee/Indicator-8_Water-management_Tallinn

Key objectives: Organisation of more efficient protection against contamination of the catchment area around Lake Ülemiste as Tallinn's surface water intake system and the supply of high-quality drinking water to inhabitants and other users.

To improve water quality and thus to reduce the chemical and energy costs of water treatment.

City strategy, scheme or project to which the initiative is linked: The main goal set by the city in the **Tallinn Environmental Strategy to 2030** is to achieve the good status of the city's water environment and sustainable use of water resources and to guarantee a healthy living environment for people. In terms of surface water protection, the main goal set in the

strategy is the improvement of the ecological and physical-chemical status of the city's larger bodies of water, i.e. guaranteeing a good ecological status, by 2021. The organisation of efficient protection against pollution for the catchment area of Lake Ülemiste and the surface water intake system of Tallinn is also important.

Source: http://www.tallinn.ee/Indicator-8_Water-management_Tallinn

Links to WFD, Floods Directive or other policy/planning process: According to analyses, the inspected indicators of water that passes into the water pipelines comply with the requirements of the Drinking Water Directive 98/83/EC every day. The quality of treated water has improved constantly and the water is bacteriologically clean.

As mentioned above, the Tallinn Environmental Strategy to 2030 aims at the improvement of the ecological and physical-chemical status of the city's larger bodies of water, i.e. guaranteeing a good ecological status, by 2021.

Source: http://www.tallinn.ee/Indicator-8_Water-management_Tallinn

Start-date/end-date: Biomanipulation 2002/2009

Status: Biomanipulation: Finished

Lead organisation(s): Water Utility company AS Tallinna Vesi, in which the city is one of the shareholders.

Key actors involved: In Biomanipulation project: Sven Miller (AS Tallinna Vesi), Ilkka Sammalkorpi (Finnish Environment Institute), Tiia Pedusaar (Estonian Environment Agency), Ain Järvalt & Kristel Panksep (Estonian University of Life Scineces)

Achievements and negative effects

Main results and benefits of the measures (ecological, social and economic): The quality of rough water in Lake Ülemiste as Tallinn's surface water intake is improving to a certain degree thanks to the measures that have been taken (the decrease of the pollution load in the catchment area of the surface water intake system, and an improvement in the lake's condition by means of biomanipulation, etc). (Tallin Environmental Strategy to 2030)

Biomanipulation project:

Fish removal. Large-scale removals have had rather moderate impact on the water quality of the lake Ülemiste, obviously dependent on the shortage of removal in the first years of biomanipulation that did not reach the designed volume. Concisely, the total removal of fish designed for 2002 was not reached before the end of 2006. Furthermore, the release of mature perch previously removed by biomanipulation, obviously withdraw the preliminary impact of the removal as good conditions for reproduction succeeded high numbers of perch in zooplanktivorous size and the successive ample grazing on zooplankton. (Panksep, 2009)

Phosphorus. During the years 2000-2009 (with an exception in 2005 presumably caused by intensive seining that favoured re-suspension of sediments), the load of total phosphorus

declined obviously due to the removal of fish in both direct and indirect way: the direct removal of phosphorus as a removal of fish and the indirect decline in the regeneration of phosphorus from sediments due to scattered populations of demersal fish species. (Panksep, 2009).

Water transparency. In 2003-2008, the transparency of water in the lake Ülemiste deepened by 15 cm, mostly due to prolonged vernal clear water periods that also favoured a moderate expansion of the habitat for submerged macrophytes. (Panksep, 2009)

Plankton. The biomass of phytoplankton has decreased approximately by a half. Considering that the biomass of zooplankton has significantly decreased and statistically the interactions between zoo- and phytoplankton have been weak, it is highly possible that the reduced inside load of phosphorus caused the reduction in the biomass of phytoplankton. Thus, the biomanipulation has obviously affected the biomass of phytoplankton not in an ordinary top-down direction, but in turn, in a bottom-up direction of control. The decrease of zooplankton in biomass has had several distinct reasons. First, the high density of fish in planktivorous size has grazed the zooplankton seriously. Secondly, the species composition of phytoplankton might have forced zooplankton to starve. Thirdly, the existence of microcystins in the lake might have been toxic to zooplankton. Although the latter assumption is not yet proved, it cannot be excluded either. (Panksep, 2009)

It can be concluded that the main aim of the project is not achieved as the cost of purification has not fallen notably. Also Lake Ülemiste is rather too large for using only one main restoration method for succesful improvement of water quality. (Panksep et al., 2009)

Negative side-effects identified: The strict protection of the lake as drinking water source is an obstacle to the recreational use of the lake by the citizens.

Biomanipulation: Increased recruitment of young-of-the-year perch (0+ and 1+ perch yearclasses feed mainly on zooplankton)

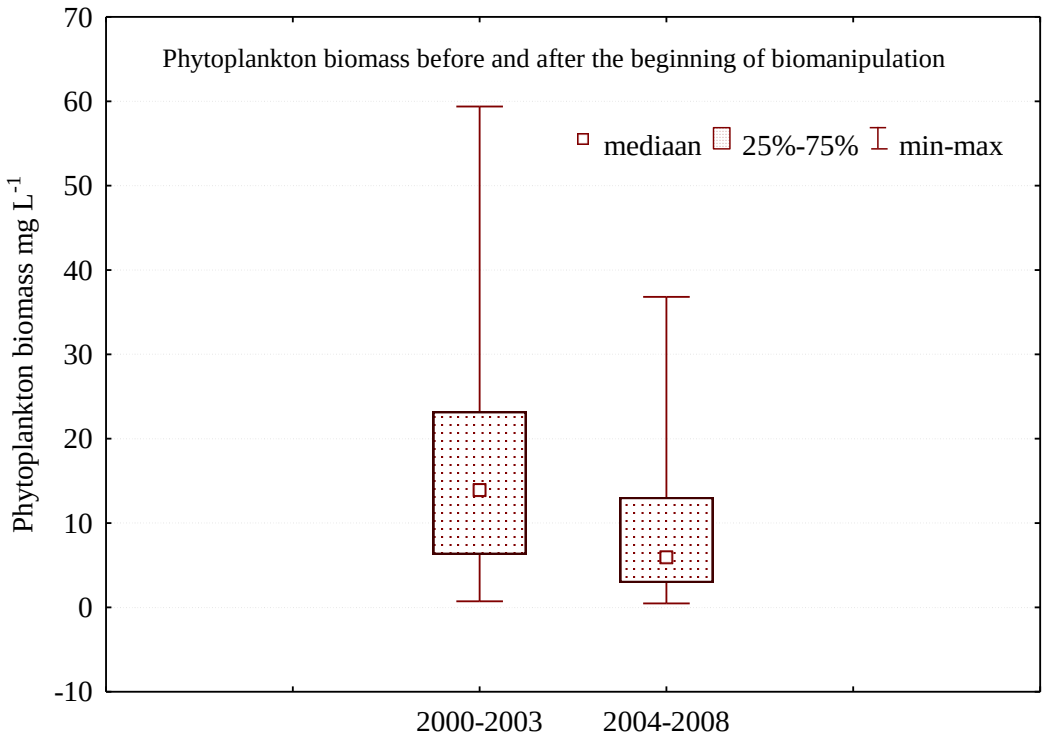
Lessons learned (constraints and positive aspects)

Governance and multi-actor cooperation: A still outstanding issue is developing cooperation with neighbouring local governments (incl. with local governments and water undertakings located on the catchment area of the Ülemiste surface water intake for improvement of the condition of Lake Ülemiste). (Tallinn Environmental Strategy to 2030)
Welfare benefits and improvements in quality of life for the public: The Water Utility company has been, in principle, open to citizens' requests to open up parts of the Lake Ülemiste shores to recreational uses and has been exploring different options (http://news.postimees.ee/1250712/peetri-town-folks-want-lake-ulemiste-partially-opened).
Is there any update on this matter?

Funding: According to the Tallinn Environmental Strategy to 2030, priority is set on drafting a common water protection plan for Lake Ülemiste and bodies of surface water in the Raku-Männiku area and the related Quaternary groundwater. However, the development of a policy of uniform protection for Lake Ülemiste and the Raku-Männiku sand area surface water bodies and the related Quaternary groundwater, as well as the preparation of a uniform water protection plan itself, is something that is yet to be properly addressed, mostly due to the lack of financial means (Tallinn Environmental Strategy to 2030) (status and relevance need to be confirmed).

Before and after photos

Southern shore of Lake Ülemiste. Source: @Sven Miller



Phytoplankton biomass before and after the beginning of the biomanipulation project. Source: Panksep et al., 2009.

Contacts
Kristel Panksep, PhD student and specialist at Estonian University of Life Sciences, Centre for Limnology Sven Miller, AS Tallinna Vesi

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Publications: Panksep, Kristel; Järvalt, Ain; Pedusaar, Tiia (2009). Biomanipulation and water quality changes of Lake Ülemiste (Tallinn, Estonia). In: Ecological response to system manipulation: Meeting of COST 869, 6-8 May 2009, Keszthely, Hungary. Panksep, Kristel (2009). The effect of biomanipulation on the ecosystem of Lake Ülemiste. Master Thesis. Estonian University of Life Sciences, Institute of Agricultural and Environmental Sciences. Tallinn Environmental Strategy to 2030, Tallin 2011, http://www.tallinn.ee/strateegia_ingl Pädam, Sirje and Ehrlich, Üllas, The Foregone Recreation Value of Lake Ülemiste (June 1, 2011). Discussions on Estonian Economic Policy, January 2011. Available at SSRN: http://ssrn.com/abstract=1884231
Websites: http://www.tallinn.ee/Indicator-8_Water-management_Tallinn
News stories: http://news.postimees.ee/1250712/peetri-town-folks-want-lake-ulemiste-partially-opened
Conference presentations:
Panksep, Kristel; Järvalt, Ain; Pedusaar, Tiia (2009). Biomanipulation and water quality changes of Lake Ülemiste (Tallinn, Estonia). In: Ecological response to system manipulation: Meeting of COST 869, 6-8 May 2009, Keszthely, Hungary.

River Liesing, Wienfluss, old Danube – Vienna, Austria

Name of initiative
Restoration measures and strategies for Vienna's urban water bodies

General characterisation (short description of area / site)
Vienna has three rivers flowing through its urban area: the Danube, the Liesing and the Wien. The Danube is the largest of Vienna's urban water bodies, and in fact the longest river in the entire European Union region, flowing through much of Central and Eastern Europe. The Liesing has a total length of 30 km; 18km of the total length flow through the southern part of the city of Vienna. Its two source rivers at an elevation of about 520 m in the Wienerwald react strongly to major rainfall events. The River Wien flows straight through downtown Vienna and its urban section has a length of about 15 km out of a total of 34 km. The Wien is characterised by flood protection works, bank reinforcement and hydrologically altered areas. The history of river regulation in the Vienna section of the River Wien is closely related to urban development and started in the 19th century in large scale.
Location (city, town, neighbourhood): Vienna, Austria
River/lake concerned: Old Danube, Wienfluss, Liesing
Setting [Main urban area; Peri-urban area]: peri-urban and urban areas

Background (key water management issues, sources of degradation and challenges)
Most of the water bodies in Vienna are heavily modified, except the small tributaries in the surrounding forested hills. All three main rivers Danube, Wien, and Liesing have been a significant flood risk to the city before major hydrological interventions in the late 19th century (for the Danube and Wien) and mid-20th century (Liesing). The **Old Danube**, which was the main branch of the Danube in former times, was disconnected from the Danube by a cutoff channel in the late 19th century and turned into an urban lake. The Danube became the site of a hydropower plant. Following measures for flood protection and the construction of a hydro-power plant in the 20th century, the water level in the backwaters was stabilized more and more. Finally, groundwater dynamics were substantially reduced, especially in the Old Danube (Vienna City Administration, pers.comm). The River **Wien** is able to produce very high floods with very high flow velocity. This is one of the reasons why the river in the city of Vienna was built to be flood proof more than 100 years ago with a paved bed along nearly the entire stretch. In addition, a total of 7 storage basins for the retention of runoff storage were built in the upper reach. Within the city stretch there is nearly no space for morphological restoration available (Vienna City Administration, pers.comm). In some sections, the river has been culverted and flows underneath the surface.

A comprehensive engineering project to control flooding was also planned for the **Liesing** in the same historical period (1902), but it was only executed in 1947-1969. Measures included the straightening of the river course, the lowering of the bed by as much as 3m in some areas, the installation of bed drops of up to 2.5m and the construction of a retention basin for solid matter. Similar to the experience with the Danube and Wien rivers, these measures ensured that flooding was no longer a problem, but on the other hand the river suffered ecologically, with lower recreational value and water quality as the Liesing served as a watercourse for the release of effluents from a nearby water treatment plant and other accidental pollution (Goldschmid et al., 2006).

Main trigger for action: The main triggers for modifications were the significant flood risk to the city of Vienna and wastewater contamination.

Objectives and description of the initiative

Type of measures implemented:

Old Danube

In the 1990s, a bluegreen algae bloom occurred in the Old Danube and extensive restoration measures were carried out. The problems with nutrient pollution were solved and a treatment of the Old Danube lake using ferric chloride to eliminate phosphorous was quite successful Finally a very good water quality has been re-established. Today we are facing other problems, in particular increasing recreation pressure and climate change (Vienna City Administration, pers.comm). These problems are addressed within a LIFE+ project on the Old Danube which involves promoting good water quality through the maintenance of a macrophyte inventory and biodiversity as well as the installation of a biological soil filter. The restoration of semi-natural banks and establishment of closed areas along the shore will provide for the protection of fish, aquatic species such as amphibians and marsh plants and not least the local beaver population (see https://www.wien.gv.at/umwelt/wasserbau/gewaesser/alte-donau/life/massnahmen/geplant.html).

River Wien

Especially for the river Wien, the frame-conditions for restoration are very difficult due to its location in the heart of the city and its heavy modification to prevent flooding. As mentioned above, within the city stretch there is nearly no space for morphological restoration available, and it is quite difficult to improve the ecology without jeopardizing infrastructure and people. For this reason, restoration measures up to now were mainly limited to the outer stretch. In the 1990s, 3 km of the Wien were revitalised in the area of the retention basin in Auhof, a peri-urban area of Vienna. At a more central location, 300m of the Vienna River were converted into a stretch with more natural banks and public accessibility to the river improved in 2014 (see https://www.wien.gv.at/umwelt/wasserbau/gewaesser/wienfluss/naturnahe-ausgestaltung.html).

The future concept for the River Wien might be a stepping stone concept with the aim to make the river passable for fish and benthic invertebrates. Within the next years, the Vienna

City Administration will continue with restoration measures in the outer part of the Wien, starting in parallel to develop a master plan for the city stretch (Vienna City Administration, pers.comm).

River Liesing

The Liesing has seen substantial restoration work, both in abating the sources of pollution and in strengthening the river's ecological condition and resilience. 5.5 km of the Liesing were restored within the LIFE-Project "Living River Liesing" from 2002-2006. Restoration included redirecting wastewater from a nearby sewage plant to Vienna's main sewage treatment plant, replacing the concrete riverbed with semi-natural bed structure, replacing bed drops with bed sills that allow fish and other small fauna to cross unobstructed, widening the straight river course, restoring the river banks and creating an urban recreational area (Goldschmid et al., 2006). In more recent years, smaller stretches in the more upstream region have been restored and within the next 5 years, the City Administration plans to improve the state of the remaining part of the Liesing (Vienna City Administration, pers.comm). Simultaneously, it is necessary to solve remaining problems due to sewage overflow and accidental pollution during dry weather.

Key objectives: Since recognising the drawbacks of many of the major technical interventions of the late 19th and early 20th centuries to ensure flood protection, authorities have since attempted to minimize the damage while continuing to ensure the safety of the city's residents and infrastructure.

The environmental objective is to achieve good "ecological potential" for the city's heavily modified water bodies as specified by the Water Framework Directive. This mostly involves the step-by-step improvement of the hydro-morphology of the rivers, starting with the outskirts of the city, where frame conditions are easier. The urban sections of the rivers are more difficult to restore, but several stretches have either been completed or are in planning, starting with the River Liesing (2015-2021) and continuing with the River Wien (2021-2027) (Vienna City Administration, pers.comm).

One of the overarching goals is to enable the migration of fish and benthic invertebrates by removing migration barriers where possible. For the city stretches, which are very difficult to restore, the city is developing master plans in each case for the entire stretch, starting with the implementation with River Liesing (2015-2021) and continuing with River Wien in the next WFD period (2021-2027).

Simultaneously, the City Administration has to resolve existing problems with sewage overflow and accidental pollution.

City strategy, scheme or project to which this initiative is linked: The projects of the Vienna City Administration for restoration of urban water bodies aim at reaching the goals of the WFD, following the national WFD implementation strategy.

Links to WFD, Floods Directive or other policy/planning process: Restoration projects related to both the River Liesing and the River Wien and the lake Old Danube are designed to be in line with the WFD requirements and aim to improve "ecological potential" or "ecological status", respectively (ecological status is relevant for the Old Danube which is

not a heavily modified water body).

Start-date/end-date:

LIFE+ Old Donau (2013 - 2017) ongoing

Activities on the River Liesing: LIFE project 2002 - 2006, further restoration measures 2006 – 2015 (four additional stretches), other activities in preparation.

Activities on the River Wien: Restoration of first stretches in the 1990s, 2006 and 2014, other activities in preparation/ongoing.

Status: Ongoing

Lead organisation(s): Department 45 – Water Management, Vienna City Administration

Key actors involved: Institute of Bioengineering and Landscape

Achievements and negative effects

Main results and benefits of the measures (ecological, social and economic): In the Old Danube, good water quality was re-established after measures taken to address a bluegreen algae bloom in the 1990s. Other activities to address recreation pressures and climate change are ongoing. The LIFE-Project "Living River Liesing" resulted in clear improvement in the structure of the river on 5.5 km of restored sections. A particularly positive impact is the large fish stock living in the re-naturalised stretch of the river. The installation of pathways enhanced the attractiveness of the Liesing valley for sporting activities and recreation.

Negative side-effects identified: None found.

Lessons Learned (constraints and positive aspects)

Welfare benefits and improvements in quality of life for the public: Increased water quality and biodiversity for recreational and business purposes.

Links to river basin management planning: Most of the water bodies in Vienna are heavily modified water bodies, so the environmental objective according to the WFD is to achieve good ecological potential in most cases. One of the overarching goals is to enable migration for fish and benthic invertebrate, by removing migration barriers where possible.

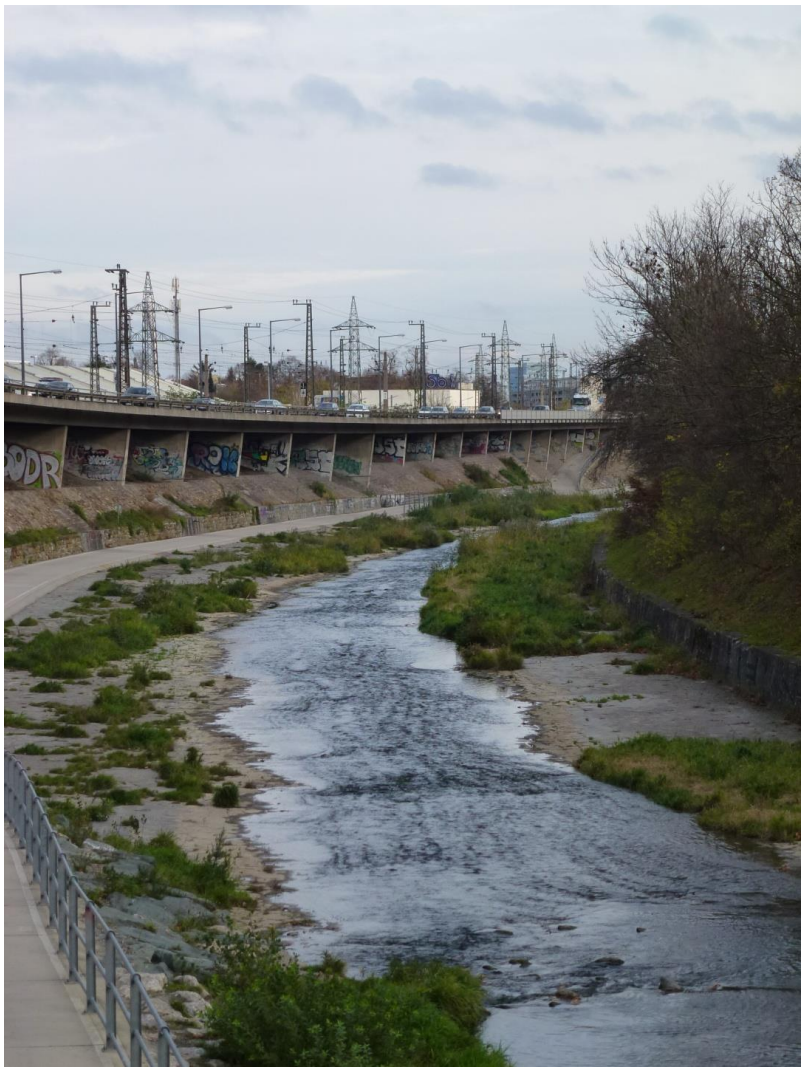
In addition, the City Administration has started to improve the hydro-morphology of water bodies step by step. The activities have started in the outskirts of the city of Vienna where the frame conditions are easier. For the urban stretches, which are very difficult to restore, master plans are developed in each case for the entire stretch, starting the implementation with the River Liesing (2015-2021) and continuing with the River Wien in the next WFD period (2021-2021). Because of lack of space in the urban area, stepping-stone concepts are being

developed.

Before and after photos

Liesing before restoration in 2014 (source: MA45-Webel).

Liesing after restoration in 2015 (source: MA45-Wiener Wildnis).



Wienfluss before restoration in 2013 (source: MA45-Webel).

Wienfluss after restoration in 2015 (source: MA45-Webel)

Contacts
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Publications: Goldschmid, U., Fellinger, W. & V. Rittsteuer, Knoll (2006). "Living River Liesing" Life-Environment-project. Publisher Vienna City Administration.
Websites: *The Liesing* http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=2118&docType=pdf https://www.wien.gv.at/umwelt/wasserbau/gewaesser/die-liesing/ *Old Danube* "Integratives Gewässermanagement – LIFE + Alte Donau" https://www.wien.gv.at/umwelt/wasserbau/gewaesser/alte-donau/life/massnahmen/geplant.html Accessed 7.4.2016 https://www.wien.gv.at/umwelt/wasserbau/gewaesser/alte-donau/life/ *Wienfluss* https://www.wien.gv.at/umwelt/wasserbau/gewaesser/wienfluss/ "Historisches zum Wienfluss" https://www.wien.gv.at/umwelt/wasserbau/gewaesser/wienfluss/historie.html 7.4.2016 „Naturnahe Ausgestaltung eines weiteren Teilstückes des Wienflusses fertig" https://www.wien.gv.at/umwelt/wasserbau/gewaesser/wienfluss/naturnahe-ausgestaltung.html. Accessed 7.4.2016