Feedback to the EU Fitness Check of the Water Framework Directive

Wetlands International – European Association, March 2019

Contents

Key messages

- Our overall goal is to revive the ambition of the Water Framework Directive (WFD) to enable a great majority of rivers, lakes and wetlands in Europe to stay or become healthy (good status objective reached by 2027).
- From the beginning of the WFD, Member States and stakeholders have advanced and improved the way of addressing problems, trying to look more at the pressure itself and to add knowledge of the problems.
- We can demonstrate local scale improvements in ecological conditions of water bodies based on a case study analysis of restoration measures across Europe. Improvements in governance of river basins and active involvement of public and stakeholders have been key to the successful delivery of these WFD measures.
- Thanks to the WFD assessments of new developments in water bodies, environmental impact assessments have become more stringent. Without the WFD, adverse impacts from pressures on water bodies would be much worse.
- Nevertheless, the pace of degradation of water bodies in Europe remains higher than the pace of improvement due to insufficiently ambitious implementation of the WFD and ongoing pressures from hydromorphological changes to surface waters, agriculture and other land use, industry and hydropower.
- The Water Framework Directive is fit for purpose, but larger scale restoration and pressure mitigation measures are needed to achieve Good Ecological Status. The distance between the WFD objectives and current status of most water bodies is huge due to lack of proper implementation, shortage of funding for measures and inadequate enforcement at EU level.
- Member States' ambition to achieve the objectives should be higher. There is too much flexibility for Member States, proven by the disproportionate and insufficiently justified application of exemptions to achieving the WFD objectives.

Wetlands International – European Association brings together eight European NGO members, working together to raise awareness about wetland ecosystems and to advocate the sustainable use of wetlands for people and nature, in particular by linking science, policy and practice. We support improved EU policy development and implementation as a means to enhance practices and investments regarding wetland and river ecosystems and sustainable water management across Europe, to enhance biodiversity and mitigate water-related hazards such as floods and droughts.

In this document, we provide our views on the Directives according to the five Fitness Check criteria (effectiveness, efficiency, relevance, coherence and EU added value). Our views are based on the analysis of case studies of Water Framework Directive implementation across Europe, on reports published by EU and national institutions, and on publications by the scientific community.

Contacts: Eef Silver, eef.silver@wetlands.org, Cy Griffin cy.griffin@wetlands.org, Paul Brotherton Paul.brotherton@wetlands.org.

Effectiveness

To what extent are the Directives performing as expected?

Achieving good status for rivers and wetlands

The EU Water related Directives advocate for the protection and restoration of rivers, lakes, groundwater bodies and riverine wetlands. No other piece of environmental legislation is better equipped than the Water Framework Directive (WFD) to accomplish sustainable and integrated river management. There is demonstrable impact of the WFD in terms of water quality improvement, mainly at local scale.

Our analysis of case studies (see Annex II) across Europe shows that the WFD has spurred water quality improvements over the past decade and has resulted in improved governance and river basin planning based on active involvement of the public and stakeholders. Improvements of ecological conditions of water bodies thanks to river restoration measures include the abundance, diversity and population structure of specific bioindicators and improvements of hydromorphological conditions or flow regime.

Although the WFD is resulting in improvements in the status of our rivers, there is still a long way to go. The European Environment Agency indicated[1] that for surface waters (rivers, lakes, transitional waters and coastal waters) the percentage in good ecological status is around 40%, while only 38% of surface waters are in good chemical status. This picture may be optimistic, as not all biological quality elements have been applied (e.g. in Italy, fish fauna has often been excluded from the classification exercise) and the coverage of monitoring is still limited in some Member States. Also, small (non-delineated) water bodies are still excluded from any assessment.

The EEA assessment which is based on the second River Basin Management Plans (RBMPs, 2009-2015) shows that we do have a better notion of the ecological health of the European water environment than during the first RBMP cycle. This has not translated into improvement at water body scale for a large number of water bodies. Many improvements are visible at the level of individual quality elements or pollutants.

The actions taken to date fall far short of what is needed to bring Europe's freshwater ecosystems into good health by the final deadline of 2027 as required by law. In its fifth Water Framework Directive Implementation Report[2], the European Commission noted several potential barriers to achieving the 2027 deadline for good status, such as Member States' lack of adequate funding and the persistent use of exemptions covering nearly half of Europe's waters. Moreover, for a large proportion of water bodies, the reported impacts of anthropogenic origin and pressures of drivers (especially hydromorphological pressures) are still unknown.

On top of that, the lack of enforcement at EU level has resulted in insufficient measures taken for protection and restoration of water bodies, while pressures on water bodies

---

[1] European Environment Agency. European waters Assessment of status and pressures 2018. EEA Report No 7/2018

[2] Commission report to the European Parliament and the Council on the implementation of the Water Framework Directive (assessment of the second River Basin Management Plans) and the Floods Directive (assessment of the first Flood Risk Management Plans), COM(2019) 95 final.

continue to grow (see our example case study in Annex I on the growing pressure of hydropower on the Douro river in Portugal and the lack of enforcement which has led to deterioration). There is ongoing deterioration related to poor water quality and the ever increasing hydromorphological alterations, including barriers being constructed for flood defence, hydropower and irrigation.

The weak implementation of the WFD by Member States and the lack of enforcement is highly concerning. Water quality improvements at water body scale depend on the ambition and political will of Member States to significantly increase the scale of protection and restoration measures.

Scale of restoration measures and interventions

The scale of restoration projects is not as large as needed to make a difference in the entire water body status before and after implementation of the measures. The scale of the pressures society has put on rivers has been massive; some examples being the extension of flood protection works, the huge amounts of sediments dredged (often in a few decades we have extracted amounts of sediments that took centuries to accumulate thanks to river processes), while restoration efforts have been mainly local.

When Member States take more ambitious restoration efforts, like the case studies we demonstrate in Annex II, the results become more visible. These case studies however also point out that an implementation gap still remains between current restoration measures and the actions required to improve ecological conditions at water body scale. One explanation for this, beside the magnitude of the pressures on rivers, is the limited scale of interventions in comparison to the spatial scale of the water bodies.

Restoration measures of a few kilometres in length are very short with respect to the mean length of the water bodies. Water bodies are often longer than 10 or 20 kilometres and up to 30 or 40 kilometres; too long to catch the results of site-scale interventions. For example, the restoration project of the river Glaven in the UK (see Annex II) shows that the spatial scale of the rehabilitation work should be proportional to system size to more effectively address the influence of catchment-scale pressures on rivers (such as agricultural practices in upper stretches having impact on downstream biological communities).

In sum, there is a large imbalance in the order of magnitude of pressures on rivers, the large spatial scale of water bodies and the limited scale at which Member States are implementing restoration efforts.

Public participation

The WFD public participation requirements have opened up the process of river basin planning and management to a wide group of stakeholders and citizens. Many governments and river basin authorities have implemented public participation in various ways to meet legal requirements. Their democratic character and their effectiveness in ecological terms have been studied extensively (see Boeuf & Fritsch, 2016[3]), and despite challenges and mixed successes, it is clear that without the WFD, water policies would have remained the

[3] Boeuf, B., and O. Fritsch. 2016. Studying the implementation of the Water Framework Directive in Europe: a meta-analysis of 89 journal articles. Ecology and Society 21(2):19. http://dx.doi.org/10.5751/ES-08411-210219

domain of only the most powerful water users with high economic interests, i.e. not necessarily delivering on environmental objectives.

An example of this, is the case of participation in river basin planning in Catalonia described by Parés (2011)[4]. It shows how the WFD has shifted water governance and management of the river Ebro and the river Ter into a more inclusive and participatory process, where previously mainly farmers and hydropower firms had access to.[5] The institutional novelty of public participation brought by the WFD has given water governance in Europe a new scenario based on consensus rather than contestation, according to Parés (2011).

Among many, Giakoumis & Voulvoulis (2018)[6], Albrecht (2015)[7] and Wright & Fritsch (2011)[8] argue that public participation (particularly *active involvement* of non-state actors) in flood risk management and river basin management delivers significant benefits and improved policy implementation. They note that public participation leads to transparency and acceptance and that stakeholders and citizens can be a useful source of information for identifying pressures and impacts. Several of the case studies in Annex II prove that public participation is a key element for successful river restoration interventions. The EEA State of Water report (2018) mentions that public participation can enhance achievement of Good Ecological Status by integrating sectors such as agriculture, energy or transport.

Despite its demonstrated significance and added value to achieve the WFD objectives, public participation in the WFD implementation process remains insufficiently embraced in a number of Member States. According to Giakoumis & Voulvoulis (2018), authorities are often following the "letter of the law", i.e. not going beyond the strict legal requirements. This is the case for example in Germany, where only minimal legal requirements have been implemented (see Albrecht, 2015).[9] Other Member States regard public participation a challenge to national administrative cultures and established water management traditions (Boeuf & Fritsch, 2016). It is clear that, to improve the state of water in Europe and achieve a sustainable water future for both people and nature, Member States need to take up active public participation following the spirit of the WFD.

---

[4] Parés, M. (2011). River Basin Management Planning with Participation in Europe: From Contested Hydro-politics to Governance-Beyond-the-State. European Planning Studies, 19(3), 457–478. https://doi.org/10.1080/09654313.2011.548454

[5] The initiative at the Ebro was called Salvem lo Delta. At the Ter, it concerned the Ter agreement between environmental NGOs, the Ter Consortium and the Catalan Water Agency, July 2017. https://www.consorcidelter.cat/actualitat/noticies/2017/07/20/acord-pel-retorn-del-cabal-del-ter)

[6] Theodoros Giakoumis & Nikolaos Voulvoulis (2018). A participatory ecosystems services approach for pressure prioritisation in support of the Water Framework Directive. Ecosystem Services, Volume 34, Part A, December 2018, Pages 126-135. https://doi.org/10.1016/j.ecoser.2018.10.007

[7] Juliane Albrecht (2015). Legal framework and criteria for effectively coordinating public participation under the Floods Directive and Water Framework Directive: European requirements and German transposition. Environmental Science & Policy 55 (2016) 368–375. http://dx.doi.org/10.1016/j.envsci.2015.07.019

[8] Stuart A.L. Wright Oliver Fritsch (2011). Operationalising active involvement in the EU Water Framework Directive: Why, when and how? Ecological Economics, Volume 70, Issue 12, 15 October 2011, Pages 2268-2274. https://doi.org/10.1016/j.ecolecon.2011.07.023

[9] Juliane Albrecht (2015). Legal framework and criteria for effectively coordinating public participation under the Floods Directive and Water Framework Directive: European requirements and German transposition. Environmental Science & Policy 55 (2016) 368–375.

Which main factors have contributed to or stood in the way of achieving the Directives' objectives?

The WFD is the key driver for water management authorities to take action to improve the status of water bodies. According to the EEA[10], "there are ample possibilities for improving water management to achieve the objectives of the WFD through the stringent and well-integrated implementation of existing legislation and the introduction of supplementary measures that reduce the pressures that cause failure to achieve good status."

Poor performance of Member States regarding a number of key elements in WFD implementation illustrate the reasons for the current gap in achievement of the environmental objectives. Below we elaborate on a few of these elements.

Funding of measures

The WFD is able to deliver on their objectives, but dedicated funding for the necessary (large-scale) river restoration and on measures ensuring synergies with Floods Directive and Habitats Directive, such as Natural Water Retention Measures, is lacking. Our analysis of cases in Annex II shows that funding has been in place for relatively small-scale interventions (in relatively short river reaches). Projects that were carried out on longer reaches consisted in the removal of some transversal structures as the main measure and in the establishment of environmental flows, not in the complete morphological restoration of the river reaches. The case study on the restoration of the Orbigo river is a notable exception though.

Many Member States have developed a long list of measures but failed to provide funding to implement these measures. As noted also by the EEA (2018), "the first RBMPs described several thousand individual measures, and by now, many of these will have been completed. However, some have been delayed, or even not been started, mainly because of funding constraints, and others have been difficult to implement." Also Carvalho e.a. (2019)[11] found that only 20% of the "basic measures" were completed in 2015 and 10% of the "supplementary measures" to tackle hydromorphological and diffuse sources. This was partly due to poor investment in restoration measures.

The need for increased investments by Member States to meet the objectives of the WFD is furthermore emphasised by the EC in its fifth WFD Implementation Report[12]. To close the gap between current and good ecological status, Programmes of Measures need to be adequately designed (including large-scale ecologically based river restoration measures), funded and implemented.

Flexibility through exemptions

---

[10] EEA (2018). European waters — Assessment of status and pressures 2018. Report No 7/2018 https://www.eea.europa.eu/publications/state-of-water/

[11] Laurence Carvalho e.a. (2019). Protecting and restoring Europe's waters: An analysis of the future development needs of the Water Framework Directive. Science of the Total Environment 658 (2019) 1228–1238.

[12] COM(2019) 95 final.

WFD art. 4 provides flexibility for Member States by stating the conditions allowing exemptions (time extension or derogations) to achieve the environmental objectives. The large number of water bodies still not in good status proves the fact that the exemption regime is still too often applied by Member States. This has also been highlighted in the EC's assessment of the second RBMPs (the fifth WFD Implementation Report).

An obvious barrier to achieving the 2027 deadline for achieving good status is the fact that exemptions to the objectives are still covering nearly half of Europe's waters. Moreover, where applied, Member States give very generic justifications, and as such fail to meet the requirements stipulated in WFD art. 4. At the same time, we observe that the application of exemptions in different Member States is rather heterogeneous: some countries have used them a lot and others not at all while still approving projects which further adversely impact water bodies.

Many Member States failed to provide new justifications for new projects and the question remains whether exemptions are proportionate, looking at the overall picture. The problem does not only concern large-scale projects such as new dams for which the need for a formal justification of exemptions may be rather clear, but also (or even mainly) smaller and "diffuse" projects, such as bank protections and other flood protection works, the transformation of old water abstraction works in hydropower plants in lowland rivers (usually raising them a bit to increase installed power, yet slowing down water flow for many more kilometres upstream), or ordinary and extraordinary "maintenance" activities carried out by local/regional authorities. For these types of activities an environmental/strategic or WFD impact assessment may not even be requested nor a justification of any exemption is given, yet these works are affecting whole rivers.

While improving water quality should be considered a continuous process, many Member States are currently trying to discard the obligation to justify exemptions to the objectives, and are pushing for an extended scope of the concept of "natural conditions" (art. 4.4 WFD) in order to delay achievement of the objectives till after 2027 (and have legal certainty already by 2021 when the third RBMPs will be submitted). This attempt to enlarge the existing flexibility provided by the WFD is putting good ecological status even further out of reach for Europe's water bodies. Rather, Member States should increase efforts and means through sound Programmes of Measures backed with sufficient funding to achieve good ecological status in the third cycle.

One-out-all-out principle

The one-out-all-out is an important precautionary principle of the WFD. It recognises that freshwater ecosystems are made up of complex, interconnected and interdependent relationships between species and physical processes, and embodies the precautionary principle in the face of uncertainty about how these complex webs of interactions and interdependencies operate.

The one-out-all-out principle is key for taking stock of those parameters which are not achieving good status. It ensures that all water problems are addressed. Member States claim that the one-out-all-out principle creates a problem in the communication about progress made or expected achievements towards good ecological status. However, authorities are allowed to also communicate the progress made and improvements achieved at the level of individual quality elements; we highlight that the obligation to reach targets set using the one-out-all-out principle does not hinder the possibility to report improvements *also* per quality element.

Eliminating the one-out-all-out principle will hamper communication because it will disenable seeing the big picture of the state of the ecosystem and will make comparisons impossible.

Delineation of water bodies

The spatial scale of water bodies (and the applied monitoring approaches) differs considerably across Member States. The delineation can be problematic for identifying degradation, addressing pressures and designing proportional measures to achieve a good status.

Overall, the scale of water bodies is very large compared to the amount and scale of pressures and management actions (often several tens of km). At the same time, small water bodies are at risk of degradation but they are not designated under the WFD. Notwithstanding the operational burden linked to a smaller size, in many cases the current delineation is not enough to ensure adequate protection, as tens of km of rivers may be impacted without changing the overall status. Conversely, the effects of restoration are not always visible, as we have demonstrated above.

Further efforts are needed to adapt the size of water bodies to the scale of the different pressures and management actions, especially in contexts where pressures are increasing (e.g. due to new water abstraction demands).

Environmental flows

There is accumulated experience in the practical application of e-flows, for example in Iberian river basins. The implementation of this measure seems to be the critical factor, not the technical base nor the body of law in water planning.

In Iberian rivers, experience with e-flows ranges from implementation at reach-scale to the large scale of complex river basins with application of tools to make all the water users in water resources management tools compatible.[13] The extensive common assessment and implementation of minimum e-flows (under Spanish national regulation of water planning) has helped sustain minimum flows in permanent rivers and improve the ecological status of some rivers in Spain.

For example, flow regulation and water diversion for agricultural purposes put a high pressure on the Gaià river in Catalonia, drying out part of the main channel until the Catalan Water Agency took measures to implement environmental flow in 2013. This has led to the recovery of some of the ecosystem services of the river system and biological monitoring confirmed improvements in fish population movements (e.g. the European eel had returned to the river after many years of absence), but further efforts are still needed to help the river recover from all pressures.

---

[13] J. Paredes-Arquiola, A. Solera, F. Martinez-Capel, A. Momblanch and J. Andreu (2014). Integrating water management, habitat modelling and water quality at the basin scale and environmental flow assessment: case study of the Tormes River, Spain. Hydrological Sciences Journal 59 (3–4) 2014.
J. Paredes-Arquiola, F. Martinez-Capel, A. Solera and V. Aguilella (2011). Implementing environmental flows in complex water resources systems – case study: the Duero river basin, Spain. River Research And Applications, https://doi.org/10.1002/rra.1617

There is still a long way to go in order to meet the standards concerning other components of e-flows set in the Spanish legislation (including limitation in maximum regular flows, limitation in ramping rate, and implementation of high flows for channel maintenance and natural processes of riparian habitats (recruitment, etc.)).

In some of the river basins with more extensive studies, the Jucar River Basin for example (one of the pilot river basins for the implementation of the WFD), there is a percentage of 61% of the water bodies where the minimum flows have been approved, whereas the maximum flow limitation has been approved in only 9% of the water bodies. The rate of change in 26% of the water bodies and the high flows for channel maintenance and riparian vegetation have not been approved legally in any water body.

Moreover, a relevant limitation concerns the very limited budget for monitoring minimum flows and their accomplishment; a much larger number of gauging sites is required, as well as smaller devices to gauge the water abstractions by the users. Many users in the river basins have not yet implemented any device for measuring flow despite the legal obligation.

Efficiency

To what extent are monitoring and reporting requirements fit for purpose?

The European Commission has identified monitoring as crucial when assessing the effectiveness of river restoration measures in terms of improving the status of water bodies, protecting biodiversity and preventing extreme events, and has recommended that monitoring measures be included in the second RBMPs. The EC's assessment of the second RBMPs however found important gaps in ecological status monitoring: "Overall, monitoring of quality elements in each water category is patchy at best, overly relying on grouping of several different water bodies and expert judgment, rather than on a more thorough assessment of each relevant water body under the specific WFD parameters. Further efforts are needed to have appropriate monitoring networks reach sufficient spatial coverage and assessment reliability."[14]

A good example concerns the monitoring efforts by the Catalan Water Agency (CWA) which has been monitoring all aquatic ecosystems soon after the adoption of the WFD, including inland and coastal waters and groundwater relationship. The CWA has been developing new tools to ensure ecological and chemical status measurements in surface waters and chemical and quantitative status in groundwater in accordance with WFD requirements. According to this, CWA started a science to policy relationship with research institutions, which have been closely involved in the development of the tools.[15]

From our case study analysis in Annex II, we found that despite an increase in number of river restoration projects, monitoring results yet remain scarce. Moreover, there is a lack of sensitivity of the current biological monitoring and assessment tools to hydromorphological

[14] COM(2019) 95 final.

[15] A. Munné et al. (eds.) (2015). Experiences from Surface Water Quality Monitoring: The EU Water Framework Directive Implementation in the Catalan River Basin District (Part I), Hdb Env Chem (2016) 42: 1–36, DOI 10.1007/698_2015_420, © Springer International Publishing Switzerland 2015, Published online: 11 August 2015.

pressures and to the improved conditions after restoration. This hinders the capacity of the WFD to protect the current status and to stop further pressures. As hydromorphological pressures are fundamental in determining the ecological status (as well as habitats) and currently too often neglected, the need has been recognized to improve current monitoring and assessment schemes, to better include and tackle hydromorphological processes.

The insufficient sensitivity of WFD metrics/classification to restoration is an issue of scale: restoration should ultimately become visible in water body classification terms (when all key pressures are tackled), but the scale of restoration vs. the scale of water bodies is too small (see the paragraph above on the scale of efforts put in place) and/or only some pressures are mitigated. This is partly related to the “simplification” introduced by WFD classification regarding the complex range of objectives of restoration. The monitoring toolbox should be widened to better reflect the effects of restoration measures.

A detailed analysis of the lack of sensitivity of monitoring and assessment tools is given in paragraph 3.3 of the case study report in Annex II.

Relevance

To what extent are the objectives still relevant and properly addressing the key problem that ecosystems and society presently face?

Wetlands such as rivers, streams, lakes, and estuaries play a critical role in supplying and regulating the quantity and quality of water and support and abundance of freshwater biodiversity. However, deterioration of water bodies is ongoing and water risks to society, including scarcity, droughts and floods, are increasing. The ever expanding hydromorphological alterations, the impacts of climate change and the accelerating loss of freshwater species[16] demonstrate that the WFD objectives remain relevant for addressing the key problems ecosystems and society face, now more than ever. We will illustrate the continued relevance of the WFD through the example of hydropower.

Hydropower plants have a range of environmental impacts, including on river hydrological regimes, morphological processes and water quality, thus impacting aquatic and connecting ecosystems (riverine protected habitats), land occupation and emissions to the atmosphere. The WFD is designed as an instrument to achieve sustainable water use while balancing societal needs such as increased energy demand and environmental needs. As such, the WFD’s provisions are especially relevant to address the pressure of hydropower on water bodies. These include the non-deterioration obligation and polluter pays principle. Moreover, sustainable human developments in water bodies are allowed in case of overriding public interest and when strict conditions are met (see the section on flexibility above).

In Europe, many river basins are heavily impacted by hydropower, and only very few rivers remain free-flowing. While the WFD should ensure the first are at least partly restored back into good ecological shape, the latter should be effectively protected from deterioration. The WFD can only serve its purpose if properly implemented by Member States and enforced by the European Commission.

[16] These trends and changes have been reported by the EEA for example in their report ‘Climate change, impacts and vulnerability in Europe 2016, An indicator-based report’. EEA Report No 1/2017.

The fact that a gap in implementation and enforcement remains, is clearly demonstrated in the case of the development of the Portuguese National Programme for Dams with High Hydropower Potential in the Douro river basin (see the case study in Annex II). The Portuguese authorities failed i.a. to justify the overriding public interest, to evaluate the cumulative impacts of the proposed dams and to assess alternatives that are a significantly better environmental option. Despite these infringements of the WFD, which were brought to the attention of the European Commission by Portuguese civil society, the Commission did not take legal steps against Portugal to bring about compliance. Moreover, the handling of the formal complaints was a case of maladministration which failed to protect up till now at least one tributary of the Douro from degradation due the construction of a new large hydropower plant.

In Italy, due to particularly favourable national incentives, the growth in number of barriers and small hydroelectric plants on watercourses has been dramatic. In the last decade, more than 2000 new plants have been built without any WFD art 4(7) procedure, and mostly small and with minor renewable energy production gains. Between 2009 and 2010 for instance, the number of plants with installed power smaller than 1 MW increased by 36% (from 1270 to 1727) with a mere 0,3% increase of total additional installed power at national scale. These are very limited benefits in relation to climate change objectives compared to their large impact on rivers.[17] The construction of these barriers have not been mentioned in the RBMPs, let alone their cumulative impacts assessed nor exemptions to the WFD objectives justified. Only after the EC opened an EU Pilot against Italy on this subject, the Italian government started to question the incentives. Currently, pending the final approval of a decree to stop incentives for small new HPP in natural water courses[18], these incentives should be strongly limited. Without the WFD, this achievement could not have been possible.

The WFD is invaluable to protect water bodies which remain in good or high status. Rivers under (nearly) undisturbed conditions have been lost in many parts of Europe, except in the Balkan countries. The Vjosa river is one of Europe's longest and unspoiled river systems with a high and unique biodiversity values and large areas of relatively undeveloped landscape. The Vjosa flows from Greece to Albania and is hugely significant as a reference site for scientific understanding of ecology and river management. It represents an important reference system for dynamic floodplains that have already been lost all across Central Europe and can provide a benchmark for environmental policy of pan-European significance. Nevertheless, these values are threatened by plans for large-scale expansion of hydropower plants in the Vjosa and its tributaries.[19]

As an Accession Candidate country, Albania must transpose and implement the WFD. While the Albanian government has incorporated the WFD in its law on Integrated of Water Resources, the transposition has been incomplete; many key provisions of the WFD are lacking and most basins have no River Basin Management Plan yet. To ensure Albania

[17] Source: CIRF (2017). Implementation of river continuity restoration in Italy: context, levers and bottlenecks, national strategies and plans, perception of this policy, links with other policies implementation. https://professionnels.afbiodiversite.fr/sites/default/files/pdf/cnrr17_presentation3.pdf

[18] See http://www.cirf.org/it/incentivi-idroelettrico/

[19] Acta ZooBot Austria (2018). The Vjosa in Albania – a riverine ecosystem of European significance. Band 155/1

provides adequate protection of the river, the European Commission should enforce and support a proper transposition of the WFD.

Coherence

To what extent is the legislation coherent with wider EU policy?

The WFD is coherent with other relevant pieces of EU environmental legislation (e.g. Birds and Habitats Directives, Marine Strategy Framework Directive, Environmental Impact Assessment (EIA) and Strategic Environmental Assessment Directives (SEA)), the Floods Directive as well as with the wider EU acquis. Ecosystem restoration measures required by the WFD have delivered a range of benefits under several of these policy objectives.

River restoration measures, Natural Water Retention Measures and other nature-based solutions help restoration and have clear co-benefits by promoting for example cost-efficient flood risk reduction. Based on a review of integrated river restoration measures in Europe[20], we found many successful examples of "integrated measures" which mention the reduction of flood risk as a main goal while achieving other benefits including:

- Increase in biodiversity (improved spatial distribution and/or abundance of species) and flagship species making a comeback as a result of habitat restoration;
- Improved conditions and/or rejuvenation of riparian vegetation; improvement of ecological and morphological status.
- Contribution to sustainable regional development and tourism.

Member States have taken efforts to translate coherence between EU policies to the national level. In Italy, for example, recent national legislation has fostered the integration between WFD, Habitats Directive and FD. In 2014, the obligation[21] was introduced for all Regional authorities to give priority and allocate at least 20% of the funding to “integrated” flood mitigation measures, i.e. those measures, mainly related to restoring space for rivers, that reduce flood risk and at the same time improve ecological conditions of river corridors. In 2015, another national law[22] has been adopted, requiring that each river district authority develops a sediment management plan as part of their RBMPs, and that all sediment management programmes need to be coherent with these planning. However, the implementation of these two laws has not started in practice in many Regions and Districts.

A lack of coherence exists between the WFD and the EU’s sectoral policies. Navigation, flood defence and hydropower are driving major hydromorphological change and are key sectors to sustainable water management. Improved compliance, cooperation and implementation between different EU level Directives could help improve sectoral integration to better balance sectoral impacts on water and are needed to unlock measures such as nature-based solutions, Natural Water Retention Measures and river restoration in these key sectors.

[20] Wetlands International and CIRF (2017). Benefits of European river restoration schemes. https://europe.wetlands.org/download/2535/

[21] Law 11 November 2014, n. 164,

[22] Law 28 December 2015, n. 221 (art. 117, c. 2-quater)

The European Court of Auditors[23] assessed the implementation of the EU Floods Directive and found that the majority of Member States did not focus their plans on “green infrastructure” projects. The ECA also recommended the EC to enforce compliance with the WFD for new floods infrastructure identified within Member States’ flood risk plans.

Looking at hydropower as a key sector, it is clear that the sector has failed to comply with the WFD objectives for ensuring that detrimental impacts on water bodies are avoided and few basin-level assessments of impacts have been carried out. For example, environmental flows regimes, no matter how well designed, are rarely implemented when dams are constructed. This is caused by a number of factors, but principally by the fact that environmental releases directly compete with profit and energy targets while their benefits to society are ignored. In the absence of close monitoring to ensure compliance, dam operators are incentivized to operate hydropower projects to maximize power generation, thus undermining environmental and societal goals.

EU added value

What is the additional value resulting from these Directives compared to what could have reasonably been expected from Member States acting at national, regional and/or international level?

Without the WFD, some European countries would not have national legislation on water management. In Portugal, the WFD is considered by the National Environmental Agency as the ultimate normative standard for water quality. The binding nature of the WFD objectives was the major driver for the improvement of the water quality in recent years. Also in Spain, the WFD has been the first step for creation of a new legislative framework on main water management issues including invasive species, pollution and establishing environmental flows. Hydrological planning in Spain has undergone a large step since the adoption of the WFD and the EU law has been the only base to defend and propose serious improvements for rivers – which has been a big revolution. A good outcome of the of the first RBMP cycle in Spain has been the development of the National Strategy for River Restoration. This Strategy has evolved into Plan Clima Adapta including measures for restoration of rivers and fluvial nature reserves. These reserves have been listed in a National Catalogue which has its own programme of measures.

The WFD is a crucial tool for protecting water bodies in newer Member States and EU Candidate countries. Through its set of water legislation including the WFD, the EU introduces a comprehensive catchment-wide planning process with clearly defined procedural steps which should be adhered to. Proper transposition of the WFD and fulfilment of environmental criteria is important for Candidate countries’ membership of the European Union. In practice, we observe that new Member States and Candidate countries are often not (yet) complying with the WFD. If RBMPs are drafted, a relevant number of those are non-compliant. For example, water quality issues may be addressed, but biodiversity and other elements are neglected and RBMPs are often used as sectoral planning tools for unsustainable infrastructure projects (see for example Croatia, which classified water bodies as ‘candidate

[23] European Court of Auditors (2018). Floods Directive: progress in assessing risks, while planning and implementation need to improve. Special Report. Nº 25.
https://www.eca.europa.eu/Lists/ECADocuments/SR18_25/SR_FLOODS_EN.pdf

HMWBs' to allow room for future navigation projects). Therefore, the EC should enforce proper and complete transposition and implementation of the WFD as part of the EU accession process.

Other examples of the value of the EU level directive include the requirement for international river basin cooperation and the non-deterioration obligation which has been key for protecting and managing river basins.

Annex I Case study on continued relevance of the Water Framework Directive

Case study: Relevance of the Water Framework Directive to address the pressure of hydropower in the Douro basin

This case study demonstrates the importance and relevance of the Water Framework Directive for protecting and enhancing aquatic ecosystems and water resources in the face of increased demand for energy security through development of hydropower. The development of the Portuguese National Programme for Dams with High Hydropower Potential in the Douro basin is a **specific example of poor compliance with the WFD at national level and lack of legal enforcement at EU level**. This case study points out that the WFD is an effective tool to achieve sustainable water use while balancing societal and environmental needs, and its provisions are especially relevant to address the pressure of hydropower on water bodies. At the same time, it is clear **evidence of the fact that the WFD can only serve its purpose if properly implemented by Member States and enforced by the European Commission.**

Hydropower developments in the Douro river basin

The Douro basin is the largest transboundary basin in the Iberian Peninsula (770 km in Spain and 143 km in Portugal). The largest part of the international catchment lies in Spain (81 %) where it is called Duero and contains 164 hydropower stations with installed capacities ranging from 8 to 855 MW, of which 23 are large scale plants highly concentrated in the downstream part of the river in Spain (Mayor e.a., 2017[24]). In Portugal, the basin is also heavily impacted by existing dams and at the same time severely threatened by plans for the construction of new large dams, including in tributaries Tua, Sabor and Tâmega. The Tua river has been dammed at the confluence with the Douro in 2016/17. The dam built in the Sabor river in 2015 has disconnected the tributary from the main channel, but its tributaries remain in good status and inside protected areas.

In Portugal, the Douro basin is home to 19 % of the Portuguese population, two Key Biodiversity Areas (Montesinho and Malcata), 13 Sites of Community Importance (22 % of total area; involves 149 water bodies, equivalent to 38 % of total number), five Special Protection Areas (13 % of the total area), four Protected Areas (approx. 10 % of the total area), and one International Biosphere Reserve (Meseta Ibérica).

Environmental impacts of hydropower plants

It is widely acknowledged that hydropower plants have a range of environmental impacts, including on river hydrologic variables (river flow, water balance, river connectivity), water quality, aquatic and connecting ecosystems (riverine protected habitats), land occupation and emissions to the atmosphere (see for example Mayor e.a., 2017).

[24] Mayor, Beatriz & Rodríguez-Muñoz, Ignacio & Villarroya, Fermin & Montero, Esperanza & Lopez-Gunn, Elena. (2017). The Role of Large and Small Scale Hydropower for Energy and Water Security in the Spanish Duero Basin. Sustainability. 9. 1807. 10.3390/su9101807. https://bit.ly/2C6hdlN

By impacting heavily on hydromorphology, new hydropower plants or new modifications at existing facilities altering hydromorphology are likely to cause deterioration of water body status as defined under the Water Framework Directive (WFD) and, therefore, should trigger an Applicability Assessment as required under the Water Framework Directive (WFD) Article 4.7.

Exemptions to the WFD objectives

CIS Guidance Documents No. 20 and 36[25] on the Exemptions to the Environmental Objectives explain that the environmental objectives of the WFD are the core of this EU legislation providing for a long-term sustainable water management on the basis of a high level of protection of the aquatic environment. Exemptions from these objectives are defined within Article 4, outlining the conditions under which the achievement of good status or potential may be phased or not be achieved, or under which deterioration may be allowed.

One key objective of the WFD, outlined in Article 4.1, is to implement the necessary measures to prevent deterioration of the status of all water bodies – the non-deterioration principle - which is of particular relevance in the context of Article 4.7. This article sets out the conditions for exemption in the event of new modifications to the physical characteristics of a body of surface water, alterations to the level of bodies of groundwater or new sustainable human development activities. The conditions to be met are (in short):

a. All practicable steps are taken to mitigate the adverse impact on the status of the body of water;
b. The reasons for those modifications or alterations are specifically set out and explained in the river basin management plan;
c. The reasons for those modifications or alterations are of overriding public interest;
d. The beneficial objectives served by those modifications or alterations of the water body cannot for reasons of technical feasibility or disproportionate cost be achieved by other means, which are a significantly better environmental option.

Portuguese National Programme for Dams with High Hydropower Potential

The Portuguese National Programme for Dams with High Hydropower Potential (PNBEPH) was approved by the Portuguese Government in 2007, allegedly to reduce energy dependency and greenhouse gas emissions, to improve the share of renewables in energy production and to complement wind power with hydroelectric pumping. The set target of the program was an increase of 1100 MW in hydroelectric capacity, over pre-existing 5900 MW. The government did not define an energy target nor study any energy alternatives to large dams.

The Government approved seven out of the ten dams proposed in the PNBEPH (there were no candidates for two dams and one had a negative Environmental Impact Assessment), with the target for installed capacity doubled and the original economic cost estimate for the construction works nearly tripled, whilst providing 14% less energy production. The average use of the installed capacity of the new dams is less than one month a year – a third of a

[25] CIS Guidance Document No. 36 on the Exemptions to the Environmental Objectives, see http://ec.europa.eu/environment/water/water-framework/facts_figures/guidance_docs_en.htm

typical hydropower project. The authorities did not provide explanation regarding the huge discrepancies between proposed power generation and cost.

The PNBEPH aimed at increasing profit from the so called national hydroelectric potential. The PNBEPH's Strategic Environmental Assessment identified all economically feasible locations for such projects and 15 of the 25 selected locations were situated in the Douro basin. Besides the dams already in place or cancelled, it included three dams in the Paiva river, three in the Côa river, one in the Mente river, one in the Rabaçal river (Tuas' tributaries), and one in the Sabor river.

Of the ten dams initially planned, one has been completed (Tua) and four are on the way, all within the Tâmega River Basin (a main transboundary tributary of the Douro river right bank): the Tâmega Hydropower Scheme (Sistema Eletroprodutor do Tâmega – SET) and the Fridão Project. The SET includes three dams (Gouvães, Alto Tâmega and Daivões) and the Fridão Project consisting of two dams.

The Tâmega Hydropower Scheme is the largest hydropower scheme in the European Union in the last 25 years. Albeit approved in 2010, heavy constructions did not commence until 2016. Fridão has been suspended (no works on the site) until 2019 for revaluation, after intense pressure from NGOs, the local population of Amarante and a political agreement between the Socialist Party Government and the Green Party in 2016. Recent political decisions demonstrate that works are likely to be resumed in mid-2019. However, the PNBEPH is under public debate over alleged corruption and nearly all political parties in Parliament have raised the need to develop a new EIA.

Together with two already approved dams Baixo Sabor and Ribeiradio Ermida, the electricity generated by the whole large dam program amounts to 3.2% of the Portuguese electricity consumption in 2010, corresponding to 0.8% of total energy demand, 0.7% savings on GHG emissions and 0.8% reduction in fossil fuel imports.[26]

Douro River Basin Management Plans: environmental objectives at the core?

The expectation of adverse environmental impacts of the PNBEPH is realistic, to say the least. Together with the completed Baixo Sabor dam – which is not part of the PNBEPH and partly situated in a Natura 2000 site – the new dams are projected in tributaries of the Douro River. They will substantially decrease the continuum naturale in the Tâmega river. It will submerge Natura 2000 areas, 177 ha of the Site of Community Importance of Alvão-Marão, and compromise the integrity of Alvão Protected area. In total, it will disturb at least 104 protected species, especially birdlife with a total 78 species (2 endangered, Circus pygargus and Pyrrhocorax pyrrhocorax; and 1 critically endangered, Circus cyaneus) and 8 mammals (e.g. Lutra lutra, Galemys pyrenaicus, Canis lupus signatus, several bats like Rhinolophus sp., Myotis sp., Pipistrellus pipistrellus). Moreover, 18 protected habitats will be directly affected, four of them 'priority conservation' habitats.

The new dams will negatively affect the majority of the Significant Water Management Issues identified for the Douro River Basin district.

[26] Memorandum, The Portuguese Dam Program: an economic and environmental disaster. GEOTA, FAPAS, LPN, Quercus, CEAI, Aldeia, COAGRET, Flamingo, SPEA. April 2011. http://www.geota.pt/xfiles/scContentDeployer_pt/docs/Doc2212.pdf

From the WFD point of view, the Portuguese authorities were therefore expected to comply with the conditions stipulated in art. 4 WFD. However, neither the first nor the second Douro Basin River Basin Management Plan (RBMP) tackled the cumulative impacts of all new large dams on the Douro river and its tributaries, contrary to the statement of the European Commission when it closed a complaint against the PNBEPH filed by civil society (see below).

The second RBMP (2016-2021) provides an analysis of the largest pressures on the water body status but lacks the aim to minimize the impacts of existing and future dams by adopting adequate mitigation measures, therefore disregarding the precautionary principle. The water bodies concerned at the Baixo Sabor and Foz Tua sites are classified with an "unknown" status, despite the existing water quality monitoring network implemented by the dam constructors. In other words, the RBMP takes (new) dams for granted and does not consider any future pressures the dams will cause. The Programme of Measures (PoM) lacks ambition to achieve the environmental objectives. For example, it does not identify actual measures that could promote compliance with WFD goals (i.e. suspension of the PNBEPH) nor does it consider the evaluation of obsolete dams (i.e. hydropower decommissioning). At the same time, the Duero River Basin Council in Spain has performed 130 dam removals[27].

Legal infringement but lack of European enforcement

Several Portuguese NGOs filed a complaint with the European Commission against the PNBEPH in 2008. They stated that the PNBEPH infringed the WFD and Habitats Directive. As a consequence, the EC commissioned an external technical assessment of the PNBEPH by Arcadis/Atecma, but the study was not disclosed to the public . The Arcadis/Atecma report[28] concluded that the PNBEPH's environmental impact assessment did not evaluate the dams' cumulative impacts and that impacts such as aggravated coastal erosion and water quality degradation have not been correctly and/or completely assessed.

Also the official environmental impact statements published for some of the dams (cf. e.g. CPPE/Ecossistema 2003 on the Baixo Sabor dam, EDP/Profico Ambiente 2008 on the Foz Tua dam) clearly identify the gravity of those environmental impacts and point at the infringement of EU environmental legislation but with no consequences in what concerns the authorisation or suspension of works. The dams were authorised and the construction works progressed.

Following a long correspondence between the Portuguese NGOs and the European Commission during 2008-2010 on the PNBEPH (EU PILOT 184/08/ENVI), the Commission closed the pilot process without making any reference to the conclusions of the Arcadis/Atecma report and leaving many critical issues unresolved, namely:

- The lack of evidence of the justification presented by the Portuguese authorities that the PNBEPH is of "overriding public interest";
- The absence of an analysis of alternatives, namely energy efficiency or increasing power capacity of existing dams;

[27] Dam Removal Map Europe https://www.damremoval.eu/dam-removal-map-europe/

[28] Arcadis/Atecma (2009), Technical assessment of the Portuguese National Programme for Dams with High Hydropower Potential (PNBEPH). Contract No 07.0307/2008/ENV.A2/FRA/0020 – Lot 2. Project – 11/004766| 07/07/2009. European Commission/DG Environment

- The refusal to disclose documents providing ‘additional explanations’ by the Portuguese authorities, after the NGOs requested this information;
- The failure to evaluate cumulative impacts on the water quality, habitats, species and coastal erosion due to sediment retention even though the existence of these impacts was not disputed by the Commission.

The priority position given to hydropower in the Portuguese energy mix becomes evident in the case of the Baixo Sabor dam. Despite the expected negative impacts on the Baixo Sabor water body, the environmental impact statement defined the construction of the dam to be an acceptable option. However, the EIA consultation shows that a zero option was never considered. According to Council of Ministers Resolution nº 4/96, this was justified by "the absence of an alternative solution which fulfils, in a timely and effective manner, those interests [public interest]". This single argument is false and infringes the EIA Directive by making it impossible to study alternative investments potentially more advantageous in terms of socioeconomic conditions and having less environmental impacts.

In the case of the Foz Tua dam, which was completed in 2017, none of the conditions required under WFD article 4.7 were met. The argument of ‘overriding public interest’ which was put forward, was a political declaration lacking realistic justification. The expected impacts on the ecosystem and cultural heritage were considered irreversible but the proposed mitigation measures were insufficient.

The Environmental Implementation Review Country Report for Portugal (2017)[29] confirms the gaps pointed out by the NGOs:

- Deficiencies in the Portuguese RBMPs result in uncertainties about the water status and effectiveness of Programmes of Measures. In particular there are weaknesses in monitoring, methodologies for status assessment and the link between pressures and Programmes of Measures. In addition, the Programmes of Measures should be adequately funded.
- New physical modifications of water bodies should be assessed in line with Article 4(7) of the WFD. In these assessments alternative options and adequate mitigation measures have to be considered.
- Portugal’s performance on implementation of the INSPIRE Directive as an enabling framework to actively disseminate environmental information to the public leaves room for improvement.

Despite the undeniable evidence of non-compliance with the WFD and the EIA Directive and the Habitats Directive, the European Commission did not launch a formal infringement procedure against the Portuguese State over the PNBEPH. It seems the main reason is not questioning before the EU Court of Justice the alleged “overriding public interest”. Moreover, the Commission shows that a policy of illegal abstention to interfere with Member States illegally omitting the enforcement of environmental legislation is in breach of articles 258 and 265 of the TFEU, whilst enforcement would help secure green growth, protect nature, and safeguard the health and quality of life of EU citizens and residents.

WFD - a tool to achieve sustainable water use and protect aquatic ecosystems

[29] SWD(2017) 54 final. The EU Environmental Implementation Review Country Report – PORTUGAL.

The case study shows the continued relevance of the WFD for protecting and enhancing aquatic ecosystems and water resources in the face of increased demand for energy security. The case of the Portuguese national dam program shows how the Portuguese authorities and the European Commission alike have failed to use the WFD as a tool to achieve sustainable water use while balancing societal and environmental needs. In particular, the following conclusions can be drawn from this case study:

- The WFD (art. 4) aims at protecting the water body (non-deterioration principle) while allowing flexibility for new sustainable human development activities under certain conditions. Member States are required to use methods and approaches compliant with the requirements of the WFD. The CIS guidance documents provide further clarification and recommendations for application by Member States.
- In the planning of the PNBEPH, none of the four conditions outlined in art. 4.7 have been met, constituting a breach of the WFD.
- Of particular relevance is the fact that cumulative environmental impacts of the PNBEPH have not been assessed (required too by other EU directives), even though a proper assessment of these impacts in comparison to the anticipated increases in energy security, could be critical to preventing further natural degradation and planning sustainable energy-water systems. In addition, decent upfront assessments can avoid complex and costly processes of reversing decisions (Mayor e.a., 2017).
- Legal enforcement of WFD compliance by the European Commission needs to be reinforced. This is important to ensure that Member States will undertake all necessary efforts to achieve the goal of “good status” for all of Europe's surface waters and groundwater by the ultimate deadline set in the WFD.
- The maladministration by the EC in handling of the complaints by civil society regarding the PNBEPH was revealed by 1) its failure to reply within the formal response time, and 2) its refusal to grant access to information in the public interest. This resulted in the inability of the EC to bring about compliance by the Portuguese authorities to prevent deterioration and protect the status of the rivers. A particularly poor performance was shown in the case of the Foz Tua dam, when the EC responded more than five years after submission of the formal complaint in 2012, only after the dam had already been constructed.

Annex II Evidence of the effectiveness of the Water Framework Directive

Successes of EU Water Framework Directive implementation

Evidence of river restoration measures improving ecological conditions

March 2019

Wetlands International – European Association

CIRF – Italian Centre for River Restoration

This report was supported by the European Commission through LIFE NGO funding. This publication reflects only the author's view. The contents of this report can in no way be taken to reflect the views of the European Commission.

Successes of EU Water Framework Directive implementation

Evidence of river restoration measures improving ecological conditions

March 2019

Bruno Golfieri

Eef Silver

SECTION 1 – INTRODUCTION

The EU Water Framework Directive (WFD, 2000/60/EC) is the main legislation in the field of water management and protection. The WFD aims at enhancing the status of aquatic ecosystems (i.e. rivers, lakes, transitional and coastal waters and groundwater) and biotic communities in a comprehensive way. Water management is brought beyond water quantity and quality, entailing provisions on land-use and governance. The WFD sets environmental objectives in terms of good status to be met by 2015, or under certain conditions the final deadline of 2027.

The WFD has acted as a driver for several interventions of river restoration aimed at the improvement of streams' ecological conditions across the Member States. In this report, we analyse the **progress in achieving the main objectives of the WFD** based on a non-exhaustive selection of relevant case studies, also looking at specific aspects such as improvement in **governance, public participation** and the **spatial scale** of restoration actions. We will underline factors that have contributed to or stood in the way of achieving the WFD objectives. Moreover, we discuss the **suitability of the monitoring and assessment tools** for detecting improvement of the ecological conditions of rivers.

The results of our analysis will serve as evidence of WFD implementation to the 2018-2019 Fitness Check of the Water Framework Directive and Floods Directive (FD, 2007/60/EC) by the European Commission.

SECTION 2 – CASE STUDIES

In this section, we present a collection of examples demonstrating the effectiveness of implementation of river restoration measures under the Water Framework Directive. We have looked for case studies that show an improvement in terms of ecological status at water body scale, of at least one quality element or more general improvements at local scale. Links with Floods Directive implementation will be indicated.

The case studies belong to different biogeographic regions and are located in four Member States (Belgium, France, Spain and UK). The category of the interventions carried out and the most significant and innovative elements of the case studies are summarised in table 1 and 2, respectively.

Case study	Member State	Category of restoration intervention		
		Morphological restoration	Hydrological connectivity	Flow regime
1. Eau Blanche and Bocq	Belgium	X	X	
2. Drac	France	X		
3. Cofio	Spain	X	X	X
4. Orbigo	Spain	X	X	
5. Segura	Spain		X	
6. Turia	Spain			X
7. Eddleston Water	UK	X		
8. Glaven	UK	X		

Table 1 - Category of the interventions carried out in the case studies.

Case study	Improvement in governance	Public participation	Integration with Floods Directive	Monitoring of additional bioindicators and/or backwaters
1. Eau Blanche and Bocq	X			
2. Drac			X	
3. Cofio				X
4. Orbigo		X	X	
5. Segura	X	X		X
6. Turia	X			
7. Eddleston Water	X	X	X	X
8. Glaven			X	X

Table 2 – Significant and innovative elements of the case studies.

1. Rivers Bocq and Eau Blanche (Belgium) – LIFE project "Walphy"

Project overview

Catchment:	Meuse
Lead organization:	Service Public de Wallonie
Total budget:	€ 2,8 million
Status:	Completed

Pressures	*WFD measures*	*Impact*
• Channelization • Floodplain disconnection • Damming and embankment	• Habitat diversification • Passability of barriers • Barrier removal • Re-meandering • Reconnection of backwater	• Enhanced habitat heterogeneity • Improved fish mobility and population size • Restored sediment transport • Spawning places

Context

The Eau Blanche and the Bocq are two medium-size catchments of the Meuse basin which were heavily affected by rectification works carried out in the middle of the last century for agricultural development and by the presence of transversal and longitudinal structures. The preparatory assessment showed that the lateral connectivity on the Bocq was not heavily affected, while the longitudinal connectivity was disrupted by numerous obstacles that are difficult or impossible for fish to cross. On the other hand, the longitudinal connectivity on the Eau Blanche was acceptable but the lateral connectivity (the natural connections between the river and the alluvial plain) was very poor.

Aims

The project focused on the restoration of the longitudinal connectivity on the Bocq through the removal/management of obstacles and on the restoration of lateral continuity on the Eau Blanche. The specific objectives of the project were to:

1. Carry out restoration works on a significant scale on some water bodies at risk of not reaching the good status, based on two axes: longitudinal and lateral continuity.
2. Monitor the restored river system and its ecological status evolution at the local level (site of intervention) and the scale of the whole water body.
3. Develop of a methodology for helping to define the restoration works to be undertaken to improve the hydromorphological quality of water bodies "at risk".
4. Refine the methodology for the development of technical guidelines (decision-making tools) for river stakeholders, in line with the implementation of the WFD.
5. Disseminate these tools and recommendations to the authorities, stakeholders and the public.

Timing and location

The project started in 2009 and was completed by 2013, involving 46 kilometers along the Eau Blanche and the Bocq, close to the city of Namur, in southern Belgium.

Measures

In total, the project was able to remove 20 obstacles to improve fish migration (19 on the Bocq and one on the Eau Blanche), with 16,6 km along the Bocq and 28,9 km along the Eau Blanche that are nowadays free of any obstacle. In some cases, the obstacles were destroyed (e.g. the demolition of a dam), however, in many cases such action was not possible. Some dam owners did not consent because they have or are planning to construct mini hydroelectric power plants. In other cases, the role of the dam is important in relation to bridges and other constructions. In those cases, other solutions were implemented solely or in combination, including the creation of bypass channels, fish passes and rock ramps (Castelain et al., 2018).

Furthermore, the lateral connectivity of around 22 kilometers along the Eau Blanche and the Bocq was improved. Different kinds of techniques were implemented. In several sites, the works were limited to the river bed with small-scale meandering and the introduction of various structures to diversify the habitat. In other areas, more ambitious works were implemented such as the restoration of a former meander on the Eau Blanche. A former side river of the Eau Blanche Plain, the Grand Morbi, was also reopened and reconnected with the Eau Blanche (Castelain et al., 2018).

Monitoring and evaluation

Monitoring activities showed that the habitat heterogeneity was enhanced, with a consequent improvement of the ecological conditions in most of the study sites. Significant examples are the weir removal at Spontin and the remeandering in Emptinale along the Bocq. At the Spontin site an improvement was observed of the number of rheophilic species, biomass and number of individuals. In addition, the value of the biotic index of fish integrity (IBIP, indicating the ecological quality based on the attributes of fish communities) moved from 19 to 23, i.e. from good to high quality class. On the other hand, no significant improvements were measured through the sampling of benthic macroinvertebrates. At the remeandered site in Emptinale, a significant improvement was observed of both the benthic macroinvertebrates-based index IBGN (Indice Biologique Global Normalisé, indicating the ecological quality for benthic macroinvertebrates) from moderate to good quality class and the fish-based index IBIP from good to high quality class (Castelain et al., 2018).

Conclusion

LIFE project “Walphy” has been a pilot project to test different techniques of river restoration and could be an example for other interventions in the Walloon Region, as the applied methodology has been summarized in a technical guide. The results of the monitoring showed an improvement of the ecological conditions at different surveyed sites. However, water quality should reach a sufficiently high level to ensure that the benefits of restoration are optimal for the aquatic organisms and ecosystem as a whole. Water conditions are still problematic and act as a limiting factor on the Eau Blanche and the Bocq for the improvement of the ecological conditions. Nevertheless, hydromorphological restoration is an indispensable tool to reach the good ecological status of the water bodies. The monitoring also showed that the removal/management of obstacles is an effective way to improve fish mobility and population size. Furthermore, the removal of obstacles improves bedload transport, resulting in higher quality gravel banks as spawning places (Castelain et al., 2018).

Figure 1. Works for weir removal at Spontin (source: LIFE project «Walphy» Layman's report).

Figure 2. Re-meandering of the Eau Blanche at Boussu-en-Fagne (source: LIFE project «Walphy» Layman's report).

2. River Drac (France)

Project overview

Catchment:	Rhône
Lead organization:	French Water Agency
Total budget:	€ 5 million
Status:	Completed

Pressures	*WFD measures*	*Impact*
• Riverbed incision due to gravel extraction	• Restoration of morphological conditions • Restoration of sediments continuity • Reconnection of tributaries • Innovative monitoring method	• Improved physico-chemical quality • Improved habitat conditions • Increased presence and abundance of aquatic and flagship species

Figure 3. The Drac in the restored reach (October 2017, picture by Bruno Boz).

Context

In 2000, a scientific study highlighted a problem of incision in the Drac riverbed, caused by the intense gravel extraction started in 1960, and ended in 2012. The incision reached up to few meters, eventually reaching a clay layer that further accelerated the incision. Along with the riverbed, the water table lowered as well, altering the riparian forest. The new clay substrate substituting the gravel one caused further alteration of the aquatic habitats, allowing an expansion of clay outcrops. Moreover, the stability of the dam at the Champsaur leisure center, a lake used for recreation and fishing, was compromised, causing significant risk.

Aims

The project aimed at reverting the regressive incision that was leading to a destablization/loss of functionality of protection work and a high risk of collapse of the Champsaur dam. This goal was coupled with the restoration of morphological dynamics of the river, particularly by developing a braided channel morphology similar to the condition of the Drac before the incision phase. Moreover, the project targeted the improvement of sediments continuity and the lateral reconnection of tributaries.

Timing and location

The project started in November 2013, and was completed in June 2014. It is located in southern France, close to the city of Grenoble. The project affected 4 km of river.

Measures

450 000 cubic meters of gravel were recovered, mainly from the terraced alluvial plain of the Drac and added to the river channel. The altimetric profile prior to extraction was in this way reconstructed. A weir was built at the downstream end of the intervention to fix the riverbed height. The weir features a passage for fish and one for canoes.

Monitoring and evaluation

Several elements were considered in the assessments carried out before the intervention, ranging from morphodynamics, to habitats and aquatic fauna. The project established a 10-year monitoring program on morphology and ecology. Innovative monitoring methods are planned for evaluating the evolution of the channel morphology: bedload tracing program using active ultra-high frequency RFID technology, repetitive high-resolution topographic surveys of the restored reach and high-frequency qualitative survey of channel changes using time-lapse cameras. The first morphologically relevant flood (15/11/2015) triggered the development of braided channel morphology.

After the intervention, the physico-chemical quality of the water improved thanks to the diminished input of organic matter, partly linked to the improved wastewater treatment in the upstream catchment. As regard the ecological conditions, an increase was observed of the value of the index based on the benthic macroinvertebrates (IBG) from 11,8 (i.e class good) to 15,8 (i.e. class high), as well as the presence of sensitive taxa. The number of fish species increased from 2 to 4, with a significant increase of the abundance of the brown trout (*Salmo trutta*), an indicator species in the Alpine contex, that indicates an improvement of the in-channel habitat conditions. Moreover, flagship species such as the Common kingfisher (*Alcedo atthis*), were rapidly seen to come back to the area.

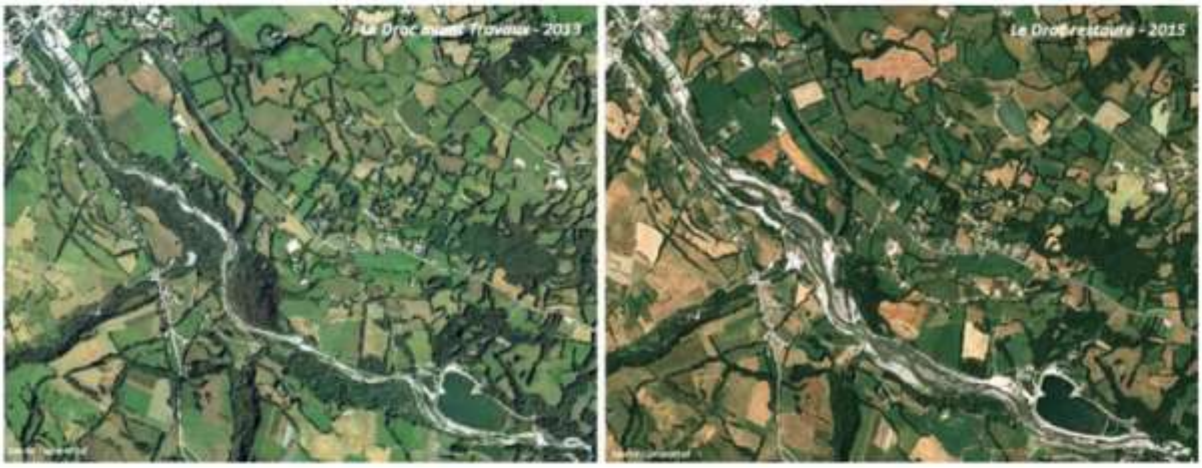


Figure 4. On the left panel, aerial view on the single channel Drac prior the 2013 intervention; the Champsaur dam can be recognized in the bottom right corner. The river flows towards the top of the picture. On the right panel, the same reach after the intervention (source: French geoportal).

Conclusion

The ecological conditions of the restored reach showed a clear improvement after the intervention and it is worth to underline that the increase of the values of the biotic metrics considered can be attributed to the improvement of both the in-stream channel condition as well as to the physico-chemical quality of the water. The regressive incision of the riverbed has been reverted and thus it has been reduced the risk of collapse of the Champsaur dam and of other protection structures. The physical restoration of the Drac required a huge amount of resources and means at a very high cost. The project would have been much smaller and less expensive if measures had been taken when riverbed incision was first observed.

3. River Cofio (Spain)

Project overview

Catchment:	Tagus
Lead organization:	Tagus River Basin Authority
Total budget:	€ 280k
Status:	Completed

Pressures	*WFD measures*	*Results*
• Damming • Water pollution	• Dam removal • Sediment extraction • Reforestation	• Improved fluvial habitats and riparian forests • Recovery of riverine communities

Context

This study is part of the river restoration project of the Cofio River (Madrid) after the demolition of the dam of Robledo de Chavela. This dam was built in the 1960s for the supply of potable water for the municipality, coming into operation in 1968. In 1990, due to problems of water quality, derived from discharges of livestock of upstream origin, it was decided to change the supply of the municipality and the dam was in disuse. In 2004, the Tajo Hydrographic Confederation recovered the ownership of the dam due to the expiration of the use and its state of evident abandonment. In the spring of 2012, leaks began to occur in the bottom drainage of the dam and, as a matter of urgency, a series of measures were implemented to prevent water contamination and to alleviate the effects on the river ecosystem. Finally, in September 2014, the dam wall was removed.

Aims

The project aims at the restoration of the longitudinal river continuity and at the re-naturalization of the riverbanks.

Timing and location

Cofio River is located in the located in the western portion of Madrid Province and the intervention was carried out in September 2014.

Measure

The works carried out, apart from the elimination of the dam wall, consisted of the extraction and relocation of sediments, and re-profiling and reforestation of the riverbanks.

Monitoring and evaluation

A complete monitoring programme was established to monitor physico-chemical, hydromorphological and biological indicators to test the effectiveness of the interventions. The evaluation of the fluvial habitat and the quality of the riparian forest shows high values of the indices IHF (Índice de hábitat fluvial) and QBR (Índice de calidad del bosque de ribera) in all the monitored stations. The stretch occupied by the dam, although still showing signs of alteration is recovering satisfactorily.

The biological parameters analyzed in 2018 regarding the community of aquatic macroinvertebrates show a High Ecological Status of the waters of the Cofio River. In addition, the improvement in all biological parameters analyzed, such as richness, indices and different percentages, is evident. The differences between the stations located outside and inside the old reservoir continue to be reduced. Downstream of the dam, the recovery was faster and the values of most of the biological parameters remain stable or are higher. The recovery of the fish community in the stretches of the old reservoir and downstream of it is remarkable. The fish community is already well defined and the values of density and biomass continue to increase with respect to the first surveys carried out in 2016. The improvement of fish populations of all the species is linked to the higher fluvial heterogeneity and the greater coverage of the riparian forests. Therefore, after four years since the demolition of the Robledo de Chavela dam, there is an evident recovery of fluvial habitats and related riverine communities.

Conclusion

This intervention demonstrate that the removal of medium to large-sized dam can be an appropriate and efficient measure to restore river continuity and the in-channel and riparian conditions. It is also worth to highlight that the monitoring of the conditions of the riparian vegetation, through the application of a specific index (i.e. QBR; Munné et al., 2003), is a key-element of the evaluation plan that can thus offer a holistic description of the river corridor (i.e. the channel and the adjacent floodplain). On the other hand, the presence of some invasive species (i.e. *Procambarus clarkii* and *Potamopyrgus antipodarum*) could be a negative for further improvements of the riverine communities and it is an element that should be carefully considered for future management actions.

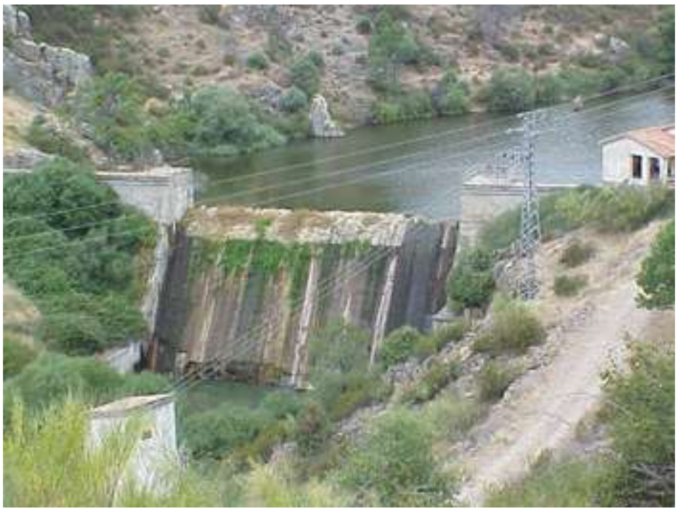


Figure 5. The Robledo de Chavela dam (source: Tajo River Basin Authority – Confederación Hidrográfica del Tajo).

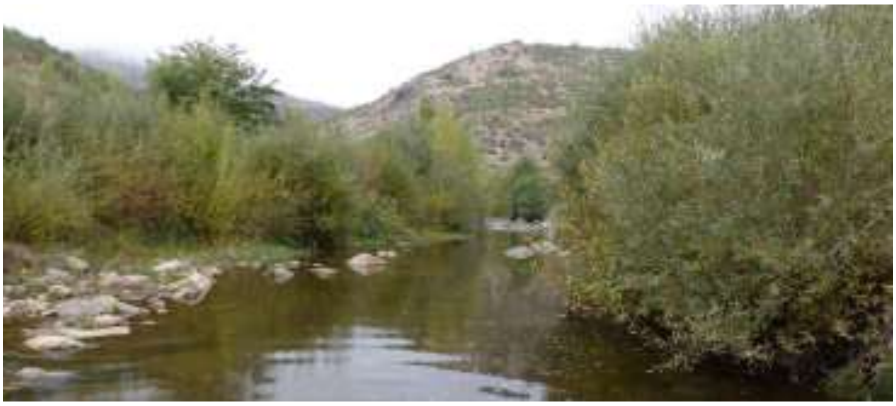


Figure 6. Riparian vegetation inside the old reservoir in 2018 (source: Tajo River Basin Authority – Confederación Hidrográfica del Tajo).

4. River Orbigo (Spain)

Project overview

Catchment:	Duero
Lead organization:	Ministry of Environment and Rural and Marine Affairs
Total budget:	€ 3 million
Status:	Completed

Pressures	*WFD / FD measures*	*Impact*
• Embankment and erosion control structures • In-channel obstacles • Channelization	• Removal and adjustment of weirs, embankments and rock armour • Reconnection of floodplains • Active public participation • Innovative monitoring method	• Improved flood risk mitigation • Habitat diversification

Context

Increased agricultural activities, mainly poplar plantations, over the last fifty years altered and impoverished the river Orbigo, resulting in the occupation of approximately 80% of the river corridor, the modification of the channel morphology (i.e. from multiple to single-thread), poor lateral connectivity, loss of longitudinal continuity as well as vegetation simplification and fragmentation. Embankments and channelization did not prevent floods that put housing in small urban stretches under risk, despite their expensive maintenance.

Aims

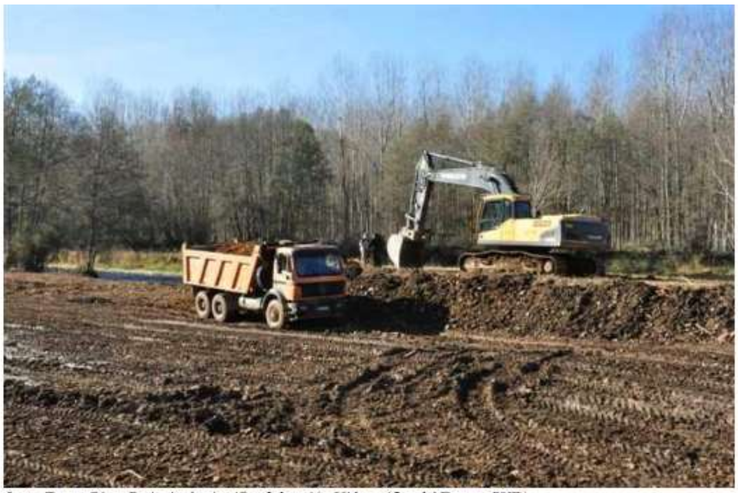
The project aimed at mitigating flood risk, by recovering the connectivity with the floodplain. It also targeted the improvement of the ecological status of the river in the embanked stretch. The project was part of the Spanish National Strategy for River Restoration.

Timing and location

The project was carried out between 2011 and 2012. It is located in northern Spain, close to the city of Leon. Overall, it affected 24 kilometers of river.

Measures

Rock armoring of river banks and earth embankments were removed from more than 13 kilometers of river channels. Some earth embankments were set-back along 5 kilometers of river channels, and other barriers such as groynes were lowered. 10 kilometers of secondary arms were reconnected and/or directly restored. Moreover, a riverbank vegetation buffer was created along 7.2 hectares that were reconnected to the river. Other in-channel obstacles, namely weirs, were modified to restore continuity for fish fauna and sediments. The project approach was very different from the experience of the local stakeholders, who were initially reluctant, especially towards expropriation. However, an active public participation process was set in place, involving stakeholders in 50 meetings during 3 years and including environmental river restoration volunteering by NGOs, eventually facilitating a successful implementation.



Source: Duero River Basin Authority (Confederación Hidrográfica del Duero, CHD)

Figure 7. An artificial levee is lowered to recover lateral connectivity (source: Duero River Basin Authority – Confederación Hidrográfica del Duero).

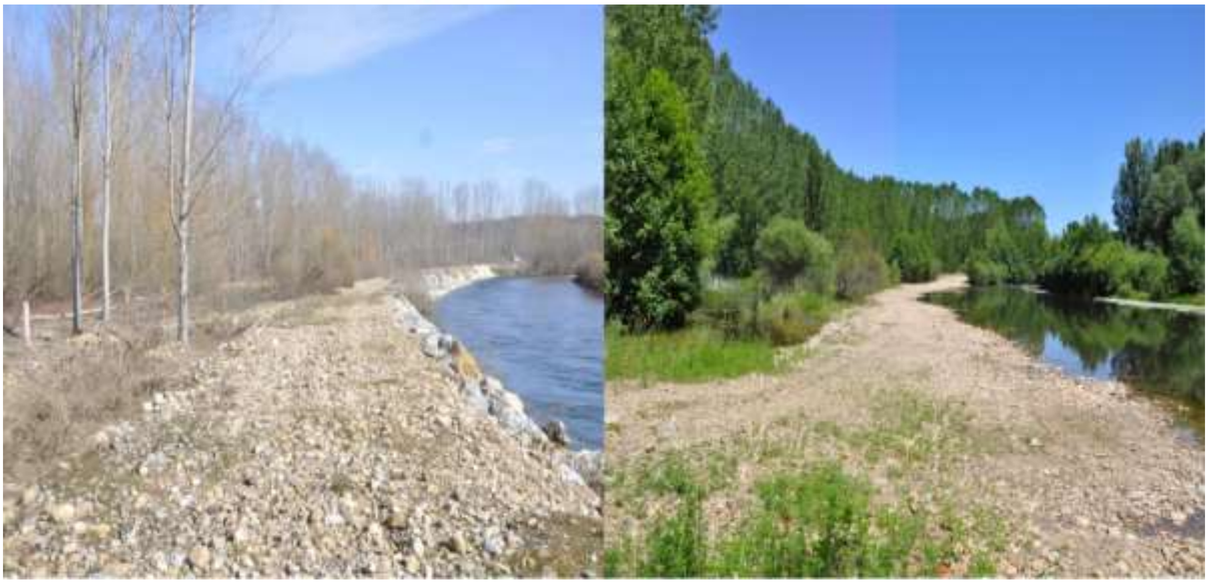


Figure 8. River bank protections were also removed along the river: on the left, the situation before the project; on the right, the river is reconnected to its floodplain (source: Duero River Basin Authority – Confederación Hidrográfica del Duero).

Monitoring and evaluation

Aerial images were collected with an innovative monitoring method (i.e. drones) to compare the river morphology before and after floods. Stakeholders were interviewed and provided qualitative assessments of the functioning of the floodplains. A quantitative assessment compared the floods of winter 2013 (160 m^3/s) and spring 2014 (250 m^3/s) to those of comparable magnitude of 1995 and 2000. The comparison showed the flood waters were successfully contained within the new river configuration, whereas in the old situation they caused serious damages.

The water quality was already good to high before the project, according to the physico-chemical indicators and the biotic indices based on diatoms and benthic macroinvertebrates. However, first evaluation results show that the ecological status of this water body has been improved. Morphological changes are also subject to monitoring and evaluation through hydromorphological indicators.

Conclusion

This restoration project lead to several significant results. First of all in terms of flood protection, i.e. material damage reduction, as well as in terms of improvement of the ecological conditions, due to the habitat diversification. In addition, the reforestation allowed to save about 7,500 tons/year of CO_2 and 3 hm^3/year of water. Moreover, the project was finalist of the 2013 IRF European Riverprize and can be considered a positive reference for the following aspects: integrated water management and land use policies, implementation of innovative concepts (i.e. “green infrastructures”), integrated approach of WFD and FD, relevance of public involvement during the whole process and impact on the media.

5. River Segura (Spain)

Project overview

Catchment:	Segura
Lead organization:	Segura River Basin Authority
Total budget:	€ 3,4 million
Status:	Completed

Pressures	*WFD measures*	*Impact*
• Damming	• Weir removal • Fish passage construction • Vegetation management • Stakeholder and public participation	• Increased fish migration • Improved condition of riparian forest • Improved governance

Context

The Segura River is heavily affected by the presence of transversal structures. These obstacles, such as dams and weirs, break up the natural flow of the water and constitute physical barriers to the natural movement of fish (migration, dispersal and colonisation) upstream and downstream, resulting in serious environmental problems and worsening the ecological status of the river.

Aims

The project aims to improve and strengthen longitudinal connectivity along the river channel.

Timing and location

The project started in 2013, and was completed by 2017, and it is a LIFE+ project (called SEGURA RIVERLINK). It involves the river segment between Cañaverosa and Abarán (i.e. 54 kilometers), and the terminal reach of Moratalla River, up to its confluence into Segura River.

Measures

The measures of the project consisted in the removal of one weir, the construction of 8 fish passages, the removal of 65 hectares covered by invasive plant species and the plantation of 2.200 trees and 4.800 shrubs along the river corridor. Moreover, 10 custody agreements with local farmers were signed and 7.000 students were volunteering in restoration activities and environmental education.

Monitoring and evaluation

A full monitoring programme has been established to monitor physico-chemical, hydromorphological and biological indicators to test the effectiveness of the interventions. The classification of the ecological status of 9 out of 18 sampling stations improved of one quality class between 2015 and 2016. One of them improved from poor to moderate status, while eight stations moved from moderate to good ecological status. Fish passes demonstrated to be effective, as about 10.000 fishes have been fished in them, and the condition of riparian forest is improving too, according to the application of the QBR index (Índice de calidad del bosque de ribera) that increased from 3 to 5 stations in class high between 2015 and 2017. Nevertheless, it is necessary to monitor and control invasive species, such as Giant reed (*Arundo donax*), and these activities are quite tricky and expensive.

Figure 9. Azud Archena weir, on the left, and lateral fish bypass for Archena weir, on the right (source: Segura River Basin Authority – Confederación Hidrográfica del Segura).

Conclusion

The LIFE+ SEGURA RIVERLINK project lead to an improvement of the longitudinal connectivity, fish passability and riparian vegetation conditions and structure. This positive results depended also on the improvement of the river governance (i.e. the custody network), as the sites that reached a good ecological status are those where administration and local farmers are working together. Other significant aspects of this project are the evaluation of the riparian vegetation in the monitoring plan and the participation and education of the public.

6. River Turia (Spain)

Project overview

Catchment:	Júcar
Lead organization:	Júcar River Basin Authority
Total budget:	n/a
Status:	Completed

Pressures	*WFD measures*	*Impact*
• Damming	• Establishment of environmental flow	• Restored spawning places and diversified habitats • Recovery of aquatic species • Improved riparian forest

Context

The Benagéber dam was built in the 1950s for water supply and significantly altered the hydrological regime of the Turia River downstream. The low flow rates resulted in consequent stress of water temperature - up to 24°C in summer. This condition affected the ecological integrity of the riverine communities and caused the almost total disappearance of the brown trout (*Salmo trutta*) throughout the water body.

Aims

The project focused on the increase of the minimum environmental flow below the dam. The effort aimed to improve one of the four aspects of environmental flows (following Spanish regulation) in the River Basin Management Plan with the overall objective to contribute to improvement of the ecological status of the water body.

Timing and location

The restored reach is located between the reservoirs of Benagéber and Loriguilla (17 kilometers in length), in the Jucár River Basin District, West of Valencia. The measure was implemented in 2014 by the Confederación Hidrográfica del Júcar (Júcar River Basin Authority).

Measures

The measure established a minimum ecological flow of 1.20 m^3 to allow the recovery of the hydrological conditions and riverine communities.

Monitoring and evaluation

The increase of the minimum flow had positive consequences on macrophytes, benthic macroinvertebrates and fish. The populations of brown trout (*Salmo trutta*) are recovering thanks to the newly created areas with loose gravel that are of fundamental importance for spawning. The abundance and diversity of benthic macroinvertebrates improved due to in-channel habitat diversification. Moreover, the condition of the riparian forest is also improving.

Figure 10. Restored flow along the Turia River (source: Pedro Merino Monzonis /RÍOS CON VIDA - Comunidad Valenciana).

Conclusion

The most innovative aspect of this restoration project is the establishment of environmental flows, a kind of restoration measure that have been shown to be important to the ecological and geomorphological dynamics of regulated rivers, with significant implications in terms of environmental services provided (Davies et al., 2014). The establishment of environmental flows can also be considered as a measure of improved river governance.

7. River Eddleston Water (United Kingdom)

Project overview

Catchment:	Tweed
Lead organization:	Tweed Forum
Total budget:	£1.4 million
Status:	In progress

Pressures	*WFD / FD measures*	*Impact*
• River straightening • Embankment	• Re-meandering • Removal of embankments • Natural flood management measures • Vegetation management • Creation of water storage • Public participation	• Habitat creation • Recovery of fish and other species (otter) • Improved flood risk management

Context

The river was severely straightened at the start of 19th century to enable the building of a toll road to Edinburgh, which, together with agricultural intensification, led to improved agricultural production. However, in combination with the subsequent building of a railway embankment and further changes in land use and forestry, this resulted in habitat loss/degradation and increased flood risk downstream. The river was classified by the Scottish Environmental Protection Agency (SEPA) as at 'bad' ecological status in 2009, largely due to the historical impacts on the physical structure of the channel and a loss of aquatic plant cover. Currently, SEPA's flood risk assessment shows some 582 properties at risk of flooding in the villages of Eddleston and Peebles under a 1:200 year scenario; the most recent floods being in 2016.

Aims

The Eddleston Water Project aims to reduce flood risk and restore the Eddleston Water for the benefit of the local community and wildlife. The project has three main objectives:

1. To investigate the potential to reduce the risk of flooding to downstream communities through the utilisation of Natural Flood risk Management (NFM) measures.

2. To improve habitats for wildlife and fish, and raise the ecological status of the river, according to the Water Framework Directive classification.

3. To work with landowners and farmers in the local community to maximise the benefits of the work, whilst sustaining farming livelihoods and practices.

The Eddleston Water project is mentioned in the Tweed River Basin Management Plan as a multiple benefit project which aims to deliver biodiversity targets, improved fisheries, natural flood management, improved water quality and the mitigation of the effects of climate change in upland catchments.

Timing and location

The Eddleston Water is a tributary of the River Tweed in the Scottish Borders and flows through the towns of Eddleston and then Peebles for around 20 km, where it joins the main river. This heavily altered upland catchment has a surface of about 70km^2. The restoration project started in 2009 and many interventions were completed in in autumn 2016. Further interventions are under negotiation.

Measures

To date, three river reaches with a total length of 2 km have been re-meandered with an increase in river length, a reduction of the slope and speed of the water flow. Re-meandering provided more space for flood waters, as well as creating new habitats and improving the landscape. Moreover, 2.9 km of flood embankments were removed and 101 flow-restricting log-jams have been installed in strategic locations in the upper catchment, to encourage out-of-bank flow and hold back water in the headwaters. Lastly, 66 hectares of native riparian woodland (i.e. some 200,000 native trees) has been planted, to increase rainfall interception and soil infiltration, and 22 stormwater ponds were created to store water during intense rainfall events. Stakeholders helped identify key ecosystem services in the catchment. All measures were carried out together with local farmers and landowners, who were key partners to the project, as was the Eddleston community.

Monitoring and evaluation

Despite still being at a relatively early stage, the project has shown an improvement in river ecology and it is on track to restore the river from Bad to Good Ecological Status. Further significant progress relies on landowners being willing to change current land use and management practices. As regards the monitoring activities, salmonid surveys were carried out before the project began and a new set of surveys will be conducted in the near future to determine the effect the works have had on fish populations. Surveys in 2014 to 2016 showed the presence of salmon redds and Eurasian otter (*Lutra lutra*) in the remeandered river reaches. Although a quantified account of ecological improvement on the Eddleston Water will require further work, it is clear from site visits that the new habitats created are being occupied by salmonids. Moreover, preliminary results show that different NFM measures can reduce flood risk through both temporarily storing surface waters and delaying the flood peaks, as well as through increased surface roughness and groundwater connectivity.

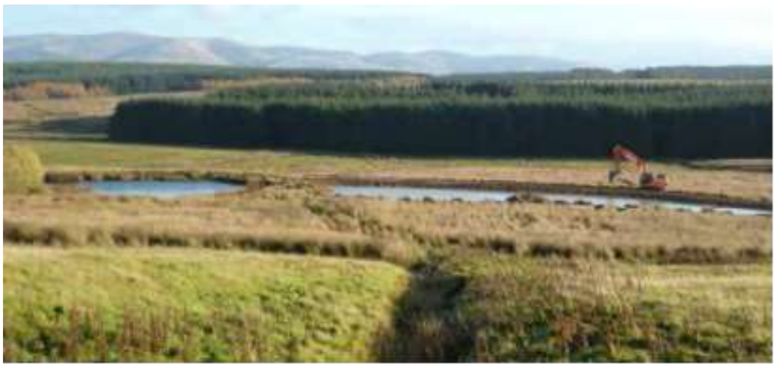


Figure 11. Construction of new ponds in the upper catchment (source: Eddleston Water Interreg Project Report 2016).

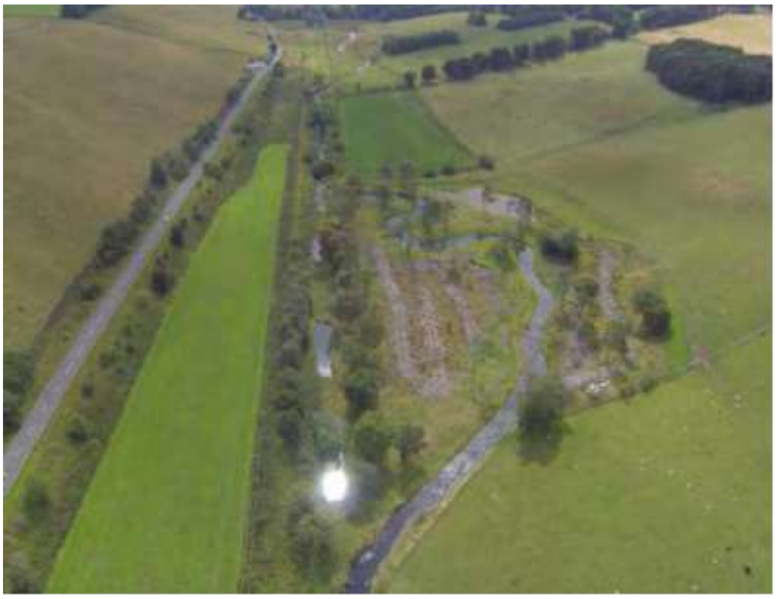


Figure 12. Re-meandered section of Lake Wood, with the old channel on the left (source: Eddleston Water Interreg Project Report 2016).

Conclusion

This project provides evidence that the restoration of the catchment can be undertaken alongside the continuation of sustainable farming and livelihoods and that the public participation is crucial to reach the objectives. Moreover, the NFM integrated measures to reduce flood risk and habitat enhancement measures to improve ecological condition provide a wide range of additional benefits and ecosystem services. Lastly, surveys of a flagship species, such as the Eurasian otter (*Lutra lutra*), were carried out beside to the monitoring of fish populations.

8. River Glaven (United Kingdom)

Project overview

Catchment:	Glaven
Lead organization:	Environment Agency
Total budget:	n/a
Status:	Completed

Pressures	*WFD / FD measures*	*Impact*
• Canalization • Floodplain disconnection • Damming and embankment • Floodplain drainage	• Floodplain reconnection • Removal of embankment • Restoration of channel morphology	• Enhanced habitat connectivity and heterogeneity • Increased vegetation richness • Increased invertebrate diversity in backwaters • Increased density of brown trout

Context

The River Glaven has historically been modified for industrial purposes through the creation of water mills. With the exception of Letheringsett Mill, these mills are no longer in use. However, water control structures such as weirs and sluices remain, and these impede the natural river flow. The River Glaven has been severely modified with canalisation and embankments were historically created to protect the adjacent floodplain farmland. Therefore a large area of floodplain is disconnected from the main river system. Coupled with this, some floodplains have been drained to further improve agricultural productivity. The dredging that occurred throughout the 1970s to 1980s in many parts of the channel resulted in the lowering of the channel bed and further disconnections between the river and its floodplain.

Aims

The aim of this restoration project was to increase hydrological connectivity between the overdeepened, embanked river and its long abandoned floodplain to improve ecological diversity within the river and floodplain. Improvements in river and floodplain biodiversity were thus the primary driver, however, flood peak attenuation was also a goal within the overall objective to improve natural river–floodplain connectivity and associated ecosystem services.

Timing and location

The restored reach is located in Hunworth Meadows, northern Norfolk, UK. A 400 m reach of river was restored and the works were conducted between 2009 and 2010.

Measures

Restoration took place at locations that were severely modified and disconnected from the floodplain, therefore measures that improved the form of the river and connectivity to the floodplain were considered. Restoration at Hunworth Meadows took place in 2 phases: during the first phase in 2009, around 400 m of embankments were removed resulting in a 40–80 m wide floodplain area (3 hectares). A second phase of work was conducted in 2010 to improve the river morphology. The intervention created a narrower and geomorphologically more diverse and meandering channel, with an associated increase of river sinuosity by 16%.

Monitoring and evaluation

Embankment removal and remeandering alongside the River Glaven at Hunworth has created a more natural flood-pulsed hydrological regime, characterised by regular, short duration inundation of the floodplain meadow, with consequent positive effects for river–floodplain ecosystem functioning (e.g. enhanced habitat connectivity and heterogeneity). Before and after control intervention (BACI) surveys of floodplain plants, aquatic macrophytes, benthic invertebrates and fish were carried out, but some results are still to be published. Vegetation surveys recorded a significant increase in macrophytes' richness following the 2 phases of restoration. Remeandering at Hunworth Meadows had no significant impact on stream invertebrate biodiversity, but when invertebrates in backwaters along the floodplain were included, a significant increase in invertebrate diversity was detected, due to the addition of several 'pond-associated' species (Sayer 2014). The backwaters were also colonised by amphibians and these observations demonstrate that the presence of these standing waters significantly enhanced biodiversity in the river–floodplain system. Restoration interventions increased the density and biomass of brown trout (*Salmo trutta*), but had no significant short-term impact on other fish populations (Champkin et al., 2018).

The restoration work had a moderate but detectable effect on flood peak attenuation, owing to the limited length of restoration (Clilverd et al., 2016), and improved free drainage into the river. A coupled hydrological/hydraulic model was utilised to analyse the impact of the floodplain reconnection before and after restoration. Using data from 2007 to 2010, the study found that the removal of the embankment resulted in widespread inundation of the floodplain at high-level flows (>$1.7 m^3 s^{-1}$). Restoration also promoted regular inundation of the immediate riparian area during lower magnitude flood extents. In addition, groundwater levels were slightly higher and subsurface storage was greater.

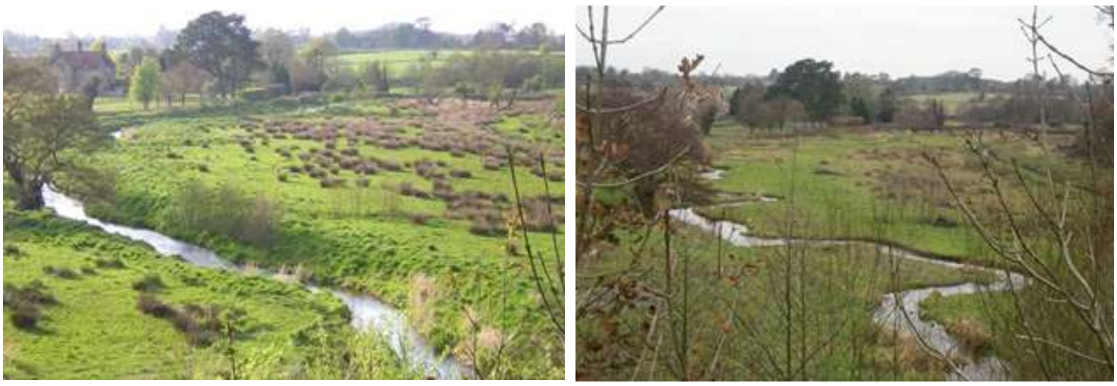


Figure 13. Re-meandered reach of the River Glaven at Hunworth: (a) In January 2009, prior to the rehabilitation project, on the left, and in December 2010, after re-creation of meanders in August on the right (source: modified by Champkin et al., 2018).

Conclusion

A significant aspect of this project is the inclusion of 6 backwaters in the monitoring plan that allow a more appropriate and detailed evaluation of the ecological conditions of the whole river corridor. On the other hand, the results in terms of ecological improvement considering in-channel bioindicators (i.e. benthic macroinvertebrates and fish) were quite limited. The results of this small-scale restoration project are not an isolated case and stress the need for catchment scale combination of measures. Numerous studies have shown that stream rehabilitation does not necessarily translate into significant improvements in biotic communities, at least in the short term, and this may be attributable to a combination of factors that cannot be addressed by localized river rehabilitation work (e.g. Palmer et al., 2010). One factor that is not addressed by reach-scale rehabilitation is the influence of catchment-scale pressures on rivers (Champkin et al., 2018). River rehabilitation efforts may be more effective if they also concentrate on improving water quality within the upper stretches of small rivers in agricultural catchments to reduce stresses placed on downstream biological communities (Palmer et al., 2010). The spatial scale of the rehabilitation work should thus be proportional to system size (Schmutz et al., 2014).

SECTION 3 – FINDINGS AND DISCUSSIONS

3.1 – Effects of restoration measures

The case studies analysed in the previous sections describe river restoration projects carried out with the aim to meet the objectives of the Water Framework Directive and, in some cases, the Floods Directive. The case studies demonstrate **positive results in the improvement of the ecological conditions of the restored river reaches.** These improvements include for example the abundance, diversity and population structure of specific bioindicators and improvements of hydromorphological conditions or flow regime.

Some of the case studies highlight relevant **improvement in river governance** (i.e. Segura, Turia, Eddleston Water and Eau Blanche and Bocq) or the crucial role of **public participation** (i.e. Orbigo, Segura and Eddleston Water). These provisions of the WFD prove to be key elements for successful river restoration interventions (Morandi et al., 2014).

3.2 – Implementation gap

The case studies also point out that an **implementation gap still remains between current restoration measures and the actions required to improve ecological conditions at water body scale**. This gap can be attributed to the:

- **Limited scale of interventions** (half of the case studies being not more than a few kilometres in length), very short with respect to the mean length of the water bodies, most of them being more than 10 or 20 kilometres and up to 30 or 40 kilometres (Champkin et al., 2018).
- **Spatial scale of the water bodies**: too long to catch the results of site-scale interventions.
- **Persistence of pressures** (e.g. water quality, alteration of flow regime and/or sediment and wood flux) in the **upstream catchment** (e.g. the case study of the Eau Blanche and Bocq rivers) (Palmer et al., 2010; Schmutz et al., 2014; Champkin et al., 2018).
- **Lack of funding for large scale interventions**. Half of the case studies are carried out in relatively short river reaches (i.e. less than 5 kilometres), while the median length of the restoration case studies is 10.3 kilometres. It is also worth to underline that the projects that were carried out on longer reaches consisted in the removal of some

transversal structures, as the main measure, and in the establishment of environmental flows, not in the complete morphological restoration of the river reaches. Orbigo case study is the only notable exception.

- **Lack of sensitivity of the monitoring and assessment tools** (i.e. the biotic indices based on the BQEs) to the improved conditions (Friberg et al., 2011; Friberg, 2014; Golfieri et al., 2018). See a detailed analysis of this aspect in paragraph 3.3.

3.3 – Monitoring and assessment tools

The WFD requires the assessment of different organism groups (i.e. benthic macroinvertebrates, benthic diatoms, aquatic macrophytes and fish) called Biological Quality Elements (BQEs) to define the ecological status of rivers. These organisms were selected because they are widely considered good indicators of water quality, the alteration of which was the main pressure acting on rivers in developed countries in the last decades (Armitage et al., 1983; Friberg, 2014).

Recent studies showed that BQE-based metrics and indices that were developed for the implementation of the WFD and that are used for standard assessment and monitoring are sensitive to water quality alteration and general habitat degradation. Conversely, their response to hydromorphological degradation is generally weak or absent (Hering et al., 2006; Friberg et al., 2009; Marzin et al., 2012; Dahm et al., 2013). Moreover, the effects of river restoration actions showed contrasting results on the BQEs richness and abundance (Kail et al., 2015). The other significant shortcoming of the WFD-compliant biotic indices is that their standard application is limited to flowing channels, i.e., sampling sites are generally located along the main channel, and side channels and lentic sites within the river corridor are not considered within the sampling protocols (Golfieri et al., 2018).

The **need for an appropriate assessment of the entire fluvial corridor** that also considers the lateral dimension of the river system, has become a priority for both the scientific community and water managers in recent years (Reyjol et al., 2014). It is evident that relying exclusively on the BQE-based indices and metrics does not allow a comprehensive assessment of the ecological conditions of the whole river corridor, in particular in large multiple-thread river systems (Golfieri et al., 2018), but also in smaller systems (e.g. chalk fed River Glaven case study). An incomplete evaluation could lead to incorrect planning in river management and restoration actions. The application of promising biotic evaluation tools based on functional traits or indicators of ecosystem functioning might provide deeper insights into the assessment of river conditions, particularly in the context of multiple pressures (Carvalho et al., 2019).

In addition to BQEs, other bioindicators have been used to evaluate the condition of riparian areas and floodplains, such as amphibians, ground beetles, riparian vegetation and dragonflies (Munné et al., 2003; Jähnig et al., 2009; Gumiero et al., 2015, Sayer, 2014; Simaika and Samways, 2009). The latter taxon is of particular interest as in recent years several dragonfly-based indices were developed across Europe to assess the condition of streams and wetlands according to the WFD requirements and classification scheme.[30]

In this report, half of the considered restoration case studies included in their monitoring plan the assessment of additional bioindicators and/or considered also the backwaters but only in two case studies (i.e. Cofio and Segura) the assessment was carried through the application of a WFD-compliant index (i.e. the QBR, Índice de calidad del bosque de ribera) which is also considered in Spanish national legislation. The two other case studies based the additional monitoring activity on the presence of a flagship species (the otter, Eddleston Water) and the sampling of different bioindicators (i.e. aquatic macrophytes, benthic macroinvertebrates, dragonflies and amphibians) in backwaters in Glaven case study.

[30] The Dragonfly Association Index in Austria (Chovanec et al., 2015), the “Odonata Community Index – Corsica” in France (Berquier et al., 2016) and the Odonate River Index in Italy (Golfieri et al., 2016).

SECTION 4 – INFORMATION SOURCES

The screening of the case studies is mainly based on the following sources. Some of the documents are not available in English.

Eau Blanche and Bocq (Belgium): LIFE Project Number LIFE07 ENV/B/000038 "Walphy" FINAL Report.

Drac (France): Technical note about the monitoring of hydromorphological restoration of the Upper Drac River (Hautes-Alpes, France). Report of the INTERREG "Alpine Space" project HyMoCARES. Irstea and Conseil Départemental des Hautes-Alpes.

Cofio (Spain): Seguimiento del Estado Ecológico del Río Cofio tras la demolición de la presa de Robledo de Chavela. Confederación Hidrográfica del Tajo. Years 2016, 2017, 2018.

Orbigo (Spain): Natural Water Retention Measures – Case study: Órbigo River ecological status improvement (Stretch I): Duero River Basin.

Segura (Spain): Departamento Inspección y Control Ambiental, Área de Control de Vertidos y Calidad de Aguas. Informe Final 2015-2017. Programa de Monitoreo del Estado Ecológico y Análisis de Sedimentos en el ámbito de actuación del Proyecto Europeo LIFE+ "Segura Riverlink"(LIFE12 ENV/ES/1140).

Turia (Spain): Andreu J., Ferrer-Polo J., Pérez M.A., Solera A., 2009. Decision Support System for Drought Planning and Management in the Jucar River Basin, Spain. 18th World IMACS / MODSIM Congress, Cairns, Australia.

Eddlston Water (United Kingdom): Case study 9. Eddleston Water Project. Working with natural processes to reduce flood risk by the UK Environmental Agency.

Glaven (United Kingdom): Case study 5. River Glaven, North Norfolk. Working with natural processes to reduce flood risk by the UK Environmental Agency.

SECTION 5 – REFERENCES

Armitage P.D., Moss D., Wright J.F., Furse M.T., 1983. The performance of a new biological water quality score system based on macroinvertebrates over a wide range of unpolluted running-water sites. Water Resources 17, 333–347.

Berquier C., Orsini A., Ferrat L., Andrei-Ruiz M.C., 2016. Odonata Community Index –Corsica (OCIC): A new biological index based on adult odonate populations for assessment of the ecological status of watercourses in Corsica. Ecological Indicators 66, 163–172.

Carvalho L., Mackay E.B., Cardoso A.C., Baattrup-Pedersen A., Birk S., Blackstock K.L., Borics G., Borja A., Feld C.K., Ferreira M.T., Globevnik L., Grizzetti B., Hendry S., Hering D., Kelly M., Langaas S., Meissner K., Panagopoulos Y., Penning E., Rouillard J., Sabater S., Schmedtje U., Spears B.M., Venohr M., van de Bund W., Solheim A.L., 2019. Protecting and restoring Europe's waters: An analysis of the future development needs of the Water Framework Directive. Science of the Total Environment 658, 1228–1238.

Castelain L., Peeters A., Halleux M., de le Court B., Verniers G., 2018. Walphy, un projet expérimental de réhabilitation de cours d'eau: suivis hydromorphologiques et écologiques. Hydroécologie Appliquée 20, 27–53.

Champkin J. D., Copp G.H., Sayer C.D., Clilverd H.M., George L., Vilizzi L., Godard M.J., Clarke J., Walker A.M., 2018. Responses of fishes and lampreys to the re-creation of meanders in a small English chalk stream. River Research and Applications 34, 34–43.

Chovanec A., Waringer J., Raab R., Laister G., 2004. Lateral connectivity of a fragmented large river system: assessment on a macroscale by dragonfly surveys (Insecta: Odonata). Aquatic Conservation: Marine and Freshwater Ecosystems 14, 163–178.

Clilverd H.M., Thompson J.R., Heppell C.M., Sayer C.D., Axmacher J.C., 2016. Coupled hydrological/hydraulic modelling of river restoration impacts and floodplain hydrodynamics. River Research and Applications 32, 1927–1948.

Dahm V., Hering D., Nemitz D., Graf W., Schmidt-Kloiber A., Leitner P., Melcher A., Feld C.K., 2013. Effects of physico-chemistry, land use and hydromorphology on three riverine organism groups: a comparative analysis with monitoring data from Germany and Austria. Hydrobiologia 704, 389–415.

Davies P.M., Naiman R.J., Warfe D.M., Pettit N.E., Arthington A.H., Bunn S.E., 2014. Flow-ecology relationships: closing the loop on effective environmental flows. Marine and Freshwater Research 65, 133–141.

Friberg N., 2014. Impacts and indicators of change in lotic ecosystems. WIREs Water 1, 513–531.

Friberg N., Bonada N., Bradley D.C., Dunbar M.J., Edwards F.K., Grey J., Hayes R.B., Hildrew A.G., Lamouroux N., Trimmer M., Woodward G., 2011. Biomonitoring of human impacts in natural ecosystems: the good, the bad, and the ugly. Advances in Ecological Research 44, 2–49.

Friberg N., Sandin L., Pedersen M.L., 2009. Assessing the effects of hydromorphological degradation on macroinvertebrate indicators in rivers: examples, constraints, and outlook. Integrated Environmental Assessment and Management 5, 86–96.

Golfieri B., Hardersen S., Maiolini B., Surian N., 2016. Odonates as indicators of the ecological integrity of the river corridor: development and application of the Odonate River Index (ORI) in northern Italy. Ecological Indicators 61, 234–247.

Golfieri B., Surian N., Hardersen S., 2018. Towards a more comprehensive assessment of river corridor conditions: A comparison between the Morphological Quality Index and there biotic indices. Ecological Indicators 84, 525–534.

Gumiero B., Rinaldi M., Belletti B., Lenzi D., Puppi G., 2015. Riparian vegetation as indicator of channel adjustments and environmental conditions: the case of the Panaro River (Northern Italy). Aquatic Sciences 77, 563–582.

Hering D., Johnson R.K., Kramm S., Schmutz S., Szoszkiewicz K., Verdonschot P.F.M., 2006. Assessment of European streams with diatoms, macrophytes, macroinvertebrates and fish: a comparative metric-based analysis of organism response to stress. Freshwater Biology 51, 1757–1785.

Jähnig S.C., Brunzel S., Gacek S., Lorenz A.W., Hering D., 2009. Effects of re-braiding measures on hydromorphology, floodplain vegetation, ground beetles and benthic invertebrates in mountain rivers. Journal of Applied Ecology 46, 406–416.

Kail J., Brabec K., Poppe M., Januschke K., 2015. The effect of river restoration on fish, macroinvertebrates and aquatic macrophytes: a meta-analysis. Ecological Indicators 58, 311–321.

Marzin A., Archaimbault V., Belliard J., Chauvin C., Delmas F., Pont D., 2012. Ecological assessment of running waters: do macrophytes, macroinvertebrates, diatoms and fish show similar responses to human pressures? Ecological Indicators 23, 56–65.

Morandi B., Piégay H., Lamouroux N., Vaudor L., 2014.How is success or failure in river restoration projects evaluated? Feedback from French restoration projects. Journal of Environmental Management 137, 178–188.

Munné A., Prat N., Solà C., Bonada N., Rieradevall M. 2003. A simple field method for assessing the ecological quality of riparian habitat in rivers and streams. QBR index. Aquatic Conservation: Marine and Freshwater Ecosystems, 13: 147–164.

Palmer M.A., Menninger H.L., Bernhardt E., 2010 .River restoration, habitat heterogeneity and biodiversity: a failure of theory or practice? Freshwater Biology 55, 205–222.

Reyjol Y., Argillier C., Bonne W., Borja A., Buijse A.D., Cardoso A.C., Daufresne M., Kernan M., Ferreira M.T., Poikane S., Prat N., Solheim A.L., Stroffek S., Usseglio-Polatera P., Villeneuve B., van de Bund W., 2014. Assessing the ecological status in the context of the European Water Framework Directive: where do we go now? Science of the Total Environment 497–498, 332–344.

Sayer C.D., 2014. Conservation of aquatic landscapes: ponds, lakes, and rivers as integrated systems. WIREs Water 1, 573–585.

Schmutz S., Kremser H., Melcher A., Jungwirth M., Muhar S., Waidbacher H., Zauner G., 2014. Ecological effects of rehabilitation measures at the Austrian Danube: A meta-analysis of fish assemblages. Hydrobiologia 729, 49 –60.

Simaika J.P., Samways M.J., 2009. An easy-to-use index of ecological integrity for prioritizing freshwater sites and for assessing habitat quality. Biodiversity and Conservation 18, 1171–1185.