Assessment of the River and Floodplain Restoration Potential in the Transboundary UNESCO Biosphere Reserve “Mura-Drava-Danube”

Austria, Croatia, Hungary, Serbia, Slovenia

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This work is dedicated to Martin Schneider-Jacoby who spent virtually half of it's lifetime for nature protection in the Balkans and along Sava and Drava.

Cover photo: Danube River near the Drava mouth (Kopački Rit), Martin Schneider-Jacoby

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List of Acronyms

AT	Austria
DEM	Digital Elevation Model
DRB	Danube River Basin
EU	European Union
FD	Floods Directive
FFHD	Flora Fauna Habitat Directive (Natura2000 network)
GIS	Geographical Information Systems
HR	Croatia
HU	Hungary
IAD	International Association for Danube Research of the Danube River
ICPDR	International Commission for the Protection of the Danube River of the Danube River
JDS 2	Joint Danube Survey 2, 2007
NGO	Non Governmental Organisation
rkm	River Kilometer
RS	Serbia
SI	Slovenia
WFD	EU Water Framework Directive
TBR MDD	Transboundary UNESCO Biosphere Reserve “Mura-Drava-Danube”

Glossary of selected terms

Active floodplain	Floodplain area between current flood defences (dikes) often designed for the 100 year flood return interval; it includes usually all water bodies
Aggradation	The building up of fine sediments due to changes in slope and flow velocity, namely in floodplains
Anabranching river section	Fluvialmorphological term for channel type (like meandering (self-explaining) or braided (see below)): Typical sinous main channel with several larger side channels and large islands
Bank reinforcement and/or bank revetment	All structures stabilising the river banks (see rip-rap) and preventing the lateral shift of the channel
Bars	Gravel and sand bars sedimented in the river channels often associated with river islands or shallow banks (point bars)
Bed load	Coarse material, namely gravel and coarse sand, responsible for the channel building and development (suspended load = fine materials, second sediment transport category)
Braided river section	Fluvialmorphological term for channel type: Multiple channels subdivided by many small islands, typically for strong accumulation stretches
Channel incision	Riverbed deepening and drop of water tables due to lack of sediment supply (dams upstream) often in combination with river straightening and increased shear stress (erosion force) on the river bottom.
Former floodplain	Floodplain outside the flood defences that could be potentially flooded and still hosting typical

	floodplain remnants such as oxbows, forests and wet meadows.
Groynes	Stone structures as partial cross dikes from the bank to the middle of the channel to focus the flow in the main channel (Thalweg). Element of so-called "low water river regulation" mostly used for navigation, but also for bank stabilisation.
Hydromorphology	The science of the physical characterisation of riverine habitats based on hydrologic, hydraulic and morphologic parameters including the channel, the banks and the floodplain of a river.
Morphological floodplain	Potentially flooded area without flood defences, e.g. along postglacial terrace systems.
Point bar	Shallow crescent-shaped sediment bar in the inner bend of a meander or a sinuous river stretch (often associate with steep banks along the outer bend).
Reflector	Stone structures parallel to the bank focusing the main river flow to the main channel (Thalweg).
Polder	Here: Artificial retention areas (basins) along middle and lower river courses which can be open during flood events (steered polders) to limit the flood peak
Rip-rap	Stones stabilizing the river banks to prevent lateral channel shift
Truncated meanders	Along the loess terrace in HR and RS the large rivers try to build meander which are limited by the steep bank (building up of morphologically high dynamic areas with side channels and break-troughts between main channel and terrace

Executive Summary

Spanning Austria, Croatia, Hungary, Serbia and Slovenia, the lower courses of the Drava and Mura rivers and related sections of the Danube are among Europe's most ecologically important river and floodplain areas, the "Amazon of Europe".

In March 2011, the environment ministers of all five countries agreed to jointly protect and manage the area as a Transboundary UNESCO Biosphere Reserve, under the name "Mura-Drava-Danube" (TBR MDD). The sections within Croatia and Hungary have already been designated by UNESCO in July 2012. The nomination process of the areas in Austria, Serbia and Slovenia is on the way.

Once finally established it will be Europe´s largest protected river area and the world's first pentalateral biosphere reserve (figure ES1).

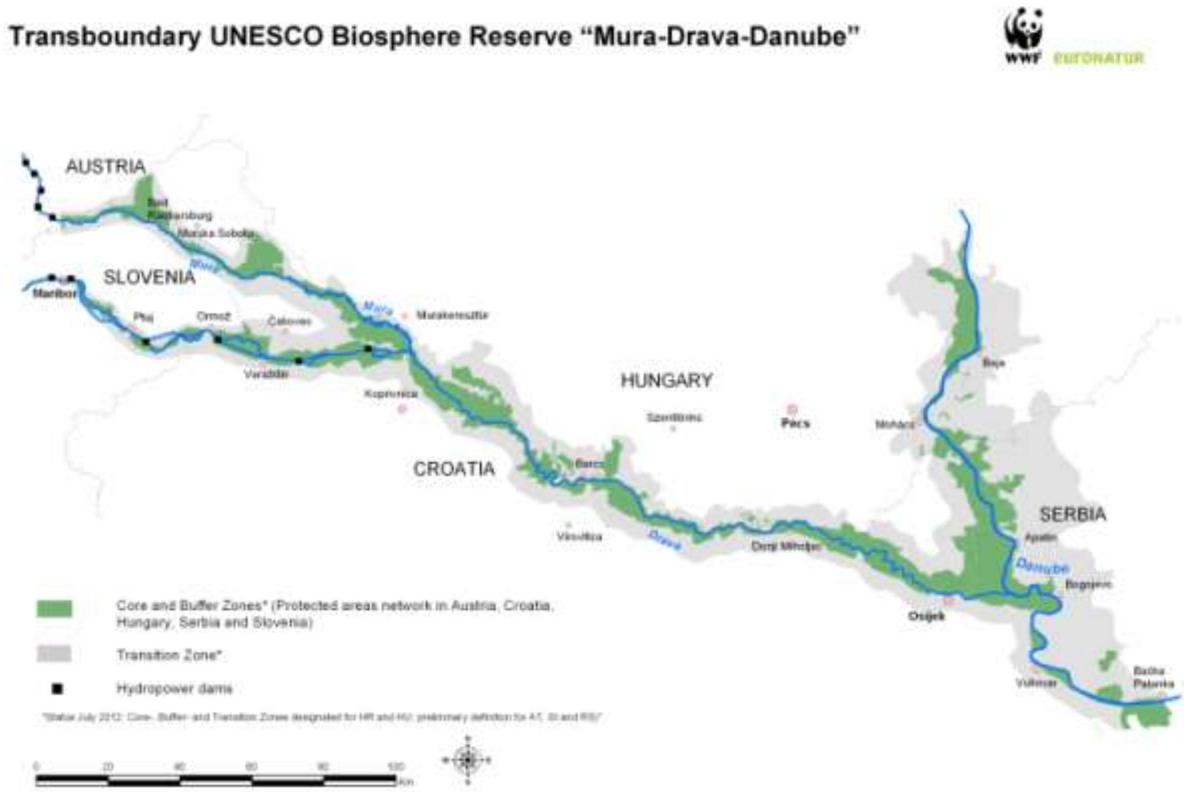


Figure ES 1: Map overview of project area, the TBR MDD.

Despite outstanding natural features and international commitments, the area is struggling with a continuing degradation of habitats and loss of endangered species in the river and floodplain areas. A century of river canalisation, the building of flood dikes, extractions of gravel and sand and the construction of hydropower plants have led to a loss of up to 80 % of the former floodplain areas and the alteration of about 1,100 km of natural river banks and stretches. These changes have direct negative consequences for the long term preservation of the region's characteristic biodiversity and rich ecosystem functions. The situation can improve only if the characteristic natural conditions are restored.

Faced with this challenge, several countries in the TBR MDD have already taken first restoration action in recent years. These efforts should be further supported and widened in scope.

The aim of the study is to provide impetus for necessary restoration efforts and to serve as a base line document for strategic restoration planning in the area. One particular aim is to support the countries in the implementation of EU environmental directives (WFD, FFHD, BD, FD) and the proposals of the ministerial agreement and follow-up for joint zoning and management planning in the Transboundary UNESCO Biosphere Reserve in Austria, Croatia, Hungary, Slovenia and Serbia. It is also intended to provide support for implementation of the “Drava Declaration”, an international agreement on river and floodplain restoration along the Drava. This declaration was signed by the heads of delegations to the ICPDR (International Commission for the Protection of the Danube River) from Slovenia, Austria, Hungary and Croatia as well as the representative of the Republic of Italy.

Methodology

The WWF study is the first comprehensive strategic document for a joint management planning of the Transboundary UNESCO Biosphere Reserve “Mura-Drava-Danube”. Drawing on extensive background data and applying coherent methodology, it analyses the ecological status of river banks and floodplain areas and defines and ranks their potential for restoration.

The restoration proposals are based on the guiding principle that initiation and promotion of hydromorphological dynamics and self sustaining natural dynamic processes of erosion (in particular lateral erosion), deposition and flooding serve the preservation of the whole spectrum of riverine habitats and species.

The various proposals were sorted into three restoration options:

Option 1: Minimum short-term restoration potential (restoration within the active floodplain focussing on the restoration of river banks and channel by the removal of bank reinforcements/groins and reconnection of side-arms).

Option 2: Maximum restoration potential as long-term restoration target (maximum floodplain extension by dike reallocation and extensive bank/channel restoration).

Option 3: Proposed restoration potential for the medium term including the prioritisation of floodplain areas (very high, high and moderate) outside flood dikes for reconnection with the rivers.

The restoration proposals follow the overall restoration objectives, which are

1) Hydromorphological and water status improvements according to the EU Water Framework Directive (WFD);

2) Ecological improvements according to the EU Habitat and Bird Directives (FFHD and BD) and

3) Flood mitigation according to the EU Floods Directive (FD).

Furthermore, the proposals follow the needs of the TBR MDD, which seek the preservation and restoration of natural conditions in the area.

Results

The assessment covered a total river length of 725 km (145 km of the Mura; 365 km of the Drava and 215 km of the Danube) and an area of 886,400 ha (figure ES 1).

River banks/stretches

The river banks – right and left – are in a natural state over a length of about 189 km (9 %), in a near-natural state over 765 km (38 %) and already altered/impacted over 1,081 km (53 %) (figure ES 2).

There is wide variation between different river sections and countries, however. In stretches such as the Mura along the border between Austria and Slovenia, 95 % of river banks are fixed by embankments (by stones, so-called rip-rap), while on some stretches of the Mura and Drava in Croatia and Hungary, and the Danube between Croatia and Serbia (Nature Park Kopački Rit), this figure is less than 40 %.

Other river structures, such as open gravel and sand banks, show a similar picture. About 70 % (about 1,700 ha) of this typical riparian habitat type has already been lost over the last 100 years. It still makes up some 731 ha, which are important breeding habitats for endangered birds and sensitive pioneer species.

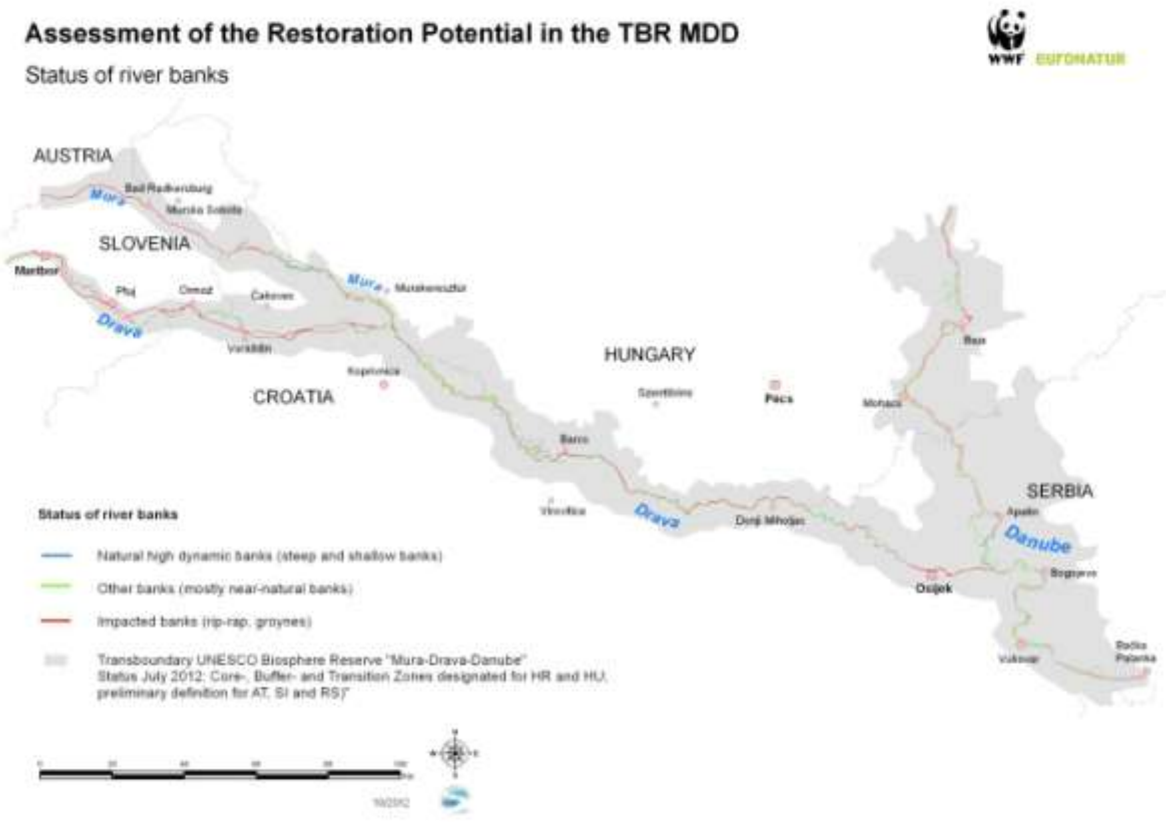


Figure ES 2: Map of status of river banks (summarised status).

The proposed restoration could considerably change the relative proportions of impacted and natural river banks. *__From about 1,081 km impacted banks 652 km (60 %) could be restored to highly dynamic banks (from now 189 km to 529 km) and other near-natural banks (from 765 km to 1,077 km)__*, while destroyed banks could be reduced to 429 km in total (21 % against 53 % before restoration). 340 km (31 %) of new highly dynamic banks and 312 km (29 %) of near-natural banks would be achieved. This would significantly increase lateral erosion for bed load supply counteracting river bed deepening and create new habitats for endangered species.

Furthermore, a total of ***<u>120 major side-channels with a length of 519 km could be reconnected with the rivers</u>*** (figure ES 3). Figures ES 4 and 5 show the results for each country, indicating the current situation and the restoration potential.

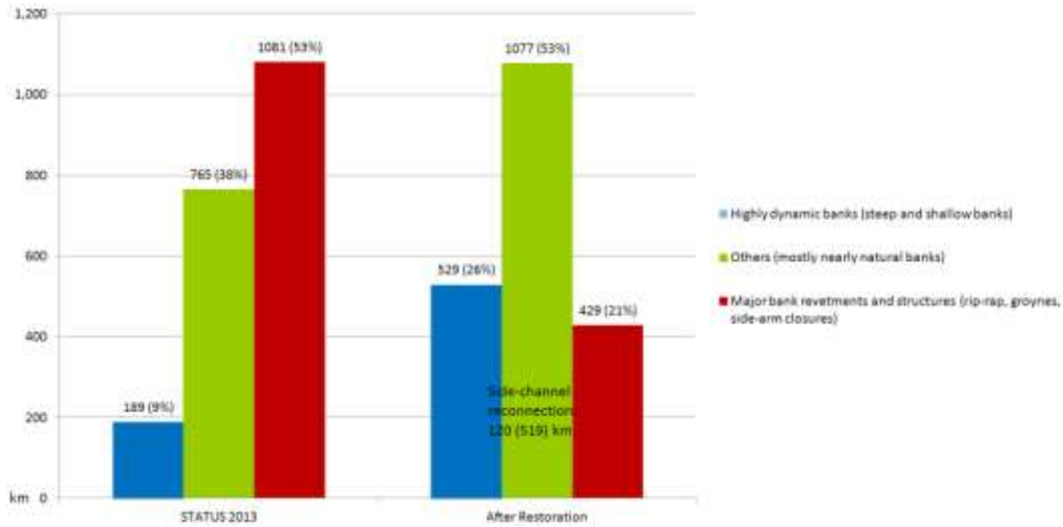


Figure ES 3: Status and restoration potential of river banks (total length, percentage for both river banks in km (not channel length in rkm)). Only main and permanent side channels were analysed for this study.

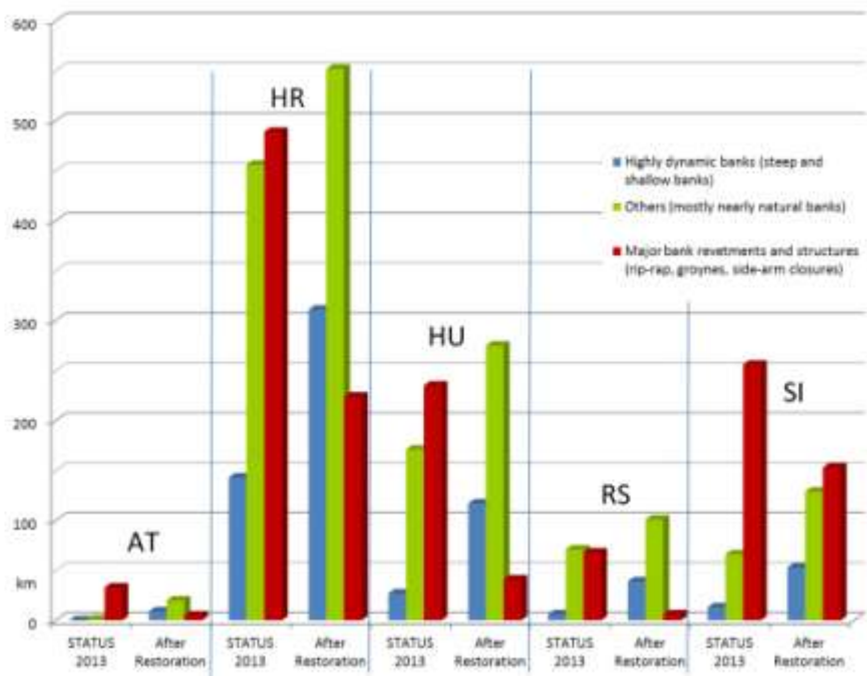


Figure ES 4: Country comparison following figure ES 3.

River banks in km		Austria	Croatia	Hungary	Serbia	Slovenia
Highly dynamic banks (steep and shallow banks)	Status	0	143	27	6	13
	After restoration	**9**	**311**	**117**	**39**	**53**
Others (mostly nearly natural banks)	Status	1	456	171	71	66
	After restoration	**20**	**552**	**275**	**101**	**129**
Major bank revetments and structures (rip-rap, groynes, side-arm closures)	Status	33	489	235	69	256
	After restoration	**5**	**224**	**41**	**6**	**153**

Figure ES 5: Country comparison in table form following figure ES 4

Floodplains

The active floodplain area distributed along all of the river stretches totals 132,341 ha, which is 22 % of its former extent, the "morphological floodplain". About 465,136 ha or 78 % has been lost through the construction of flood dikes (compare figures ES 6 and ES 7).

In different countries, the loss of active floodplains varies from 66 % to 90 % (figure ES 8). About 91,040 ha of the morphological floodplain outside the flood dikes consist of typical floodplain remnants (oxbows, forest and grasslands called as the "former floodplain").

From 465,136 ha of floodplains outside the dikes 165,318 ha (36 %) could be reconnected which would be raising the size of active floodplain from 132,341 ha to 297,659 ha, reducing the overall loss to about 50 % (figure ES 7; country comparison in figure ES 8 and 9, see next pages).

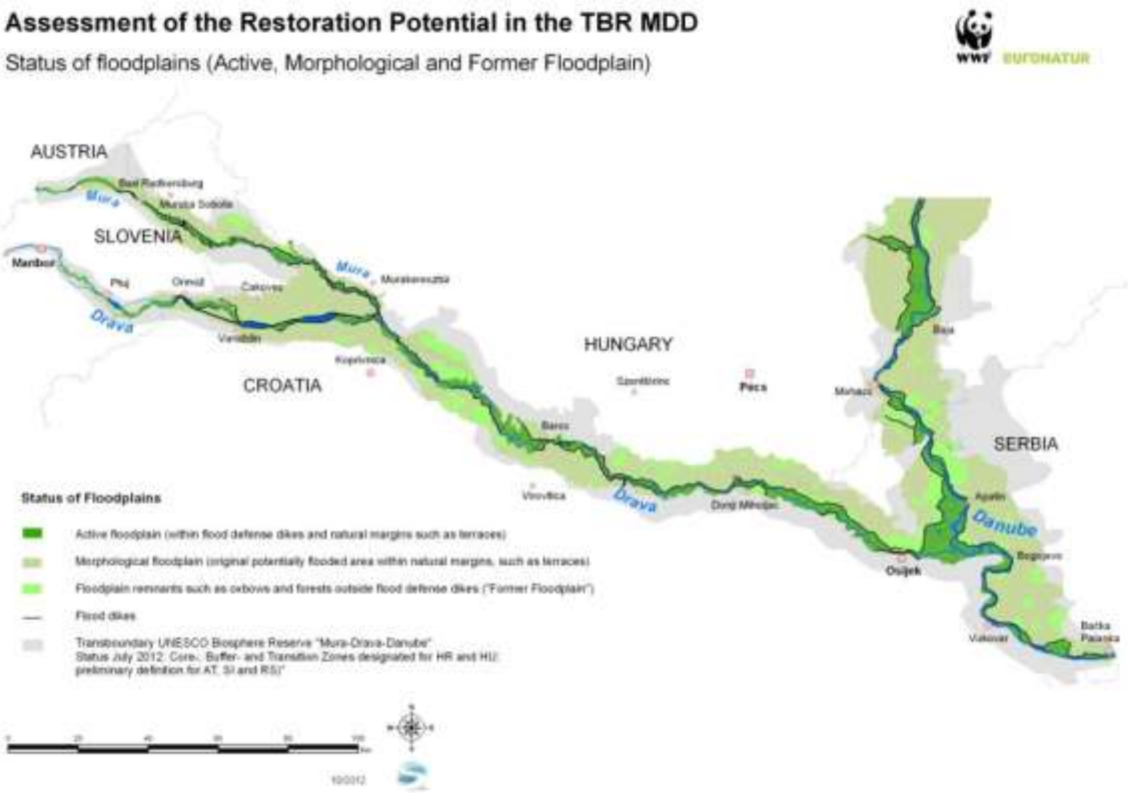


Figure ES 6: Map of floodplain status.

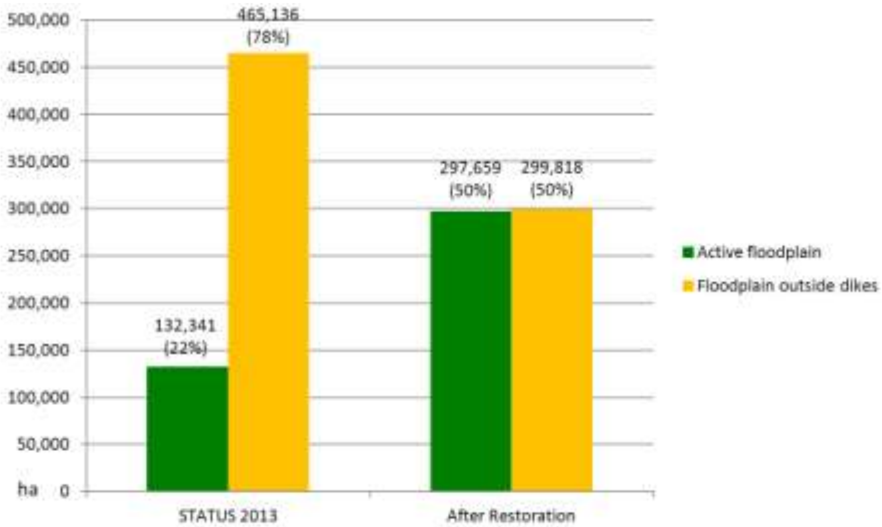


Figure ES 7: Status and restoration potential of floodplains.

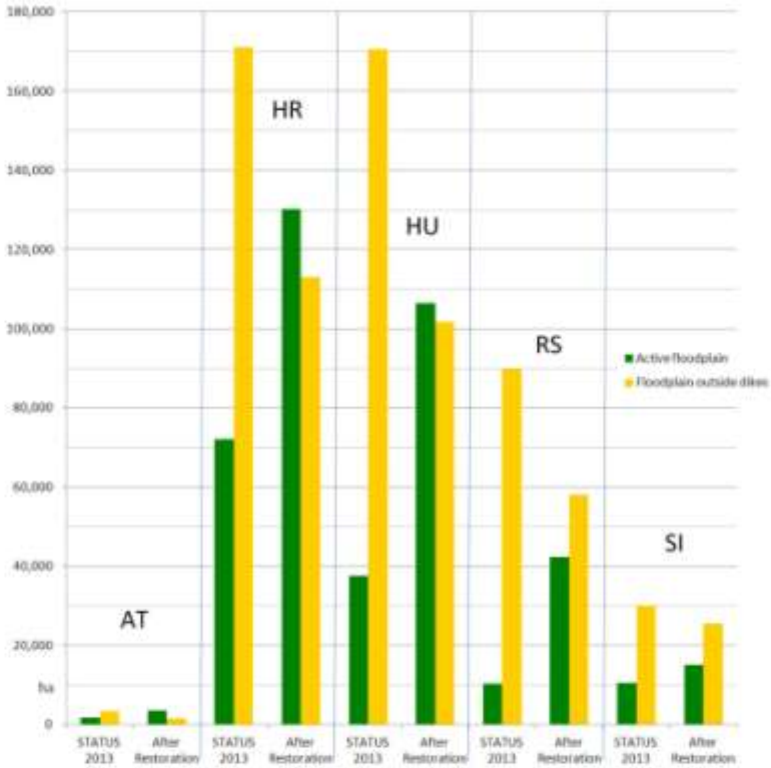


Figure ES 8: Country comparison following figure ES 6.

Floodplain in ha		**Austria**	**Croatia**	**Hungary**	**Serbia**	**Slovenia**
Active floodplain	Status	1,757	72,143	37,562	10,357	10,522
	After restoration	**3,610**	**130,223**	**106,430**	**42,284**	**15,112**
Floodplain outside dikes	Status	3,361	171,139	170,667	89,880	30,089
	After restoration	**1,508**	**113,059**	**101,799**	**57,953**	**25,499**

Figure ES 9: Country comparison in table form following figure ES 7

Prioritisation of floodplain reconnection

Altogether *74 potential priority restoration areas* have been identified along the three rivers (Figures ES 10 and ES 11, list of areas in the map). It makes up *254,093 ha*, and includes land on both active and morphological floodplains outside flood dikes.

Figure ES 10 shows the detailed distribution of prioritisation classes (based on landuse/habitats, nature protection, flood retention potential and hydromorphological situation). The calculation is based on only 72 areas, since two areas contain no floodplain extension (floodplain of Gemenc in Hungary and south of Drava confluence into Danube in Croatia). Their overall size is 165,318 ha. *The first category, “very high potential”, is represented by nine areas (26,392 ha), the second category, “high potential” by 53 areas (130,689 ha) and the third, “moderate” category by ten areas (8,237 ha).*
In areas of highest priority, an average of about 10 km of dikes must be removed or relocated.

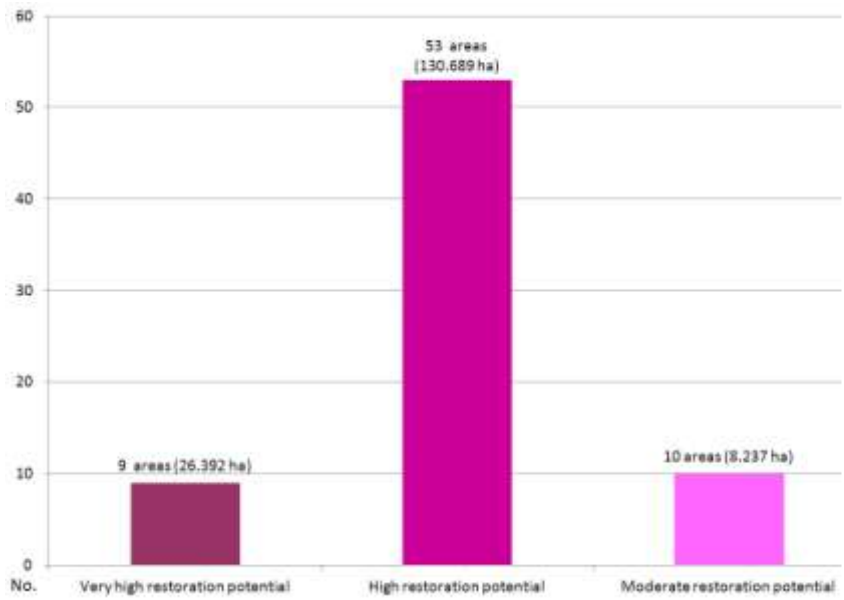


Figure ES 10: Prioritisation of floodplain areas for reconnection (compare fig. ES 11).

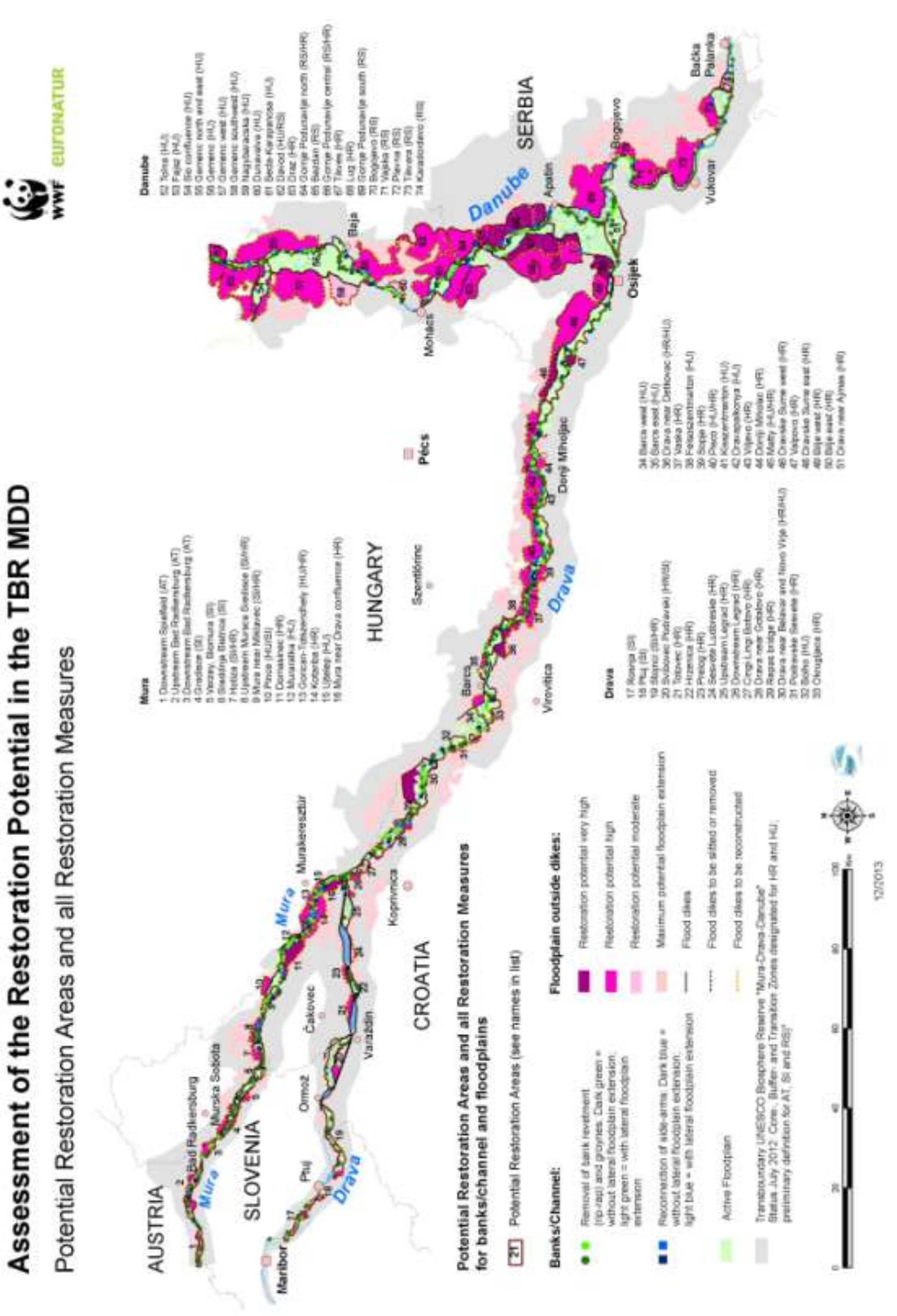


Figure ES 11: Joint map of potential restoration areas and measures.

Natural values at stake

The rich biodiversity of the TBR MDD is based on its extensive free-flowing river stretches and adjacent floodplain and wetland areas, and is reflected in a wide range of characteristic and endangered habitats and species. The area is notable for having the largest and best preserved softwood forests and floodplain areas in the Danube Basin (Kopački rit area) and highly dynamic and meandering river stretches with typical habitats such as gravel and sand banks, steep banks, river islands, side arms and oxbows (e.g. Lower Drava, Drava downstream Drava-Mura confluence, Border Mura between HR and SI). These qualities are the basis for largest breeding population of the white-tailed eagle in Continental Europe. The area is home for nearly the whole range of typical “river birds” such as little and common terns, little-ringed plover, sand piper, sand martin, kingfisher and bee-eater as well as nearly-extinct fish species such as the ship sturgeon. These species are excellent indicators for the state of the river landscape. Their habitats, however, are at risk. For example, nearly 80 % of the sand martin population along the Drava has been lost in the last 10 years, mainly due to the still-ongoing replacement of natural steep banks by new embankments. The restoration of natural conditions would be a big win for the TBR MDD. In addition to conserving biodiversity, it would bring multiple benefits for flood protection, water purification (and thus healthy drinking water), fish grounds, favourable groundwater conditions for forests and agriculture and recreation for local people.

Costs of restoration

A very preliminary cost estimate is based on reference projects in Austria and Germany and the assumption that prices (of planning, land purchase/compensation and restoration measures) are in general lower in the respective countries. The total cost would be €1.1 billion, which comprises removal of 652 km of embankments (€260 million), 120 side-channels for reconnection (€12 million only for works without dredging or land purchase) and reconnection of 164,900 ha of floodplain, including the relocation of flood dikes (€825 million). This would be shared by five countries (to be adjusted by prices and conditions over the coming decades).

Conclusions

Compared to other rivers in Europe, the stretches of the Mura, Drava and Danube rivers within the Transboundary Biosphere Reserve have retained more of their natural assets than many other Western and Central European rivers. However, there has been a considerable loss of natural river stretches and floodplains in the last 100 years (up to 1,100 km of natural river banks (total length) with associated gravel and sand bars and 80 % of the former floodplain areas). Comprehensive restoration efforts are essential in the upcoming decades to counteract and reverse these negative trends.

The study shows that there is substantial restoration potential in this area. It outlines a way forward for comprehensive restoration, starting with the removal of river bank reinforcements and reconnection of side-channels and culminating with the large-scale reconnection of floodplain areas with the rivers.

Restoration projects, implemented in sufficient numbers, could significantly reduce the further degradation of the river bed and floodplain areas along the entire river reaches. This would safeguard the long-term survival of the characteristic habitats and species, and of the ecosystem benefits the river system provides.

Restoration is definitely one of the major tasks of the Transboundary Biosphere Reserve “Mura-Drava-Danube” and will support the countries in achieving EU evironmental objectives (WFD, FFHD, BD, FD) as well as the objectives agreed in the international “Drava Declaration” in Maribor in September 2008.

In order to achieve the appropriate implementation a transboundary river restoration programme should be developed across the five countries. EU funding e.g. LIFE, Structural Funds etc. should be used to develop and implement concrete restoration projects. There are already first restoration projects in the TBR area implemented and ongoing as well as good practice examples across Europe (e.g. Danube, Upper Drava and Mura, Loire/Allier, Elbe, Rhine) which demonstrate the multiple benefits of restoration for nature and people.

1. Introduction

Spanning Austria, Croatia, Hungary, Serbia and Slovenia, the lower courses of the Drava and Mura Rivers and related sections of the Danube are among Europe's most ecologically important river and floodplain areas, the "Amazon of Europe". The three rivers form a 725 kilometers long "green belt" connecting 886,400 hectares of highly valuable natural and cultural landscapes and a network of 12 single protected areas from all five countries (figure 1).

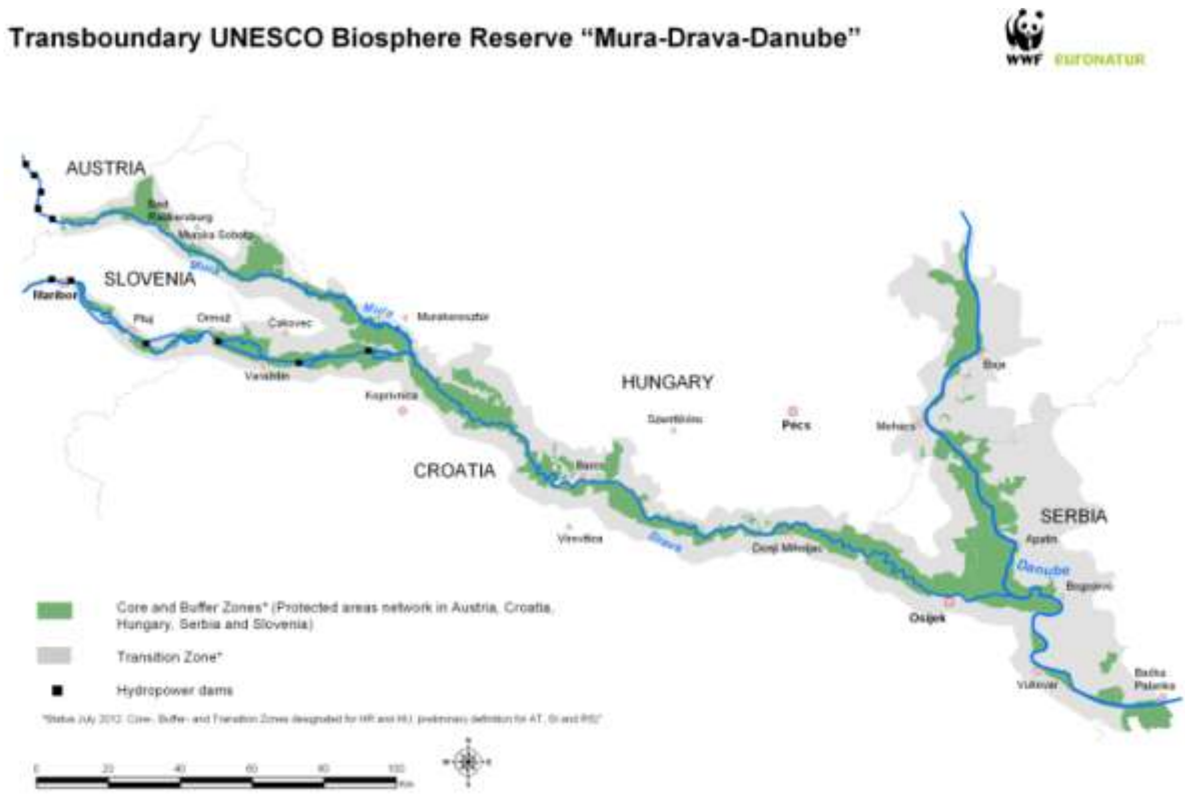


Figure 1: Map overview of project area, the TBR MDD.

On 25 March 2011, the ministers responsible for environment of Austria, Croatia, Hungary, Serbia and Slovenia signed a declaration to jointly protect and manage this area as the Transboundary UNESCO Biosphere Reserve Mura-Drava-Danube (TBR MDD). The section within Croatia and Hungary has already been designated by UNESCO in 2012, whereas designation of the sections within Austria, Serbia and Slovenia is on the way. Once established it will be Europe´s largest protected river area and the world's first pentalateral Biosphere Reserve.

Despite the international commitment, the high ecological values of the river systems are threatened by an increased degradation of the river and floodplains areas. One century of river regulation, building of flood protection dikes, extraction of gravel and sand as well as construction of hydropower dams upstream have led to a loss of more than 80 % of the former floodplain areas and a degradation of about 1,100 km of natural river banks.

The environmental and socio-economic consequences are considerable. The degradation of river and floodplains lead to deepening of riverbeds, falling groundwater tables, drying out of wetlands and floodplain forests. It ruins natural river habitats and threatens endangered species. This is shown among others in the decline of breeding pairs of the sand martin (Riparia riparia) along the Drava, falling from 12,000 in 2005 to 3,000 in 2010. It also has negative impacts on drinking water, forests, agriculture, fish stocks and natural flood protection of the area.

Faced with this undesired situation, restoration is recognised as a matter to be attended to. One major challenge of the joint Biosphere Reserve Mura-Drave-Danube, as agreed by the ministers and formulated in follow-up actions, is to preserve the natural river stretches and floodplain areas, while aiming for the restoration of already degraded parts.

And the potential for restoration is enormous. This study shows that up to 650 km destroyed river banks in bends of the Mura, Drava and Danube could be restored and up to 225,447 ha of lost floodplain areas could be re-connected with the rivers again. It also provides a list of 74 priority sites for floodplain restoration.

Restoration would be a big win for the TBR MDD. It would bring multiple benefits, most of all substantial gains in biodiversity conservation, but also natural flood protection, water purification, healthy drinking water, fish grounds, forests and recreation for local people.

River and floodplain restoration is also a key instrument in achieving the EU environmental objectives according to the EU Water Framework Directive (WFD), Habitat and Birds Directives (FFHD) and

Floods Directive (FD) for the countries involved. Restoration efforts are also enforced by international agreements (Ramsar, Bern Conventions etc.) as well as the international “Drava Declaration” which was signed by the Heads of Delegation of the International Commission for the Protection of the Danube River (ICPDR) of all five Drava countries in Maribor in September 2008.

In order to achieve the appropriate implementation of these goals, a transboundary river restoration strategy and programme should be developed across the five countries. The TBR MDD provides the ideal international framework for this.

In recent years several countries in the TBR MDD have already undertaken first restoration efforts (e.g. for the Mura in Austria and Slovenia, and for the Danube and the Drava in Hungary). These efforts should be supported and widened in scope. The aim of this study is to provide further impetus for these developments.

EU funding as LIFE and the Structural Funds can be used to outline and implement concrete restoration projects. The first experiences of restoration efforts across the countries show that restoration offers a big gain for nature and for the people of the region.

2. Assessment approach

The initial phase of the study consisted of a detailed analysis of the three rivers using hydromorphological and habitat/floodplain inventories and floodplain delineations (morphological, existing (active) and former floodplains) resulting in a premise on restoration measure potentials. This phase included the preparation and completion of existing data by GIS mapping and depended upon previous studies as reported in the International Association for Danube Research (IAD) pilot study on hydromorphological assessment (Schwarz 2007), ICPDR - Joint Danube Survey (JDS 2) with relevant topics of hydromorphological assessment along the entire Danube (ICPDR 2008), WWF Restoration Potential studies for the Danube Basin and the Lower Danube (Schwarz 2010 and Schwarz 2011) and DravaVision, (Schwarz & Mohl 2009).

The IAD pilot study defines hydromorphological “River section types” and their “reference conditions”. These serve as a basis in a direct comparison between still existing near-natural habitats and those habitats to be restored. It is important to rank potential restoration measures within restoration areas according to these reference conditions, for braided, ana-branching and meandering stretches require different restoration measures due to their specific hydromorphological characteristics.

To underline the hydromorphological intactness of individual reaches existing bird data was used. Regular monitoring since about 2005 is provided by Darko Grlica (Grlica 2012) and Borut Stumberger in particular for steep banks and gravel/sand bars.

The main restoration goal is the initiation and promotion of self-sustaining processes for hydromorphological dynamics in the river, along its banks and floodplains as opposed to local measures like only the conservation of oxbows, construction of polders or measures requiring predominantly extensive dredging (regarding side-channels or lowering of floodplain parts).

Based on the assessment, as a next step a concise restoration proposal was prepared that included river and floodplain restoration measures such as the removal of rip-rap banks and groynes, reconnection of side-arms and oxbows as well as the indication of potential floodplain areas for reconnection. The results are detailed restoration maps in a scale of 1:25,000 (Danube 1:50,000).

Regarding the extension of floodplains beyond the existing flood protection dikes, a prioritisation of potential restoration areas lead to a manageable list of potential projects in support of next implementation steps. The prioritisation list includes a summary of the information on landuse/habitats, existing infrastructure (dikes, hydraulic structures), protected area status as well as the size of the areas involved (important for flood water retention).

This pragmatic approach will facilitate the definition of restoration targets and requirements for a final selection of a few project development areas. This study does not expand on the feasibility of individual restoration projects, in particular data of land owner-ship, must be taken into consideration for the next step. Croatia provides a public information system providing all the land owners, in Hungary, Slovenia and Austria similar data is available.

2.1 Principles for restoration measures

The efforts of restoration should be guided by hydromorphological improvements focussing on the reduction of technical structures such as bank revetment (rip-rap, groynes and side-arm closures) and maximisation of the lateral extension of active floodplains to initiate more lateral shift (e.g. Kondolf 2006). Wherever expansion of dynamic processes is feasible, focus should be given to the restoration of steep banks and lateral erosion. Extensions of floodplains should be evaluated in the light of flood protection concepts for the whole of the river corridors. For the assessment of biological quality elements under the WFD it is necessary to prepare a deeper analysis of hydromorphological reference conditions, based on the defined reference conditions. This will allow for the assessment of the current situation and to derive restoration targets. In most cases the restoration targets are only approximations and can only be realised in small steps or in small parts of the riparian landscape, limited by current impacts such as the chain of dams in Austria, Slovenia and Croatia. Following so called river scaling concepts those conditions should be applied to basin wide levels (for example for sediment balance) via longer river sections down to single short river reaches.

Over the past 100-200 years the rivers were seriously affected by channelisation for navigation and by dam construction and flood protection works. Negative effects due to changes in landuse in the catchment areas go back to 1,000-2,000 years. Changes in the catchment area, like deforestation and changes in agricultural practises are difficult to reverse. The same limitation applies to changes in river stretches with a chain of hydropower plants or within very dense settlements. However, the remaining free-flowing reaches in less dense populated areas still have a great potential for restoration.
As a preferred settlement area for the human civilisation, river valleys are a good indicator for the resilience of ecosystems and host a great potential for restoration. But restoration is a challenging task and will need several generations as we know from the slow but continuous implementation of large-scale river-floodplain restoration projects in North America and Europe (see for example BfN, 2009).

2.2 Base data assessment

2.2.1 Hydromorphology and floodplains

Hydromorphological inventories and assessments

A good database exist based on the IAD study (Schwarz 2007) for lower Mura and Drava rivers as well as for Danube by the Kopački Rit study (Schwarz 2005) and the JDS study (ICPDR 2008). A slight decrease of hydromorphological conditions was indicated by a short analysis from 2011 (Schwarz et al. 2012), mostly due to the ongoing channel incision, further dredging and new bank revetments (rip-rap). The dredging was mostly for commercial reasons and exceeded the annual transport capacities twice over the past decades. The scope of this activity is currently reduced.

The assessments of this study focus on the channel and river banks. Floodplains are at least basically covered, as more precise data regarding the delineation and landuse of floodplains was a prerequisite that could not always met. The proposal of restoration sites emphasises the rectification and systematic stabilisation of the main channels, in particular the river banks were assessed in detail.

Floodplain delineation

Earlier studies determined the total size of floodplains and its major lowland floodplains in the Danube basin (DPRP 1999). In the current study, the delineation of active and morphological floodplains along the three rivers was completely revised and extended giving a rather good approximation of the extent of potentially flooded areas. Comparable approaches can be found for the German Floodplain Balance and Assessment (BfN 2009). Projects like the EU "Danube Floodrisk" should be able to verify these figures based on high resolution DEM and 2D hydrodynamic modelling on a transboundary base.

Even in the still active floodplains along the free-flowing river sections of the TBR MDD, changes over the past century have been substantial. The most important factor causing change is a decrease in flood dynamics (the duration and magnitude of flooding) and consequently of sediment dynamics. Water stored in upstream reservoirs (hydropower dams), as part of flood protection measures, has altered the discharge regime. This has caused changes in the ecological conditions of floodplains at most of the rivers. Another important issue affecting ecological conditions is the aggradation of fine sediment in floodplains caused by river regulation works (narrowing of the river-floodplain cross section by dikes, deepening of channels) and short flood peaks with often very high suspended load concentrations (due to the changed hydrological regime and land-use practices).

Floodplain types assessed in this study applicable for Mura, Drava and Danube are:

1) *Active floodplains* with still more or less typical habitat conditions (natural or near-natural), side-arms with pioneer stands, floodplain forests and pastures, wetlands and oxbows.
2) *Active elevated floodplains*, strongly altered due to substantial aggradation (sedimentation) and mostly used for agriculture; but still potentially flooded during major flood events (e.g. all 50-100 years).
3) *Active, but strongly altered floodplains* along impounded reaches under influence of backwater or residual former river channels (often disconnected laterally from the main channel). Both types are still flooded regularly by tributary

confluences and the backwater of major flood events in the main channel (from 5-10 year flood events and upwards).

4) *Former floodplains* (within the morphological floodplain) as remnants of the maximum potential floodplain area defined by the postglacial lower terraces and natural floodplain delineation, e.g. in valley breakthroughs.
5) *Flood polders* are so far not found within the project area.

The floodplain delineation is based on DEM/SRTM and Aster DEM elevation data combined with high resolution satellite data - such as GoogleEarth - and the definition of terraces by a combination of Aster elevation data with satellite data and physical riparian landscape features, like former side channels, oxbows, meander loops riffles and pools. These landscape features are mostly indicated by moisture and vegetation, even visible in agricultural land.

Entry data:

- DEM data (Aster 2) and basic river flow hydrological data (peak discharges, flow regime, applied without modelling but for basic verification).
- Landuse data (CORINE and other available classifications often lacking spatial resolution, therefore overlaid and extracted from high resolution satellite images such as Google Earth).
- Diverse maps (historical topographic maps and other thematic maps, including online available sources) such as geomorphological and soil maps. Flood risk maps were also used as well as corresponding vector data (for rivers, dams and flood dikes).

There is still no systematic floodplain inventory for the Drava or this part of the Danube basin (such as for Austria, SCHWARZ et al. 2010), neither does a floodplain typology exist (such as for Germany, KOENZEN 2005). Restoration proposals like this should consider the wide range of floodplain types from high alpine to huge lowland floodplains as well as hydromorphological indicators (e.g. HABERSACK et al. 2008). From Austria (which hosts a great variety of floodplains) we know from red lists of habitats that floodplains can be seen as biodiversity hotspots that are highly endangered regardless of type and characteristics.

2.2.2 Landuse/ main habitats

As the large scale overview mapping such as CORINE (landuse) or the Croatian general habitat map (or for that matter actually all landuse maps in a scale of approximately 1:100,000) are insufficiently detailed, it was necessary to prepare a map with higher resolution and fairly homogenise classes (which is difficult in particularly due to the transboundary situation).

Working scale for these maps was approximately 1:10,000 – 1:25,000 (for Danube and for some remote areas 1:50,000). In total about 17,000 habitat polygons were digitized in 14 summarizing classes allowing a basic assessment. These maps can of course not substitute national habitat maps or even local detailled vegetation maps, therefore the assessment based on FFH annex habitats or even EUNIS habitat classes is not possible (with the exception of some stretches in which the primary data was of sufficient high resolution).

2.2.3 Birds

Data from 2005-2012 for Mura and Drava, and from 2010 onwards including the Danube, give a concise monitoring overview of breeding sites for steep bank and gravel/sand bar breeders prepared by Darko Grlica (Natural History Society Drava), e.g. Grlica 2012 and Borut Stumberger (Euronatur). This data is used in support of the hydromorphological assessment.

In the year 2010 “river watch” maps were prepared showing the distribution of important species during the past 10 years. For this study only the breeding density per km of intact steep bank was considered as a basic estimation on how the population could increase after successful restoration.

2.3 Short review of existing restoration projects

No specific analysis of already existing restoration projects in the TBR MDD was prepared (several EU projects like “RESTORE” and http://www.restorerivers.eu/ try to collect and compare restoration experiences throughout Europe).

In Austria an Interreg project was carried out (border Mura widening and side-channel reconnection along some hundred meters), in Slovenia several Life projects were completed (e.g. BioMura or near Melinci/Mota). In Croatia several smaller projects were finished (wetland rehabilitation near Virovitica, smaller projects in Kopački Rit) and several proposals for oxbow management and reconnection along the lower Drava by Croatian Waters (Hrvatske Vode 2006) exisit. In Hungary several restoration measures were initiated by the Danube-Drava National park, in particular for Gemenc, but also along the Drava (recently first side-channel reconnections) and by WWF (proposals for side-channel and oxbow reconnection). In Serbia smaller wetland management projects were completed recently and further proposals are planned by Institute for Nature Conservation for Gornje Podunavlje protected area.

The output of this study should support and facilitate the further development of restoration projects on national but also on transboundary level (Croatia will become eligible for EU Funding such as “Life” from summer 2013 onwards).

A separate assessment, exchange of experience and comparison of measures and costs would be necessary. Especially evaluation of effectiveness and quality control of restoration measures over a longer period would be an important tool in the optimisation of new measures and projects (The River Restoration Centre (RRC) 2011).

2.4 Proposal of potential restoration areas and measures

A new comprehensive list of potential restoration areas was elaborated based on the analysis of the extensive background data and the list of already existing projects. New areas and river stretches were added iteratively (see figure 2) using criteria like:

- Landuse and habitats on both sides of the flood dikes.
- Exclusion of existing settlements and infrastructure.
- Current protection status (in particularly based on the UNESCO zone concept for the TBR MDD)
- Suitability for flood retention (size, shape and position).
- Lateral channel shift development.

- Main river section types (hydromorphological main units, which increase the feasibility of certain measures to improve the sediment deficit, lateral activity or oxbow management).

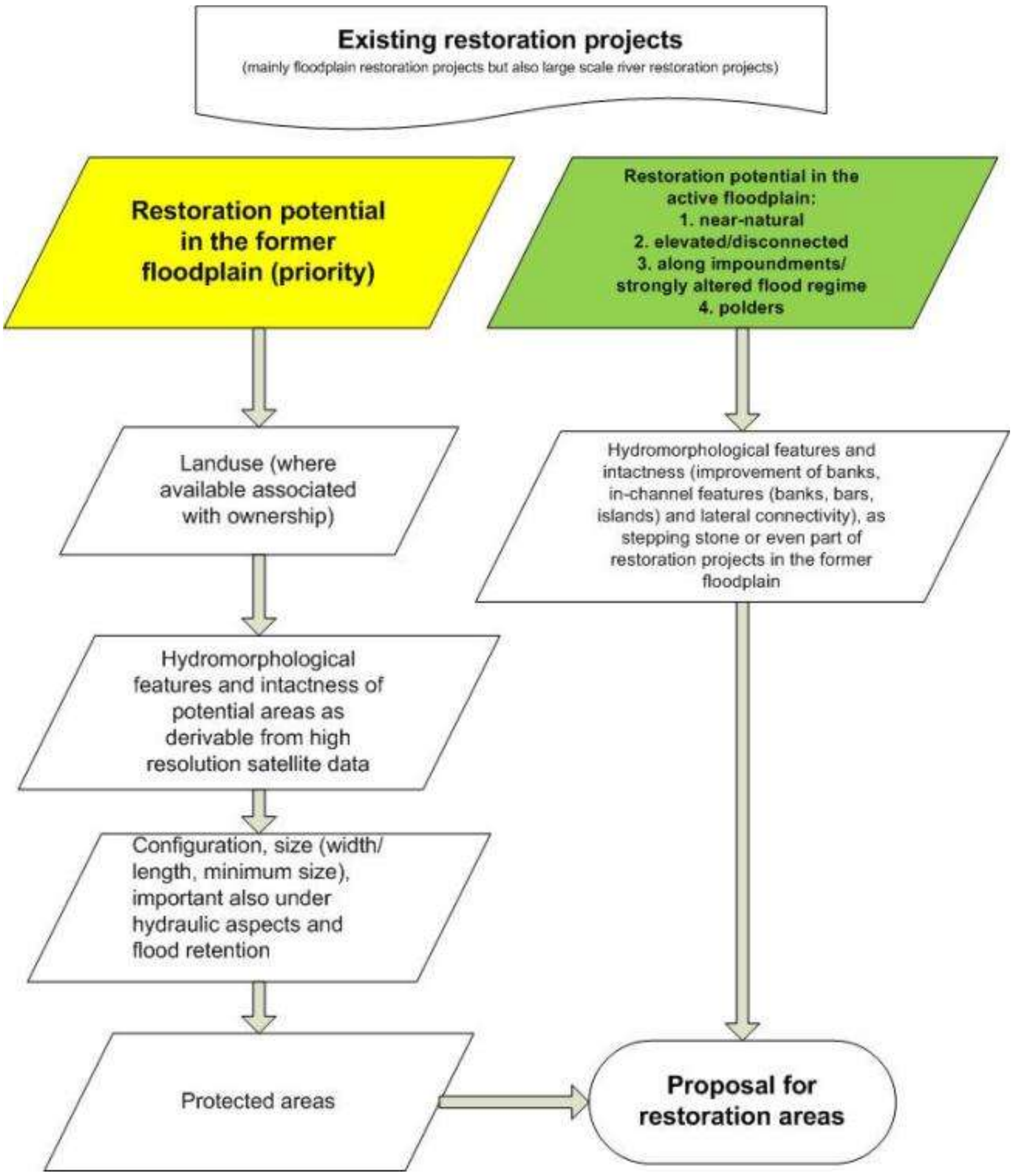


Figure 2: Proposal of new potential restoration areas used as basis for this study (from Schwarz 2010).

The various restoration proposals were collected into three restoration options:

Option 1: Minimum short-term restoration potential (restoration within the active floodplain): Removal of bank/channel stabilisation and improved lateral connectivity limited to the river and the river banks in the active floodplain.

Option 2: Maximum restoration potential as long-term restoration target (maximum floodplain extension): Removal of bank/channel stabilisation and improved lateral connectivity based on the theoretic maximum for lateral enlargement of the floodplains, including the morphological and former floodplains. Excluded are areas with settlements and infrastructure. Some potential restoration areas have to include smaller tributaries to secure their connection with water sources by tributaries and high groundwater level.

Option 3: Proposed restoration potential for the medium term (prioritised restoration areas and projects beyond the active floodplain): Removal of bank/channel stabilisation and improved lateral connectivity based on a prioritisation of selected restoration areas (based on floodplain areas for reconnection).

Measures:

Removal of bank/channel stabilisation works: The removal of bank revetment (rip-rap), groynes and other reflectors is a feasible and successful restoration measure, and a common approach in many countries. The bank sections proposed for restoration are defined based on the inventory of banks (impacted banks by rip-rap and old partially collapsed revetments). The length of proposed sections varies between 100 m and 5 km. If those bank protections are situated in bands and curves the potential for high dynamic steep bank development was estimated. This creates a particularly cost-efficient restoration measure by improvement of pioneer habitats, steep banks, point bars and reactivation of lateral gradient of bed material (in particular gravel to coarse sand).

Side-arms: Only the main side-arms were taken into consideration. In many cases side-arms have to be restored to the river channel on both their upper and lower ends. In cases in which the side-arm extends to the former floodplain, both ends have to get a connection through the flood dike, which is to be slitted or removed. More technical solutions for reconnection, as for example the connection of oxbows in the former floodplain with the main channel by a culvert, were not considered or proposed. A full in-detail assessment to find the best and most feasible solutions is always required. Due to the long period of disconnection during which incision of main channel have occurred, differences in elevation are in several cases a serious danger for the realisation of restoration goals (as differences might be up to 1.5-2 m). The initiation of bank erosion and self re-connection processes should have priority over more expensive reconnection measures that require regular dredging or the construction of structures.

Floodplain extension: The relocation of flood dikes is the most substantial restoration target of entire riparian landscapes in the long term. Only a few successful examples of large scale extensions exist worldwide, but the planning of such projects is widely spread. In many cases the old dike must be removed or at least sufficiently opened and a new dike must be build. Where terraces protect settlements along the edge of the morphological floodplain it is not necessary to build new dikes. In special cases existing cross dikes or traffic lines (highway, railway) can take over the function of flood defence dike. An individual assessment based on detailed elevation models and hydraulic modelling is necessary to find the best solution for each area. Restoration requires the change of landuse from the current forms of intensive agricultural towards more extensive types of agriculture such as meadows. Changes like these also apply to floodplain remnants such as oxbows and floodplain forests, which serve as a buffer for nutrients and fine sediment input. In addition to the ecological improvements and more lateral space for the rivers, the increase of retention volume has significant positive effects on local and regional flood levels. A chain of larger retention areas can reduce the flood risk for areas downstream by reducing the wave volume, diminishing of flood peak and retardation of flood propagation. As an example: the Tullnerfeld on the Danube between Krems/Wachau and Vienna (25,000 ha) reduces the 100-year flood discharge with about 1,200 m³/s further downstream (10,000 m³/s instead of 11,200 m³/s) (ZENAR 2003). The Kopački Rit is also well known for reducing flood discharges further downstream.

The difference of natural flowing retention and artificial flood polder retention lies in the difference in strategy (reduced flow volume over a certain stretch versus a cut-off of the flood peak below a critical mark). Other differences are related to maintenance costs and the possibility for operation. A functioning polder relies on precise hydrological forecasts and technical equipment such as the inlet- and outlet-structures. Polders could be on the long-term more expensive. Ecologically the natural retention is much more efficient and sustainable. If improvement of the ecological quality of the polder area is an objective additional “ecological flooding” is necessary as such operated for polders along the Upper Rhine in Germany and France.

2.5 Floodplain prioritisation for reconnection

The prioritisation of the proposed restoration options focus on the overall management objectives, which are:

1. Hydromorphological improvements (improvement of sediment balance and in support of the WFD by improving habitats for biological quality elements (fish, macrozoobenthos, macrophytes), nutrient reduction and carbon retention in floodplains). The river basin management plans under the WFD should be coordinated on national and international level.

2. Ecological improvements (FFH), in particular improvement of highly dynamic habitats (pioneer stands on gravel, sand and mud), but also of soft and hardwood forests and lowland meadows.

3. Flood mitigation (FD), increase of floodplain areas can have significant positive effects on flood mitigation, reduced flood magnitude and propagation speed. A further positive effect of dikes away from the river is a possible lower dike crest and less intensive maintenance compared to dikes located very close to the river. Dikes in several countries must by renovated within the next decades.

The prioritisation allows a basic estimation of restoration potential according to very high (1), high (2) or moderate (3) under the given overall management objectives. These categories are based on the following parameters:

1. Landuse and habitats: Percentage of agricultural area (mainly fields) versus valuable former floodplain habitats outside the flood protection dike:

<30 % agriculture = very high (1)

30-60 % agriculture = high (2)

> 60 % agriculture = moderate (3)

For other landuse and habitat groups (forests, grasslands, and wetlands) the study assumes that these habitats and their extensive use will not be impacted by restoration projects but benefit from them. For farmers compensation mechanism must be defined.

2. Nature protection: Protection status (FFH and other protected areas, in particular for areas beyond the active floodplain):

>60 % overlap = very high (1)

30-60 % = high (2)

<30 % = moderate (3)

3. Flood protection: Size classes as an indicator for retention capacity. Smaller areas are cheaper and more feasible to restore, they can have local measurable benefits for flood protection, however for the whole corridor they would have no significant influence:

Size classes (retention capacity) for Mura and Drava:

>3,000 ha = very high (1)

500- 3,000 ha = high (2)

<500 ha = moderate (3)

Size classes (retention capacity) for Danube (aligned with previous studies) are > 5,000 ha; 1000-5000 ha; <1,000 ha.

4. Hydromorphological status: Depending on the hydromorphological status and in particular related to channel incision (deepening of the main channel) restoration and lateral shift is more or less affordable and feasible. The base information is coming from Drava-Mura Survey (IAD) and JDS 2 (ICPDR) for Danube. The overall hydromorphological categories (five class assessment) are used:

Overall hydromorphological category:

class 1-2 = very high (1)

class 3 = high (2)

class 4-5 = moderate (3)

5. Dike Removal: As the proportion of existing dike length to newly constructed dike length after restoration:

< 100 % = very high (in the best case floodplains could be expand towards natural terraces or at least significantly decreasing length of existing dikes)

100-120 % = high (only slight increase of dike length)

> 120 % = moderate (not only the construction costs but also the land purchase for the area covered directly by the dike is expensive)

6. River section type (reference conditions): Evaluation of improvement of natural hydromorphological dynamics (type and size specific) through restoration (self-reconnection of disconnected side-arms or oxbows, channel shift, steep banks) (The Mura was subdivided in an upper anabranching and lower meandering part, the Drava was subdivided in two stretches upstream the Mura confluence (partially braiding river system) and two part downstream of Mura confluence (anabranching and meandering). Finally the Danube was split into two parts, north of the Drava confluence in a purly meandering river system. Downstream of the confluence with Drava Danube is limited by loess steep terrace on the southern bank, building a river system with truncated meander and many side-arms):

1 = very high

2 = high

3 = moderate

The final assessment value can be calculated as the mean value of the six parameters with arithmetic classes: 1-1.6 will result in a “very high”, 1.7-2.3 in “high” and 2.4-3.0 in “moderate” restoration potential. Additionally the matrix table in the result chapter 3 allows the individual comparison for all or selected parameters.

From the scientific point of view, two extra aspects needed to be addressed: The amount of gravel was estimated roughly that is gained by newly initiated steep banks and lateral erosion This potentially reduces the bed load deficit in the main channel as well as generates new breeding sites of sand martin colonies breeding in the steep banks. Finally, initial cost estimation are made for bank and dike removal, as well as purchase of land is given (no detailed cost estimations based on detailed land owner-ship due to different costs in various countries, future maintenance and usage of areas etc. are given).

These two parameters influence feasibility, but were excluded from the prioritisation due to their data incompleteness. Beyond these estimations, the future implementation of large scale restoration projects depends on various factors such as the political willingness, local initiatives, specific funding opportunities in combination with compensation measures for other projects and many more aspects (compare chapter 4).

3. Results

The first sub-chapter presents the hydromorphological reference conditions and river section types, established in earlier studies in 2005 and 2006 (Schwarz 2005 and Schwarz 2006) as a basic framework for the understanding of the riparian landscape and as the main outline for large scale river restoration projects. The next three sub-chapters summarise the results for the habitats/landuse maps, the hydromorphological status of the channel/banks and in the third sub-chapter the status and loss of floodplains. The fifth and sixth sub-chapters highlight the restoration potential for channel/river banks and floodplains. In the last subchapter 74 potential restoration areas are proposed and visualised in detailed maps.

3.1 Hydromorphological reference conditions

The restoration of river-floodplain systems should be based on so-called reference conditions based on historical data, which then serve as a fundament to derive restoration targets from.

As an introduction to this concept the following map/image series on the following pages show the comparison of three significant development steps for the riparian landscapes in the TBR MDD. These maps will reveal strong anthropomorphic impact on the rivers by direct alteration through river engineering works. Other anthropomorphic impacts, like the landuse in the catchment areas and along the rivers is a function of a much longer process (about 1,500 years of de- and afforestation periods) and cannot easily be shown on maps or images:

1. Situation of about 1770 (taken from the First Austrian K&K Landesaufnahme, available as scans e.g. at www.arcanum.hu): River regulation in the TBR MDD was, at this time, only relevant for some special places of main capitals, locally for ship mills or small harbours.

2. Representing the situation in 1860 (taken from the Second Austrian K&K Landesaufnahme): At least for Drava and Mura nearly all significant shortenings (meander cut-offs) were already accomplished, the regulation of the Danube had started.

3. Situation 2005 (http://wikimapia.org/): Many time steps in the 20th century were omitted. Available are maps from 1885 (“Third Landesaufnahme”), 1925, 1940, 1970-1995 - but most map representations are heterogeneous and partially only available in black and white. The “visual” changes to today’s situation are not as significant as expected. On the contraty, even the rivers along the former Iron curtain (Mura, Drava) started to develop meanders again this century (compare figure 14). However the significant pressures of hydropower plants, sediment exploitation as well as flood protection works overlay this morphological development.

The figures 3-8 (see maps and image series on the following pages) highlight the most significant changes:

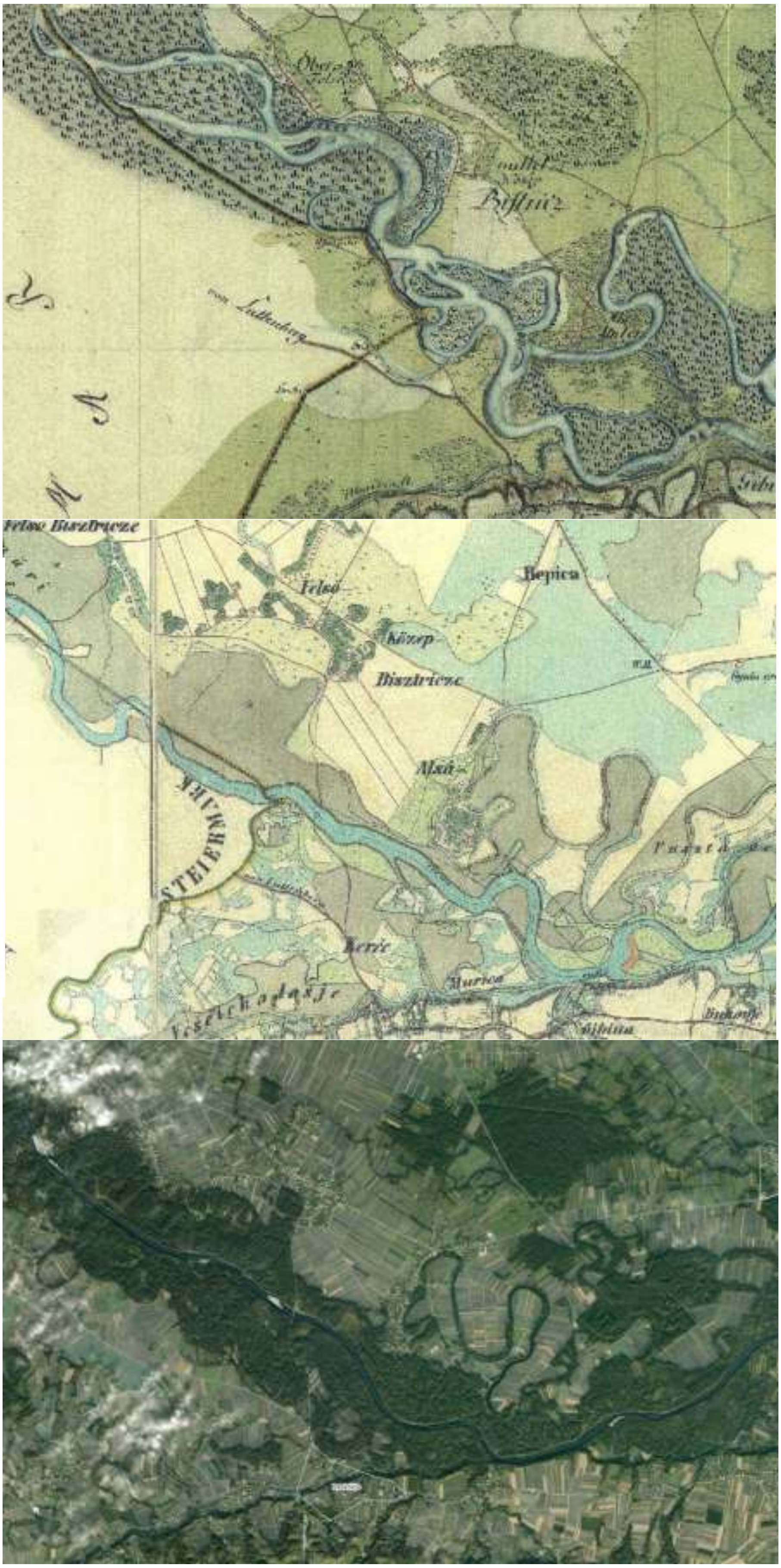


Figure 3: Mura: “Upper” Mura south of Melincze: The formerly highly dynamic ana-branching channel (several side-arms; the occurring gravel bars are not properly visualised in the map) was turned into a single-thread channel with much less lateral dynamic.

Figure 4: Lower Mura: The strongly meandering lower Mura was characterised by permanent cut-offs of natural meanders and large floodplain forests.

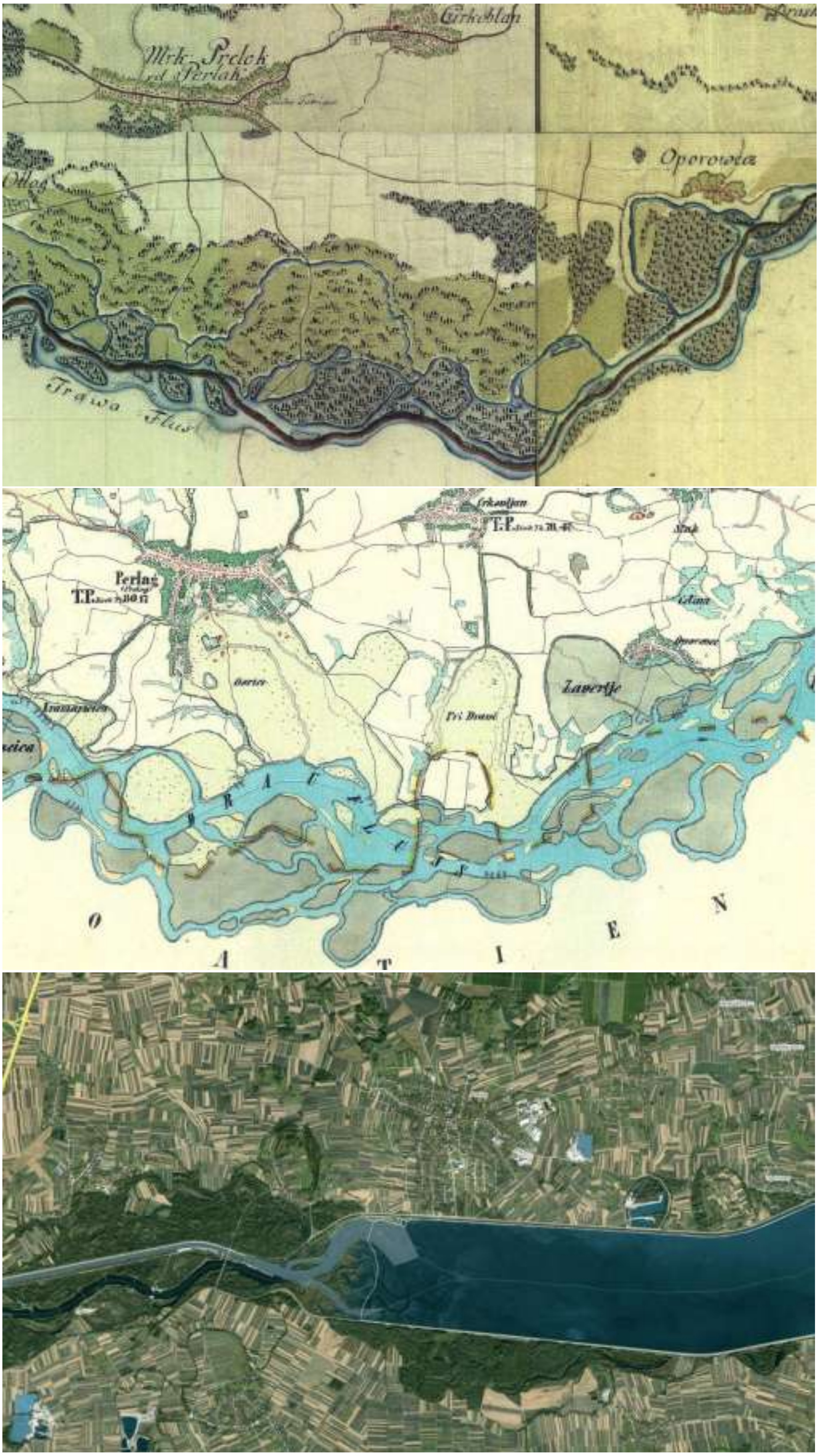


Figure 5: "Upper Drava" near Prelog reveals highly dynamic side-channels (partly braided river type) and islands disappeared by the hydropower reservoirs.

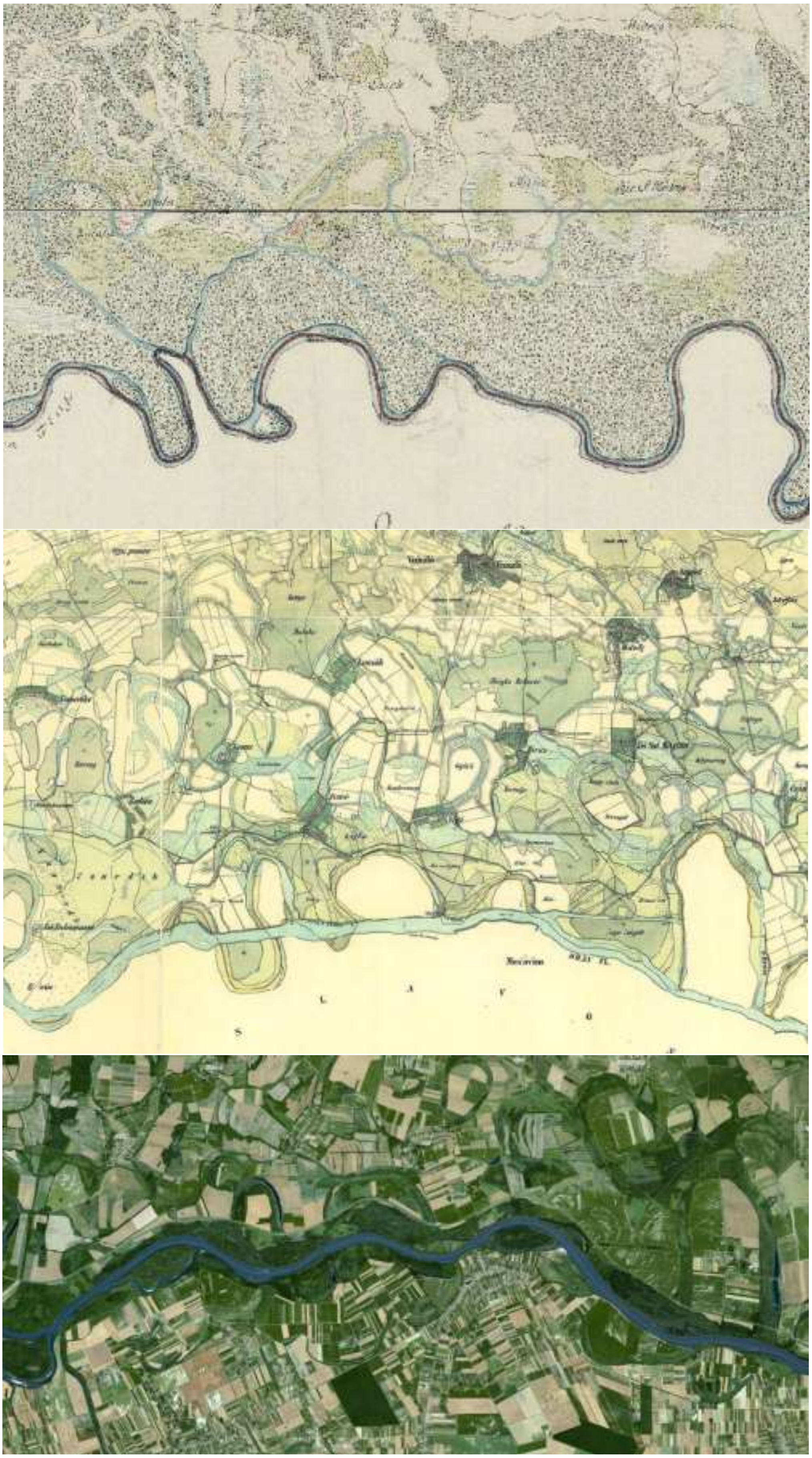


Figure 6: Lower Drava south of Ormansag plain, indicating the rather early straightening (meander cut-offs under the K&K monarchy mainly for navigation purposes and land reclamation) and the re-establishment of a more sinuous main channel after the first world war (compare fig. 14).

Figure 7: Meandering Danube near Batina: In this stretch the Danube provided a strongly meandering channel spreading on several locations into two main branches and reaching floodplain widths from over 15 km. Today the channel is regulated primarily for navigation purposes.

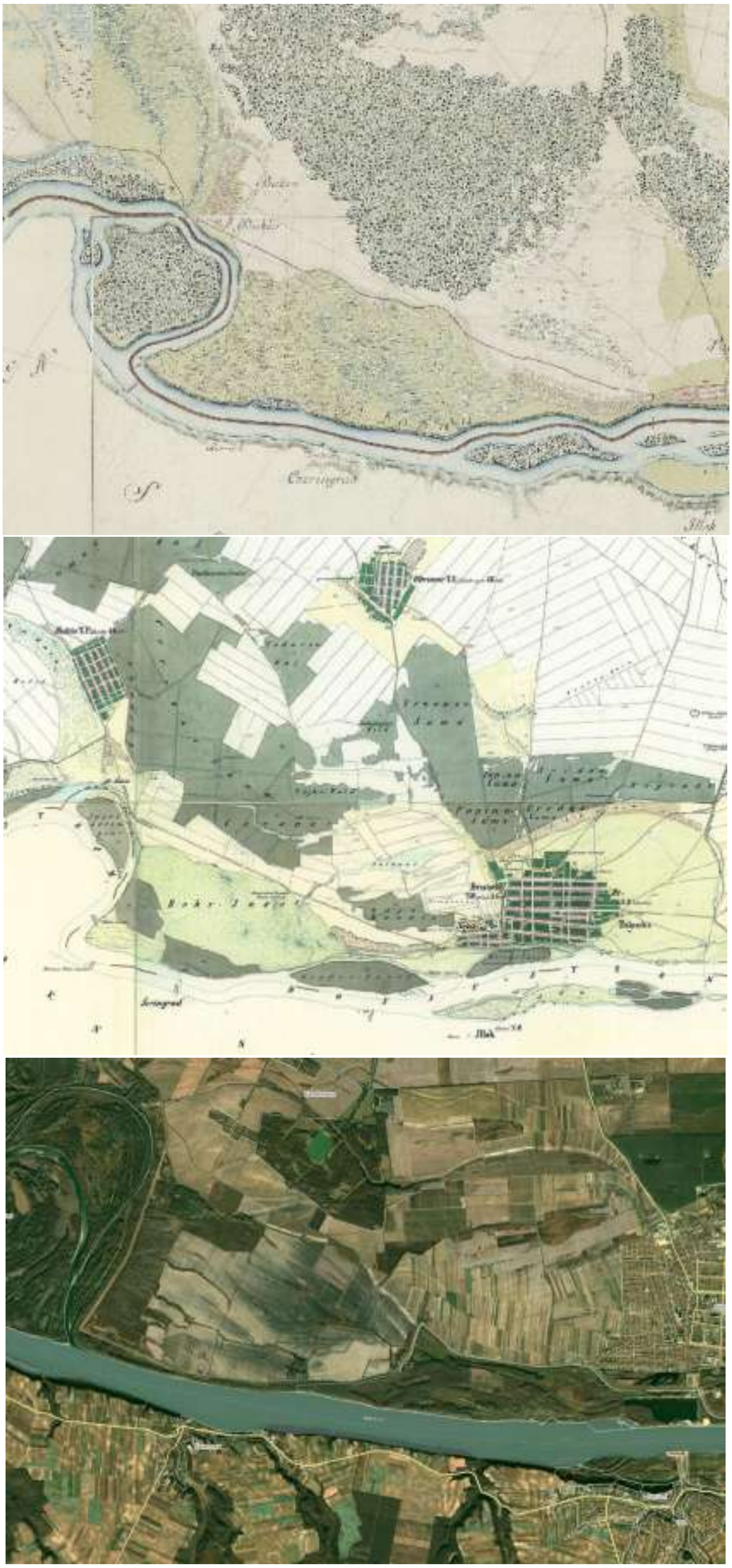


Figure 8: Danube along the steep bank near Illok: Even along the steep loess terrace
Danube tries to establish meander (or better the half of meanders or “truncated meanders”). Some inaccessible parts of the steep banks can be described still today as “natural”.

River section types as reference condition

The formulation of "river section types" offer an categorisation of main river stretches with similar parameters regarding discharge, slope, fluvial morphological indicators and features (like planform – whether meandering or braided, or by number and size of bars and islands) and floodplain types. This typology is used to estimate the deviation from the current state to this reference state. This facilitates the formulation of general restoration outlines for a certain river reach. The following maps and tables summarise river section types for all rivers with a focus on the Mura and Drava rivers.

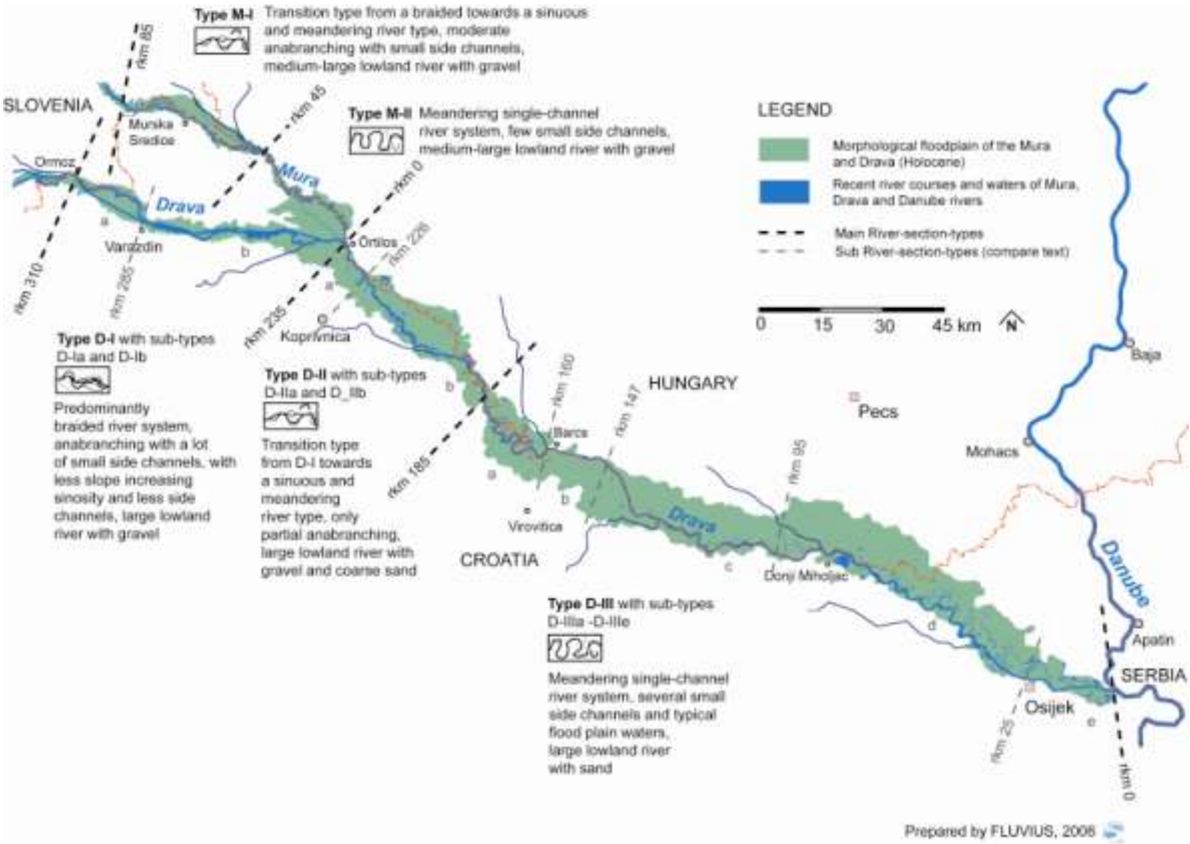


Figure 9: River section types for Lower Mura and Drava (Schwarz 2007).

Table 1: Description of River section types exemplary for Lower Mura and Drava.

River-section-type	Stretch location	Main characteristics
River-section-type Mura M-I	rkm 85 (Mura near Ljutomer) – rkm 45 (near Letenye)	Transition type from a braided towards a sinuous and meandering river type, moderate anabranching with small side channels, medium-large lowland river with gravel.
River-section-type Mura M-II	rkm 45 (near Letenye) – rkm 0 (Drava confluence, Örtilos)	Meandering single-channel river system, few small side channels, medium-large lowland river with gravel.
River-section-type Drava D-I	rkm 310 (Ormoz) – rkm 235 (Mura confluence, Örtilos/Legrad)	Predominantly braided river system, anabranching with a lot of small side channels, with less slope increasing sinuosity and less side channels, large lowland river with gravel.
River-section-type Drava D-II	rkm 235 (Mura confluence, Örtilos/Legrad) – rkm 185 (near Babocsa)	Transition type from D-I towards a sinuous and meandering river type, only partial anabranching, large lowland river with gravel and coarse sand.
River-section-type Drava D-III	rkm 185 (near Babocsa) – rkm 0 (Danube confluence, Aljmas)	Meandering single-channel river system, several small side channels and typical floodplain waters, large lowland river with sand.

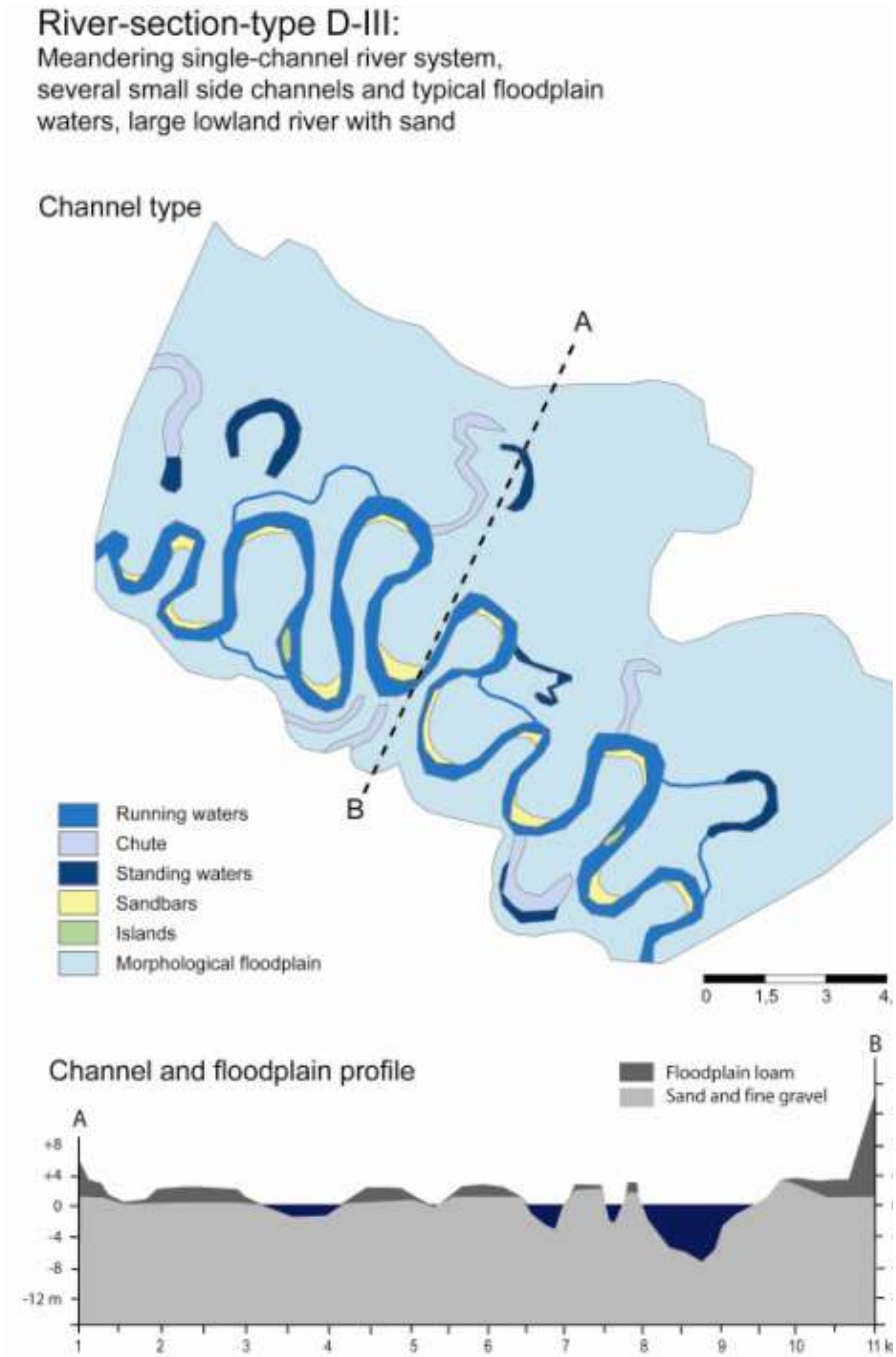


Figure 10: Visualisation of River section type (example for lower Drava, Schwarz 2007).

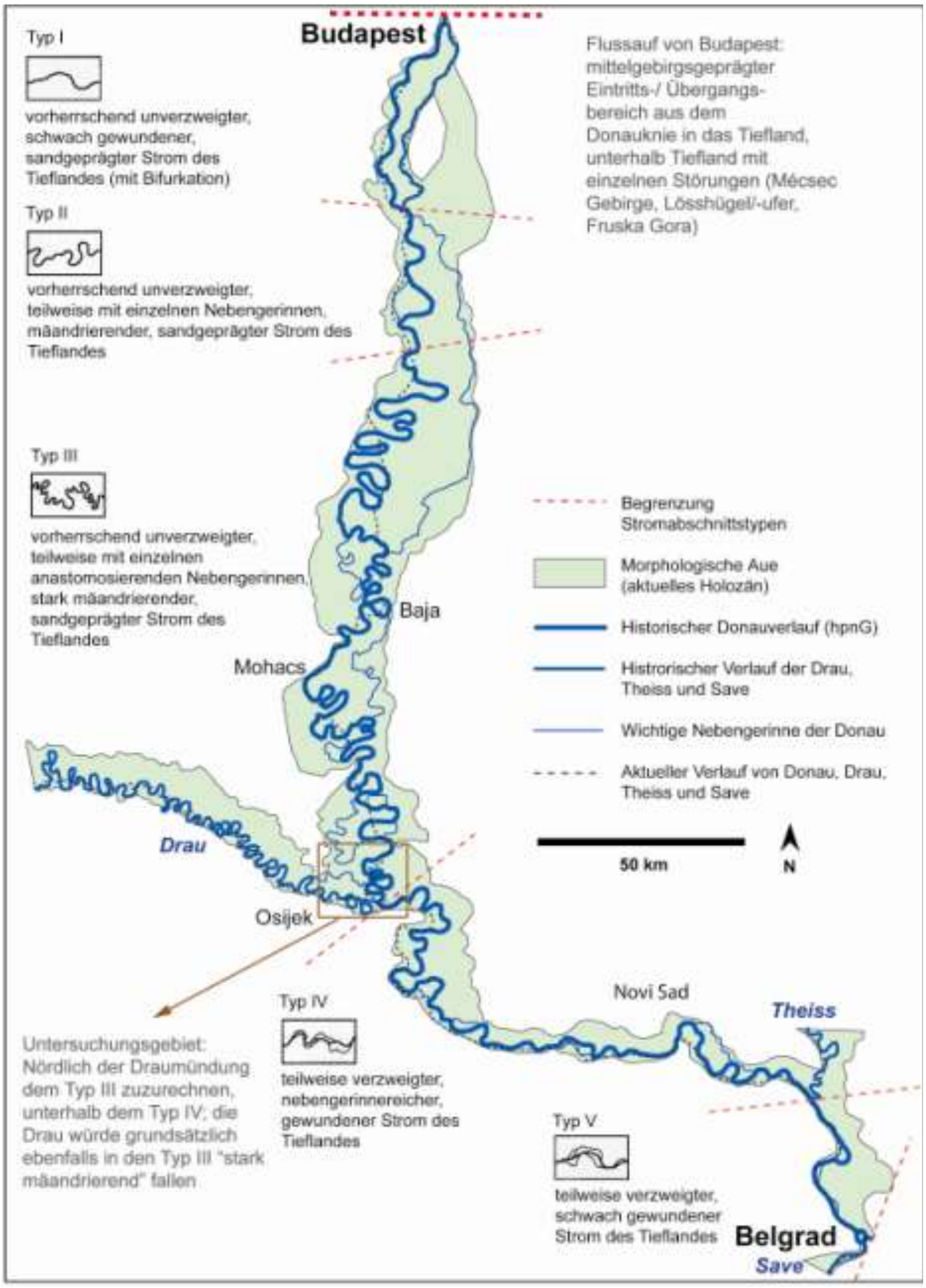


Figure 11: Main river section types for the Danube (in German, from Schwarz 2005) showing the two section types (up- and downstream from Drava confluence). North of the Drava confluence a purely meandering river system can be found. Downstream of the confluence the system is delimited by loess steep terrace on the southern shore, revealing a river system with truncated meanders and many side-arms.

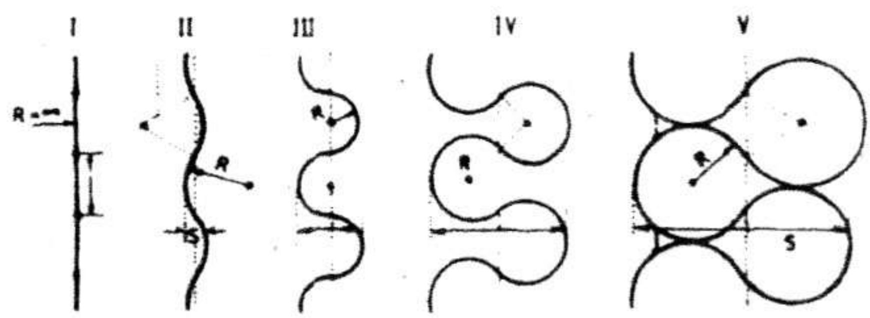
The morphological characterisation of the reference conditions offers a comprehensive way to compare the current situation with the reference state of a river section. Discrepancies are an indication for changes in the fluvio-morphologic processes. Assessments for the whole riverine landscape give valuable information for long-term restoration goals (tables 2, 3 and figure 12, all taken from Schwarz 2007).

Table 2: Important fluvio-morphological parameters in comparison with the reference conditions for the lower Mura River.

Parameter	Mura M-I (reference state/ current situation)	Mura M-II (reference state/ current situation)
Reach length in km	47 / 40	54 / 45
Channel width in m	80-250 / 50-180	80-150 / 40-100
Meander wave length in km	3.2 / 5.7	1.5 / 2.2
Meander amplitude	2 / 0.9	3.2 / 2.3
Sinuosity	1.5 / 1.3	2.1 / 1.9
Number of islands	approx. 80 / 10	7 / 4
5 meander development stages (in percent of the reach length, compare fig. 12)	II (40 %) / (50 %) III (45 %) / (50 %) IV (10 %) / (0 %)	II (20 %) / (49 %) III (40 %) / (50 %) IV (30 %) / (1 %) V (10 %) / (0 %)

Table 3 and figure 12: Important fluvio-morphological parameters in comparison with the reference conditions for the lower Drava River.

Parameter	Drava D-I (reference state/ current situation)	Drava D-II (dereference state / current situation)	Drava D-III (reference state/ current situation)
Reach length in km	95 / 75	68 / 50	295 / 185
Channel width in m	100-850 / 40-150	100-1500 / 80-450	200-400 / 120-300
Meander wave length in km	-	4 / 6.2	3.8 / 5.3
Meander amplitude	-	3.1 / 1.1	4.5 / 2.2
Sinuosity	1.3 / 1.1	1.5 / 1.2	2.2 / 1.5
Number of islands	approx. 500 / 30 (former Drava)	90 / 15	45 / 6
5 Meander development stages (in percent of the reach length, compare fig. 12)	- (braided)	II (20 %) / (70 %) III (60 %) / (30 %) IV (20 %) / (0 %)	II (15 %) / (50 %) III (45 %) / (50 %) IV (35 %) / (0 %) V (5 %) / (0 %)



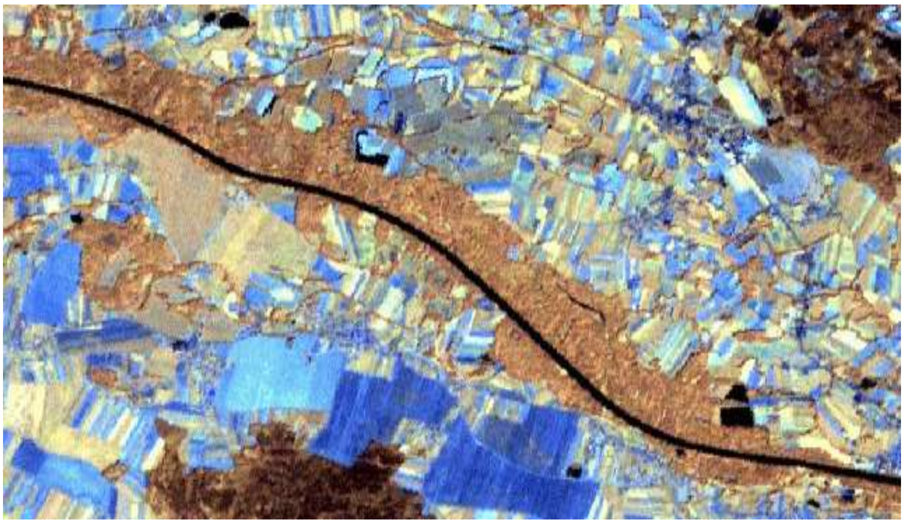
Different stages of meander development used for the morphological characterisation.

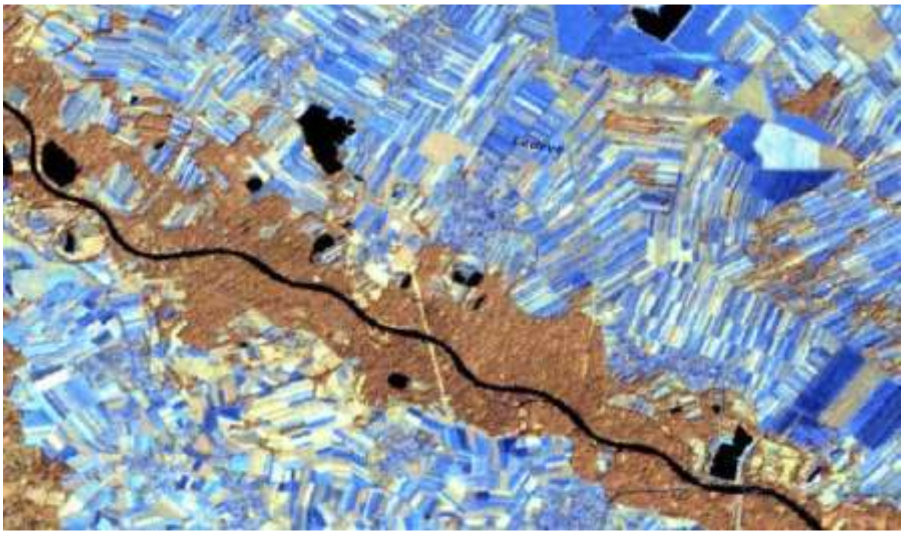
In comparison with the reference length, the overall decrease in river length for the Mura is moderate with only 15 %. However, the reduction of the lower meandering Drava is considerable, and reaches nearly 40 %. The average channel width of the Mura was reduced by about 30-40 %. The upper Drava D-I reach (table 3) lost about 40-80 % of its former average channel width and most of its variability in channel width.

The sinuosity (the ratio between the channel length and the valley length) and meander parameters, including the 5 stages of meander development (figure 12), clearly indicate the considerable reduction of meander activity for all sections. Only selected sub-sections such as D-IIIa and D-IIId still host typical meander sequences. Whereas the meanders of the lower Mura and of section D-IIa are mostly fixed by riprap and river engineering, section D-IIId still possesses conditions for a free meander development. The detailed evaluation of the distribution of the meander development stages for that section is very interesting as it currently comprises mostly initial stadiums of meanders and very few reaches of the fifth stage (with developed cut-offs). The main reason is the relatively short period of 150 years since the river was completely straightened for navigation. Since 1910 abandoned maintaining measures allowed for renewed meandering (see figure 14.).

At the end of this chapter, two examples of the application of hydromorphological assessment methods (CEN 2004 and 2010) and the resilience of riparian landscapes are presented (for Danube compare ICPDR 2008).

Figure 13 (next page): The hydromorphological assessment methods and consequently the derivation of the current river state to the reference conditions can be explained by comparing three river stretches in the upper Mura with partly similar basic hydromorphological characteristics. These streches are all partly braided to sinuous, anabranching to a meandering river system) which can be assessed by the five class CEN system (CEN 2004 and 2010) using integral values of channel, bank and floodplain assessments. The upper image shows the border Mura between Austria and Slovenia) which is classified as third class (moderately modified, banks/channel alone tends even to the fourth class), the second section is located further downstream and would barely reach the second class (slightly modified). The third section, already loacted along the Croatian border, could fall in the first stage (near-natural) but is on the boundary to be evaluted as second stage. The third section could serve as a reference state for restoration of the upper two stretches.





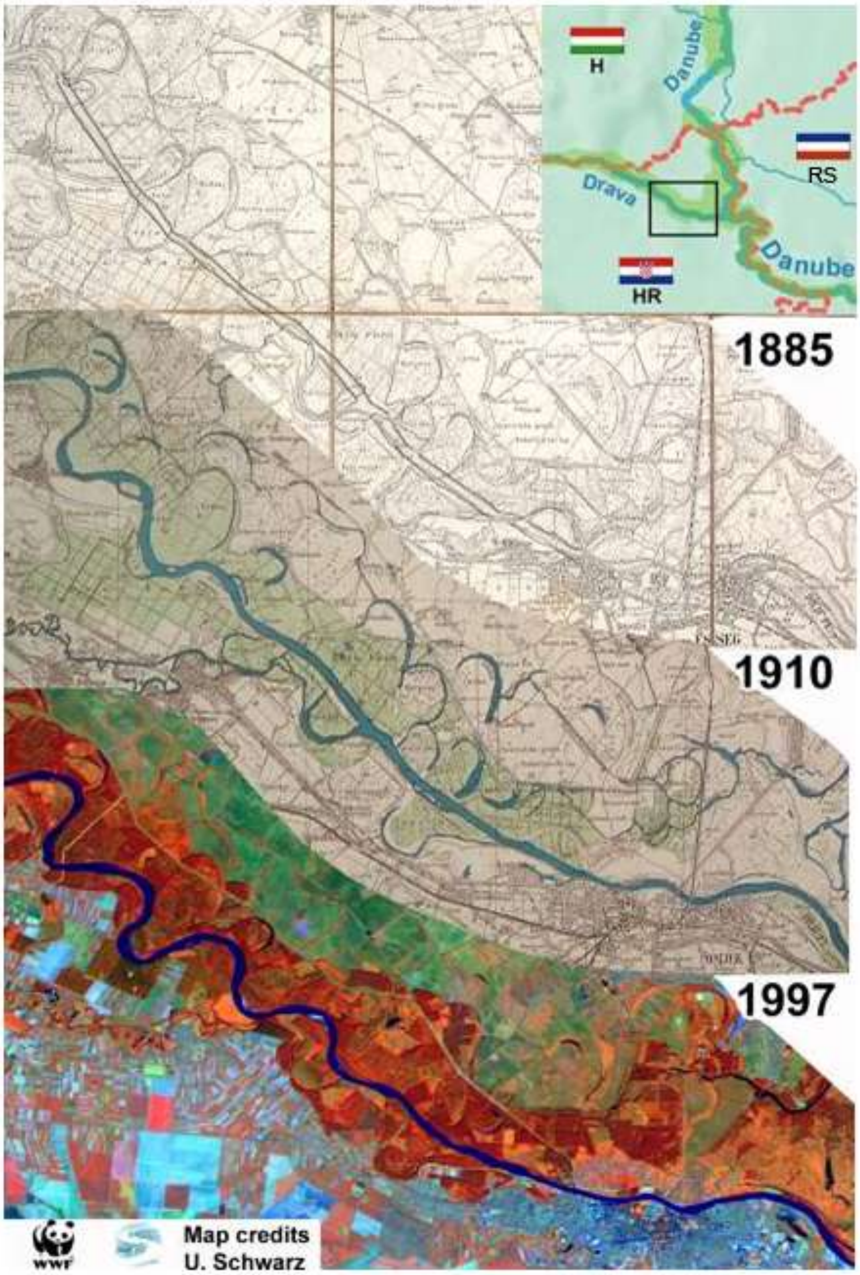


Figure 14: Time series of river course development upstream of Osijek (1885: complete straightening for navigation purposes under the Austrian-Hungarian monarchy; 1910: abandoned maintaining measures allow re-meandering; 1997: further re-meandering of the river course). The series show the resilience of riparian landscapes, even when influenced by altered upper river courses.

3.2 Land use/ main habitats

A total of about 380,500 ha were digitised, containing the entire active floodplain as well as those areas of the former floodplain which are subject of a detailed restoration potential analysis.

The data revealed to be rather homogenous across the entire area and its character highlights the international importance of the TBR MDD.

The area contains about 26,500 ha of valuable natural water bodies (excluding hydropower accumulations and fish ponds), 730 ha of high dynamic pioneer stands, 38,000 ha of near-natural softwood and 28,000 ha of hardwood and mostly oak dominated lowland forests, 9,000 ha of reed beds as well as over 30,000 ha extensive grasslands (from wet to dry).

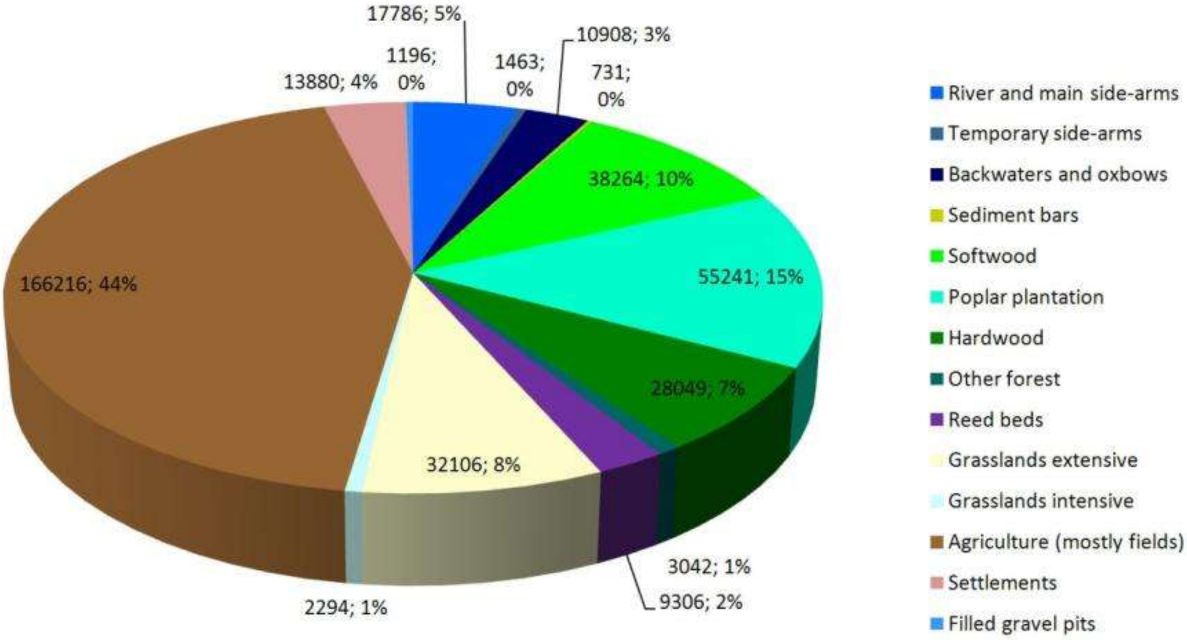
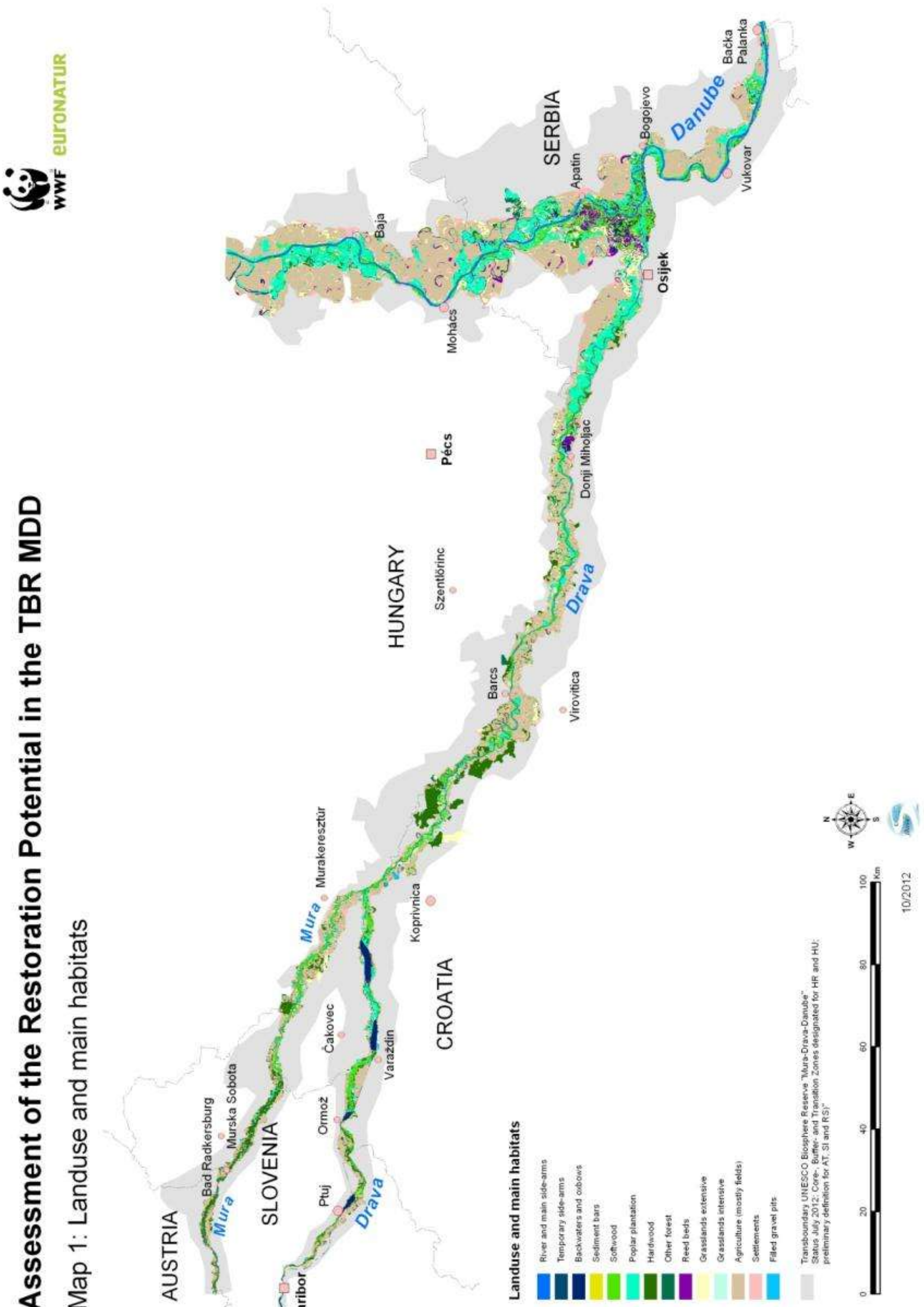


Figure 15: Distribution of landuse/ main habitats.



Map 1: Landuse and main habitats.

3.3 Status of river banks/channels

A series of pictures is used to show the different types of banks and structures found in the TBR MDD.

Figure 16: Natural shallow bank (as gravel point bar) in a sinuous channel reach (© Darko Grlica).

Figure 17: Natural steep bank (sand) with Sand Martin colony (© Darko Grlica).

Figure 18: „Other banks“ as recorded for most of this category with invariant slope, little erosion, and near-natural conditions (© Darko Grlica).

Figure 19: „Other banks“ including overgrown remnants of bank stabilization as recorded for a minor part of this category (© Darko Grlica).

Figure 20: Collapsed bank revetment with radial pool development (© Ulrich Schwarz, FLUVIUS).

Figure 21: Continuous bank revetment by rip-rap (© Darko Grlica).

Figure 22: Recently constructed „T-groynes“(© Darko Grlica).

Figure 23: Reflectors (rip-rap guiding wall) (© Darko Grlica).

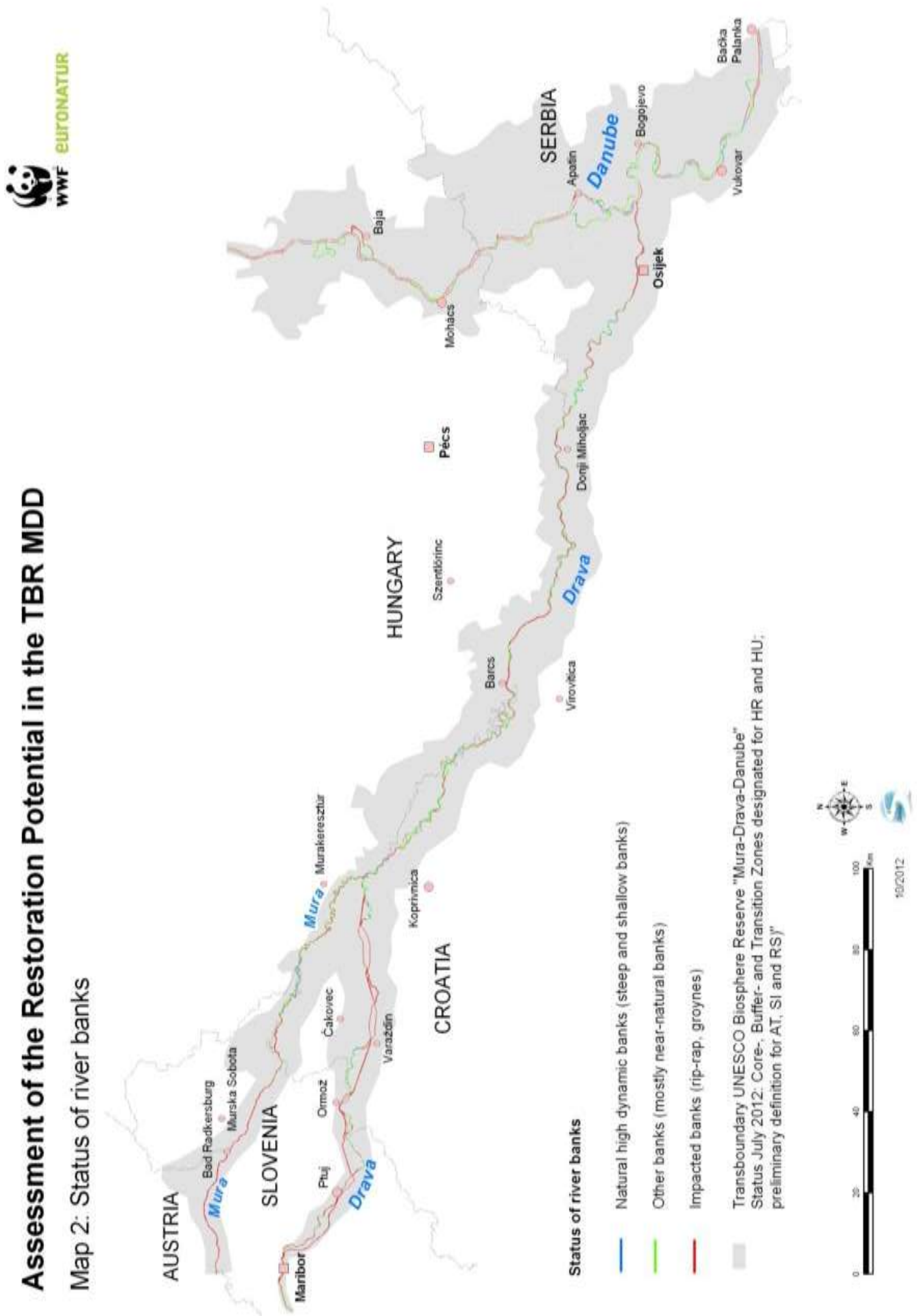
At the first step, the still remaining natural banks, like high dynamic steep or shallow banks (often with point bars, see figure 16) were identified. Additionally a class called “other banks (mostly near-natural)” characterises banks with low dynamics, intermediate slope which can be found in-between of meanders, having not specific features of steep or shallow banks or being partially protected by very old overgrown bank reinforcement (Map 2).

Two classes were defined for the impacted banks (fully maintained with rather new structures, and old, less maintained, structures, e.g. collapsed rip-rap or groynes). Two main groups of structures were identified. First the river banks which are mostly fixed by rip-rap (revetments) along the steep banks preventing any lateral shift of the channel. Secondly groynes, reflectors, guiding walls and in particular closures of side-arm can be seen as significant structures preventing also lateral shift of the river system and concentration of the flow in the main channel. For the better calculation for the "length of modified channel" and overview reasons only the length of banks were calculated (considering groynes and channel closures as regulation).

Depending on river sections the results differ strongly, for instance on the upper Mura beginning at the Austrian-Slovenian border, almost 95 % of banks are fixed by rip-rap. Less than 40 % of lower Mura and Drava, as well as on the lower Danube stretch (where the Danube flows alongside of the high loess terrace) are fixed, which also depends on the river type.

Table 4: Status of river banks (total length, percentage for both river banks in km (not channel length in rkm); (main and permanent side channels were analysed for this study).

Banks/channel	**Total (all rivers)**
Highly dynamic banks (steep banks with erosion)	102 km (5 %)
Shallow banks (associated with point bars)	87 km (4 %)
Others (mostly nearly natural banks)	765 km (38 %)
Old structures (collapsed rip-rap and groynes)	154 km (8 %)
Major bank revetments and structures (rip-rap, groynes, side-arm closures)	927 km (45 %)
Gravel and sand bars	731 ha



Map 2: Map of status of river banks (summarised status).

The Drava and a certain part of lower Mura provide several still intact large steep bank sections (Table 5). The Danube is mostly fixed, however, due to reduced maintenance within the last 20 years some free banks can be found close to Kopački Rit Nature Park and in particular along the natural steep loess terraces downstream of the Drava confluence.

The total area of open gravel and sand bars sums up to 731 ha, calculated for approximately mean water level. Considering an estimated 514 banks with an average size of 1.4 ha, reasonable bank sizes seem available for bar breeding birds or sensitive pioneer species. Naturally bank sizes differ per river with Danube still holding the largest banks. Historical analysis indicates a decrease of at least 70 % (1,700 ha) of this type of riparian habitat (Schwarz 2007).

Table 5: Bank evaluation per river in km (summarising types).

Banks/channel (including permanent side-arms and hydropower plants) in km	**Mura**	**Drava**	**Danube**
Highly dynamic banks (steep banks with erosion)	13 (13 %)	46 (45 %)	43 (42 %)
Shallow banks (associated with point bars)	9 (10 %)	46 (53 %)	32 (37 %)
Others (mostly nearly natural banks)	77 (10 %)	366 (48 %)	322 (42 %)
Old structures (collapsed rip-rap and groynes)	14 (9 %)	56 (36 %)	84 (55 %)
Major bank revetments and structures (rip-rap, groynes, side-arm closures)	185 (20 %)	539 (58 %)	203 (22 %)
Gravel and sand bars in ha	35 (5 %)	323 (44 %)	373 (51 %)

Table 6: Bank evaluation in km per country in detail.

Banks/channel	AT	HR	HU	RS	SI
Highly dynamic banks (steep banks with erosion)	-	81 (7 %)	15 (3 %)	2 (1 %)	4 (1 %)
Shallow banks (associated with point bars)	-	61 (6 %)	13 (3 %)	4 (3 %)	9 (3 %)
Other, nearly natural banks	1 (4 %)	456 (42 %)	171 (39 %)	71 (49 %)	66 (20 %)
Old structures (collapsed rip-rap and groynes)	-	65 (6 %)	55 (13 %)	14 (10 %)	20 (6 %)
Major bank revetments and structures (rip-rap, groynes, side-arm closures)[1]	33 (96 %)	424 (39 %)	180 (42 %)	54 (37 %)	236 (70 %)
Number of groynes[2]	1	239	165	25	3
Gravel and sand bars in ha	-	477 (65 %)	155 (21 %)	65 (9 %)	34 (5 %)

[1] Groynes and side-arm closures measured as approximate equivalent bank sections; in case of rip-rap and groynes none are counted extra

[2] Only larger and good visible groynes (length was not surveyed in detail)

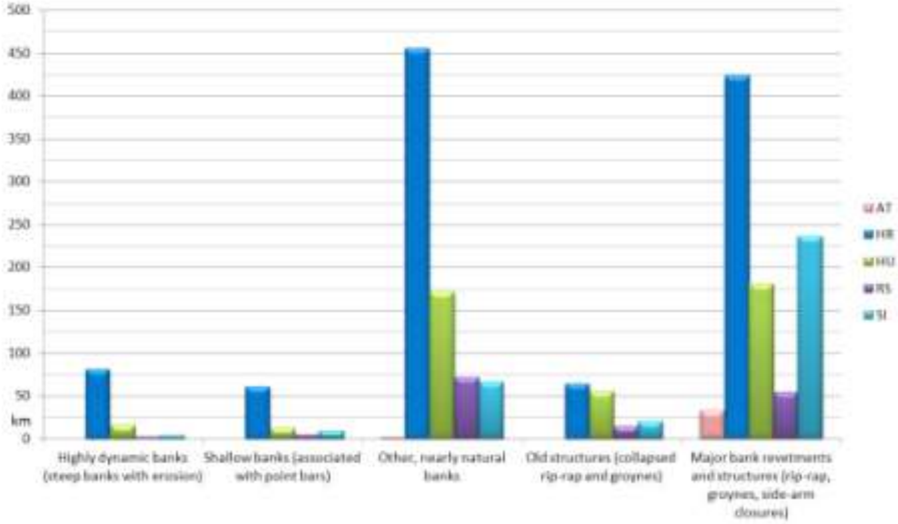


Figure 24 shows the specific importance of the Croatian river bank status in especially the first three “intact” classes. Croatia (dark blue) has significant longer stretches of near-intact river banks. For the values, see table 6.

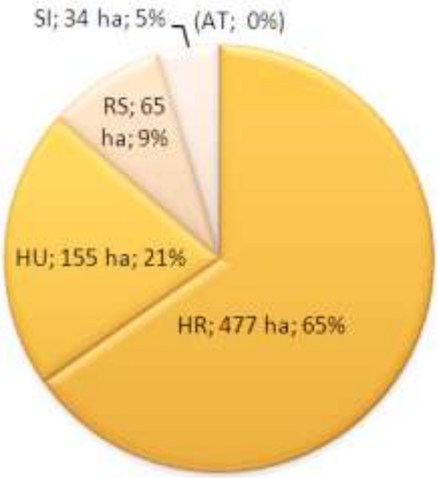


Figure 25 shows the area of still existing gravel and sand bars along all three rivers, per country in ha. Again the importance of Croatia is highlighted by its total share of 65 %.

3.3 Status of the floodplains

Figure 26 and 27: The Kopački Rit area (during the August flood 2002) is one of the last large natural floodplain areas along the entire Danube (© Mario Romulić).

Floodplains are found along all river stretches, naturally bordered by terraces. The overall floodplain loss by flood dikes and land reclamation amount to 78 % (465,136 ha, compare map 3). It is remarkable that the overall loss per river varies only within a small range (rounded the value is equal), which speaks for similar water and flood management planning (table 8). On the national level the figures vary much between 66 % and 90 % decrease in floodplain. Within the morphological floodplains, outside the flood dikes, an area of about 91,000 ha can be found with typical floodplain remnants (oxbows, forest and grasslands that can be linked to the former floodplain).

Table 7: Overview of floodplain status (totals) in ha.

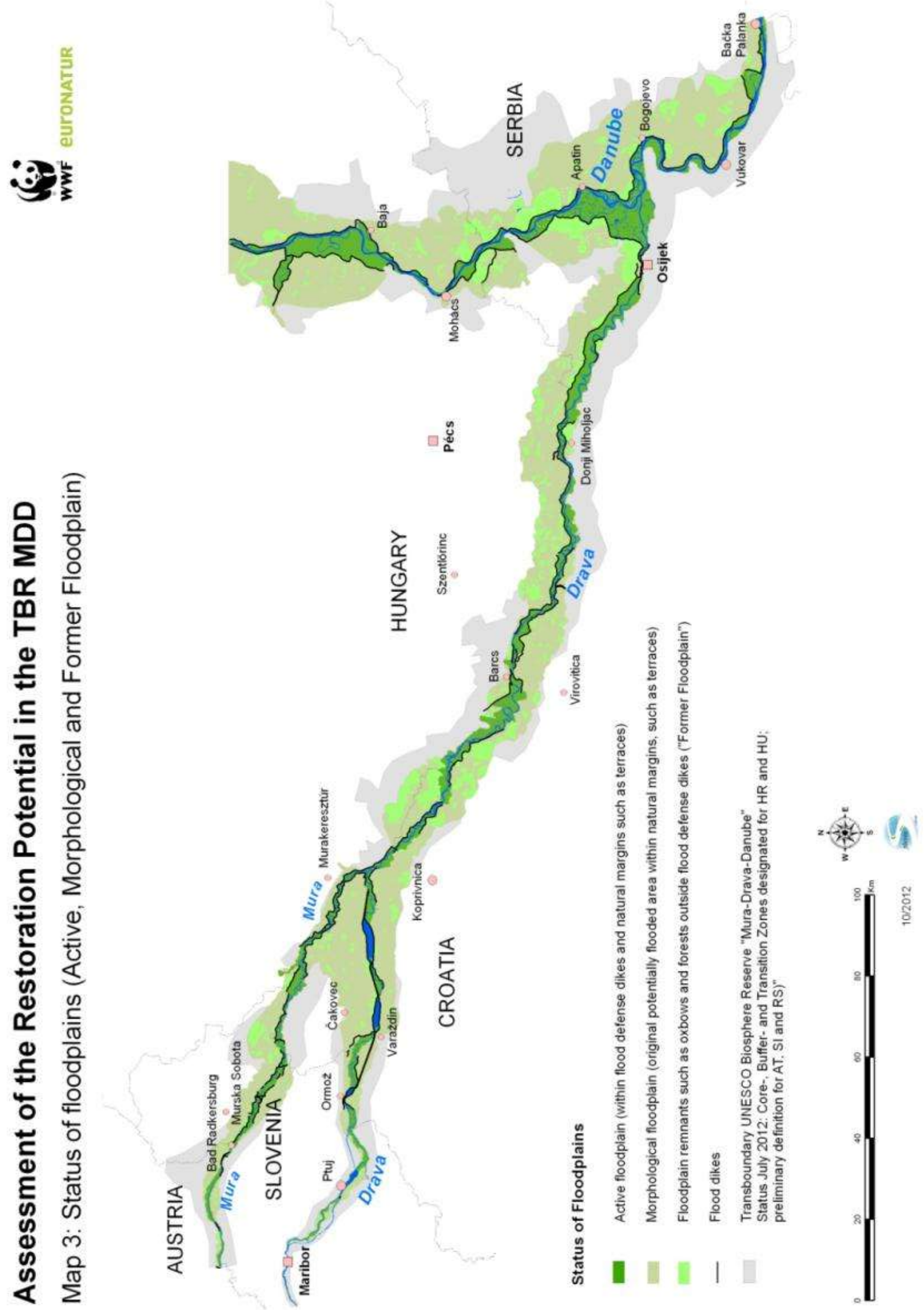
Floodplain (including river channels)	Total
Active floodplain	132,341 ha
Morphological floodplain	597,477 ha
Total decrease	78 %
Floodplain remnants (oxbows, forest and grasslands)	91,040 ha

Table 8: Overview of floodplain status, per river in ha.

Floodplain	Mura	Drava	Danube	Total
Active floodplain	14,232	53,693	64,416	132,341
Morphological floodplain	64,715	240,981	291,781	597,477
Decrease	78 %	78 %	78 %	78 %

Table 9: Overview of floodplain status, per country in ha.

Floodplain in ha	AT	HR	HU	RS	SI	Total (all coun-tries)
Active floodplain	1,757	72,143	37,562	10,357	10,522	132,341
Morphological floodplain	5,118	243,282	208,229	100,237	40,611	597,477
Decrease	66 %	70 %	82 %	90 %	74 %	78 %



Map 3: Map of status of floodplains (active and morphological floodplain).

Table 10: Floodplain remnants in the morphological floodplain, per country in ha.

	AT	HR	HU	RS	SI	Total (all countries)
Floodplain remnants, oxbows, forests, grasslands in ha	604	40,940	29,139	15,930	4,427	91,040

3.4 Restoration potential

3.4.1 Banks/channel

The restoration of river banks by removement of bank revetments became a common practice during the last ten years on many medium and large size rivers (Danube, Rhine). The upper and middle sections of these rivers were initially nearly 100 % stabilised by rip-rap and groynes, while in the meandering lowland stretches it would be less (70 %). Restoration works in these sections are usually limited to shorter stretches of some 100 meters up to several kilometers. Plans for the Danube east of Vienna foresee in the removal of around 40 % of existing bank stabilisations, dealing only with the low dynamic banks, while additional groynes or some stone packages (cabions) below the low-water line will continue to stabilise the channel prevent any shift (ViaDonau: www.via-donau.org/en/). Basically this number of 40 % removal potential is valid for the upper Mura, lower Drava and the entire Danube ("other banks") of the TBR MDD.

This investigation focuses on river stretches with steep banks and other banks with a high potential for lateral erosion and channel shift. Evaluations for works aimed at navigation are limited to non-structural measures keeping the current navigation conditions in these unique river sections of the TBR MDD. Likewise, this study considers existing settlements, bridges and flood dikes as given, as there is no realistic possibility to relocate these.

Table 11: Restoration potential as total length and percentage of gained free banks and reconnected major side-arms.

Restoration potential banks/channel	**Total (all rivers)**
Option 1: Minimum restoration	442 km (679 bank sections, 41 % of existing impacted banks); 82 side-arm reconnections
Option 2: Maximum restoration (estimation based on maximum lateral extension and existing settlements/infrastructure)	681 km (925 bank sections, 63 %) App. 150 side-arm reconnections
Option 3: Proposed restoration option (proposed restoration areas)	652 km (925 bank sections, 60 %) 120 side-arm reconnections

In option 1 "minimal restoration", 192 km of the 442 km of rip-rap removal would enable highly dynamic steep banks (in meander bends and sinuous side-arms). For option 3 "proposed restoration", this would mean a total of 340 km of new steep banks along all rivers (102 km exists today). This would significantly increase lateral erosion and bed load supply and would create habitats for the Sand martin colonies and Little ring plover on steep banks and bars. Additionally out of the total of 425 mapped groynes in all rivers, a maximum of 337 could be removed without increasing threats to settlements/infrastructure, without assessing specific navigation needs. In total 120 major side-arms could be reconnected.

For option 1 "minimal restoration", it should be pointed out that the removal of stabilisation involves a great amount of removal of invariant banks, currently not located in river bends. These can easily be removed without danger for flood protection by immediate channel shift. This is different for the expected steep banks in river bends. Since the minimum restoration option does not contain floodplain extension, natural erosion might endanger flood dikes and infrastructure in the long run. Adjacent land proposed in this study outside the flood dikes should be spared from infrastructure and settlements, so floodplain extension remains an option, otherwise it might be necessary to re-enforce banks near infrastructure and improve existing flood protection dikes once initial erosion and channel shift pose a threat at these locations.

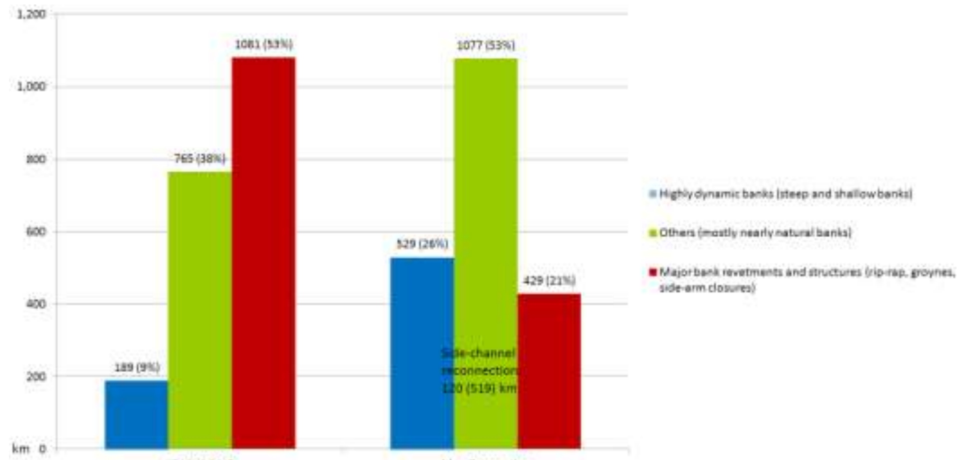


Figure 28: Status and restoration potential of river banks (total length, percentage for both river banks in km (not channel length in rkm) and side channels. The potential is equivalent to option 3: "proposed option".

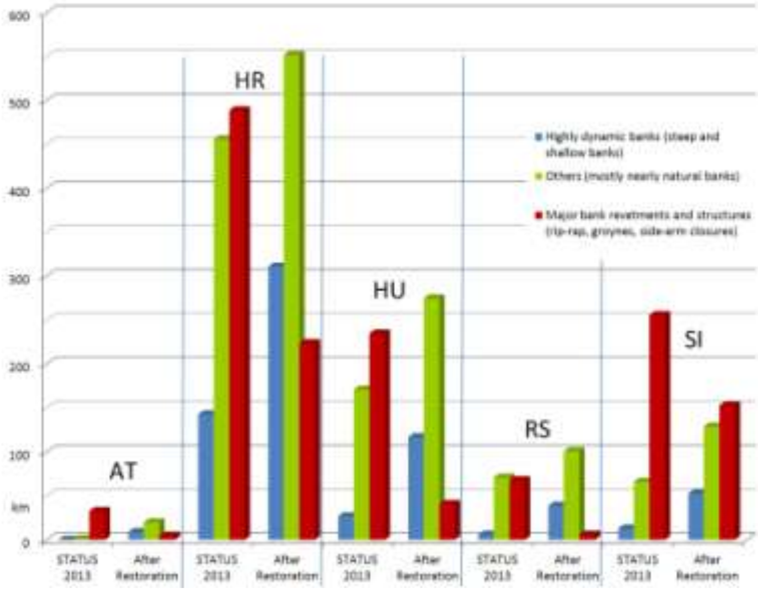
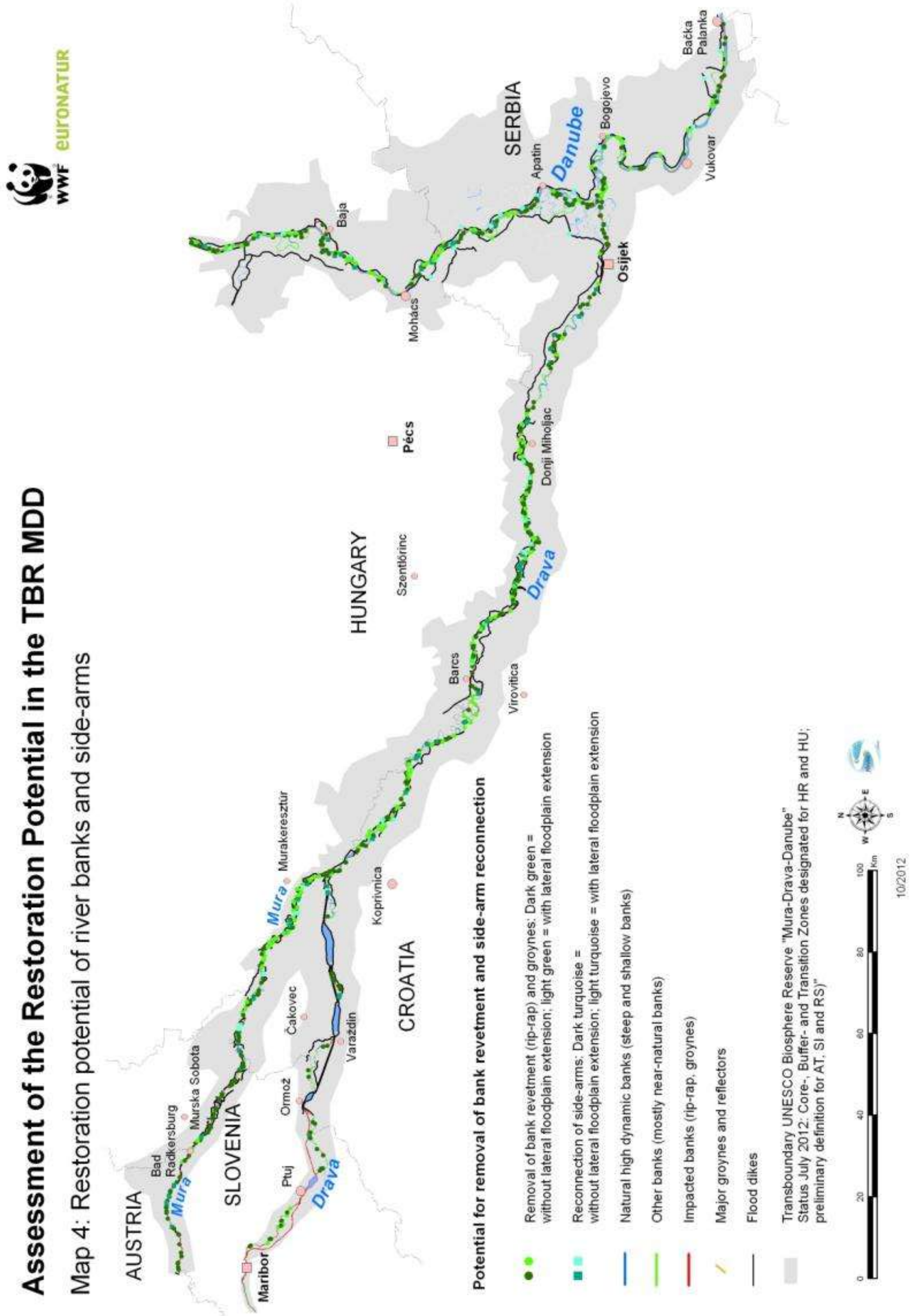


Figure 29: Status and restoration potential of river banks, per country (compare figure 28).



Map 4: Map of all proposed restoration measures for banks and side-arms.

Table 12: Country comparison in table form following figure 29.

River banks in km		Austria	Croatia	Hungary	Serbia	Slovenia
Highly dynamic banks (steep and shallow banks)	Status	0	143	27	6	13
	After restoration	**9**	**311**	**117**	**39**	**53**
Others (mostly nearly natural banks)	Status	1	456	171	71	66
	After restoration	**20**	**552**	**275**	**101**	**129**
Major bank revetments and structures (rip-rap, groynes, side-arm closures)	Status	33	489	235	69	256
	After restoration	**5**	**224**	**41**	**6**	**153**

This study limited itself to the estimation of the restoration potential of major side-arms. There are many more disconnections, in particular larger oxbows are disconnected from the river already for a long time. It makes no sense to connect all possible side-arms. Many side-arms must be maintained due to local unfavourable conditions. Initiation of a strong lateral erosion, also to cut former side channels behind existing natural bank levees, is to be preferred.

Lateral erosion reduces the sediment deficit, an estimation should be subject of further investigations as it strongly depends on the material the river erodes (gravel, sand, silt). An initial assumption would be to calculate with an average of 10 m lateral shift of the river per year (depending on discharge and bank situation this value can significantly bigger or smaller). Considering at least two meters height of the banks (several steep banks reach up to four meters, the highest are 30 m, but these consists mostly of fine material) the minimum option would mobilise a total for the whole TBR MDD of up to 3 million m^3/year. This seems a lot, but most of this material is too fine to play a role in the reduction of channel incision. Some of it will be deposited locally (on next point bars), but over time the deposits will be important in reducing the overall annual deficit. The bed load (coarse material, limiting the channel incision) must be recalculated for the different river sub-stretches, but for lower Drava the estimation would be rather optimistic based on the current low level of approximately 60,000 m^3/year of bed load and 250,000 m^3/year of suspended load downstream of the Mura confluence. The annual transport can be estimated at four times higher before the construction of dams (SINP 2010), which implies even a stronger decrease for bed load. For comparison, the Danube transports through the project area some 6 million m^3 sediment per year.

The Sand martin is a typical breeder of fresh steep banks. A significant increase of the breeding population can be assumed as a result of restoration measures. Currently a breeding density of about 90 pairs per km of intact steep bank can be assumed. This number can be considered typical for the existing 110 km of steep banks. In option 1 "minimum restoration", an additional 180 km could be gained increasing the potential population by three times.

The table on the next pages present the restoration proposals for banks and side-channels with detailed information.

Table 13: Proposal for removal of bank revetments and reconnection of side-arms.

Feasible without floodplain extension
Feasible only with floodplain extension

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
MU_SI_BR_001	870	141,3	BR	No
MU_AT_BR_001	1,690	140,8	BR	No
MU_AT_BR_002	1,430	139,8	BR	Yes
MU_SI_BR_002	1,490	139,6	BR	No
MU_SI_BR_003	2,240	137,8	BR	Yes
MU_AT_BR_002	3,580	137	BR	No
MU_AT_BR_003	1,220	134,8	BR	Yes

[3] If the side-arm is located alongside the active floodplain margin in the former floodpain the rkm indication is an approximation of a rectangular line to the river axis

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
MU_SI_BR_004	3,170	132,3	BR	Yes
MU_AT_BR_004	2,730	132	BR	No
MU_SI_BR_005	940	130,4	BR	Yes
MU_SI_SCR_001	5,100	130,2	SCR	-
MU_AT_BR_005	1,090	127,4	BR	No
MU_AT_BR_006	1,360	125,9	BR	Yes
MU_SI_BR_006	6,290	125,5	BR	No
MU_AT_BR_007	880	124,7	BR	No
MU_SI_SCR_002	860	124,4	SCR	-
MU_AT_SCR_001	1,800	123,5	SCR	-
MU_AT_BR_008	2,060	122,8	BR	Yes
MU_SI_BR_007	750	121,8	BR	Yes
MU_AT_BR_009	1,220	121,7	BR	No
MU_AT_SCR_002	780	121	SCR	-
MU_SI_BR_008	1,400	120,6	BR	No
MU_AT_BR_010	1,600	120,4	BR	Yes
MU_SI_BR_009	2,560	119,1	BR	No
MU_AT_SCR_003	1,960	118,7	SCR	-
MU_AT_BR_011	4,690	117,7	BR	No
MU_SI_BR_010	2,680	116,3	BR	No
MU_AT_BR_012	1,700	112,5	BR	Yes
MU_SI_BR_011	1,050	111,6	BR	No
MU_AT_BR_013	2,540	109,8	BR	No
MU_SI_BR_012	2,350	108,4	BR	No
MU_SI_BR_013	1,300	108	BR	Yes
MU_SI_BR_014	1,340	106,3	BR	No
MU_SI_BR_015	270	105,5	BR	Yes
MU_SI_BR_015	840	104,9	BR	Yes
MU_SI_BR_016	850	104,8	BR	No
MU_SI_BR_017	1,940	104,2	BR	Yes
MU_SI_SCR_003	1,540	103,9	SCR	-
MU_SI_BR_018	2,170	102,7	BR	No
MU_SI_BR_019	1,770	101,7	BR	Yes
MU_SI_BR_020	1,960	101	BR	No
MU_SI_BR_021	1,070	100,8	BR	No
MU_SI_BR_022	1,050	100,7	BR	Yes
MU_SI_BR_023	400	97,8	BR	No
MU_SI_BR_024	400	97,8	BR	No
MU_SI_BR_025	1,420	97,6	BR	No
MU_SI_BR_026	1,350	96,6	BR	Yes
MU_SI_BR_027	1,230	95,6	BR	Yes
MU_SI_BR_028	1,570	95,1	BR	Yes

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
MU_SI_BR_029	1,200	92,6	BR	No
MU_SI_BR_030	1,540	92,5	BR	Yes
MU_SI_BR_031	390	91,6	BR	Yes
MU_SI_BR_032	1,010	91,1	BR	No
MU_SI_BR_033	2,390	88,7	BR	No
MU_SI_BR_034	760	87,4	BR	Yes
MU_SI_BR_035	720	87,3	BR	No
MU_SI_BR_036	1,400	86,4	BR	No
MU_SI_BR_037	1,590	86,1	BR	Yes
MU_SI_BR_038	1,060	83,4	BR	No
MU_SI_SCR_004	1,100	82,7	SCR	-
MU_SI_BR_039	1,130	82,4	BR	No
MU_SI_BR_040	1,280	82	BR	Yes
MU_SI_BR_041	300	81,4	BR	Yes
MU_SI_BR_042	1,390	79,1	BR	Yes
MU_SI_BR_043	2,160	77,9	BR	Yes
MU_SI_BR_044	990	77,6	BR	No
MU_HR_SCR_001	2,810	76,5	SCR	-
MU_HR_SCR_002	1,650	75,3	SCR	-
MU_ HR _BR_001	930	74,8	BR	No
MU_ HR _BR_002	770	74	BR	No
MU_ HR _BR_003	810	73,5	BR	No
MU_ HR _BR_004	1,160	72,8	BR	Yes
MU_ HR _BR_005	1,230	72,7	BR	Yes
MU_ HR _SCR_003	1,050	72,4	SCR	-
MU_SI_SCR_005	1,250	71,7	SCR	-
MU_ HR _BR_006	1,350	71,5	BR	No
MU_ HR _SCR_004	2,120	70,7	SCR	-
MU_ HR _BR_007	1,050	70,2	BR	No
MU_ HR _BR_008	280	67,9	BR	Yes
MU_ HR _BR_009	460	67,1	BR	Yes
MU_ HR _BR_010	1190	65,2	BR	Yes
MU_ HR _BR_011	320	65,2	BR	Yes
MU_ HR _BR_012	270	64,4	BR	Yes
MU_SI_BR_045	310	64,2 (SA)	BR	Yes
MU_HR_SCR_005	1,780	64,1	SCR	-
MU_SI_BR_046	610	64	BR	Yes
MU_SI_BR_047	360	63,9	BR	No
MU_HR_SCR_006	1,090	63,7	SCR	-
MU_SI_BR_048	360	63	BR	Yes

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
MU_HR_SCR_007	1,670	62,2	SCR	-
MU_ HR _BR_013	940	61,4	BR	Yes
MU_ HR _BR_014	960	59,5	BR	Yes
MU_SI_BR_049	880	59,7	BR	No
MU_SI_SCR_006	1,620	59,4	SCR	-
MU_ HR _BR_015	660	58,7	BR	Yes
MU_ HR _BR_016	350	56	BR	Yes
MU_ HR _BR_017	910	54,8	BR	Yes
MU_HR_SCR_008	2,130	53	SCR	-
MU_ HR _BR_018	610	52,8	BR	Yes
MU_ HR _BR_019	330	52,2	BR	Yes
MU_ HR _BR_020	470	50,3	BR	Yes
MU_SI_BR_050	720	49,6	BR	Yes
MU_ HR _BR_021	370	48,6	BR	No
MU_ HR _BR_022	960	47,5	BR	Yes
MU_ HR _BR_023	1,150	45,7	BR	Yes
MU_ HU _BR_001	340	45,1	BR	Yes
MU_ HR _BR_024	520	44,5	BR	Yes
MU_ HR _BR_025	400	44,0	BR	Yes
MU_ HU _BR_002	320	44,1	BR	Yes
MU_ HR _BR_026	860	43,5	BR	Yes
MU_HU_SCR_001	1,630	41,9	SCR	-
MU_ HU _BR_003	430	41,7	BR	Yes
MU_ HR _BR_027	210	41,5	BR	No
MU_ HR _BR_028	610	41,1	BR	Yes
MU_ HU _BR_004	430	40	BR	Yes
MU_ HR _BR_029	840	39,3	BR	Yes
MU_HU_SCR_002	2,080	38,5	SCR	-
MU_ HU _BR_005	450	38,4	BR	Yes
MU_ HU _BR_006	440	38,1	BR	Yes
MU_ HR _BR_030	630	37,7	BR	Yes
MU_ HU _BR_007	470	37,2	BR	Yes
MU_ HU _BR_008	1,030	35	BR	No
MU_HU_SCR_003	1,120	34,5	SCR	-
MU_ HR _BR_031	860	33,9	BR	Yes
MU_ HU _BR_009	940	32,9	BR	Yes
MU_ HU _BR_010	280	32,3	BR	No
MU_ HR _BR_032	1,070	31,7	BR	Yes
MU_ HU _BR_011	760	30,7	BR	No
MU_HR_SCR_009	1,410	30,5	SCR	-
MU_ HU _BR_012	600	30,1	BR	Yes
MU_HR_SCR_010	920	29,7	SCR	-

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
MU_ HU _BR_013	830	28,6	BR	Yes
MU_ HR _BR_033	1,940	27,3	BR	Yes
MU_ HU _BR_014	990	35,8	BR	Yes
MU_HU_SCR_004	3,710	25,6 (SA)	SCR	-
MU_ HR _BR_034	1,740	24,6	BR	Yes
MU_HR_SCR_011	1,630	24,3	SCR	-
MU_ HU _BR_015	1,270	23	BR	Yes
MU_ HR _BR_035	1,190	21,2	BR	Yes
MU_ HU _BR_016	1,490	20,7	BR	No
MU_ HU _BR_017	2,370	19,2	BR	Yes
MU_ HR _BR_036	470	18,1	BR	Yes
MU_ HR _BR_033	350	17,9	BR	Yes
MU_HR_SCR_012	1,860	17,8	SCR	-
MU_ HU _BR_018	550	17,1	BR	Yes
MU_ HR _BR_037	730	16,5	BR	Yes
MU_ HU _BR_019	730	15,5	BR	Yes
MU_ HR _BR_038	1,090	15,1	BR	Yes
MU_ HU _BR_020	1,830	13,5	BR	Yes
MU_ HR _BR_039	1,310	11,7	BR	Yes
MU_HR_SCR_013	2,250	11,6	SCR	-
MU_ HU _BR_021	790	10,8	BR	Yes
MU_HR_SCR_014	1,780	9,7	SCR	-
MU_ HR _BR_040	1,280	9	BR	Yes
MU_ HR _BR_041	1,260	6,8	BR	Yes
MU_ HR _BR_042	470	4,7	BR	Yes
MU_ HR _BR_043	480	4,1	BR	Yes
MU_ HR _BR_044	1,680	2,4	BR	Yes
MU_ HR _BR_045	700	2,0	BR	Yes
MU_ HU _BR_022	620	1,2	BR	Yes
MU_ HR _BR_046	600	0,4	BR	Yes
DR_SI_BR_001	1,220	362,6	BR	No
DR_SI_BR_002	730	362,3	BR	No
DR_SI_BR_003	1,130	357,8	BR	Yes
DR_SI_BR_004	1,110	356,6	BR	Yes
DR_SI_BR_005	1,870	356,3	BR	No
DR_SI_BR_006	1,650	342,4	BR	Yes
DR_SI_BR_007	660	351,6	BR	No
DR_SI_BR_008	640	350,9	BR	Yes
DR_SI_BR_009	1,100	350,1	BR	No
DR_SI_BR_010	1.090	349,9	BR	No
DR_SI_BR_011	730	347,2	BR	Yes

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
DR_SI_BR_012	860	346,5	BR	No
DR_SI_BR_013	2,840	345,2	BR	No
DR_SI_BR_014	1,420	333	BR	Yes
DR_SI_SCR_001	1,400	332,4	SCR	-
DR_SI_BR_015	820	332	BR	No
DR_SI_BR_016	1,280	327,7	BR	No
DR_SI_BR_017	1,150	325,5	BR	Yes
DR_SI_BR_018	560	322,2	BR	No
DR_SI_SCR_002	1,160	321,7	SCR	-
DR_SI_BR_019	830	320,3	BR	Yes
DR_HR_BR_001	350	317	BR	Yes
DR_HR_BR_002	540	316,4	BR	No
DR_HR_BR_003	560	300,6	BR	Yes
DR_HR_BR_004	350	298,5	BR	Yes
DR_HR_BR_005	720	288,9	BR	No
DR_HR_BR_006	2,880	287,8	BR	Yes
DR_HR_BR_007	910	274,6	BR	Yes
DR_HR_SCR_001	1,500	274,3	SCR	-
DR_HR_SCR_002	1,080	273,9	SCR	-
DR_HR_BR_008	940	272,3	BR	No
DR_HR_BR_009	1,360	371,6	BR	No
DR_HR_BR_010	820	271,4	BR	No
DR_HR_BR_011	800	269,5	BR	Yes
DR_HR_BR_012	3,180	268,6	BR	No
DR_HR_BR_013	780	267,5	BR	No
DR_HR_BR_014	490	252	BR	Yes
DR_HR_SCR_003	1,970	241,9	SCR	-
DR_HR_SCR_004	1,580	241,6	SCR	-
DR_HR_SCR_005	1,040	240	SCR	-
DR_HR_BR_015	130	238	BR	Yes
DR_HR_BR_016	710	236,8	BR	Yes
DR_HR_BR_017	130	236,3	BR (SA)	Yes
DR_HR_BR_018	100	236,1	BR (SA)	Yes
DR_HU_BR_001	570	235,5	BR	Yes
DR_HR_BR_019	360	233,9	BR	
DR_HR_BR_020	940	233,3	BR	Yes
DR_HR_BR_021	720	230,5	BR	Yes
DR_HR_BR_022	960	225,6	BR	Yes
DR_HR_BR_023	1,390	224,5	BR	Yes
DR_HR_BR_024	460	224,1	BR	Yes
DR_HR_SCR_006	9,500	224	SCR	-
DR_HR_BR_025	230	223,8	BR	Yes

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
DR_HR_BR_026	1,170	223,2	BR	Yes
DR_HR_SCR_007	1,800	220,6	SCR	-
DR_HR_BR_027	520	220,2	BR (SA)	Yes
DR_HR_BR_028	340	220	BR	Yes
DR_HR_BR_029	410	219,9	BR	Yes
DR_HR_BR_030	780	219,3	BR (SA)	Yes
DR_HR_BR_031	490	219,1	BR (SA)	Yes
DR_HR_BR_032	380	218,1	BR (SA)	Yes
DR_HR_BR_033	400	217,2	BR	Yes
DR_HR_BR_034	410	217	BR (SA)	Yes
DR_HR_BR_035	640	216,1	BR (SA)	Yes
DR_HR_SCR_008	2,480	215,7	SCR	-
DR_HR_SCR_009	3,440	214,8	SCR	-
DR_HR_BR_036	1,210	214,5	BR	Yes
DR_HR_BR_037	140	213,8	BR	Yes
DR_HR_BR_038	540	213,4	BR	Yes
DR_HR_BR_039	180	213,3	BR	Yes
DR_HR_BR_040	210	212,7	BR	Yes
DR_HR_SCR_010	4,480	212,2	SCR	-
DR_HR_BR_041	400	210,3	BR	Yes
DR_HR_BR_042	780	209	BR (SA)	Yes
DR_HR_BR_043	730	208,6	BR	No
DR_HR_BR_044	280	207,2	BR	Yes
DR_HR_BR_045	210	205,9	BR	Yes
DR_HR_SCR_011	2,300	204	SCR	-
DR_HR_BR_046	570	203,8	BR	No
DR_HR_BR_047	650	203,2	BR	No
DR_HR_BR_048	480	201,6	BR	No
DR_HR_BR_049	1,450	201,3	BR	Yes
DR_HR_BR_050	880	201	BR	No
DR_HR_BR_051	640	200,2	BR	Yes
DR_HR_SCR_012	4,580	199,9	SCR	-
DR_HR_BR_052	310	199,7	BR	Yes
DR_HR_BR_053	440	199,6	BR (SA)	Yes
DR_HR_BR_054	110	199,5	BR	No
DR_HR_BR_055	690	199	BR	No
DR_HR_BR_056	120	198,8	BR (SA)	No
DR_HR_BR_057	300	198,5	BR (SA)	No
DR_HR_BR_058	300	197,8	BR (SA)	No
DR_HR_BR_059	600	194,3	BR	Yes
DR_HR_SCR_013	3,880	194,2	SCR	-
DR_HR_BR_060	140	194,1	BR	Yes

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
DR_HR_BR_061	900	193,5	BR	Yes
DR_HR_SCR_014	710	191,7	SCR	-
DR_HR_BR_062	1,890	191,5	BR	Yes
DR_HU_BR_002	300	190,9	BR	No
DR_HR_SCR_015	3,000	190,8	SCR	-
DR_HR_BR_063	440	190,2	BR	Yes
DR_HU_BR_003	360	189,7	BR	Yes
DR_HU_BR_004	230	187,2	BR	Yes
DR_HR_SCR_016	1,950	186,9	SCR	-
DR_HR_BR_064	1,450	185,9	BR	Yes
DR_HU_BR_005	320	184,9	BR	Yes
DR_HU_SCR_001	5,720	184,5	SCR	-
DR_HR_BR_065	1,970	183,8	BR	No
DR_HR_BR_066	1,150	183,3	BR	Yes
DR_HU_BR_006	1,820	182,3	BR	Yes
DR_HU_BR_007	1,500	181,5	BR	No
DR_HR_BR_067	950	181,1	BR	Yes
DR_HR_BR_068	600	181,1	BR	Yes
DR_HR_BR_069	600	175	BR	Yes
DR_HU_SCR_002	23,300	173,6	SCR	-
DR_HR_BR_070	600	171,8	BR	Yes
DR_HR_BR_071	1,750	169,5	BR	Yes
DR_HR_BR_072	1,450	166,8	BR	Yes
DR_HR_BR_073	2,000	164,6	BR	Yes
DR_HR_BR_074	260	161,5	BR	Yes
DR_HU_BR_008	1,820	160,5	BR	Yes
DR_HU_BR_009	770	159,2	BR	No
DR_HU_SCR_003	3,840	157,9	SCR	-
DR_HU_BR_019	2,230	156,9	BR	Yes
DR_HU_BR_011	1,000	156,4	BR	No
DR_HR_BR_075	1,230	155,3	BR	No
DR_HU_BR_012	770	151,8	BR	No
DR_HU_BR_013	1,950	150,1	BR	No
DR_HR_BR_076	2,130	149,4	BR	No
DR_HU_SCR_004	4,300	149,3	SCR	-
DR_HU_BR_014	170	148,9	BR	Yes
DR_HU_BR_015	910	148,3	BR	Yes
DR_HR_BR_077	200	147,9	BR	No
DR_HU_SCR_005	1,530	147,8	SCR	-
DR_HU_BR_016	510	147,5	BR	Yes
DR_HR_BR_078	900	146,8	BR	Yes
DR_HU_BR_017	750	145,5	BR	No

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
DR_HU_SCR_006	950	145,2	SCR	-
DR_HR_SCR_017	1,680	145,1	SCR	-
DR_HR_BR_079	140	145	BR	No
DR_HR_BR_080	180	144,8	BR (SA)	Yes
DR_HU_BR_018	100	144,4	BR	No
DR_HU_BR_019	2,190	142,8	BR	Yes
DR_HR_BR_081	2,280	142,5	BR	No
DR_HR_BR_082	1,320	140,6	BR	No
DR_HU_BR_020	510	140	BR	No
DR_HR_BR_083	260	139,7	BR	No
DR_HR_SCR_018	5,480	139,6	SCR	-
DR_HU_BR_021	1,170	139,1	BR	Yes
DR_HR_BR_084	1,440	139	BR	No
DR_HU_SCR_007	2,180	137,7	SCR	-
DR_HR_BR_085	750	137,5	BR	No
DR_HU_BR_022	1,400	136,6	BR	Yes
DR_HR_BR_086	2,200	135,7	BR	No
DR_HU_BR_023	2,300	135,4	BR	No
DR_HR_BR_087	250	134,2	BR	No
DR_HU_BR_024	900	133,5	BR	Yes
DR_HR_BR_088	1,210	133,4	BR	No
DR_HR_BR_089	2,840	131,2	BR	Yes
DR_HU_BR_025	3,380	131	BR	No
DR_HR_BR_090	1,380	129,3	BR	Yes
DR_HU_SCR_008	3,380	128,5	SCR	-
DR_HR_BR_091	600	128,4	BR	Yes
DR_HU_BR_026	640	128,2	BR	No
DR_HU_BR_027	450	127,5	BR	Yes
DR_HU_BR_028	1,090	126,6	BR	Yes
DR_HU_BR_029	100	125,7	BR	No
DR_HR_BR_092	880	125,6	BR	Yes
DR_HU_BR_030	900	125,3	BR	No
DR_HR_BR_093	340	124	BR	No
DR_HU_BR_031	680	123,7	BR	Yes
DR_HR_SCR_019	880	124,8	SCR	-
DR_HR_BR_094	100	123,4	BR	No
DR_HR_BR_095	150	123,1	BR	Yes
DR_HR_BR_096	120	123	BR	No
DR_HR_BR_097	460	122,3	BR	Yes
DR_HU_BR_032	550	122	BR	No
DR_HU_SCR_009	1,010	121,9	SCR	-
DR_HU_BR_033	170	121,5	BR	No

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
DR_HU_BR_034	1,100	121,3	BR	Yes
DR_HR_SCR_020	1,850	120,3	SCR	-
DR_HR_BR_098	1,020	120,1	BR	Yes
DR_HU_BR_035	640	119,9	BR	Yes
DR_HU_SCR_010	1,730	119,7	SCR	-
DR_HU_BR_036	1,000	119,1	BR	No
DR_HU_SCR_011	2,060	118,6	SCR	-
DR_HU_BR_037	270	117,9	BR	No
DR_HR_BR_099	750	117,1	BR	Yes
DR_HR_SCR_021	1,330	115,3	SCR	-
DR_HU_BR_038	1,690	115,1	BR	Yes
DR_HU_SCR_012	1,980	114,7	SCR	-
DR_HR_BR_100	400	114,4	BR	Yes
DR_HR_BR_101	980	113,5	BR	Yes
DR_HR_SCR_022	1,820	112,4	SCR	-
DR_HR_BR_102	680	112,2	BR	No
DR_HR_BR_103	160	111,7	BR	No
DR_HU_BR_039	1,330	111,5	BR	Yes
DR_HU_SCR_013	4,800	111,3	SCR	-
DR_HU_BR_040	840	110	BR	Yes
DR_HR_BR_104	400	107,8	BR	No
DR_HR_BR_105	170	107,5	BR	No
DR_HU_BR_041	830	107,2	BR	Yes
DR_HR_BR_110	480	106,4	BR	Yes
DR_HR_SCR_023	2,500	106,3	SCR	-
DR_HR_BR_106	1,170	105,6	BR	No
DR_HU_BR_042	1,700	105,5	BR	No
DR_HU_BR_043	770	104,7	BR	Yes
DR_HU_BR_044	820	104	BR	Yes
DR_HR_BR_107	1,280	103	BR	No
DR_HR_SCR_024	2,260	102,6	SCR	-
DR_HU_SCR_014	3,880	102,3	SCR	-
DR_HR_BR_108	1,290	102,2	BR	Yes
DR_HU_SCR_015	4,730	101,5	SCR	-
DR_HU_BR_045	990	101,1	BR	Yes
DR_HU_BR_046	370	100,8	BR	Yes
DR_HR_BR_109	1,640	100,5	BR	No
DR_HU_BR_047	1,560	100	BR	Yes
DR_HR_SCR_025	1,690	99,8	SCR	-
DR_HR_BR_110	1,100	99,2	BR	Yes
DR_HU_BR_048	1,200	98,5	BR	No
DR_HR_BR_111	180	97,9	BR	No

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
DR_HR_SCR_026	1,670	97,8	SCR	-
DR_HR_BR_112	370	97,6	BR	Yes
DR_HU_BR_049	2,130	97	BR	Yes
DR_HR_BR_113	120	96,6	BR (SA)	No
DR_HR_BR_114	720	95,5	BR	No
DR_HU_BR_050	1,870	95,1	BR	No
DR_HR_BR_115	2,270	94,5	BR	Yes
DR_HU_BR_051	130	93,8	BR	No
DR_HU_BR_052	140	93,1	BR	No
DR_HU_SCR_016	7,700	93	SCR	-
DR_HU_BR_053	1,740	92,4	BR	Yes
DR_HR_BR_116	380	92,1	BR	Yes
DR_HR_BR_117	2,010	91,6	BR	No
DR_HU_SCR_017	8,800	90,9	SCR	-
DR_HU_BR_054	1,300	90,5	BR	No
DR_HU_BR_055	200	89,5	BR	No
DR_HU_BR_056	630	89	BR	No
DR_HU_BR_057	700	88	BR	No
DR_HR_BR_118	1,100	87,9	BR	Yes
DR_HU_BR_058	580	87,5	BR	No
DR_HU_BR_059	150	87	BR	No
DR_HR_BR_119	160	86,6	BR	No
DR_HU_BR_060	760	86,3	BR	Yes
DR_HU_SCR_018	2,550	86	SCR	-
DR_HU_BR_061	900	85,4	BR	Yes
DR_HR_BR_120	390	84,7	BR	Yes
DR_HR_BR_121	1,000	84	BR	Yes
DR_HU_BR_062	740	83,2	BR	Yes
DR_HU_BR_063	920	82,5	BR	Yes
DR_HU_BR_064	710	81,7	BR	Yes
DR_HR_BR_122	870	81,2	BR	Yes
DR_HR_BR_123	790	79	BR	No
DR_HU_BR_065	1,040	78,6	BR	Yes
DR_HR_BR_124	900	77,3	BR	Yes
DR_HU_BR_066	810	76,9	BR	No
DR_HR_BR_125	1,110	76,3	BR	No
DR_HU_BR_067	150	76,1	BR	No
DR_HU_BR_068	1,410	75,2	BR	Yes
DR_HR_SCR_027	2,370	74	SCR	-
DR_HR_SCR_028	890	73,7	SCR	-
DR_HR_BR_126	1,960	73,1	BR	Yes
DR_HU_BR_069	1,270	71,8	BR	Yes

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
DR_HU_BR_070	630	70,7	BR	Yes
DR_HR_BR_127	1,610	69,5	BR	Yes
DR_HR_BR_128	1,490	69,2	BR	Yes
DR_HR_BR_129	500	56,4	BR	Yes
DR_HR_BR_130	1,860	55,5	BR	Yes
DR_HR_SCR_029	4,030	54,8	SCR	-
DR_HR_BR_131	400	54,5	BR	No
DR_HR_BR_132	2,590	52,5	BR	No
DR_HR_BR_133	1,120	52,1	BR	Yes
DR_HR_BR_134	880	51,1	BR	No
DR_HR_BR_135	1,970	50,1	BR	Yes
DR_HR_SCR_030	5,370	50	SCR	-
DR_HR_BR_136	460	48,7	BR	No
DR_HR_BR_137	630	47,1	BR	Yes
DR_HR_BR_138	1,960	47,6	BR	No
DR_HR_BR_139	1,960	45,6	BR	Yes
DR_HR_SCR_031	3,450	45,5	SCR	-
DR_HR_BR_140	760	44,5	BR	No
DR_HR_BR_141	610	44,2	BR	No
DR_HR_BR_142	1,680	43,4	BR	Yes
DR_HR_BR_143	970	42,2	BR	Yes
DR_HR_SCR_032	1,120	34	SCR	-
DR_HR_BR_144	1,910	33,2	BR	Yes
DR_HR_BR_145	740	31,5	BR	Yes
DR_HR_BR_146	900	30,6	BR	Yes
DR_HR_BR_147	800	29,5	BR	Yes
DR_HR_BR_148	1,670	27,9	BR	Yes
DR_HR_BR_149	1,100	26,6	BR	Yes
DR_HR_SCR_033	4,300	25,4	SCR	-
DR_HR_BR_150	1,420	23,9	BR	Yes
DR_HR_BR_151	3,310	15,8	BR	Yes
DR_HR_BR_152	2,100	15,1	BR	No
DR_HR_BR_153	1,360	13,2	BR (SA)	No
DR_HR_BR_154	1,360	13,1	BR	Yes
DR_HR_BR_155	1,940	12,9	BR	No
DR_HR_BR_156	1,340	11,2	BR	Yes
DR_HR_BR_157	1,580	11	BR	No
DR_HR_BR_158	1,240	10	BR	No
DR_HR_BR_159	2,300	9	BR	Yes
DR_HR_BR_160	600	7,8	BR	Yes
DR_HR_SCR_034	6,200	7,7	SCR	-
DR_HR_BR_161	3,020	5,7	BR	No

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
DR_HR_BR_162	3,820	5,6	BR	No
DR_HR_BR_163	2,360	3,5	BR	Yes
DR_HR_SCR_035	10,600	3,4	SCR	-
DR_HR_BR_164	1,880	2,3	BR	Yes
DR_HR_BR_165	1,150	0,8	BR	Yes
DR_HR_BR_166	1,270	0,7	BR	Yes
DR_HR_BR_167	250	0,1	BR	No
DU_HU_BR_001	420	1,511,4	BR	Yes
DU_HU_BR_002	670	1,511,3	BR	No
DU_HU_BR_003	620	1,510,4	BR	No
DU_HU_BR_004	1,010	1,510,3	BR	Yes
DU_HU_BR_005	620	1,509,6	BR	No
DU_HU_BR_006	1,200	1,508,6	BR	No
DU_HU_SCR_001	6,400	1,508	SCR	-
DU_HU_BR_007	920	1,506,8	BR	No
DU_HU_BR_008	1,870	1,506,5	BR	No
DU_HU_BR_009	320	1,505,9	BR	No
DU_HU_BR_010	2,260	1,504,8	BR	No
DU_HU_BR_011	2,840	1,504,5	BR	Yes
DU_HU_BR_012	510	1,502,7	BR	No
DU_HU_BR_013	710	1,502,3	BR	No
DU_HU_SCR_002	2,000	1,501,3	SCR	-
DU_HU_BR_014	1,660	1,501	BR	No
DU_HU_BR_015	2,190	1,500,4	BR	Yes
DU_HU_BR_016	700	1,498,3	BR	No
DU_HU_BR_017	1,310	1,497,7	BR	No
DU_HU_BR_018	3,340	1,497	BR	No
DU_HU_BR_019	1,640	1,496,9	BR	Yes
DU_HU_BR_020	630	1,494,5	BR	No
DU_HU_BR_021	1,250	1,493,5	BR	Yes
DU_HU_BR_022	490	1,493,4	BR	No
DU_HU_SCR_003	6,950	1,493,3	SCR	-
DU_HU_BR_023	2,470	1,491,8	BR	No
DU_HU_BR_024	1,310	1,489,8	BR	No
DU_HU_BR_025	400	1,489,5	BR	No
DU_HU_SCR_004	8010	1,487	SCR	-
DU_HU_BR_026	1,690	1,486,6	BR	No
DU_HU_BR_027	1,760	1,486,2	BR	Yes
DU_HU_BR_028	490	1,485,5	BR	No
DU_HU_BR_029	900	1,485,2	BR	No
DU_HU_BR_030	1,120	1,484	BR	No

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
DU_HU_BR_031	1,280	1,483,9	BR	No
DU_HU_BR_032	240	1,483,3	BR (SA)	No
DU_HU_BR_033	1,270	1,482,9	BR	Yes
DU_HU_BR_034	1,170	1,481,7	BR	No
DU_HU_BR_035	2,080	1,478,5	BR (SA)	No
DU_HU_BR_036	2,750	1,476,5	BR (SA)	No
DU_HU_BR_037	2,820	1,475,8	BR	Yes
DU_HU_SCR_005	3,670	1,475,3	SCR	-
DU_HU_BR_038	880	1,475,2	BR	No
DU_HU_BR_039	970	1,474,2	BR	No
DU_HU_BR_040	1,450	1,474,1	BR	No
DU_HU_BR_041	1,150	1,472,4	BR	No
DU_HU_BR_042	2,300	1,473,3	BR	Yes
DU_HU_BR_043	260	1,471,7	BR (SA)	No
DU_HU_BR_044	740	1,470,7	BR	No
DU_HU_BR_045	1,950	1,469	BR	No
DU_HU_SCR_006	12,640	1,468,6	SCR	-
DU_HU_BR_046	840	1,468,4	BR	Yes
DU_HU_SCR_007	3,170	1,468,2	SCR	-
DU_HU_BR_047	1,700	1,467,2	BR	No
DU_HU_BR_048	1,210	1,466	BR	No
DU_HU_SCR_008	17,020	1,465,8	SCR	-
DU_HU_BR_049	490	1,465,7	BR	No
DU_HU_BR_050	930	1,465	BR	Yes
DU_HU_BR_051	640	1,464,3	BR	Yes
DU_HU_BR_052	2,220	1,463,7	BR	No
DU_HU_SCR_009	2,100	1,463	SCR	-
DU_HU_BR_053	430	1,459,1	BR	No
DU_HU_BR_054	2,390	1,458,2	BR	Yes
DU_HU_BR_055	210	1,456,5	BR	No
DU_HU_BR_056	2,360	1,456	BR	No
DU_HU_BR_057	2,010	1,455,3	BR	Yes
DU_HU_BR_058	1,010	1,453,5	BR	No
DU_HU_BR_059	1,000	1,445,3	BR	No
DU_HU_BR_060	3,000	1,444,9	BR	Yes
DU_HU_BR_061	600	1,442,8	BR	Yes
DU_HU_BR_062	1,160	1,442,2	BR	Yes
DU_HU_SCR_010	15,100	1,441,8	SCR	-
DU_HU_SCR_011	5,500	1,440,8	SCR	-
DU_HU_BR_063	900	1,440,4	BR	Yes
DU_HU_BR_064	2,500	1,439,9	BR	No
DU_HU_SCR_012	5,440	1,439,3	SCR	-

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
DU_HU_BR_065	1,000	1,439	BR	Yes
DU_HU_BR_066	1,170	1,437,9	BR	Yes
DU_HU_BR_067	560	1,437,3	BR	Yes
DU_HU_SCR_013	1,900	1,437	SCR	-
DU_HU_SCR_014	2,280	1,436,9	SCR	-
DU_HU_BR_068	620	1,436,7	BR	Yes
DU_HU_BR_069	710	1,436,5	BR	Yes
DU_HU_SCR_015	5,110	1,436,2	SCR	-
DU_HU_BR_070	1,570	1,435,7	BR	No
DU_HU_BR_071	3,130	1,435,4	BR	No
DU_HU_BR_072	1000	1,435,0	BR	No
DU_HU_BR_073	870	1,434,7	BR	No
DU_HU_BR_074	1,430	1,434	BR	No
DU_HU_BR_075	680	1,433,5	BR	No
DU_HU_SCR_016	3,760	1,433,4	SCR	-
DU_HR_BR_001	880	1,432,3	BR	No
DU_HR_BR_002	3,990	1,432	BR	Yes
DU_HR_BR_003	520	31,7	BR	No
DU_HR_SCR_001	7,200	1,430,1	SCR	-
DU_HR_SCR_002	14,400	1,430	SCR	-
DU_HR_SCR_003	2,150	1,429,8	SCR	No
DU_HR_BR_004	2,040	1,428,7	BR	Yes
DU_HR_BR_005	810	1,427,9	BR	Yes
DU_HR_BR_006	680	1,427,2	BR	Yes
DU_RS_SCR_001	8,760	1,426,3	SCR	-
DU_HR_BR_007	520	1,426	BR	No
DU_RS_BR_001	200	1,424	BR	Yes
DU_RS_BR_002	700	1,422,9	BR	Yes
DU_HR_SCR_004	1,820	1,422,8	SCR	-
DU_HR_BR_008	320	1,421,6	BR	No
DU_HR_BR_009	1,250	1,420,8	BR	No
DU_RS_BR_003	3,130	1,420,6	BR	No
DU_HR_BR_010	540	1,419,9	BR (SA)	Yes
DU_HR_BR_011	2,400	1,419,8	BR	Yes
DU_HR_SCR_005	3,900	1,419,2	SCR	-
DU_HR_BR_012	1,140	1,418,2	BR	No
DU_HR_SCR_006	6,100	1,417,9	SCR	-
DU_HR_SCR_007	3,690	1,417,4	SCR	-
DU_RS_BR_004	290	1,416,9	BR	No
DU_RS_BR_005	2,370	1,415,5	BR	Yes
DU_RS_SCR_002	2,750	1,415,1	SCR	-
DU_RS_BR_006	520	1,413,4	BR	Yes

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
DU_RS_BR_007	260	1,413,3	BR	Yes
DU_HR_BR_013	1,290	1,412,3	BR	Yes
DU_HR_BR_014	1,190	1,411,5	BR	Yes
DU_HR_BR_015	800	1,410	BR	Yes
DU_HR_BR_016	840	1,409,9	BR	Yes
DU_RS_SCR_003	23,500	1,409,2	SCR	-
DU_HR_BR_017	2,650	1,409,1	BR	No
DU_HR_BR_018	150	1,409	BR	Yes
DU_HR_SCR_008	1,630	1,408,6	SCR	-
DU_HR_BR_019	200	1,408,5	BR	Yes
DU_HR_BR_020	1,250	1,407,4	BR	Yes
DU_HR_BR_021	730	1,406,3	BR	Yes
DU_HR_BR_022	860	1,405,2	BR	Yes
DU_RS_BR_008	220	1,404,9	BR	No
DU_RS_SCR_004	7,550	1,404	SCR	-
DU_HR_BR_023	970	1,398,3	BR	No
DU_HR_BR_024	800	1,397,8	BR	Yes
DU_HR_BR_025	140	1,397,7	BR	No
DU_RS_BR_009	380	1,397,5	BR	No
DU_RS_BR_010	190	1,397,2	BR	No
DU_HR_BR_026	710	1,396,8	BR	Yes
DU_RS_BR_011	760	1,396,3	BR	Yes
DU_HR_BR_027	1,250	1,394,6	BR	Yes
DU_HR_BR_028	470	1,393,2	BR	Yes
DU_HR_BR_029	500	1,392,7	BR	No
DU_HR_SCR_009	35,600	1,392,2	SCR	-
DU_HR_BR_030	1,290	1,391,9	BR	Yes
DU_HR_BR_031	240	1,390.8	BR	Yes
DU_RS_SCR_005	7,310	1,390.6	SCR	-
DU_RS_BR_012	170	1,390,2	BR	Yes
DU_RS_BR_013	350	1,389,9	BR	Yes
DU_RS_BR_014	870	1,389,1	BR	No
DU_RS_BR_015	190	1,388	BR	No
DU_HR_BR_032	190	1,387,8	BR	No
DU_HR_BR_033	230	1,387	BR	No
DU_HR_BR_034	180	1,386,4	BR	No
DU_HR_BR_035	4,300	1,384,9	BR	Yes
DU_HR_BR_036	1,280	1,383	BR	Yes
DU_HR_BR_037	570	1,381,6	BR	Yes
DU_HR_BR_038	200	1,381,1	BR	Yes
DU_RS_BR_016	170	1,380,8	BR	No
DU_HR_BR_039	460	1,380,7	BR	Yes

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
DU_HR_BR_040	220	1,380,5	BR	Yes
DU_RS_BR_017	160	1,380,2	BR	No
DU_HR_BR_041	390	1,379,7	BR	Yes
DU_RS_BR_018	200	1,379,2	BR	No
DU_RS_BR_019	250	1,378,5	BR	No
DU_RS_BR_020	230	1,378,2	BR	No
DU_HR_BR_042	800	1,375,9	BR	Yes
DU_HR_BR_043	1,030	1,375,7	BR	Yes
DU_RS_BR_021	1,550	1,374,5	BR	Yes
DU_RS_BR_022	370	1,372,7	BR	Yes
DU_RS_SCR_006	9,700	1,367,6	SCR	-
DU_HR_SCR_010	4,700	1,367,5	SCR	-
DU_HR_BR_044	660	1,367,2	BR	No
DU_RS_BR_023	1,250	1,364,5	BR	Yes
DU_RS_BR_024	930	1,362,8	BR	Yes
DU_RS_BR_025	750	1,362,1	BR	Yes
DU_RS_BR_026	600	1,361,4	BR	Yes
DU_RS_SCR_007	15,200	1,361	SCR	-
DU_HR_BR_045	1,410	1,359,9	BR	No
DU_RS_BR_027	4,200	1,358,3	BR	Yes
DU_RS_BR_028	830	1,356	BR	No
DU_RS_BR_029	1,700	1,352,5	BR	Yes
DU_RS_BR_030	130	1,350,1	BR	No
DU_RS_BR_031	260	1,349,6	BR	No
DU_RS_BR_032	300	1,349	BR	No
DU_RS_BR_033	3,330	1,343,4	BR	Yes
DU_RS_BR_034	170	1,332	BR (SA)	No
DU_RS_BR_035	3,440	1,326,6	BR	Yes
DU_RS_SCR_008	5,610	1,325,1	SCR	-
DU_RS_BR_036	510	1,324,9	BR	No
DU_RS_BR_037	430	1,320	BR	No
DU_RS_BR_038	2,540	1,317,7	BR	No
DU_HR_BR_046	140	1,315,4	BR	No
DU_HR_SCR_011	1,510	1,315,3	SCR	-
DU_RS_BR_039	1,280	1,315,2	BR	Yes
DU_RS_BR_040	900	1,315	BR	Yes
DU_HR_BR_047	1,350	1,313,7	BR	Yes
DU_HR_BR_048	2,390	1,312	BR	No
DU_RS_BR_041	1,890	1,311,9	BR	Yes
DU_RS_SCR_009	9,680	1,310,3	SCR	-
DU_RS_BR_042	2,590	1,309,8	BR	Yes
DU_HR_BR_049	1.780	1,308,9	BR	Yes

Code (incl. river name: MU=Mura, DR=Drava, DU=Danube)	Length in m (removal of bank stabilisa-tion works or length of side-arm) rounded to 10 m)	app. rkm for side-arm re-connection[3] or removal of bank stabilisa-tion works (center)	Removal of bank stabilisation works (BR) or side-arm reconnection (SCR) SA side-arm)	Exp. High dy-namic bank (steep bank, bend)
DU_RS_BR_043	3,620	1,305,8	BR	No
DU_RS_BR_044	1,320	1,303,9	BR	Yes
DU_RS_SCR_010	6,950	1,302,8	SCR	-
DU_RS_BR_045	3,710	1,302	BR	No
DU_HR_BR_050	805	1,299,5	BR	No
DU_HR_BR_051	1,740	1,296,4	BR	No

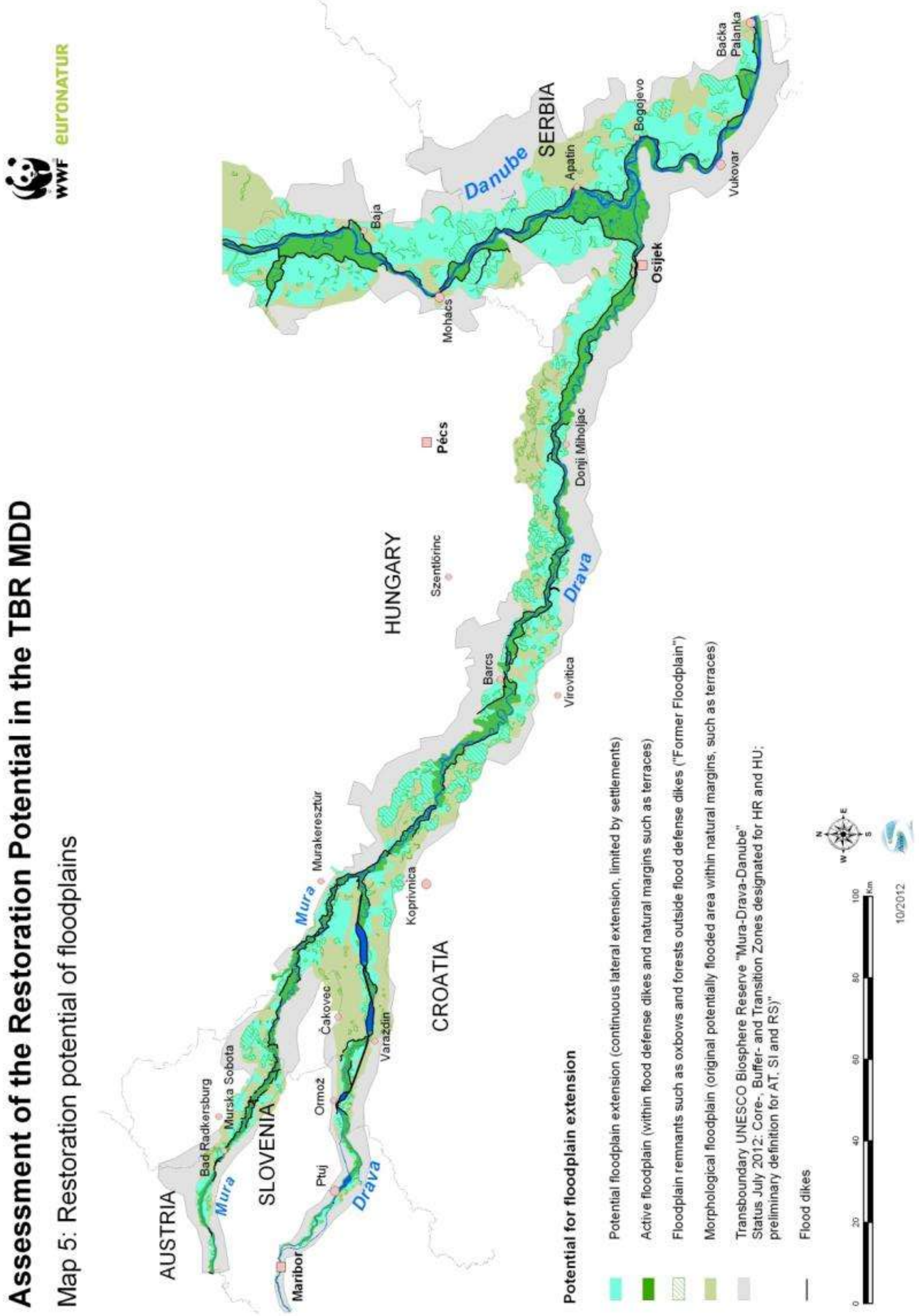
3.4.2 Floodplains

The restoration of floodplains was assessed in two steps: First the maximum possible continuous extension was defined. Secondly discrete restoration areas were delineated and prioritised as part of the former floodplain in detail.

The geographical maximum extension of the floodplain would reduce the overall loss from 78 % to about 40 % (option 3 "proposed restoration" to some 50 %). Many areas have a complicated shape and their connection to the active floodplains might not be feasible without addressing the current lack of connection to original water resource of these areas from tributaries and high groundwater levels.

Table 14: Restoration potential for floodplains.

Restoration potential for floodplain outside dikes	**Total**
Minimum restoration option	Non for former floodplain, but the active floodplain will benefit from all proposals for banks and side-channels
Maximum restoration option	225,447 ha
Proposed restoration option	165,318 ha (26,392 ha with highest priority)



Map 5: Map of maximum extent of floodplain restoration.

In total 74 potential restoration areas were defined in detail, including areas in the active and the former floodplain. The prioritisation process was only applied for the portion in the former floodplain that is outside the flood dikes. The main target of this process was to assess the potential lateral extension, not to focus on management and restoration measures in the still active floodplain. Throught these 74 areas a total of 165,318 ha outside of the flood dikes was analysed on restoration potential.

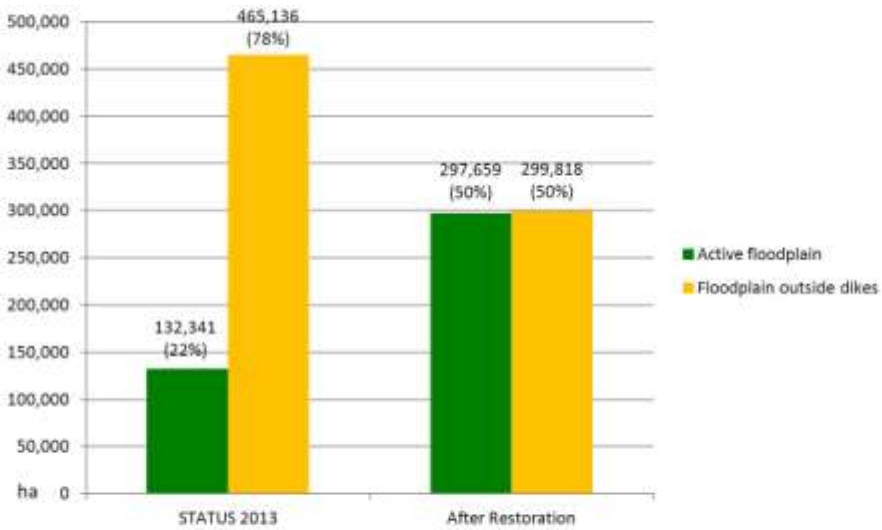


Figure 30: Status and restoration potential of floodplains (is equivalent to “proposed option”).

As can be seen in figure 31 (next page) there are huge potentials for floodplain restoration in Croatia and in Hungary.

In option 1 " minimum restoration", no floodplain extension is foreseen, due to the rather complicated implementation and still limited restoration experience (e.g. large scale restoration projects in Europe), however the “floodplain regulation corridor” was choosen not wide enough (as for many other rivers) which hampers the lateral shift of the main channel and reduces also the options for the bank restoration and side-channel reconnection. But even without floodplain extension many of those measures can be started earlier (with less effort than by restoring large floodplain areas).

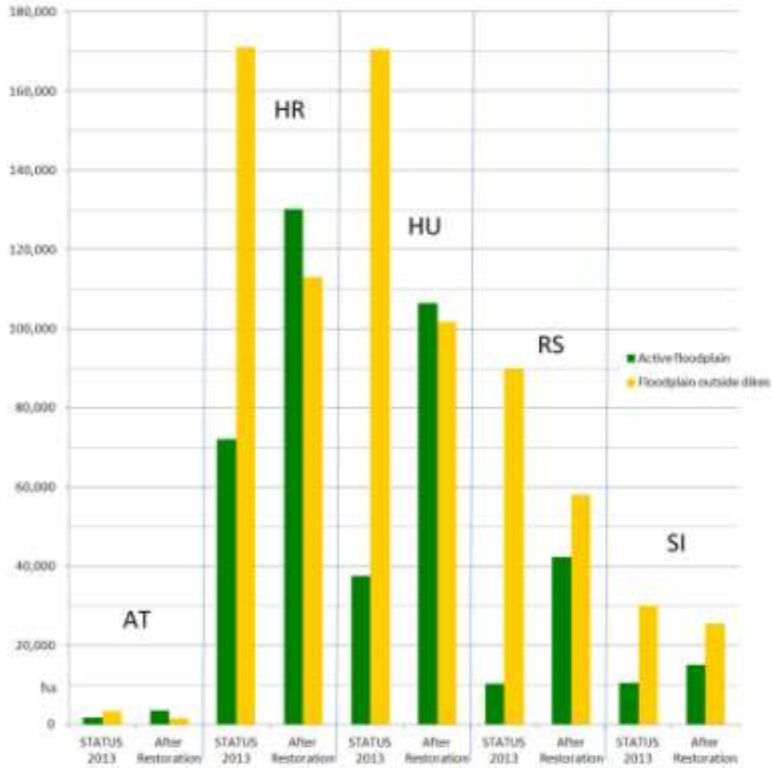


Figure 31: Country comparison following figure 30.

Table 15: Country comparison in table form following figure 31.

Floodplain in ha		Austria	Croatia	Hungary	Serbia	Slovenia
Active floodplain	Status	1,757	72,143	37,562	10,357	10,522
	After restoration	**3,610**	**130,223**	**106,430**	**42,284**	**15,112**
Floodplain outside dikes	Status	3,361	171,139	170,667	89,880	30,089
	After restoration	**1,508**	**113,059**	**101,799**	**57,953**	**25,499**

Figure 32 shows the resulting distribution of priority classes for a toal of 72 areas, two areas do not contain any possibility for floodplain extension. The first class "very high potential" is represented by nine areas (12 % or 26,392 ha), the second class with "high potential" is represented by 53 areas (74 % or 130,689 ha) and the third class "moderate potential" with ten areas (14 % or 8,237 ha).

For areas with highest prioritisation in average about 10 km of dikes must be removed or relocated.

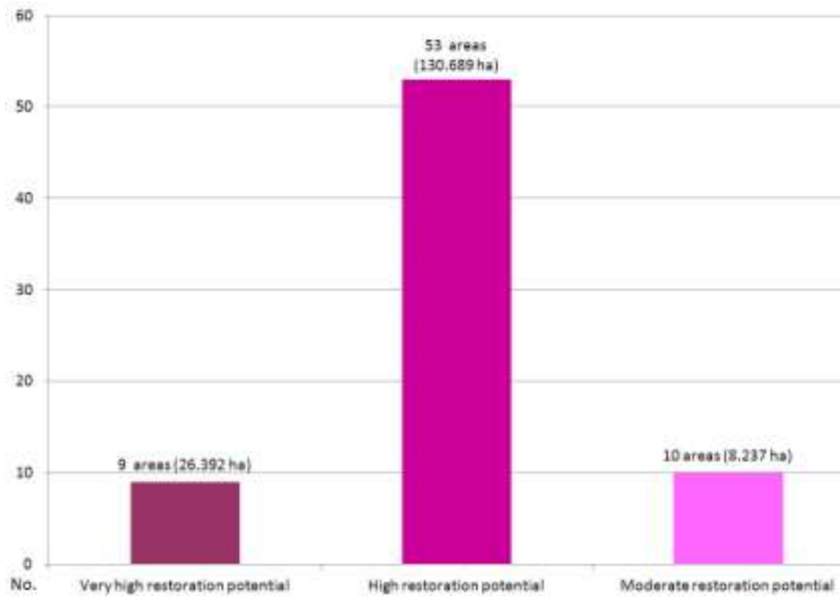
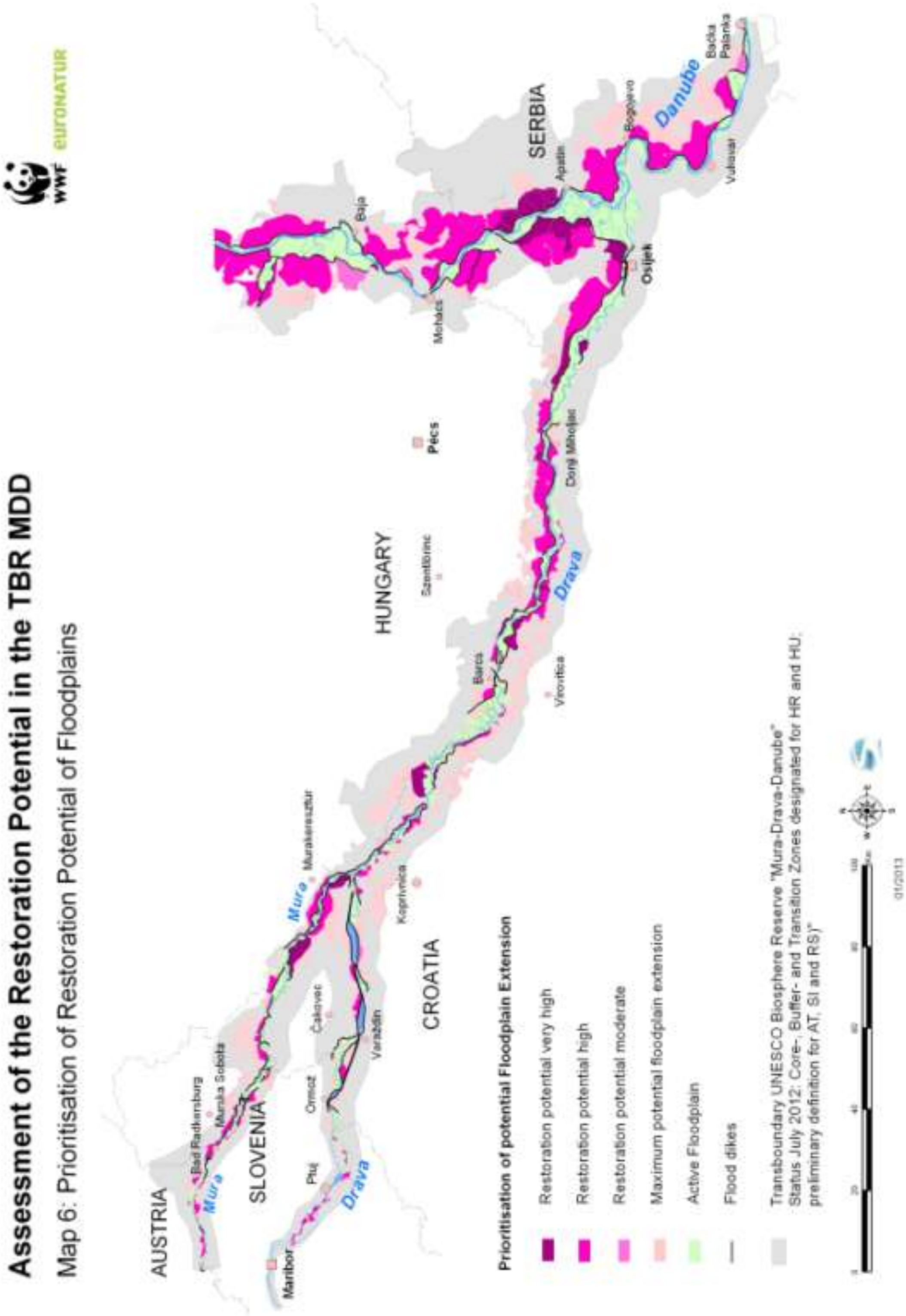


Figure 32: Prioritisation of floodplain areas for reconnection.



Map 6: Map of prioritised floodplain restoration potential.

There are a few areas in which the natural floodplain boundaries can be used to substitute existing flood dikes. Any flooplain sestoration planning should go hand in hand with the long-term planning, necessary maintenance and improving of dikes as well as the fact that the new flood dikes would be located at larger distance to the rivers (lower crest of dikes). For the areas with the highest prioritisation about 108.8 km of dikes must be relocated or removed (app 12.1 km per project area).

The table 16 on next pages contains the assessment matrix of the floodplain extension areas.

Table 16: Proposed restoration areas and prioritisation matrix for floodplain extension (compare the chapter 2.5 for methodology and scoring and 3.5 and 3.6 for more area details):

Very High (1-1.6)
High (1.7-2.3)
Low (2.4-3)

RestPot Area name	Landuse/ Habitats outside flood dike	Nature Protection	FloodProtection	HYMO status	Dike Relocation	RST refcon (hymo pot)	Total
Downstream Spielfeld*	2	2	3	2	1	1	**1,8**
Upstream Bad Radkersburg	3	1	2	2	1	1	**1,7**
Downstream Bad Radkersburg	2	2	2	2	3	1	**2**
Gradisce	2	2	2	2	2	1	**1,8**
Verzey, Biomura	3	3	2	2	2	1	**2,2**
Sreddnja Bistrica	3	3	3	2	3	1	**2,5**
Hotiza	2	1	2	2	3	2	**2**
Upstream Mursca Sredisce	2	1	2	2	3	2	**2**
Mura near Miklavec	3	3	3	2	2	2	**2,5**
Pince	1	2	2	3	2	3	**2,2**
Domasinec	2	1	2	1	1	1	**1,3**
Muraratka	3	3	3	2	1	3	**2,5**
Gorican-Totszendhely	2	2	2	2	2	1	**1,8**
Kotariba	3	1	2	2	2	2	**2**
Ujtelep	1	3	3	1	2	3	**2,2**

RestPot Area name	Landuse/ Habitats outside flood dike	Nature Protection	FloodProtection	HYMO status	Dike Relocation	RST refcon (hymo pot)	Total
Mura near Drava confluence	3	1	2	1	1	1	**1,5**
Rosnja	2	1	2	3	3	3	**2,3**
Ptuj	3	1	3	3	3	3	**2,7**
Stojnci	2	1	3	3	3	3	**2,5**
Svibovec Podravski	3	1	2	3	1	3	**2,2**
Totovec	1	1	2	3	3	3	**2,2**
Prelog	1	1	3	3	3	3	**2,3**
Sesvete Ludbreske	2	1	3	3	3	3	**2,7**
Upstream Legrad	2	1	3	3	2	2	**2,2**
Downstream Legrad	3	1	3	1	3	1	**2**
CingiLingi Botovo	3	1	3	1	3	1	**2**
Drava near Gotalovo	2	1	2	1	2	2	**1,7**
Repas bridge	1	1	3	1	3	3	**2**
Drava near Belavar and Novo Virje	2	1	2	1	2	1	**1,5**
Podravske Sesvete	3	1	2	2	2	2	**2**
Bolho	2	1	3	2	1	2	**1,8**
Okrugljaca	3	1	3	1	3	2	**2,2**
Barcs west	2	2	2	1	2	3	**2**
Barcs east	2	1	2	2	3	2	**2**
Drava near Detkovac	2	1	2	2	1	1	**1,5**
Vaska	3	1	2	2	3	1	**2**
Felsoszentmarton	2	3	2	2	1	1	**1,8**
Sopje	2	1	2	1	3	1	**1,7**
Pisco	2	3	1	1	2	1	**1,7**
Kisszentmarton	2	2	2	2	3	1	**2**
Dravapalkonya	3	3	1	2	3	1	**2,2**
Viljevo	2	1	3	2	1	3	**2**
Donlji Miholac	2	2	2	1	3	2	**2**
Matty	2	3	2	1	3	1	**2**
Dravske Sume west	2	1	2	1	1	2	**1,5**
Valpovo	1	1	2	1	1	2	**1,3**

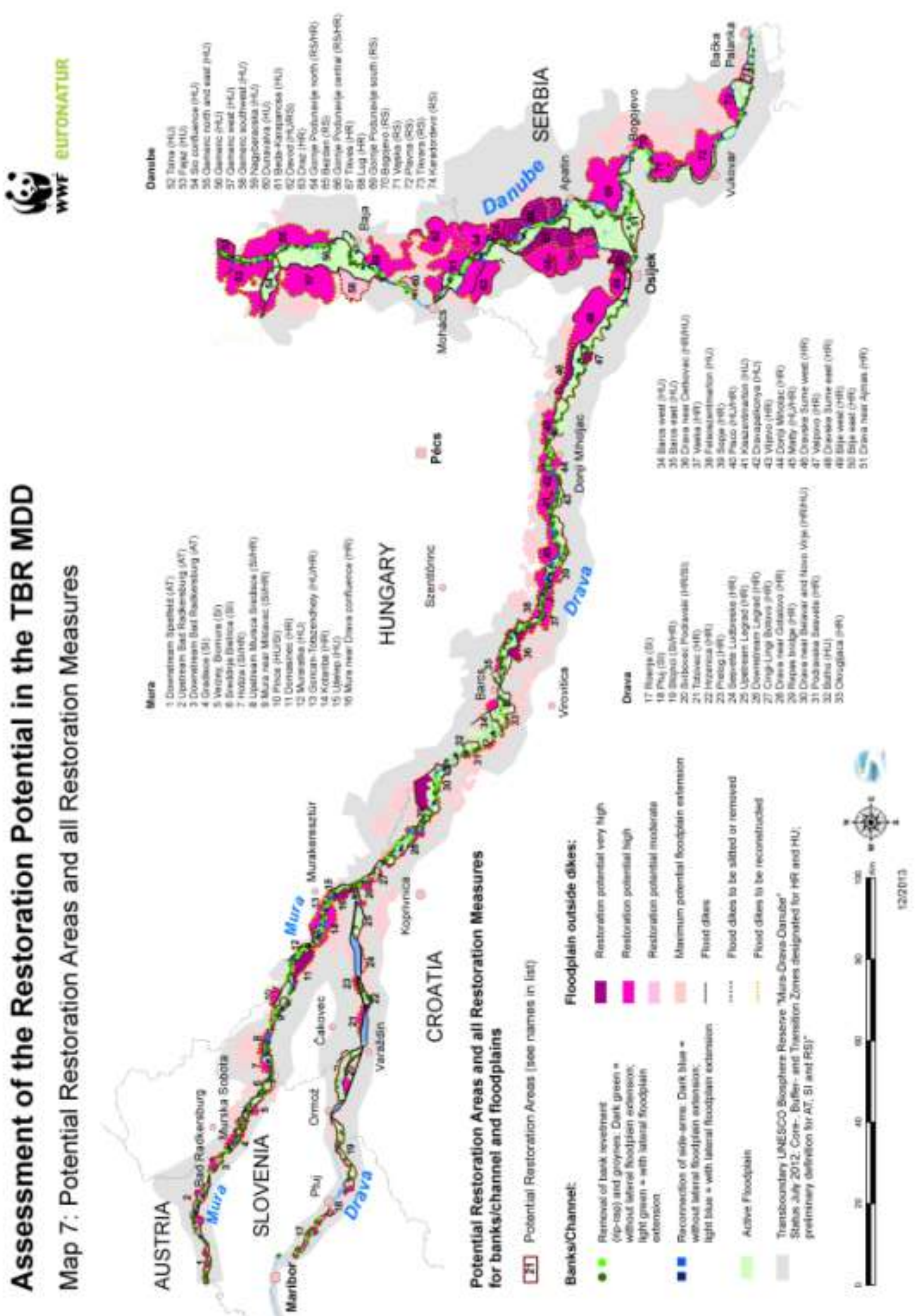
RestPot Area name	Landuse/ Habitats outside flood dike	Nature Protection	FloodProtection	HYMO status	Dike Relocation	RST refcon (hymo pot)	Total
Dravske Sume east	3	2	1	1	3	1	**1,8**
Bilje west	1	1	2	3	3	1	**1,8**
Bilje east	1	1	2	2	1	1	**1,3**
Tolna	3	3	1	2	3	2	**2,3**
Fajsz	3	3	2	2	3	3	**2,7**
Sio confluence	3	3	2	3	2	1	**2,3**
Gemenc north and east	3	3	1	2	3	1	**2,2**
Gemenc[4]	3	1	3	2	1	1	**1,8**
Gemenc west	3	3	1	2	3	1	**2,2**
Gemenc southwest	3	3	2	2	3	2	**2,5**
Nagybaracska	3	3	1	2	3	1	**2,2**
Dunavalva	2	3	3	2	3	3	**2,7**
Beda-Karapancsa	2	2	1	2	3	1	**1,8**
Davod	3	3	1	2	3	2	**2,3**
Draz	2	2	2	2	3	2	**2,2**
Gornje Podunavlje north	2	1	2	2	2	1	**1,7**
Bezdan	3	3	2	2	1	2	**2,2**
Gornje Podunavlje central	1	1	1	2	3	1	**1,5**
Tikves	1	1	1	2	3	1	**1,5**
Lug	3	2	1	2	1	1	**1,7**
Gornje Podunavlje south	3	3	1	1	2	1	**1,8**
Bogojevo	3	3	2	1	3	2	**2,3**
Vajska	3	3	2	1	1	2	**2**
Plavna	3	3	1	1	2	1	**1,8**
Tikvara	3	2	2	1	3	2	**2,2**
Karadordevo	3	3	3	2	1	3	**2,5**

[4] Only very small area (200 ha) south of the main Gemenc area, not mentioned in main analysis

A few potential areas were included that are mostly or even entirely in the active floodplain (such as Drava near Ajmas and Gemenc, which are included on map 7 but were not listed in the prioritisation table 16), and some smaller areas along the impounded stretch of the Upper Drava. For those areas the parameters “flood retention” and “dike relocation” are omitted. In general the situation of active floodplains has to be improved as well. The active floodplains suffering by channel incision, fine material aggradation (strong succession) and forestry management (poplar plantations). Furthermore, within the potential restoration areas the connection between the active river and the floodplain must be planned in detailed, because without improved hydromorphological dynamics the floodplain extension will not be connected sufficiently.

3.5 Potential restoration areas (“restoration areas”)

All together 74 potential restoration areas for restoration along all three rivers were identified (map 7, compare the list of names in the map). The total size of these areas is 254,093 ha including both the active as well as the morphological floodplain. 26,392 ha in the former floodplain hold a very high, 130,689 ha a high and 8,237 ha a moderate restoration potential. The remaining 88,775 ha of still active floodplain should be subject of restoration measures as well: the huge Gemenc and the area south of the Drava confluence. Most of the proposed stretches for bank and channel restoration fall into the 74 areas and therefore should be seen as an integral part of a comprehensive large scale restoration area planning.



Map 7: Joint map of potential restoration areas and measures.

Table 17: Overall restoration potential for the TBR MDD.

Restoration option	Banks/channel and side-arm reconnections (total TBR MDD)	Floodplain extension (total TBR MDD)
Minimum restoration option	442 km; 82 side-arm reconnections	0 ha (only active floodplain)
Maximum restoration option	681 km; app. 150 side-arm reconnections	225,447 ha (based on continuous extension not on delineated areas)
Proposed restoration option (for floodplains three priority classes: very high, high, moderate)	652 km; 120 side-arm reconnections	165,318 ha 26,392 ha in the “very high” priority class

Table 18: Proposed potential restoration areas.

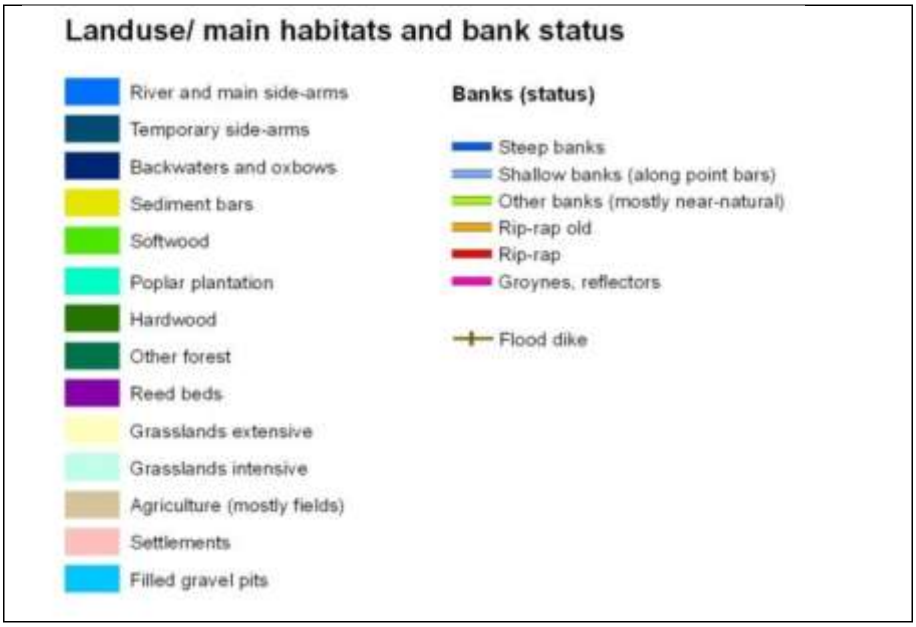
No.	Potential project area	River	Name	Size in ha (total size, in brackets portion outside of the flood dikes[5])
1	AT_RP12_01	Mura	Downstream Spielfeld	1,107 (449*)
2	AT_RP12_02	Mura	Upstream Bad Radkersburg	2,435 (767*)
3	AT_RP12_02	Mura	Downstream Bad Radkersburg	988 (637)
4	SI_RP12_01	Mura	Gradisce	1,494 (761)
5	SI_RP12_02	Mura	Verzey, Biomura	2,221(710)
6	SI_RP12_03	Mura	Sreddnja Bistrica	895 (375)
7	SI_HR_RP12_04	Mura	Hotiza	1,190 (578)
8	SI_HR_RP12_05	Mura	Upstream Mursca Sredisce	1,322 (546)
9	SI_HR_RP12_06	Mura	Mura near Miklavec	1,312 (242)
10	HU_SI_RP12_01	Mura	Pince	669 (669)
11	HR_RP12_01	Mura	Domasinec	2,814 (2,183)

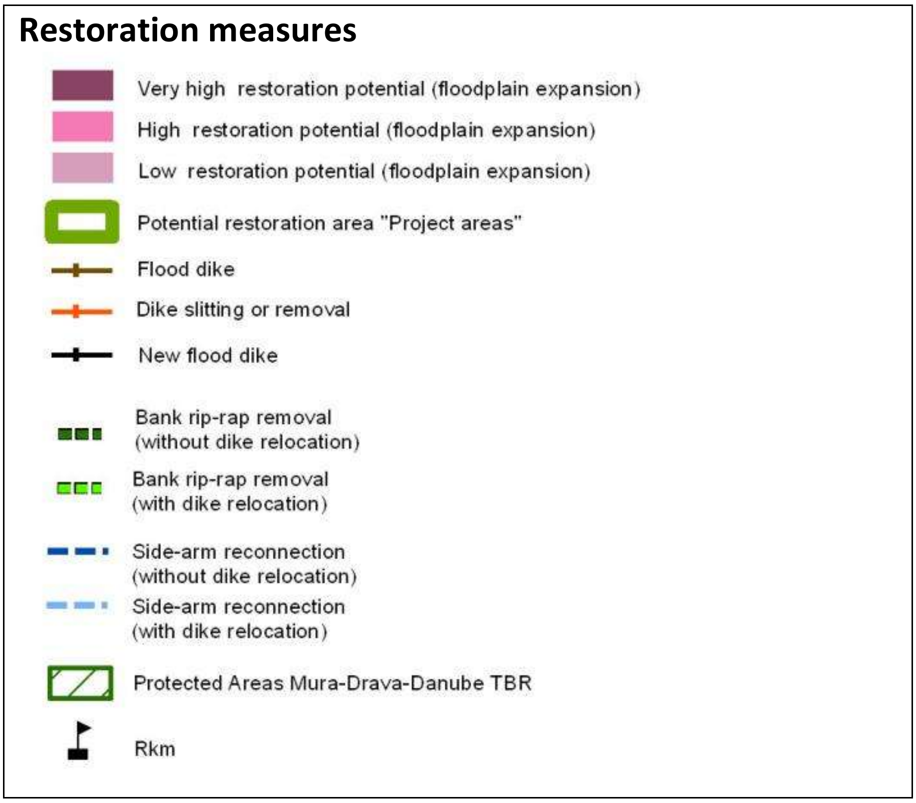
[5] For several areas (marked by *) along very upper Drava and Mura and middle Drava no continouse dike lines exist. Therefore the area comprises also higher areas used by agriculture.

No.	Potential project area	River	Name	Size in ha (total size, in brackets portion outside of the flood dikes[5])
12	HU_RP12_02	Mura	Muraratka	319 (158)
13	HU_HR_RP12_03	Mura	Gorican-Totszendhely	3,087 (1,970)
14	HR_RP12_02	Mura	Kotariba	1,789 (1,402)
15	HU_RP12_04	Mura	Ujtelep	321 (237)
16	HR_HU_RP12_03	Mura	Mura near Drava confluence	1,567 (941)
17	SI_RP12_07	Drava	Rosnja	1,370 (783*)
18	SI_RP12_08	Drava	Ptuj	174 (174)
19	SI_HR_RP12_09	Drava	Stojnci	2,815 (421*)
20	HR_SI_RP12_04	Drava	Svibovec Podravski	3,126 (571)
21	HR_RP12_05	Drava	Totovec	713 (713)
22	HR_RP12_06	Drava	Hrzenica	951 (-)
23	HR_RP12_07	Drava	Prelog	410 (410)
24	HR_RP12_08	Drava	Sesvete Ludbreske	499 (499)
25	HR_RP12_09	Drava	Upstream Legrad	2,108 (304)
26	HR_RP12_10	Drava	Downstream Legrad	536 (318)
27	HR_RP12_11	Drava	Cingi-Lingi Botovo	686 (198)
28	HR_RP12_12	Drava	Drava near Gotalovo	3,561 (1,282)
29	HR_RP12_13	Drava	Repas bridge	299 (123)
30	HR_HU_RP12_14	Drava	Drava near Belavar and Novo Virje	5,954 (2,520)
31	HR_RP12_15	Drava	Podravske Sesvete	1,116 (643)
32	HU_RP12_05	Drava	Bolho	800 (104)
33	HR_RP12_16	Drava	Okrugljaca	1,164 (189*)
34	HU_RP12_06	Drava	Barcs west	1,975 (598)
35	HU_RP12_07	Drava	Barcs east	1,071 (549)
36	HR_HU_RP12_17	Drava	Drava near Detkovac	3,763 (1,907)
37	HR_RP12_18	Drava	Vaska	2,694 (2,144)
38	HU_RP12_08	Drava	Felsoszentmarton	3,379 (1,734)
39	HR_RP12_19	Drava	Sopje	1,188 (789)
40	HU_HR_RP12_09	Drava	Pisco	6,051 (3,135)
41	HU_RP12_10	Drava	Kisszentmarton	2,417 (2,107)
42	HU_RP12_11	Drava	Dravapalkonya	3,324 (2,547)
43	HR_RP12_20	Drava	Viljevo	545 (84*)
44	HR_RP12_21	Drava	Donlji Miholac	927 (690)
45	HU_HR_RP12_12	Drava	Matty	3,726 (2,089)
46	HR_RP12_22	Drava	Dravske Sume west	5,231 (2,112)
47	HR_RP12_23	Drava	Valpovo	966 (561)
48	HR_RP12_24	Drava	Dravske Sume east	10,851 (8,033)
49	HR_RP12_25	Drava	Bilje west	2,505 (2,087)
50	HR_RP12_26	Drava	Bilje east	2,100 (1,990)
51	HR_RP12_27	Drava	Drava near Ajmas	3,975 (-)

No.	Potential project area	River	Name	Size in ha (total size, in brackets portion outside of the flood dikes[5])
52	HU_RP12_13	Danube	Tolna	9,047 (8,225)
53	HU_RP12_14	Danube	Fajsz	1,452 (1,181)
54	HU_RP12_15	Danube (Sio)	Sio confluence	4,753 (2,115)
55	HU_RP12_16	Danube	Gemenc north and east	10,420 (8,946)
56	HU_RP12_17	Danube	Gemenc	12,152 (200)
57	HU_RP12_18	Danube	Gemenc west	8,924 (8,924)
58	HU_RP12_19	Danube	Gemenc southwest	3,497 (3,497)
59	HU_RP12_20	Danube	Nagybaracska	6,695 (6,113)
60	HU_RP12_21	Danube	Dunavalva	1,214 (761)
61	HU_RP12_22	Danube	Beda-Karapancsa	11,602 (8,674)
62	HU_RS_RP12_23	Danube	Davod	6,305 (6,305)
63	HR_RP12_28	Danube	Draz	3,672 (3,672)
64	RS_HR_RP12_01	Danube	Gornje Podunavlje north	4,561 (3,941)
65	RS_RP12_02	Danube	Bezdan	1,346 (1,346)
66	RS_HR_ RP12_03	Danube	Gornje Podunavlje central	9,077 (7,448)
67	HR_RP12_29	Danube	Tikves	10,441 (6,730)
68	HR_RP12_30	Danube	Lug	9,074 (9,074)
69	RS_RP12_04	Danube	Gornje Podunavlje south	13,648 (8,925)
70	RS_RP12_05	Danube	Bogojevo	1,503 (1,290)
71	RS_RP12_06	Danube	Vajska	4,724 (3,609)
72	RS_RP12_07	Danube	Plavna	6,971 (5,643)
73	RS_RP12_08	Danube	Tikvara	5,341 (2,737)
74	RS_RP12_09	Danube	Karadordevo	1,174 (929)

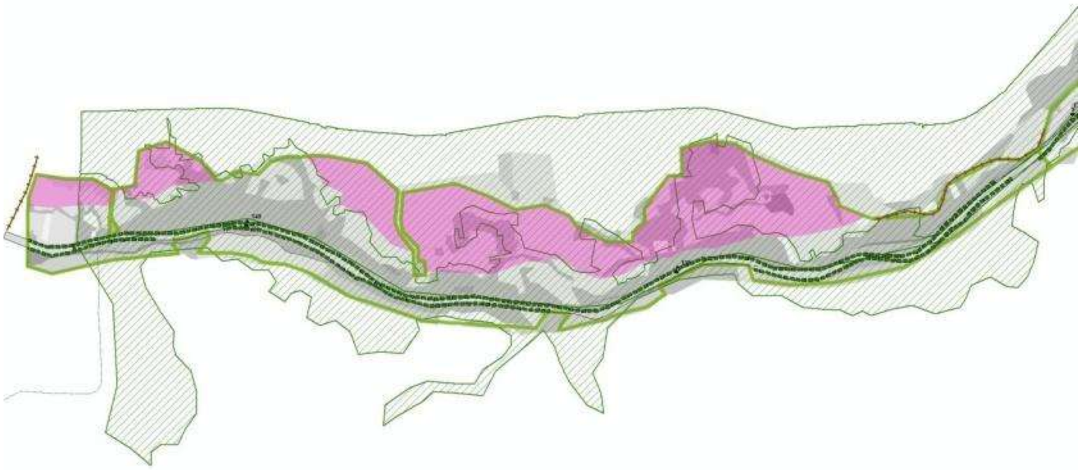
3.6 Maps of potential restoration areas



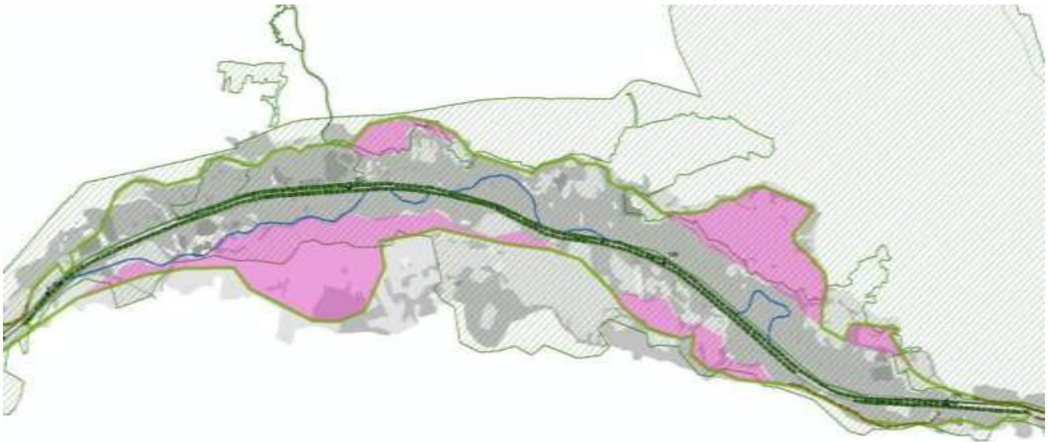


3.6.1 Mura

1 Downstream Spielfeld (AT) 1,107 (449) ha

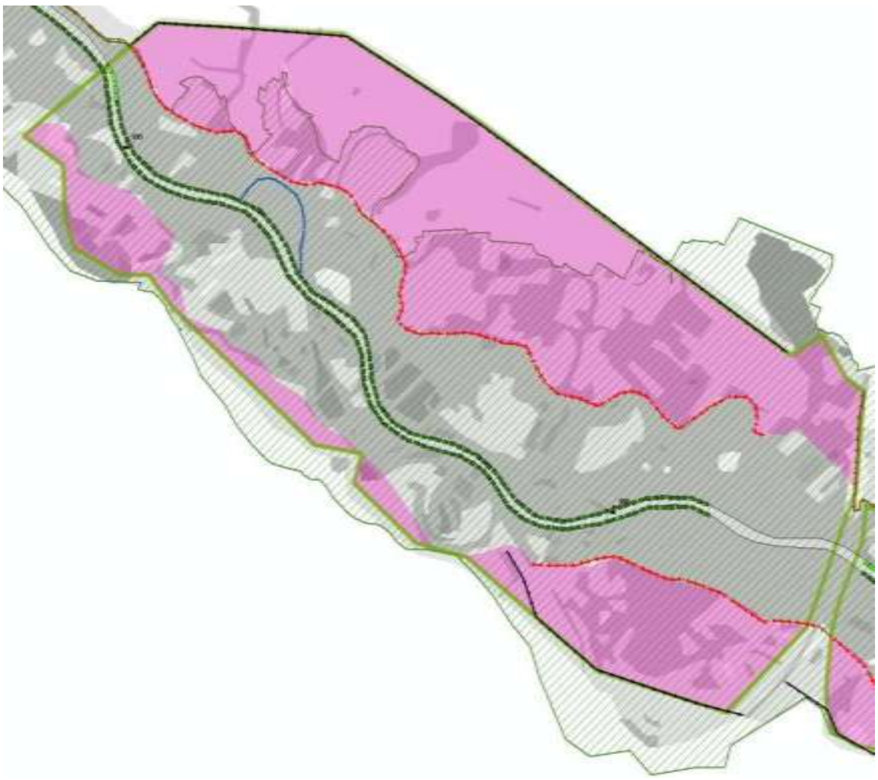


2 Upstream Bad Radkersburg (AT) 2,435 (767) ha

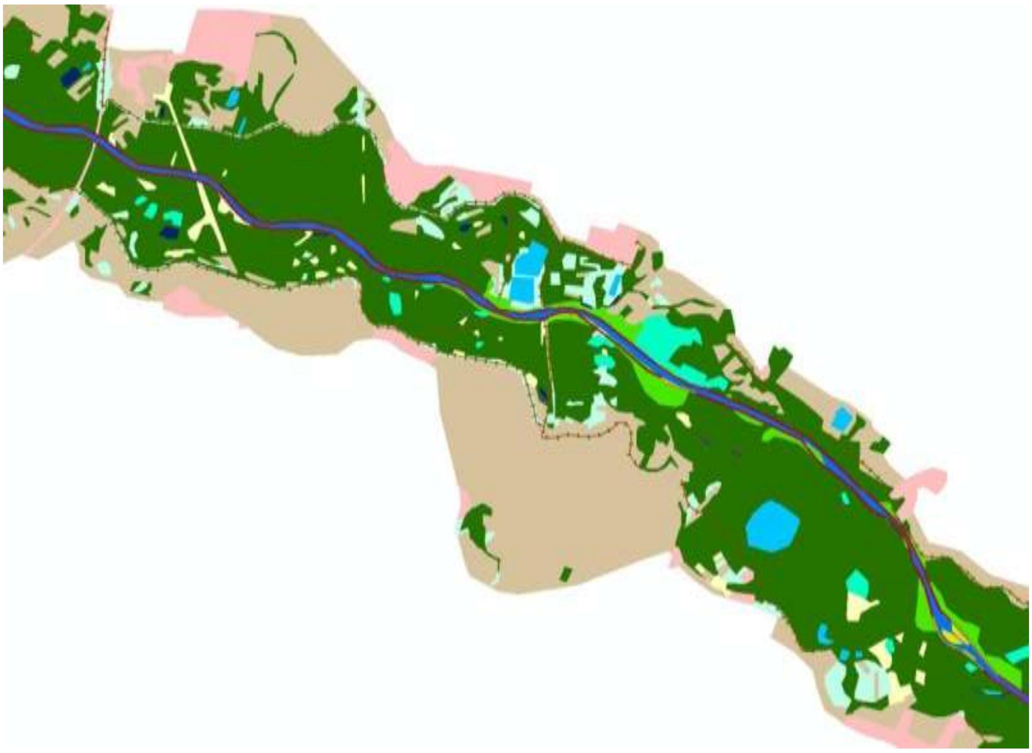


3 Downstream Bad Radkersburg (AT) 988 (637) ha

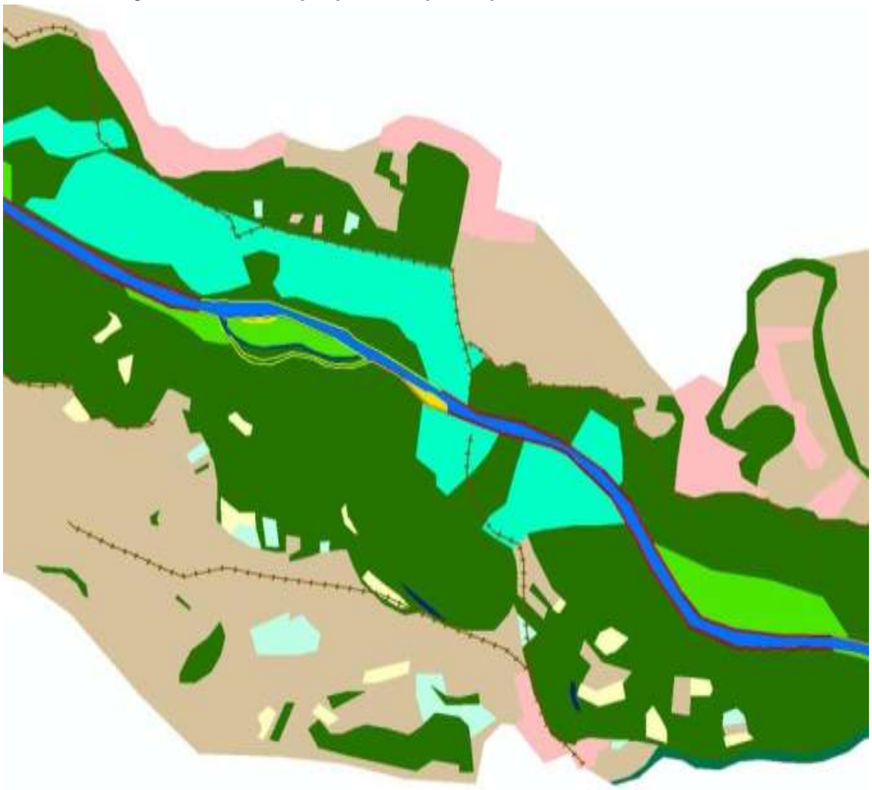
4 Gradisce (SI) 1,494 (761) ha

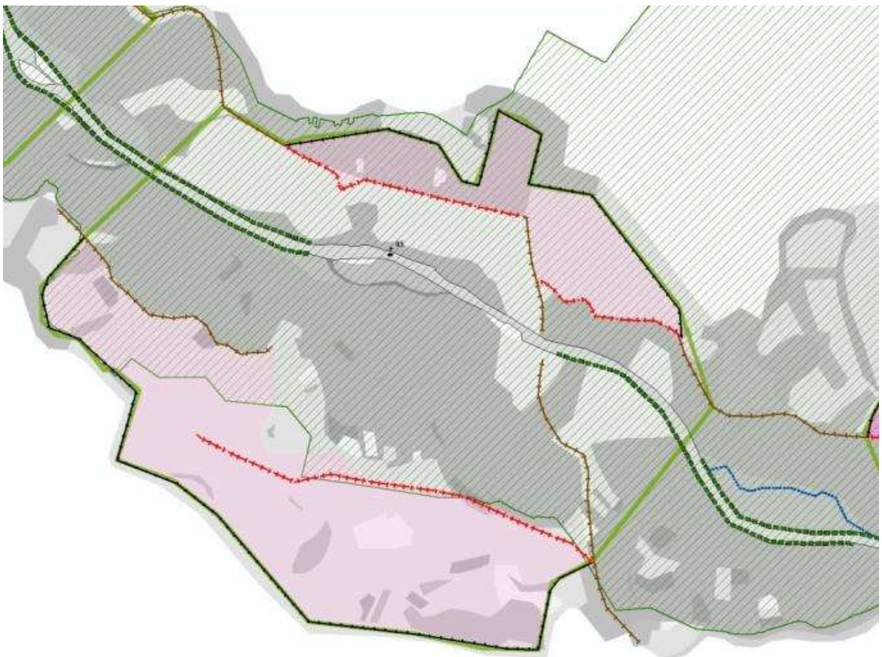


5 Verzey, Biomura (SI) 2,221(710) ha

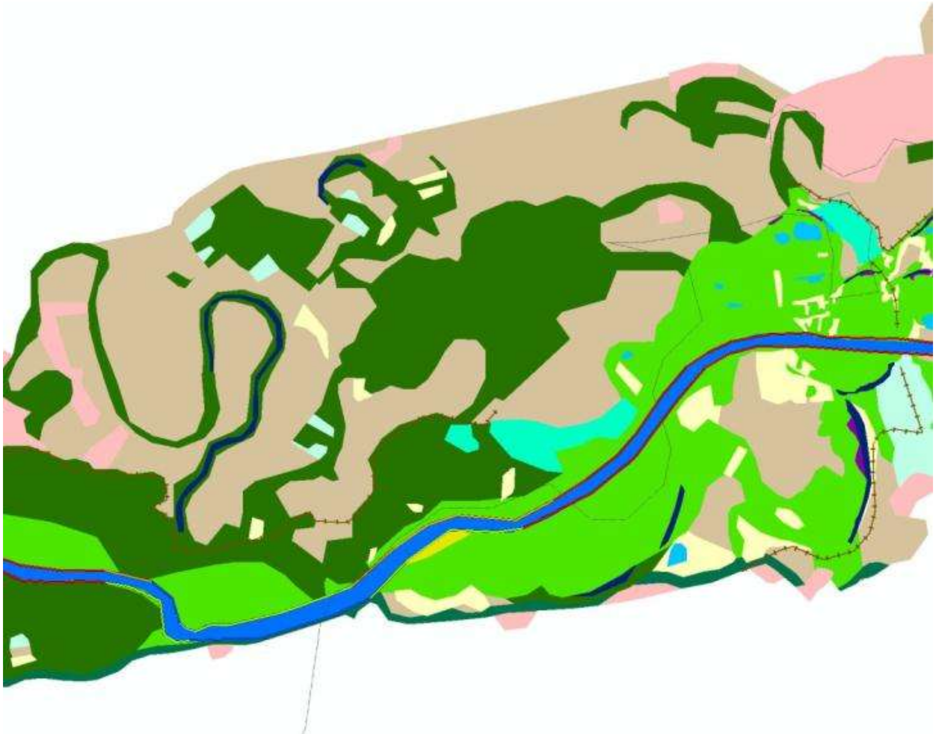


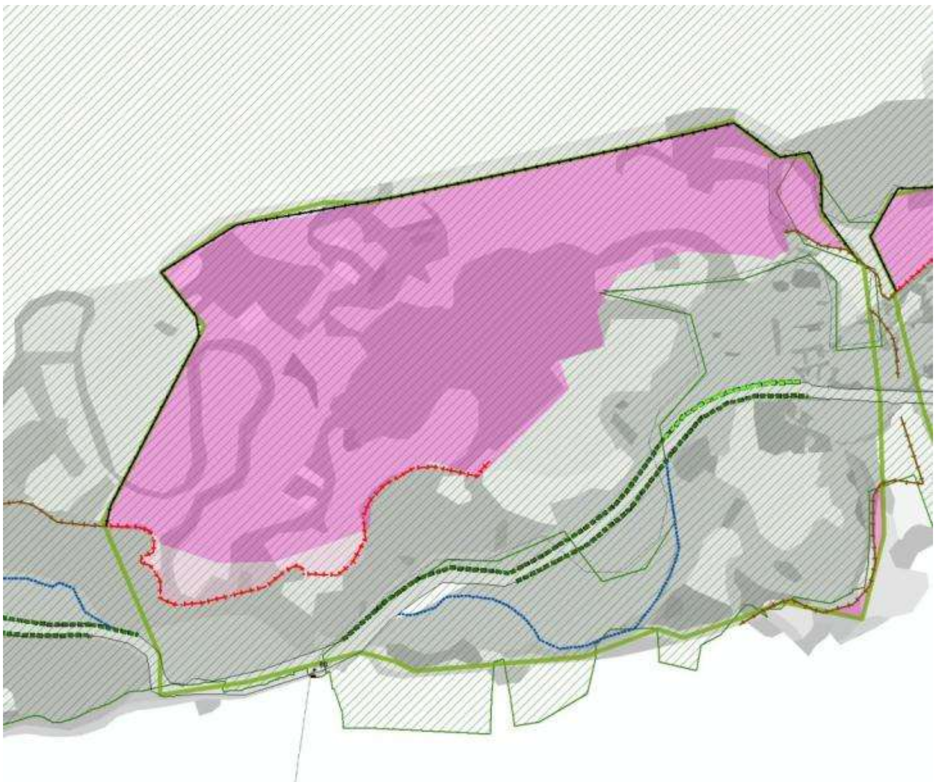
6 Sreddnja Bistrica (SI) 895 (375) ha



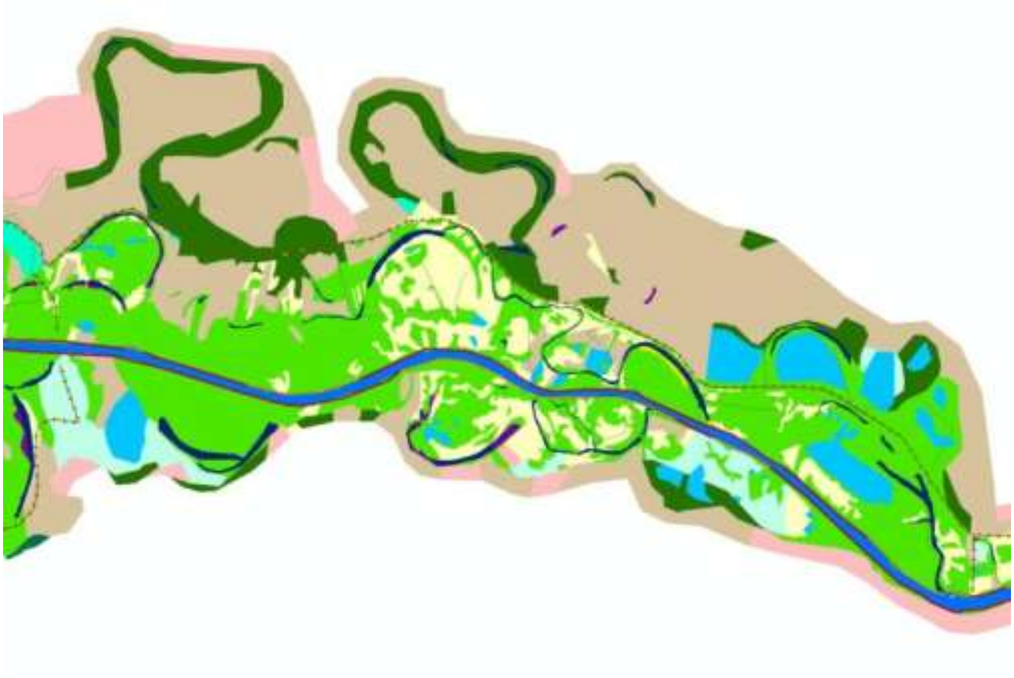


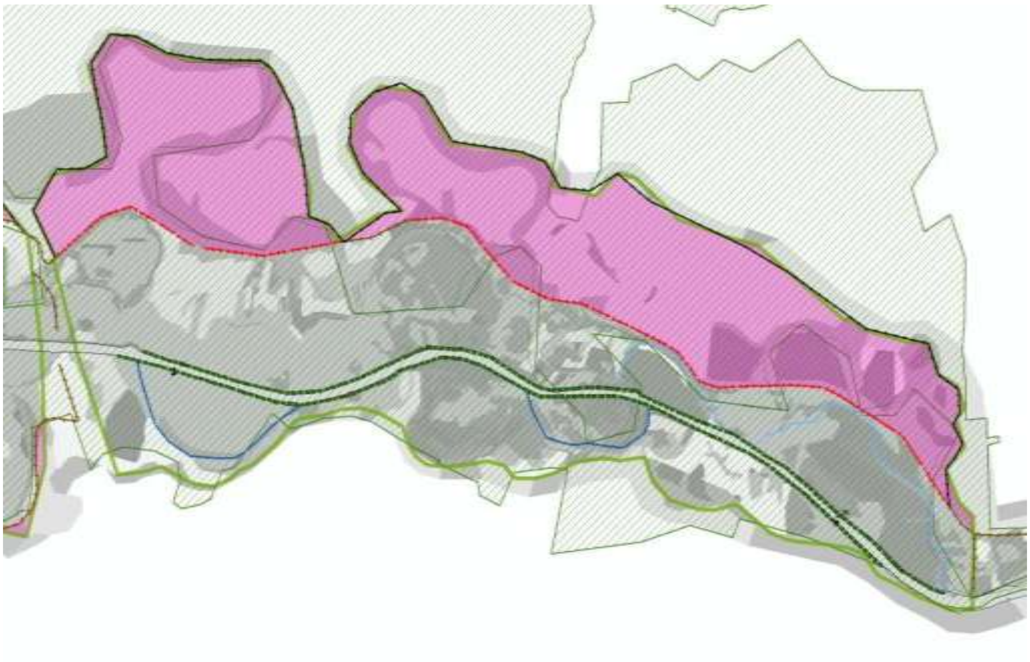
7 Hotiza (SI/HR) 1,190 (578) ha





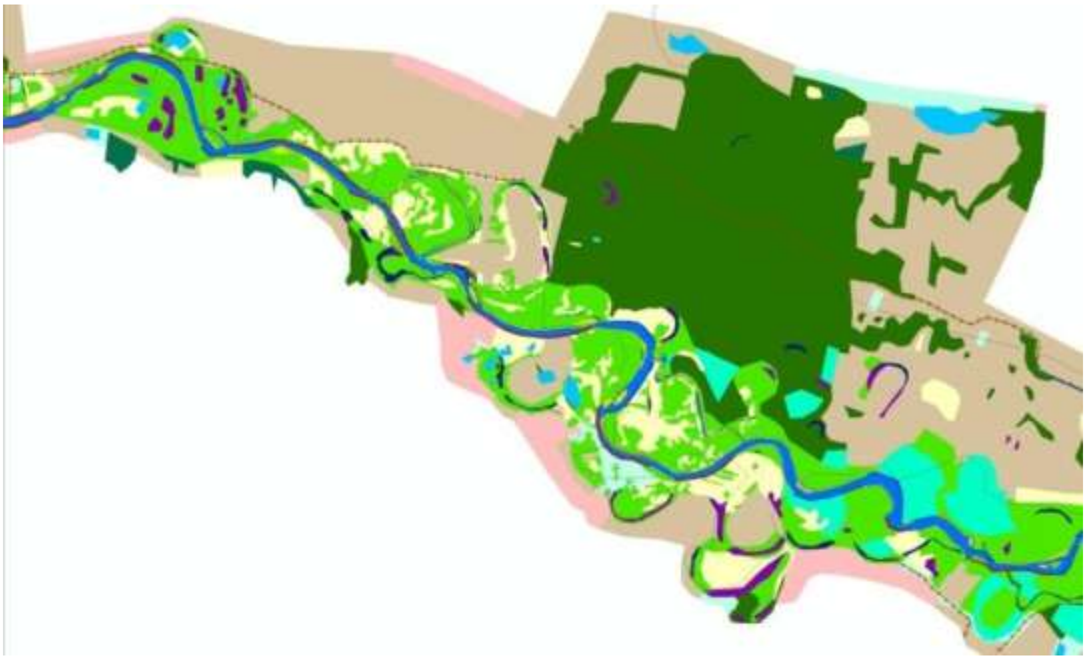
8 Upstream Mursca Sredisce (SI/HR) 1,322 (546) ha

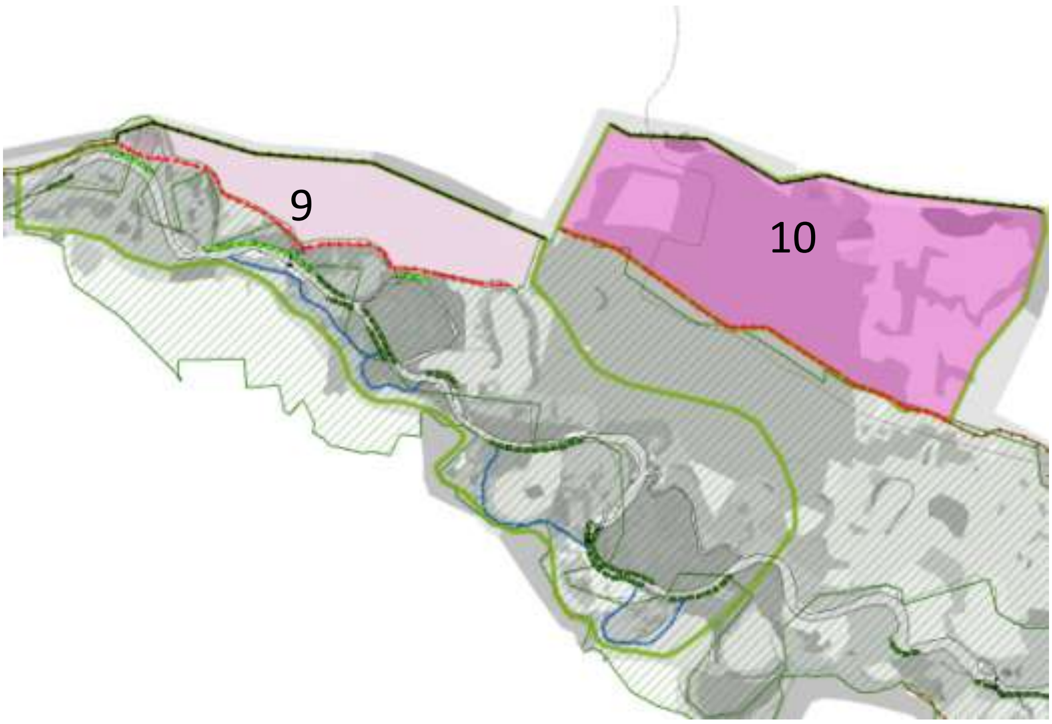




9 Mura near Miklavec (SI/HR) 1,312 (242) ha &

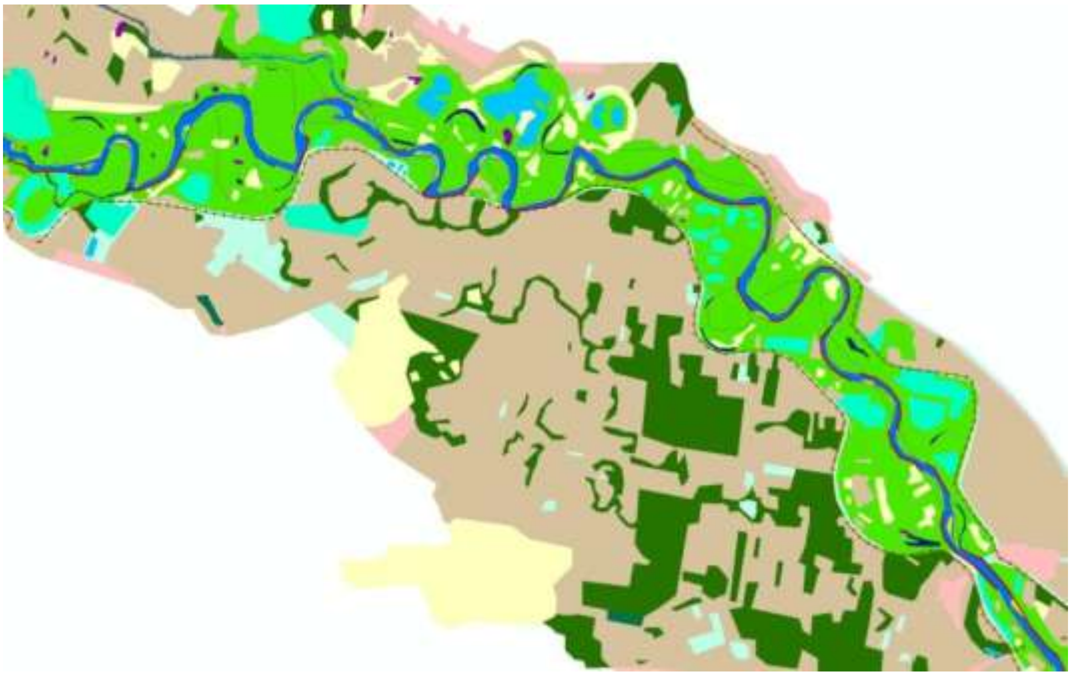
10 Pince (HU/SI) 669 (669) ha

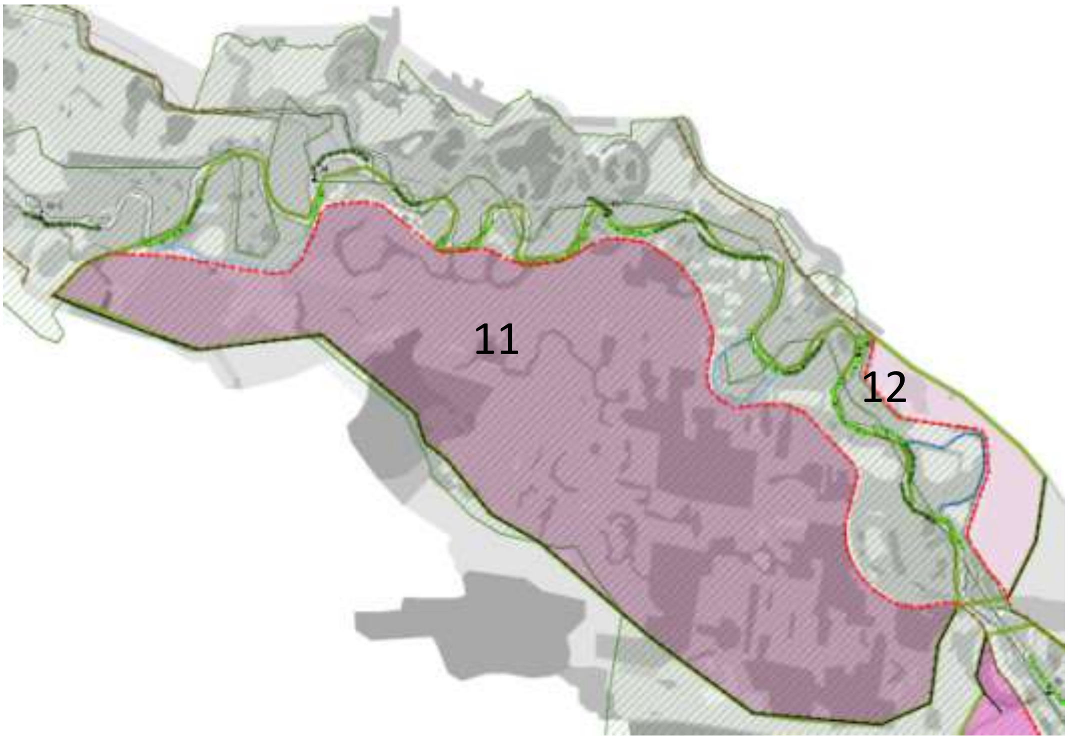




11 Domasinec (HR) 2,814 (2,183) ha &

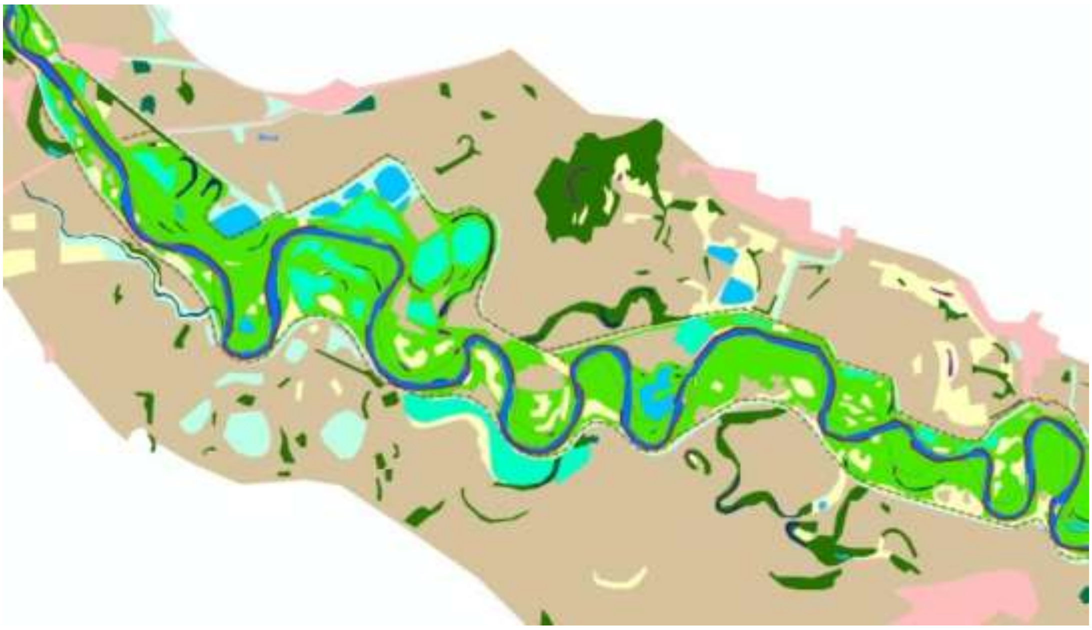
12 Muraratka (HU) 319 (158) ha

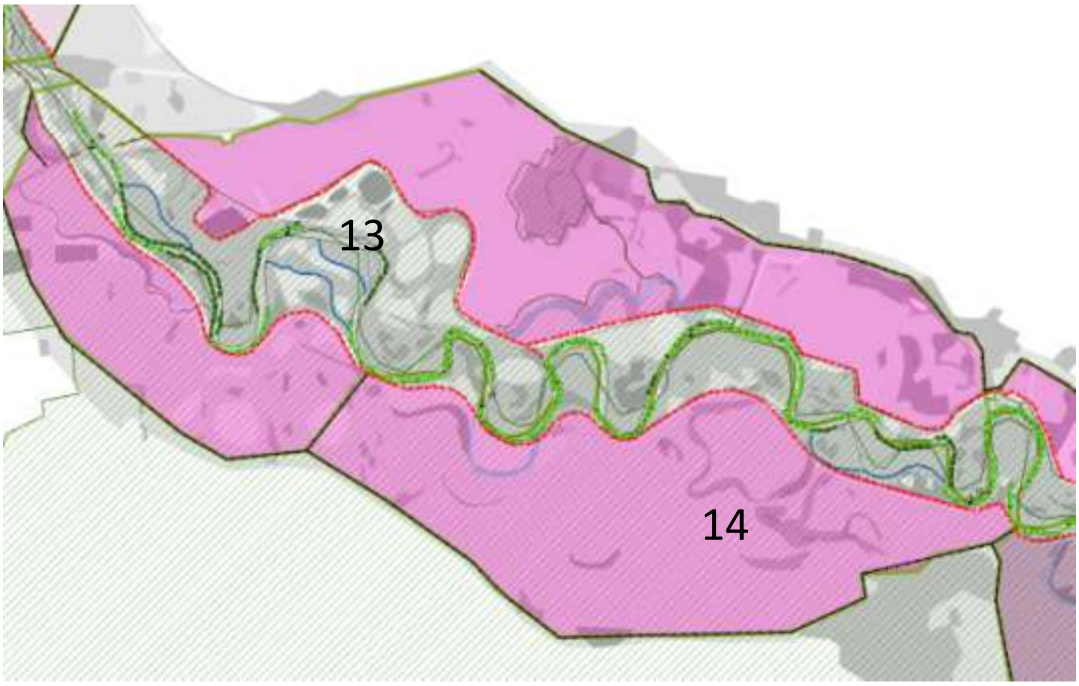




13 Gorican-Totszendhely (HU/HR) 3,087 (1,970) ha &

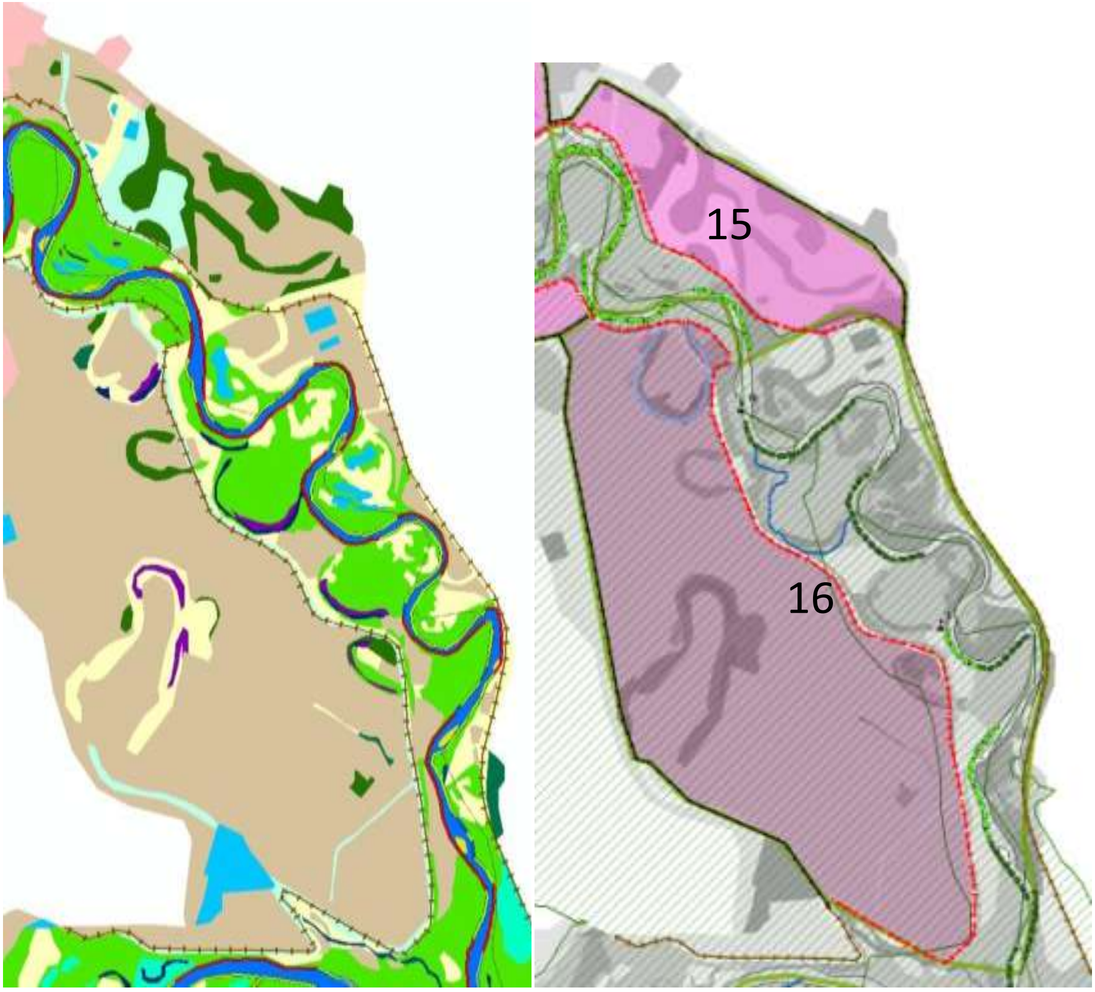
14 Kotariba (HR) 1,789 (1,402) ha





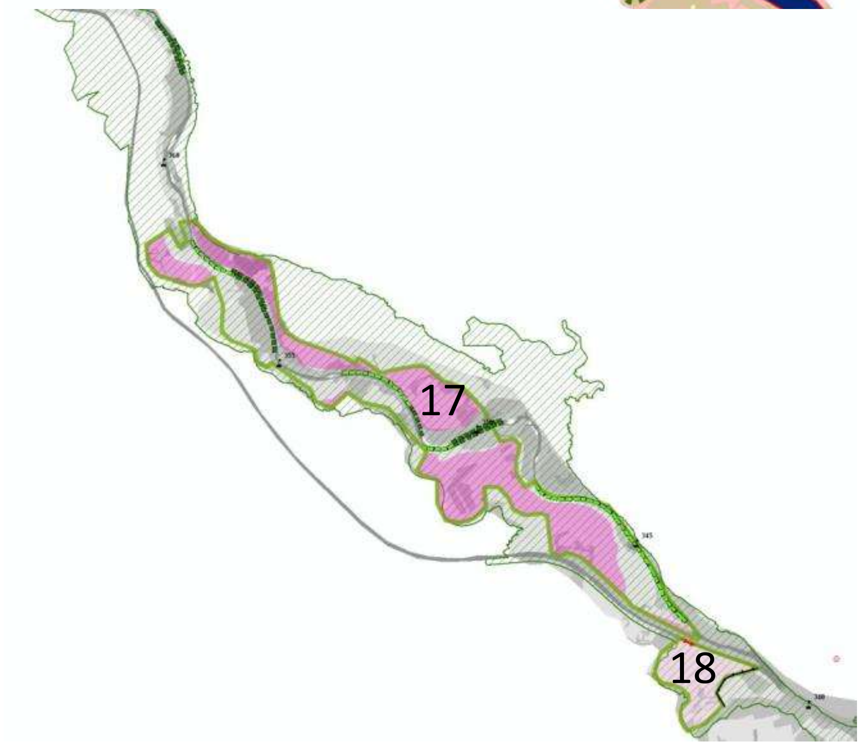
15 Ujtelep (HU) 321 (237) ha &

16 Mura near Drava confluence (HR) 1,567 (941) ha



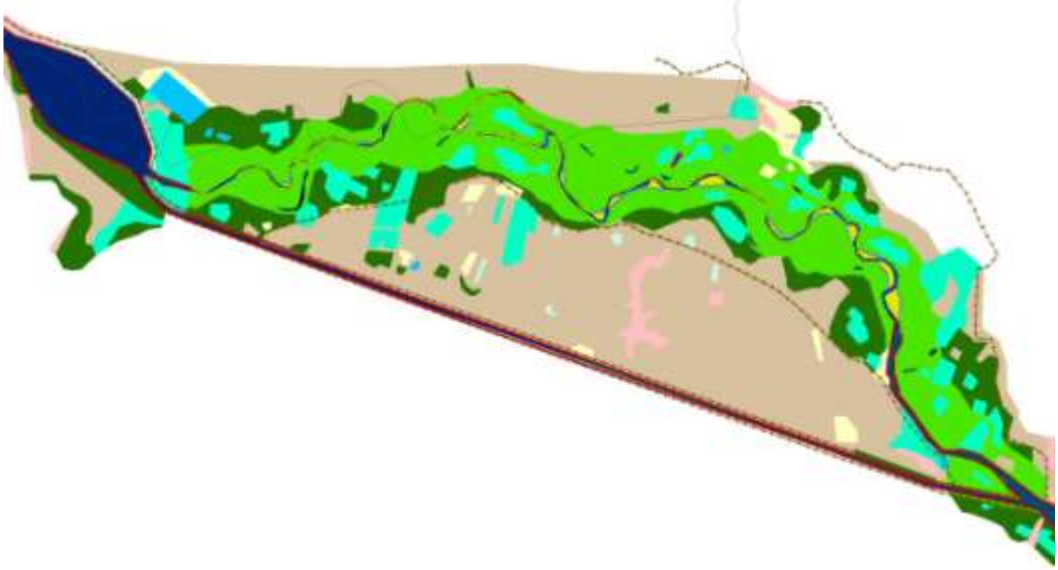
3.6.2 Drava

17 Rosnja (SI) 1,370 (783) ha & 18 Ptuj (SI) 174 (174) ha

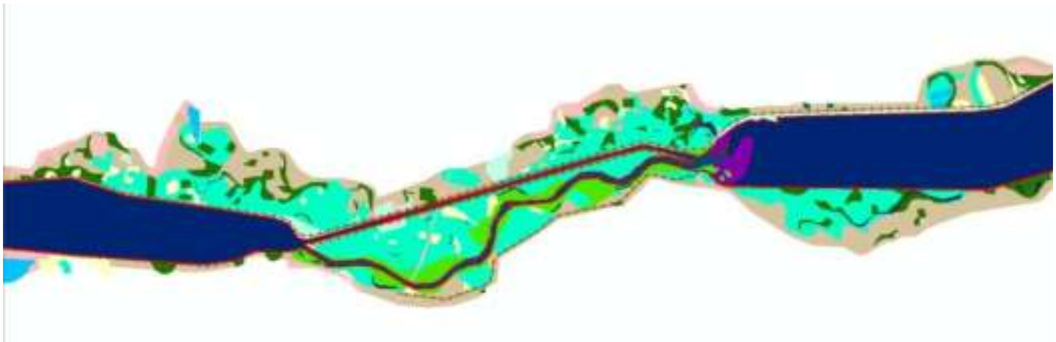


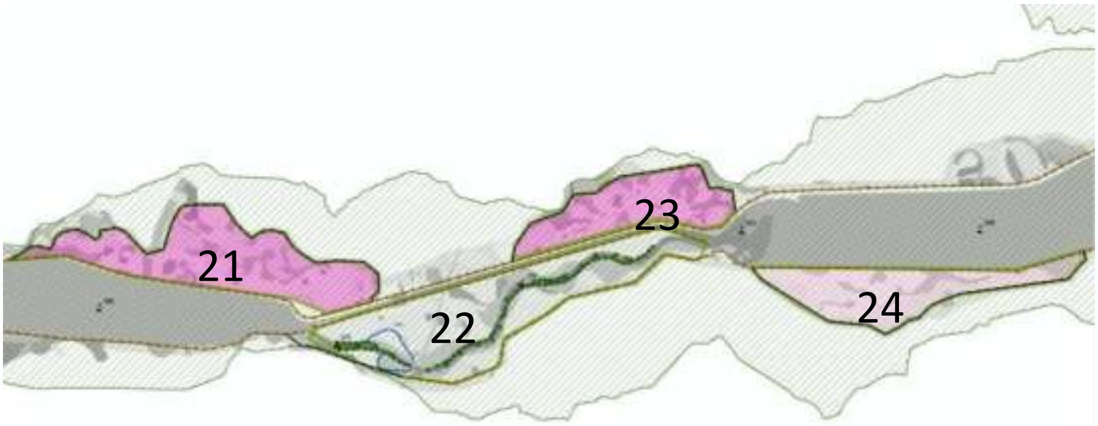
19 Stojnci (SI/HR) 2,815 (421) ha

20 Svibovec Podravski (HR/SI) 3,126 (571) ha

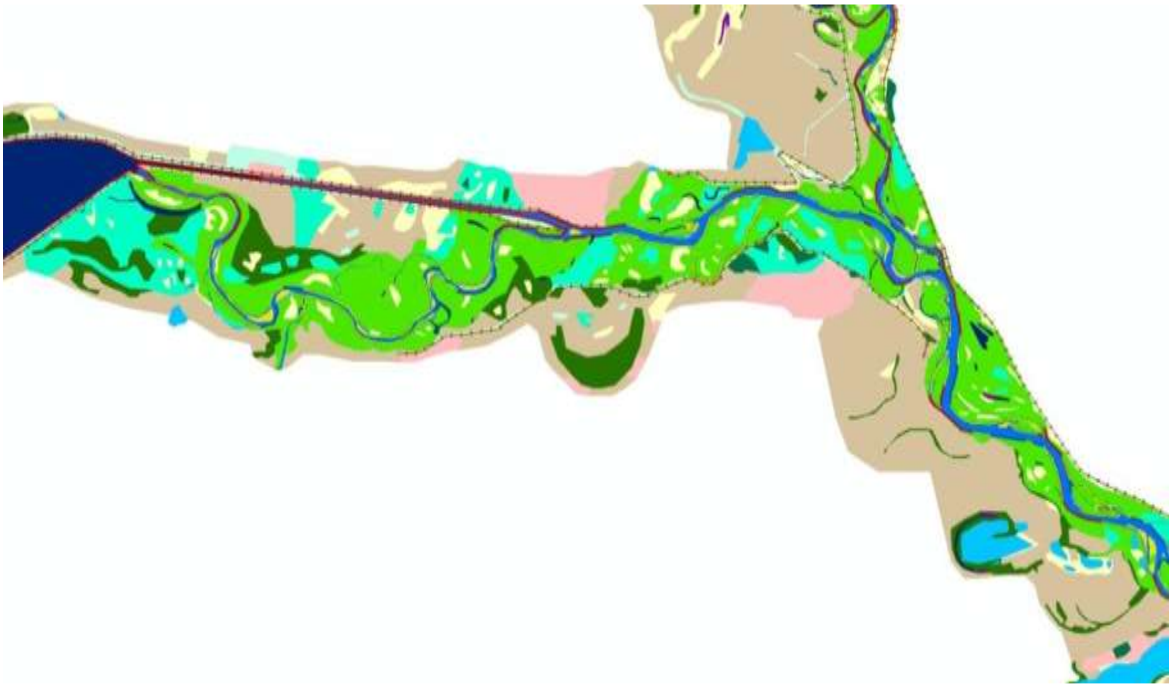


21 Totovec (HR) 713 (713) ha & 22 Hrzenica (HR) 951 (-) ha & 23 Prelog (HR) 410 (410) ha & 24 Sesvete Ludbreske (HR) 499 (499) ha

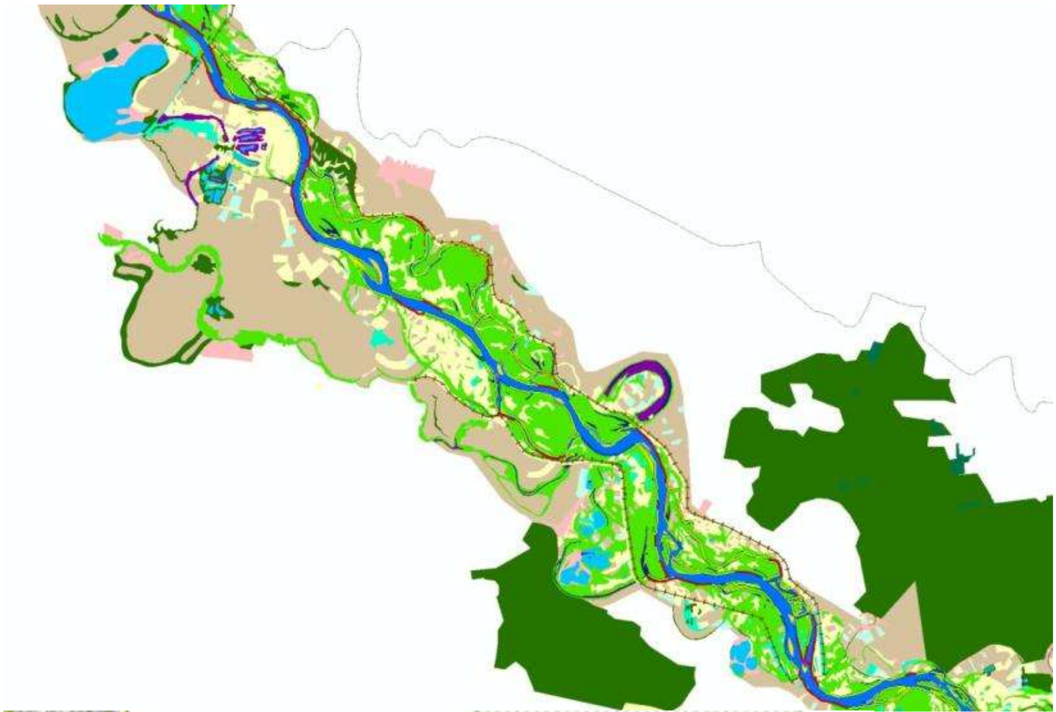


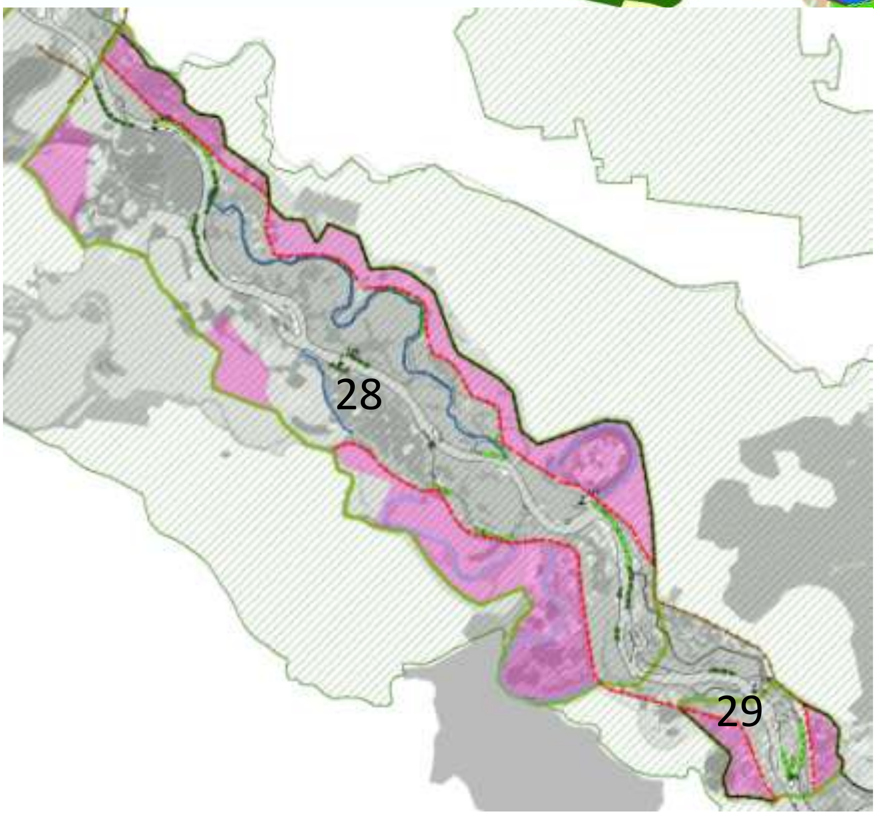


25 Upstream Legrad (HR) 2,108 (304) ha & 26 Downstream Legrad (HR) 536 (318) ha & 27 Cingi-Lingi Botovo (HR) 686 (198) ha

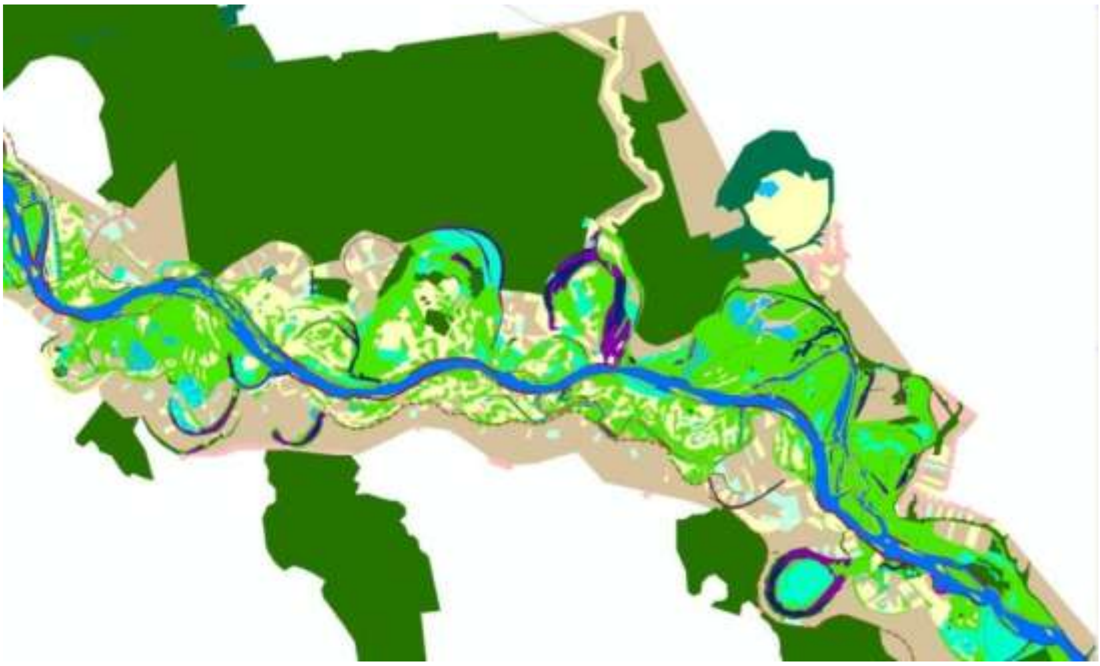


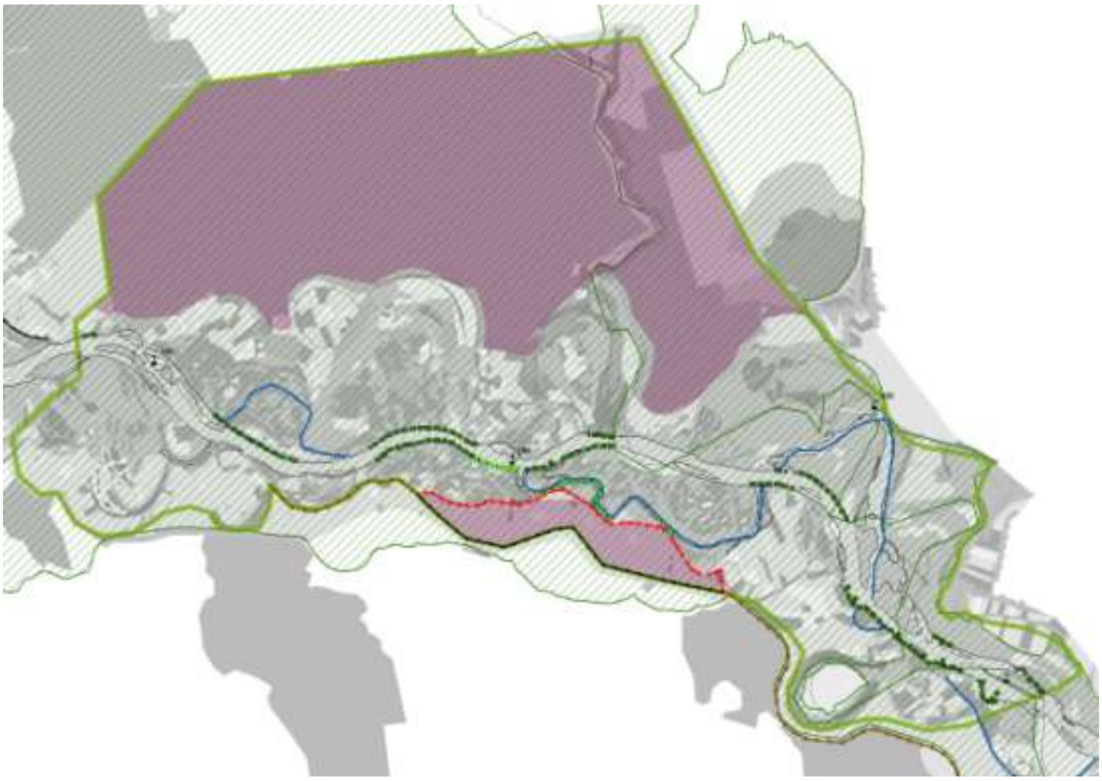
28 Drava near Gotalovo (HR) 3,561 (1,282) ha & 29 Repas bridge (HR) 299 (123) ha



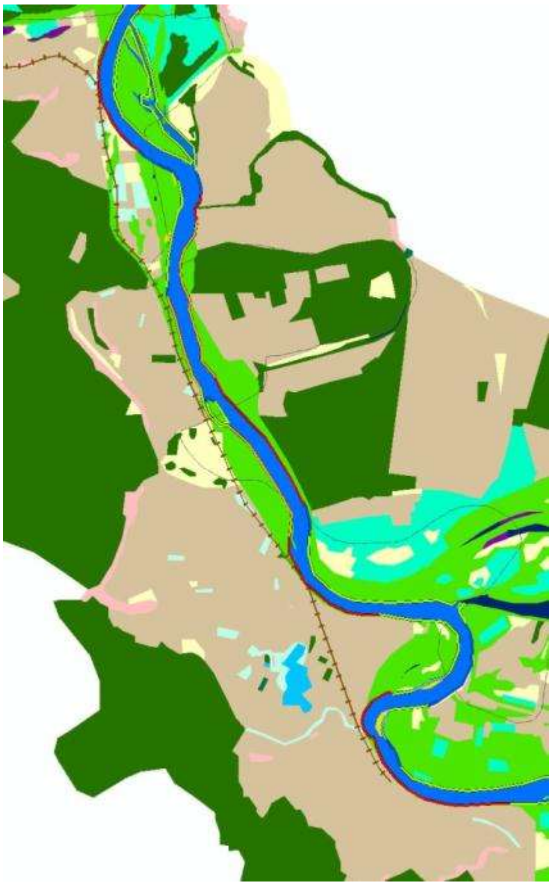


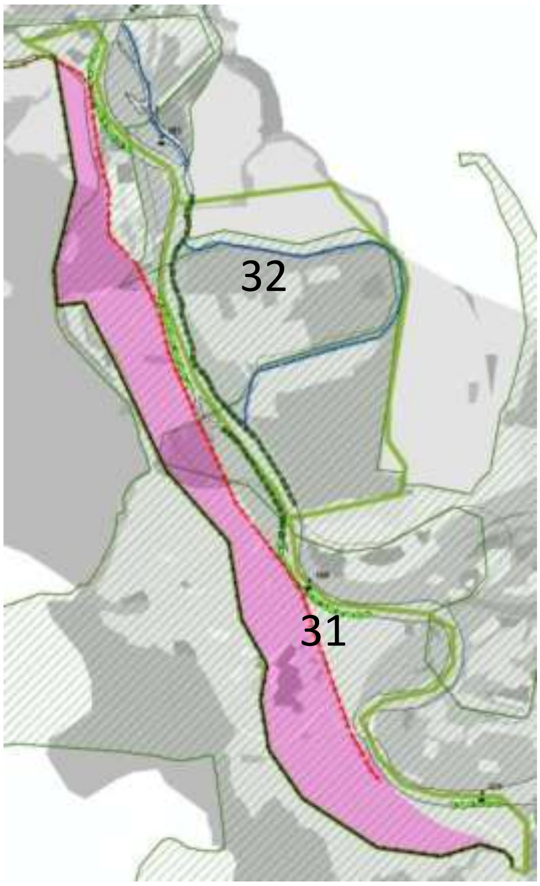
30 Drava near Belavar and Novo Virje (HR/HU) 5,954 (2,520) ha



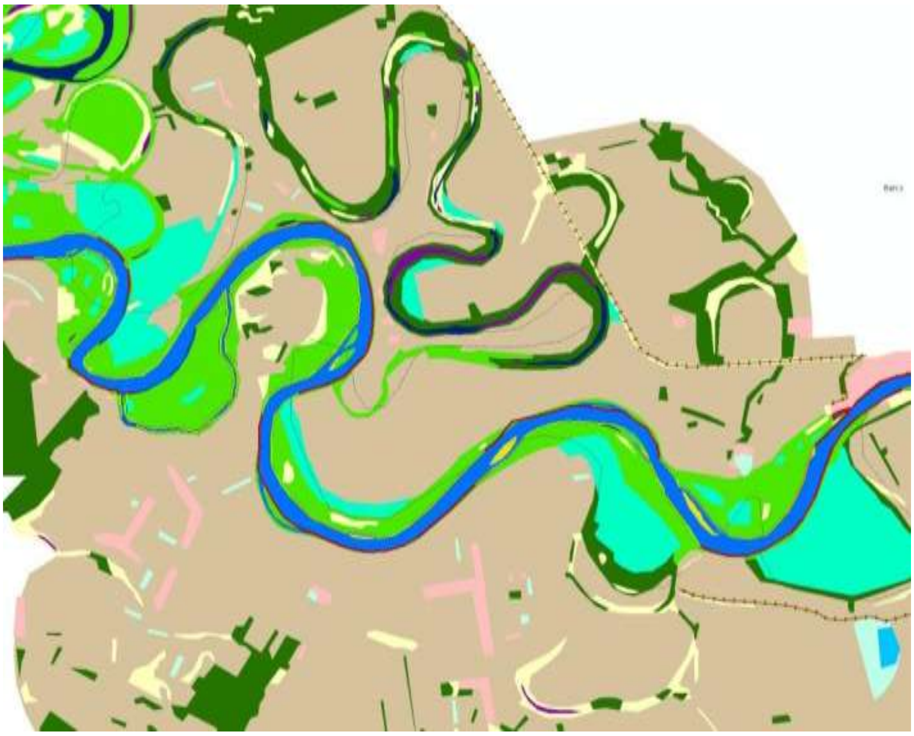


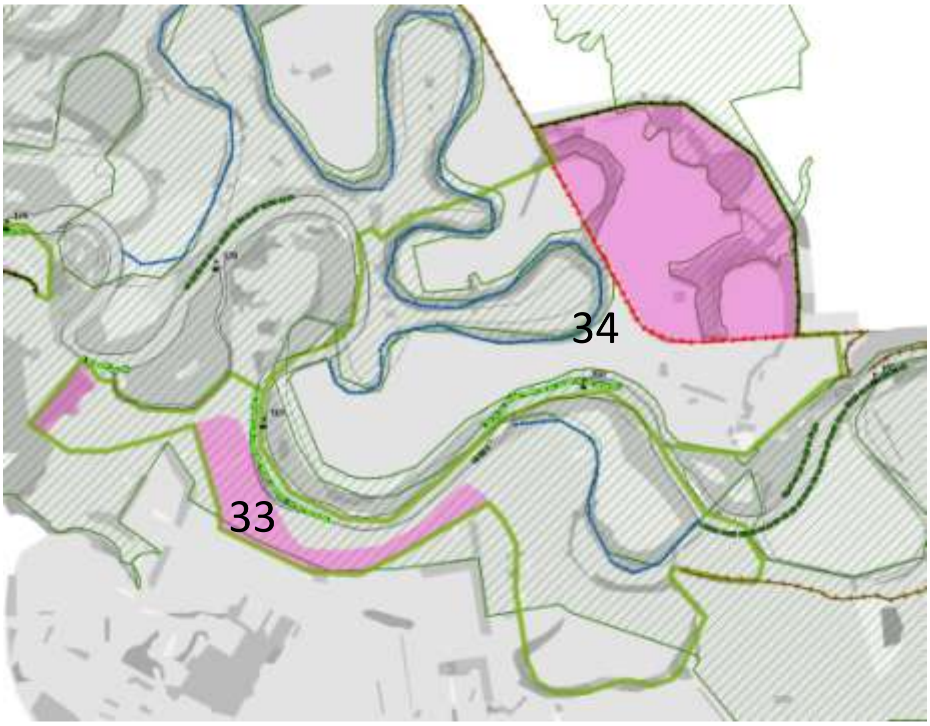
31 Podravske Sesvete (HR) 1,116 (643) ha & 32 Bolho (HU) 800 (104) ha



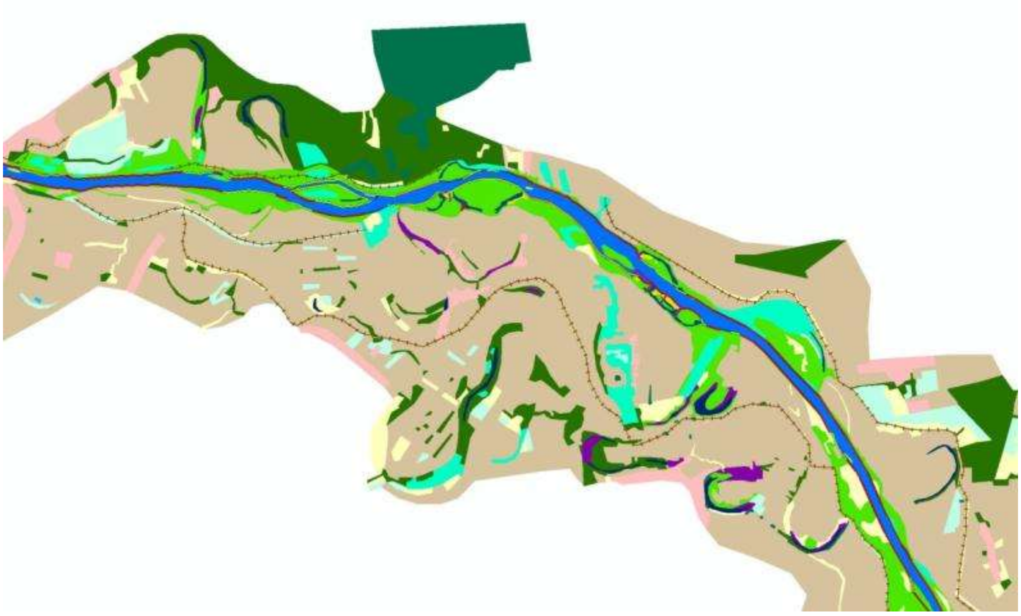


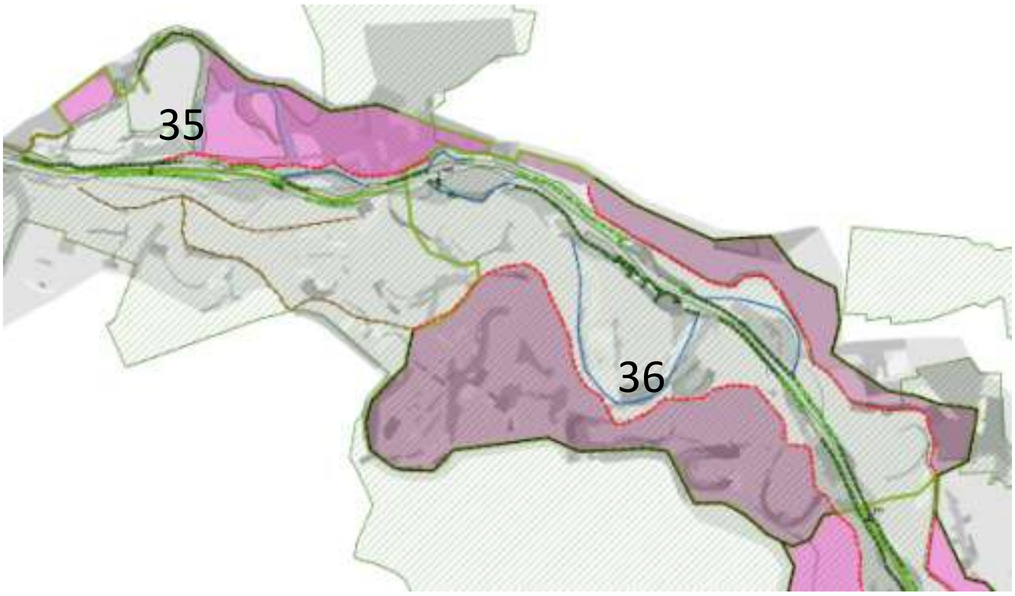
33 Okrugljaca (HR) 1,164 (189) ha & 34 Barcs west (HU) 1,975 (598) ha



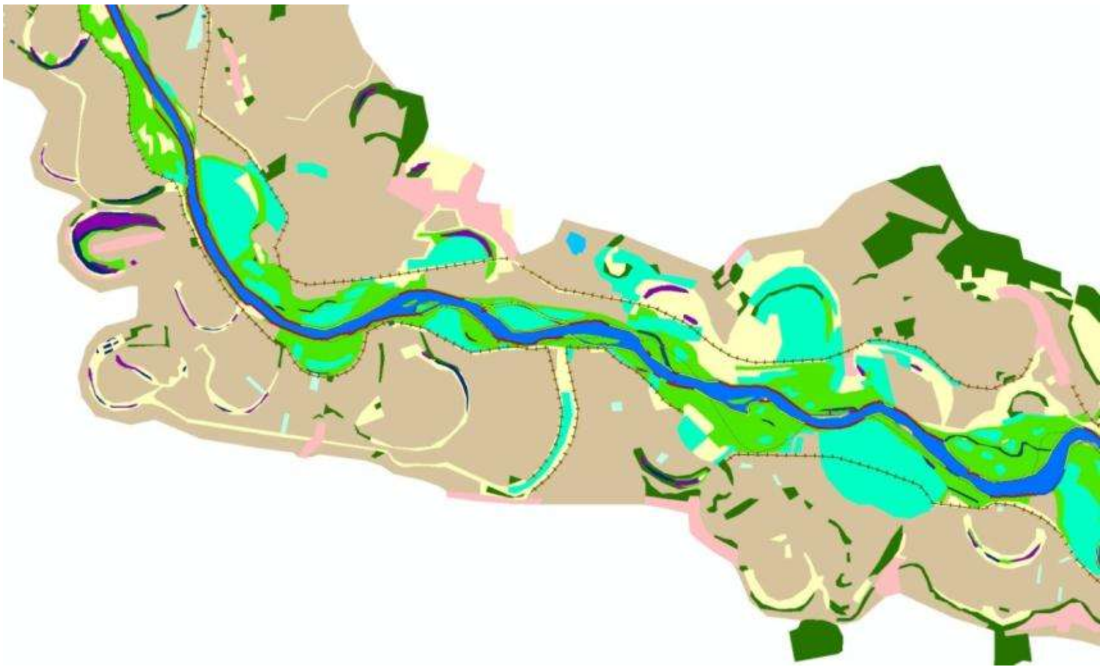


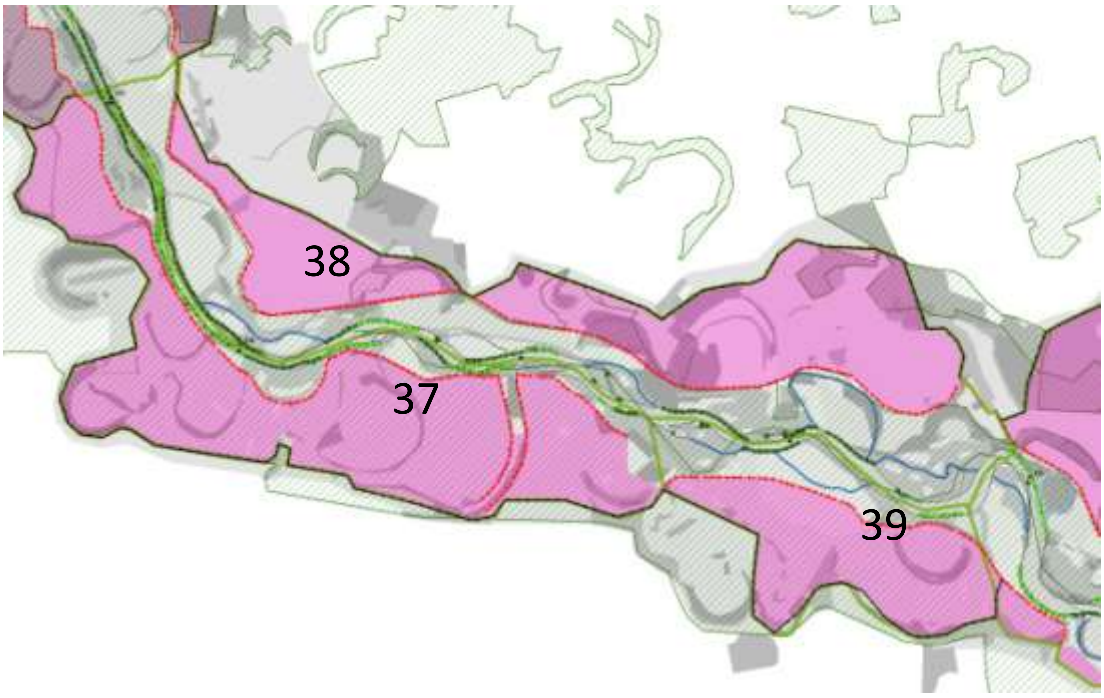
35 Barcs east (HU) 1,071 (549) ha & 36 Drava near Detkovac (HR/HU) 3,763 (1,907) ha



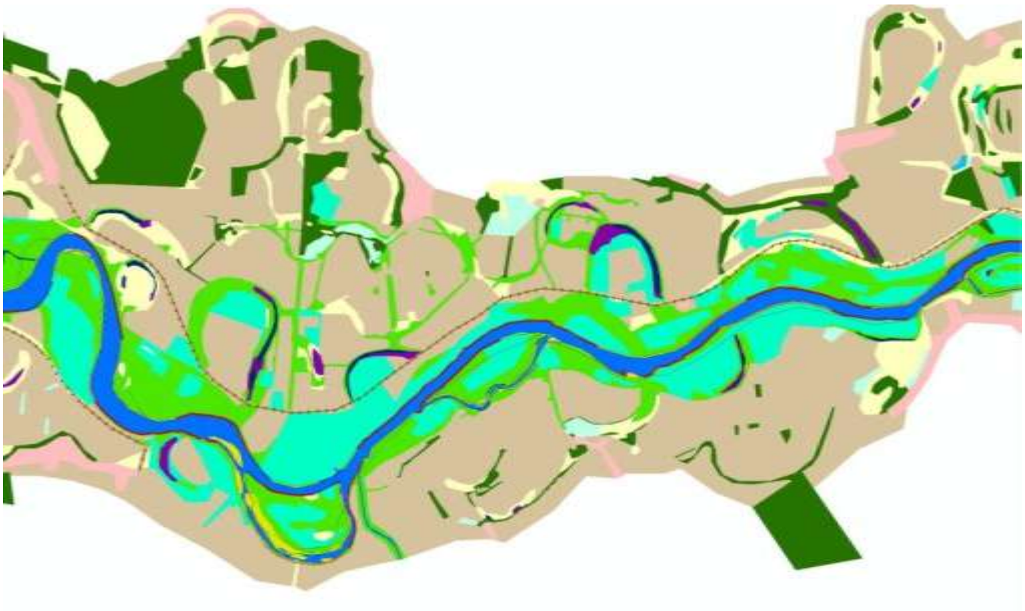


37 Vaska (HR) 2,694 (2,144) ha & 38 Felsoszentmarton (HU) 3,379 (1,734) ha & 39 Sopje (HR) 1,188 (789) ha

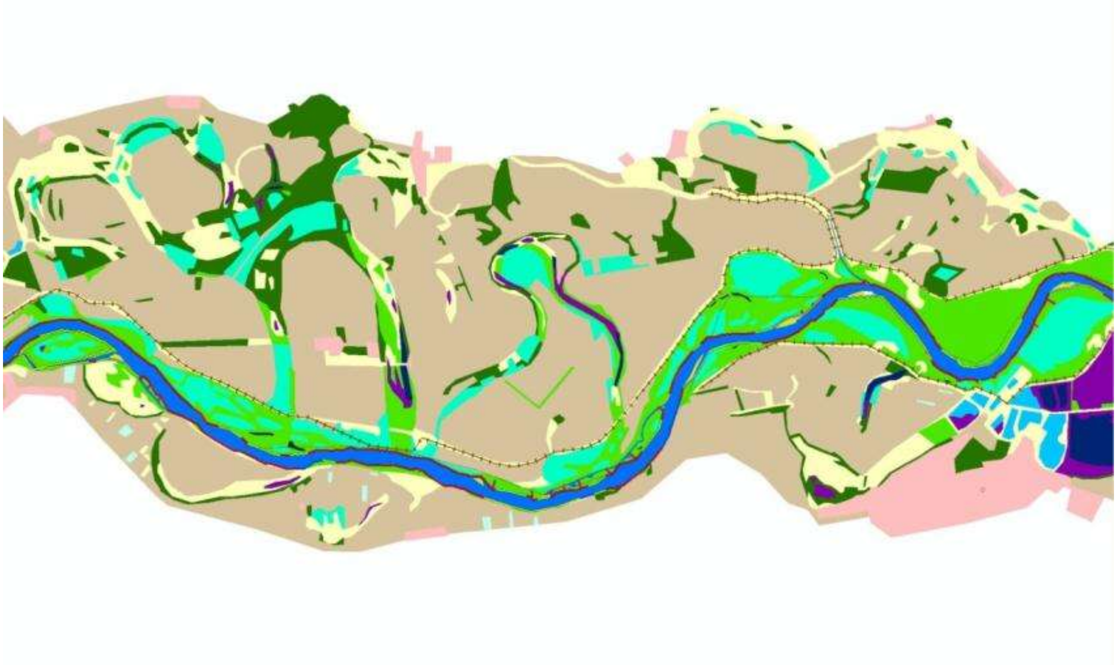




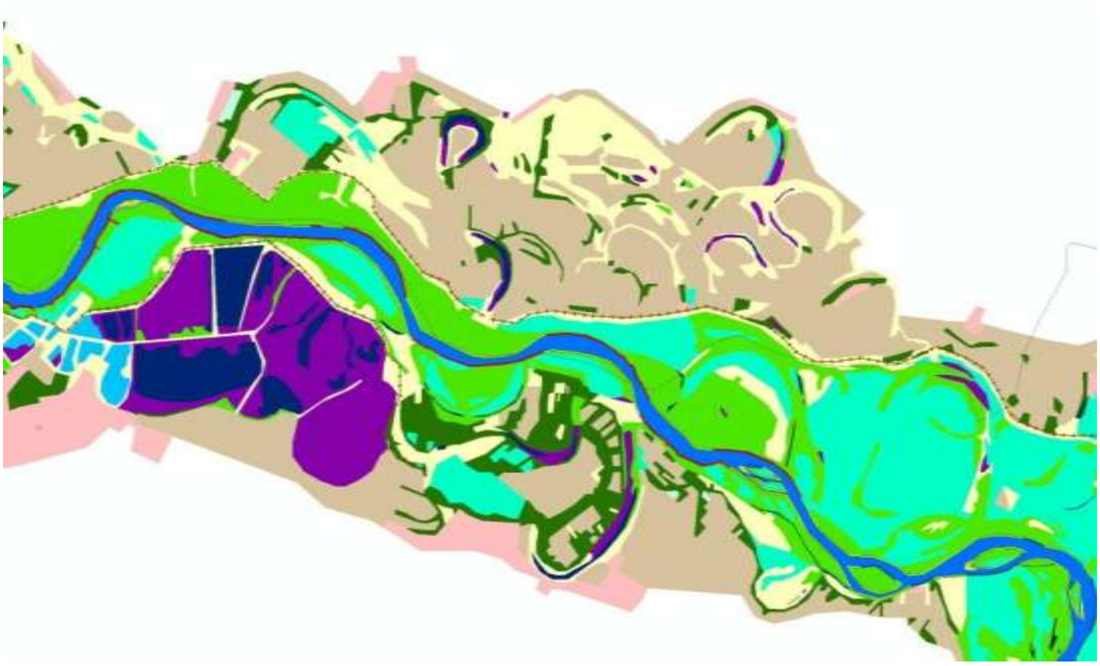
40 Pisco (HU/HR) 6,051 (3,135) ha

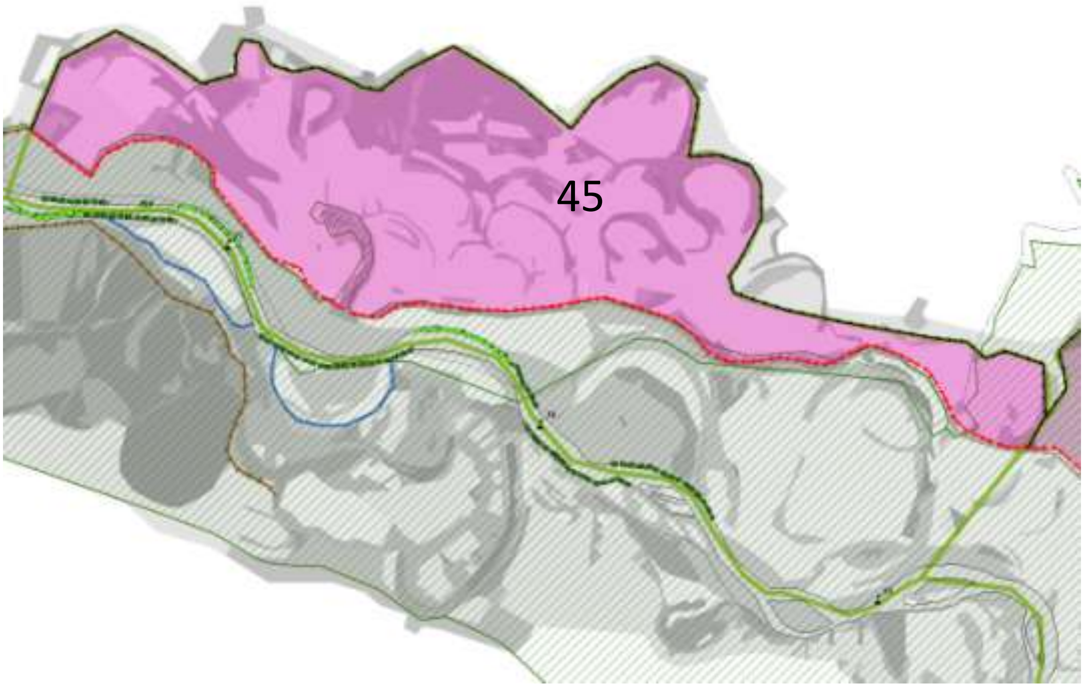


41 Kisszentmarton (HU) 2,417 (2,107) ha & 42 Dravapalkonya (HU) 3,324 (2,547) ha & 43 Viljevo (HR) 545 (84) ha & 44 Donlji Miholac (HR) 927 (690) ha

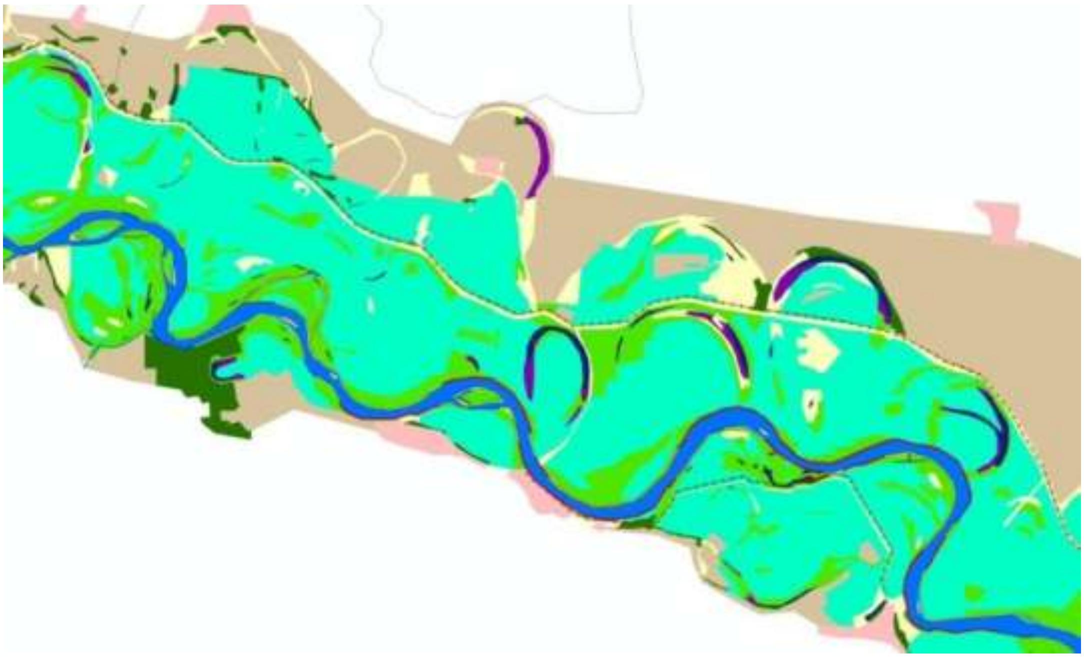


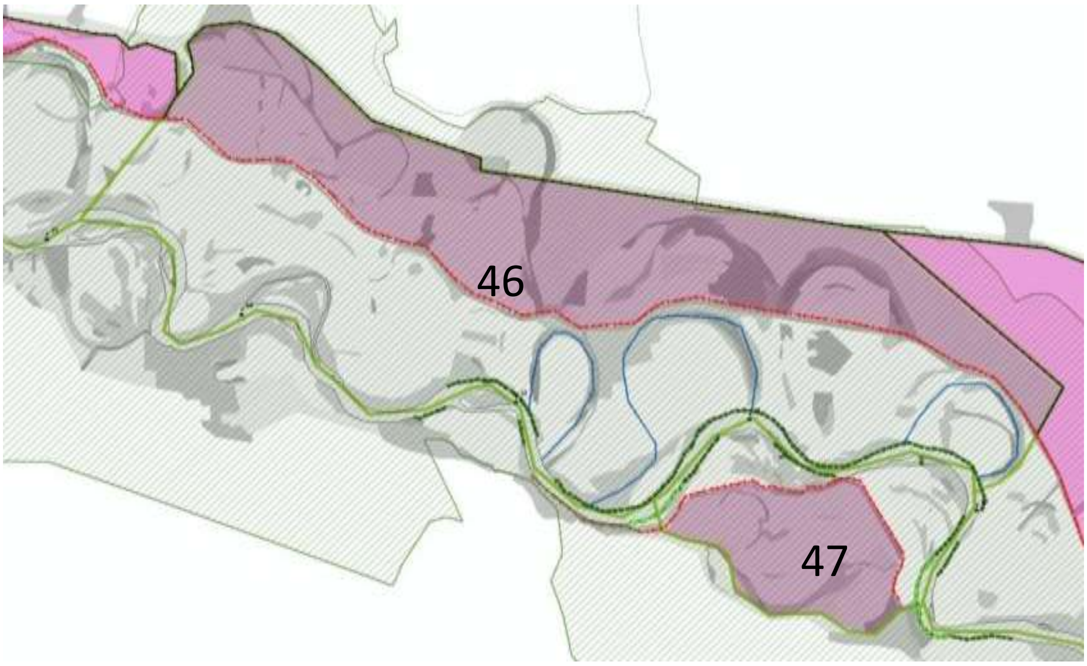
45 Matty (HU/HR) 3,726 (2,089) ha



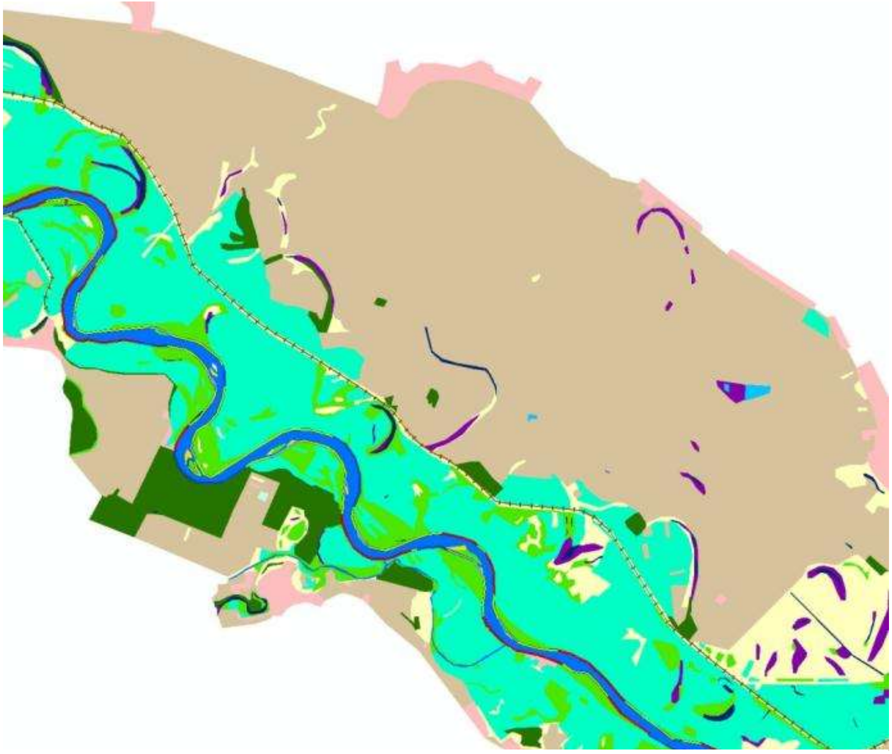


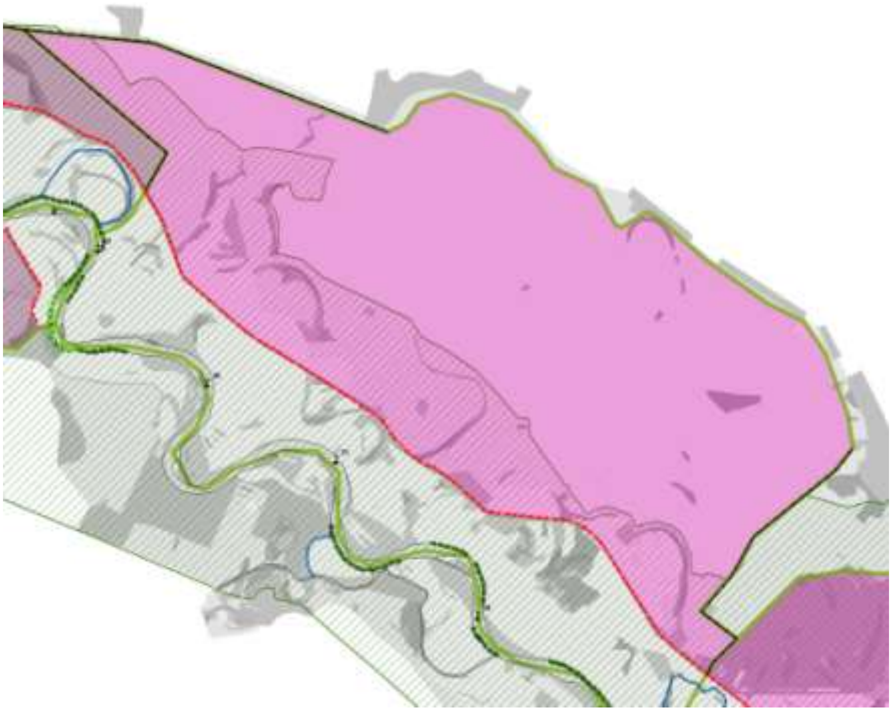
46 Dravske Sume west (HR) 5,231 (2,112) ha & 47 Valpovo (HR) 966 (561) ha



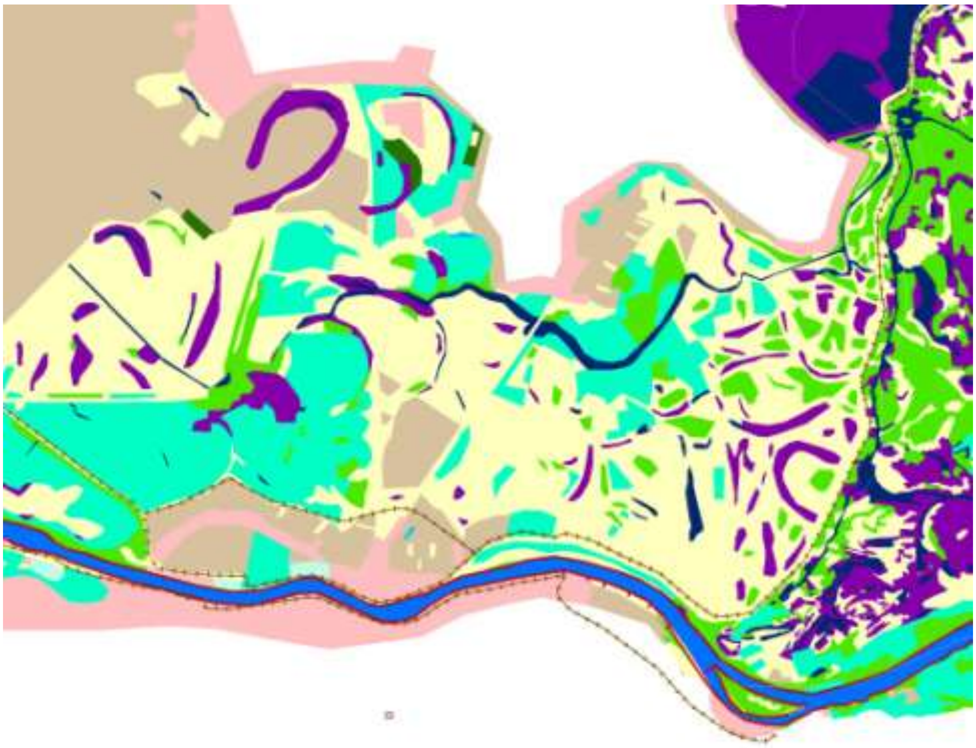


48 Dravske Sume east (HR) 10,851 (8,033) ha

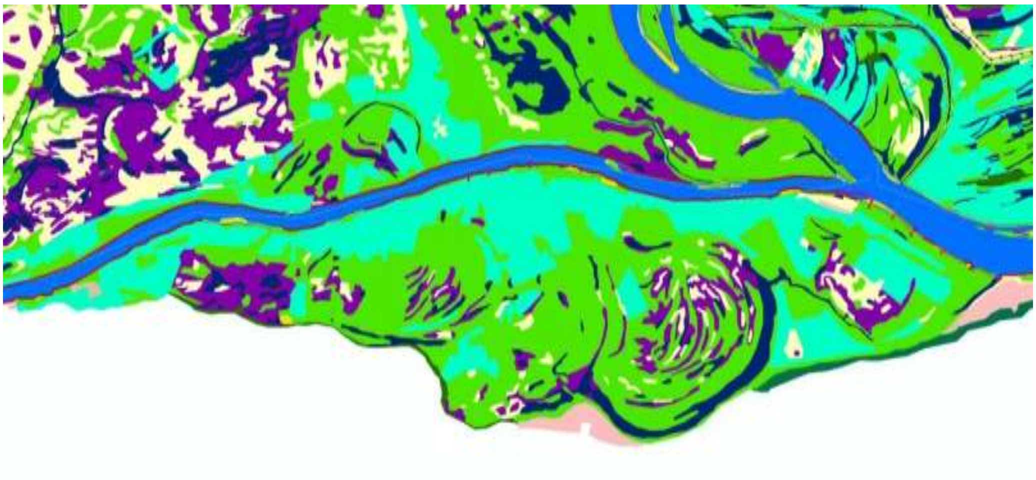




49 Bilje west (HR) 2,505 (2,087) ha & 50 Bilje east (HR) 2,100 (1,990) ha

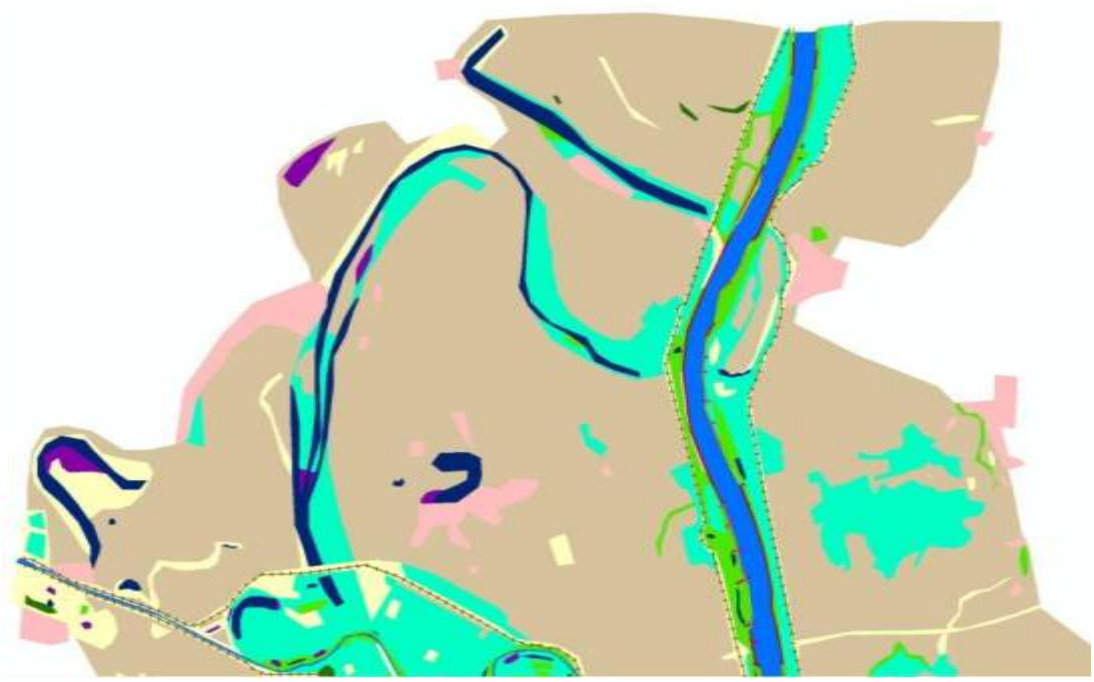


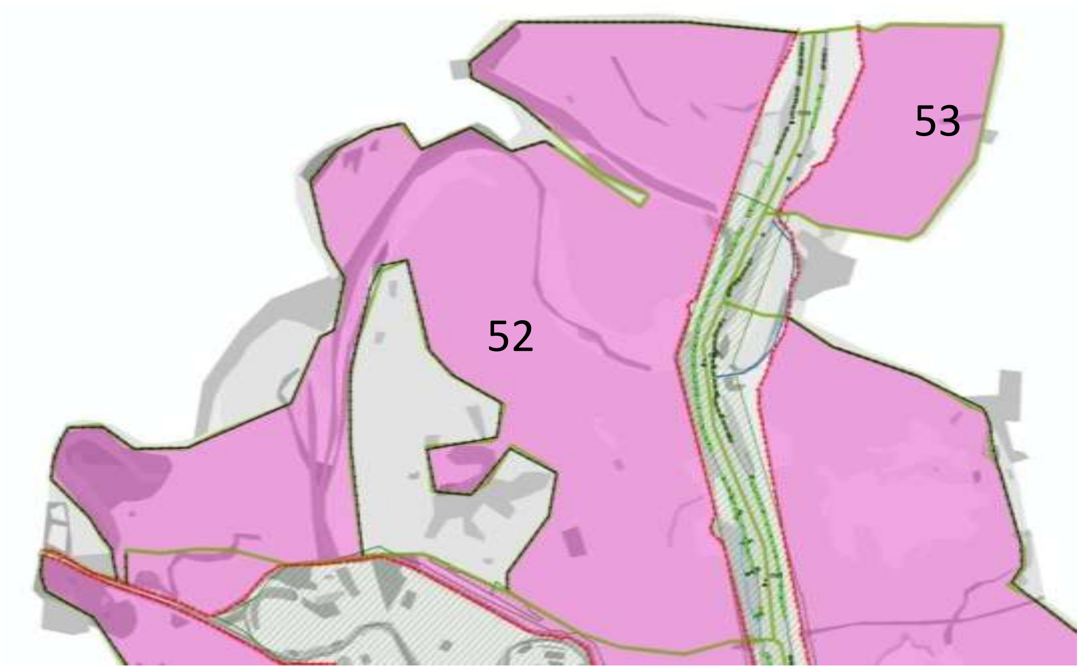
51 Drava near Ajmas (HR) 3,975 (-)ha



3.6.3 Danube

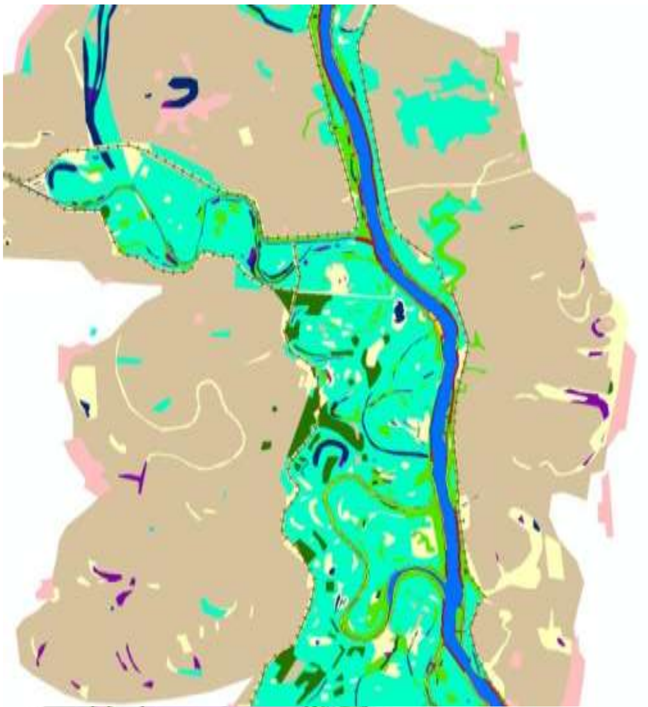
52 Tolna (HU) 9,047 (8,225) ha & 53 Fajsz (HU) 1,452 (1,181) ha

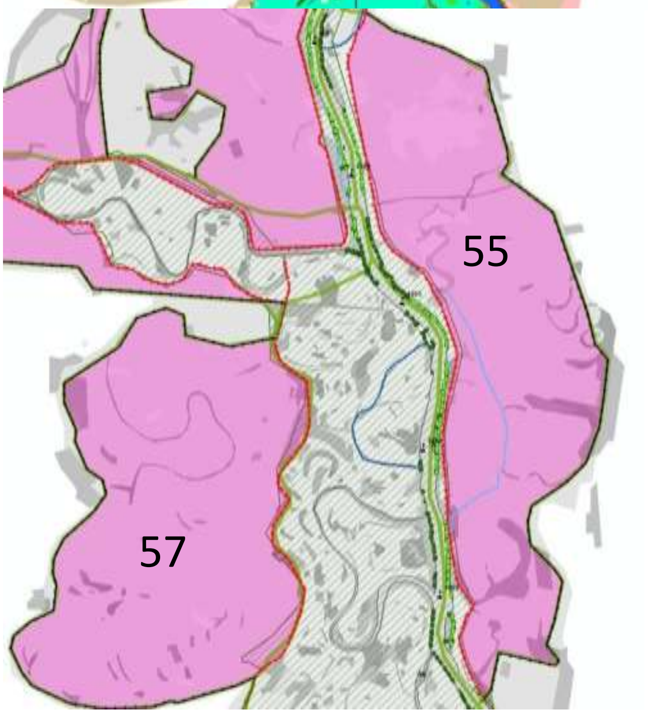




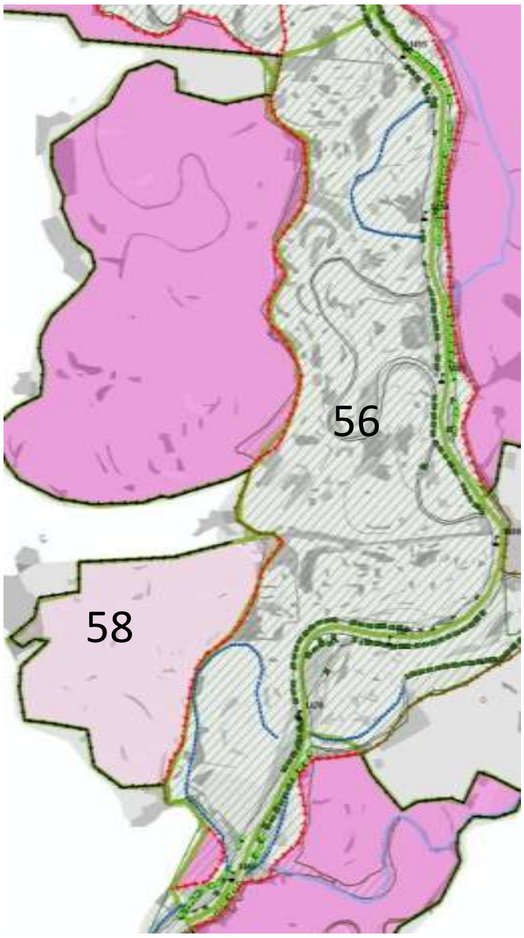
54 Sio confluence (HU) 4,753 (2,115) ha

55 Gemenc north and east (HU) 10,420 (8,946) ha & 57 Gemenc west (HU) 8,924 (8,924) ha

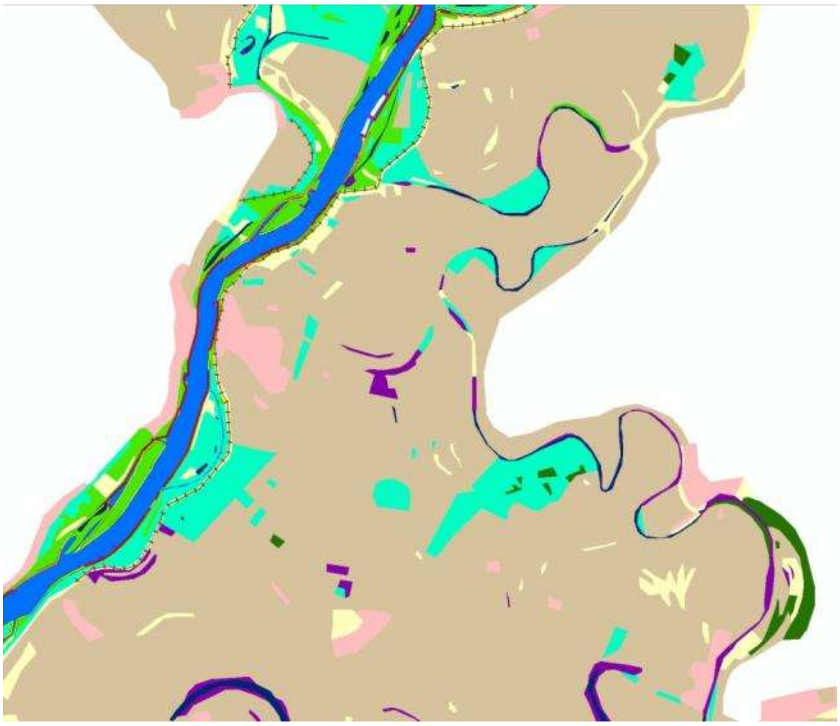


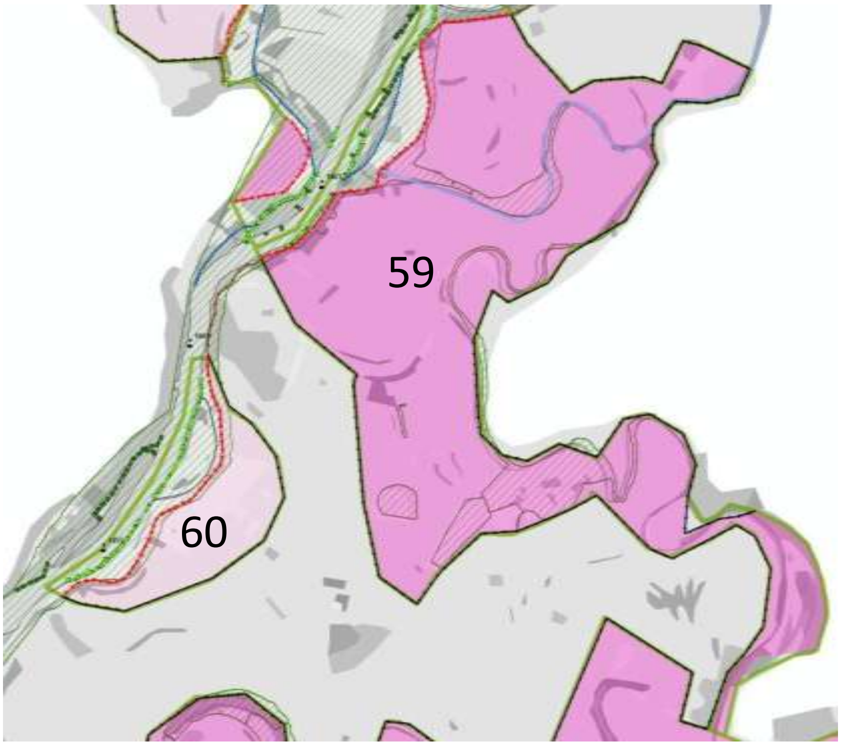


56 Gemenc (HU) 12,152 (200) ha & 58 Gemenc southwest (HU) 3,497 (3,497) ha

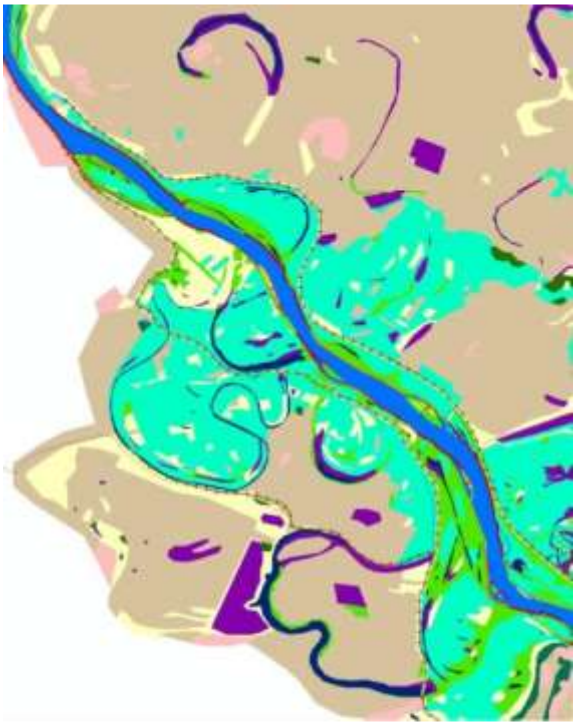


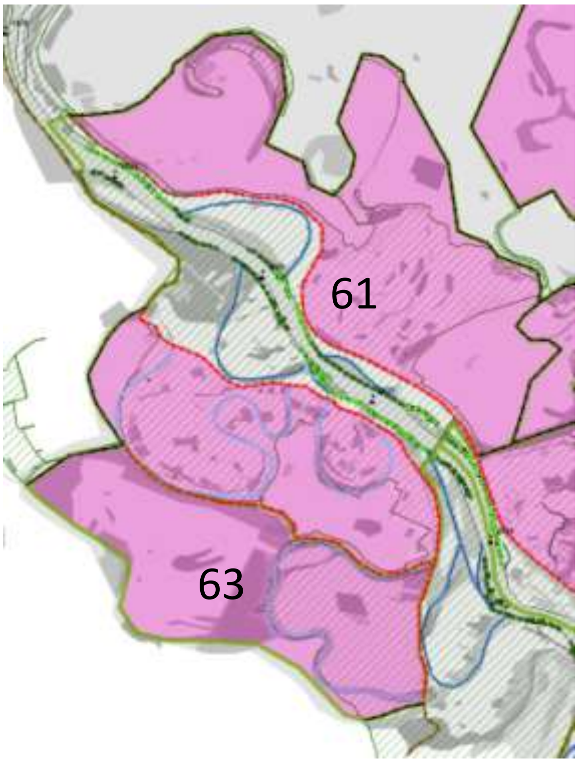
59 Nagybaracska (HU) 6,695 (6,113) ha & 60 Dunavalva (HU) 1,214 (761) ha





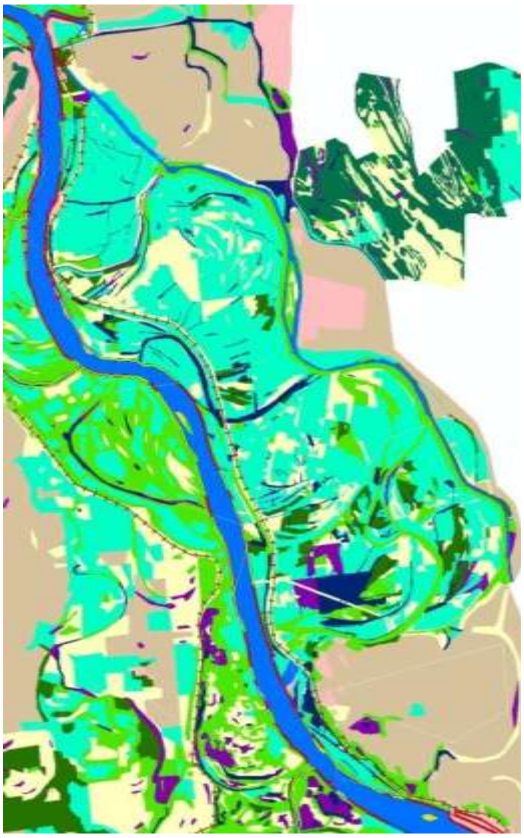
61 Beda-Karapancsa (HU) 11,602 (8,674) ha & 63 Draz (HR) 3,672 (3,672) ha

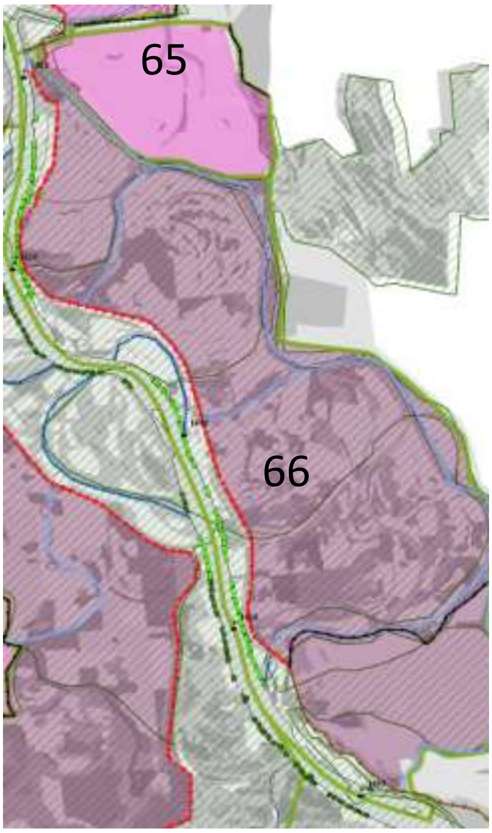




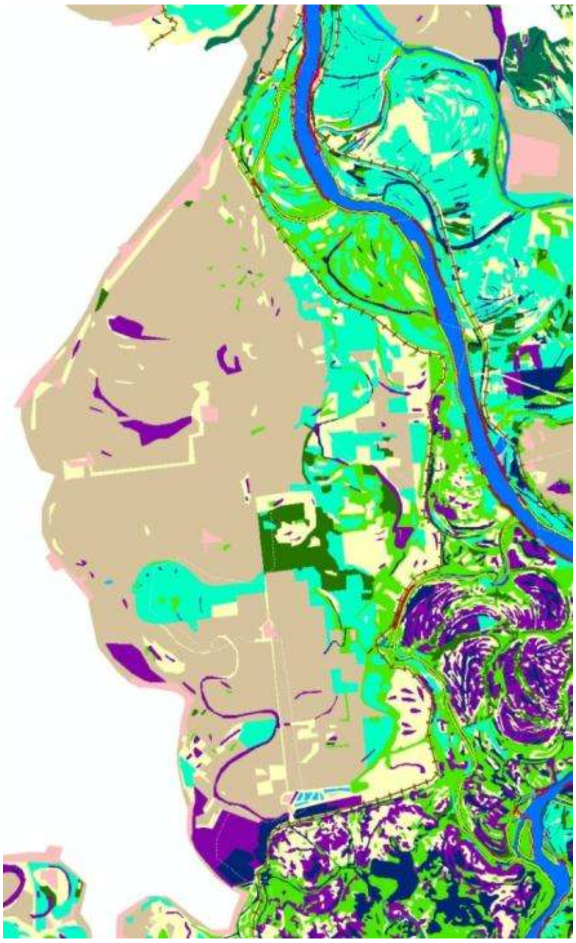
62 Davod (HU/RS) 6,305 (6,305) ha & 64 Gornje Podunavlje north (RS/HR) 4,561 (3,941) ha

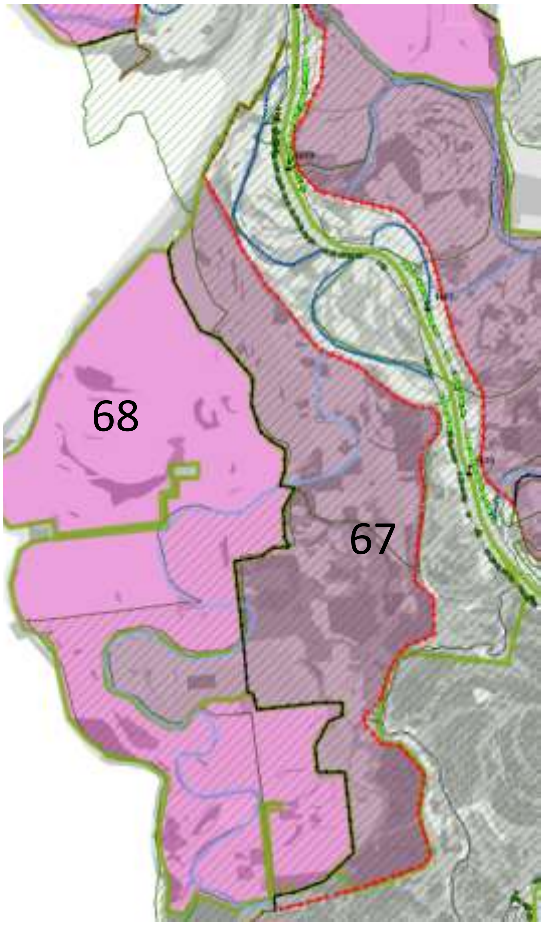
65 Bezdan (RS) 1,346 (1,346) ha & 66 Gornje Podunavlje central (RS/HR) 9,077 (7,448) ha



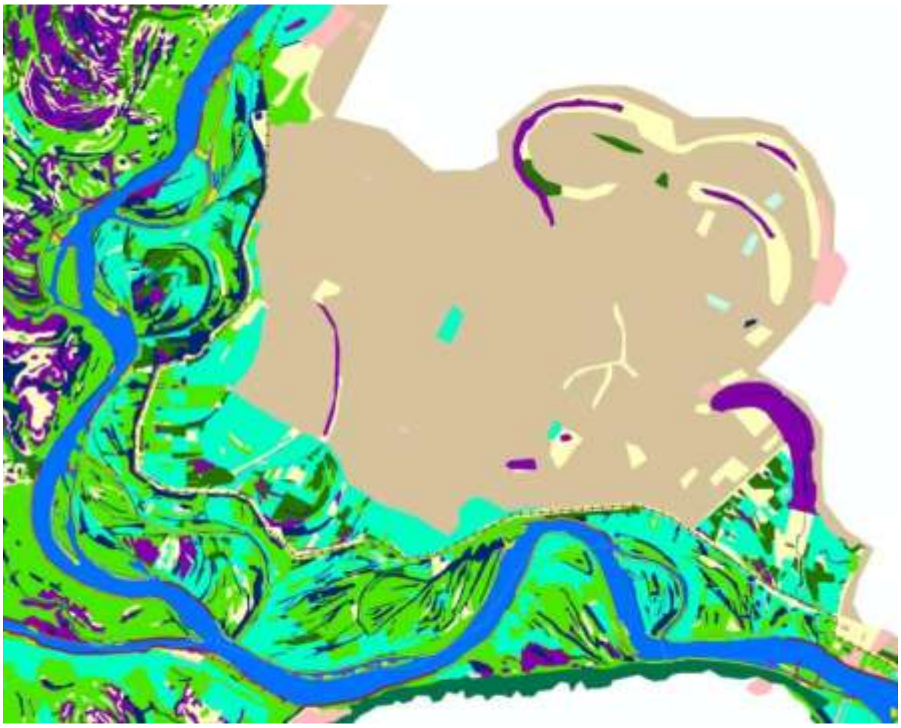


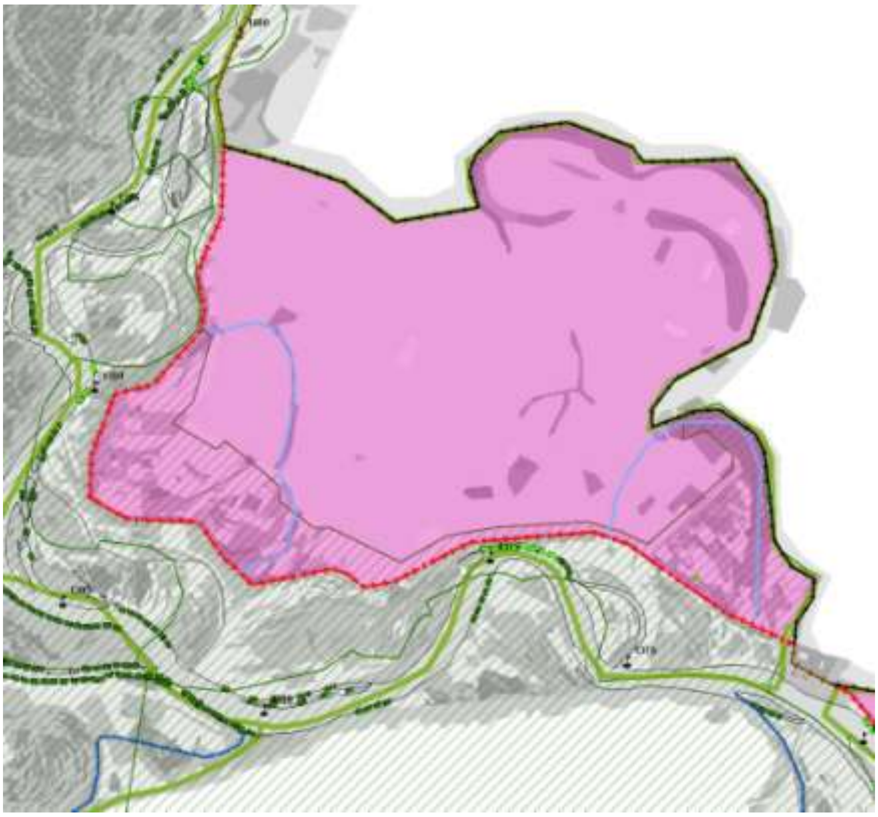
67 Tikves (HR) 10,441 (6,730) ha & 68 Lug (HR) 9,074 (9,074) ha



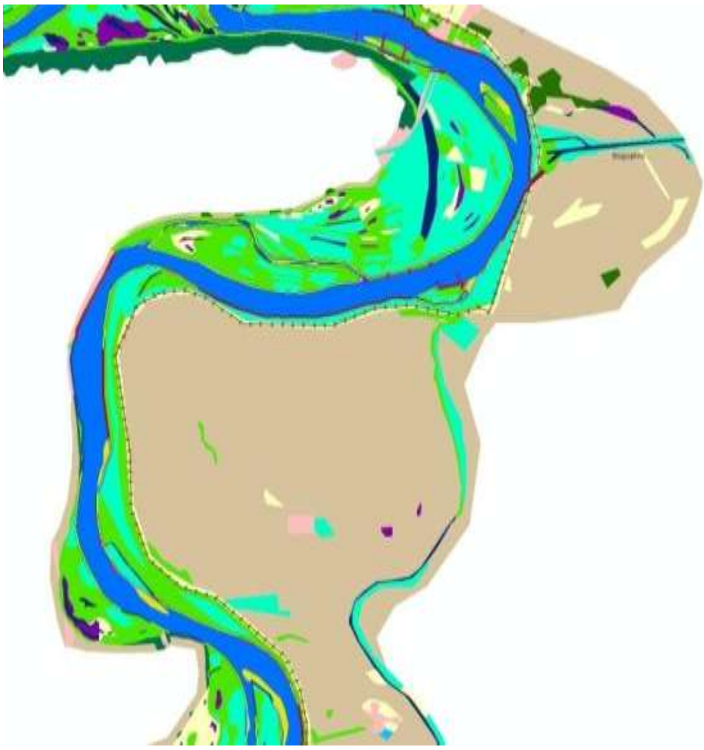


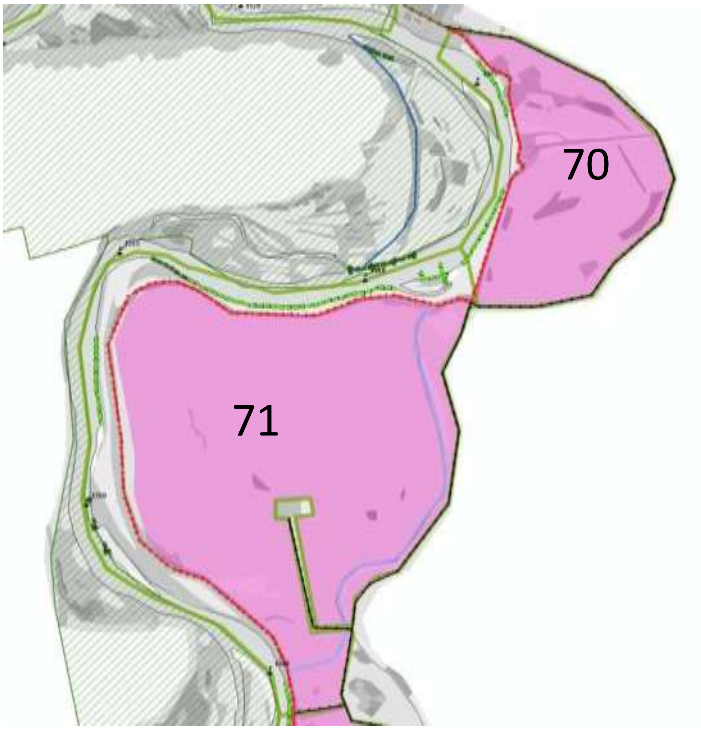
69 Gornje Podunavlje south (RS) 13,648 (8,925) ha



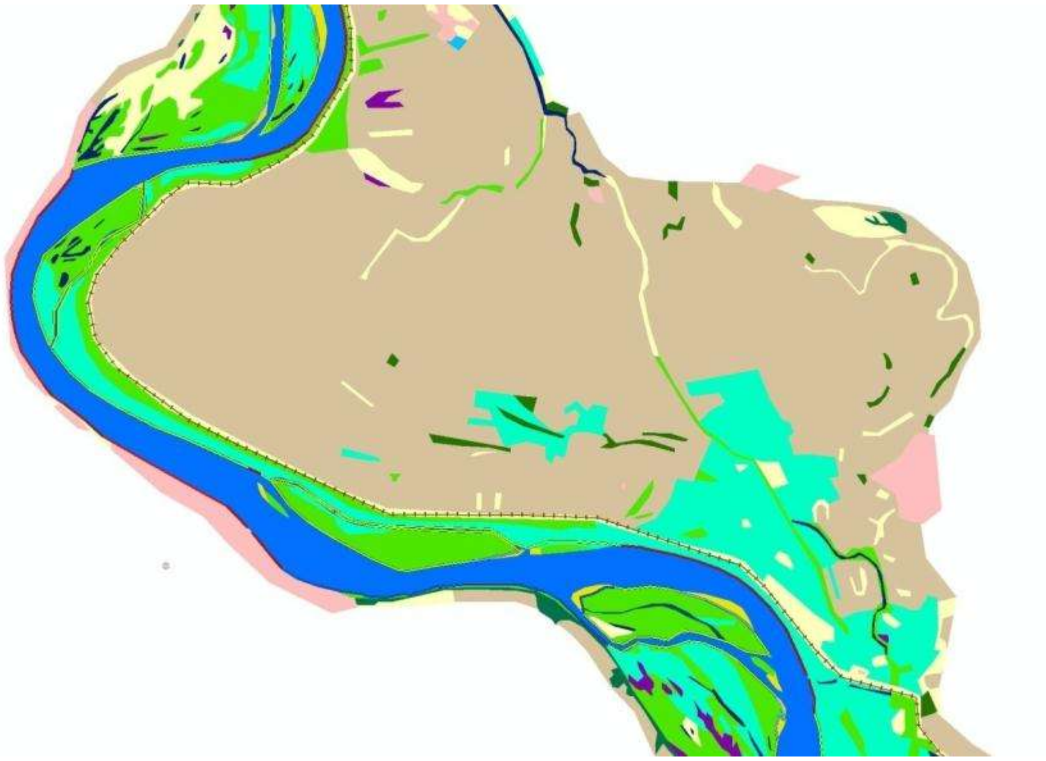


70 Bogojevo (RS) 1,503 (1,290) ha & 71 Vajska (RS) 4,724 (3,609) ha

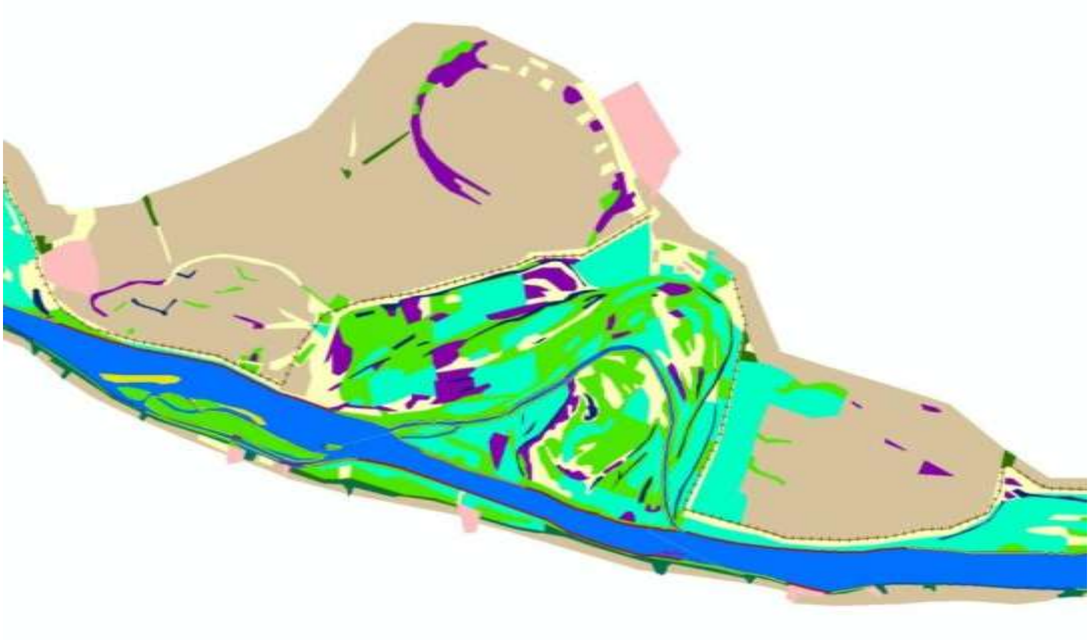




72 Plavna (RS) 6,971 (5,643) ha



73 Tikvara (RS) 5,341 (2,737) ha & 74 Karadordevo (RS) 1,174 (929) ha



4. Feasibility and costs of restoration

4.1 Feasibility

The feasibility of each individual restoration project cannot be based on the technical feasibility of restoration measures alone. Any large scale restoration project has to address a wide range of issues and obstacles, like:

- Land ownership. Probably the most critical issue for all restoration projects, as costs of land purchases can create serious limitations on the realisation of larger projects. Even if ownership is not transferred, accompanying compensation payments can be considerable. Preferred are public owned areas along the rivers.
- Insufficient detailed knowledge of the proposed measures and costs estimations of the restoration project. Often data is inadequate or missing, while different variants must be developed.
- Its legal framework. In addition to the relevant EU legislation, national regulations play a key-role in the prospects of a project: Is there an intention to keep/increase retention areas? How is (agricultural) compensation managed? Are there agricultural programmes in the area? Can processing and approval by authorities be achieved? And is there political willingness (often an immeasurable aspect)?

Table 19: Legal framework and ownership (initial overview).

Country	Legal framework	Ownership
Austria	Preservation of retention areas, non-structural flood management is a political agreement, Program for the lower Morava, Danube Floodplain National Park, EU- Directives (FD, WFD)	Mostly private, “public waterproperty” often limited to the land within the flood dikes or bank strips
Hungary	EU-Directives (FD, WFD)	Private and public (strong privatisation since 1990)

Country	Legal framework	Ownership
Croatia	ICPDR involvement in flood management	Mostly private, but large forests in public ownership (active floodplain mostly public)
Serbia	ICPDR involvement in flood management	Mostly private, but large forests in public hand (active floodplain mostly public)

An integrated landuse planning should consider the following principles:

- Land acquisition (establishing a land bank/corridor) by reparcelling, outplacement (farmer, entrepreneurs) and buy out (expropriation).
- Land consolidation (implementing new functions, land purchases and sales, land management).
- Stakeholder involvement: Nature conservation, business (enterprises, hydropower), urban actors, project developers, land owners and land users (agriculture), fishery, water sports, etc.
- Integrated planning approaches support the planning, assessing the area within the planning boundaries, the variety of stakeholders, conflicting interests, public and private partners and tools such as "Sketch and match" workshops.

Large scale restoration projects can take at least 5 to 10 years; land procurement and planning approval can take years and therefore require well-developed administrative structures and sufficient funding. Restoration is often not limited to changes in dike lines, but requires changes in the management of the adjacent river and floodplain areas. In most cases improvements of lateral connectivity and changes in landuse (e.g. less intensive forestry, hunting or meadow management) are necessary to accelerate the reconnection and to improve the ecological conditions along the respective river stretch. Monitoring is a necessary tool to assess the restoration progress over years or decades. Restoration areas must be protected and integrated in the existing protection network.

Regarding different stakeholders and users in the TBR MDD some further specific recommendations can be given:

- Gravel excavation: Mining from the river bed should be stopped as soon as possible and maintenance dredging for flood and infrastructure protection should be limited to a minimum while the material has to be given back to the river in the closer vicinity. In the active floodplain gravel mining close to drinking water should be prevented. New extraction sites should be placed on the lower terraces or even above (maybe in areas with intensive agriculture –keeping in mind buffer areas to groundwater protected areas to generate secondary habitats in the intensive used landscape).
- Forest: Over 70 % of forests in the active floodplain are poplar plantations. This is also the case in most of the proposed restoration areas and in particular for the lower Drava and Serbian Danube stretches. In the future the total percentage of the plantations in the core zone (active floodplain) should be reduced. For the large oak forests on the lower terrace the ground water regime should be monitored (better connectivity would improve the oak production).
- Gas exploitation: In several floodplain areas (active and former floodplains) in the wider area of Koprivnica, Durdjevac and Virovitica gas exploitation wells can be found. Depending on licences no new explotations within the floodplain should be allowed and in middle term the existing sites should be moved outside the floodplain.
- Meadows: Several large lowland wet grasslands that are an integral part of the wider river valley should be incorporated in the protection concept (some potential restoration sites already include those areas). Several especially dry habitats are typical for some valleys, mostly located on aeolic sands (eg. Durdjevac dunes or in Vojvodina).
- Tributaries: Connections to external water resources, like tributaries should be an integral part of the landscape connection also during restoration planning.
- Fish ponds: Special management in an extensive way as they host a rich biodiversity and are important for migratory bird species (e.g. also Somogy comitat between Balaton and Drava).

4.2 Restoration costs

Restoration costs can be subdivided into many parts, such as land purchase, planning and implementation costs, future compensation in the case of flood (if current land use and landowners remain), and on-going costs for management, maintenance as well as monitoring. Restoration costs vary significantly with the purpose, size, type of construction work, land purchase and other parameters. Projects at the lower Drava might be considerably less expensive then on along other sections due to the differences in gross domestic product (GDP) per capita (currently in Serbia €6,000, Croatia/Hungary around €14,000, Slovenia €25,000 and Austria €36,000). Counting with the expenses in Austria or Germany, taken from the examples in this chapter, a reduction of some 30-50 % for Croatia and Hungary is assumed. Therefore only raw cost indicators can be given for selected parts.

Land purchase: Where larger parts of the river and its adjacent land are public property, restoration measures can be carried out efficiently. In case of private ownership, additional complications might arise from the differences in property structures in the different countries. For example, the large scale agriculture with huge field size in Hungary, as an outcome of socialistic agricultural economy, could support easy negotiations, while in Croatia, where a lot of landowners possess only small plots of land, land acquisition might be a much slower process. While generally the gap is decreasing, land prices are still significantly different between the upper and lower corridor countries. One hectare agricultural land costs about €3,000 in Hungary while in Austria up to €13,000. Compensation cost for land which would become part of the active floodplain is about €4,500 per hectare in Austria, and as a consequence of the price difference, less in Hungary.

Removal of bank stabilisation and side-arm closures can be estimated on the basis of projects in various countries. Often behind the first protection line other, older bank protection lines is found, which have to be removed as well to enable a shifting river. Indicative examples are the removal of bank revetments in the Danube National park near Hainburg (Austria), with a cost of €1,8 million for a section of 2,5 km long. For another stretch near Witzleinsdorf, that included changes for groynes and a reflector, the costs where €1,5 million for a 2 km long river section.

For the lower Drava this would mean some €40,000 per 100 m removal of bank stabilisation works. For option 1 "minimum restoration" with a total of 400 km, this would mean about €160 million shared by all countries and implemented over decades. The 100 side-channel reconnections would cost around €10 million, assuming a simple reconnection project without taking dredging and land purchase into account.

Flood dike relocation: The most expensive part of large scale restoration projects is the slitting of or the full removal of existing flood dikes and the construction of new dikes. In an effort to reduce costs the new dike line has to be planned carefully and should be shorter than the original one. By widening of the floodplain the hydrostatic pressure and flow velocities on the dike will be reduced and could reduce the requirements on the crest height of the new dike (other advantage might be the fact that the floodplain elevation increases with distance to the main channel). In cases where the new dike can be aligned with the the natural terrace the costs can be significantly reduced. Usually it is not necessary to remove the entire original dikes, slitting on strategic positions is more efficient. Since most of the flood dikes and facilities along the rivers are currently under revision and renovation the time is rather suitable to initiate dike relocations. In areas with adjacent settlements potential changes in the groundwater regime need to be estimatedIn any way the flood protection for settlements should be secured and where possible improved.

The next examples reveal that for flood dike relocation no strong relation exists between area and costs:

- Lenzen, Elbe river: 1,559 ha (dike relocation for 424 ha); old dike 7,5 km (which was slitted for 20 % of its length along six stretches); new dike 6,1 km. Costs: €15,5 million (including costst of land purchase).
- Fridolfing, Salzach river in Bavaria: 110 ha floodplain extension with 4,8 km new dike. Costs: €8,5 million. Planning costs can be considered as approximately 10 % of the overall costs.

Based on the Elbe example some €5,000 per hectare and assuming a 30-50 % regional reduction of costs, an average project with some 1,000 hectare would cost about €5 million.

5. Conclusions and recommendations towards a restoration strategy

The study significantly improved the availability of knowledge needed for the decision making process for restoration projects for the entire TBR MDD corridor. The geographic database contains floodplain delineations, land use and habitat maps. Improvements of the data were based on existing data sources and selected habitat maps by intensive usage of high resolution satellite images, including maps of infrastructure, in particular of bank revetments, hydraulic structures and flood dikes. Data availability has been extended on both a quantitative as well as on a qualitative level. The scale of this study naturally imposes limitations on the usability on individual restoration projects. A further refinement is necessary on detailed land ownership, tenure data, regional and local spatial planning, technical feasibility, missing data on hydraulics, biodiversity, land management, cost benefit analysis etc. These tasks are to be managed by each country on the basis of individual projects.

The definition and total list of potential restoration sites serves as a strategic tool for the future planning and prioritisation of restoration efforts, and allows for the focus on any sub-set of areas. The long-time experience shows that the realisation of individual projects strongly depends on a wide range of factors, including financing feasibility, overall public acceptance and the support of local stakeholders.

If a large number of restoration projects will be realised within the next decades, adverse water management issues, such as the continues degradation of the river bed, the disconnections of floodplains and the decrease in flood protection level by the reduction of flood retention in the remaining floodplains, can be significantly reduced along all river reaches. In the study navigation on Danube and lower Drava was not considered as a restriction for proposed restoration efforts. If navigation is to be maintained in these river sections of the TBR MDD, only non-structural measures should be applied. Maintenance of the navigation on the lower Drava upstream of Osijek is expensive and should be critically revised by the public transport sector. A downgrade of the navigation class or even the abandonment of navigation on that part of the Drava would have a major positive impact on all restoration activities. Considering the high ecological values in the Kopački Rit/Gornje Podunavlje section, maintenance of navigation on the Danube should be limited to a minimum, and executed carefully. The existence of this unique protected nature reserve depends on strong fluvial dynamics (discharge, sediments) of both the rivers Danube and Drava. Plans to reinforce the Danube banks along this reserve, to regulate the in- and outflow of the floodplains and to stabilise the water tables in the area by ground sills or even dams, using the argument to “protect” this floodplain, must be seen as very critical.

Based on the results of the floodplain delineation and the evaluation of restoration potential, it is now possible to compare and assess the different areas aiming at more detailed restoration proposals and the formulation of the targets of a future strategy. The following recommendations aim to achieve such a restoration strategy:

- Convince/support countries to develop realistic restoration targets. It is important that a common understanding on restoration requirements and benefits exist. Existing case studies should be assessed, and one large pilot restoration site per country can be used as blueprint for future efforts until 2021 (next water management cycle of WFD).
- Futher development of favourable legal framework, e.g. clear protection of still-existing retention areas (no-go areas for further land development in floodplains), strong spatial planning instruments and tight administrative and political structures that allow transparent public participation are requirements for successful restoration projects.
- Develop national, or even international, floodplain inventories (e.g. SCHWARZ et al. 2010 for Austria, BfN 2009 for Germany). It is necessary to increase transboundary knowledge of TBR MDD floodplains.
- The tools and approaches applied in this study (in particular prioritisation) should be further developed in line with FFHD, WFD and FD plans within the WFD planning cycle timelines. Those approaches should not be overloaded with pre-justifications regarding ecological or technical outcomes. A database to share experiences and development would support the further work.
- Type-specific and adaptive restoration strategies are needed. Protection and improvement (restoration) of existing floodplains is important (only about 10 % remain under near-natural conditions).

- Embed river and floodplain restoration into national and international biological corridor network planning as well as spatial planning ("EU Danube Strategy", compare also SCHWARZ 2008).
- Restoration efforts must go hand-in-hand with protected areas and their management. Floodplains are very dynamic systems that host a variety of habitats and species within close vicinity. For example, the reconnection and reactivation of protected oxbows are also important for the river-floodplain system, and restoration of both floodplain and oxbow should coexist in the limited given space for river development.
- Infrastructure (navigation) and hydropower will further aggravate the ecological situation of many rivers and floodplains. Water management authorities (together with the stakeholders of hydropower, navigation and flood protection) must offer joint solutions on halting further bed incision and degradation. State of the art measures must be considered, such as sediment feeding or grannulometric bed improvements because lateral sediment input by restored steep banks can only reduce the deficit to a certain degree. Further floodplain aggradation by fine sediments should also be addressed jointly. Preferably, hydropeaking on the Drava must be significantly reduced among other significant hydrological changes such as the suppression of ecologically important 1-5 year floods (by using the hydropower reservoirs) or strong water abstraction during the dry summer months for agriculture. Governments, together with the actors involved, must provide the needed financial resources.

Further recommendations for successful restoration projects:

- It must be emphasised that floodplain restoration without river restoration (hydromorphological-lateral integrity of the river-floodplain ecosystem) makes little sense.
- Very important to ensure successful restoration is the availability of land (ownership is often most critical), and also of other data, in particular hydraulic models for ecological planning.
- Clear impact assessments of the project on local, regional and international levels regarding floods, ecology and other

ecosystem services are necessary for successful restoration processes.

- Requirements for local planning and approval by authorities (e.g. influence on local flood levels, water quality and so on) must be considered from the beginning.
- Broad stakeholder involvement and interdisciplinary planning is a pre-condition for successful restoration.

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