DANUBE RIVERS

Title		**Danube East of Vienna** The Integrated River Engineering Project and its Pilot Projects Bad-Deutsch Altenburg and Witzelsdorf	
Organization		Viadonau	
Start	**End**	October 2010	March 2016
Length		48 km	
River typology		Meandering, wandering	
Target species/habitat		Alluvial forest, hydromorphology	
Q mean		1,930 m^3/s	
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LOCATION AND CONTEXT

Danube East of Vienna project comprises a free-flowing reach of 48 km length between the Freudenau power plant in Vienna (river kilometre 1921.0) and the end of the Austrian-Slovakian border (river kilometre 1872.7).

The Danube and its wetlands are home to around 60 species of fish, more than 30 mammalian species and about 100 species of breeding birds. More than 800 plants of high order species form its forest.

Figure 1. Location of Danube East Vienna river reach

Here, where the river can still flow freely (without any anthropic impediments), the consequences of the upstream dams of the Danube power plants are visible: the natural flow of gravel along the riverbed is interrupted as the Danube digs deeper and deeper into its riverbed causing both surface and groundwater levels to drop. During the course of the large-scale project to regulate the river in the 19th century (Great Danube Regulation), both riverbanks were heavily protected, reinforced with stone blocks, thus cutting off all the secondary tributaries of the river from the main stream. Sidearms are cutted-off or have discharge only for a few days a year and slowly fall dry. This led to a decoupling between the river and the riparian forest, reinforced by falling water levels. In addition, fine sediment

deposited during flood events also contributes to an increase of the surrounding areas from the river. Due to these slow but steady changes many typical riverine habitats have already been lost. Without countermeasures these negative developments will continue.

During the last 50 years the Danube's riverbed has suffered an important incision of one meter.

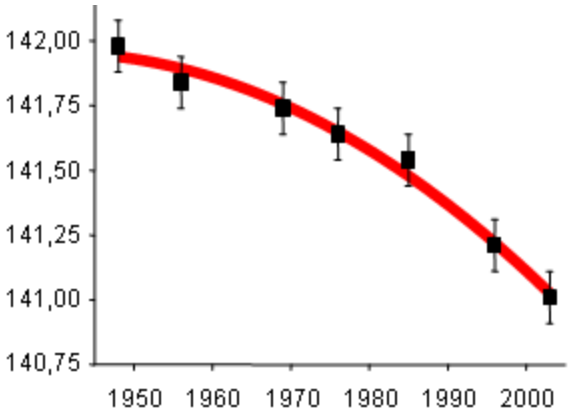


Figure 2. Incision on Danube River in the last 50 years. Source: Donau consultant

The Danube east of Vienna is also part of an international waterway connecting the North Sea to the Black Sea. The Main-Danube Canal was opened in 1992 and the Rhine-Main-Danube Waterway now connects a total of 14 European states by waterway. The total length between the mouth of the Danube into the Black Sea and the Rhine estuary into the North Sea is 3,504 kilometers (viadonau).

In order to enable the Danube to play its role as an environmentally friendly transport alternative, shipping requires safe and economical waterway conditions. Critical shallow areas (fords) restrict the competitiveness of inland waterway vessels compared to lorries and railways, because cargo vessels often have to travel with less cargo in times of low water levels (a reduction of just ten centimeters in the water level means about 100 tons less cargo per vessel unit transported). Almost all the critical ford areas on the Austrian Danube stretch are located to the east of Vienna. These are fords from a navigation point of view. Critical fords have a water depth under 2.5 m under LNWL (= Low navigable water level). In the "original Danube" (up to first half of 19th century), these were also the places to cross the river – as the Danube was much wider, divided into many parallel arms and shallower.

The better utilisation of existing transport capacities on the Danube not only reduces greenhouse gases and pressure on road infrastructure (impervious surfaces), but also transport costs, thus safeguarding Austria as a business location.

PRESSURES & IMPACTS
1) Navigation
2) Lateral defences
3) Side-arms deconnection
4) Dams

5) Incision

In 1996, the Donau-Auen National Park was established to preserve this sensitive ecosystem. The Danube east of Vienna is a Natura 2000 site and a National Park. The river engineering measures, which are needed to maintain or to improve ecological conditions, are described in the management plan for the protective area, which is written by the National Park and accepted by the governments of the provinces of Vienna and Lower Austria and the Federal Ministry of Environment. Together with the National Park we are working to be more detailed every year to simplify permission procedures. The planning and decision procedure which measures and projects are needed is under responsibility of viadonau – which is not part of the National Park Management. The National Park is a project partner and a very important stakeholder. The Integrated River Engineering Project and its Pilot Projects Bad-Deutsch Altenburg and Witzelsdorf seeks an integrative approach considering the transport corridor and the environmental aspects, considering the sediment management and the recovery of floodplains function and fulfilling Water Framework Directive requirements.

OBJECTIVES

The project has the objectives:

- **Stabilization of water levels, prevention of incision**
- **Improvement of environmental conditions: channel widening, recovery of fluvial space**
- **Improvement of infrastructure**

Incision has become an important problem on Danube River that affects surface and groundwater levels and decoupling of river and floodplains with affections on environmental conditions of floodplain but also on the transport infrastructure of Danube. Incision prevention, though, is one of the main objectives that pursues Danube East Vienna project along with maintaining its free flowing.

Granulometric river bed improvement is a goal, adding gravel sizes of approximately 40-70 mm (within the natural grain size spectrum) and reducing bed load transport capacity from 300,000-400,000 m^3/a to 30,000-50,000 m^3/a.

Figure 3. Gravel addition evolution: before, after (~25 cm of gravel addition) and final situation.

Along with this and as a way of reverting the incision another objective is the improvement of Danube floodplain habitats by widening the channel, recovering fluvial space, which creates new habitats, contributes to maintain the good ecological status and the increase of water retention on the floodplain that increases flood protection as well.

At the same time, during low-water periods the Danube is too shallow for navigation which limits its competitiveness of inland navigation and requests high maintenance costs, as waterway conditions have to be kept during low water conditions, according to the international AGN agreement (2.50 metres loaded draft on at least 300 days per year or 2.50 metres fairway depth at Low Navigation Water Level (LNWL)). So the objective is to have better minimum depths during low-water periods reducing the maintenance costs.

All of the three objectives (prevention of degradation, channel widening and improvement of infrastructure) are considered of equal importance, as consequence they have to be developed through an integrative planning of river engineering measures incorporating different interests.

These objectives are being developed with the help of the Catalogue of Measures described in the Restoration actions section.

Target species/habitats	Alluvial forest, Hydromorphology

RESTORATION ACTIONS

The development of the described objectives are achieved by a combination of river engineering measures. The Catalogue of Measures is the result of an **integrative planning process** and is based on the findings of optimised waterway and traffic management, along with the multi-year conceptual pilot project phase of the Integrated River Engineering Project for the Danube East of Vienna. A priority ranking system has been established for each of the types of measures (viadonau).

1) INTEGRATIVE BEDLOAD MANAGEMENT

Gravel is excavated every year at the shallow spots to allow navigation. Besides that, there are also bedload traps. This material is reintroduced upstream in the river (as far as possible, about 18 km), where the riverbed is deep. This supposes a redistribution of bedload. It is a way of counteract the extraction of gravel and riverbed degradation of the river which is enhanced with additional deposit of coarse gravel**.** This incision control and reduction is key for maintaining water levels and underwater conditions, fundamental also for the security of the Freudenau power plant and so they contribute in the first 11 kilometers of the Danube east of Vienna to it.

A pilot project was implemented in the river section east of Vienna in 2015. The main objective of the pilot was to obtain information for the development of a bedload management system. The analysis took into account the effects on the riverbed as well as constructional considerations. The findings gained from the results help improve the ongoing bedload management and allow for the use of synergies between maintenance dredging and bedload management measures (viadonau).

Juvenile fish is impacted by the waves of navigation, some measures for improving their habitat and achieving the good ecological status focused on fish fauna are the construction of gravel banks from dredged material, river bank restoration removing bank reinforcement of Danube regulation and the reconnection of side arms on the free flowing river reaches.

The construction of artificial gravel islands and gravel banks is part of our integrative bedload management for practical reasons, as we use the gravel we dredge under the bedload management. These structures fulfil more than one function – regulation structure, habitats for gravel breeding birds & pioneer vegetation, wave breaker for fish etc.

The river bank restoration and the reconnection of side arms are not part of the bedload management – they contribute a only a little through the remobilisation of fine sediments and gravel (due to erosion).

But the ultimate aim for our bedload management is to counteract river bed degradation. And the contribution of the river bank restoration and the reconnection of side arms to this objective is significant (widening of the river -> reduces stress on the river bed).

2) SIDE-ARM RECONNECTION

Side-arms are the veins of the water forest and have unfortunately become a rare type of habitat. Large historical side-arm systems in the Donau-Auen National Park are therefore being reconnected (viadonau). These side-arms reconnections besides recovering the drainage network, tributaries and secondary channels, improving ecologically reduces the water pressure and erosion of the main channel, lowers also the flood water levels.

Figure 4. Opening of the Johler side-arm (viadonau)

3) RIVERBANK RESTORATION

Riverbank restoration projects consist on removing stone armour structures to naturalize river banks, create new habitats for pioneer vegetation and birds and reduce water level during floods. When removing hard riverbank structures along the main stream, any possible effects on flood protection, navigation, settlement areas and technical infrastructure are all taken into consideration (viadonau).

Figure 5. Before and after of a restored riverbank (viadonau)

4) OTHER ACTIONS

Improvement, optimisation of regulation, groynes.

Several structures, as groynes, are located in shallow areas, in ford areas to concentrate the water and to facilitate navigation. In areas with erosion processes, these regulation measures are reduced, widening the channel by removing the groynes or by lessening their height.

Figure 6. Groynes to increase low water levels in part of the channel (viadonau)

MONITORING

Continuous status evaluations and monitoring, or scientific support respectively are necessary for planning and success control of the measures and the integrative planning process (viadonau). The application of measures has flexibility depending on the new findings and results from the monitoring with a "learning from the river" philosophy.
As it is not always possible to have a previous existing knowledge, the monitoring and research cooperation is implemented from the Christian Doppler Laboratory for "Sediment research and management" (https://boku.ac.at/en/wau/iwa/christiandopplerlaborfuersedimentforschungund-management)

Integrative monitoring programme include abiotic monitoring (hydrology and hydraulics, groundwater, sediment budget and transport, morphodynamics and navigation) and biotic monitoring (ecological functions and processes, landscape dynamics, habitat diversity and biodiversity and bioindication).

ACHIEVEMENTS

There is a pilot phase with 6 pilot projects:

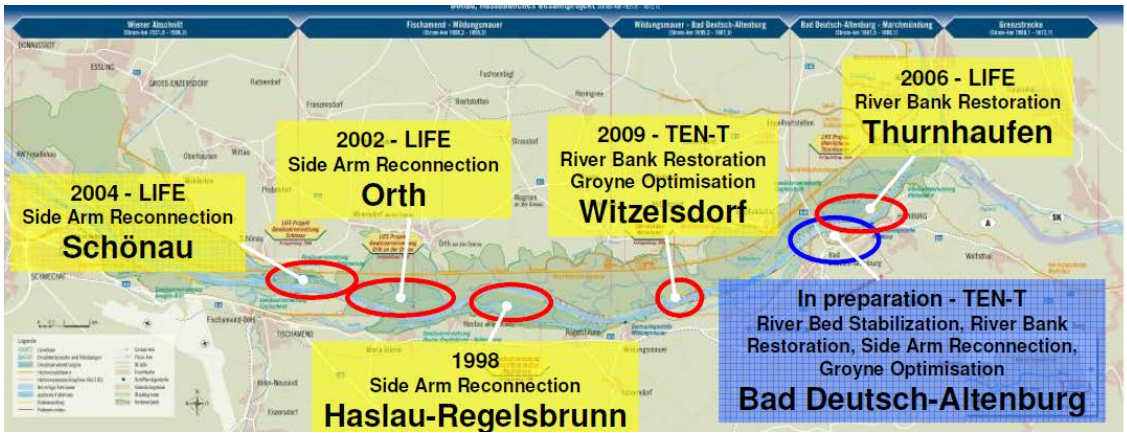


Figure 7. Location of the 6 pilot projects

Pilot project Witzelsdorf, was implemented between November 2007 and May 2009 in 1.7 km of river reach (1893.4-1891.7 km) on the left river bank: new innovative groynes and increasing dynamics at the riverbank. This river reach has been considered one of the most heavily obstructed sections along the entire Danube. In addition to the armoured stone blocks that reinforce the riverbanks, there was a longitudinal structure (training structure) and eight transverse structures (groynes) located along less than two kilometres of the riverbank (viadonau).

Post-monitoring of the project showed that in a short time, an ecological improvement was given on the riverbanks and erosion of the riverbed was significantly reduced in the river reach. In 2015, based on the evaluation results, a moderate increase in the height of the training structure and the groynes in the project area was carried out in order to impede any undesired sedimentation in the fairway and create a balanced state for the riverbed (viadonau).

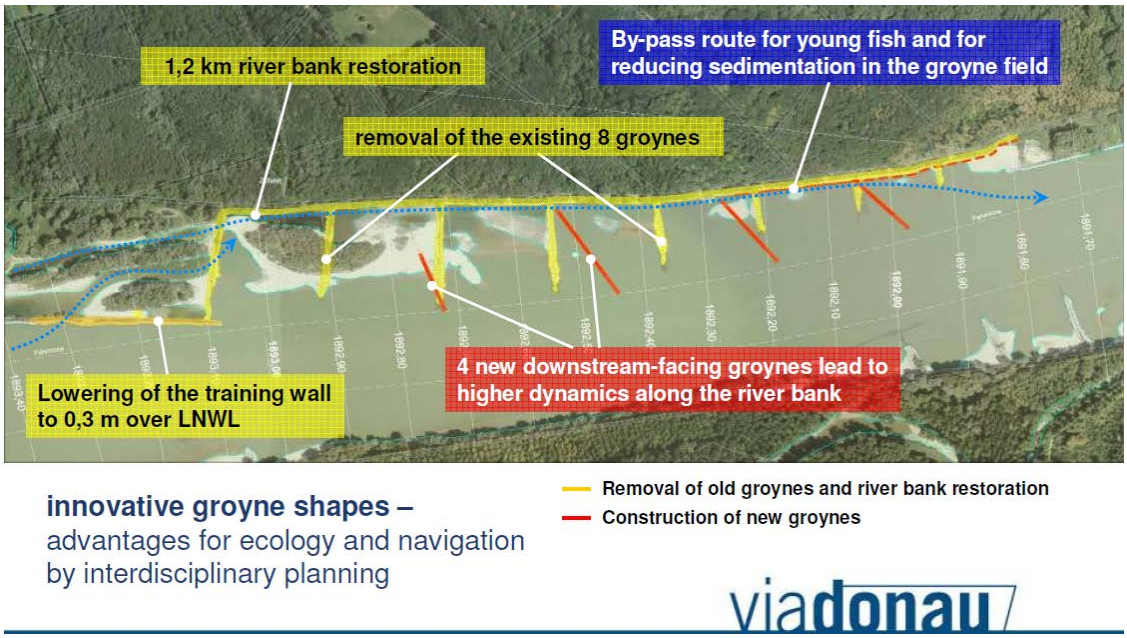
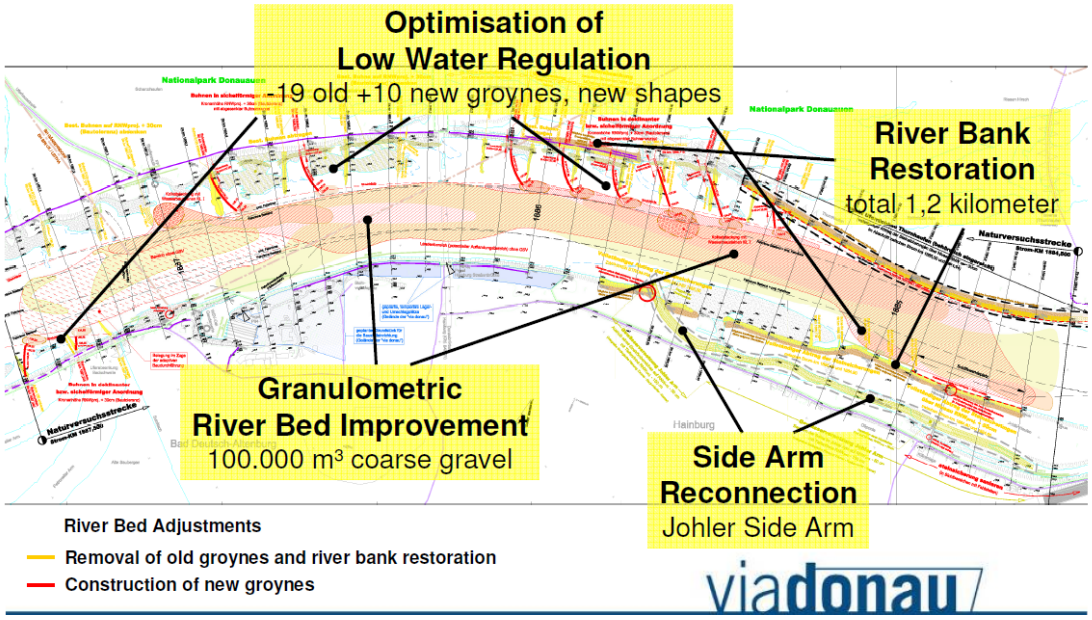


Figure 8. Restoration actions implemented on the Pilot Project Witzelsdorf (Source: viadonau)

Pilot project Bad Deutsch-Altenburg, 3 km of river reach (1887.5-1884.5 km): introduction of 120.000 m^3 coarse gravel, optimization of groynes (removal of some and new ones, in total 9 less), removal of 1.2 km of bank stone amour, reconnection of the Johler side arm of 1.4 km long with a 10 m^3/s discharge at low water. It is the sixth pilot project implemented in the Donau-Auen National Park, it was developed between February 2012 and July 2014. The objective was to test river engineering measures which are to be implemented along the entire stretch of the Danube between the Freudenau power plant and the Austrian national border.



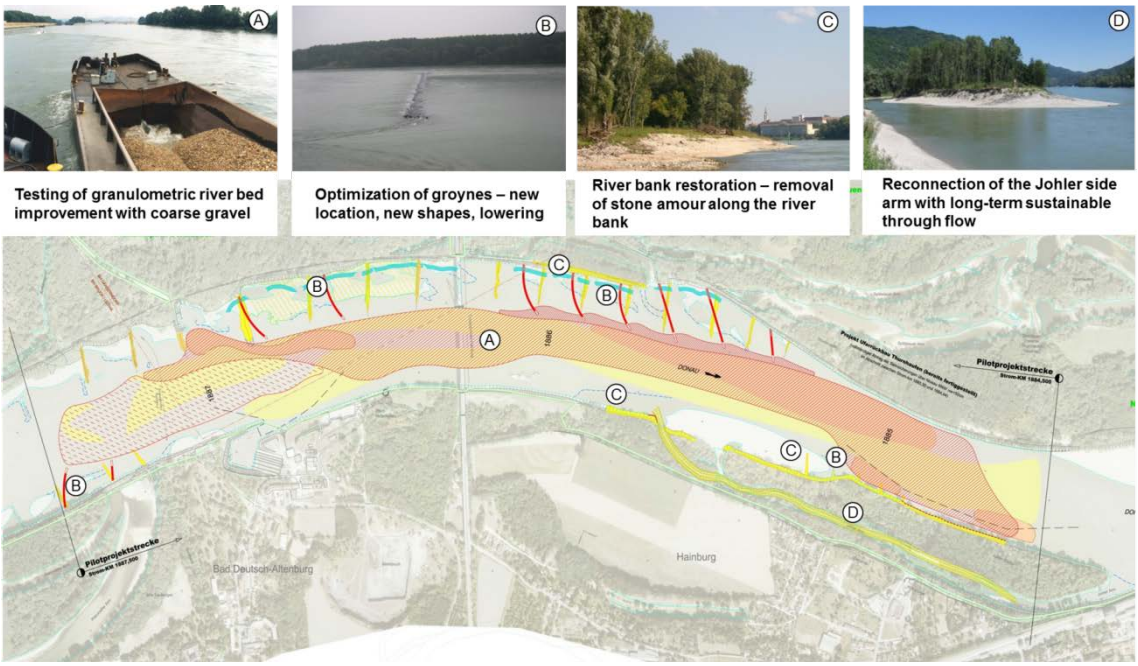


Figure 9. Restoration actions implemented on the Pilot Project Bad Deutsch-Altenburg (Source: viadonau)

The gravel addition was implemented after computing simulations and experiments in the hydraulic engineering laboratory at the Vienna University of Technology.

There is an interdisciplinary monitoring since 2005. 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. Research was carried out by the University of Natural Resources and Applied Life Sciences Vienna (BOKU), the Vienna University of Technology (TU Wien), the University of Vienna and Wassercluster Lunz (a non-profit aquatic ecosystem research center). The specially designed Christian Doppler laboratory "IM Fluss" was responsible for a part of the abiotic investigations and used the results of open-air measurements for their research activities. In addition to viadonaus's experts, specialized companies were also involved in the monitoring.

The realization of the Pilot Project Bad Deutsch-Altenburg stabilised the riverbed in the experimental section; no further erosion of the riverbed has been detected since the end of the works. The reconnection of the Johler side-arm, the first side-arm in the national park where water flows through all year round has been re-established. Restoration of riverbanks has created natural banks that have been rapidly colonised by the vegetal and animal species.

Riverbank restoration Thurnhaufen was completed in 2006 within a LIFE project in cooperation with the Donau-Auen National Park.

A total of approximately 50,000 cubic meters of armoured stone blocks running for 2.85 kilometers between river kilometre 1885.75 and 1882.90 on the left bank of the Danube were removed. After some floods, naturally structured riverbanks were created. It was the first ever riverbank restoration project on a navigable river with the dimensions of the Danube. For this innovation in ecological water engineering, the project received an award from the European Commission for the best LIFE Nature project of 2007/2008.

Side-arm reconnection Schönau was completed in 2004 within a LIFE project in cooperation with the Donau-Auen National Park. The project was developed between river kilometres 1910.1 and 1906.67, the 'Äußere Kühwörther Wasser' (an old side-arm / tributary of the Danube) was reconnected to the main flow of the river. The connection was made by significantly lowering riverbank protection structures. Two large bridge-like passages were installed to reduce the frequency of log jams (blockages caused by driftwood) (viadonau).

Figure 10. Schönau side-arm reconnection (viadonau)

Side-arm reconnection Orth was completed in 2002 within a LIFE project in cooperation with the Donau-Auen National Park. The project was developed between river kilometres 1905.3 and 1901.9 the *'Große Binn'* and the *'Kleine Binn'* tributaries were reconnected with the Danube.

Side-arm reconnection Haslau-Regelsbrunn was completed in 1998. The 10-kilometer-long Haslau-Regelsbrunn side-arm system, is located between river kilometres 1905 and 1895.5 on the right bank of the river. The project to reconnect this system was the first major restoration project on the Austrian Danube and started in 1996 before the founding of the Donau-Auen National Park.

The average throughflow of the side-arm system was increased from an average of 20 to more than 200 days per year due to the installation of three concreted casement openings and four overflow sections - a milestone in ecological river engineering, especially on navigable rivers (viadonau). As a result of falling water levels due to riverbed erosion, the period of connection is decreasing from year to year, so much so that after fifteen years the side-arm is only free-flowing for 140 days of the year. This makes it clear that stabilisation of water levels is an important prerequisite for sustainable renaturation measures (viadonau).

With the conclusion of the first evaluation phase of the Pilot Project Bad Deutsch-Altenburg in 2016, the conceptual and pilot project phase of the Integrated River Engineering Project for the Danube East of Vienna was brought to an end. On the basis of the findings, as well as developments in waterway and traffic management, a new direction is now taken with the Catalogue of Measures, drawn up to achieve ecological and nautical conservation targets on the Danube east of Vienna.

The annual gravel deficit decreased by over 40 per cent between 2006 and 2016 compared to 1996-2006, based on profiles done every each 100 m. The reasons for this are the pilot projects at Witzelsdorf and Bad Deutsch-Altenburg, as well as a modified maintenance strategy. Since 2009, gravel, which is dredged during the course of maintenance work, is systematically shipped upstream and dumped there. From 2015 onwards, average distances for the transportation of material relating to riverbed management have increased

significantly (approximately 10 kilometers on average), meaning that the gravel remains substantially longer in the section of the Danube (viadonau).

Later a couple of bedload traps were created, one in 2017, in the area of the Treuschütt ford the other in 2021 in Hainburg area. Gravel from these areas is dumped at the beginning of the viadonau maintenance section in order to counteract the deepening of the riverbed as effectively as possible (viadonau).

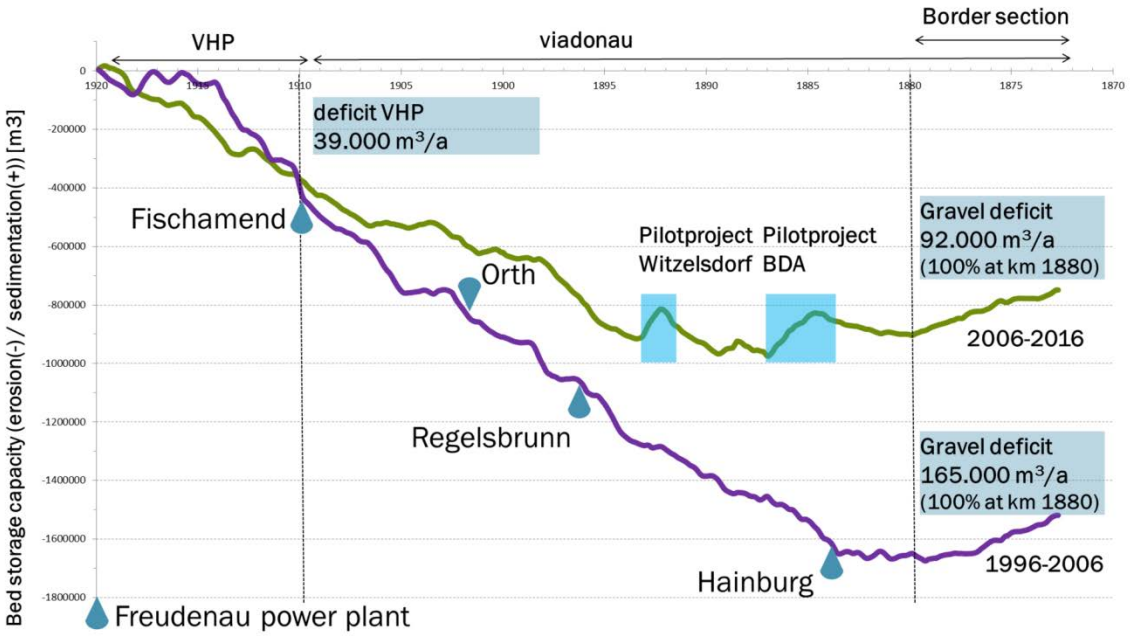


Figure 11. Gravel deficit (Source: viadonau)

There are ongoing measures being implemented through different projects and actions:

- Dynamic LIFE Lines Danube (DLLD)
  https://www.viadonau.org/en/company/project-database/dynamic-life-lines-danube

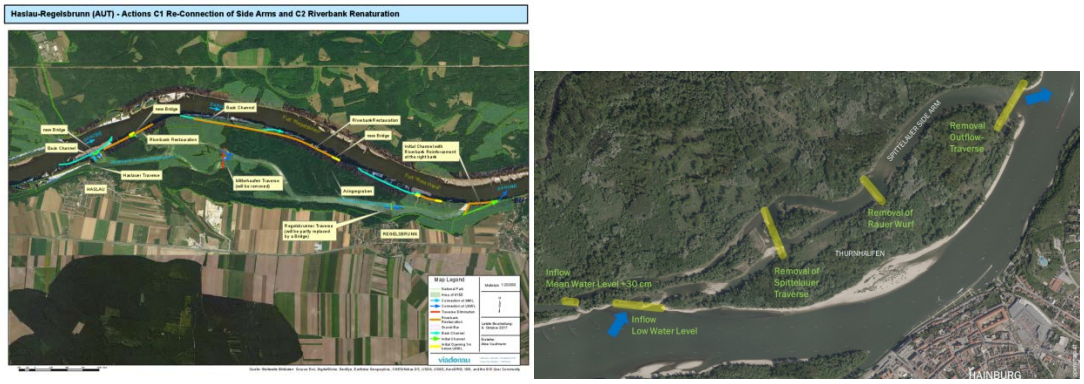


Figure 12. Restoration actions within the Dynamic LIFE Lines Danube project

- DANUBE4all (Horizon Europe). Project duration: 01.01.2023 - 31.12.2027
  Total project budget: EUR 8.42 million.
  https://www.viadonau.org/en/company/project-database/danube4all

Figure 13. Restoration actions within the DANUBE4all project

- MERLIN (Horizon 2020 / Green Deal). The EU funding amounts to about 21 million euros. In addition, the partners contribute their own funds. The project started on 01.10.2021 and will run for 4 years. https://www.viadonau.org/en/company/project-database/merlin

Figure 14. Restoration actions within the MERLIN project

- LIFE WILDisland - Danube Wild Island Habitat Corridor. Project volume: approx. 14.2 million EUR (thereof approx. 65% co-financing from the EU LIFE funding program for nature and biodiversity).

Project start: 01/09/2021. Project end: 31/08/2027. https://www.viadonau.org/en/company/project-database/life-wildisland

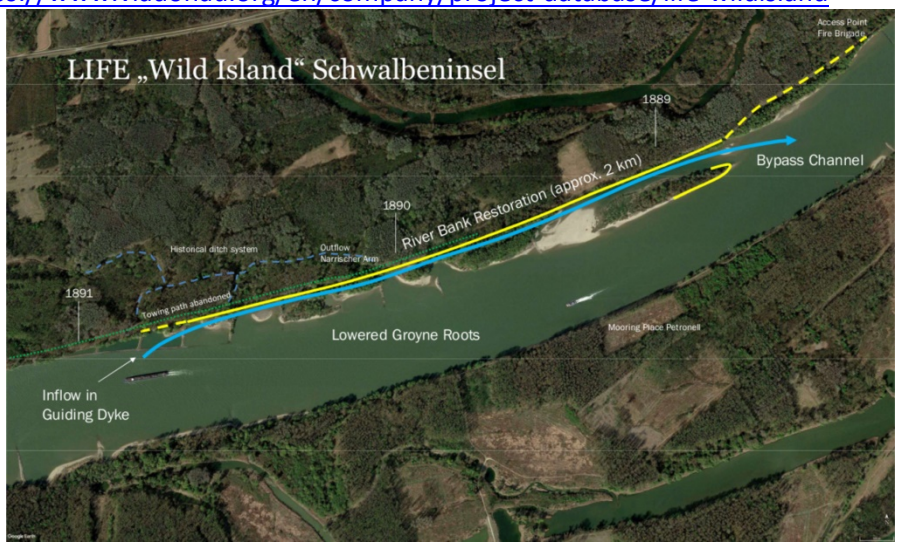


Figure 15. Restoration actions within the Dynamic LIFE WILDisland project

GOVERNMENT AND SOCIAL IMPACT

The involvement of the most diverse stakeholders and civil society is an important prerequisite for the development and implementation of socially and environmentally compatible solutions. Therefore, the implementation of the Catalogue of Measures is accompanied and supported by a participation model. At the centre of the model is an advisory board made up of representatives from industry, environmental NGOs, the ICPDR (International Commission for the Protection of the Danube River), the Donau-Auen National Park and viadonau. Together they cover the majority of the existing interests (viadonau).

There is a steering group, a planning team with a moderation process with all the stakeholders involved.

The implementation of the Pilot Project Bad Deutsch-Altenburg was accompanied by a stakeholder participation model. Affected and interested groups thus had the opportunity to participate in the concrete design and evaluation of the project within its legal framework.

Following the first presentation and discussion of the stakeholder participation model in 2011, a total of twenty meetings took place. At a meeting held on 2015, a joint final statement was published.

The Thurnhaufen bank restoration realized with the Donau-Auen National Park was honored by the European Commission as the best LIFE-Nature Project 2007/2008.

BUDGET

Co-financed by the European Union within the Trans-European Transport Network (TEN-T).

WEBSITES

https://www.viadonau.org/en/company/project-database/integrated-river-engineering-project-catalogue-of-measures

https://www.viadonau.org/en/search?q=danube+east+of+vienna

BIBLIOGRAPHY

https://www.viadonau.org/fileadmin/content/viadonau/01Newsroom/Dokumente/2015/Fachtagung_2015_Pilotprojekt_Bad_Deutsch-Altenburg.pdf (German)

Videos:

https://www.youtube.com/watch?v=mAGty2Y7tdg