



T3.2.2 Best Practices- EN

Evaluation document

SEDDON II (AT HU10)





Project coordination:

Helmut Habersack¹, Sándor Baranya², Károly Gombás³, Jürgen Gruber⁴

**Authors AT: Sebastian Pessenlehner¹, Marlene Haimann¹, Markus Eder¹, Doris Gangl¹, Angelika Riegler¹
Helmut Habersack¹**

Authors HU: Sándor Baranya², Szilveszter Dömötör³

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 Bundesamt
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SEDDON II (AT HU10)

Sedimentforschung und –management an der Donau II

A Duna hordalékvizsgálata II

¹ **University of Natural Resources and Life Science, Vienna**
Department of Water, Atmosphere and Environment
Institute of Hydraulic Engineering and River Research (IWA)

² **Budapest University of Technology and Economics BME**


³ **North Transdanubian Water Directorate ÉDUVIZIG**

⁴ **BOKU - Wasserbaulabor Errichtungs- und Betriebs-Gesellschaft m.b.H.**

⁵ **Federal Agency for Water Management, Vienna**
Institute for Hydraulic Engineering and Calibration of Hydrometrical
Current-Meters



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Gesellschaft m.b.H.

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1 Best Practice evaluation document

The present evaluation document of best practice examples was prepared within the framework of the project Sediment Research and -management at the Danube River II (SEDDON II) within the ERDF-funded program for cross-border cooperation, Austria-Hungary 2014-2020. The study was based on already implemented river engineering measures from the entire Danube basin and beyond. The projects are classified according to their main drivers: flood protection, ecology, navigation and hydropower. An evaluation matrix provides information on the relevance and technical feasibility on the upper and middle Danube (Austrian and Hungarian project area). A detailed description of the summarized projects was developed in Activity 3.2.1 (Summary of Best Practice Examples).

1.1 Flood protection

Project number	River Basin	Project	Main Driver	Interrelation	Aim, background and measures	Area of application	Austria				comment/technical feasibility	Hungary				comment/technical feasibility
							convenient	rather convenient	rather not convenient	not convenient		convenient	rather convenient	rather not convenient	not convenient	
F1	Danube	DuReFlood	Flood protection	Navigation	DuReFlood Project was a cross-border cooperation project between Slovakia and Hungary focusing on flood protection and morphological alteration of the regulated section of the Danube influenced by the hydropower plant (HPP) Gabčíkovo. The whole project reach is between rkm 1810 to 1708. Based on the assessment of the current state, a proposal of measures for effective flood protection and lateral connectivity restoration to improve ecological status was prepared. Due to river bed erosion, groynes which were originally designed to concentrate the water in the navigation channel during low discharges, are too high at present. In addition, sediments are being deposited between the groynes, reducing the cross-sectional area of the river channel. The 'ineffective' groyne elevation and sediment deposition tend to increase the river channel's resistance to the flow of high discharges and may cause a rise in water levels during floods.	Free-flowing section	x				reconnection of side-channels possible, reduction of groin elevation, defforestation of groins and dredging of deposits possible	x				The HU partner took part in the DuReFlood project.
F2	Danube	Restore lateral erosion processes downstream of the reservoir	Flood Protection	Ecology	Restoration of lateral erosion processes downstream of the Isalnitza reservoir under consideration of the potential risk to create a possible sedimentation area downstream of the reservoir by manoeuvring/operating the hydraulic equipment (intake dam gates, flushing container gates, sedimentation tank gates)	river banks downstream of dams				x	no HPP in project reach			x	no HPP in project reach	
F3	Danube	Open revetment / Open cover	Flood Protection	Ecology of water body (structuring elements installed; removal of embankments)	Open cover (or revetment): large stones, which are bigger than the existing bed material, are placed onto the riverbed, covering about half of the area. The stones increase the resistance for the water flow and protect the finer, natural bed material in their shelter zones.	Free-flowing section, gravel bed river			x		due to requirements for navigation not feasible			x	might be feasible locally, after thorough preliminary analysis	
F4	Danube	LIFE project "Natur Wachau" (2003-2008) / Reconnection of side-channels	Flood Protection	Navigation (water depth during low flow), Ecology, Infrastructure (e.g. roads, electricity cables close to side-channel), Hydropower/water abstraction (less discharge in the main stream)	The Wachau-project (rkm 2033.5 – 2009.0) was the first realized LIFE-project in the Wachau, which aimed at the preservation of endangered habitats in that region. Amongst others, the reconnection of side-channels was one important measure. The backwaters of "Grimsing", "Aggsbach Dorf" and "Rührsdorf-Rossatz" were all reconnected to the Danube. The purpose of this measure, was to ensure the long-term sustainable connection to the Danube, which has now been successfully implemented.	Free flowing section, Reconnection of side-channels	x				reconnection of side-channels feasible		x		detailed assessment of the restoration plans are needed to avoid intensive sedimentation in the reconnected side-channel	
F5	Danube	LIFE+ project "Mostviertel-Wachau" (2009-2014) / Revitalization of side-channels	Flood Protection	Navigation (water depth during low flow), Ecology, Infrastructure (e.g. roads, electricity cables close to side-channel), Hydropower/water abstraction (less discharge in the main stream)	The reconnection of side-channels primarily leads to improved ecological conditions in these river systems. This measure creates new aquatic habitats and refugial areas, where organisms are protected against wave influences. The shallow gravel banks, where water has a high velocity, serve many fish species as spawning areas; the bays with a steadier flow is primarily used by juvenile fish. The deep areas and potholes of the river are important wintering areas. Altogether, every stage in the lifetime of fish is considered	Free-flowing section, reconnection of side-channels, creation of a biotope, redesign of a tributary mouth ("Pielach")	x				reconnection of side-channels feasible		x		detailed assessment of the restoration plans are needed to avoid intensive sedimentation in the reconnected side-channel	
F6	Danube	LIFE+ project "Auenwildnis Wachau" (2015-2020) / Revitalization of side-channels	Flood Protection	Navigation (water depth during low flow), ecology, infrastructure (e.g. roads, electricity cables close to side-channel), hydropower/water abstraction (less discharge in the main stream)	The project follows two former LIFE projects in the "Wachau" region and builds on their findings. This projects primarily aims at improving the ecological conditions in the floodplains by conducting species protection measures. These measures create new aquatic habitats and refugial areas, where organisms are protected against wave influences.	Free-flowing section, revitalization of existing backwaters and reconnection of a side-channel	x				reconnection of side-channels feasible		x		detailed assessment of the restoration plans are needed to avoid intensive sedimentation in the reconnected side-channel	

Project number	River Basin	Project	Main Driver	Interrelation	Aim, background and measures	Area of application	Austria					Hungary					
							convenient	rather convenient	rather not convenient	not convenient	comment/technical feasibility	convenient	rather convenient	rather not convenient	not convenient	comment/technical feasibility	
F7	Danube	Pilot project Bad Deutsch-Altenburg / Reconnection of a side-channel ("Johler Arm")	Flood Protection	Navigation (water depth during low flow), ecology, infrastructure (e.g. roads, electricity cables close to side-channel), hydropower/water abstraction (less discharge in the main stream)	The realization of the Pilot Project Bad Deutsch-Altenburg (rkm 1885.6 – 1884.3) enabled the stabilization of the riverbed in the test section. Through the reconnection of the Johler side-channel, the first side-channel in the national park where water flows through all year round has been re-established. Restoration of riverbanks has created natural shore areas. These newly created habitats were immediately embraced by the animal world of the Danube floodplains. Scientific support was responsible for the evaluation of the pilot project and the knowledge gained from it is an essential basis for the design of the "Catalogue of Measures".	Free-flowing section, reconnection of a side-channel	x					was implemented in the project reach		x			detailed assessment of the restoration plans are needed to avoid intensive sedimentation in the reconnected side-channel
F8	Elbe	Floodplain excavation - Pilot project Klöden	Flood Protection	Ecolology (connectivity of river and floodplain)	to 290 is characterized by high erosion of the riverbed. Since 1996, bedload feeding is performed in this eroding section. Thus, the aims here were to: - Identify causes of erosion, - Establish a bed stabilization concept, - Test the applicability in a pilot section and - Realize and perform monitoring in the pilot section. The 15 km long reach near Klöden was selected as a first pilot measure to stop/reduce erosion. Here, a set of measures was discussed, e.g. the partial lowering of the floodplain by excavation.	Floodplain				x		not feasible in the area of the national park				x	multiple use and complex coverage characterize the floodplain along the study reach.
F9	Danube	Removal of natural levees	Flood protection	Navigation, Agriculture	In the 18th/19th century, this section of the Danube was straightened, oxbows were removed and bank reinforcements were installed. These activities enabled the surrounding land to be used for agriculture. The high morphological dynamic was lost. A small portion of typical soft wood floodplain forests was maintained near Imsing. 60 years ago, a flood protection was built that further constrained the forested area. An oxbow of 500 m length ("Pfannenstiel") was maintained but it was only connected to the Danube during flooding events. As a consequence of the bank reinforcements, sediment levees have grown on the river bank during the past decades by 2 cm/a. These levees protect the floodplain from flood events and thereby further reduce the floodplain dynamics. With the goal of revitalising the floodplain forest, the responsible authority held intense stakeholder consultations with the regional nature protection authorities, the local fishing association and local residents. Instead of connecting the oxbow, which would change the character of the floodplain altogether, the decision was made to enable a near-natural development by removing the levees over a stretch of 400 m and reconstructing the floodplain troughs/ditches.	Bedload carrying, alpine river with massive embankments						technically feasible, necessity has to be evaluated				x	there are no natural levees along the study reach

1.2 Ecology

Project number	River Basin	Project	Main Driver	Interrelation	Aim, background and measures	Area of application	Austria				comment/technical feasibility	Hungary				comment/technical feasibility
							convenient	rather convenient	rather not convenient	not convenient		convenient	rather convenient	rather not convenient	not convenient	
E1	Donau	Introducing sediment downstream of weir	Ecology (creating new habitats downstream of weir and restoration of river sections downstream)	Flood protection, hydropower	Prevent erosion downstream of weir. Sediment was dredged from the weir reservoir and recouped directly downstream (rkm 142.9).	Free-flowing section (river with alpine characteristics, carrying gravel; river banks have been stabilized)			x		technically feasible but grain sizes in the reservoir of HPP Freudenu are finer than bed material downstream of HPP				x	not relevant at the Hungarian study section.
E2	Elbe	Widening of the river cross section	Ecology	Flood protection, hydropower, navigation	BeeSandFish project is a LIFE project with a goal to restore steep Danube River banks for bird nesting. To reach the goal, bank protection removal measures were proposed and possible localities were chosen based on numerical modelling results. An integrated effect for stabilisation of river bed and decrease of sediment transport capacity in the same river reach can be reached together with re-introducing of sediments downstream of Gabčíkovo dam.	Free-flowing sections	x				already implemented		x			might be a good alternative to prevent further bed erosion, however, the faith of the eroded sediments from the river banks has to be assessed with preliminary modeling.
E3	Donau	River bank restoration Thurnhaußen / Integrated River Engineering Project - Pilot Project Phase - LIFE project	Ecology	Flood protection (prevent infrastructure from being damaged by lateral erosion), Navigation (water depth in the fairway, fairway width)	This project involved the removal of all artificial elements protecting the left bank of the Danube in the reach opposite the town Hainburg. This project was the first river bank restoration measure at a river of a dimension like the Danube. Possible conflicts with flood protection, shipping, settlement areas and technical infrastructure were taken into account.	Free-flowing section gravel bed river	x				already implemented		x			might be a good alternative to prevent further bed erosion, however, the faith of the eroded sediments from the river banks has to be assessed with preliminary modeling.
E4	Elbe	Removal of bank protection	Ecology	Navigation	Ecological optimization of hydraulic structures: - Creation of dynamic, unsealed bank areas by allowing erosion and accretion processes, such as the formation of steep banks. These measures are an important contribution to achieving the good ecological state and a dynamic development of the river. Rivers can again form habitats such as pools, moving inner and outer bends as well as sand or gravel bars.	River banks, free-flowing section	x				already implemented		x			might be a good alternative to prevent further bed erosion, however, the faith of the eroded sediments from the river banks has to be assessed with preliminary modeling.
E5	Elbe	Groyne notch	Ecology	Navigation	In the early 1990s, the Elbe River (between river-km 440 and 445) had a few groyne notches that were almost completely destroyed and many groyne fields that showed massive damage in the form of breaches. In the case of the almost completely destroyed groyne fields, reparation was almost equivalent to a new construction. Thus, redesigning the groyne geometry in such a way that a more favourable structure of the banks and groyne fields for site-typical plants and animals can develop was considered. In the case of groyne fields with breaches, diverse flow patterns were evident in the groyne fields, so that opportunities to increase structural diversity were seen here.	Main channel	x				already implemented	x				There are similar plans under preparation for the Hungarian study reach.
E6	Elbe	Change of groyne orientation	Ecology	Navigation	In the early 1990s, the Elbe River (between river-km 440 and 445) had a few groyne notches that were almost completely destroyed and many groyne fields that showed massive damage in the form of breaches. In the case of the almost completely destroyed groyne fields, reparation was almost equivalent to a new construction. Thus, redesigning the groyne geometry in such a way that a more favourable structure of the banks and groyne fields for site-typical plants and animals can develop was considered.	Free-flowing sections (priority given to heavily destroyed groyne fields)	x				already implemented	x				There are similar plans under preparation for the Hungarian study reach.

1.3 Navigation

Project number	River Basin	Project	Main Driver	Interrelation	Aim, background and measures	Area of application	Austria				comment/technical feasibility	Hungary				comment/technical feasibility
							convenient	rather convenient	rather not convenient	not convenient		convenient	rather convenient	rather not convenient	not convenient	
N1	Rhine	Bedload management at the free-flowing section of the Rhine River	Navigation	Flood protection, hydropower	The Rhine River has been greatly altered by human use over time. Besides the diking of the floodplains, especially the regulations of the river course, the low and medium water regulation of the riverbed as well as the protection of the banks and finally the damming have seriously influenced the hydrological and morphological conditions. The prevailing bedload deficit and the heterogeneous bedload distribution lead to a constantly progressing riverbed deepening over long stretches, while other areas remain stable or are in the process of uplift. Damage to the ecosystem of the floodplain, restriction of the unloading depth for navigation and disadvantages for water management and rural culture are the consequences.	Free-flowing section	x				Gravel feeding: amount and grain size has to be selected based on transport capacity and the grain size of the natural bedload Optimisation of groin elevation already implemented, dredging and upstream feeding already implemented, bedload trap implemented, coarse gravel feeding feasible with suitable grain sizes		x			There are still significant knowledge gaps of the bedload transport along the HU section. Bedload management would be essential.
N2	Rhine	Sediment management in the Dutch Rhine arms	Navigation	Coastal protection, ecology	Due to the regulation measures along the Lower Rhine, insufficient sediment supply from the Upper Rhine, damming of the tributaries and the interception of bedload in the area of the mountains between Duisburg and Wesel, there is a bedload deficit of 250,000 m³ per year between rkm 800 and 860. As a result of this and also because of the reduced water levels in the Rhine arms, water levels lowered in the Lower Rhine in the 20th century and the river bed deepened. Bed erosion reduced the stability of the banks and structures, and the cover of cables and pipelines in the river was reduced. Because of decreasing water levels, the performance of intake and outlet structures decreases. Groundwater levels decrease and the unloading depth for ships in river sections with stable beds becomes lower. Continuation of this process will make future use of the river more difficult and will also affect the river ecology.	Free-flowing section		x			feasible: -Lowering of the low-water bed in the lower reaches of the feeders. -Sediment addition in erosion reaches -Optimization of dredging and dumping strategies -Restriction of sediment removal -Lowering of groynes technically possible, but not suitable: - Increasing the discharge capacity of the flood plains -Constriction of the low-water bed by guiding walls -Installation of partially stabilized layers in narrow outer bends		x			There are still significant knowledge gaps of the bedload transport along the HU section. Bedload management would be essential.
N3	Danube	Pilot project Witzelsdorf / Alternative groyne types	Navigation	Flood protection (no changes in flood water levels allowed), Ecology (improvement of conditions)	The section between river kilometres 1893.4 and 1891.7 has for a long time been one of the most heavily obstructed sections along the entire Danube. In addition to the bank protection structures that reinforce the riverbanks, there was a longitudinal structure (guiding wall) and eight groynes located along less than two kilometres of the riverbank. However, this riparian section, which is not directly exposed to the current of the river, offered the ideal conditions for riverbank restoration and the testing of innovative groynes in an optimized form and arrangement. The construction was carried out between November 2007 and May 2009. An optimization of the groynes and the guiding wall was implemented in September and October 2015 to reduce / stop the dredging, which was necessary after a shallow developed. The height of the groynes and the guiding wall was increased by 40-65 cm.	Free-flowing section - gravel bed river	x				already implemented	x			There are similar plans under preparation for the Hungarian study reach.	
N4	Danube	Pilot project Witzelsdorf / Lowering of the guiding wall	Navigation	Flood protection (no changes in flood water levels allowed)	The section between river kilometres 1893.4 and 1891.7 has for a long time been one of the most heavily obstructed sections along the entire Danube. In addition to the bank protection structures that reinforce the riverbanks, there was a longitudinal structure (guiding wall) and eight groynes located along less than two kilometres of the riverbank. However, this riparian section, which is not directly exposed to the current of the river, offered the ideal conditions for the restoration of the guiding wall. The measures involved the lowering of the longitudinal structure at a level of 0.5 m above the low navigation and regulation level (LNRL). The construction was carried out between November 2007 and May 2009.	Free flowing section - gravel bed river	x				already implemented	x			There are similar plans under preparation for the Hungarian study reach.	

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N5	Elbe	Temporary gravel islands	Navigation	Flood protection, ecology	Implementation of hydraulic structures to improve the fairway requirements and hydraulic conditions by equalizing the flow and transport behaviour. Initiation and maintenance of structure-building processes. Restoration and improvement of protected biotopes and habitats of particularly protected animal and plant species; resting and nesting areas and breeding habitats are created by the island.	Free-flowing section	x				already implemented once, further locations should be investigated		x			Financial aspects have to be considered (who shall pay?)
N6	Elbe	Construction/Replacement of guiding walls	Navigation	Flood protection, ecology	With this measure, the protection of valuable bank areas is aimed. The structure is intended to create, maintain and develop areas of shallow water. Initiation, improvement and restoration of morphological processes in the bank area and waterbody are likely. Restoration and improvement of protected biotopes and habitats of particularly protected animal and plant species, that are typical for the floodplain and waterbody is aimed.	Free-flowing section		x			technically feasible in inner bends, but bank protection at inner bends already removed in the project area	x				There are similar plans under preparation for the Hungarian study reach.
N7	Elbe	Groyne extension	Navigation	Ecology	By improving the hydraulic conditions so that flow and transport processes are more homogenic, local deposition in the fairway shall be reduced. Local depositions in the fairway shall be reduced by improving the hydraulic conditions induced by groyne extensions improving the flow and transport behaviour. This measure can reinforce the uncoupling of the floodplain and harbours and bears the additional risk of stronger bed erosion. Furthermore, there are possible conflicts, as homogenizing the transport behaviour can reduce the depth variance and decrease morphological heterogeneity.	Free-flowing section			x		technically feasible, but increase of the height more convenient	x				There are similar plans under preparation for the Hungarian study reach.

1.4 Hydropower

Project number	River Basin	Project	Main Driver	Interrelation	Aim, background and measures	Area of application	Austria				comment/technical feasibility	Hungary				comment/technical feasibility	
							convenient	rather convenient	rather not convenient	not convenient		convenient	rather convenient	rather not convenient	not convenient		
H1	Danube	Pilot project Bad Deutsch-Altenburg / Granulometric bed improvement	Hydropower	Ecology and groundwater (clogging, reduced habitat availability if stones are too big and are never transported), Navigation (water depth in the fairway, impact on ship propellers - size of the gravel and distance between ship propeller and river bed), Flood protection (dykes - flood water level should not be increased when adding the material)	The Pilot Project Bad Deutsch-Altenburg (PP BDA) was the sixth pilot project implemented in the national park "Donau-Auen". The objective was to test river engineering measures which are to be implemented along the entire stretch of the Danube between the Freudenu power plant and the Austrian national border. All types of measures were implemented on-site for the first time in the three-kilometre-long project section (river kilometres 1887.5 - 1884.5) including the granulometric improvement to stabilize the riverbed. The behaviour of the added material was monitored during and after the implementation.	Free-flowing section - gravel bed river		x				technically feasible, but feeding method has to be tested and optimized also grain size of the added material has to be determined and adapted if necessary			x		Thorough preliminary assessments need to be performed. Not only physical, but biological aspects. Financial aspects have to be considered (who shall pay?)
H2	Danube	Granulometric improvement (study)	Hydropower	Navigation	Located downstream of the hydropower plant Straubing (rkm 2308.8 – 2307.8), this free-slowing section is subject to erosion. To increase the water levels and to ensure navigation during low-flow periods, regular feeding of sediment is undertaken in this Danube stretch. To reduce the cost of feeding, a pilot study "sediment management concept for the Danube" was launched in 2009 with the goal of analysing which gravel sizes are optimal for establishing a sustainable sediment balance. The study analysed grain sizes between 4 - 63 mm to avoid negative impacts on ship propellers.	Free-flowing section - gravel bed river		x				technically feasible, but feeding method has to be tested and optimized also grain size of the added material has to be determined and adapted if necessary			x		Thorough preliminary assessments need to be performed. Not only physical, but biological aspects. Financial aspects have to be considered (who shall pay?)
H3	Danube	Introducing sediment downstream of weir - Sylvenstein dam	Hydropower	Ecology	The Sylvenstein dam was built for flood protection of towns and cities along the Isar (until Munich). Sediment is deposited in auxiliary dams upstream of the Sylvenstein dam. Due to strong erosion in the downstream Isar river, bedload is episodically dredged out of the auxiliary dams and fed into the Isar downstream of the dam. As of 2017, bedload will be dredged and fed yearly.	Free-flowing section (alpine, gravel-carrying river)			x			technically feasible, but deposition of sediment in form of dams not suitable in the project reach; other forms of gravel feeding might be convenient				x	Not feasible: upstream HPP is located in SK.
H4	Danube	Removal of river embankments / widening (Acheringer Schwelle)	Hyropower	Flood protection, ecology, habitat diversity (improvement of structure)	Since the 1920s, the originally meandering and multi-branched Isar has been straightened and embanked. As a consequence, the bed deepened about 5-6 metres with local bed break-downs and scours up to 7 metres. The groundwater level in the floodplain dropped drastically. Since a major hotspot occurred at the "Acheringer Schwelle", river embankments were removed, allowing the river to widen and access a natural bedload source, which reduced the deficit.	Bedload carrying, alpine river with massive embankments	x					already implemented		x			might be a good alternative to prevent further bed erosion, however, the faith of the eroded sediments from the river banks has to be assessed with preliminary modeling.
H5	Danube	Feeding / gravel supply downstream of HPP Freudenu	Hyropower	Navigation, flood protection, ecology	Due to the HPP Freudenu, the sediment continuity is interrupted. Because of the sediment deficit downstream of the HPP, deepening of the river bed can be observed. In order to maintain a stable river bed level and prevent it from further erosion processes, the hydropower plant operator VHP has to add about 235.000 m3/a bedload material to the Danube downstream of HPP Freudenu.	Free-flowing section - downstream of HPP Freudenu (river-km 1921.0 - 1910.0)	x					already performed upstream of the project reach				x	Not feasible: upstream HPP is located in SK.
H6	Danube	"Eizendorfer Haufen" renaturation project / Reconnection of side-channel system, riverbank restoration	Hydropower	Navigation (water depth during low flow), infrastructure (e.g. roads, electricity cables close to the side-channel), ecology, flood protection (increased flood retention)	As the operator of the Danube hydropower plants in Upper Austria, VHP has completed the "Eizendorfer Haufen" renaturation project in the backwater area in Ybbs-Persenbeug in the municipality of Saxen (Upper Austria). The "Eizendorfer Haufen", also called "Reischelau", is situated on the left river bank of the Danube (near Ardagger Markt rkm 2087.2 – 2086.2). This is an almost completely disused element, which is typical of the landscape on the left bank of the Danube and was greatly affected by the construction of a training structure at the start of the 20th Century. Due to gravel deposits, a floodplain plateau was created, which in the course of the years separated itself from the Danube. As part of a special renaturation project, this silted up side-channel has once again been reconnected to the Danube. Through specifically designed new, diverse riverbank structures, fish and bird species of the Danube should once more gain an additional habitat. The landscape elements of the original island and land surface along the Danube are typical to the landscape. It re-emerged thanks to the reconnection to the Danube and stretches out in total for 1.7km and is 200m wide. The newly created natural area will in future serve once more as a winter residence for cormorants and as a breeding ground for different species of birds. One can also find different types of floodplain, which in terms of vegetation are particularly worth protecting.	Floodplains, river bank, impounded section - gravel bed river					x	no reservoir in the project reach		x			detailed assessment of the restoration plans are needed to avoid intensive sedimentation in the reconnected side-arm