HANDBOOK for the Implementation of Freshwater Ecosystem Conservation Measures

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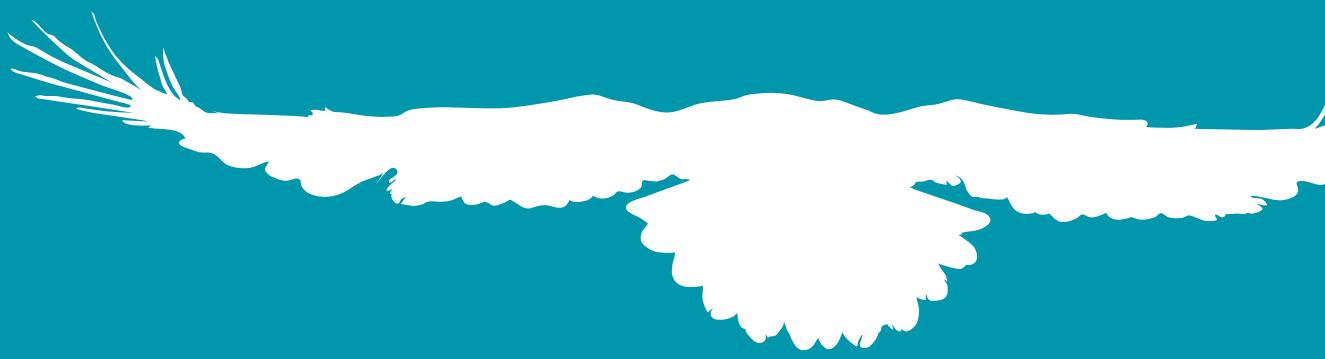
CONTENTS

LIST OF ACRONYMS

FPA, cro. BP	Flood Protectection Area
EU	European Union
Main AA, cro. GO	Main Appropriate Assessment (Main assessment of acceptability considering the implications for the ecological network)
IAS	Invasive alien species
ARBD, cro. JVP	Adriatic River Basin District
PI, cro. JU	Public institution for the management of protected areas and ecological network sites
MESD, cro. MINGOR	Ministry of Economy and Sustainable Development
NHC, cro. NKS	National Habitat Classification
OG, cro. NN	Official Gazette
WFD	Water Framework Directive
AA, cro. OPEM	Appropriate Assessment (Assessment of acceptability considering the implications for the ecological network)
EIA Screening, cro. OPUO	Screening (to determine whether an Environmental Impact Assessment is required) (Assessment of the need for an Environmental Impact Assessment)
AA Screening, cro. PO	Appropriate Assessment Screening (Preliminary assessment of acceptability considering the implications for the ecological network)
SPA, cro. POP	Special Protection Area (Area of conservation important for birds)
SCI, cro. POVS	Site of Community Interest (Area of conservation important for species and habitat types)
SAC, cro. PPOVS	Special Area of Conservation (Special area of conservation important for species and habitat types)
RBMP, cro. PUVP	River Basin Management Plan
WMD, cro. VGO	Water Management Department
WMO, cro. VGI	Water Management Branch Office
DRBD, cro. DVP	Danube River Basin District
pSCI, cro. vPOVS	Proposed Site of Community Interest (Proposed special area of conservation important for species and habitat types)
WA, cro. ZOV	Water Act
NPA, cro. ZZP	Nature Protection Act
EPA, cro. ZZO	Environmental Protection Act

1 Introduction



This Handbook has been prepared as part of the *Development of the Natura 2000 Management Framework project*, co-funded under the *Competitiveness and Cohesion Operational Programme 2014 - 2020*, for the purpose of achieving Specific Objective (SO) 6iii2: *Establishing a Framework for Sustainable Biodiversity Management* (with a primary focus on the Natura 2000 ecological network). The implementation of this project is of key importance for ensuring compliance of the Republic of Croatia with its obligations in the field of nature protection arising from EU membership. The beneficiary of the project is the Ministry of Economy and Sustainable Development (hereinafter referred to as "the Ministry"), while the Institute for Environment and Nature participates as a project partner.

The purpose of the *Development of the Natura 2000 Management Framework* project is to contribute to achieving the conservation objectives and establishing the conservation measures for target species and habitat types identified in the Natura 2000 ecological network sites on the territory of the Republic of Croatia. The main objective of the project is to establish a framework for effective management of the Natura 2000 ecological network in Croatia through participatory development of site-specific management plans, development of institutional and individual management capacities as well as through raising public awareness of the importance of conserving the Natura 2000 ecological network sites.

Among other, the project scope also includes the monitoring of effectiveness of freshwater ecosystem conservation measures, which has led to the preparation of this Handbook and the associated Field Handbook that both provide information and guidance on the implementation of freshwater ecosystem conservation measures when undertaking planned works included in the regular maintenance programmes drawn up with the aim of ensuring protection from the harmful effects of water.

1.1 Purpose and Intended Use of the Handbook

This Handbook has been prepared based on the analyses made by different experts (biologists, hydrotechnical engineers, experts on different taxonomic groups), results of the research on plant and animal taxonomic groups undertaken in connection with the execution of standardised mowing, cutting and woody debris removal works, and the previous experience of all stakeholders involved in the execution of different steps of the appropriate assessment procedure (hereinafter referred to as "the AA procedure")[1] in respect to a programme of maintenance works prepared with the aim of ensuring protection from the harmful effects of water (hereinafter referred to as "the water main-

1 In Croatian: Ocjena prihvatljivosti za ekološku mrežu (OPEM); "the assessment of acceptability considering the implications for the ecological network (of a project/plan)" or "the OPEM procedure"

tenance programme", as defined in the Water Act[2], OG[3] No. 66/19, 84/21) and the implementation of the nature protection requirements prescribed as a result of that procedure (more precisely, the implementation of freshwater ecosystem conservation measures) on the territory of the Republic of Croatia.

This Handbook has been prepared and is intended to ensure better performance of all stakeholders involved in the implementation and monitoring of the implementation of freshwater ecosystem conservation measures prescribed as a result of the AA procedure conducted in respect of a particular water maintenance programme.

By presenting examples of good practice, this Handbook aims to show how different standardised water maintenance works can be properly executed in combination with the relevant freshwater ecosystem conservation measures.

In addition to the conservation measures that should be implemented when undertaking standardised water maintenance works, such as mowing, selective cutting and sediment and woody debris removal, this Handbook also covers the freshwater ecosystem conservation measures that should be implemented when undertaking standardised renovation and repair works on existing regulating structures that do not involve changes in dimensions. The Handbook, however, does not cover the conservation measures that should be implemented in connection with construction of new hydrotechnical structures or such water management structures that are subject to special administrative procedures, i.e. EIA screening (OPUO), AA screening (PO) and/or AA (GO). This Handbook primarily refers to the water maintenance programme, i.e. it presents the examples of good practice in executing different standardised water maintenance works to ensure protection from the harmful effects of water.

The input data used in the preparation of this Handbook include the following: (1) the freshwater ecosystem conservation measures that the Ministry, as the main national competent authority for nature protection, prescribes as nature protection requirements in the process of appropriate assessment of water maintenance programmes, (2) the *Programme of Maintenance Works Aimed at Ensuring Protection from the Harmful Effects of Water for the Period 2019 – 2022*, the programming document applicable at the time this Handbook was being prepared, and (3) the instructions and guides/manuals implemented so far.

2 In Croatian: Zakon o vodama; referring to watercourses and other types of water

3 In Croatian: Narodne novine (NN); "the Official Gazette"

EXAMPLES OF GOOD PRACTICE FROM OTHER EU MEMBER STATES - IRELAND

The system of freshwater ecosystem conservation measures presented in this Handbook is partly based on the system of conservation measures implemented in Ireland in connection with regular technical watercourse maintenance works. Croatia made the first contact with its Irish colleagues in this regard in 2016, although Irish guidelines had been applied in defining the system of freshwater ecosystem conservation measures in Croatia already in 2011. To ensure a better understanding of the Irish example, a study visit to Ireland was organised for selected participants from the Croatian water management and nature protection sectors, during which they had the opportunity to learn how to undertake the relevant works in compliance with the environmental guidance on watercourse maintenance that has been applied for more than 10 years now by the Irish *Office of Public Works* (hereinafter referred to as: "OPW"), the national competent authority for the execution of public works, including watercourse maintenance to ensure drainage and flood relief. Two workshops and two 1-day visits to the selected work sites were organised during the study visit to give the participants the opportunity to observe how conservation measures are implemented on site as well as to learn how the implementation of such measures should be monitored.

The OPW's *Environmental Guidance on Watercourse Maintenance* (Brew and Gilligan 2019) has resulted from an internal initiative and internal experience as well as from cooperation with other institutions from the environmental and nature protection sector. The impact of the implementation of conservation measures is being continuously monitored and great efforts are being invested in improving the guidelines and educating the workers. In addition, the OPW fosters strong intersectoral cooperation with other institutions in the field of nature protection, referring, for example, to the restoration projects implemented in cooperation with *Inland Fisheries Ireland*, Ireland's dedicated state agency for inland fisheries, with the aim of improving the status of water bodies and biodiversity. The *Design Guidance for Fish Passage on Small Barriers* (Office of Public Works 2021) is one of the outcomes of this cooperation.

If implemented in Croatia, the good practices with which the study visit participants have familiarised themselves in Ireland would contribute to the improvement of the system for adopting water maintenance programmes, the associated AA procedure, the implemen-

tation of water maintenance programmes, and to the effectiveness of implementation of conservation measures. Organisation of educational programmes intended for contractors, which would be conducted by professional biologists and which would focus primarily on the provision of information required for recognising the species and habitat types for which conservation measures are prescribed, is seen as an important step forward in terms of watercourse maintenance in Croatia. With the aim of improving the system as a whole, it is further recommended to employ professional biologists at the level of Water Management Departments (locally known as "VGO") or Water Management Branch Offices (locally known as "VGI"), whose expertise would contribute to the effectiveness of implementation of conservation measures on site as well as help improve the coordination between the water management sector and the sector dedicated to nature protection. Other recommendations include establishing a database of spatial information associated with the works planned to be executed within a period of four years, and monitoring of the execution of those works and implementation of conservation measures at individual sites.

2 Legal Basis for the Preparation and Use of the Handbook

The legal basis for the preparation and use of this Handbook are EU Council directives and national regulations, which also provide the relevant statutory framework, as explained below.

2.1 Water Framework Directive

All activities that depend on or affect waters are managed in accordance with the principles laid down in the *Water Framework Directive* (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) that provides a framework for action in the field of water policy to be followed by EU Member States. The *Water Framework Directive* (hereinafter referred to as "the WFD") refers to inland surface waters (rivers and lakes), transitional waters, coastal waters, and groundwaters.

The main objective of the WFD is to ensure that, where it already exists, the "high and good water status" is maintained, that deterioration of the existing water status is prevented, and that measures are implemented to achieve at least the "good water status" in regard to those water bodies that are currently not at good status. "Good surface water status" means the status achieved by a surface water body when both its ecological status and its chemical status are at least "good" (where the "ecological status" of a water body is assessed taking into account the biological, hydromorphological and basic physicochemical and chemical indicators supporting the relevant biological elements, and the "chemical status" of a water body is assessed taking into account the chemical status indicators). "Good groundwater status" means the status achieved by a groundwater body when both its quantitative status and its chemical status are at least "good". The requirements and normative rules associated with the assessment of water status in accordance with the WFD refer to watercourses whose basin area exceeds a given size, i.e. they apply to rivers whose basin area exceeds 10 sq. km.

One of the novelties introduced by the WFD is a system for classification of watercourses by type. In typologising the Croatian hydrographic network, all mandatory factors prescribed by the WFD have been considered, while the choice of optional factors was based on the ecological and faunistic characteristics of the national territory of the Republic of Croatia. The mandatory criteria applied in the process of typologising the watercourses found on the territory of the Republic of Croatia are as follows: (1) position of Croatia according to the limnological regionalisation of Europe (Illies 1978), i.e. the limnological ecoregion(s) to which the watercourses of Croatia belong according to Illies, namely the Pannonian (11 – Hungarian lowlands) and the Dinaric (5 – Dinaric Western Balkan) inland ecoregions; (2) elevation; (3) basin size (area); and (4) geological and lithological features (Table 2.1.1).

Specific reference values and class limits relating to the relevant quality elements are determined for each surface water body type, which values and limits serve as the basis for assessing the ecological status of the waters concerned. The type-specific reference conditions correspond to the values of the quality elements representative of a particular surface water body type in the absence of significant anthropogenic pressures and impacts. The list of surface water body types identified on the territory of the Republic of Croatia constitutes an integral part of the *Regulation on Water Quality Standards* (OG No. 96/19).

By adopting the WFD, the EU Member States, including the Republic of Croatia, have undertaken to manage their water resources in a manner that ensures the achievement of at least the "good ecological status" in respect of natural water bodies, and at least the "good ecological potential" in respect of heavily modified or artificial water bodies.

Before the adoption of the WFD, the assessment of the ecological status was based primarily on the analysis of physicochemical, chemical and biological indicators (periphyton, macrophytes, benthic macroinvertebrates, and fish). After the WFD was adopted, hydromorphology was also introduced as an essential aspect that should be taken into account in the assessment of the ecological status considering that it deals with the structure and morphological dynamics of hydrological systems, i.e. gives insight into various hydrological and morphological elements (including vegetation), and processes that take place in water bodies. The bottom line is that hydrological regimes change over time due to various impacts, both natural and anthropogenic (e.g. change in land use, construction of hydrotechnical structures/facilities, climatic changes, and similar), and such changes can substantially affect the status of waters.

TABLE 2.1.1 *Criteria for typologising flowing waters (streams and rivers) whose basin area in Croatia exceeds 10 sq. km*

Abiotic factors considered in the process of typologising rivers / flowing waters*	
mandatory	**optional**
1. Ecoregion - Pannonian Ecoregion - Dinaric Ecoregion: • Dinaric Inland Subecoregion • Dinaric Marine Subecoregion • Dinaric Marine Subecoregion - Istria	**1.** Medium-sized substrate particles (> 2 mm) **2.** Large substrate (> 6 cm) **3.** Alluvial rivers with a small bed slope **4.** Rivers in karst fields (*polje*) **5.** Karst rivers with a bed slope exceeding 5 ‰ **6.** Intermittent rivers **7.** Karst rivers with a barrage lake
2. Basin Size (Area) - 10 – 100 sq. km – streams and small rivers - 100 – 1000 sq. km – medium-sized rivers - 1000 – 10.000 sq. km – large rivers - > 10,000 sq. km – very large rivers	
3. Geological and lithological substrate - silica - limestone - mixed: silica and limestone or limestone and silica (depending on which is more present), or limestone and flysch organogenic - mixed: silica and organogenic - mixed: limestone and organogenic	
4. Elevation - lowland rivers (< 200 m) - foothill rivers (200 – 500 m) - highland (mountain) rivers or highland streams (> 500 m)	

* According to the RBMP 2016 – 2021 (Decision to Adopt the River Basin Management Plan 2016 – 2021 (OG No. 66/2016) [4]))

4 In Croatian: Odluka o donošenju Plana upravljanja vodnim područjima 2016. – 2021. (NN 66/2016)

The WFD also makes a distinction among natural, heavily modified and artificial water bodies. **Natural water bodies** are those sections of surface watercourses that show no evidence of significant anthropogenic impact and along which natural processes normally take place. As opposed to natural water bodies, **heavily modified water bodies** are those watercourse sections where significant hydromorphological changes have occurred, which prevent the achievement of the "good ecological status". It is precisely for this reason that achievement of at least the "good ecological potential", and not status, is established by the WFD as the environmental objective for heavily modified water bodies. The potential causes of significant hydromorphological changes include:

- presence of significant physical changes and hydromorphological impacts on at least 70% of the section length,
- presence of one or more users from the field of hydropower production, navigation, flood protection or urban development on the observed section, whose activities may cause significant hydromorphological changes,
- presence of one or more significant physical causative factors (pressures), such as dams/locks, regulating/meander "straightening" structures or facilities, bank reinforcement/stabilisation structures or facilities, on the observed section, and
- determination of the risk of failure to achieve the "good ecological status" due to the afore-mentioned hydromorphological changes made in respect of a particular watercourse section on the basis of professional assessments, according to one or more of the following criteria, i.e. identification of:

    1. impassable barriers (dams) disrupting wildlife migration passages,
    2. a change in surface water classification (e.g. from a natural river to a heavily modified water body upstream of a dam),
    3. a significant reduction in water flow (e.g. as the water remains stored in reservoirs in the periods when water levels are low), and
    4. a disruption of lateral connectivity (e.g. as a result of construction of embankments or dams on the tributaries, etc.).

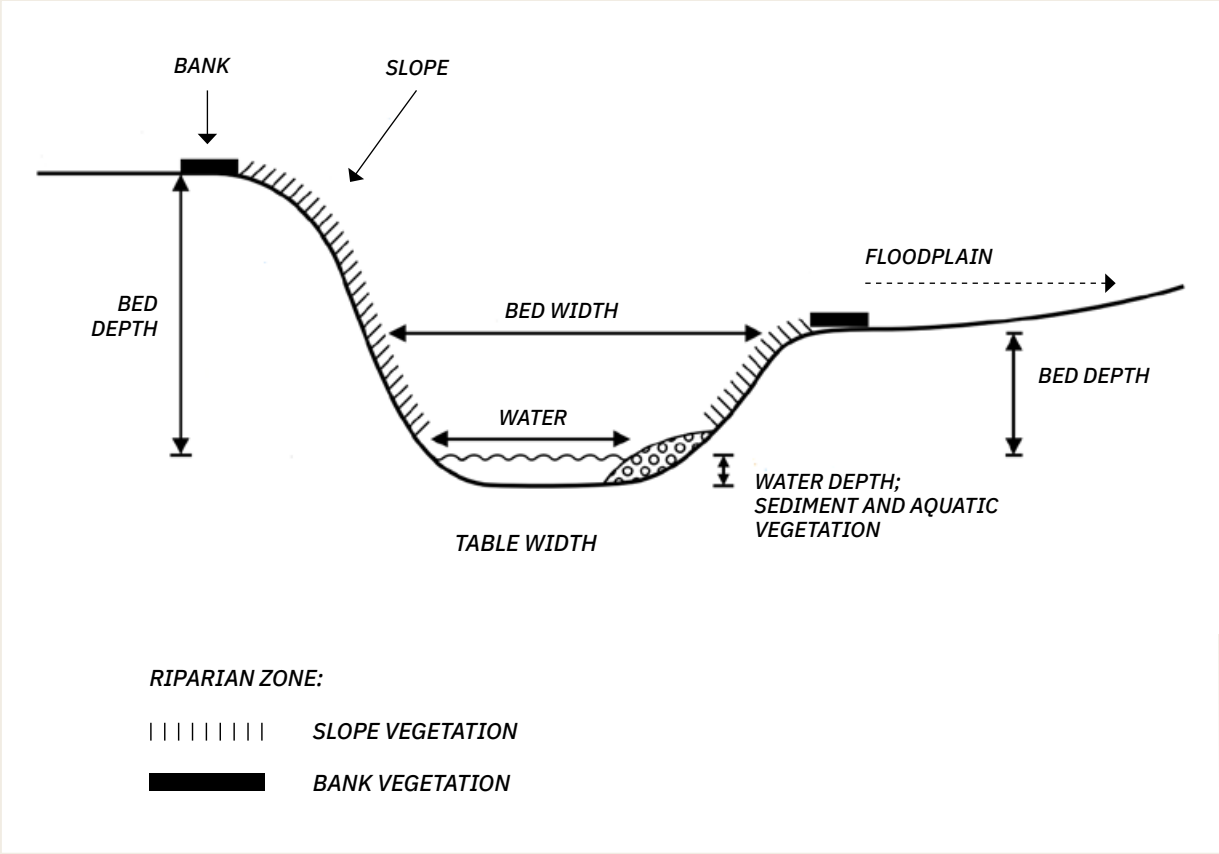
The hydromorphological quality elements to be considered and monitored in connection with different water body types are also defined in the WFD. More precisely, as provided in Annex V of the WFD, the hydromorphological quality elements to be monitored in respect of flowing waters (in particular, rivers), are as follows:

1. hydrological regime (the quantity and dynamics of a river's water flow, its connectivity with groundwater bodies),
2. river continuity, and
3. morphological conditions (the variations in the depth and width of a river, the structure and substrate (sediment) of its bed, the structure of the associated riparian zone).

The hydromorphological quality elements supporting the biological quality elements are also defined for the standing waters (lakes) as well as for transitional and coastal waters. The list of the hydromorphological elements to be measured are defined in Annex 2 of the Regulation on Water Quantity Standards (OG No. 96/19).

The criteria for assessing the hydromorphological status are the hydrological regime (the quantity and dynamics of the water flowing through a river), flow continuity (taking into consideration the water, the sediment, and the biota) and morphology of the riverbed and the associated riparian zone (riverbed geometry, erosion and sedimentation processes and geoindicators, vegetation characteristics, interaction with groundwaters and the floodplain). The purpose of hydromorphological monitoring is, on the other hand, to determine the presence of particular natural, modified or artificial hydromorphological features and properties in the riverbed, on the banks, in the riparian zone and in the hinterland of a watercourse.

The hydromorphological features of rivers are determined through water status monitoring. The figure below (Figure 2.1.1) shows a simplified illustration of the parts of a watercourse and its hinterland used to determine the hydromorphological features of a (stream or) river for the purposes of assessing its hydromorphological status.



↑ FIGURE 2.1.1 *A cross-section of a watercourse bed with a presentation of different parts of the river bed considered in the assessment of the hydromorphological status*
(Source: a graphic presentation adjusted according to Environment Agency 2003)

The environmental objectives established in the WFD are to be achieved through the implementation of programmes of measures defined in the river basin management plans.

Explanation of terms:

Slope – a stretch of land that extends from the water table to the bank line (in the cross-section, the bank line is determined by the bank height).

Riparian zone – a zone that extends across the banks and slopes of the bed of a stream or river. It is a transitional area between aquatic and terrestrial habitats, with elements of both, where the soil and vegetation are constantly being influenced by a standing or flowing water. Riparian vegetation has a significant impact on the hydrological, morphological and ecological status of the associated aquatic ecosystem as it provides, depending on the type, covered area and density, the essential functions such as shade, leaves and branches (organic matter), filtration, and other. In the process of hydromorphological monitoring, the structure of the vegetation growing on the slopes and banks of a water body (more precisely, on a 1 m stretch of land from the bank line) is assessed. Besides the structure of the riparian vegetation (growing on the banks and slopes of a water body), to determine the hydromorphological status of a water body, ***the presence, structure and composition of aquatic vegetation in the bed*** must also be checked and identified.

Aquatic vegetation – the presence, structure and composition of aquatic vegetation are determined in the process of hydromorphological monitoring. Aquatic vegetation includes the ***amphibian vegetation***, i.e. plants that spend part of the year submerged in water and part of the year above the surface of the water.

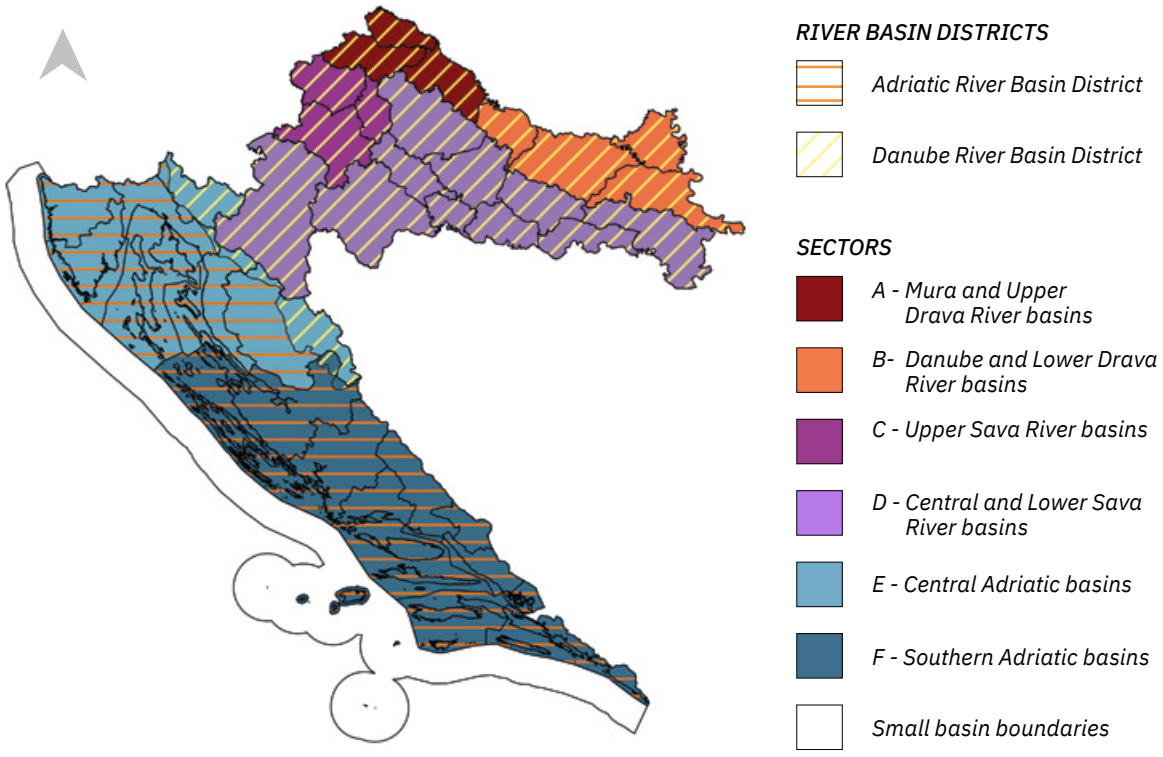
The hydromorphological monitoring process entails the determination of the composition of the banks and the bed, i.e. determination of the (natural or artificial) material of which **the banks and the bed are composed** (the structure of the sediment), and determination of the presence of **any modifications made to the banks or the bed of a watercourse.** The determination of the bed characteristics, as a component of the hydromorphological monitoring process, also includes the determination of the presence of potential artificial solid materials in the bed, which have caused a change in the composition and structure of the natural bed sediment.

Floodplain (alluvial plain, inundation area) – an area that extends laterally along a river, which is occasionally flooded or which used to be frequently flooded (before human intervention – regulation). Land use (in a natural floodplain) and the associated features identified on the observed section and water body, as the factors considered in the process of hydromorphological monitoring, are determined based on the qualitative and quantitative assessment of the presence of natural, or artificial land cover behind the riparian zone.

2.2 River Basin Management Plan

A river basin management plan (hereinafter referred to as "the RBMP") is a document that defines a programme of measures integrating the obligations arising from various EU directives on environmental protection. This approach greatly facilitates the communication with the stakeholders and the public in the public consultation phase, as it allows comprehensive consideration of water management issues and, as such, a comparison of the advantages and weaknesses of individual measures and activities in light of different interests, benefits and costs as well. In structuring the document, the logic and requirements laid down in the Water Act and the Water Framework Directive were followed.

From the aspect of hydrography, the territory of the Republic of Croatia belongs to the Adriatic Basin and the Black Sea Basin and, in accordance with the Water Act, it is further divided into two river basin districts, the Danube River Basin District and the Adriatic River Basin District. Other fundamental territorial water management units defined in the Water Act, besides river basin districts, include sub-basins, small basins and sectors established for the purpose of enabling effective operational organisation and implementation of water management measures at the local level (Figure 2.2.1).



↑ **FIGURE 2.2.1** *Territorial water management units on the territory of the Republic of Croatia*
(Source of information: RBMP 2016 – 2021, prepared by: Oikon Ltd.)

A RBMP is a programming document prepared for a period of six years. The purpose of the programme of measures defined in the RBMP is to achieve the environmental objectives established in the WFD (for surface waters, groundwaters, and the protected areas). The WFD, however, provides for the possibility that there may be situations in which it will not be possible to achieve the established environmental objectives, or in which the status of a groundwater and/or surface water body will deteriorate. In such cases, certain conditions must be met in order to allow execution of new projects or undertaking of new anthropogenic activities in the field of sustainable development. More specifically, when planning new anthropogenic activities at a particular site, all steps must be taken to mitigate the negative effect of such activities on the status of the water body affected, the planned activities must have significant beneficial consequences for human health, safety and sustainable development, or they must be of overriding public interest, and it must be ascertained that no significantly better ecological options with costs proportionate to those of the planned activity or project exist. The reasons for modifying or altering a water body in consequence of new anthropogenic activities must be explained in the relevant RBMP, while the environmental objectives must be reviewed every six years. A RBMP must also contain a specification of the measures aimed at controlling and mitigating the hydromorphological pressures on the water bodies covered, and additional measures for protected areas where maintenance or improvement of the status of water is an important factor in protection of species and habitats, in particular:

- measures aimed at mitigating the hydromorphological impacts of new projects/ pressures,
- measures aimed at mitigating the hydromorphological impacts of existing hydromorphological pressures,
- measures aimed at mitigating the impacts of hydromorphological pressures occurring as a result of **regular watercourse maintenance**, including conservation and recovery of biodiversity as well as of target species and habitat types of the Natura 2000 ecological network.

2.2.1 Hydromorphological pressures affecting waters and hydromorphological monitoring

The hydromorphological pressures affecting waters are tracked through the monitoring of the hydromorphological status based on the parameters indicative of the hydrological regime, river continuity and the morphological conditions characteristic to a particular water body.

In most cases, the hydromorphological pressures affecting watercourses are a result of construction and use of the infrastructure required to perform various activities, such as agriculture, hydropower production, flood protection, and internal navigation. Less often, these pressures are a result of construction and use of the water supply and sewerage infrastructure.

The information about the hydromorphological pressures affecting waters are collected

in the lists and registers maintained by the owners/managers of water management structures/infrastructure, i.e. facilities and systems. The most important collections of information of this kind (according to the RBMP 2016 – 2021) are as follows:

- information about **water regulation and protection structures, drainage improvement structures and flood protection systems**, which is collected by the local and regional organisational units of Croatian Waters, the national water management company, and stored in the Water Information System,
- information about the **structures that form part of hydropower systems** managed by HEP, the national electric power company
- information about the **inland waterways** managed by the Directorate for Inland Navigation of the Ministry of the Sea, Transport and Infrastructure.

Other water structures and infrastructure facilities and systems are mainly owned by the local and regional self-government (irrigation structures) and providers of water services (water intake structures, public sewage outlets).

The above-mentioned information refers to different physical structures introduced into an aquatic system that affect the morphological and/or hydrological characteristics of the water body concerned. The completeness and reliability (i.e. integrity) of the information collected for different sections of individual river basin districts differ depending on the manner in which the records are kept.

Depending on the predominant type of hydromorphological changes they cause, information is collected for the following **three groups of hydromorphological pressures:**

(1) PHYSICAL CHANGES ALONG THE BED, BANKS AND THE FLOODPLAIN

Linear water management structures and activities (embankments, bank reinforcement and stabilisation, lining of the slopes and bottom of the bed with rock or concrete, channelization and deepening of the river-

↘ FIGURE 2.2.2
A linear structure in the streambed (Čedanj Stream)
(Source: Elektroprojekt JSC)

bed, and similar) lead to the loss of natural variations in the width and depth of a river as well as in a number of physical habitat characteristics, substrate types, the flow, properties of the sedimentation and erosion processes, etc. As a result, specific aquatic habitats are lost. The structures and activities of this kind may also cause a disruption in the interaction between the aquatic and terrestrial habitats existing in a river valley, particularly in the floodplains that have an important role in terms of water infiltration and recharging of aquifers as well as in terms of erosion and sediment distribution and deposition, and similar. The changes in a river's longitudinal and transversal profiles often affect the river-groundwater connectivity.

(2) TRANSVERSE WATER STRUCTURES

The presence of transverse structures (dams, locks, weirs, steps, and similar) in a watercourse bed has significant ecological consequences considering that such structures prevent the natural flow of water and sediment as well as migration of aquatic organisms, which results in changes in habitat conditions and the structure of communities upstream and downstream of the barrier. Since many species greatly depend on different habitat characteristics, particularly for the purposes of reproduction, they must be free to move longitudinally.

↓ FIGURE 2.2.3
Transverse structure (Kašina Stream)
(Source: Oikon Ltd.)

(3) **STREAMFLOW DYNAMICS CONTROL** Streamflow dynamics control refers to those parts and sections of a watercourse that are exposed to sudden changes in flow dynamics (hydropeaking), reduced flow velocity, and other similar changes caused by various anthropogenic activities, which lead to significant changes in habitat conditions and may also lead to deterioration of the good water body status.

2.3 Natura 2000 Ecological Network

Natura 2000 is an ecological network established within the European Union comprising various sites important for the conservation of endangered species and habitat types. The purpose of the Natura 2000 ecological network is to preserve or restore the good status of more than a thousand endangered and rare species and approx. 230 natural and semi-natural habitat types (MESD 2021). Natura 2000 currently stretches over more than 18% of the EU's land area and more than 8% of the Union's marine territory, which makes it the largest coordinated network of protected areas (sites) in the world (EC 2021). It has been established on the basis of the following EU directives:

1. **Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (codified version) (OJ L 20, 26/01/2010)** (hereinafter referred to as "the Birds Directive"), and
1. **Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22/07/1992)** (hereinafter referred to as "the Habitats Directive").

The Birds Directive was adopted in 1979, and its goal is to protect all wild birds and their most important habitats across the EU. It restricts certain activities, such as keeping or selling wild birds, and introduces legal mechanisms to regulate other activities, such as hunting, in order to ensure their sustainability. The Directive requires that all EU Member States designate the areas considered most important for 194 endangered species and sub-species of birds and all migratory species of birds as Natura 2000 sites (more precisely, as Special Protection Areas – SPAs), most particularly the wetlands of international importance (MESD 2021; EC 2021). By the end of 2021, the EU sites designated as SPAs covered a total area of 832,080 sq. km, of which 527,569 sq. km land area and 304,511 sq. km marine area (EEA 2021).

In 1992, the EU adopted the Habitats Directive, introducing a number of measures aimed at protecting the European wild flora and fauna similar to those laid down in the Birds Directive yet excluding birds from its scope. More precisely, the Habitats Directive relates to 1000 species from other taxonomic groups (plants, mammals, reptiles, amphibians, fish, and certain groups of invertebrates) and more than 230 habitat types (including wetlands, grasslands, forests, marine habitats, and other habitat types). Based on 218 habitat types listed in Annex I and the species listed in Annex II of the Directive (including 294 animal and 449 plant species), the Member States propose to the European Commission the areas that should be considered for designation as Sites of Community Importance (SCIs). Such areas are called the proposed Sites of Community Importance (pSCI). Following evaluation and the approval process, the pSCIs are declared as Sites of Community Importance (SCIs). After establishing the necessary conservation measures, including, if need be, the preparation of appropriate management plans, such areas are declared as Special Areas of Conservation (SACs). To facilitate the evaluation and consideration of proposals submitted by different Member States in the wider European environmental context, the territory of the EU has been divided into nine biogeographical regions distinguished by vegetation, climate, topography, and geology.

The boundaries of those biographical regions have been defined in a manner that allows the monitoring of trends in the conservation status of particular species and habitats occurring in similar conditions across Europe, disregarding the national borders. More precisely, three biographical regions are identified on the territory of the Republic of Croatia, namely the Alpine, the Continental, and the Mediterranean (MESD 2021). By the end of 2021, the EU biogeographical regions, established in accordance with the Habitats Directive (comprising the pSCIs, SCIs and SACs), covered a total area of 945,785 sq. km (of which 590,131 sq. km land area and 355,654 sq. km marine area).

The purpose of managing the Natura 2000 ecological network is to maintain or improve the favourable conservation status of the target species and habitat types identified in a specific area. The concept of Natura 2000 does not preclude sustainable development. Quite the contrary, it supports it. More precisely, the idea is not to completely stop all development activities, but to set the standards whose implementation would make it possible to simultaneously pursue development and conserve biodiversity (MESD 2021).

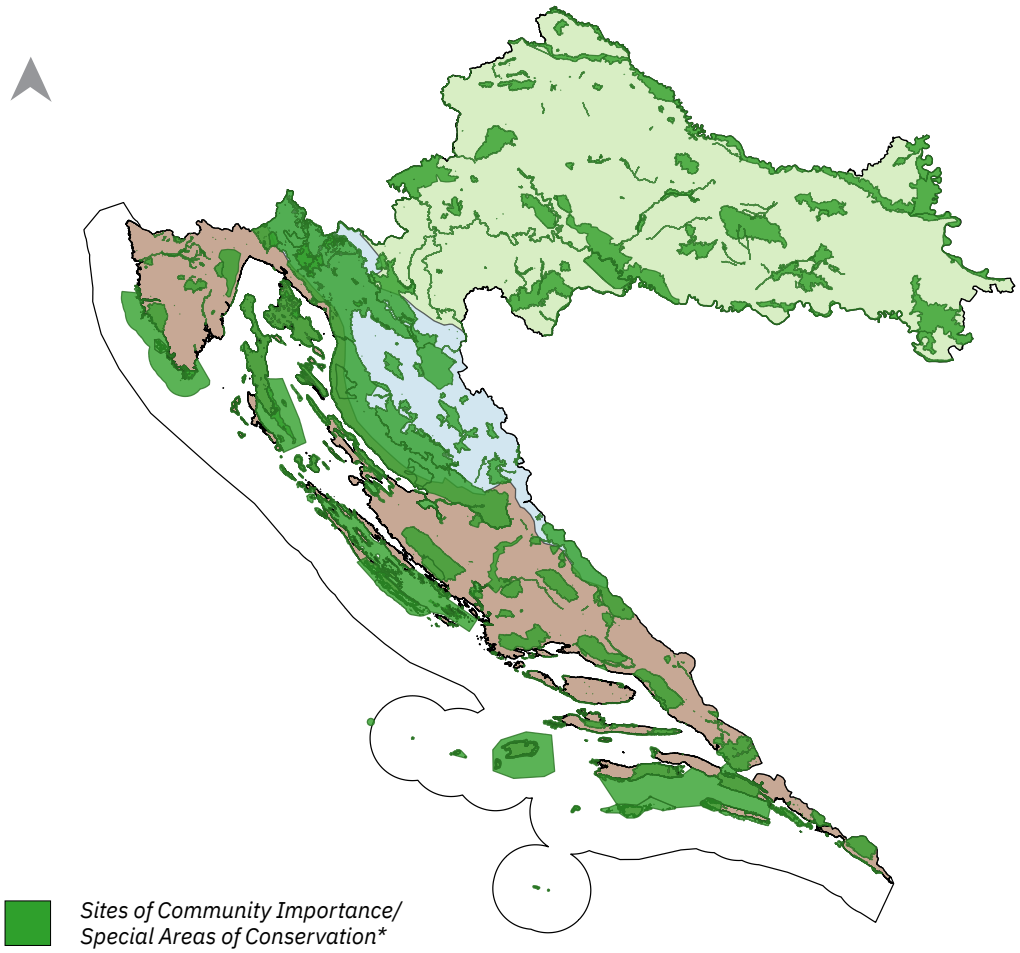
The **Natura 2000 ecological network sites on the territory of the Republic of Croatia** are defined by the Regulation on the Ecological Network and the Authority of Public Institutions for Managing the Ecological Network Sites (OG 80/19) (hereinafter referred to as "the Regulation"). An

overview of the Natura 2000 sites is available on http://bioportal.hr/gis/. The ecological network comprises the following types of areas/sites: Special Protection Areas – SPAs (locally known as areas of conservation important for birds, POP), Sites of Community Importance – SCIs (areas of conservation important for species and habitat types, POVS), proposed Sites of Community Importance – pSCIs (potential areas of conservation important for species and habitat types, vPOVS) and Special Areas of Conservation – SACs (special areas of conservation for species and habitat types, PPOVS). The ecological network sites cover 36.8% of the land area and 9.3% of the marine area of the Republic of Croatia, including 745 areas of conservation important for species and habitat types (pSCIs, SCIs and SACs) and 38 areas of conservation important for birds (SPAs). The conservation objectives and the associated conservation measures relating to areas of conservation important for birds and the rules that ensure correct implementation of the same are defined in the Rulebook on Conservation Objectives and Conservation Measures for Bird Target Species at Ecological Network Sites (OG No. 25/20, 38/20). The conservation objectives and the associated conservation measures relating to areas of conservation important for species and habitat types are defined in the Rulebook on Conservation Objectives and Conservation Measures for Target Species and Habitat Types at Ecological Network Sites (OG No. 111/2022).

Pursuant to the Nature Protection Act (OG No. 80/13, 15/18, 14/19, 127/19), the authority for managing the ecological network sites lies with the public institutions for managing the protected areas and ecological network sites. The Regulation defines the authority of public institutions to manage the ecological network and to adopt the associated ecological network management plans. The basic method for managing the sites forming part of the ecological network is the establishment and implementation of conservation measures designed for target species and habitat types integrated in site-specific management plans, natural resources management plans, and strictly protected species management plans. Conservation measures are also considered when undertaking projects that might affect the site-specific conservation objectives.

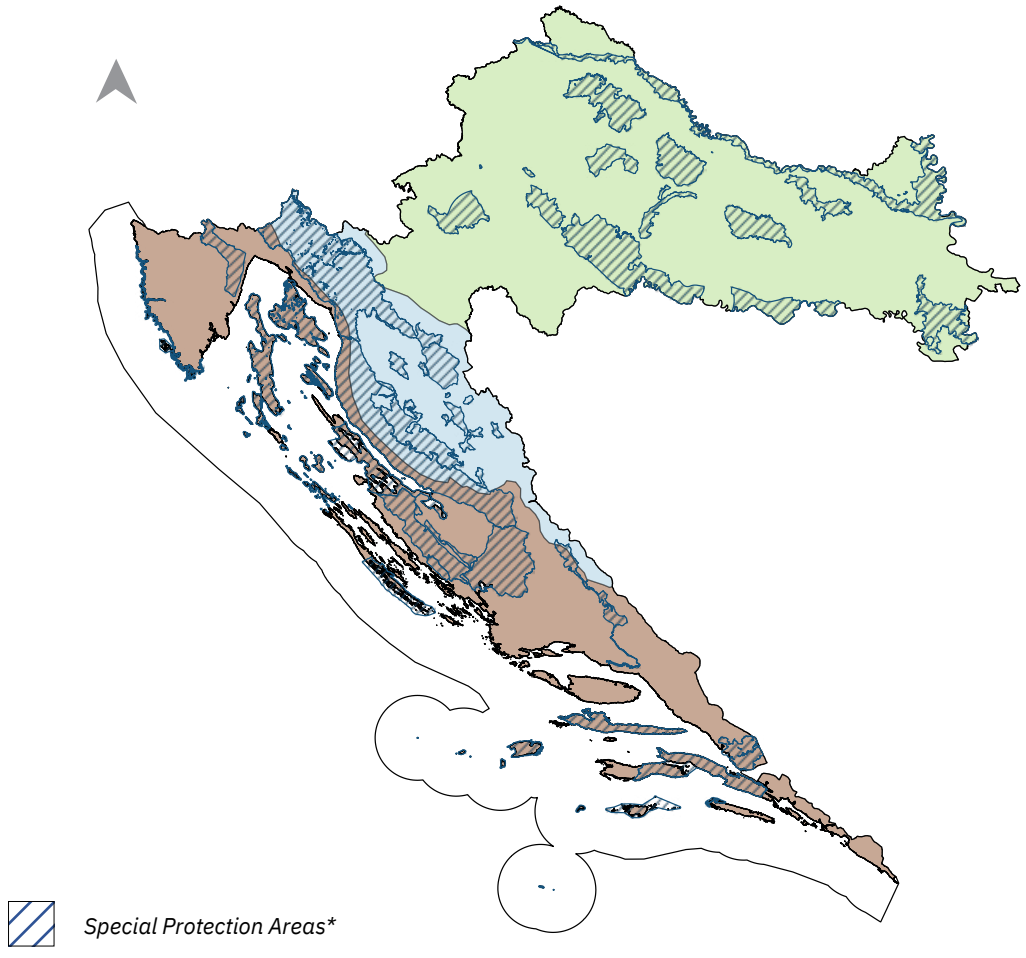
The most important mechanism applied to ensure protection of the Natura 2000 ecological network is the **appropriate assessment procedure** ("the assessment of acceptability of a plan/project considering its implications for the ecological network", OPEM). The purpose of this procedure is to assess the impact of strategies, plans, programmes and projects that might have a significant adverse effect on the established conservation objectives and the integrity of the ecological network. The appropriate assessment procedure consists of the following steps: the AA screening process ("the preliminary assessment of implications for the ecological network", PO), the appropriate assessment process ("the main assessment of implications for the ecological network", GO), imperative reasons

of overriding public interest (IROPI) that enable the negatively assessed project to proceed in the absence of alternatives and subject to compensatory measures. The objective of this procedure is to ensure sustainable use of natural resources, which entails conservation of biodiversity.



↑ FIGURE 2.3.1
Special water protection areas designated for the protection of species and habitats (locally: POVS)
(Source of information: MESD 2020, prepared by: Oikon Ltd.)

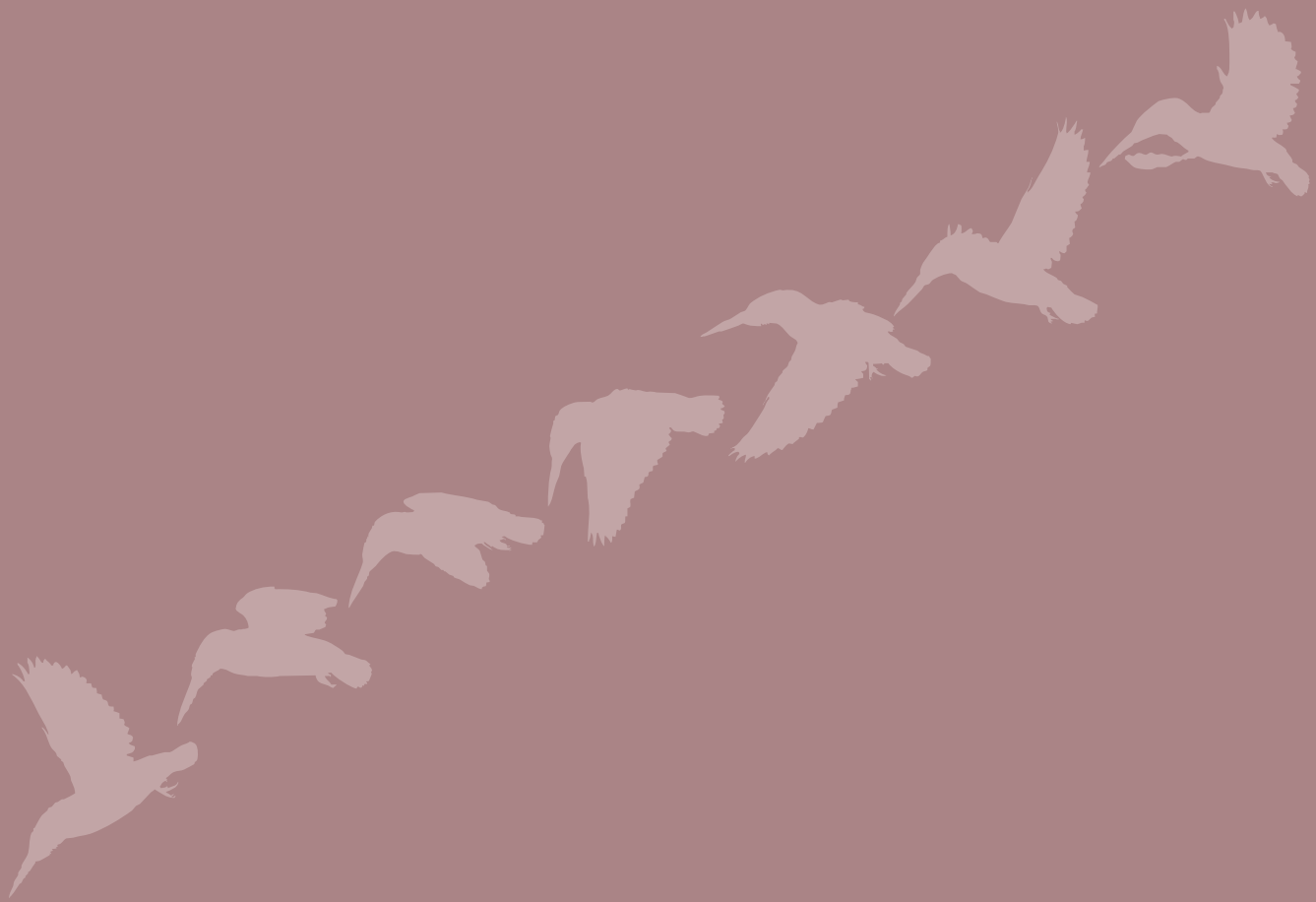
Furthermore, in accordance with the Water Act, certain areas are designated as **special water protection areas**. Such areas are designated for the protection of habitats or species where maintenance or improvement of the status of water is an important factor in their protection (Figure 2.3.1, Figure 2.3.2).



↑ **FIGURE 2.3.2**
Special water protection areas designated for the protection of species and habitats – Special protection area (locally: POP)
(Source of information: MESD 2020, prepared by: Oikon Ltd.)

Special water protection areas include the Natura 2000 ecological network sites important for the conservation of species and habitat types dependent on aquatic ecosystems. According to the current RBMP, the purpose of protecting aquatic environments is to ensure that additional quality standards and requirements regarding the conservation of special water protection areas, which are defined by special regulations, particularly the Nature Protection Act and the relevant subordinate legislation, are complied with. Special water protection areas are listed in the register of protected areas, an overview of which constitutes a mandatory section of a RBMP.

3 Programme of maintenance works aimed at ensuring protection from the harmful effects of water



Croatian Waters, the national water management company, is responsible for the management of waters in the Republic of Croatia. Among other, water management also involves the management of the risks associated with the harmful effects of water, including the water development activities. Within the meaning of the Water Act, water development refers to the construction of water regulation and protection structures, construction of basic drainage improvement structures and **water maintenance works undertaken for the purpose of ensuring a harmless water flow**.

The water maintenance programme comprises the water development activities undertaken for the purpose of water maintenance. Within the meaning of the regulation on simple structures and works, such activities are categorised as simple works. In accordance with the applicable nature protection regulations, **water maintenance programmes are subject to the appropriate assessment**, i.e. the implications of the programme for the ecological network must be assessed. The responsibility for conducting the appropriate assessment of a water maintenance programme as well as for establishing the related nature protection requirements lies with the central administrative authority competent for nature protection. The appropriate assessment of water maintenance programmes has been carried out, and the nature protection requirements have been established since 2012.

The water management and nature protection sectors started collaborating on water maintenance programmes in 2011. As part of the preparation for conducting an appropriate assessment of the then proposed water maintenance programme, a consultation process involving participants from the water management and nature protection sectors was conducted through a series of work meetings and workshops. The main outcome of this collaboration was the definition of standardised water maintenance works and freshwater ecosystem conservation measures, which are prescribed as nature protection requirements and whose purpose is to avoid the negative effects of regular water maintenance works on the ecological network, and biodiversity in general. Based on the consultations conducted with the water management sector and a number of examples of good practice, the then Ministry of Environmental and Nature Protection defined 70 standardised measures and recommendations for conservation of biodiversity in general for 11 groups of standardised works. The works relating to construction of new water and regulation structures and emergency response works were excluded from the water maintenance programme. The freshwater ecosystem conservation measures were defined based on the examples of good practice from the relevant literature and on the results of the collaboration and agreement between the two sectors. The European Commission recognized this approach as an example of good practice in undertaking the appropriate assessment of a programming document associated with the ecological network (Sabolić et al. 2019; Sundseth and Roth 2013; Sundseth K, ur. 2013).

The water maintenance programme is prepared for the entire territory of the Republic of Croatia, and covers 34 flood protection areas managed by six water management departments. Until 2019, the water maintenance programme was adopted annually and usually covered from 3000 to 5500 locations. In 2019, the water maintenance programme became a multi-year document prepared for a period of 4 years, which entailed a significant increase in the number of locations covered and the scope of maintenance works planned under the programme. Furthermore, as documents explaining the works and the prescribed nature protection requirements that should be complied with when executing the maintenance works programme, i.e. implementing the prescribed conservation measures, did not exist during this entire period (i.e. from 2012 until today), difficulties in terms of inconsistent interpretation and inappropriate implementation of the prescribed conservation measures occurred, which may potentially have an adverse effect on biodiversity and the ecological network. This, for example, refers to the interpretation of standardised works, the scope of such works and the manner in which they should be executed, the use of suitable mechanical equipment depending on the species present at the worksite, and the failure to establish more specific conservation measures depending on the type of the watercourse affected or the biogeographical region to which it belongs (Sabolić et al. 2019). As a result, the need for monitoring the effectiveness of the implementation of conservation measures and a more detailed elaboration and review of the system of standardised works and conservation measures and education of all stakeholders participating in the appropriate assessment of the programme, the planning and execution of maintenance works and the implementation and monitoring of conservation measures has been identified. In response to these needs, which are also supported by the *Analysis of the State of Nature in the Republic of Croatia for the period 2008 – 2021* (State Institute for Nature Protection 2014), *Monitoring the Effectiveness of Freshwater Ecosystem Conservation Measures and Handbook Preparation* was introduced as a component of the *Development of the Natura 2000 Management Framework project*. The said project component was planned and elaborated in detail and has resulted, among other, in the preparation of this Handbook.

3.1 Water Maintenance Activities

Water maintenance activities include the works that result in the achievement of reliable flood protection, favourable flow regime status and effective protection from the harmful effects of water in general, as they are undertaken for the purpose of maintaining or improving the stability of existing water management structures and ensuring or improving the continuity of water flow in riverbeds and floodplains (Šimundić 2008).

In accordance with Article 121 of the Water Act, water maintenance activities include the following:

1. **maintenance of natural and artificial watercourses and other waters:** cleaning and removal of sediment, earthworks and similar bank development and maintenance works, minor earthworks in floodplains, clearing and mowing of vegetation, maintaining the permeability of watercourse culverts and crossings,
2. **maintenance of water regulation and protection structures:** repair works on the embankment crest and slopes, clearing, mowing and works on the vegetative protection of water structures, repair of damaged parts of water structures,
3. **maintenance of basic drainage improvement structures:** cleaning, technical and vegetative maintenance of structures and the area adjacent to such structures, earthworks associated with small modifications to the canal network, maintenance of the drainage pipe outlet discharge
4. **maintenance of structures used to prevent and stop erosion, or to prevent the effects of torrential watercourses,**
5. **protection measures, i.e. establishing and cutting trees and other vegetation.**

Croatian Waters has standardised, i.e. typologised the descriptions and purposes of these activities in the context of regular water maintenance. Such standardised descriptions of activities distinguished by type are used in the preparation of water maintenance programmes in all organisational units of Croatian Waters involved in the preparation of such programmes and the associated activities.

A water maintenance programme encompasses maintenance works to be carried out on watercourses of the first and second order. The list of first-order waters, which includes interstate waters, coastal waters, other major waters and canals and powerful torrential watercourses, is determined by a decision of the Government of the Republic of Croatia (Decision on the List of Waters of the 1st Order, OG No. 79/2010). All other surface waters are classified as waters of the second order.

Water maintenance works are carried out on both natural and artificial watercourses (canals) as well as on retention basins or reservoirs found along such watercourses. Standardised works, depending on the types of activities included in different groups of such works, include the works carried out in the watercourse bed (including the bottom and the slope), in the adjacent floodplain, and at retention basin or reservoirs, where they exist. The programme also encompasses the works on embankments and other water structures or parts of such structures as well as on access and service routes.

According to the typology developed in 2011, water maintenance works were classified in 11 groups of activities. However, in order to ensure compliance with the requirements arising from the Water Framework Directive, Directive 2011/92/EU of the European Parliament and of the Council on the assessment of the effects of certain public and private projects on the environment and the Regulation on Environmental Impact Assessment (OG No. 61/14, 3/17), Annex 3: "2.2. Canals, embankments and other flood and bank erosion protection structures", all works involving construction of new small and simple regulation and water structures in watercourses and all emergency response works were excluded from the scope of the water maintenance programme in 2018. As a result, some of the standardised works from Group 9 (*Establishing the functional status of waters through renovation or construction of small and simple water and other types of structures*), i.e. works referring to new construction projects, and from Group 10 (*Establishing the necessary protection from adverse and progressive effects of erosion through construction of small and simple regulation structures in the watercourse bed*) were excluded from the water maintenance programme. To clarify, although these works referred to small-scale construction projects (e.g. construction of bank revetments up to 50 m in length), building a series of small-scale structures of the same type on a single water body creates the risk of a higher or potentially significant cumulative impact, which is why such construction projects are subject to both the EIA and AA procedures. The typology of water maintenance activities in effect since 2018 includes 9 groups of standardised works, as presented in the following table (Table 3.1.1).

TABLE 3.1.1 *Typology of water maintenance works in scope of the water maintenance programme*

NO.	GROUPS OF STANDARDISED WORKS IN SCOPE OF THE WATER MAINTENANCE PROGRAMME
1.	Waste removal
2.	Woody debris removal
3.	Sediment removal
4.	Removal of vegetation by mowing (of grass and/or sedge and/or reed) and/or by clearing (of small brush Ø < 5 cm and/or shrubs)
5.	Selective cutting of brush Ø > 5 and/or trees Ø >10 cm (with or without removal and disposal of stumps)
6.	Establishing vegetation by seeding and planting
7.	Maintenance, i.e. repair of damage to existing water and other types of structures without changing the dimensions of the structure(s) concerned
8.	Establishing protection from the harmful effects of erosion through renovation of regulation structures in watercourse beds (renovation of existing structures without changing the dimensions of the structure(s) concerned)
9.	Establishing the functional status of waters through renovation of small and simple water and other types of structures

Emergency response activities (Group 11 – *Establishing the functional status of waters and water structures during and/or immediately after floods – emergency response activities*), whose purpose is to prevent, either temporarily or permanently, the harmful effects of water in case of imminent danger to people's lives or property, are also excluded from the scope of a water maintenance programme. Emergency response activities are subject to the provisions of the Nature Protection Act (Article 8) and the Environmental Protection Act (Article 174).

The following works are also excluded from the scope of a water maintenance programme:

1. works that refer to distributaries and oxbow lakes, i.e. aquatic ecosystems of exceptional importance for nature protection (important fish spawning sites, bird nesting and feeding sites, shelters for numerous animal species, protected habitat types); it is necessary to elaborate management measures for such locations through management plans and, where necessary, also restoration plans;

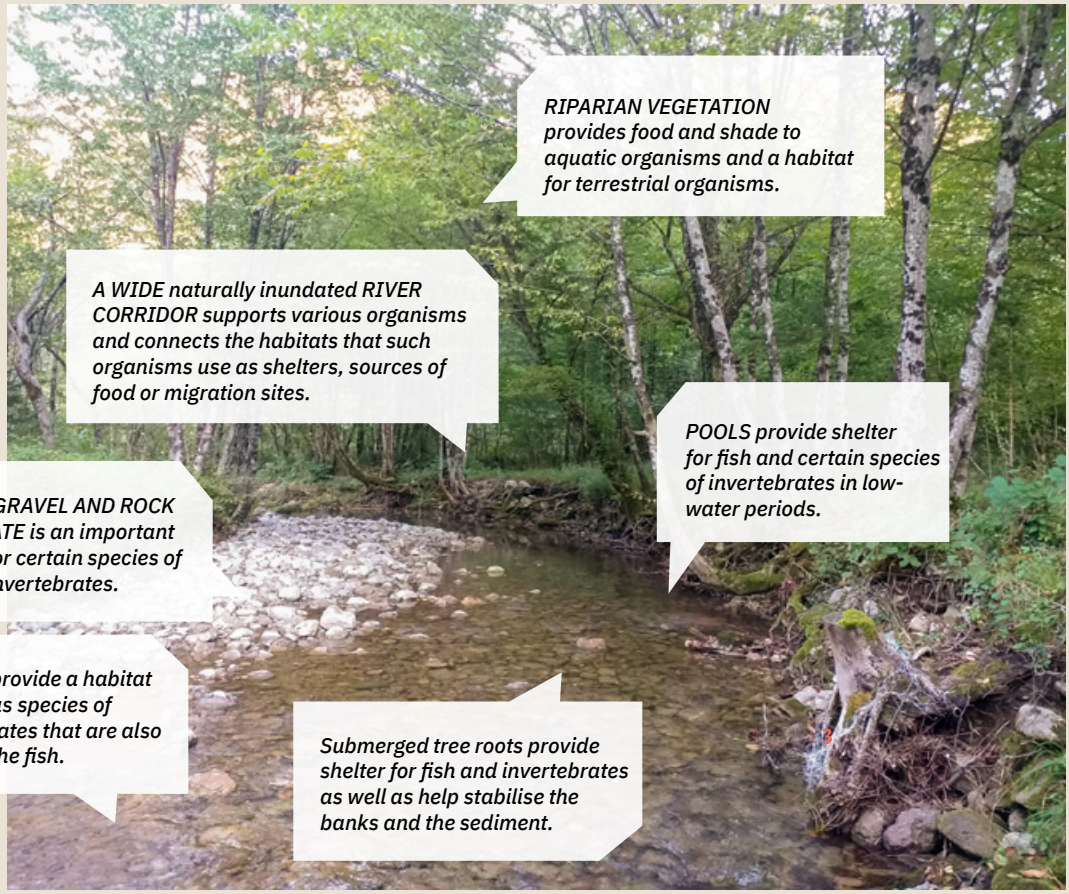
2. works on sites where the creeping marshwort (*Apium repens*) is present: the entire course of the Slunjčica and Lička Jesenica rivers (Danube RBD, PA 11: Kupa River watershed), the source of the Gacka River (Adriatic RBD, PA 25: Lika River watershed) and the source of the Rudnica stream (Tounjčica River tributary, Danube RBD, PA 11: Kupa River watershed).
3. works on sites near mire, bog and fen habitats, as such habitats are very sensitive and may be adversely affected by maintenance works (e.g. if such works cause changes in the hydrological regime); it is necessary to elaborate management measures for such locations through management plans and, where necessary, also restoration plans; this applies to all sites where mire, bog and fen habitat types are present (National Habitat Classification C.1.)

3.2 Breakdown of the System of Freshwater Ecosystem Conservation Measures by Standardised Works

The purpose of implementing conservation measures is to avoid, to the greatest extent possible, the negative effects of the execution of works on the wildlife living in and alongside watercourses, while also ensuring effective protection from the harmful effects of water.

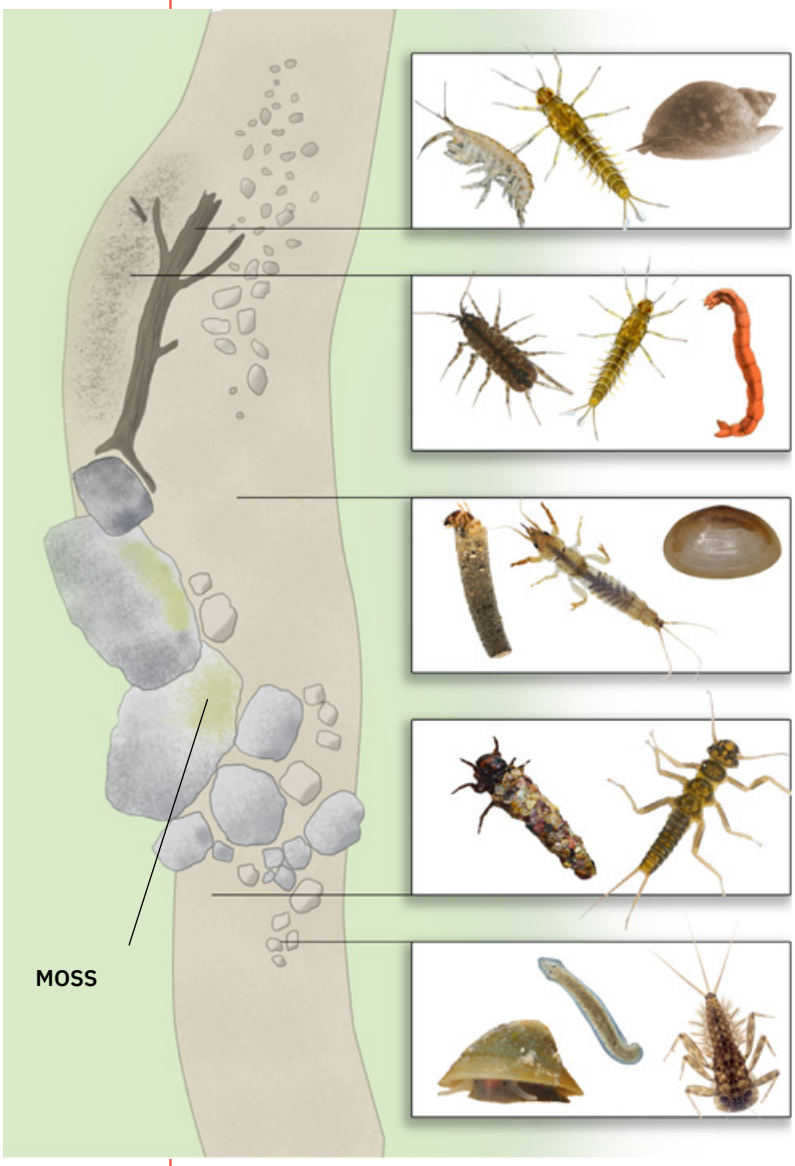
Proper implementation of conservation measures is necessary to sustain the biological and ecological functions of a watercourse, i.e. to sustain the functions of aquatic and the related terrestrial ecosystems, where the physical, chemical and ecological processes that take place in a natural river create a habitat mosaic (Figure 3.2.1) and favourable conditions for a large number of species (Figure 3.2.2), which has direct implications for the conservation of biodiversity.

Non-implementation or improper implementation of conservation measures when undertaking maintenance works on watercourses may have negative effects on the biodiversity of freshwater ecosystems as well as the related terrestrial ecosystems. For example, the riparian vegetation provides shelter to numerous terrestrial and aquatic organisms and overshades the water bodies (which helps reduce the risk of temperature extremes and evaporation as well as prevents the increase in primary production). Riparian vegetation also improves the quality of the water by retaining the sediment and preventing the washing out of soil particles, nutrients and pollutants from the adjacent areas, primarily agricultural land, while the roots of the vegetation helps stabilise the banks and the bed, thus reducing erosion and sedimentation (Lončar et al. 2017). Removal of the vegetation from the slopes and banks of watercourses and



↑ **FIGURE 3.2.1**
The processes that take place in a natural river create various (micro) habitats and favourable conditions for different groups of organisms (location: Mala Belica Stream)
(Source: author of the background photo – Matej Faller; illustration adjusted according to Addy et al. 2016)

canals without the implementation of appropriate conservation measures may lead to increased bank erosion, loss of microhabitats for animal species, increase in primary production, less shade and, consequently, also an increase in the temperature of water in the bed. Higher water temperature in the bed of a watercourse (according to Wilkerson et al. 2006, as provided in Shilla and Shilla 2012) results in reduced oxygen bearing capacity and increased rate of organic decomposition as well as affects the rate of release of nutrients from suspended sediments. Removal of the forest cover from the banks of watercourses also results in an increase in water temperature (according to Horwitz et al. (2008), as provided in Shilla and Shilla 2012), which causes a significant reduction in species biodiversity and the total number of benthic organisms.



LOGS

Snails (e.g. genus *Physa*)
Mayfly larvae (e.g. genus *Baetis*)
Amphipoda (e.g. genus *Gammarus*)

FINE DETRITUS

Bloodworms (e.g. genus *Chironomus*)
Mayfly larvae (e.g. genus *Baetis*)
Isopoda (e.g. species *Asellus aquaticus*)

SAND

Freshwater shellfish (e.g. genus *Pisidium*)
Mayfly larvae (e.g. genus *Ephemera*)
Caddisfly larvae (e.g. genus *Sericostoma*)

GRAVEL

Stonefly larvae (e.g. genus *Perlodes*)
Caddisfly larvae (e.g. genus *Silo*)

ROCK

Snails (e.g. genus *Ancylus*)
Mayfly larvae(e.g. genus *Ecdyonurus*)
Flatworms (class *Turbellaria*)

↑ FIGURE 3.2.2

The physical, chemical and ecological processes occurring in rivers result in the creation of a mosaic of (micro) habitats in an aquatic ecosystem. The figure shows a mosaic habitat of a small flowing watercourse and the typical aquatic species found on particular microhabitats.

(Authors: Elektroprojekt JSC and Matej Kopecki, according to: Bostelmann 2008)

The figures below show two different examples of poor practice in the execution of watercourse maintenance works (Figure 3.2.3, Figure 3.2.4).

→ FIGURE 3.2.3
An example of poor practice: the Bednja River after carrying out the activity of cutting woody vegetation without applying the selective cutting method and without implementing appropriate conservation measures.
(Source: Elektroprojekt JSC)

→ FIGURE 3.2.4
An example of poor practice: the Tomašica Stream after carrying out the standardised activity of removing vegetation by mowing grass and/or sedge and/or clearing small brush (with a diameter of) Ø < 5 cm without implementing appropriate conservation measures (i.e. the mowing was not carried out using proper mechanical equipment and, instead of carrying out the standardised activity of mowing, the watercourse was profiled)
(Source: Elektroprojekt JSC)

As previously described, the consultation process between the water management and nature protection sectors resulted in the definition of standardised works and freshwater ecosystem conservation measures, which are prescribed as nature protection requirements in the process of appropriate assessment with the aim of minimising the adverse effects of regular water maintenance activities on biodiversity. The relevant conservation measures are typologised and organised in a system by groups of standardised works.

The structure of the **system of conservation measures** follows the basic classification of standardised works. The previously described consultation process, which was conducted in 2011 for the purpose of assessing the then proposed water maintenance programme, resulted, among other, in the definition of conservation measures for different groups of standardised works with the objective to ensure conservation of freshwater habitats and favourable habitat conditions for all species associated with such habitats. In that context, a codebook of the established conservation measures was prepared as well, in which the measures are classified into seven different categories and correspondingly marked with letters "A." to "F.", and "P.". In addition to the work-specific measures that should be implemented when undertaking a particular standardised activity (marked with letters "A." to "E."), certain general measures (marked with letters "F." and "P."), which depend on the activity (works on a watercourse, canal, floodplain, retention basin/reservoir, embankment, water structure, torrential watercourse, etc.) and worksite in question, are specified for each group of standardised works as well. Depending on the nature of the worksite and presence of particular species and habitat types, the water maintenance programme may include certain special measures (marked with a star) prescribed in addition to the set of standard measures defined for a particular standardised activity.

For the purposes of this Handbook, the conservation measures implemented so far have been reviewed on the basis of the results of the consultations conducted with the stakeholders directly involved in the preparation and implementation of water maintenance programmes, the experience of the competent authorities in the field of nature protection and the results of the monitoring of effectiveness of freshwater ecosystem conservation measures. The objective was to provide a more detailed specification of:

1. characteristics of the water bodies covered by a particular water maintenance programme (geographic position, hydrographic features, etc.), and
2. characteristics of the species and habitat types affected by the planned water maintenance works.

4 Freshwater ecosystem conservation measures

This section gives an overview of the standard freshwater ecosystem conservation measures that are generally prescribed in connection with the execution of standardised water maintenance works. The standardised works excluded from the water maintenance programme (i.e. Groups 10 and 11 and some of the standardised activities from Group 9 that refer to new construction projects (building new structures); for more details see ***Section 3.1 Water Maintenance Activities***) are not included in the overview. Considering that conservation measures are prescribed as nature protection requirements, all the measures prescribed are binding, i.e. their implementation is mandatory.

Section 4.1 General Freshwater Ecosystem Conservation Measures gives an overview of the general conservation measures (marked with letters "F." and "P."), with the exception of the general measures prescribed with the aim of conserving the favourable status of habitats for watercourse-dependent species and other taxonomic groups of organisms.

In this Handbook, the conservation measures prescribed specifically in connection with the execution of standardised water maintenance works (***Section 4.2 Conservation Measures Prescribed in Connection with Standardised Water Maintenance Works***) are presented graphically (photos, illustrations) to show the proper manner in which standardised works should be executed in compliance with the prescribed conservation measures, with additional explanations. For certain conservation measures, both good and poor practice examples are provided.

The freshwater ecosystem conservation measures (including some of the general measures from Groups F. and P.), whose aim is to maintain or create favourable ecological conditions for freshwater organisms closely dependent on watercourses in terms of the relevant ecological functions, and the habitats which the watercourses provide, are explained in more detail in ***Section 4.3 Measures Aimed at Conserving the Favourable Habitat Conditions for Plant and Animal Species***. In addition to descriptions of specific conservation measures, the section also provides graphic presentations with the aim of helping the designers, contractors and supervising engineers understand and recognise the characteristics of the groups of organisms to which the conservation measures refer and the characteristics of their habitats.

Certain measures defined in connection with the standardised works which refer to mowing and cutting (i.e. measures from Groups B. and C.) are gradational in nature, in particular:

- B.2. – B.4. are prescribed in connection with the mowing of vegetation on the slopes, banks and the floodplain,
- B.8. – B.9. are prescribed in connection with the mowing of aquatic vegetation,
- C.1. – C.4. are prescribed in connection with selective cutting.

Although a full set of conservation measures from Groups B. or C. are prescribed in connection with the mowing or cutting works undertaken at a particular site, only such gradational measure (from those listed above) which is deemed suitable considering the conditions at the relevant worksite will be implemented. This approach is applied with the aim of complying with the flood protection requirements, while minimising the negative effects on biodiversity. The responsibility for deciding which measure will be implemented lies with the competent employees of Croatian Waters present on site and is made depending on the conditions at the site concerned (taking into consideration the type of the watercourse, flood protection risks, i.e. the need to ensure flow continuity, etc.). It is advisable to establish cooperation with experts from the competent public institution for the management of protected areas and ecological network sites (hereinafter referred to as "the PI") and, if deemed necessary and depending on the measures prescribed, visit the relevant sites before commencing the works in order to agree on the measure that should be implemented and the method of implementation that should be used.

4.1 General Freshwater Ecosystem Conservation Measures

4.1.1 General conservation measures

The general conservation measures are prescribed in connection with all or particular standardised works and depending on the location where the works are intended to be performed ("worksite") with the aim of reducing or preventing the impact on natural habitats (in particular, on endangered and rare habitat types, target habitat types included in the Natura 2000 ecological network, and the types of habitat deemed suitable for strictly protected species and target species identified at different Natura 2000 ecological network sites). General conservation measures are prescribed with the aim of limiting the scope of works to what is strictly necessary in order to achieve the purpose for which they are undertaken, i.e. to ensure protection from the harmful effects of water, while also preserving biodiversity. These measures also serve to ensure that the mechanical equipment (i.e. machinery and tools) used to execute the relevant works is such that causes minimum damage to the habitats and natural vegetation found within the work area and such that prevents the unnecessary damage to habitat types outside the work area and planned dimensions of works. The purpose of these measures is also to allow for and lay the foundations for supervision by inspection and PIs during the execution of works as well as to ensure prior communication and cooperation between those responsible for planning and undertaking the relevant works and the competent PIs.

The **general conservation measures include:**

1. measures aimed at preventing pollution of watercourses, the riparian zone, groundwaters and soil, and measures relating to the organisation of the work area and access to the worksite,
2. measures associated with the conservation of specific aquatic, wetland and marshland habitats,
3. measures aimed at ensuring that the works are scheduled taking into consideration the periods which are of key importance in the life cycle of the species dependent on aquatic habitats,
4. measures aimed at preventing the introduction and spread of invasive alien species, and
5. measures associated with the cooperation with the PIs and provision of information to competent institutions to allow inspection and supervision.

General Conservation Measures (F.)

F.1.* The appropriate assessment procedure is required.

→ *For more information regarding the implementation of this measure, see* ***Section 4.2.8 Procedure to be followed when implementing Measure F.1. and undertaking standardised works excluded from the water maintenance programme.***

* Measures prescribed with regard to specific sites where deemed necessary.

General Conservation Measures (F.)	
F.2.	No later than two weeks before commencing the works, or through delivery of an annual dynamic plan encompassing all works (subject, however, to the requirement of subsequent notification of any modifications), the nature protection inspection and the competent public institutions for the management of protected areas and ecological network sites must be informed about the planned works. Where necessary, the possibility of visiting the site(s) before, during and/or after the execution of works must be ensured.
F.3.	Photo documentation of the area before and after the works must be prepared and, upon request, delivered to the competent public institution, nature protection inspection and the Ministry.
F.4.	If strictly protected species and their dwellings are found (e.g. bird nests, homes of other animals (dens, lodges, holts, etc.), injured or dead specimens of strictly protected species), the works performed in the immediate vicinity of the place where they are found must be discontinued and the competent public institutions for the management of protected areas and ecological network sites, the nature protection inspection and the Ministry must be immediately notified of such circumstance. All further actions must be taken in consultation with the named institutions.
F.8.	All measures aimed at preventing watercourse pollution must be implemented. Where handling of oil, oil derivatives, other types of oils and lubricants is involved, it must be done at places situated at an appropriate distance from the watercourse, and appropriate precautionary measures must be applied.
F.9.	All maintenance works carried out in the watercourse bed must be performed in the upstream direction to avoid secondary disturbance and endangerment of the fauna moving downstream.
F.10.	Where possible, the works should be executed and mechanical equipment (machinery and tools) should be used in such manner that the bottom of the watercourse is minimally affected (e.g. by using floating dredgers, long reach arm hydraulic dredgers when mowing from the land, water mowers that do not touch the bottom when mowing from within the bed, or by undertaking manual mowing). → *For more information regarding the implementation of this measure, see* ***Annex 6.2. Proposed Mechanical Equipment for Undertaking Watercourse Maintenance Works****.*
F.13.*	With the aim of preserving the morphology and specific habitat conditions of the sea coastline zone, encroachment of working machinery on such area must be prevented.

General Conservation Measures (F.)

F.14.* With the aim of preserving the morphology and specific habitat conditions of areas where travertine barriers and waterfalls are found, encroachment of working machinery on such areas must be prevented.

F.24.* When undertaking works resulting in strips of bare soil on canal slopes and the floodplain, revegetation of exposed areas should be stimulated through seeding and planting. Where trees are planted, care should be taken that only the species native to the regional area are used.

→ *For more information regarding the implementation of this measure, see* ***Annex 6.2. Proposed Mechanical Equipment for Undertaking Watercourse Maintenance Works.***

F.34.* When undertaking works, the mechanical equipment manoeuvring area should be limited as much as possible to the access area and the narrow work area where strictly necessary.

F.35.* When undertaking works, the hydrological regime of the surrounding wet habitats must not be disturbed.

F.36.* A 2 m wide vegetation strip should be left along the watercourse bed, provided the public water domain is wide enough. If not, the strip should be as wide as possible.

→ *For more information regarding the implementation of this measure, see* ***Section 4.2.4 Removal of vegetation by mowing (grass and/or sedge and/or reed) and/or clearing (small brush Ø < 5 cm and/or shrubs)***

F.38.* The works should be performed without the use of heavy mechanical equipment/machinery (e.g. only a handsaw, chainsaw, and similar should be used).

F.39.* The works should be undertaken only during dry periods when the watercourse bed is completely dry. Any remaining pools should be left undisturbed.

F.40.* Before commencing the relevant works, the competent public institution for the management of protected areas and ecological network sites must be notified, and the works should be undertaken in consultation/cooperation with the relevant competent public institution and, where necessary, a joint visit to the site should be organised.

F.41. Removal of woody vegetation for the purpose of enabling the crew and the necessary mechanical equipment to reach the watercourse should be minimised. Whenever possible, it should be ensured that the existing access routes are used for this purpose.

* Measures prescribed with regard to specific sites where deemed necessary.

General Conservation Measures (F.)

F.42. If woody vegetation is removed and/or a new access route is built for the purpose of enabling the execution of the relevant works, it must be ensured that, after the works are completed, the affected areas are rehabilitated, i.e. that the access routes are removed and that seedlings of woody species native to the regional area are planted, or that natural revegetation is made possible.

4.1.2 General measures aimed at maintaining the favourable conservation status of natural habitats

The general measures aimed at maintaining the favourable conservation status of natural habitats (conservation measures from Group P.) are prescribed in connection with all standardised works, but also depending on the site where maintenance is to be performed. The purpose of these measures is to conserve the favourable habitat conditions and prevent the disturbance, injury and killing of different species alongside watercourses.

The **general measures aimed at maintaining the favourable conservation status of natural habitats include:**

1. measures determining the manner in which particular standardised works should be carried out, e.g. Measures P.1. – P.6., which are prescribed primarily in connection with the standardised works referring to mowing (although they may also be prescribed for some other standardised works, depending on the specific circumstances of a particular site),
2. measures defining the periods of the year when water maintenance works should (or rather should not) be carried out in order to avoid undertaking of works in the periods when individual taxonomic groups (e.g. amphibians and birds) are most sensitive,
3. additional measures aimed at conserving the favourable habitats for certain taxonomic groups (e.g. butterflies, amphibians, birds).

General measures aimed at maintaining the favourable conservation status of natural habitats (P.)

P.1. Mowing should be carried out later in the year, i.e. in the period after the 15th of August to ensure that grassland bird species can nest freely and that the life cycles of grassland vegetation, butterflies and the grassland fauna in general can proceed normally.

P.2. In addition to the mandatory implementation of Measure B.2., if the floodplain is wide enough, a 10 m wide stretch of riparian vegetation should be left intact (unmown/uncut) along each bank.

General measures aimed at maintaining the favourable conservation status of natural habitats (P.)

P.3. When mowing, the highest possible cutting height should be set (at least 8 cm from the ground).

P.4. The vegetation cuttings should be left on the ground for a few days to keep the animals sheltered until they find a new suitable habitat in the surrounding area.

P.5. If two mowing (cutting) cycles are undertaken during one vegetative period, the mowing/clearing of a canal should not be carried out simultaneously on both banks, but alternately (e.g. one slope and bank should be mown during the first cycle and the other slope and bank during the second cycle). By doing so, the more firmly established vegetation is maintained at least on one bank during each mowing cycle.

P.6. In areas where it is not possible to leave a 2 m wide riparian vegetation strip intact (unmown/uncut), as the relevant land is privately owned, it should be arranged with the land owners, whenever possible, that either trees be planted, but only the species native to the regional area (alders, willows, and similar), and/or grass be sown on that stretch of land to help stabilise the slope and provide shadow over the watercourse.

P.7. The works should not be performed in the period from 1 March until 1 July because that is when the amphibians spawn.

↑ FIGURE 4.1.1
Spawn of the amphibians: ↖ left he yellow-bellied toad, Bombina variegata (Author: Ivona Burić) and ↗ right the agile frog, Rana dalmatina (Author: Boris Lauš)

P.9. The works in the watercourse bed should be carried out in the period from 15 August until 31 March to avoid disturbance during the nesting period of birds.

General measures aimed at maintaining the favourable conservation status of natural habitats (P.)

P.10. In cooperation with the relevant public institutions, it must be ensured that particularly important sections where prior inspection by professional ornithologists is needed are marked on the maps. This is necessary for the purpose of determining the location of the colonies and nests of strictly protected bird species, and to avoid subsequent suspension of works or potential disturbance, injury or killing of strictly protected species.

P.11. A strip of riparian vegetation along the watercourse at least 2 to 3 metres in width should be maintained in agricultural areas. Where such vegetation does not exist, the relevant stretch of land must be revegetated to prevent the washing out of nutrients and pollutants from agricultural areas and in doing so improve and preserve good water quality. Revegetation should be done by planting the species native to the regional area.

→ *For more information regarding the implementation of this measure, see* ***Section 4.2.6 Establishing vegetation by seeding and planting***

P.12. When undertaking the relevant works, manoeuvring with mechanical equipment across wet habitats is not permitted. All pools/ponds and standing waters found within or in the vicinity of the worksite must be preserved (e.g. old borrow pits).

(!) **Conservation measures P.1., P.2. i P.3.** cannot be implemented at the same site or watercourse section simultaneously with Measure B.7.

More precisely, in accordance with Measure B.7., at such sites/watercourse sections where stands of invasive alien plant species are found, the mowing (cutting) or clearing may, if necessary, be carried out several times a year.

The employees of Croatian Waters are nevertheless advised to consult with the PIs regarding the methods and dynamics of removing the stands of invasive alien plant species before commencing the relevant works.

4.2 Conservation Measures Prescribed in Connection with Standardised Water Maintenance Works

4.2.1 Waste removal

Purpose of implementing conservation measures when undertaking this type of standardised work: The standardised works from this group are undertaken for the purpose of regular maintenance to ensure proper development and cleaning of watercourses, floodplains, retention basins or reservoirs, and the continuity of the flow in the same, as well as to ensure the functioning and access to different water structures. From the aspect of nature protection, waste removal works are purposeful and desirable in their own right and therefore require no conservation measures. However, considering that waste removal works may entail the use of mechanical equipment (various types of machinery and tools) and the need to secure access of machinery to the watercourse, appropriate conservation measures, which are prescribed in exceptional cases for particular sensitive sites, are implemented to ensure that the works are undertaken in a manner that is least invasive and that guarantees minimum disturbance of the existing watercourse-dependent species and minimum damage to natural (micro) habitats..

TABLE 4.2.1 *Standardised works that refer to waste removal*

No.	Types of standardised regular maintenance works undertaken on first- and second-order waters, i.e. types of standardised flood prevention works	Freshwater Ecosystem Conservation Measures[1]
1.	Waste removal	
1.1.	Removal of waste from **watercourse beds**	No requirements or measures
1.2.	Removal of waste from **canals**	No requirements or measures
1.3.	Removal of waste from **floodplains**	No requirements or measures
1.4.	Removal of waste from **retention basins or reservoirs**	No requirements or measures
1.5.	Removal of waste from **embankments and/or areas adjacent to water structures**	No requirements or measures

[1] Depending on:
- the worksite (location where the works are performed),
- site sensitivity,
- potential presence of an endangered, strictly protected or target species or habitat type included in the Natura 2000 ecological network,

additional conservation measures, e.g. in connection with a particular species or habitat type, or the obligation to execute the standardised works in cooperation with the competent PI may be prescribed.

↑ FIGURE 4.2.1 *Large waste left alongside watercourses. Photo to the left: the Sava River floodplain downstream of Zagreb (Source: Oikon Ltd), photo to the right: Vranić Stream (Source: Elektroprojekt JSC)*

4.2.2 Woody debris removal

Woody debris refers to dead trees (logs), branches (sticks), and trees that are felled and laid down which can be transported by water through the riverbed. This group of standardised works **does not include removal of sediment** (see ***Section 4.2.3 Sediment removal***).

Purpose of implementing conservation measures when undertaking this type of standardised work: Deposition of dead trees (logs) and branches (sticks) in a watercourse is a result of natural processes, e.g. the effects of winds, aging of trees, and erosion. Small woody and plant material and organic detritus accumulate on the surface of large trees and branches. Such structures (accumulations) of dead woody material and detritus affect the morphology of the watercourse, i.e. they increase the microhabitat diversity by creating areas with variable water current/flow velocity. Watercourses abounding in woody debris have greater biodiversity and a richer ichtyofauna due to increased availability of suitable habitats (e.g. shelters from predators for the freshwater fauna, spawning and wintering sites for fish and other freshwater organisms) and accumulations of organic matter, an important source of food for invertebrates which are, in turn, an important source of food for fish (Siemens et al. 2009). Woody debris represents an important habitat for aquatic invertebrates, providing a place to hide (shelter), a source of food, a place to lay eggs, a place to latch onto, and similar (Siemens et al. 2009).

TABLE 4.2.2 *Standardised works that refer to woody debris removal and conservation measures prescribed in connection with such works*

No.	Types of standardised regular maintenance works undertaken on first- and second-order waters, i.e. types of standardised flood prevention works	Freshwater Ecosystem Conservation Measures[1]
2.	Woody debris removal	
2.1.	Removal of woody debris from **watercourse beds**	A.1., F.2., F.4., F.5., F.6., F.7., F.8., F.9., F.10., F.41., F.42.
2.2.	Removal of woody debris from **canals**	Bez uvjeta i MEASURE
2.3.	Removal of woody debris from **floodplains**	P.12., F.41., F.42.
2.4.	Removal of woody debris from **retention basins or reservoirs**	F.2., F.4., F.5., F.6., F.7., F.8., F.41., F.42.
2.5.	Removal of woody debris from **embankments**	Bez uvjeta i MEASURE
2.6.	Removal of woody debris **from water structures and/or areas adjacent to water structures**	F.41., F.42.

[1] Depending on:
- the worksite (location where the works are performed),
- site sensitivity,
- potential presence of an endangered, strictly protected or target species or habitat type included in the Natura 2000 ecological network,

additional conservation measures, e.g. in connection with a particular species or habitat type, or the obligation to execute the standardised works in cooperation with the competent PI may be prescribed.

↑ FIGURE 4.2.2 *Woody debris in the Žumberačka reka watercourse (Source: Elektroprojekt JSC)*

CONSERVATION MEASURES PRESCRIBED IN CONNECTION WITH THE GROUP OF STANDARDISED WORKS THAT REFER TO WOODY DEBRIS REMOVAL (A.)

MEASURE A.1.

Woody debris comprising dead wood (logs and sticks) and trees that are felled or laid down should be left in watercourses. If they obstruct the water flow, they should be either relocated or turned in the direction of the water flow. Woody debris should be removed from watercourses only if and where necessary to ensure flood protection.

← FIGURE 4.2.3
An example of the implementation of Measure A.1.: woody debris is removed only if and where necessary to ensure flood and infrastructure protection; the figure shows an accumulation of woody debris stuck against a column of a bridge
(Source: Oikon Ltd.)

(!) NOTES REGARDING THE IMPLEMENTATION OF MEASURE A.1.

If standardised work of this type is necessary, localised execution approach should be applied whenever possible, or execution should be limited to small stretches only.

When preparing a watercourse maintenance programme, next to each worksite named in it there should be an indication as to whether the execution will be localised or the removal of woody debris will be undertaken on small watercourse stretches.

The decision concerning the need to remove woody debris is made by the competent employee of Croatian Waters on site, depending on the site-specific circumstances (watercourse characteristics, flood protection risks).

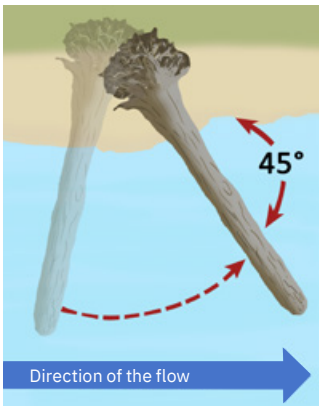
If they obstruct the water flow, woody debris (in particular, felled/fallen trees) should be t**urned in the direction of the flow**, ideally in parallel with the bank or at an angle in relation to the bank. The possibility of placing felled/fallen trees (logs) at an angle in relation to the bank depends on the type of the watercourse and its size. The recommended angle for large rivers (e.g. Sava River, Drava River, etc.) is 45°.

Where stable positioning of a log in a watercourse cannot be secured, due to its weight and shape structure, then the "anchoring" method should be used to stabilise it. Depending on the situation on site (the type and size of the watercourse, structure of the

banks and the bottom, flow volume, etc.), several methods can be used:

- logs can be fixed by steel wire rope slings onto various firm structures/objects found on the bank,
- logs can be fixed to the bank or the bottom by steel rods,
- logs can be fixed between the rocks inside the bed, if they exist,
- one end of a log can be buried in the bank,
- logs can also be fixed applying the "anchoring" method, i.e. by installing concrete anchors in the riverbed.

EXAMPLES OF GOOD PRACTICE: DIFFERENT WAYS OF PLACING AND FIXING DEAD TREES (LOGS) IN A WATERCOURSE BED



↑ FIGURE 4.2.4
Turning woody debris (a log) in the direction of the flow at an angle in relation to the bank (the recommended angle for large rivers, e.g. the Sava and Drava rivers, is 45°)
(Author: Matej Kopecki, according to: Macomb County Public Works Office, n.d.)

↑ FIGURE 4.2.5
An example of the practice of fixing logs using steel wire rope slings
(Source: Paulus 2015)

← FIGURE 4.2.6
Placing of logs at an angle in relation to the bank
(Source: Verein zur Revitalisierung der Haseauen e.V., website 2022)

→ *For more information regarding the implementation of measures prescribed in connection with the standardised works referring to woody debris removal and methods of placing and fixing logs in the bed, see* ***Section 5 Sources of Information.***

4.2.3 Sediment removal

Sediment refers to the particles formed as a result of erosion of the bed and banks of a watercourse or the particles washed into a watercourse from the adjacent land, which then form deposits in suitable locations along the watercourse. Two types of sediment are distinguished: 1) bed load sediment, which is dragged along the bottom of the riverbed, and 2) suspended sediment, which is found in the water column and flows together with the water. Sediment can include anything from fine-grained sand and silt with organic matter to small and large rocks (boulders).

Purpose of implementing conservation measures when undertaking this type of standardised work: Sediment particles are continually transported downstream by water. At some point, they begin to distribute and form sediment deposit at the bottom of watercourses, in river bends and in slow-flowing watercourse sections. The microhabitats created as a result of sediment deposition are important for the development of aquatic plant species as well as for aquatic invertebrates and fish that find a source of food or a place to lay eggs in/on sediment deposits. By removing sediment deposits (primarily referring to the surface layer), a microhabitat supporting numerous organisms and playing an important role in their development stages is lost. Furthermore, by removing sediment deposits, the part of the bottom covered with detritus, i.e. organic material with an important function in the food chain, is removed as well. The sand and gravel sediment deposits formed in the bed may be used as spawning sites or as habitat for invertebrates. Removal of sediment in one section of a watercourse affects the amount of sediment that will be transported downstream or deposited in the bed, on the banks or in bends. Reduction in sediment supply downstream prevents the formation of microhabitats necessary to support the plant and animal species that live in or on such (micro) habitats. If removal of sediment is undertaken for the purpose of bed profiling, the bed is often deepened, which may also result in the lowering of groundwater levels in the hinterland and adversely affect the vegetation and habitats hydrologically dependent on the water regime of the watercourses alongside which they are found.

TABLE 4.2.3 *Standardised works that refer to sediment removal, and conservation measures prescribed in connection with such works*

No.	Types of standardised regular water maintenance works undertaken on first- and second-order waters, i.e. types of standardised flood prevention works	Freshwater ecosystem Conservation Measures[1]
3.	Sediment removal	
3.1.	Removal of sediment from **watercourse beds**	A.2., F.2., F.3., F.4., F.5., F.6., F.7., F.8., F.9., F.10., F.41., F.42.
3.2.	Removal of sediment from **canals**	No requirements or measures

3.3.	Removal of sediment from **floodplains**	P.12., F.41., F.42.
3.4.	Removal of sediment from **torrential watercourse beds**	A.2., F.2., F.3., F.4., F.5., F.6., F.7., F.8., F.9., F.10., F.41., F.42.
3.5.	Removal of sediment from **retention basins or reservoirs**	A.2., F.2., F.4., F.5., F.6., F.7., F.8., F.41., F.42.
3.6.	Removal of sediment from **water structures and/or areas adjacent to water structures**	F.41., F.42.

[1] Depending on:
- the worksite (location where the works are performed),
- site sensitivity,
- potential presence of an endangered, strictly protected or target species or habitat type included in the Natura 2000 ecological network,

additional conservation measures, e.g. in connection with a particular species or habitat type, or the obligation to execute the standardised works in cooperation with the competent PI may be prescribed.

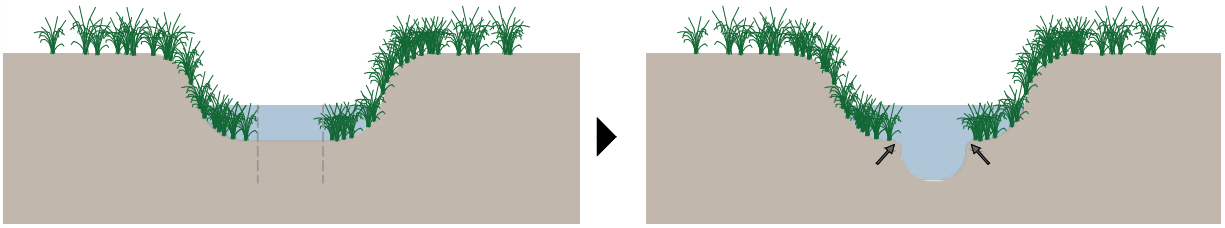
CONSERVATION MEASURES PRESCRIBED FOR THE GROUP OF STANDARDISED WORKS THAT REFER TO SEDIMENT REMOVAL (A.)

MEASURE A.2.

Sediment may be removed only if and where necessary, i.e. sporadically on such watercourse sections where it obstructs the flow and thus presents a risk of harm to the health and property of people. Otherwise, the bed should be left in its natural state.

← FIGURE 4.2.7 *An example of the implementation of Measure A.2.: sediment is removed only if and where necessary, i.e. where it obstructs the flow and thus presents the risk of harm to the health and property of people; sediment deposits found next to a bridge may increase the risk of flooding*
(Source: Scottish Environment Protection Agency 2010)

MEASURE A.2.



REMOVING THE SEDIMENT ALONG THE CENTRAL BED LINE

A LATERAL ELEVATION IS FORMED IN THE BED THAT HELPS PRESERVE AQUATIC HABITATS AND BANK VEGETATION

↑ FIGURE 4.2.8 *An example of good practice in removing sediment from artificial watercourses (canals)*
(Author: Beatrica Perkec, according to: Scottish Environment Protection Agency 2009)

→ *For more information regarding the implementation of the conservation measure prescribed in connection with the standardised works referring to sediment removal, see* ***Section 5 Sources of Information.***.

(!) NOTES REGARDING THE IMPLEMENTATION OF MEASURE A.2.

The decision concerning the need to remove sediment is made by the competent employee of Croatian Waters on site, depending on the site-specific circumstances (watercourse characteristics, flood protection risks).

When preparing a watercourse maintenance programme, next to each worksite named in the programme there should be an indication:

- as to whether the execution will be localised or the removal of sediment will be undertaken on small longitudinal water-course stretches, and
- in the case of temporarily flowing torrential

When undertaking activities from this group of standardised works, in order to assess the magnitude and significance of impact as well as to define appropriate freshwater ecosystem conservation measures, it is necessary to:

- define the quantity of the sediment that will be removed,
- specify as precisely as possible the exact locations and length of the stretch from which sediment will be removed, and
- specify the locations where the removed sediment will be disposed.

When removing sediment, care must be taken that the very bottom of the watercourse bed is not encroached upon. To ensure that this requirement is complied with, Measure F.10. is prescribed. In accordance with this measure, the works should be executed in such manner that the bottom of the watercourse is minimally affected (e.g. by using floating dredgers, long reach arm hydraulic dredgers when mowing from the land, water mowers that do not touch the bottom when mowing from within the bed, or by undertaking manual mowing).

The removed sediment may not be deposited on the edges of the watercourse bed, as otherwise it would destroy the riparian and amphibious vegetation and potential habitats supporting certain terrestrial species.

When undertaking the relevant works, care must be taken to avoid the deepening of the watercourse and formation of steep slopes, i.e. the existing bed depth and the substrate on the bottom of the bed should be preserved, while the cross section of the watercourse should be widened without significant increases in slope, i.e. keeping the slope angles as small as possible. In doing so, the required flow (capacity) is ensured, the impact on biodiversity is reduced, and the lowering of groundwater levels in the hinterland and the negative effect on the surrounding habitats along the watercourse are avoided.

Due to the potential impact of sediment removal works on the animal species present at the worksite, measures from the group of general conservation measures aimed at minimising the impact of sediment removal and limiting the time during which such works may be performed in order to reduce the potential adverse effects on the populations of fish and other animal species are prescribed (e.g. Measures F.9.F.10., P.7.). More precisely, sediment removal may have the following consequences: loss of habitat, direct harm (injury or death) to adult specimens or specimens in different development stages (fish eggs, fish larvae, insect larvae, molluscs, benthic fish species, spawn of amphibians) and loss of (key) habitats which certain endangered and strictly protected species use as their spawning, feeding, migration and nesting sites. Due to the associated bed deepening and slope profiling, removal of sediment from the bed of a watercourse may result in lowering of the water level, changes in hydrology and reduced humidity in hinterland habitats. It is precisely for this reason that a measure obligating the contractor to make sure that the execution of works will not adversely affect the hydrological regime of the surrounding area is prescribed. Taking into account that molluscs filter large quantities of water to be able to breathe and find food (i.e. to extract suspended food particles) (Riisgard and Larsen 2000), removing large quantities of fine sediment and silt when undertaking works may disturb the active process of filtration and have an adverse effect on their populations in the affected watercourse. Sediment removal works may also disrupt the spawning process or cause degradation of the spawning site (due to a large amount of suspended material) down-

stream of the work area. Fish eggs laid on a gravel-covered bottom are highly sensitive to silting, which may result from the large amounts of fine sediment causing a reduction in oxygen inflow (Guttmann 2015). Considering the said impact, Measure F.11. is also prescribed in connection with sediment removal works (see ***Section 4.3.3 Measures aimed at conserving the favourable habitat conditions for fish***).

If a wider area is considered, it should be noted that forests growing in watercourse basins serve to protect the land from erosion. By conserving the protective forests in watercourse basins, the washing out of the soil in periods of precipitation and the amount of sediment that may eventually reach the watercourse as a result are reduced. Implementation of erosion protection measures and execution of appropriate activities defined under the relevant river basin management plans, particularly conservation of protective forests, are of great importance.

4.2.4 Removal of vegetation by mowing (of grass and/or sedge and/or reed) and/or by clearing (of small brush Ø < 5 cm and/or shrubs)

Purpose of implementing conservation measures when undertaking this type of standardised work: The manner in which grassland vegetation, aquatic plants and marshland habitats extending along watercourses (banks and floodplains) and in the bed are maintained affects the structure of the vegetation and preservation of diversity of plant species and communities living next to watercourses, which provide a source of food and shelter to numerous animal species. In such habitats alongside watercourses insects, amphibians, small mammals and birds live and search for food. The vegetation that spends part of the year submerged in water and part above the water surface (the so-called "amphibious vegetation") must be conserved in its own right due to its specific nature as a type of vegetation, but also for the purpose of preserving the diversity of the microhabitats that it provides for invertebrates, fish, amphibians, and certain birds. Marshland plants growing along the banks of watercourses are part of the riparian zone, a transitional habitat between the terrestrial and aquatic environments, and have a role in preventing bank erosion and reducing the impact of diffuse pollution which may, for example, come from agricultural areas as a consequence of washing out of additive nutrients (such as mineral fertilisers) and pesticides, which cause water quality degradation. The conservation measures prescribed with regard to this type of standard works are aimed at ensuring protection of the natural riparian, aquatic and grassland vegetation in the floodplain as well as at enabling, by ensuring proper execution of the relevant works, conservation and restoration not only of the said vegetation, but also of the populations of animal species dependent on it.

By leaving certain stretches unmown and preserving the vegetation strip on the slopes and banks of watercourses, the process of succession and gradual establishment of the woody riparian vegetation is stimulated. In the long run and particularly on significantly regulated and highly modified watercourses, the newly established woody vegetation will provide shelter and shade, and thus contribute to the increase in the diversity of habitats within the riparian zone.

← FIGURE 4.2.9
Jasenova Canal – a site where the standardised brush mowing and cutting activities are planned; the purpose of implementing conservation measures in the execution of mowing works is to conserve the amphibious and riparian vegetation as much as possible
(Source: Udruga Hyla)

TABLE 4.2.4 *Standardised works that refer to removal of vegetation by mowing (of grass and/or sedge and/or reed) and/or by clearing (of small brush Ø < 5 cm and/or shrubs), and conservation measures prescribed in connection with such works*

No.	Types of standardised regular maintenance works undertaken on first- and second-order waters, i.e. types of standardised flood prevention works	Freshwater Ecosystem Conservation Measures[1]
4.	**Removal of vegetation by mowing (of grass and/or sedge and/or reed) and/or by clearing (of small brush Ø < 5 cm and/or shrubs)**	
4.1.	Removal of vegetation by mowing of grass and/or sedge and/or by clearing of small brush with a diameter of Ø < 5 cm and/or shrubs from the **crest, slope, shoulders and access ramps of embankments or earthfill dams**	No requirements or measures
4.2.	Removal of vegetation by mowing of grass and/or sedge and/or by clearing of small brush with a diameter of Ø < 5 cm and/or shrubs from **access routes to embankments and/or water structures**	No requirements or measures
4.3.	Removal of vegetation by mowing of grass and/or sedge and/or by clearing of small brush with a diameter of Ø < 5 cm and/or shrubs from **service routes running alongside embankments**	No requirements or measures
4.4.	Removal of vegetation by mowing of grass and/or sedge and/or reed and/or by clearing of small brush with a diameter of Ø < 5 cm and/or shrubs from **floodplains**	B.2., B.3., B.4., B.5., B.7., F.2., F.4., F.5., F.6., F.7., F.41., F.42., P.12., P.2., P.3., P.4, P.10., P.11.

No.	Types of standardised regular maintenance works undertaken on first- and second-order waters, i.e. types of standardised flood prevention works	Freshwater Ecosystem Conservation Measures[1]
4.5.	Removal of vegetation by mowing of grass and/or sedge and/or reed and/or by clearing of small brush with a diameter of Ø < 5 cm and/or shrubs from **the area adjacent to water structures**	F.2., F.4., F.5., F.6., F.7., F.8., F.41., F.42.
4.6.	Removal of vegetation by mowing of grass and/or sedge and/or reed and/or by clearing of small brush with a diameter of Ø < 5 cm and/or shrubs from **the bottom and/or slope of the watercourse bed**	B.1., B.2., B.3., B.5., B.7., B.8., B.9., B.10., F.2., F.4., F.5., F.6., F.7., F.8., F.9., F.10., F.41., F.42., P.3., P.6., P.10., P.11.
4.7.	Removal of vegetation by mowing of grass and/or sedge and/or reed and/or by clearing of small brush with a diameter of Ø < 5 cm and/or shrubs from **the bottom and/or slope of the canal bed**	F.2., F.41., F.42., P.3.

[1] Depending on:
- the worksite (location where the works are performed),
- site sensitivity,
- potential presence of an endangered, strictly protected or target species or habitat type included in the Natura 2000 ecological network,

additional conservation measures, e.g. in connection with a particular species or habitat type, or the obligation to execute the standardised works in cooperation with the competent PI may be prescribed.

To ensure proper implementation of conservation measures when undertaking mowing activities, the difference between mulching and mowing of grass must be explained and understood. **Mulching** (carried out using the so-called „mulchers“) refers to the cutting and grinding of vegetation to the ground level and leaving it as such on the surface to decompose. Depending on the power of the machine, the mulching method may also be used to cut and grind small brush and shrubs. **Mowing** is however performed using mowers, and the grass is cut to a certain height from the ground. Grass cuttings are collected either immediately or after they dry (hay). If grass cuttings are left on the ground or if the mulched particles are too big, they may block the sunlight and prevent moisture from penetrating the soil on which the grass grows, which results in the so-called “suffocation” (or drying out) of grassland vegetation. Finally, **if vegetation cuttings are left in a watercourse, the natural organic matter decomposition process will result in reduced concentration of oxygen diluted in the water,** which may lead to suffocation of fish and other aquatic fauna, and may also affect water quality. For more information regarding the mechanical equipment used to perform the mowing activities, see ***Annex 6.2 Proposed mechanical equipment for undertaking water maintenance works.***

↑ FIGURE 4.2.10 *An example of poor practice: vegetation growing along the watercourse mown with a mulcher, at some places even all the way to the ground (location: Gliboki Stream)*
(Author: Martina Šašić Kljajo)

↑ FIGURE 4.2.11 *An example of good practice: mowing with a sickle bar mower, thus ensuring the appropriate cutting height*
(Source: Briliant Ltd., website 2021)

CONSERVATION MEASURES PRESCRIBED IN CONNECTION WITH THE GROUP OF STANDARDISED WORKS THAT REFER TO REMOVAL OF VEGETATION BY MOWING (OF GRASS AND/OR SEDGE AND/OR REED) AND/OR BY CLEARING (OF SMALL BRUSH Ø < 5 CM AND/OR SHRUBS) (B.)

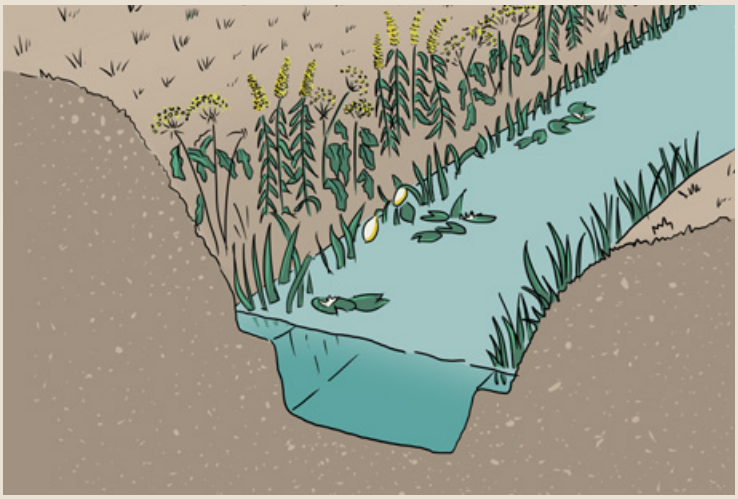
MEASURE B.1.

Amphibious vegetation (vegetation that spends part of the year submerged in water and part of the year above the water surface) should not be mown.

→ FIGURE 4.2.12
Amphibious vegetation – a water clower stand (Marsilea quadrifolia) (location: Gajna)
(Source: Institute for Environment and Nature, MESD)

MEASURE B.2.

A 2 m wide strip of riparian vegetation should be left unmown/uncleared on both sides of a watercourse. In the case of watercourses where a 2 m wide strip of riparian vegetation cannot be left and removal is necessary, care must be taken to ensure that such strip is as wide as possible considering the circumstances, and Measure B.3. should be implemented. In order to prevent the washing out of nutrients and pollutants, a 2 m wide strip of riparian vegetation should, whenever possible, be left between watercourses and agricultural land.



← FIGURE 4.2.13
An illustration of the implementation of Conservation Measure B.2.
(Author: Matej Kopecki, according to: Buisson et al. 2008)

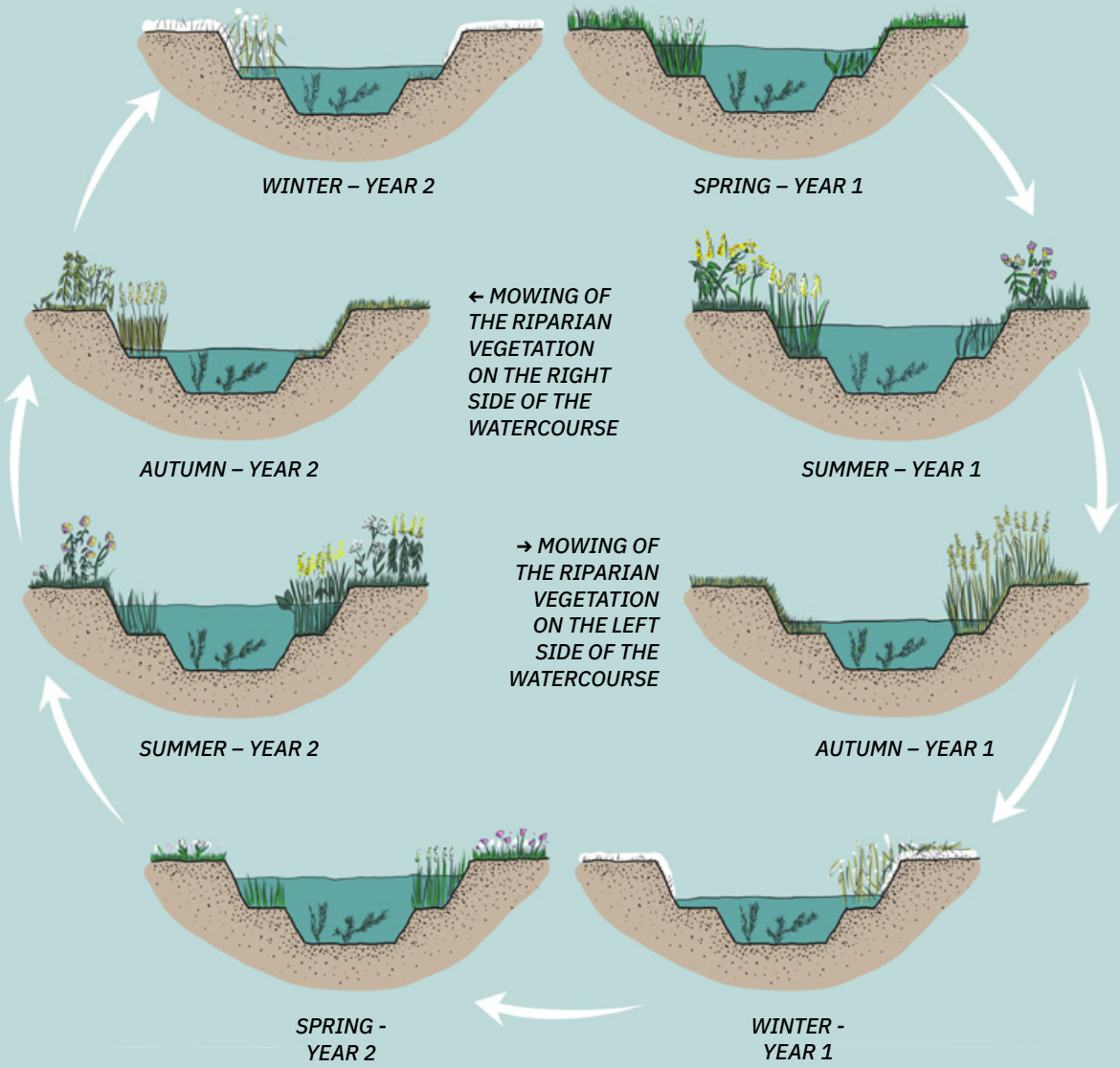
← FIGURE 4.2.14
An example of good practice in implementing Measure B.2., i.e. a strip of unmown riparian vegetation is left next to agricultural land to prevent the washing out of nutrients and pollutants (Tomašnica watercourse)
(Source: Elektroprojekt JSC)

↑ FIGURE 4.2.15
An example of good practice in implementing Measure B.2., i.e. an approximately 2 m wide strip of unmown and uncleared riparian vegetation is left (Zrmanja River)
(Source: Elektroprojekt J)

↑ FIGURE 4.2.16
An example of poor practice, i.e. failure to leave a 2 m wide strip of unmown riparian vegetation next to agricultural land to prevent the washing out of nutrients and pollutants (Subocka watercourse)
(Source: Oikon Ltd.)

MEASURE B.3.

If both riparian and amphibious vegetation must be mown on a particular section of a watercourse, the mowing carried out during a single vegetative period (i.e. a year) should be limited to one bank, while the vegetation on the other bank should be left intact. On the bank where the clearing of brush and shrubs is performed, care must be taken to avoid removing the firmly established shrubs as much as possible (as they contribute to bank stabilisation, provide shade, etc.).



↑ FIGURE 4.2.17 *An example of the implementation of Measure B.3. – a 2-year riparian vegetation maintenance cycle – mowing*
(Author: Matej Kopecki, according to: Buisson et al. 2008)

← FIGURE 4.2.18
An example of poor practice: failure to implement the rotational (mosaic) mowing method and to leave a strip of vegetation on the edge of the watercourse to provide shade over the bed and shelter
(Source: Elektroprojekt JSC)

MEASURE B.4.

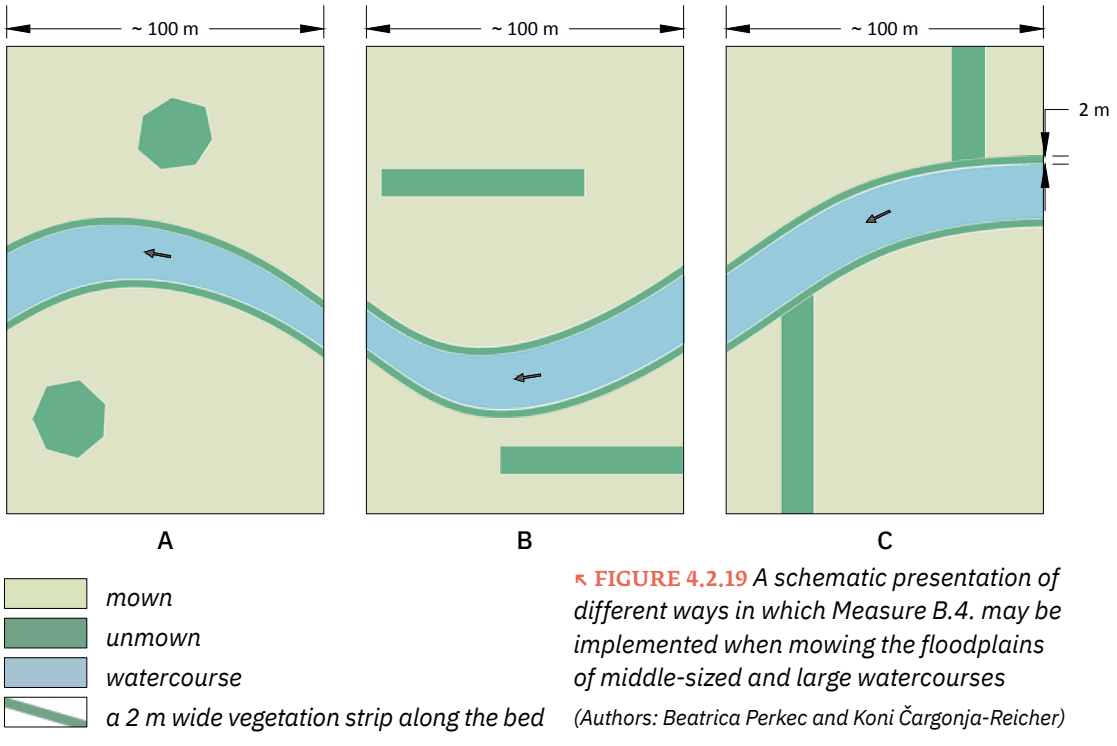
When mowing a section of a floodplain, rotational (mosaic) mowing and/or clearing method should be applied, i.e. different segments should be mown/cleared at different intervals. More precisely, it must be ensured that, at every 100 m stretch, approx. 10% of the vegetation-covered area (in the shape of small strips or patches) is left unmown/uncleared. During the next mowing cycle, those strips/patches should be mown/cleared, while some other 10% of the relevant 100 m stretch should be left intact. When undertaking clearing works, care must be taken that trees and well-established shrubs are preserved as much as possible.

(!) NOTES REGARDING THE IMPLEMENTATION OF MEASURE B.4.

Measure B.4. is implemented on middle-sized and large watercourses where the floodplain is wide enough to permit such approach.

A schematic presentation of different ways in which Measure B.4. may be implemented (Figure 4.2.19)

At every stretch of approx. 100 m in length that is mown, at least 10% of the area in the shape of patches (implementation method A) or short strips of vegetation should be left unmown. The selected strips may be either parallel (implementation method B) or perpendicular in relation to the bed (implementation method C). During the next mowing cycle, those patches/strips should be mown, while some other 10% of the relevant 100 m stretch should be left intact.



↖ FIGURE 4.2.19 *A schematic presentation of different ways in which Measure B.4. may be implemented when mowing the floodplains of middle-sized and large watercourses*

(Authors: Beatrica Perkec and Koni Čargonja-Reicher)

MEASURE B.5.

The mowing/clearing works in built-up urban settings and areas used for tourism or sporting and recreational purposes may, if needed, be undertaken several times a year. During each mowing/clearing cycle, at least 10% of the area, i.e. strips or patches of vegetation, should be left unmown/uncleared.

(!) NOTES REGARDING THE IMPLEMENTATION OF MEASURE B.5.

When preparing a watercourse maintenance programme, next to each worksite there should be an indication as to whether the relevant section of the watercourse is located within a built-up urban area or not. If that is the case, only and specifically Measure B.5. may be prescribed for such a site.

MEASURE B.7.

Measures B.1., B.2., B.3., B.4., and Measures P.1., P.2., P.3. do not refer to the mowing and clearing of stands of the common ragweed (*Ambrosia artemisiifolia*), japanese knotweed (*Reynoutria* spp.) or false indigo bushes (*Amorpha fruticosa*), or the stands of other invasive alien species that must, if needed, be mown/cleared several times a year. After the mowing/clearing works are completed, the cuttings must be properly disposed of.

→ *For more information regarding the implementation of this measure, see* ***Section 4.3.7 Measures aimed at preventing the introduction and spread of invasive alien species***

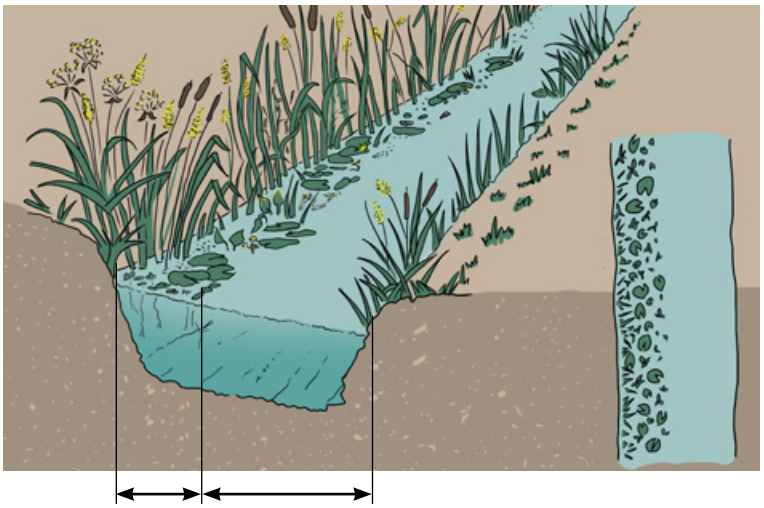
MEASURE B.8.

Aquatic vegetation should only be removed if the watercourse flow continuity is compromised and therefore presents a risk of harm to the health and property of people.

MEASURE B.9.

If mowing/clearing of aquatic vegetation in a particular section of the watercourse bed is necessary, such works should be undertaken on an area equal in size to no more than 2/3 of the watercourse width, while leaving the substrate and the aquatic and wetland vegetation growing along the banks intact. In exceptional cases, i.e. if it significantly obstructs the flow or disrupts the functioning of the pumping stations, removal of aquatic and wetland vegetation growing in the bed may be allowed. As regards channelised watercourses, the area within the bed should be mown in such manner so as to form sinusoidal (meandering) swaths.

→ FIGURE 4.2.20
An illustration of the implementation of Conservation Measure B.9.
(Author: Matej Kopecki, according to: Buisson et al. 2008)



→ FIGURE 4.2.21
An example of good practice in implementing Measure B.9.: a sinusoidal aquatic vegetation mowing pattern in channelised watercourses
(Source: Wasserverbandstag 2015)

MEASURE B.10.

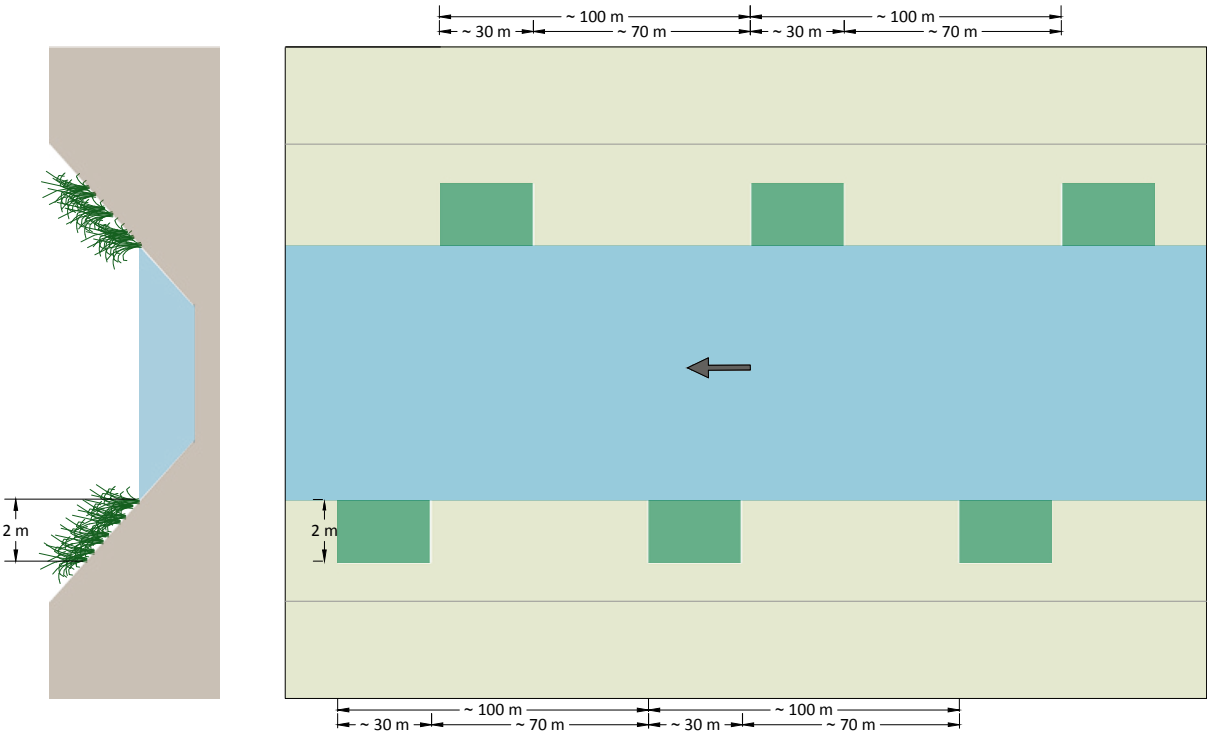
All vegetation clippings and cuttings left after mowing must be removed from the watercourses to prevent the lowering of oxygen levels in the water, or obstructions affecting downstream structures.

MEASURE B.11.*

If aquatic vegetation classified under *Habitat Type A.3.3.2 Rooted submerged communities of flowing waters* (alliance *Ranunculion fluitantis*) is established in the watercourse affected by the works, at least 1/3 – 1/2 of such vegetation should be left intact across the watercourse width.

MEASURE B.12.*

In exceptional cases, when mowing of the riparian vegetation on both sides of a watercourse section is required, different segments should be mown at different intervals. Care should be taken that on each 100 m stretch of the relevant watercourse section at least 30% of the riparian vegetation, i.e. strips extending at least 2 m in width from the edge of the watercourse, is left unmown at all times.



↑ FIGURE 4.2.22
A schematic presentation of one of the ways in which Conservation Measure B.12. may be implemented
(Authors: Beatrica Perkec and Koni Čargonja-Reicher)

* Measures prescribed with regard to specific sites where deemed necessary.

4.2.5 Selective cutting of brush Ø > 5 cm and/or trees Ø > 10 cm (with or without the removal and disposal of stumps)

Purpose of implementing conservation measures when undertaking this type of standardised work: Riparian vegetation is established in the transitional area between water and land, on the slopes and banks (see Figure 2.1.1), where it creates a corridor for animals that live both on land and in the water. For example, otters build their holts inbetween the roots of woody riparian vegetation, bats rest and find shelter in the trees, and some bird species nest in the trees and shrubs found along the water. The network of roots also provides shelter and a place where invertebrates, amphibians and fish lay their eggs. The leaves and the insects falling off the riparian vegetation in the water provide food for the species living in the water. The woody material that originates from the riparian vegetation has a significant role in the watercourse as a source of food for invertebrates, and a potential shelter for fish and amphibians. The shadow created by the vegetation above the water provides shade to aquatic animals as well as ensures a normal level of oxygen in the water and prevents the establishment of algae. The roots also help reinforce the banks and prevent erosion. Finally, by maintaining the riparian vegetation, the favourable ecological conditions and diversity of species living in the riparian zone and in the watercourse are maintained as well.

TABLE 4.2.5 *Standardised works that refer to selective cutting of brush Ø > 5 cm and/or trees Ø > 10 cm (with or without removal and disposal of stumps), and the conservation measures prescribed in connection with such works*

No.	Types of standardised regular maintenance works undertaken on first- and second-order waters, i.e. types of standardised flood prevention works	Freshwater Ecosystem Conservation Measures[1]
5.	**Selective cutting of brush ø > 5 cm and or trees ø > 10 cm (with or without removal and disposal of stumps)**	
5.1.	5.1. Selective cutting of brush with a diameter of Ø > 5 cm and trees with a diameter of Ø > 10 cm in watercourse beds, and selective cutting of brush and trees on **the slopes and in the area alongside watercourse beds**, with or without removal and disposal of stumps	C.1., C.2., C.3., C.4., C.5., C.7., C.8., C.9., F.2., F.3., F.4., F.5., F.6., F.7., F.8., F.9., F.10., F.41., F.42., P.10., P.11.
5.2.	Selective cutting of brush with a diameter of Ø > 5 cm and trees with a dimeter of Ø > 10 cm in canal beds, and selective cutting of brush and trees **along canal beds**, with or without removal and disposal of stumps	F.41., F.42.

No.	Types of standardised regular maintenance works undertaken on first- and second-order waters, i.e. types of standardised flood prevention works	Freshwater Ecosystem Conservation Measures[1]
5.3.	Selective cutting of brush with a diameter of Ø > 5 cm and trees with a diameter of Ø > 10 cm **in floodplains**, with or without removal and disposal of stumps	C.1., C.2., C.3., C.4., C.5., C.7., C.8., C.9., F.2., F.3., F.4., F.5., F.6., F.7., F.8., F.41., F.42., P.12., P.10.
5.4.	Selective cutting of brush with a diameter of Ø > 5 cm and trees with a diameter of Ø > 10 cm **in retention basin areas**	C.4., C.5., C.7., C.8., C.9., F.41., F.42.
5.5.	Selective cutting of brush with a diameter of Ø > 5 cm and trees with a diameter of Ø > 10 cm in **torrential watercourse beds**, and selective cutting of brush and trees **on the slopes and in the area along torrential watercourse bed**s, with or without removal and disposal of stumps	temporary torrential watercourses: C.4., C.5., C.7., C.8., C.9., F.2., F.4., F.41., F.42.; torrential watercourses: C.1., C.2., C.3., C.4., C.5., C.7., C.8., C.9., F.2., F.3., F.4, F.5., F.6., F.7., F.8., F.9., F.10., F.41., F.42., P.10., P.11.
5.6.	Selective cutting of brush with a diameter of Ø > 5 cm and trees with a diameter of Ø > 10 cm **off of water structures and/or in areas adjacent to water structures**, with or without removal and disposal of stumps	F.41., F.42.

[1] Depending on:
- the worksite (location where the works are performed),
- site sensitivity,
- potential presence of an endangered, strictly protected or target species or habitat type included in the Natura 2000 ecological network,

additional conservation measures, e.g. in connection with a particular species or habitat type, or the obligation to execute the standardised works in cooperation with the competent PI may be prescribed.

CONSERVATION MEASURES PRESCRIBED IN CONNECTION WITH THE GROUP OF STANDARDISED WORKS THAT REFER TO SELECTIVE CUTTING OF BRUSH Ø > 5 cm AND/OR TREES Ø > 10 cm (WITH OR WITHOUT REMOVAL AND DISPOSAL OF STUMPS) (C.)

MEASURE C.1.

The trees and brush should be removed only if they obstruct the continuity of the watercourse flow to that extent that they cause a risk of harm to the health and property of people. Otherwise, the vegetation should be left in its natural state, intact.

MEASURE C.2.

Whenever possible, the required flow continuity should be ensured by removing the overhanging branches reaching the highest water level (the so-called "tunnel principle"), and individual trees obstructing the flow.

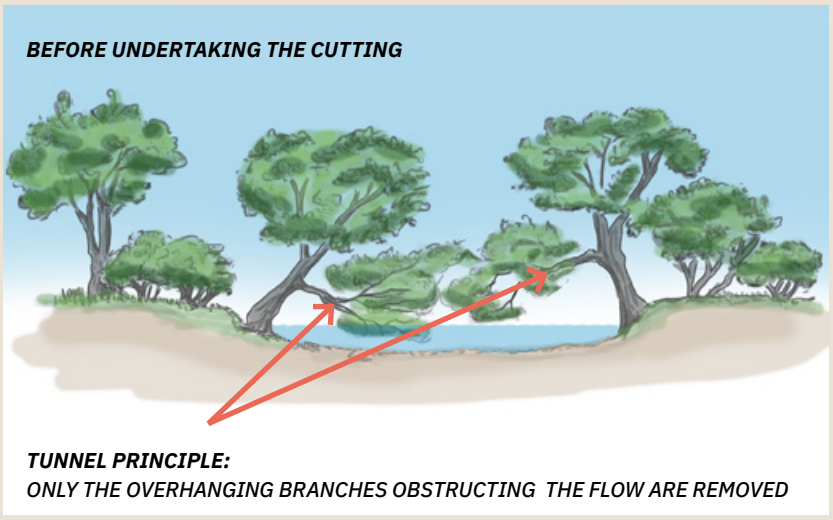


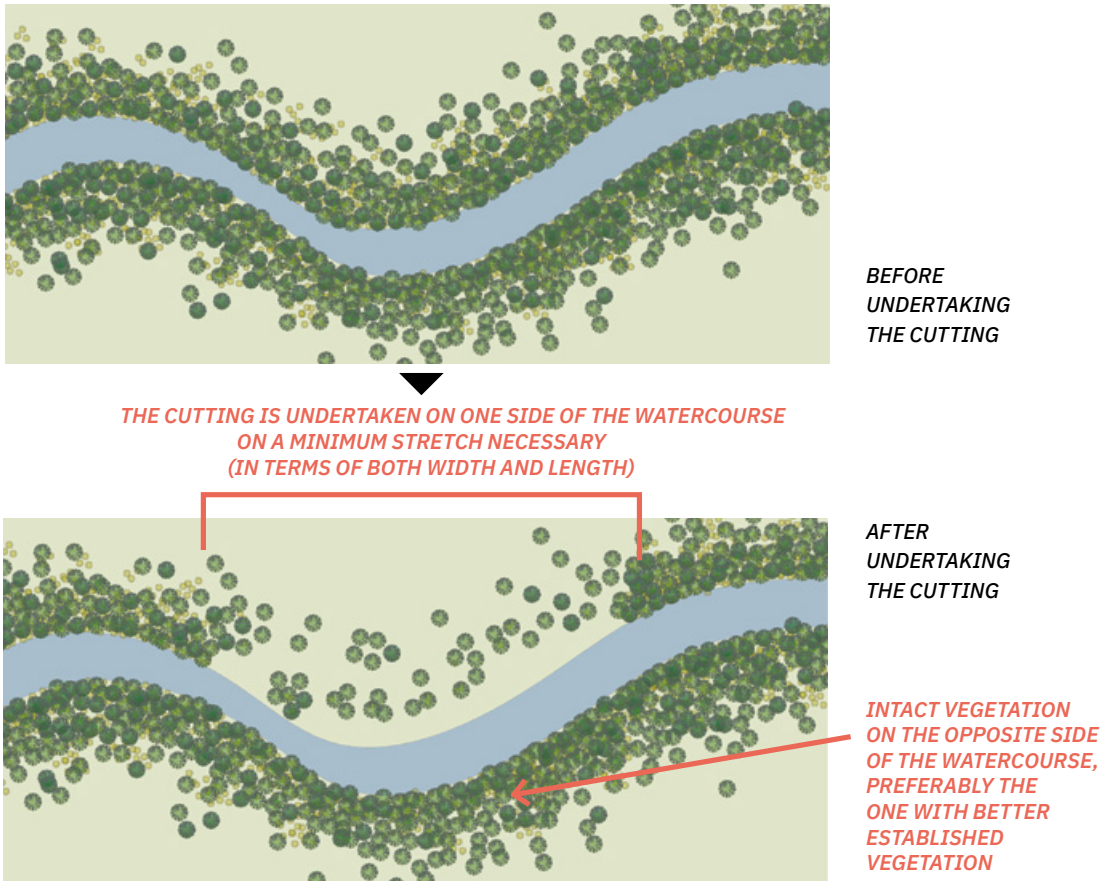
FIGURE 4.2.23
An illustration of the implementation of Conservation Measure C.2. (↖ up: condition before; ← left: condition after undertaking the selective cutting by implementing Measure C.2.)
(Author: Matej Kopecki, according to Derigon and Dechavann 2013)

MEASURE C.3.

If Measures C.1. and C.2. are not sufficient to ensure the required flow continuity, the trees and brush should be removed, but only on one side of the watercourse (i.e. the bank with less firmly established trees and brush), while the vegetation strip on the opposite bank should be left intact. Removal works should be undertaken only on such stretch which is limited in both length and width to what is minimally necessary to ensurethe required flow continuity, while the trees and brush which do not disrupt the flow should, whenever possible, be left intact in order to preserve some of the favourable habitats on that side (bank) of the watercourse as well.

(!) NOTES REGARDING THE IMPLEMENTATION OF MEASURE C.3.

The manner in which Measure C.3. will be implemented depends on the situation on site (watercourse characteristics, possibilities of accessing the watercourse and achieving flow continuity). The decision regarding the manner in which the measure will be implemented is made by the competent employee of Croatian Waters present on site.

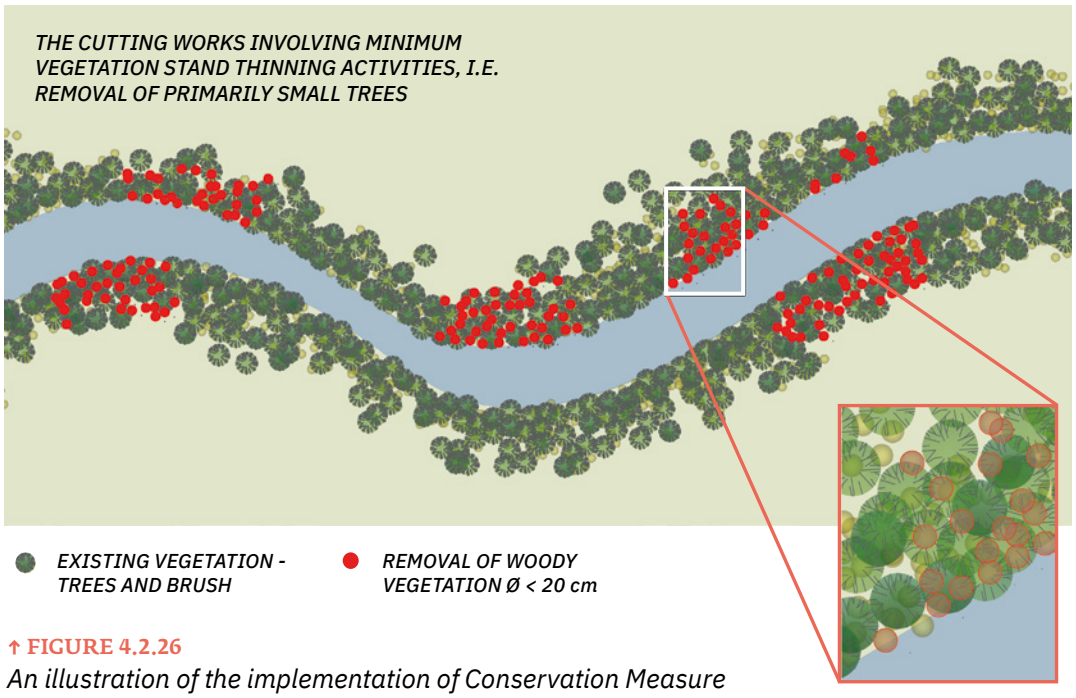


↑ FIGURE 4.2.24
An illustration of one of the ways in which Measure C.3. may be implemented, where selective cutting is undertaken on one side of the watercourse only, in strips which are as short as possible and minimally wide *(Authors: Beatrica Perkec and Koni Čargonja-Reicher)*

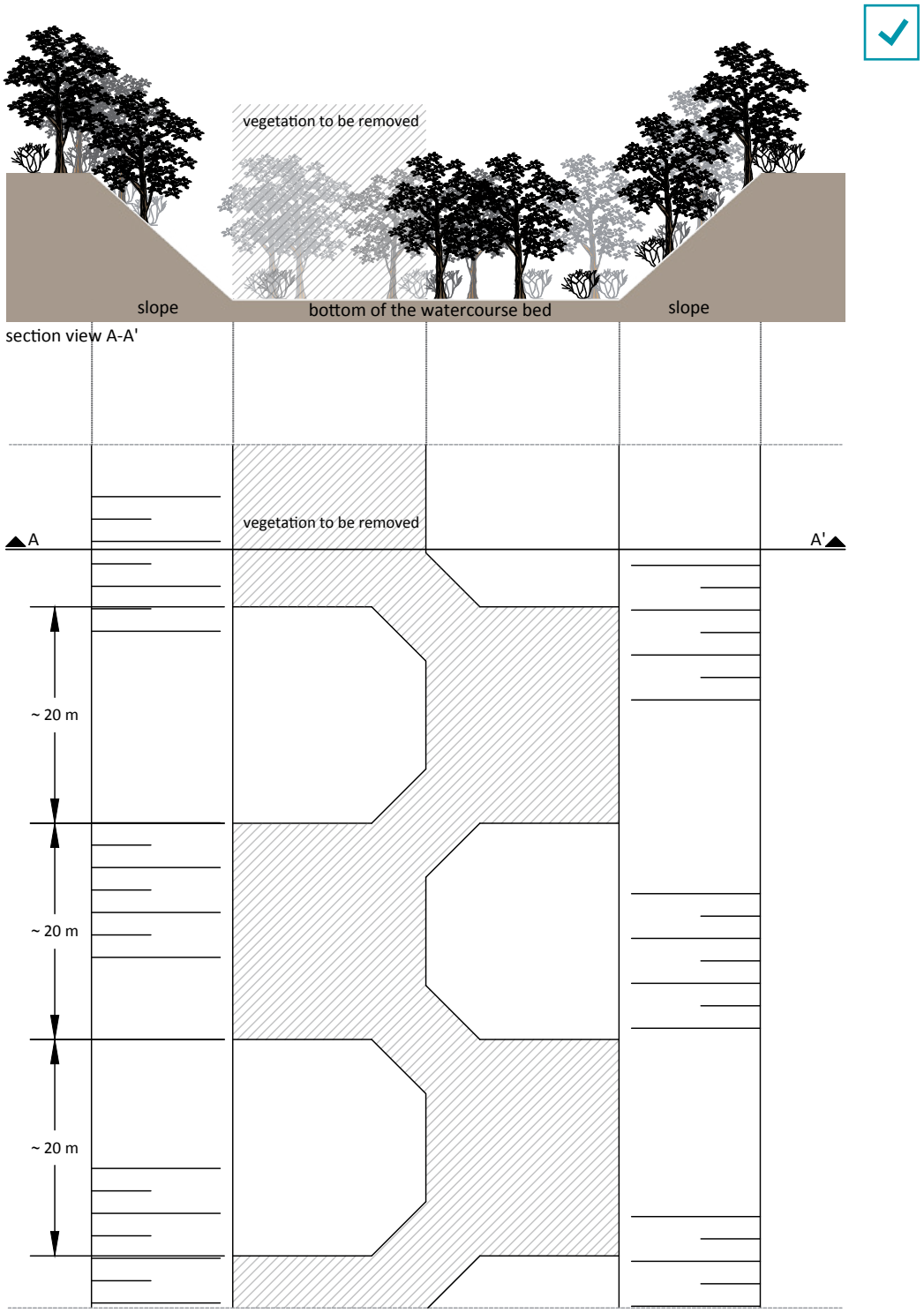
← FIGURE 4.2.25
An example of selective cutting undertaken in combination with partial implementation of Conservation Measure C.3. – the vegetation on one watercourse bank is left entirely intact, while no trees are left on the other bank
(Source: Institute for Environment and Nature, MESD)

MEASURE C.4.

If Measures C.1., C.2. and C.3. are not sufficient to ensure the required flow continuity, the minimum scope of clearing and cutting works should be undertaken for the purpose of thinning the vegetation stand. In that process, the woody vegetation with a diameter of less than 20 cm should be removed first, while the groups of large trees should be left intact as much as possible. Care must be taken that the removal works be limited to what is minimally necessary to ensure the required flow, and that the trees and brush which do not obstruct the flow be left intact, as much as and whenever possible, in order to help preserve the existing bank habitats.



↑ FIGURE 4.2.26
An illustration of the implementation of Conservation Measure C.4.: selective cutting by thinning a bank vegetation stand through removal of trees with a diameter of less than 20 cm, while leaving groups of large trees intact
(Authors: Beatrica Perkec and Koni Čargonja-Reicher)



↑ FIGURE 4.2.27

An example of good practice in implementing Measure C.4.: cutting the trees in the bed without mowing the aquatic vegetation; a schematic presentation of the planned cutting works undertaken on the Konavočica watercourse

(Authors: Beatrica Perkec and Koni Čargonja-Reicher, in accordance with the tree cutting plan prepared by Croatian Waters, Water Management Branch Office for the Dubrovačko primorje Watershed)

← FIGURE 4.2.28
An example of good practice in implementing Measure C.4. on the Konavočica watercourse – the trees in the bed are cut, while the aquatic vegetation is left unmown
(Source: Institute for Environment and Nature, MESD)

← FIGURE 4.2.29
An example of good practice in undertaking the necessary selective cutting works to ensure watercourse flow continuity (Slakovec lateral canal)
(Source: Elektroprojekt JSC)

MEASURE C.7.

Old trees with crevices and cavities that may potentially be habitats of strictly protected species (e.g. bats and burrowing birds) should be left uncut whenever possible. If strictly protected species are found, the competent public institutions for the management of protected areas and ecological network sites and the Ministry should be immediately notified, and all further steps should be taken in agreement with those institutions.

MEASURE C.8.

After cutting/felling mature trees, the logs should be left resting in place for a period of 24 hours prior to removal in order to allow the potentially present bats and other fauna to leave the tree.

MEASURE C.9.

The areas covered with invasive alien species of woody plants (e.g. false indigo, *Amorpha fruticosa*) may, if necessary, be cleared several times a year, provided the cuttings are properly disposed of.

→ *For more information regarding the implementation of this measure, see* ***Section 4.3.7 Measures aimed at preventing the introduction and spread of invasive alien species.***

→ *For more information regarding the implementation of conservation measures prescribed in connection with cutting works, see* ***Section 5 Sources of Information.***

↑ FIGURE 4.2.30
An example of poor practice in undertaking cutting activities – failure to carry out the selective cutting in combination with the appropriate conservation measures (location: Slatnik, Gornje Pokupje)
(Source: Elektroprojekt JSC)

4.2.6 Establishing vegetation by seeding and planting

Purpose of implementing conservation measures when undertaking standardised works of this type: The standardised works of this type are undertaken for regular maintenance purposes with the aim of stabilising the embankments and developing the areas adjacent to water structures (by planting grass), i.e. for the purpose of preventing erosion processes and developing the landscape surrounding the water structures (by planting trees). The standardised works of this type (the planting of trees in particular) is very desirable in that it contributes to the conservation of natural banks and favourable ecological conditions for wildlife communities living alongside or inside watercourses. By restoring the riparian vegetation native to the regional area at the very places where they were damaged or where other works have left the banks bare, the ecological functions of the riparian vegetation, e.g. prevention of bank erosion and mitigation of effects of diffuse pollution on the quality of water, are restored as well.

The recommended tree species native to the regional area which may be planted alongside watercourses are: willows (*Salix* sp., e.g. *S. alba*, S. x *fragilis*), poplars (*Populus* sp., e.g. *P. alba*, *P. nigra*), alders (*Alnus* sp., e.g. *A. incana*, *A. glutinosa*). These species, with the exception of *A. incana*, form parts of communities present in all three biographical regions of the Republic of Croatia. Of the three biogeographical regions, the grey alder (*A. incana*) is not native only to the Mediterranean biogeographical region (EEA 2006; Topić et al. 2006; Vukelić 2012; Nikolić (ur.) 2005).

TABLE 4.2.6 *Standardised works that refer to establishing vegetation by seeding and planting, and conservation measures prescribed in connection with such works*

No.	Types of standardised regular maintenance works undertaken on first- and second-order waters, i.e. types of standardised flood prevention works	Freshwater Ecosystem Conservation Measures[1]
6.	Establishing vegetation by seeding and planting	
6.1.	Establishing vegetation by planting grass (seeding)	D.1.
6.2.	Establishing vegetation by planting tree species native to the regional area	D.1.

[1] Depending on:
- the worksite (location where the works are performed),
- site sensitivity,
- potential presence of an endangered, strictly protected or target species or habitat type included in the Natura 2000 ecological network,

additional conservation measures, e.g. in connection with a particular species or habitat type, or the obligation to execute the standardised works in cooperation with the competent PI may be prescribed.

CONSERVATION MEASURES PRESCRIBED IN CONNECTION WITH THE GROUP OF STANDARDISED WORKS THAT REFER TO ESTABLISHING VEGETATION BY SEEDING AND PLANTING (D.)

MEASURE D.1.

Mineral fertilisers and other chemical substances used to stimulate revegetation should not be applied, i.e. care must be taken to avoid the washing out of harmful substances into watercourses and prevent eutrophication.

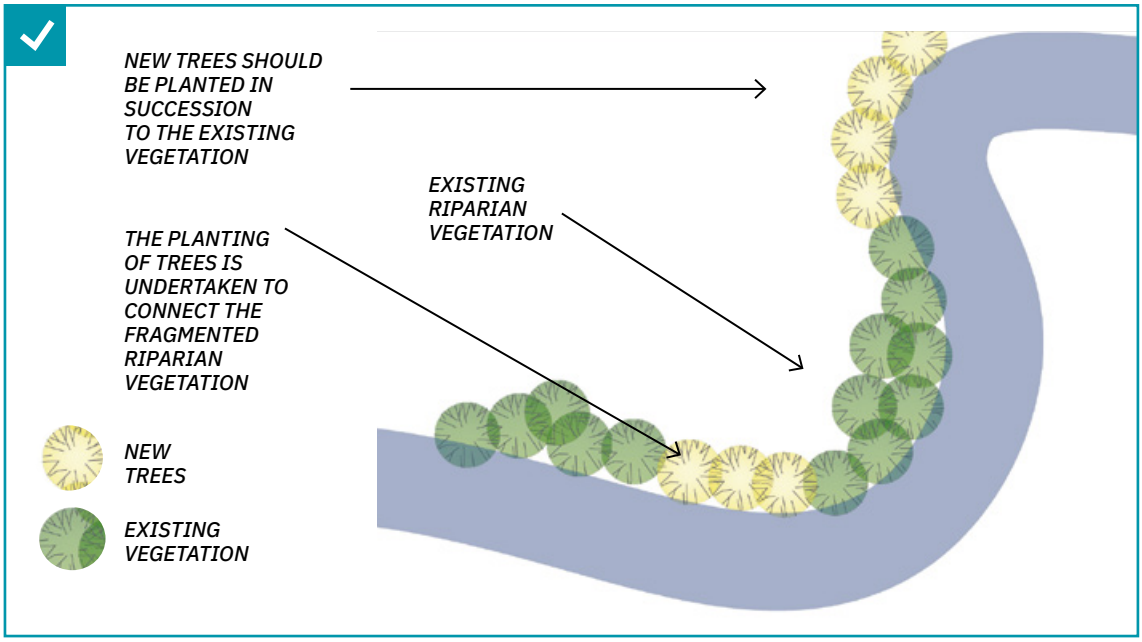
MEASURE D.2.

After completing the works that result in the creation of bare soil on the slopes of watercourses or in the adjacent floodplains, revegetation of the affected area must be stimulated exclusively by seeding and planting the plant species native to the (relevant) regional area.

MEASURE D.2. is prescribed only if deemed necessary.

→ *For more information regarding the implementation of measures prescribed in connection with the standardised works that refer to establishing vegetation by seeding and planting, see* ***Section 5 Sources of Information.***

AN EXAMPLE OF GOOD PRACTICE: HOW SHOULD THE PLANTING OF WOODY SPECIES IN THE RIPARIAN VEGETATION ZONE BE PLANNED?



↑ FIGURE 4.2.31 *An example of good practice in planning the planting of woody species for the purpose of establishing new vegetation covered areas and thus connect the small fragmented sections into a continuous strip of woody riparian vegetation*

(Author: Beatrica Perkec, according to: Scottish Environment Protection Agency 2009)

EXAMPLES OF POOR AND GOOD PRACTICE IN PLANTING VEGETATION

The figure below (Figure 4.2.32) shows a situation in which after the works have resulted in a strip of bare soil on the slope of a watercourse Conservation Measure D.2. was not implemented, i.e. revegetation was not stimulated by seeding (sowing) and planting. With the aim of stabilising the slope on the sections of the bank with stretches of bare soil, the said measure must be implemented. In addition, if increasing bank resistance to erosion is deemed necessary due to the composition of the soil and/or substrate, biodegradable geotextile may be used as an underlay before the planting (Figure 4.2.3). Biodegradable geotextiles are made from natural fibres (coconut and/or straw) and are net wrapped. The nets used are made from a suitable natural material (e.g. jute). Besides being biodegradable, this type of underlay retains moisture, prevents soil erosion and creates favourable conditions for vegetation development.

↑ FIGURE 4.2.32
An example of poor practice: failure to implement Measure D.2. after completing works on the bank, thus compromising its stability due to increased exposure to erosion
(Source: Kathy Dale, in: Scottish Environment Protection Agency 2009

↑ FIGURE 4.2.33
An example of good practice: planting of vegetation on the slope using biodegradable geotextile as an underlay to increase erosion resistance
(Source: AquaTerra Solutions, website 2021)

ADVICE

The seeding and planting should be undertaken as soon as possible after the execution of works resulting in strips of bare soil on the banks or the floodplain. In doing so, the risk of bank erosion and spread of invasive alien plant species is reduced.

Where better erosion resistance is required, biodegradable geotextiles may be used as an underlay before seeding or planting.

After the planting, the progress and development of the planted vegetation should be regularly monitored. Where necessary, measures should be taken to eliminate potential invasive alien plant species.

4.2.7 Maintenance, repair of damage to and renovation of existing water and other structures, renovation of regulation structures in the watercourse bed and establishing the functional status through renovation of small and simple water and other types of structures

This section gives an overview of the following groups of maintenance works:

7. **maintenance, i.e. repair of damage to existing water and other types of structures without changing the dimensions of the structure(s) concerned,**
8. **establishing protection from the harmful effects of erosion through renovation of the regulation structures in watercourse beds (renovation of existing structures without changing the dimensions of the structure(s) concerned),**
9. **establishing the functional status of waters through renovation of small and simple water and other types of structures.**

When standardised works of this type (i.e. works from Groups 7, 8 and 9) are undertaken, **the dimensions**, i.e. the area of the existing water or other type of structure undergoing renovation, being maintained or repaired, **may not be changed**. It is important to note that renovation of old revetments (bank fortifications) found along large rivers in Croatia is not considered renovation of existing water structures. Renovation activities of that kind are considered to present new construction projects because the water structures concerned are usually heavily damaged and very often no longer serve the purpose for which they were initially built, and the plans for their renovation usually involve a significant change in dimensions (Figure 4.2.34).

← FIGURE 4.2.34
An example of an old revetment (location: (Drava River, downstream of the Donja Dubrava Hydropower Plant)
(Source: Institute for Environment and Nature, MESD)

At certain location in Croatia dry-stone walls are built along the banks of watercourses and, as such, are important in terms of flood protection. Repair of such drywalls, in their function as protection structures (Figure 4.2.35), will be considered an activity that belongs to this group of standardised works provided that the dimensions of the dry-stone wall(s) undergoing repair remain unchanged and that neither concrete nor any other stone bonding agents are used.

← FIGURE 4.2.35
An example of a restored dry-stone wall used as a protection (water management) structure on an intermittent (torrential) watercourse
(Source: Croatian Waters)

Purpose of implementing conservation measures when undertaking standardised works of this type: The purpose of implementing freshwater ecosystem conservation measures in connection with the works that refer to maintenance, i.e. repair of damage to and renovation of existing water and other types of structures, including the regulation structures in watercourse beds, is to mitigate the impact of such works on the conservation of favourable ecological conditions for freshwater species and their habitats.

Depending on the location where the works are (to be) performed ("worksite"), care must be taken that only such activities that will have the least possible impact on the affected watercourse and its surrounding area are undertaken and that the existing natural habitats, natural shelters and favourable habitat conditions for the species present on the worksite are preserved. For example, the steep, eroded banks of large Croatian rivers (e.g. the Sava, the Drava, or the Danube) must be preserved, particularly if the sand martin (*Riparia riparia*), the European bee-eater (*Merops apiaster*) or the common kingfisher (*Alcedo atthis*) have started nesting there.

Among the various standardised works that pertain to maintenance, i.e. repair of damage and renovation of water structures, attention should be drawn to Standardised Work No. 7.12. *Maintenance, i.e. repair of damage to watercourse or canal beds occurring due to slope erosion*, as the relevant activities might have a significant impact on biodiversity in the sense of changes they may cause with respect to riparian and aquatic habitats and natural erosion processes in rivers. The only way to minimise the impact of activities of this kind is to ensure consistent and proper implementation, which also entails the execution of slope protection and bed stabilisation works without resorting to the use of rocks. The natural vegetation growing outside the bank stabilisation perimeter must be preserved to the greatest extent possible, while recovery of the riparian vegetation affected by the stabilisation and rehabilitation works performed on an eroded slope must be properly stimulated. This is also associated with Standardised Work 7.12. *Maintenance, i.e. repair of damage to watercourse or canal beds occurring due to slope erosion*, because well-established riparian vegetation may in some situations significantly contribute to slope stabilisation and therefore reduce the frequency and scope of undertaking this type of standardised work. For more information regarding the planting of riparian vegetation, see ***Section 4.2.6 Establishing vegetation by seeding and planting.***

Where transverse water structures are built, it must be ensured that they do not disrupt or obstruct the upstream or downstream migration of fish and invertebrates in particular. If they do disrupt or obstruct the migration pathways of aquatic animals, they should be adjusted whenever possible and appropriate. The crossings and bridges must be renovated in such manner so as to allow an undisturbed flow of sediment, woody debris and freshwater species.

TABLE 4.2.7 *Standardised works that refer to maintenance, i.e. repair of damage to and renovation of existing water and other types of structures, renovation of regulation structures in watercourse beds and establishing the functional status through renovation of small and simple water and other types of structures, and conservation measures prescribed in connection with the such works*

No.	Types of standardised regular maintenance worksundertaken on first- and second-order waters, i.e. types of standardised flood prevention works	Freshwater Ecosystem Conservation Measures[1]
7.	**Maintenance, i.e. repair of damage to existing water and other types of structures without changing the dimensions of the structure(s) concerned**	
7.1.	Maintenance, i.e. repair of damage to the embankment crest, slope, shoulders and access ramps, possibly also including partial reinforcement of the embankment body and/or partial superelevantion of the crest	No requirements or measures
7.2.	Maintenance, i.e. repair of damage to the embankment caused by filtration or regressive erosion	No requirements or measures
7.3.	Maintenance, i.e. repair of damage to the access route leading to the embankment and/or water structure	No requirements or measures
7.4.	Maintenance, i.e. repair of damage to the service route running along the embankment	No requirements or measures
7.5.	Maintenance, i.e. repair of damage in the floodplain	F.2., P.12., F.41., F.42.
7.6.	Maintenance, i.e. repair of damage to an earth-fill dam of a retention basin or reservoir, including works on the related facilities and equipment	No requirements or measures

No.	Types of standardised regular maintenance worksundertaken on first- and second-order waters, i.e. types of standardised flood prevention works	Freshwater Ecosystem Conservation Measures[1]
7.7.	Maintenance, i.e. repair of damage to a concrete dam of a retention basin or reservoir, including works on the related facilities and equipment	No requirements or measures
7.8.	Maintenance, i.e. repair of damage to locks, including works on the related facilities and equipment	F.2., F.41., F.42.
7.9.	Maintenance, i.e. repair of damage to the plugs and/or culverts and/or crossings over watercourses or canals and/or siphons and/or hydrotechnical tunnels	F.2., F.41., F.42.
7.10.	Maintenance, i.e. repair of damage to pumping stations, including works on the related facilities and equipment	No requirements or measures
7.11.	Maintenance, i.e. repair of damage to the ramps, kilometre signs and other types of signs on embankments and along watercourses	No requirements or measures
7.12.	Maintenance, i.e. repair of damage to watercourse or canal beds occurring due to slope erosion	E.5., F.2., F.3., F.4., F.8., F.10., F.41., F.42.
7.13.	Maintenance, i.e. repair of damage to existing regulation structures in watercourse beds (revetments, or groynes, or longitudinal structures, or traverses, or barriers, etc.)	E.5., F.2., F.3., F.4., F.8., F.10., F.41., F.42.
7.14.	Maintenance, i.e. repair of damage to existing regulation structures in torrential watercourses: barriers with the associated facilities, sills, cascades, weirs (steps with a stilling basin), sediment settling basins, chutes and other structures and facilities whose function is to dissipate the energy of a powerful flow regime	temporary torrents, when dry: F.2., F.3.; permanent torrential watercourses: E.5., F.2., F.3., F.4., F.8., F.10., F.41., F.42.

No.	Types of standardised regular maintenance worksundertaken on first- and second-order waters, i.e. types of standardised flood prevention works	Freshwater Ecosystem Conservation Measures[1]
8.	**Establishing protection from the harmful effects of erosion through renovation of regulation structures in watercourse beds (renovation of existing structures without changing the dimensions of the structure(s) concerned)**	
8.1.	Establishing protection from the harmful effects of erosion through renovation of revetments, groynes, longitudinal structures, traverses, barriers, etc. in watercourse beds (renovation of existing structures without changing the dimensions of the structure(s) concerned)	E.1., E.3., E.5., E.6., F.2., F.3., F.4., F.5., F.6., F.7., F.8., F.10., F.41., F.42.
8.2.	Establishing protection from the harmful effects of erosion through renovation of barriers, sills, cascades, weirs (steps), stilling basins, sediment settling basins, chutes, the associated facilities and similar, in torrential watercourses (renovation of existing structures without changing the dimensions of the structure(s) concerned)	temporary torrents, when dry: E.5., F.2., F.3., F.4., F.41., F.42.; permanent torrential watercourses: E.5., E.6., F.2., F.3., F.4., F.5., F.6., F.7., F.8., F.10., F.41., F.42.
9.	**Establishing the functional status of waters through renovation of small and simple water and other types of structures**	
9.1.	Renovation of plugs, culverts, crossings over watercourses or canals, siphons, ramps, kilometre and other signs on embankments and along watercourses.	E.7., F.2., F.41., F.42. (F.3. in connection with watercourse crossings)

[1] Depending on:
- the worksite (location where the works are performed),
- site sensitivity,
- potential presence of an endangered, strictly protected or target species or habitat type included in the Natura 2000 ecological network,

additional conservation measures, e.g. in connection with a particular species or habitat type, or the obligation to execute the standardised works in cooperation with the competent PI may be prescribed.

CONSERVATION MEASURES PRESCRIBED IN CONNECTION WITH THE GROUP OF STANDARDISED WORKS THAT REFER TO MAINTENANCE, I.E. REPAIR AND RENOVATION OF WATER AND OTHER TYPES OF STRUCTURES (E.)

MEASURE E.1.

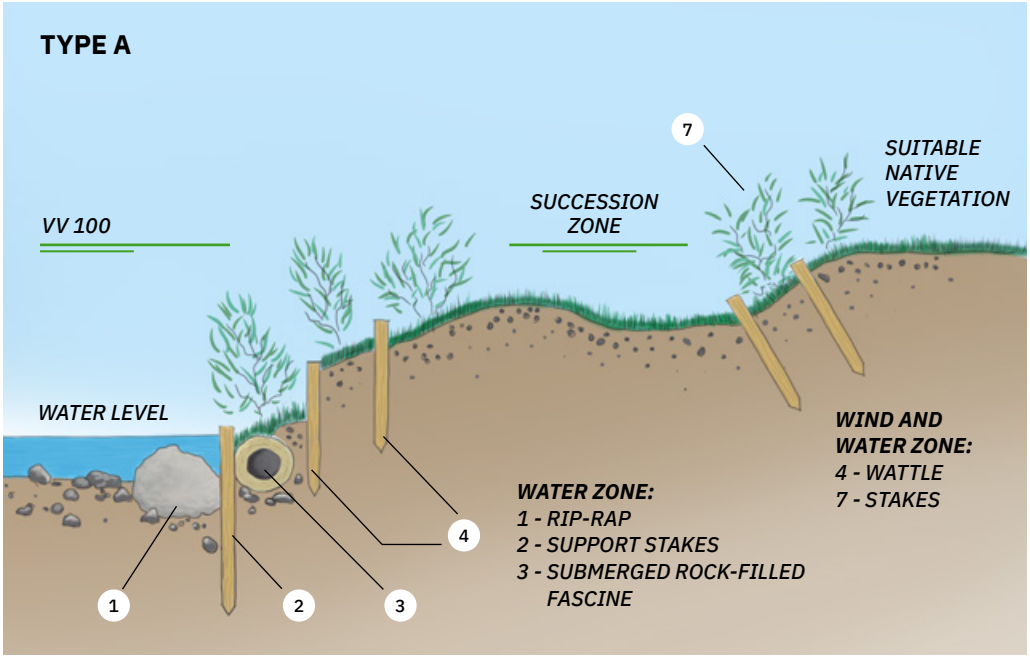
The possibility of using other bank reinforcement and erosion protection methods besides those based on the use of rocks and concrete (bioengineering methods) should be considered. Additionally, when undertaking works of this type, it should be ensured that the bank stretches to be rock armoured or reinforced with some other material are as small as possible. If the floodplain is wide enough, the possibility of installing a trench fill revetment on the land section up to the cut-off line should be considered as a method to be used instead of bank lining.

EXAMPLES OF IMPLEMENTATION OF MEASURE E.1.

The figures below (Figure 4.2.36, Figure 4.2.37, Figure 4.2.38) present several ways in which Measure E.1. can be implemented. Two of the examples (i.e. **Type A and Type B**) refer to **a bank which is prone to erosion**, while the third example (**Type C**) refers to a **bank which is not prone to erosion.**

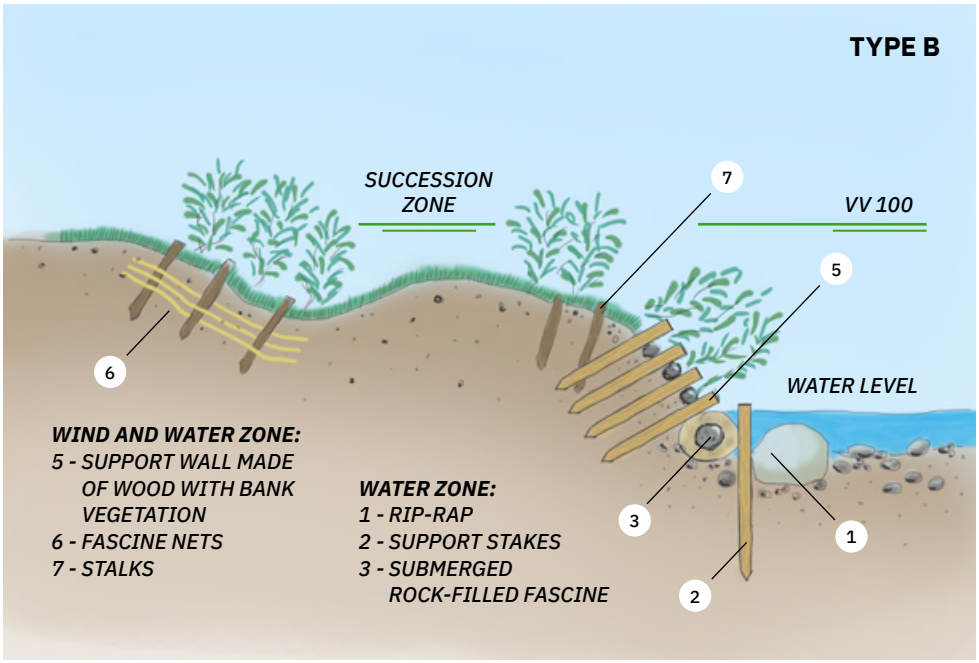
Type A (Figure 4.2.36) – to armour a bank prone to erosion, the bank slope is reinforced, up to the height representing the low to medium water level ("water zone"), by installing **riprap, support stakes and an underwater rock-filled fascine**. The **fascines** are usually wrapped in brushwood (which forms a 10 cm thick cover) and are filled with crushed stone or large gravel. The full diameter of a filled fascine depends on the aggregate. More precisely, if large aggregate is used, the fascines may range in diameter from 1.1 to 1.2 m, and if small aggregate is used, from 0.7 to 1.6 m. In the zone that extends up to the height representing the high water level, which is exposed to the effects of winds as well ("the wind and water zone"), the bank slope is armoured with **wattles**, while the remaining bank area, in the high water level zone (marked in the figures as "VV 100"), is reinforced with stakes. The wattles are usually made using willow stakes and sticks, and are arranged in rows, approx. 0.5 to 1.0 m apart from each other, parallel to the bank. To make an ordinary **wattle**, 1.5 m long stakes with a diameter of 6 – 15 cm are used. They are stuck into the bank so that they partly protrude from the ground, i.e. up to the height of 50 – 60 cm. To ensure growth, live stakes with seedlings must be used. The installed stakes are then interlaced with fresh willow sticks of 2 cm in diameter. The area between the lines where the stakes and the wattles are installed is the

so-called "succession zone" where natural bank revegetation and progressive vegetation processes are expected to occur (the establishment of herbaceous plants, then shrubs and, finally, woody vegetation).



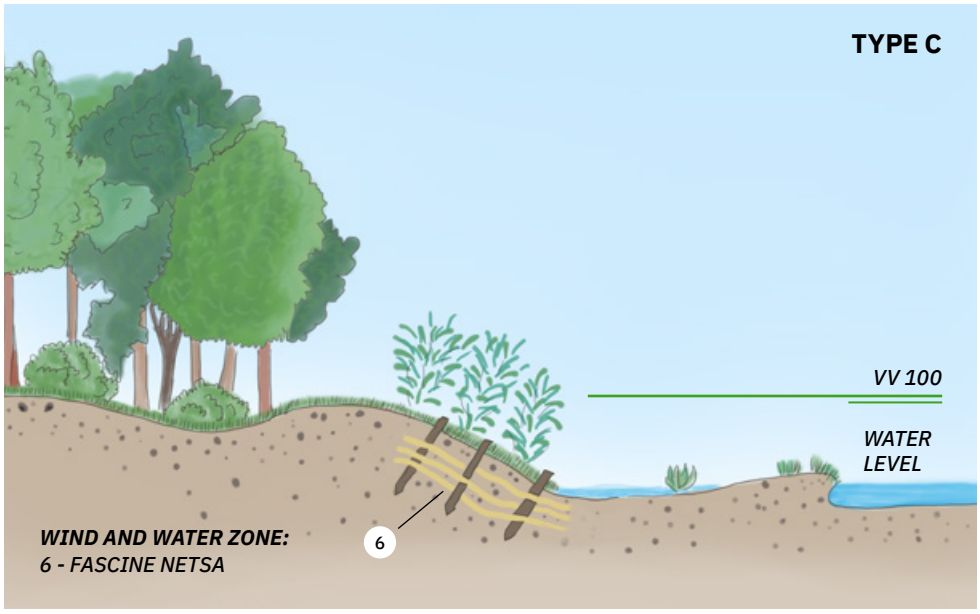
↑ FIGURE 4.2.36 *An example of the implementation of Measure E.1. –a schematic presentation of a method of managing a bank prone to erosion (Type A)*
(Author: Matej Kopecki, according to Elektroprojekt JSC)

Type B (Figure 4.2.37) – to armour a bank prone to erosion, the bank slope is, in this case too, **reinforced**, up to the height representing the low to medium water level ("**water zone**"), by installing **rip-rap, support stakes and an underwater rock-filled fascine. In the "wind and water zone"**, however, a support wall made of wood is used to reinforce the slope, while the bank is covered with vegetation. The stakes are stuck in the ground at the point where the wall of wood ends. At the height representing the high water level, a **fascine net** is installed. Fascine nets are made from bundles of brushwood tied by a wire, and may vary in size. Humus with grass seeds can be used to fill the space between net openings. The area between the lines where stakes and fascine nets are installed is the so-called "succession zone", where natural bank revegetation processes are expected to occur, i.e. where woody vegetation is expected to develop.



↑ FIGURE 4.2.37 *An example of the implementation of Measure E.1. – a schematic presentation of a method of managing a bank prone to erosion (Type B)*
(Author: Matej Kopecki, according to: Elektroprojekt JSC)

Type C (Figure 4.2.38) – a bank which is not prone to erosion is left intact up to the height representing the low to medium water level ("water zone"). **In the "wind and water zone", however, fascine nets are used to reinforce the bank slope.**

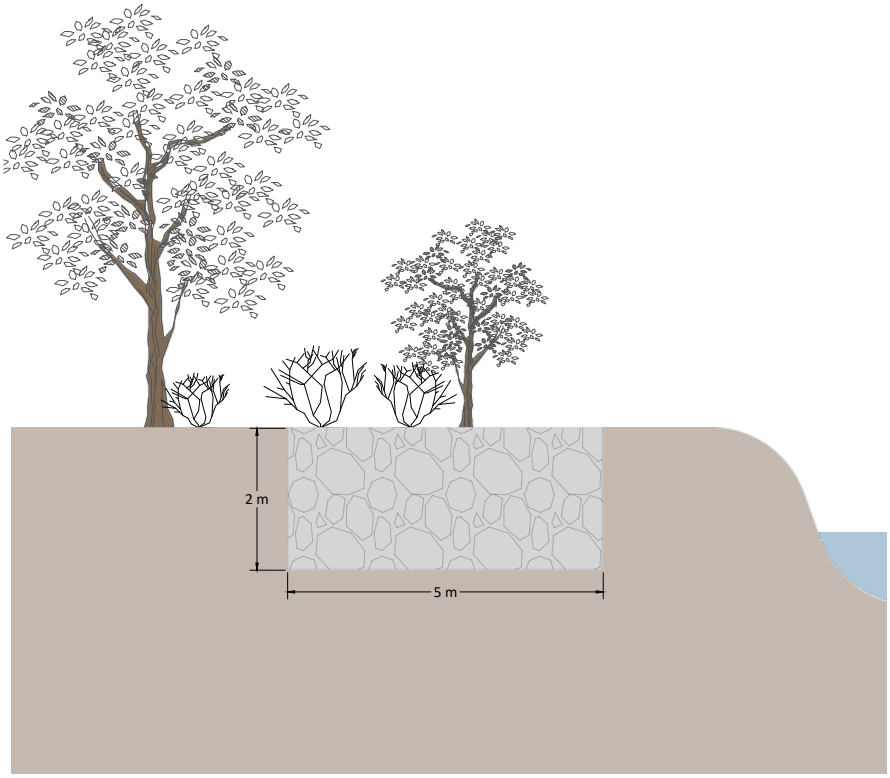


↑ FIGURE 4.2.38 *An example of the implementation of Measure E.1. – a schematic presentation of a method of managing a bank which is not prone to erosion (Type C)*
(Author: Matej Kopecki, according to: Elektroprojekt JSC)

← FIGURE 4.2.39
An example of good practice in implementing bioengineering methods to stabilise a slope of a small watercourse (location: Međimurje)
(Source: Međimurska priroda – Public Institution for Nature Protection)

↑ FIGURE 4.2.40 *An example of good practice in implementing bioengineering methods to stabilise a slope of a small watercourse at a site in Međimurje; using fascines to stabilise the slope* (↖ left); *at a site in Nespeš, Sv. Ivan Zelina; using fir tree boards and stakes to stabilise the slope* (↗ right)
(Source: Croatian Waters)

The figure below (Figure 4.2.41) shows an example of a situation in which **a trench fill revetment** is used to reinforce the bank. In such cases, the piles of rocks are buried at a certain distance from the main bed. After a trench is dug, it is filled with crushed stone. After levelling the terrain, a trench fill revetment is covered with backfill (soil). In situations where erosion processes may not be accurately predicted, this method provides a certain level of protection from the harmful effects of water and, most importantly, by implementing this method, the natural hydromorphological processes are not disturbed and the natural habitats, such as steep river banks, are preserved.



← FIGURE 4.2.41
A schematic presentation of a trench fill revetment installed to reinforce the bank
(Author: Beatrica Perkec, based on the drawing prepared by Croatian Waters 2018)

MEASURE E.3.

After the works on a regulation structure are completed, the area must be rehabilitated, i.e. earthfilled and seeded.

↑ FIGURE 4.2.42
A new earthfill revetment (location: Mala Neretva)
(Source: Institute for Environment and Nature, MESD)

MEASURE E.5.

If invasive alien plant species are identified during the revegetation period, they must be actively removed (and properly disposed of) until the natural woody vegetation is reestablished.

MEASURE E.6.

When undertaking maintenance works on dams and other structures in the area surrounding the barrier, which structures obstruct the upstream and/or downstream passage of freshwater fauna, i.e. compromise the continuity of the ecological system, such structures should be permanently adjusted to allow free movement/passage of freshwater fauna. If technically feasible, when executing major repairs or renovating such structures, works aimed at making them more environmentally-friendly should also be planned (e.g. building cascades below dams, developing special fish passes, and executing similar technical projects).

EXAMPLE OF IMPLEMENTATION OF MEASURE E.6.

The figure below shows a change that occurred after the step, which had been the cause of disruption in longitudinal connectivity, was removed to mitigate the impact on the migration of the biota and sediment. Once the barrier was removed, the river continuity was restored, allowing the fish to migrate freely, and rest areas have developed, contributing to the increase in the variety of microhabitats at the site.

FIGURE 4.2.43
An example of the implementation of Measure E.6. – mitigating the impact of a weir in a watercourse bed (↖ left the state before and ↗ right after removing the step; Hučava River, Slovakia)
(Source: Rob Kleinjans, Dam Removal Europe 2022).

MEASURE E.7.

When renovating culverts and crossings over watercourses within the range of otters and beavers, free passage across the banks must be ensured for the said species (i.e. a dry animal passage/corridor must be secured). Culvert renovation projects may not be executed in a manner that causes a disruption in watercourse continuity, i.e. a disruption in the migration of fish and other fauna (e.g. only semi-circular culverts and culverts in the shape of a bridge, which do not affect the watercourse bed, may be planned). It must also be ensured that the bottom of the culvert is below or at the level of the watercourse bottom slope.

← FIGURE 4.2.44
An example of the implementation of Measure E.7.: a passage for otters built under a bridge with a lateral bank superelevation to ensure dry conditions for safe animal passage
(Source: Z. Chabadová, in: Hahn 2015)

← FIGURE 4.2.45
An example of the implementation of Measure E.7.: an example of a culvert, where the load-bearing structure of the bridge does not disturb the bank or the bed of the watercourse
(Source: Scottish Environment Protection Agency 2010)

→ For more information regarding the implementation of conservation measures prescribed for the group of standardised works that refer to maintenance, i.e. repair of damage to and renovation of water and other types of structures (E.), see ***Section 5 Sources of Information.***

4.2.8 Procedure to be followed when implementing Measure F.1. and undertaking standardised works excluded from the water maintenance programme

In the process of assessing water maintenance programmes prepared for specific sites, Measure F.1. (**The appropriate assessment procedure (i.e. the assessment of acceptability of works considering the implications for the ecological network) is required.**) is prescribed in connection with certain standardised works.

Measure F.1. may be prescribed **in connection with particular sites** in cases where the information available to the competent authority conducting the water maintenance programme assessment procedure indicates that **the relevant site is important for the conservation of a population of a particular target species or habitat type**, and the details about the works which are planned to be performed at that site are not specific enough. In such cases, the appropriate assessment procedure (i.e. the assessment of acceptability of the works considering the implications for the ecological network) must be performed in order to establish whether there is a possibility that the planned works could have a significant negative effect on the established conservation objectives and the integrity of the ecological network.

This measure is often prescribed because of the inability of the competent authority to assess the level of impact and prescribe appropriate conservation measures because **the information about the scope of works provided in the water maintenance programme submitted for assessment is incomplete** (e.g. in the case of works referring to sediment removal, the information about the estimated amount of sediment that will be removed, about the size of the section where removal works will be undertaken, or the sediment disposal site may not be provided).

If Measure F.1. is prescribed, the appropriate assessment procedure (hereinafter referred to as "the AA procedure"), as defined in the Nature Protection Act, must be conducted in respect of the relevant works and the site in question. The first step is the AA screening procedure ("preliminary assessment of acceptability considering the implications for the ecological network"), which is initiated by the competent administrative authority (the Ministry or the relevant County) based on the request for preliminary assessment of acceptability of the project considering the implications for the ecological network submitted by Croatian Waters (i.e. the competent organisational unit). The mandatory content for the AA screening procedure is defined by the Nature Protection Act (Article 30), as follows:

1. **project proponent information,**
2. **project and project site information,**
3. **a short description of the project.**

If the competent authority, taking into account the opinion of the Institute for Environment and Nature of the Ministry of Economy and Sustainable Development rules out the possibility that the project will have a significant negative impact on the established

conservation objectives and integrity of the ecological network, it will make a decision that the project is acceptable considering its implications for the ecological network within 30 days from the receipt of a properly submitted request.

However, if potential negative impacts of the project on the ecological network cannot be ruled out, the competent authority will issue a decision by which it will call upon the project owner to comply with the obligation of submitting the project to the next step, which is the appropriate assessment ("main assessment of acceptability of the project considering the implications for the ecological network"), which entails the mandatory preparation of a report on the assessment of acceptability of the project considering the implications for the ecological network prepared by an authorized company. The main assessment procedure and all further steps are defined in the Nature Protection Act (Articles 31 – 44) (Figure 4.2.46).

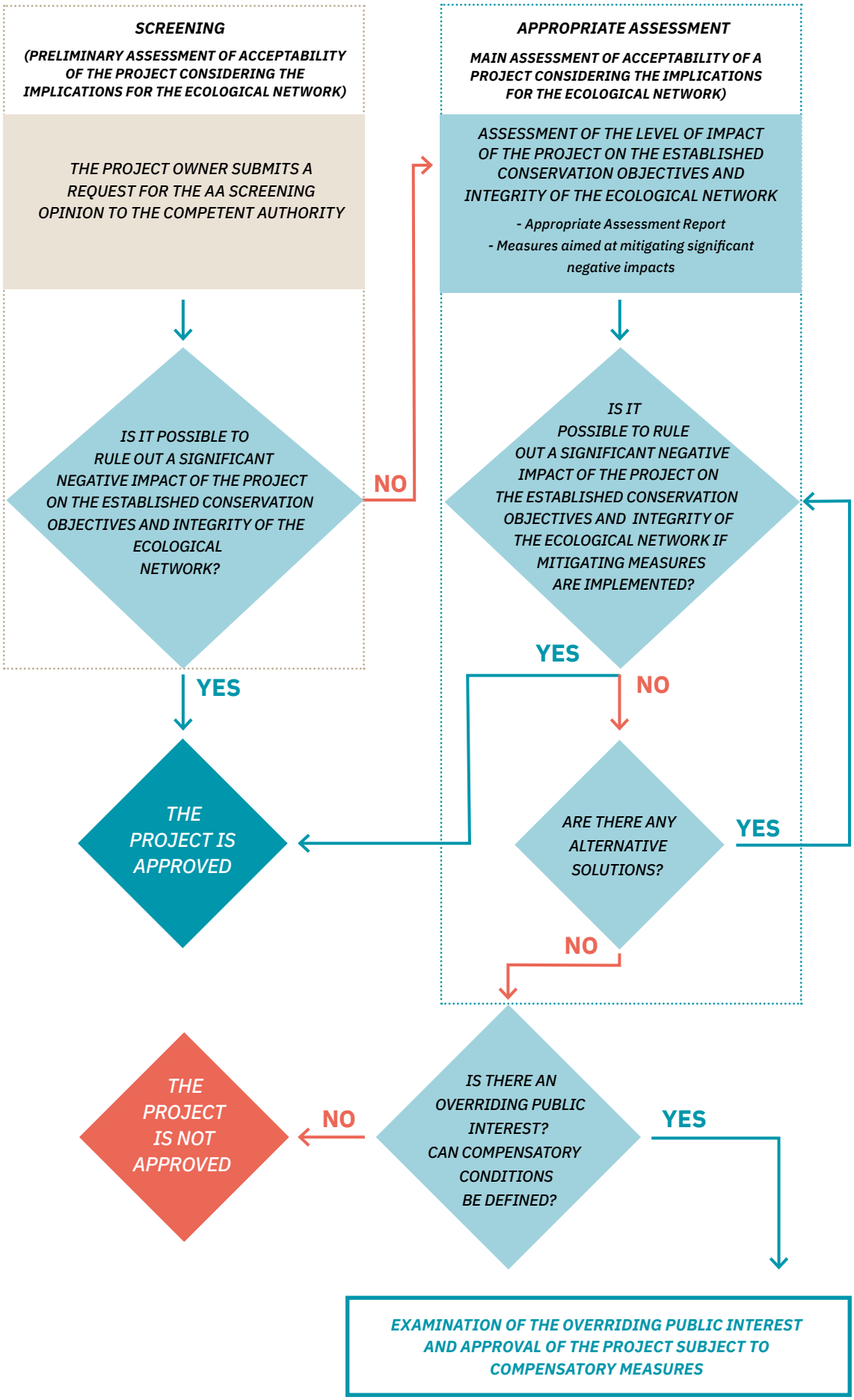
The maintenance works from Group 10 and some works from Group 9, which are excluded from the maintenance programme, refer to construction of new water structures:

9.	**Establishing the functional status of waters through renovation or construction of small and simple water and other types of structures**
9.1.	Renovation or construction of plugs, culverts, crossings over watercourses or canals, siphons, ramps, kilometre and other signs on embankments and along watercourses
10.	**Establishing the necessary protection from the harmful and progressive effects of erosion through construction of small and simple regulation structures in watercourse beds**
10.1.	Establishing the necessary protection from the harmful and progressive effects of erosion through construction of small and simple revetments, groynes, longitudinal structures, traverses, and similar in watercourse beds
10.2.	Establishing the necessary protection from the harmful and progressive effects of erosion through construction of barriers, sills, cascades, steps, stilling basins, sediment settling basins, chutes and other structures whose function is to dissipate the powerful flow regime in torrential watercourses

The above-mentioned types of works are listed in Annex III of the Regulation on Environmental Impact Assessment (OG No. 61/41, 3/17). Both the assessment of the need for environmental impact assessment ("EIA screening") and the assessment of acceptability considering the implications for the ecological network ("AA procedure") must be conducted in respect of such standardised works, in which case the AA screening is conducted at the same time as the EIA screening procedure. The EIA screening request, which is submitted by the project owner to the competent authority, must include the Environmental Protection Report, the content of which is prescribed by the Regulation on Environmental Impact Assessment and prepared by a licenced company. The outcome of this procedure is a decision as to whether or not the project is deemed acceptable for the environment (the "EIA decision") and whether or not the project is deemed acceptable considering its implications for the ecological network (the "AA determination").

ADVICE The persons charged with the task of preparing water maintenance programmes are advised to be as specific as possible when providing information about the relevant (micro) locations and scope of works (e.g. the surface area or length of the affected watercourse section) to the competent body for the purposes of assessment. In doing so, they help the competent authority appropriately assess the implications of the works for the ecological network and determine the appropriate conservation measures, which results in a smaller number of cases in which Measure F.1. is prescribed.

→ **FIGURE 4.2.46**
Appropriate Assessment Flowchart
(Source: Oikon Ltd.)


SCREENING
(PRELIMINARY ASSESSMENT OF ACCEPTABILITY OF THE PROJECT CONSIDERING THE IMPLICATIONS FOR THE ECOLOGICAL NETWORK)
THE PROJECT OWNER SUBMITS A REQUEST FOR THE AA SCREENING OPINION TO THE COMPETENT AUTHORITY
IS IT POSSIBLE TO RULE OUT A SIGNIFICANT NEGATIVE IMPACT OF THE PROJECT ON THE ESTABLISHED CONSERVATION OBJECTIVES AND INTEGRITY OF THE ECOLOGICAL NETWORK?
NO
YES
THE PROJECT IS APPROVED
APPROPRIATE ASSESSMENT
MAIN ASSESSMENT OF ACCEPTABILITY OF A PROJECT CONSIDERING THE IMPLICATIONS FOR THE ECOLOGICAL NETWORK)
ASSESSMENT OF THE LEVEL OF IMPACT OF THE PROJECT ON THE ESTABLISHED CONSERVATION OBJECTIVES AND INTEGRITY OF THE ECOLOGICAL NETWORK
- Appropriate Assessment Report
- Measures aimed at mitigating significant negative impacts
IS IT POSSIBLE TO RULE OUT A SIGNIFICANT NEGATIVE IMPACT OF THE PROJECT ON THE ESTABLISHED CONSERVATION OBJECTIVES AND INTEGRITY OF THE ECOLOGICAL NETWORK IF MITIGATING MEASURES ARE IMPLEMENTED?
YES
NO
ARE THERE ANY ALTERNATIVE SOLUTIONS?
YES
NO
IS THERE AN OVERRIDING PUBLIC INTEREST? CAN COMPENSATORY CONDITIONS BE DEFINED?
NO
THE PROJECT IS NOT APPROVED
YES
EXAMINATION OF THE OVERRIDING PUBLIC INTEREST AND APPROVAL OF THE PROJECT SUBJECT TO COMPENSATORY MEASURES

4.3 Measures Aimed at Conserving the Favourable Habitat Conditions for Plant and Animal Species

Purpose of the implementation of conservation measures aimed at preserving the favourable habitat conditions for plant and animal species: The main purpose of this group of conservation measures is to prevent the deterioration of favourable habitats and disturbance of the species dependent on aquatic and riparian habitats, as well as on floodplain grassland habitats, during the key periods of their life cycles. These measures are prescribed in connection with a number of taxonomic groups of organisms, including plants, invertebrates (butterflies, decapods, molluscs, beetles, dragonflies), fish, amphibians and reptiles, birds and mammals, and they are aimed at eliminating disturbance and preventing the deterioration of favourable habitats during sensitive parts of life cycle periods (e.g. spawning and nesting periods). Furthermore, these measures also serve to prevent the deterioration of habitats of certain strictly protected plant species, until their full annual life cycle is completed. Finally, this set of measures also includes a number of measures aimed at preventing the introduction and spread of invasive alien plant and animal species considering that spreading of such plants and animals could have an indirect negative effect on the status of populations of native species.

4.3.1 Measures aimed at conserving the favourable habitat conditions for plants

MEASURE F.32.*

Due to potential presence of habitat type A.3.2. Free floating and submerged hydrophytes and/or A.3.3.1.5 Communities of clasping-leaf pondweed, the works in the watercourse bed must be undertaken only in the period from 1 October until 31 March.

← FIGURE 4.3.1
A stand of clasping-leaf pondweed (NHC A.3.3.1.5.), Species: Potamogeton perfoliatus
(Source: Krzysztof Ziarnek, Kenraiz, Creative Commons License 2017)

MEASURE F.33.*

The mowing activities should be undertaken after the blooming of the amethyst meadow squill *(Chouardia litardierei)*, a strictly protected plant species, i.e. after 15 July. The execution of works may not cause a disruption in the hydrological regime of the wet habitats where this species is present. After the works are completed, the cuttings must be collected and disposed of.

← FIGURE 4.3.2
The amethyst meadow squill (Chouardia litardierei) (a habitat found along the Bakovac Stream in Lika)
(Author: Ana Đanić)

MEASURE F.22.*

If the presence of the checkered lily *(Fritillaria meleagris)*, a strictly protected plant species, is confirmed, no works should be carried out in March and April, and it must be ensured that the execution of works does not cause a disturbance in the hydrological regime of the surrounding wet habitats.

← FIGURE 4.3.3
The checkered lily (Fritillaria meleagris) (a habitat found along the Pakra watercourse)
(Author: Vida Posavec Vukelić)

* Measures prescribed with regard to specific sites where deemed necessary.

4.3.2 Measures aimed at conserving the favourable habitat conditions for invertebrates

The invertebrates dependent on freshwater ecosystems primarily include (in terms of abundance): insects, crustaceans and molluscs (shellfish and snails). They represent an important loop in the food chain and are considered a reliable indicator of the environmental status and the functioning of aquatic ecosystems.

The willow and alder forests growing in floodplains provide an important habitat for the endangered saproxil coleopters (the species dependent on live, dead or dying trees), while reed and rush bushes and habitats with amphibious vegetation are important for dragonflies. The floodplain and wet habitats found alongside watercourses (within the floodplain area) include meadows and edges of floodplain forests as the most important habitats for the endangered daily butterfly species. Butterflies have an important role as the indicators of changes occurring in the community in which they live.

These conservation measures specifically refer to the above-mentioned groups, and are aimed at conserving the habitats for dragonflies, molluscs and decapods. They also serve to determine the periods in which the mowing should or should not be performed on watercourses along which butterflies are distributed.

CONSERVATION MEASURES – DECAPODS

MEASURE F.19.*

At sites where presence of freshwater decapods is determined, care should be taken that as much as possible woody debris, riparian and aquatic vegetation, trees and brush be preserved along the edges of watercourses in order to preserve or create favourable habitats and provide shadow above the water.

From the four native freshwater decapod species, three are strictly protected, namely the white-clawed crayfish (*Austropotamobius pallipes*), the stone crayfish (*Austropotamobius torrentium*) and the noble crayfish (*Astacus astacus*).

← FIGURE 4.3.4
An example of a watercourse with a typical habitat for the stone crayfish (Velika Belica Stream): the tree roots along the bank and large chunks of wood inside the watercourse bed provide shelter for crustaceans; the rocky substrate in the watercourse bed consisting of rocks in various sizes increases the diversity of microhabitats; the water quality if very good, which is of vital importance for this species (Author: Matej Faller).

* Measures prescribed with regard to specific sites where deemed necessary.

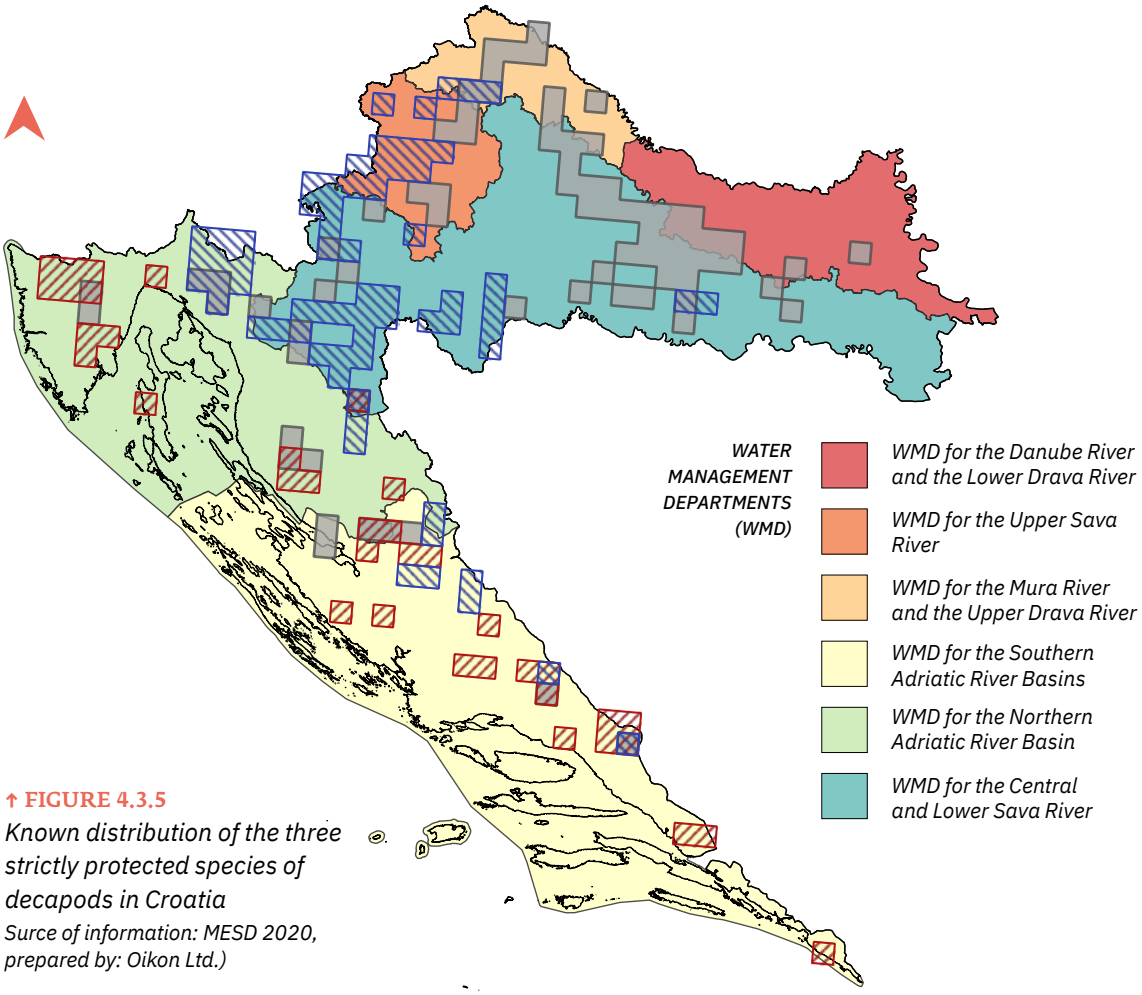
Conservation measures prescribing the period of the year when works should or should not be undertaken are not determined with regard to freshwater decapods and molluscs, as they are always present in the water and the works, whenever undertaken, are bound to affect them. For example, considering their biological characteristics and life cycle, decapods are sensitive to disturbance and changes in the habitat practically all year round (and particularly in spring, summer and autumn). It is therefore of highest importance for decapods, as well as for other aquatic invertebrates, that appropriate measure be taken to ensure conservation of the relevant habitats (in the case of crustaceans: primarily the riparian vegetation and bed substrate; in the case of molluscs: also the substrate, i.e. the bottom of the watercourse bed), and to avoid causing changes in the physical and chemical status.

THE NOBLE CRAYFISH

THE WHITE-CLAWED CRAYFISH

THE STONE CRAYFISH

Photos taken by: Matej Faller



↑ **FIGURE 4.3.5**
Known distribution of the three strictly protected species of decapods in Croatia
Surce of information: MESD 2020, prepared by: Oikon Ltd.)

CONSERVATION MEASURES – DAILY BUTTERFLIES

MEASURE F.20.*

Where the presence of strictly protected butterfly species, namely the marsh fritillary (*Euphydryas aurinia*) and/or large copper (*Lycaena dispar*), is determined, only one third of the floodplain should be mown each year. More precisely, the floodplain should be divided in three longitudinal stretches alongside the watercourse, which will then be mown rotationally in three-year cycles, i.e. each stretch may be mown every three years, and not before. Where this approach is not possible, the worksite should be divided in three sections (or in strips up to 1 km in length) and each such strip should be mown every third year, never at the same time. When mowing, the mechanical equipment (machinery) used may not encroach on the sections that are not scheduled to be mown in that cycle.

(!) NOTES REGARDING THE IMPLEMENTATION OF MEASURE F.20.

The manner in which this measure will be implemented depends on the type and size of the watercourse concerned. Rotational mowing undertaken on longitudinal stretches of vegetation is applied on large and medium-sized watercourses.

↑ FIGURE 4.3.6 *An example of the implementation of the rotational mowing method where two thirds of the area alongside a watercourse is left unmown (the white arrow) for the butterflies; the Sava River floodplain*
(Source: Institute for Environment and Nature, MESD)

MEASURE F.23.*

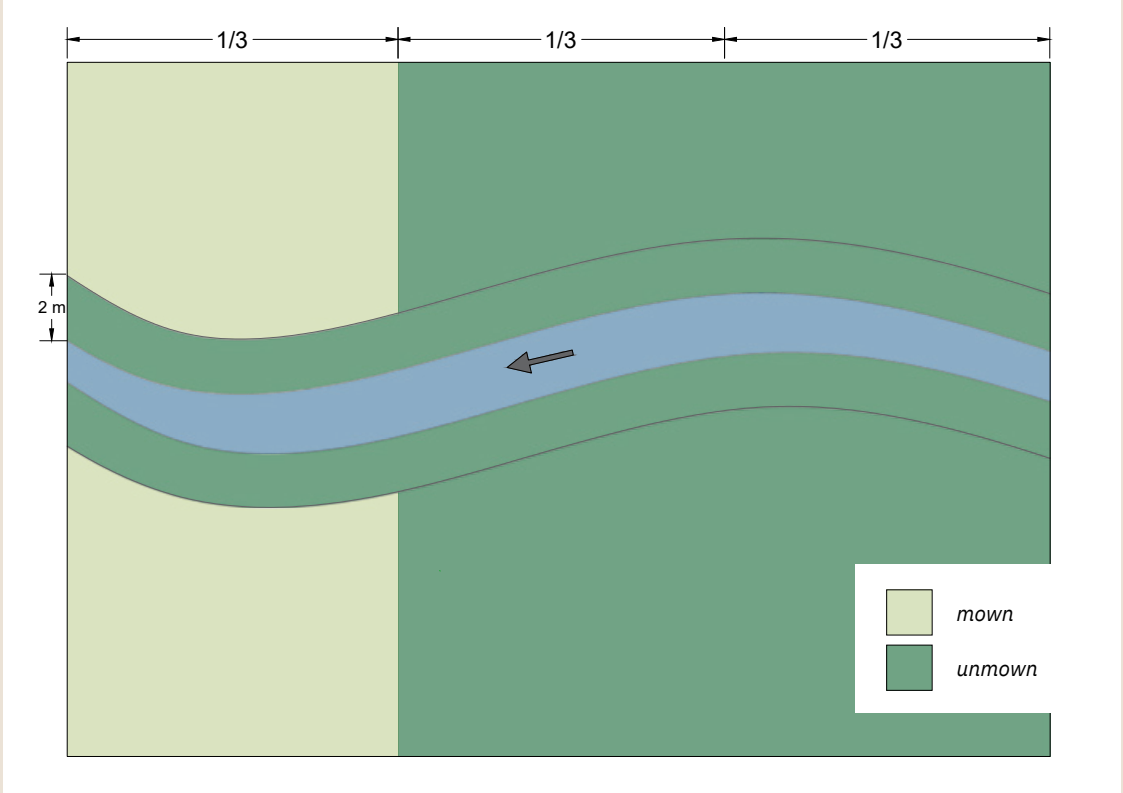
Where the presence of strictly protected butterfly species, namely the scarce large blue (*Phengaris teleius*) and/or large copper (*Lycaena dispar*), is determined, the floodplain should not be mown in the period from the beginning of June until mid-July. The execution of works may not cause a disruption in the hydrological regime of the adjacent wet habitat.

MEASURE F.25.*

Where the presence of the Alcon blue (*Phengaris alcon*), a strictly protected butterfly species, is determined, mowing in the floodplain should be undertaken after 15 September.

MEASURE F.26.*

Where the presence of the false ringlet (*Coenonympha oedippus*), a strictly protected butterfly species, is determined, mowing in the floodplain should be undertaken after 15 September applying the rotational mowing method on one third (1/3) of the area every three years.



↑ FIGURE 4.3.7 *A schematic illustration of the implementation of Measure F.26. – rotational mowing*
(Autori: Beatrica Perkec and Koni Čargonja-Reicher)

MEASURE F.27.*

Where the presence of the dusky large blue (*Phengaris nausithous*), a strictly protected butterfly species, is determined, the floodplain should be mown in the period until 15 June or after September 15.

MEASURE F.28.*

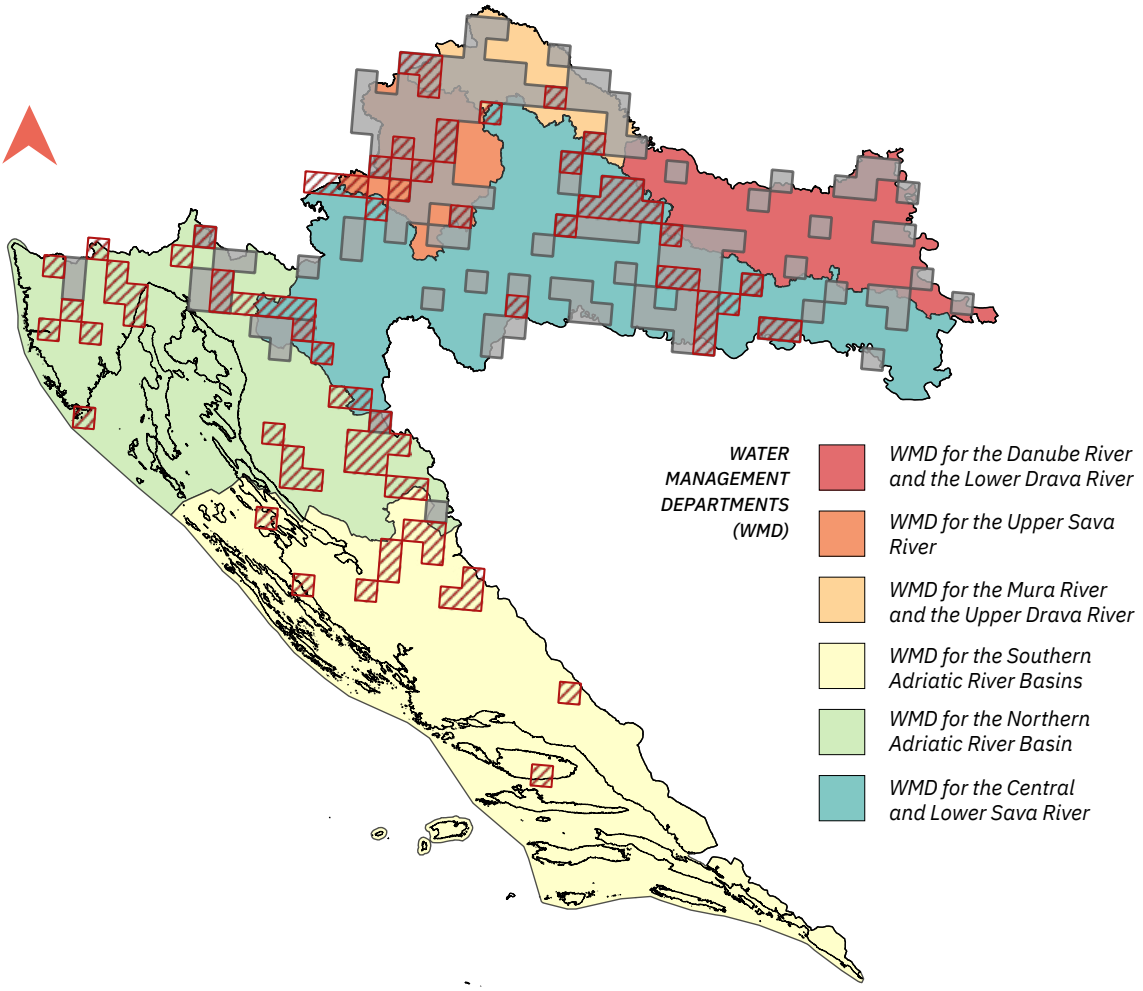
Where the presence of the scarce large blue (*Phengaris teleius*), a strictly protected butterfly species, is determined, the floodplain should be mown in the period until 15 June or after September 15.

** Measures prescribed with regard to specific sites where deemed necessary.*

MARSH FRITILLARY

LARGE COPPER

Photos taken by: Martina Šašić Kljajo



↑ FIGURE 4.3.8

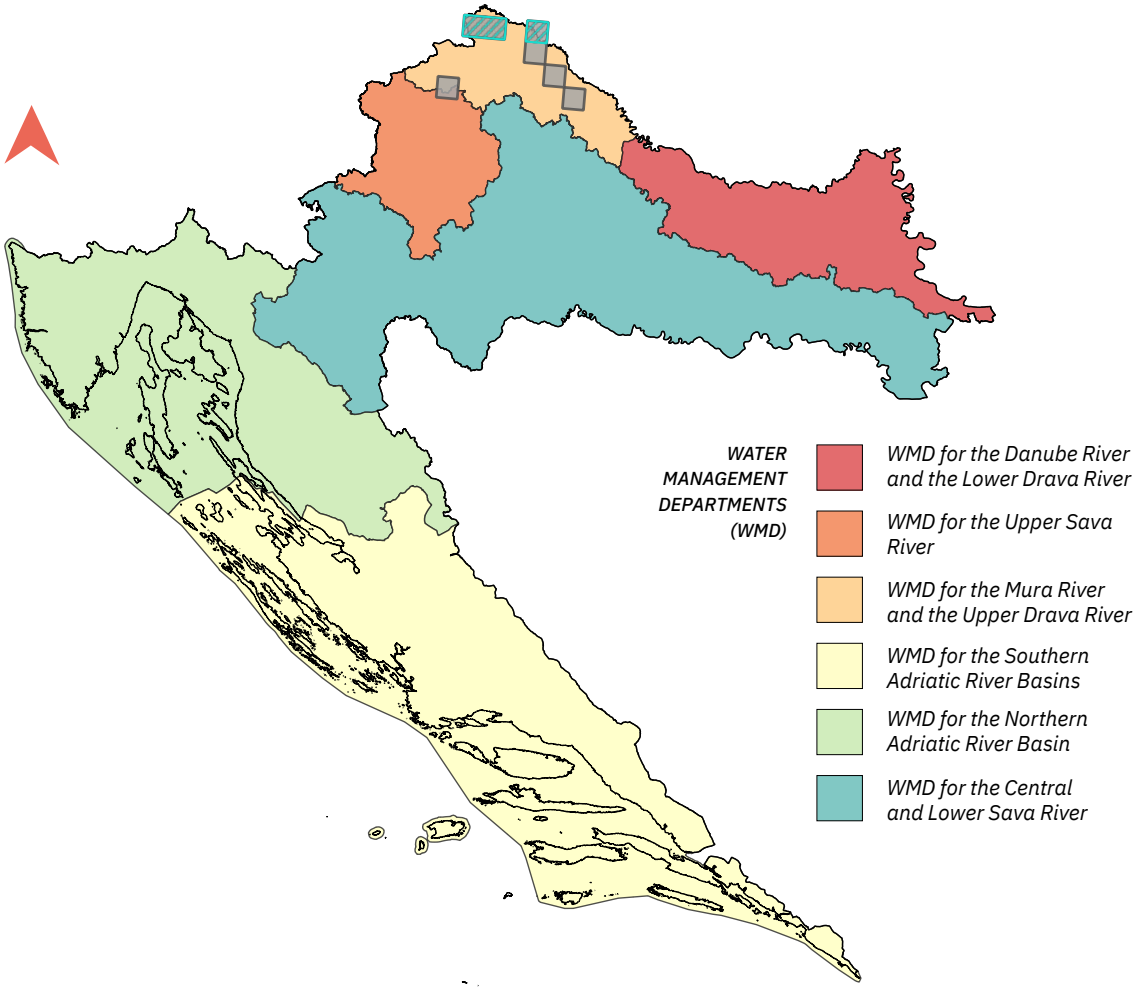
Known distribution of the marsh fritillary (Euphydryas aurinia) and large copper (Lycaena dispar) butterflies in Croatia

((Source of information: MESD 2020, prepared by: Oikon Ltd.)

SCARCE LARGE BLUE

DUSKY LARGE BLUE

Autor fotografija: Martina Šašić Kljajo

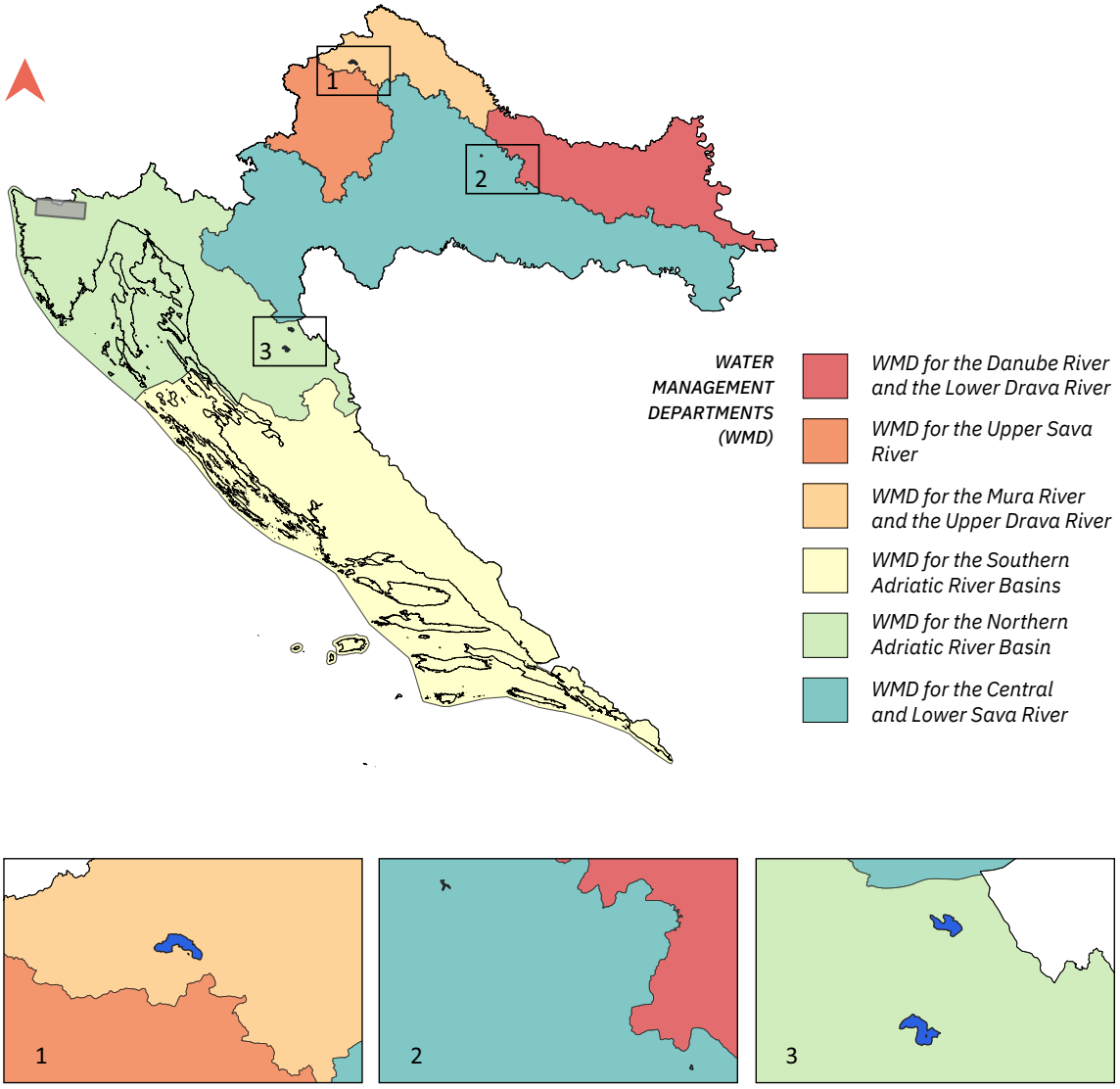


↑ FIGURE 4.3.9
Known distribution of the scarce large blue (Phengaris teleius) and the dusky large blue (Phengaris nausithous) in Croatia
(Source of information: MESD 2020, prepared by: Oikon Ltd.)

ALCON BLUE

ALSE RINGLET

Photos taken by: Martina Šašić Kljajo



↑ FIGURE 4.3.10

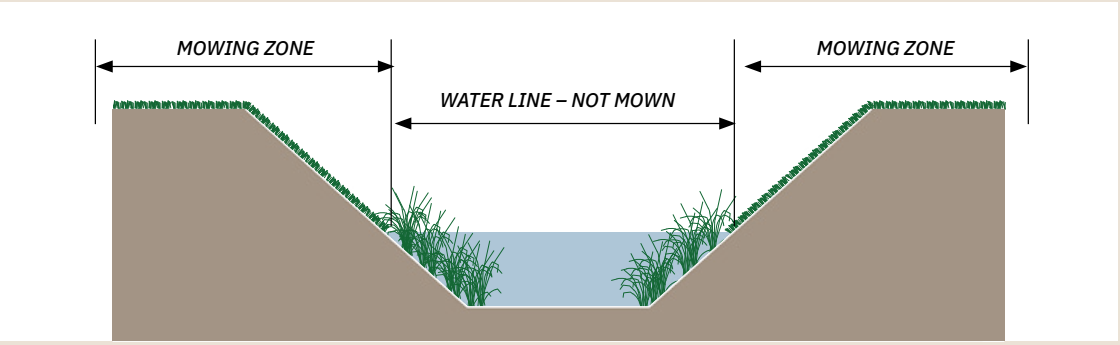
Known distribution of the false ringlet (Coenonympha oedippus) and the alcon blue (Phengaris alcon alcon) in Croatia

(Source of information: MESD 2020, prepared by: Oikon Ltd.)

CONSERVATION MEASURES – OTHER TYPES OF INVERTEBRATES

MEASURE F.30.*

Where the presence of populations of the thick-shelled river mussel (*Unio crassus*), a strictly protected shellfish species, is determined, only the area up to the water line should be mown (the bottom of the watercourse bed should be left intact).



↑ FIGURE 4.3.11 *An illustration of the implementation of Measure F.30. – the riparian vegetation is mown up to the water line, while the bottom of the watercourse bed is left intact*
(Authors: Beatrica Perkec and Koni Čargonja-Reicher)

MEASURE F.31.*

Where the presence of populations of the thick shelled river mussel (*Unio crassus*), a strictly protected shellfish species, is determined, the works in the watercourse bed must be limited to what is strictly necessary, and care should be taken to leave the sediment deposited at the bottom of the watercourse bed as undisturbed as possible.

→ FIGURE 4.3.12
The thick-shelled river mussel (Unio crassus) in a watercourse
(Source: Alexander Mrkvicka, Creative Commons License 2009)

MEASURE F.37.*

Where potential or actual presence of populations of the beetle species *Carabus variolosus* is determined, the existing alder forests growing alongside watercourses must be preserved.

→ FIGURE 4.3.13 *The Carabus variolosus beetle*
(Source: Jacek Proszyk, Creative Commons License 2018)

* Measures prescribed with regard to specific sites where deemed necessary.

MEASURE F.43.*

To ensure habitat conservation (i.e. conservation of the aquatic and riparian vegetation) and undisturbed reproduction and emergence of water insects, such as dragonflies, works in the riverbed should be performed only in the period from 15 August until 1 May.

MEASURE F.44.*

No works are permitted in watercourse sections where the presence of the water soldiers or water pineapples (*Stratiotes aloides*), a strictly protected plant species, is recorded. The purpose of the restriction is to protect the said species and to ensure the conservation of the green hawker (*Aeshna viridis*), a strictly protected dragonfly species whose life cycle is dependent on the afore-mentioned plant species.

MEASURE F.45.*

In order to conserve the habitat of the larvae of the strictly protected dragonfly species called the eastern spectre (*Caliaeschna microstigma*), vegetation should be mown only up to the water line, while the substrate and the vegetation found in the watercourse section which is under water should be left intact. More specifically, works should be undertaken in the period when the watercourse bed is completely dry.

MEASURE F.46.*

Works should be performed in the dry period. When undertaking the works, care should be taken to avoid and keep any remaining ponds, pools or puddles undisturbed in order to ensure conservation of the strictly protected species called the black pennant (*Selysiothemis nigra*).

* Measures prescribed with regard to specific sites where deemed necessary.

ADVICE

Care should be taken that maintenance works are planned in the manner that ensures existence of a favourable habitat for aquatic invertebrates at all times, i.e. a refuge habitat where the motile animals can find temporary shelter during the execution of works. More precisely, the planned works should be undertaken in different periods of time (in several phases and on short sections) and/or the works in the bed and on the banks should not be performed on both sides of the watercourse simultaneously.

Where possible, old live trees as well as dead or dying trees should be left intact, as they provide an important habitat for saproxyl coleopters.

4.3.3 Measures aimed at conserving the favourable habitat conditions for fish

Freshwater fish represent one of the best indicators of the status of aquatic ecosystems and their role in such systems is manifold. More precisely, they connect food networks and enhance the cycling of nutrients. Due to their dependence on aquatic habitats in which they live and the increasing anthropogenic pressures on such habitats, fish are one of the most endangered species of vertebrates. During their spawning season, they migrate upstream or in lateral direction towards lowland floodplains. Disruptions in watercourse connectivity are reflected in the age of the fish in a community (i.e. predominance of old specimens). Water temperature is yet another important sensitivity factor where fish are concerned. If riparian vegetation is removed, the watercourse is exposed to direct sunlight, which causes the water temperature to rise more quickly. In addition, maintenance works in aquatic environments and removal of organic material and woody debris (trees and branches) reduce the number of available spawning habitats.

The purpose of conservation measures prescribed specifically in respect of different fish species is to avoid disturbance during their spawning season. As regards the conservation measures prescribed in connection with different types of standardised work, care should be taken that, wherever applicable, Measure E.6. is implemented in order to ensure watercourse continuity and undisturbed migration of aquatic fauna.

MEASURE F.11.*

To avoid the fish spawning season, the works in watercourse beds should be undertaken exclusively in the period from September until February. The only exception are the trout waters (i.e. the salmonid spawning sites) where works should be undertaken in the following time windows:

- from 25 August to 1 December in the case of the Krka River, from the spring to the Brljansko Lake, and the Jadro, Vrljica and Žrnovnica rivers,
- from 15 August to 15 October in the case of all other trout waters.

← FIGURE 4.3.14
The European bullhead (Cottus gobio)
(Source: Oikon Ltd.)

← FIGURE 4.3.15
An example of a watercourse that provides a typical habitat for the European bullhead (Velika Belica Stream)
(Source: Oikon Ltd.)

* Measures prescribed with regard to specific sites where deemed necessary.

↑ FIGURE 4.3.16
The Adriatic trout (Salmothymus obtusirostris), a species endemic to the Adriatic River Basin
(Source: Oikon Ltd.)

↑ FIGURE 4.3.17
An example of a watercourse providing a typical habitat for the Adriatic trout (Jadro River)
(Source: Oikon Ltd.)

↑ FIGURE 4.3.18
The spotted minnow (Delminichthys adspersus), a species endemic to the Adriatic River Basin
(Source: Oikon Ltd.)

→ FIGURE 4.3.19
The Matica River – a habitat of the spotted minnow
(Source: Oikon Ltd.)

If the preliminary assessment of acceptability of a proposed water maintenance programme considering its implications for the ecological network results in the determination that certain works could bring such changes in the habitats affected which would cause major disturbance in the lives of particular endangered and very rare and/or endemic fish species, i.e. species with a rather limited distribution, the requirement to undergo the appropriate assessment procedure will be prescribed (i.e. Measure F.1.).

4.3.4 Measures aimed at conserving the favourable habitat conditions for amphibians and reptiles

Thanks to Croatia's geographic position, i.e. its location at the intersection of three biogeographical regions, an abundance of herpetofauna (amphibians and reptiles) has developed on a relatively small area, among which as many as eight species (13%) are designated as endangered (Jelić et al. 2015). The major reasons for such designations are the loss or degradation of habitats caused by anthropogenic activities, urban development, construction and use of transport infrastructure, intensification of agricultural activities, abandonment of agricultural land, and water management and use. Amphibians are the most endangered group of vertebrates and they react quickly even to the smallest changes in the environment. As such, they are considered good environmental indicators, i.e. changes in their populations may indicate the presence of adverse impacts on the environment.

Intermittent and/or premanent standing water bodies (ponds, bogs, lakes, oxbow lakes, floodplains) and/or slow-flowing watercourses (distributaries, canals, ditches, and similar) represent important habitats for amphibians in watercourse floodplains. Among the reptiles dependent on freshwater ecosystems, freshwater turtles, who spend most of their active season in rivers, streams, irrigation canals, ponds, lakes and marshes, are considered an endangered species.

MJERE OČUVANJA – VODOZEMCI

MEASURE F.15.*

For the purpose of ensuring conservation of strictly protected species, namely the Danube crested newt (*Triturus dobrogicus*) and the Italian crested newt (*Triturus carnifex*), care should be taken that the works are scheduled taking into consideration the biogeographical region where they are planned to be performed in order to protect the spawns, larvae and adult specimens in the state of hibernation. In the habitats found in intermittent and permanent standing water bodies and slow-flowing watercourses (ponds, bogs, lowland river basins, floodplains, canals, ditches, and similar), no works should be undertaken:

- in the period from 15 February to 1 October in the Mediterranean and Continental regions, and
- in the period from 1 April until 1 September in the Alpine region.

When undertaking works in the periods when execution of works is allowed, care must be taken that:

- the works are carried out in a manner that ensures conservation of wet habitats, especially the small water bodies such as ponds/pools, canals, gravel pits, roadside ditches, and similar; more precisely, such habitats should not be covered with any material, movement of the mechanical equipment should be restricted to access routes, and the water regime and mild bank slope must be preserved,

- the debris such as branches, stumps, and similar, found in the area surrounding the relevant water bodies, must be left intact to the greatest extent possible, as the crest newts hibernate on such microhabitats after emerging from the water (enter the stage in their life cycle when they live on land).

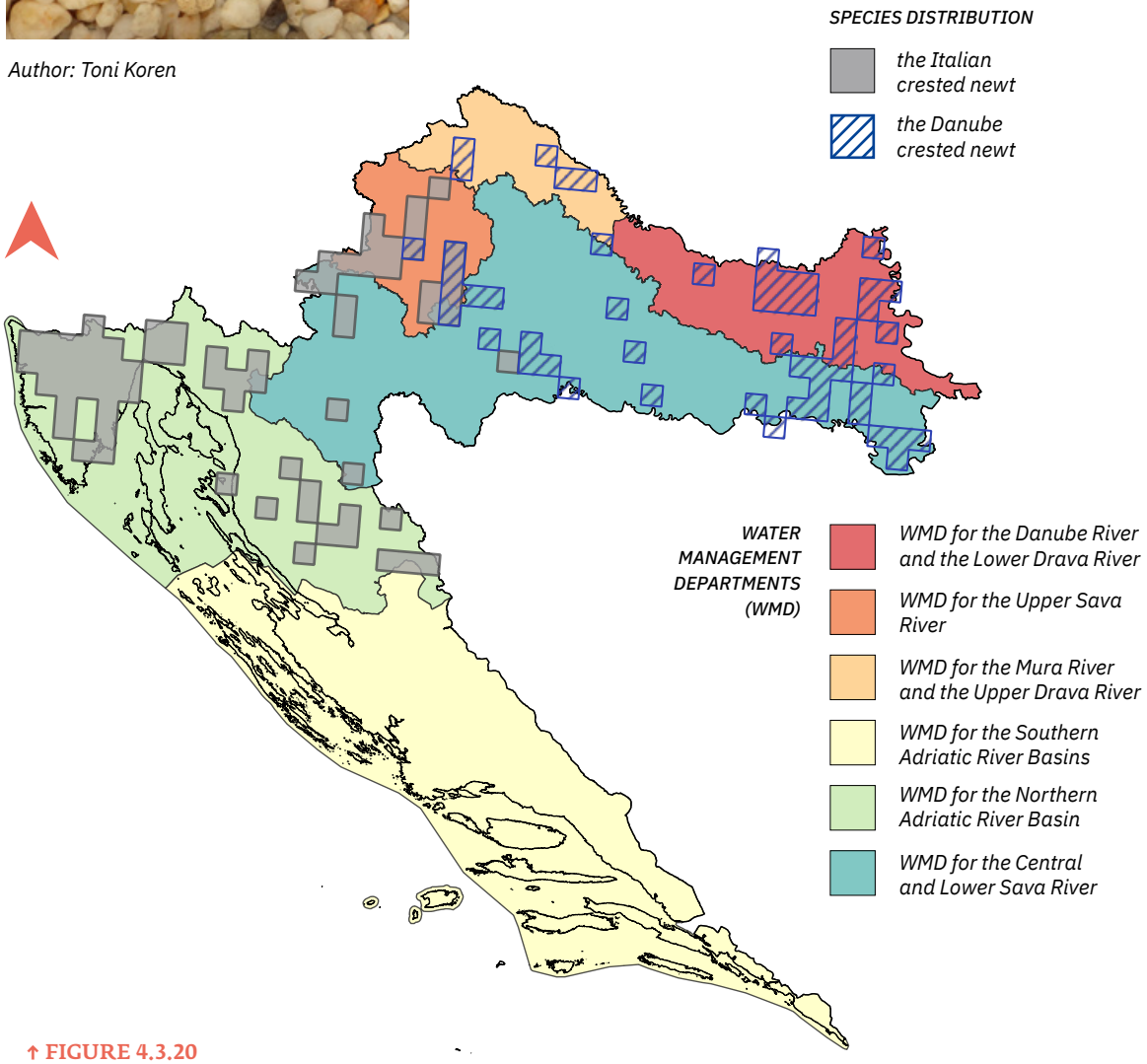
* Measures prescribed with regard to specific sites where deemed necessary.

ITALIAN CRESTED NEWT

Author: Toni Koren

DANUBE CRESTED NEWT

Author: Daria Kranželić



↑ FIGURE 4.3.20
Known distribution of crested newts in Croatia
(Source of information: MESD 2020, prepared by: Oikon Ltd.)

MEASURE F.16.*

Works are not to be carried out in the period from the beginning of April until the end of August because that is when the fire-bellied toad (*Bombina bombina*), a strictly protected species, spawns and a large number of larvae is present in aquatic habitats, such as ponds, bogs, lakes, marshes, springs, retention basins, canals, gravel pits, ruts, slow-flowing streams and rivers, and wet grasslands. When undertaking works in the period when execution is permitted, care should be taken that the works are performed in a manner that ensures conservation of the mentioned habitats, as some specimens can hibernate in the silt deposited at the bottom of such water bodies. More precisely, the habitats of this toad species should not be covered, movement of the mechanical equipment in the relevant area should be restricted to access routes, the water regime and a mild bank slope must be preserved, while the sediment found at the bottom of the water body must be left undisturbed.

MEASURE F.17.*

Works are not to be carried out in the period from the beginning of April until the end of September because that is when the yellow-bellied toad (*Bombina variegata*) spawns and a large number of larvae is present in intermittent and permanent aquatic habitats, such as ponds, forest depressions, springs, retention basins, canals, gravel pits, ruts, streams, floodplains, and riparian zones. This species hibernates in underground holes and underneath rocks and branches, which is why the works should be carried out in a manner that ensures that such habitats are conserved to the greatest extent possible: they should not be covered, movement of the mechanical equipment should be restricted to access routes, and the water regime and a mild bank slope must be preserved.

MEASURE F.18.*

Works are not to be carried out in the period from 15 February until 15 July because that is when the Italian agile frog (*Rana latastei*), a strictly protected species, spawns and its larvae are present in slow-flowing and almost standing water bodies, slow-flowing sections of meandering streams and small rivers, canals, ponds, and floodplain forests. This species prefers colder and shadowed parts of watercourses with constant wet conditions. It is therefore necessary to ensure that the riparian and aquatic vegetation in such watercourses be preserved to the greatest extent possible. The submerged branches and aquatic vegetation found in the water bodies which are to be left intact must not be disturbed, as they represent favourable microhabitats for spawning. When undertaking works in the period when execution is permitted, care must be taken that the works are performed in a manner that ensures conservation of these favourable habitats, i.e. that they are not covered, that movement of the mechanical equipment is restricted to access routes, and that the water regime and a mild bank slope are preserved.

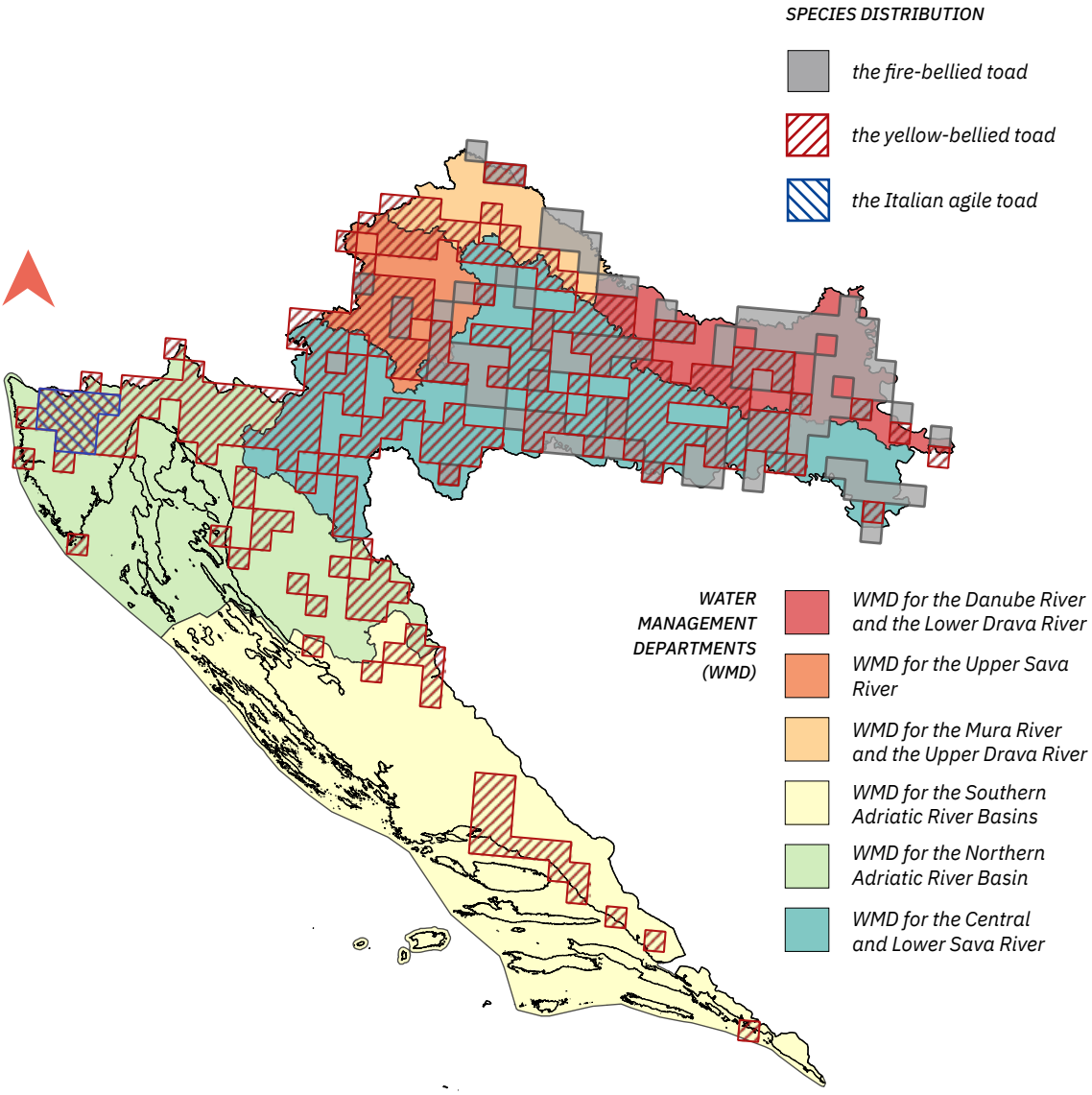
* Measures prescribed with regard to specific sites where deemed necessary.

FIRE-BELLIED TOAD

YELLOW-BELLIED TOAD

ITALIAN AGILE TOAD

Photos taken by: Bruno Schmidt



↑ FIGURE 4.3.21

Known distribution of bombinatoridae (Bombina sp.*) and the Italian agile toad (Rana latastei) in Croatia*

(Source of information: MESD 2020, prepared by: Oikon Ltd.)

In the effort to conserve important amphibian populations, **Measure P.7.** may be prescribed in addition to the general measures from Group F. as well. Where potential significance of habitats found on a particular site for this particular taxonomic group is determined, the implementation of Measure P.7. ensures t**hat the works are carried out outside the spawning season of amphibian species, i.e. in the period from 1 March until 1 July** (see ***Section 4.1.2 General measures aimed at maintaining the favourable status of natural habitats***).

CONSERVATION MEASURES – REPTILES

MEASURE F.29.1.*

With the aim of protecting and conserving the populations of the Balkan terrapin (*Mauremys rivulata*), works should not be carried out in the period from 1 April until 1 July. Also, when planning and undertaking works, a mild bank slope should be maintained on the greater stretch of the affected section to ensure free passage of the specimens onto the bank. The mowing of the riparian vegetation should be performed applying the mosaic method, as the specimens both sunbathe and hide in such vegetation, and it is also their source of food. Furthermore, the aquatic and riparian vegetation represent favourable microhabitats where young specimens can find suitable shelter. Removal of logs from the water should be minimised, as logs and other woody debris provide favourable sunbathing spots for terrapins. To ensure protection of the eggs laid in the soil in the wider area surrounding the affected water bodies, care must be taken that the worksite is mainly accessed via access and service routes.

MEASURE F.29.2.*

With the aim of protecting and conserving the populations of the European pond terrapin (*Emys orbicularis*), works should not be carried out in the period from 1 April until 1 July. Also, when planning and undertaking works, a mild bank slope should be maintained on the greater stretch of the affected section to ensure free passage of the specimens onto the bank. The mowing of the riparian vegetation should be performed applying the mosaic method, as the specimens both sunbathe and hide in such vegetation, and it is also their source of food. Furthermore, the aquatic and riparian vegetation represent favourable microhabitats where young specimens can find suitable shelter. To ensure protection of the eggs laid in the soil in the wider area surrounding the affected water bodies, care must be taken that the worksite is mainly accessed via access and service routes. Removal of logs from the water should be minimised, as logs and other woody debris provide favourable sunbathing spots for terrapins. If works are carried out in the terrapin hibernation period (October – April) it is necessary to ensure that the silt layers of the water body, i.e. their hibernation sites, are disturbed as minimally as possible.

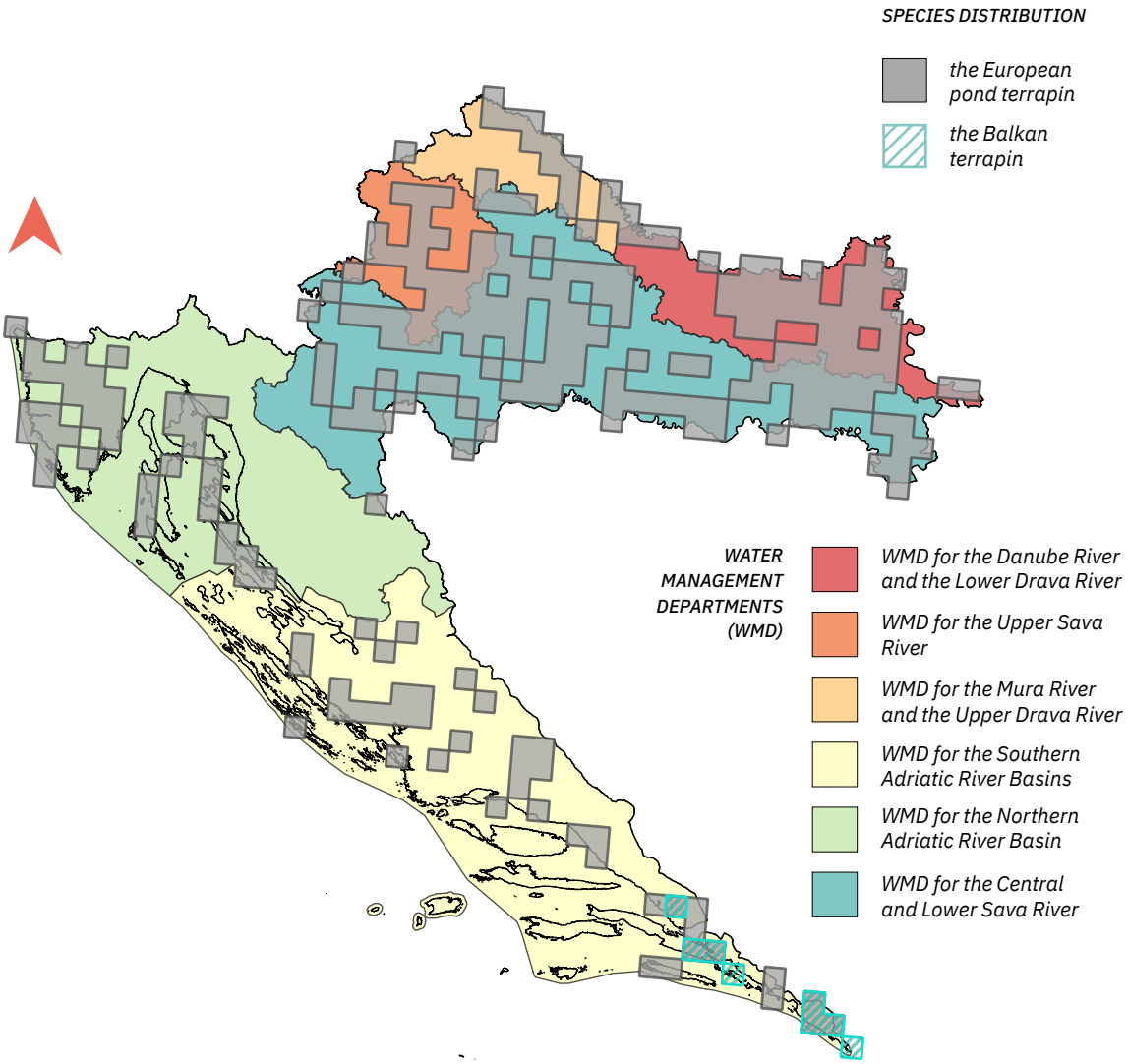
* Measures prescribed with regard to specific sites where deemed necessary.

EUROPEAN POND TURTLE

Photo taken by: Bruno Schmidt

BALKAN TERRAPIN

Photo taken by: Ana Štih Koren



↑ FIGURE 4.3.22

Known distribution of the Balkan terrapin (Mauremys rivulata) and the European pond terrapin (Emys orbicularis) in Croatia

(Source of information: MESD 2020, prepared by: Oikon Ltd.)

4.3.5 Measures aimed at conserving the favourable habitat conditions for birds

Riparian habitats are particularly important for **the common kingfisher** (***Alcedo atthis***) and the **sand martin** (***Riparia riparia***), and to somewhat lesser degree for **the bee-eater** (***Merops apiaster***). These three species use steep and eroded watercourse banks as nesting habitats. The common kingfisher and the sand martin nest on the banks directly by the watercourse, while the bee-eaters are not exclusively dependent on watercourses, as they also live in the eroded (collapsed) parts of the banks and inland pits, which may sometimes be located at quite a distance from the water bodies. The common kingfisher is a solitary nesting bird, and the nesting pair defends its territory. The nests of common kingfishers are found at the end of up to 1 m long tunnels dug in the ground. If there are branches or trees within their nesting territory, they provide a suitable spots where the common kingfisher can stand to catch prey from the water. The sand martins and the bee-eaters are more sociable and build large or small colonies along steep or eroded banks. Just as the common kingfisher, they also dig holes in the ground at the end of which they create nests.

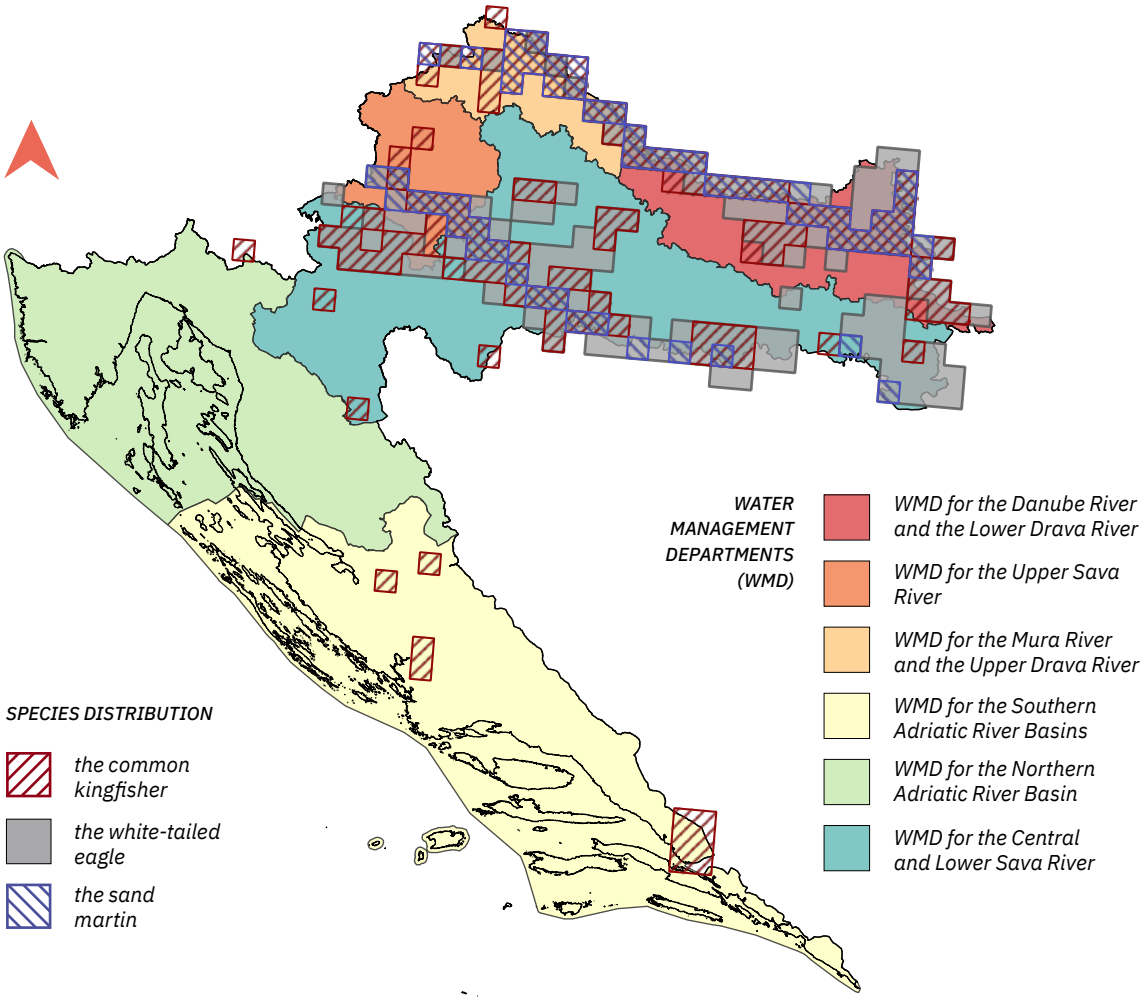
The white-tailed eagle (***Haliaeetus albicilla***) is the largest predator bird of the Pannonian lowland region. It nests alongside fresh- and saltwaters: in large marshlands, alongside large rivers and lakes, and carp fishponds. It builds its nests on high, pedunculate oak, white ash, black and white poplar, and white willow trees. It used to nest alongside the see shore, on the steep cliffs of the Kvarner islands, but that population died out in the early 20th century.

↑ FIGURE 4.3.23 *The white-tailed eagle (Haliaeetus albicilla) (Author: Ksenija Hocenski)*

↑ FIGURE 4.3.24 *The common kingfisher (Alcedo atthis) (Author: Matej Kopecki)*

↑ FIGURE 4.3.25 *The sand martin ((Riparia riparia) (Source: Frank Vassen, Creative Commons License 2015)*

↑ FIGURE 4.3.26 *A colony of sand martins (Source: Shkumbin Saneja, Creative Commons License 2008)*



↑ FIGURE 4.3.27
Known distribution of the common kingfisher (Alcedo atthis), the sand martin (Riparia riparia) and the white-tailed eagle (Haliaeetus albicilla) in Croatia
(Source of information: MESD 2020, prepared by: Oikon d. o. o.)

The European roller (***Coracias garrulus***) lives in spacious agricultural areas where it nests in the crevices and cavities of old trees. Such trees are found on the edges of forests and groves characterised by good aeration, and in planted tree lines. The nesting sites must be close to open spaces abounding in insects, such as meadows, pastures or extensively used plough-fields. In the Ravni kotari region, which is the most significant European roller nesting site in Croatia, these birds naturally nest in old poplar trees planted several decades ago to protect the crop from the effects of winds. Such tree lines are often found alongside canals managed by the water management sector.

The corncrake (***Crex crex***) primarily lives in wet hay meadows with high vegetation. It sometimes also nests in abandoned meadows, which are already in the succession stage, as well as alongside marshes and canals where thick grass vegetation stands are present. It nests in lowland Croatia, in the karst fields (*polje*) of Lika, on the glades in the mountainous region of Croatia and, although sporadically, in the karst fields (*polje*) of the Dalmatian hinterland region (Dalmatinska zagora: Paško polje, Imotsko polje).

↑ FIGURE 4.3.28 *The European roller (Coracias garrulus)*
(Source: Zeynel Cebeci, Creative Commons License 2020)

↑ FIGURE 4.3.29 THE *corncrake (Crex crex)*
(Source: Ron Knight, Creative Commons License 2013)

All species of birds, including the previously mentioned ones, are most sensitive to disturbance during the nesting season. It is precisely for that reason that the conservation measures established specifically for this group are aimed at reducing the possible causes of disturbance that may affect the individuals during the nesting season.

CONSERVATION MEASURES – BIRDS

MEASURE B.6.*

The mowing of floodplains and banks of watercourses and canals (managed by Croatian Waters) in areas where corncrakes nest should be carried out in the period from 15 August until 15 March.

MEASURE C.5.

Removal of woody vegetation should only be carried out in the period from 15 August until 31 March in order to avoid the nesting season of most bird species.

MEASURE C.6.*

If presence of the common kingfisher on a wider area is determined, the riparian vegetation should be preserved as much as possible, and the removal of trees and shrubs should be carried out only in the period from 1 September until 31 January.

* Measures prescribed with regard to specific sites where deemed necessary.

MEASURE F.7.

If colonies (clusters of active nests) of strictly protected bird species (e.g. sand martins, bee-eaters, and others) are found at a particular worksite, the works must be discontinued and a quiet, undisturbed zone extending within the radius of 250 m upstream and downstream of the site must be secured until the end of the nesting season. In that case, it is also required to notify the competent public institutions for the management of protected areas and ecological network sites, the nature protection inspection and the Ministry, and all further actions should be taken in agreement with those institutions.

With the aim of preventing disturbance during the nesting season of the white-tailed eagle, the obligation to ensure a complete movement restriction within the radius of 500 m from the eagle's nest in the period from 1 January until 15 July must be rigorously enforced. In the quiet zone, works can be carried out only outside the nesting season and they must be carried out in a way that does not result in deterioration of habitat conditions within the radius of 100 m upstream and downstream of the bird colony, and the radius of 200 m from the nest of the white-tailed eagle.

MEASURE F.21.*

The works should be carried out outside the nesting season of the European roller (*Coracias garrulus*), a strictly protected species. More precisely, they should be carried out in the period from 15 August until 30 April. Furthermore, to ensure protection and conservation of this species, old poplar trees growing along the watercourses and/or canals should not be removed. Once they naturally die and fall, they should be, if possible and in cooperation with the competent public institution, replaced with seedlings of native poplar species.

(!) NOTES REGARDING THE IMPLEMENTATION OF MEASURE F.21.

This measure is prescribed in connection with the works planned to be executed in the region of Bokanjačko blato, Ravni kotari and Sinjsko polje, i.e. exclusively within the European roller distribution (flood protection areas BP 26., 27. and 28.).

* Measures prescribed with regard to specific sites where deemed necessary.

4.3.6 Measures aimed at conserving the favourable habitat conditions for mammals – beavers and otters

Beavers and otters are among the main species of mammals monitored as environmental indicators in connection with the status of aquatic and wetland habitats.

The Eurasian otter *(Lutra lutra)* is a timid animal from the family of martens active mainly at night. Its presence can be determined based on its droppings (spraint), paw prints, remains of prey and its den (holt). Otters often leave their droppings on elevated locations under or close to bridges, on fallen trees, by the water, in the transitional zone between the bank slope and the high section of the bank, or around the ditches between aquatic habitats. Their spraint is easy to recognise and most frequently contains fish bones and scales or the exoskeletons of crustaceans, and it smells like fish oil. The colour of the spraint varies from light yellow to almost black. The otters usually leave their droppings on high and visible locations, such as protruding rocks or large woody debris. Otters mark their territories with a jelly-like secretion released from their anal glands that has an intense fish smell, which they leave in places similar to those where they leave their droppings (Jelić 2010). Their paw prints may be found impressed in soft substrates, such as mud or snow. Otters dig their dens (holts) usually inbetween the roots of the trees growing near the water. They built several types of dens: shelters, holts (couches), and natal (maternity) dens. Shelters are usually very shallow holes dug in the banks that the otter occasionally uses to hide or rest; holts (couches) are generally found deeper underground, have a tunnel and a wider area at the end; while natal (maternity) dens are often found at a certain distance from the water (even up to 1 km). Actively used holts differ from those which are not actively used primarily in that they show evidence of fresh paw prints at the entrance, freshly trampled path from the water body to the entrance into the holt, and sometimes it may also possible to smell the otter at the entrance into the holt. Otters are widely distributed in aquatic habitats of continental and mountainous regions of Croatia. In the Mediterranean region, it is present in the Zrmanja and Krka Rivers, and their tributaries (Jelić 2020; Jelić 2013).

↑ FIGURE 4.3.30 *An otter's paw print*
(Author: Vedran Slijepčević)

↑ FIGURE 4.3.31 *Entrance into an otter's holt*
(Source: Oikon Ltd.)

↑ FIGURE 4.3.32 *Entrance into an otter's holt*
(Source: Oikon Ltd.)

↑ FIGURE 4.3.33 *An otter's spraint*
(Source: Oikon Ltd.)

The Eurasian beaver *(Castor fiber)* can be found in the forest-covered lowland areas with lakes, marshes, small rivers, and oxbow lakes, as well as in and around canals and artificial lakes surrounded by willows and poplar trees. The animal avoids large rivers with strong currents and significant fluctuations in water level. Beavers are a semi-aquatic species requiring constant water depth of more than 30 cm or the possibility to build a dam if the water level drops. It is a terrestrial species that lives in families comprising a male, a female, last year's and this year's young. It marks its territory using the intensely smelling anal gland secretion, which it usually leaves at locations where it comes out of the water and on logs. A beaver's lodge may be a mound or a pit with at least two, and usually four to five underwater entrances, while the upper area is usually found at the height of 20 cm above water level. Beavers build their aboveground lodges from wood, soil, sand and other material available in locations where the difference in altitude between the ground level and the water level is small. Pits are underground dens built in places where the bank is high enough (bank dens). The signs indicating activity inside a beaver's den are as follows: paw prints in the mud in the immediate vicinity of the den, fresh mud and branches/twigs found on the den, and evidence of mud in different parts of the den (muddy branches/twigs). Characteristic signs include paw prints in the mud or snow near the exit hole, exit ditches leading onto banks, gnawed and felled trees, aboveground lodges (mounds and dams) (Grubešić 2008).

↑ FIGURE 4.3.34
An illustration of a beaver's paw print
(Author: Matej Kopecki)

↑ FIGURE 4.3.35
A beaver's droppings
(Source: Oikon Ltd.)

← FIGURE 4.3.36
A beaver's lodge (mound)
(Source: Oikon Ltd.)

↑ FIGURE 4.3.37
Evidence of a beaver's activity on a tree
(Source: Oikon Ltd.)

↑ FIGURE 4.3.38
A dam built by a beaver
(Author: Vedran Slijepčević)

With the aim of **conserving the favourable habitat conditions for beavers and otters in aquatic ecosystems and preventing disturbance, injury or death of individual specimens**, specific conservation measures are prescribed.

CONSERVATION MEASURES – MAMMALS (BEAVERS, OTTERS)

MEASURE F.5.

If an active lodge or dam built by a beaver is found, the works must be discontinued within the area that extends 200 m upstream and downstream of the lodge/barrier.

If an activity which is not allowed to be carried out at sites where strictly protected species are found (e.g. deliberate disturbance, activities by which the breeding or resting areas are deliberately damaged or destroyed) must be performed in order to continue the works, a permission from the competent authority for nature protection must be obtained and complied with.

Heavy mechanical equipment may not be used in the vicinity of an actively used lodge, and only small groups of workers are allowed to pass near it.

MEASURE F.6.

If an actively used otter's holt is found, the works must be discontinued within the area that extends 100 m upstream and downstream of the holt.

If an activity which is not allowed to be carried out at sites where strictly protected species are found (e.g. deliberate disturbance, activities by which the breeding or resting areas are deliberately damaged or destroyed) must be performed in order to continue the works, a permission from the competent authority for nature protection must be obtained and complied with.

Heavy mechanical equipment may not be used in the vicinity of an actively used den, and only small groups of workers are allowed to pass near it.

4.3.7 Measures aimed at preventing the introduction and spread of invasive alien species

An alien species is a non-native species that is not naturally found in a particular ecosystem, which has nevertheless been or may be introduced into such ecosystem deliberately or accidentally. Invasive alien species (hereinafter referred to as "IAS") are those alien species that have become naturalised thanks to their ability to spread quickly and far, and their exceptional ability to regenerate. Invasive alien species may have numerous adverse effects on the native species and ecosystems, as they cause changes in the structure and quality of habitats. Finally, they may even push out the native species from their natural ranges through the process of competition, spread of diseases and hybridisation.

↑ FIGURE 4.3.39 *Location: LK Vagovina – a canal (↖left) densely covered with an aquatic IAS – floating primrose-willow (Ludwigia peploides)s (↗right); a stand of the floating primrose-willow marked by the white arrow (Source: Hyla Association)*

The machinery and other mechanical equipment used in the execution of maintenance works may be the cause (or pathway) of introduction and spread of invasive alien plants and animals. The spreading of IAS in watercourses and floodplain habitats may even be accelerated by the natural drift processes and flooding of the floodplain. Improperly executed maintenance works (particularly mowing) may result in significant localised degradation of natural habitats extending along watercourses, thus making room for the spread of invasive alien plant species with the ability to quickly develop thick stands and, in doing so, change the species composition and structure of the habitat.

← FIGURE 4.3.40
The signal crayfish (Pacifastacus leniusculus), an invasive alien decapod (Author: Matej Faller)

CONSERVATION MEASURES – INVASIVE ALIEN SPECIES

MEASURE F.12.1.*

Alien species must be actively removed. The list and information about the distribution of invasive alien species (IAS) is available on: https://invazivnevrste.hr/.

Invasive alien species, including:

- common milkweed (*Asclepias syriaca*),
- IAS from the genus Impatiens: Himalayan balsam (*Impatiens glandulifera*), Balfour's touch-me-not (*I. balfourii* Hooker f.), small balsam (*I. parviflora* DC.),
- velvetleaf (*Abutilon theophrasti* Medik),
- IAS from the genus Amaranthus: common tumbleweed (*Amaranthus albus* L.), low amaranth (*A. deflexus* L.), green amaranth (*A. hybridus* L.), red-rooted amaranth (*A. retroflexus* L.),
- common ragweed (*Ambrosia artemisiifolia* L.),
- Chinese mugwort (*Artemisia verlotiorum* Lamotte),
- devil's beggarticks (*Bidens frondosa* L.),
- paper-milberry (*Broussonetia papyrifera* (L.) Vent.),
- butterfly-bush (*Buddleja davidii* Franch.),
- rounded chamomile (*Chamomilla suaveolens* (Pursh) Rydb.),
- Mexican tea (*Chenopodium ambrosioides* L.),
- IAS from the genus Conyza: Canadian fleabane (*Conyza canadensis* (L.) Cronquist), tall fleabane (*C. sumatrensis* (Retz.) E.Walker),
- field dodder (*Cuscuta campestris Yuncker*),
- thorn apple (*Datura stramonium* L.),
- wild cucumber (*Echinocystis lobata* (Michx.) Torr. et Gray),
- Indian goosegrass (*Eleusine indica* (L.) Gaertn.),
- fringed willow-herb (*Epilobium ciliatum* Raf.),
- annual fleabane (*Erigeron annuus* (L.) Pers.),
- IAS from the genus Euphorbia: spotted sandmat (*Euphorbia maculata* L.), prostrate sandmat (*E. prostrata* Aiton),
- IAS from the genus Galinsoga: common quickweed (*Galinsoga ciliata* (Raf.) S.F.Blake), lesser quickweed (*G. parviflora* Cav.),
- Jerusalem artichoke (*Helianthus tuberosus* L.),
- path rush (*Juncus tenuis* Willd.),

- Virginia pepperweed (*Lepidium virginicum* L.),
- common evening-primrose (*Oenothera biennis* L.),
- witchgrass (*Panicum capillare* L.),
- fall panicgrass (*Panicum dichotomiflorum* Michx.),
- Virginia creeper (*Parthenocissus quinquefolia* (L.) Planchon),
- American pokeweed (*Phytolacca americana* L.),
- cutleaf coneflower (*Rudbeckia laciniata* L.),
- IAS from the Solidago genus: Canadian goldenrod (*Solidago canadensis* L.), giant goldenrod (*S. gigantea* Aiton),
- Johnson grass (*Sorghum halepense* (L.) Pers.),
- bird's eye speedwell (*Veronica persica* Poir.),
- IAS from the genus Xanthium: spiny cocklebur (*Xanthium spinosum* L.) and common cocklebur (*X. strumarium* L. ssp. *italicum* (Moretti) D. Löve)

must be removed **by mowing** the invaded area during springtime, i.e. in the period from **15 May until 15 June**, and late summer, i.e. in the period from *15 August until 15 September*.

MEASURE F.12.2.*

If the mechanical equipment used to perform works in the bed of a watercourse where invasive alien species have been identified (the list and distribution of invasive alien species are available on: https://invazivnevrste.hr/**) is to be relocated and used on other watercourses or sections of the same watercourse where such invasive alien species have not been identified, the following precautionary measures should be taken:

1. the equipment used in the execution of maintenance works must be cleaned from silt and vegetation,
2. the machines and other equipment must be checked in order to determine whether there are any animals and/or vegetation (shellfish, snails, etc.) left and, if there are, they must be removed,
3. the equipment must be kept in a dry location for at least four weeks before being transported to some other watercourse (if this is not possible, the contaminated equipment must be thoroughly washed using hot pressurized steam),
4. the equipment used in such watercourses where presence of invasive alien decapods has been determined (e.g. spiny-cheek crayfish (*Orconectes limosus*), the signal crayfish (*Pacifastacus leniusculus*), the marbled crayfish (*Procambarus fallax*

f. *virginalis*)) must be thoroughly dried after use in order to prevent the spread of crayfish plague into other watercourses in which alien crustaceans are not present.

If alien and/or invasive alien species have been identified in a water body, work execution should be scheduled so that the planned activities are first performed on the furthest upstream section moving downstream to the furthest downstream section of the relevant water body in order to prevent upstream spreading.

* Measures prescribed with regard to specific sites where deemed necessary.

** The list of invasive alien freshwater species and their known distribution – see ***Annex 6.1. Invasive alien freshwater invertebrates and aquatic plants present in Croatia***

Invasive alien plant species frequently found along watercourse banks, in the floodplains and/or in the transitional zones ("the edge") extending towards agricultural areas: **false indigo** (*Amorpha fruticosa*), **knotweeds** (*Reynoutria japonica, R. sachalinensis, R.* x *bohemica),* **goldenrods** (giant goldenrod (*Solidago gigantean*) and Canadian goldenrod (S. *canadensis*)), **common milkweed** (*Asclepias syriaca*), **ash-leaved maple** (*Acer negundo*), **common ragweed** (*Ambrosia artemisiifolia*), **wild cucumber** (*Echinocystis lobata*), **annual fleabane** (*Erigeron annus*), **Jerusalem artichoke** (*Helianthus tuberosus*), **Himalayan balsam** (*Impatiens glandulifera*), **American pokeweed** (*Phytolacca americana*), **cutleaf coneflower** (*Rudbeckia laciniata*), and **spiny cocklebur** (*Xanthium spinosum*).

Important invasive alien aquatic plants that frequently form thick clusters in the water: **Canadian waterweed** (*Elodea canadensis*), **floating primrose-willow** (*Ludwigia peploides*), **Nuttall's waterwee** (*Elodea nuttallii*), **Brazilian waterweed** (*Egeria densa*), and **water lettuce** (*Pistia stratiotes*).

Important invasive alien species of invertebrates that can be relatively easily noticed macroscopically: **spiny-cheek crayfish** (*Orconectes limosus*), **marbled crayfish** (*Procambarus virginalis*), **signal crayfish** (*Pacifastacus leniusculus*), **zebra mussel** (*Dreissena polymorpha*), **Asian freshwater clam** (*Corbicula fluminea*), and **Chinese pond mussel** (*Sinanodonta woodiana*).

Other **invasive alien invertebrates**, i.e. species from the following orders: Amphipoda (*Echinogammarus ischnus, Dikerogammarus villosus, Dikerogammarus bispinosus, Dikerogammarus haemobaphes, Chelicorophium curvispinum*), Mysidacea (*Hemimysis anomala, Katamysis warpachowskyi, Limnomysis benedeni*), and Isopoda (*Jaera istri*).

Important invasive alien fish species, i.e. the invasive Ponto-Caspian gobies: **monkey goby** (*Neogobius fluviatilis*), **round goby** (*Neogobius melanostomus*), (big-head) **Kessler's goby** (*Ponticola kessleri*), and **racer goby** (*Babka gymnotrachelus*).

In Croatia, these species are spreading upstream along large lowland rivers belonging to the Danube River Basin.

In addition to the applicable general measures (F.12.1.*, F.12.2.*), when undertaking standardised works that refer to mowing, selective cutting and renovation of regulation structures, Conservation Measures B.7., C.9., and E.5. are also prescribed. Their purpose is to reduce the risk of introduction or further spread of invasive alien plants.

ADVICE

More information about the invasive alien species, their characteristics and distribution is available via the **invasive alien species portal** in Croatia: https://invazivne vrste.hr/.

In 2020, the Ministry of Economy and Sustainable Development introduced a system for reporting new invasive alien species via a mobile application, i.e. **Invazivne vrste u Hrvatskoj** (Invasive Species in Croatia), which is available for IOS and Android devices, and can be downloaded for free from *App Store* and *Google Play*.

If possible, the invasive plant species should be removed from the worksite before commencing work. Considering that different invasive alien plant species have different ecological and biological needs, successful removal must be ensured by implementing the methods deemed suitable taking into account the specific needs of each individual species (see Annex 2).

MOBILE APPLICATION
Invasive Species in Croatia

Google Play

App Store

PORTAL
https://invazivnevrste.hr

Recommended methods for removing the most frequently encountered invasive alien plant species

Most invasive alien plant species should be removed before they start producing fruit (seeds). All invasive alien species can be mown or cleared several times a year. It is, however, recommended that most of such plant species be mown at least two times a year, i.e. in spring and in autumn, in accordance with the time frames defined by Measure F.12.1.*.

In addition to removing invasive alien plant species by mowing or clearing, the relevant conservation measures also include the requirement of "proper disposal". This means that the biomass left after mowing/cutting or clearing, which contains invasive alien plant cuttings, should be removed from the site and transported on a tarpaulin or in thick plastic bags to a suitable landfill or composting area. The vegetative parts of the plants and those that have not yet flowered may be composted on site, i.e. they may be left to dry in the air or covered.

However, if the species which is being removed reproduces vegetatively, the collected biomass must be placed on a tarpaulin, or some other impermeable base material, so that it does not touch the ground. Before leaving the site, the mechanical equipment must be thoroughly cleaned, i.e. there may not be any soil left on it which could contain seeds and parts of the removed plants. If possible, all remaining dirt should be washed out.

Considering that the fruits and vegetative parts of some species may be spread by water, it should be envisaged that the mown or cleared biomass be disposed of as far away from the watercourse and the floodplain as possible.

An overview of invasive alien plant species that are most frequently found alongside watercourses, in the floodplains and/or in the transitional zone, which extends towards the agricultural areas, is provided below, along with the recommended methods of removal.

FALSE INDIGO
(Amorpha fruticosa)

The false indigo bush (***Amorpha fruticosa***) should be removed **mechanically** (**by cutting**) before the fruit production phase (i.e. **before 1 August**). Once removed, the parts that have been cut or pulled out must be disposed of safely (i.e. in a location where it can be ensured that the vegetative parts of the plant are physically separated from the soil and removed outside the floodplain) considering that the uprooted plants are still able to reproduce vegetatively for some time and, if disposed of in the vicinity of a watercourse, they may be transported downstream where new populations may consequently be established.

Although one-time removal is not sufficient to completely eradicate this species, considering that it can grow from the remaining underground parts, repeated localised removal efforts may eventually lead to permanent removal.

Where applicable, it is also recommended, after removing this invasive plant and disposing of the resulting biomass, that the affected area be grazed by animals in order to maintain it and prevent reestablishment.

↑ FIGURE 4.3.41 *False indigo bush, false indigo or bastard indigo bush (Amorpha fruticosa);* UP *in bloom,* MIDDLE *the habitat,* DOWN *a stand*
(Source: Oikon Ltd.)

COMMON COCKLEBUR
(*Xanthium strumarium* ssp. *italicum*)

The spread of t**he common cocklebur** (***Xanthium strumarium* ssp. *italicum***) should be controlled by employing mechanical methods (mowing). More precisely, it should be mechanically removed before the fruit production phase.

← FIGURE 4.3.42 *The common cocklebur (Xanthium strumarium* ssp. *italicum) (Source: Oikon Ltd.)*

COMMON MILKWEED
(*Asclepias syriaca*)

The common milkweed *(Asclepias syriaca)* is mainly found in habitats along river embankments. The recommended control method is repeated cutting of aboveground parts before pollination. It can also be mown and uprooted.

Besides through a combination of mechanical and chemical methods, this species can also be effectively eradicated mechanically, i.e. by repeated mowing every 2 to 3 weeks during its vegetative season.

Considering its capacity for vegetative reproduction, the cuttings of the common milkweed must be disposed of safely, i.e. in a safe location, to prevent further spread by water and consequently the development of roots (propagation).

↖ FIGURE 4.3.43 *The common milkweed (Asclepias syriaca) (Source: Oikon Ltd.)*

ASH-LEAVED MAPLE
(Acer negundo)

The recommended method for controlling the spread of **the ash-leaved maple** (***Acer negundo***) is to mow the seedlings and young plants before the fruit (seed) development phase (i.e. before 15 August), or to cut mature trees.

← ↑ FIGURE 4.3.44
The ash-leaved maple (Acer negundo)
(Source: Oikon Ltd.)

WILD CUCUMBER
(Echinocystis lobata)

The spread of **the wild cucumber** (***Echinocystis lobata***) can be effectively controlled by employing mechanical methods over several consecutive seasons, while taking care that removal is undertaken before the plant starts developing fruit, as the seeds may be successfully transported by water.

Considering that the blooming period of this species lasts from June to October, the first mowing cycle should already be carried out in June, or even earlier (15 May – 15 June).

→ FIGURE 4.3.45
The wild cucumber (Echinocystis lobata)
(Source: Oikon Ltd.)

KNOTWEEDS

(*Reynoutria japonica*, R. *sachalinensis*, R. *x bohemica*)

One of the ways in which the species from the genus **Reynoutria** (***Reynoutria japonica, R. sachalinensis, R. x bohemica***) could be effectively removed is by cutting the thick clone stands of those species several times during the season in combination with the uprooting, i.e. pulling out the shoots immediately after cutting. To ensure eradication, this method would have to be implemented systematically over a period of several years.

Just as in the case of **the false indigo** (***Amorpha fruticosa***), small fragments of underground stems (rhizomes) left in the soil after the plant is pulled out present a problem in the efforts to control the spread of this species, as very soon such small parts can develop into new, vital plants. The knotweeds which reproduce in Europe primarily vegetatively present an even bigger problem in that regard. This is precisely why uprooting instead of mulching is recommended as the best control method for this species.

The resulting biomass must be disposed of properly, i.e. outside the floodplain, and it may not get into direct contact with the soil.

↘ FIGURE 4.3.46
The giant knotweed or bohemian knotweed (Reynoutria × bohemica); photo, right down – a stand ((Source: Oikon Ltd.)

CUTLEAF CONEFLOWER
(Rudbeckia laciniata)

The spread of **the cutleaf coneflower** (***Rudbeckia laciniata***) may be controlled employing the mechanical method of removing the plant's shoots from the ground. However, this method is effective only on small areas because it stimulates the germination of the achenes resting on the ground. In any case, removal must be performed repeatedly before the fruit development phase.

→ FIGURE 4.3.47
The cutleaf coneflower (Rudbeckia laciniata)
(Source: Oikon Ltd.)

HERBACEOUS PLANTS:

ANNUAL FLEABANE *(Erigeron anuus)*

DEVIL'S BEGGARTICKS *(Bidens frondosa)*

COMMON RAGWEED *(Ambrosia artemisiifolia)*

GOLDENRODS *(Solidago gigantea, Solidago Canadensis)*

To control the spread of herbaceous plants: **the annual fleabane** (***Erigeron annuus***), **the devil's beggarticks** (***Bidens frondosa***), **the common ragweed** (***Ambrosia artemisiifolia***), and **the goldenrods** (***Solidago gigantea, Solidago Canadensis***), care must be taken that they are regularly mown before the fruit development phase. The first mowing cycle should be carried out already in June or even earlier (in the period from 15 May until 15 June).

↖ FIGURE 4.3.48 *The annual fleabane (Erigeron anuus)*
(Source: Oikon Ltd.)

↖ FIGURE 4.3.49
The devil's beggarticks (Bidens frondosa)
(Source: Oikon Ltd.)

← FIGURE 4.3.50
Giant or early goldenrod (Solidago gigantea)
(Source: Oikon Ltd.)

JERUSALEM ARTICHOKE
(Helianthus tuberosus)

The Jerusalem artichoke (***Helianthus tuberosus***) can be effectively controlled if mown two times a year during summer for several years in a row. In addition to this method, it is also advisable to remove young plants in their early sprouting phases (by mulching).

This species spreads only through its vegetative propagule, i.e. the bulb, particularly when the water level is high and during floods. Therefore, when implementing control measures in relation to this species, it should be checked whether the bulb may have been left in the ground.

↗ FIGURE 4.3.51 *The Jerusalem artichoke (Helianthus tuberosus)*
Source: Oikon Ltd.w)

HIMALAYAN BALSAM
(Impatiens glandulifera)

The Himalayan balsam (***Impatiens glandulifera***) spreads through seeds that are successfully distributed by flowing waters. It is therefore recommended that the spread of this species be controlled by mowing or other mechanical removal methods of specimens before the fruit development phase.

It blooms during July and August. It is therefore recommended that the first mowing or clearing cycle be undertaken before the blooming season.

← FIGURE 4.3.52 *The Himalayan balsam (Impatiens glandulifera)*
(Source: Oikon Ltd.)

AMERIČKI KERMES
(Phytolacca americana)

The recommended method for controlling the spread of the American pokeweed (***Phytolacca Americana***) is uprooting, i.e. pulling out the plants from the ground together with their roots (mulching) consecutively during the period of 1 to 2 years.

↓ FIGURE 4.3.53 *The American pokeweed (Phytolacca americana)*
(Source: Oikon Ltd.)

5 Sources of Information

Legislative Framework

NATIONAL LEGISLATIVE FRAMEWORK

1. Decision to Adopt the 2016 - 2021 River Basin Management Plan (OG No. 66/2016)
2. Decision on the List of Waters of the 1st Order (OG No. 79/2010)
3. Rulebook on Conservation Objectives and Conservation Measures for Bird Target Species at Ecological Network Sites (OG No. 25/2020, 38/2020)
4. Rulebook on Conservation Objectives and Conservation Measures for Target Species and Habitat Types at Ecological Network Sites (OG No. 111/2022)
5. Rulebook on the List of Habitat Types and Maps (OG No. 27/2021)
6. Regulation on the Ecological Network and Authority of Public Institutions for the Management of Ecological Network Sites (OG No. 80/2019)
7. Regulation on Environmental Impact Assessment (OG No. 61/2014, 3/2017)
8. Regulation on Water Quality Standards (OG No. 96/2019)
9. Water Act (OG No. 66/2019, 84/2021)
10. Environmental Protection Act (OG No. 80/2013, 153/2013, 78/2015, 12/2018, 118/2018)
11. Nature Protection Act (OG No. 80/2013, 15/2018, 14/2019, 127/2019)

EU LEGISLATIVE FRAMEWORK

1. DIRECTIVE 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (codified version) (OJ L 20, 26/01/2010), as last amended by Council Directive 2013/17/EU of 13 May 2013 adapting certain directives in the field of environment, by reason of the accession of the Republic of Croatia (OJ L 158, 10/06/2013) ("Birds Directive")
2. Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22/07/1992), as last amended by Council Directive 2013/17/EU of 13 May 2013 adapting certain directives in the field of environment, by reason of the accession of the Republic of Croatia (OJ L 158, 10/06/2013) ("Habitats Directive")
3. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy ("Water Framework Directive") (OJ L 327, 22/12/2000)
4. DIRECTIVE 2011/92/EU of the European Parliament and of the Council on the assessment of the effects of certain public and private projects on the environment (OJ L 26, 28/01/2021)

General Handbooks and Sources of Information

1. Addy S., Cooksley S., Dodd N., Waylen K., Stockan J., Byg A., Holstead K. (2016): River Restoration and Biodiversity: Nature-based solutions for restoring rivers in the UK and Republic of Ireland, IUCN NCUK and CREW.
2. Alegro A. (2013): *Nacionalni programi za praćenje stanja očuvanosti vrsta u Hrvatskoj: Chouardia litardierei (Breistr.) Speta* (National Programmes for Monitoring the Conservation Status of Species in Croatia: *Chouardia litardierei (Breistr.) Speta*), State Institute for Nature Protection, Zagreb.
3. Antolović J., Frković A., Grubešić M., Holcer D., Vuković M., Flajšman E., Grgurev M., Hamidović D., Pavlinić I. and Tvrtković N. (2006): *Crvena knjiga sisavaca Hrvatske* (Red Book of Mammals of Croatia), Ministry of Culture, State Institute for Nature Protection, Zagreb.
4. Babić Mladenović M. (2018): *Uređenje vodotoka* (Watercourse Development), Jaroslav Černi Institute for Development of Water Resources, Belgrade.
5. Bardi A., Papini P., Quaglino E., Biondi E., Topić J., Milović M., Pandža M., Kaligarič M., Oriolo G., Roland V., Batina A., Kirin T. (2016): *Karta prirodnih i poluprirodnih nešumskih kopnenih i slatkovodnih staništa Republike Hrvatske. Dodatak 3 – Terenski priručnik s vodičem za identifikaciju* (Map of natural and semi-natural non-forest terrestrial and freshwater habitats of the Republic of Croatia, Annex 3 – Field Manual and Identification Guide), AGRISTUDIO s.r.l., TEMI S.r.l., TIMESIS S.r.l., HAOP.
6. Bostelmann R. (2008): Ökologische Funktionen kleiner Fließgewässer. Available on: https://www.waldwissen.net/de/lebensraum-wald/naturschutz/gewaesser/oekologische-funktionen-kleiner-fliessgewaesser). Accessed on: 27 September 2021
7. Brew T., Gilligan N. (2019): Environmental Guidance: Drainage Maintenance and Construction. Series of Ecological Assessments on Arterial Drainage Maintenance No 13. Environment Section, Office of Public Works, Trim, Co. Meath, Ireland. Available on: https://www.gov.ie/en/policy-information/5fc871-environmental-activities/
8. Budinski I., Zec M., Dender D., Korša M., Mikulić K., Turkalj J., Čulig P., Grgić M., Kapelj S., Engelen A., Thomas Taylor L. (2021): *Izvješće o procjeni utjecaja Pilot mjere za zaštitu ptice kosca (Crex crex) iz Programa ruralnog razvoja Republike Hrvatske za razdoblje 2014. – 2020. na očuvanje vrste uz prijedlog poboljšanja provedbe za 2021. godinu* (Report on the Assessment of Impact of the Pilot Measure for the Protection of the Corncrake (Crex crex) Implemented in the Framework of the Rural Development Programme of the Republic of Croatia for the Period 2014 – 2020 on the Conservation of that Species, including an Implementation Improvement Proposal for 2021), Biom Association, SKUA Nature Protection Services, Zagreb.

9. Dam Removal Europe (2022): Removal of Barriers and Dams on watercourses – Case Studies. Available on: https://damremoval.eu/case-studies/. Accessed on: 27 September 2021.

10. Eberstaller-Fleischanderl D., Eberstaller J. (2014): Flussbau und Ökologie. Flussbauliche. Maßnahmen zur Erreichung des gewässerökologischen Zielzustandes: Ministerium für Ein Lebenswertes Österreich, Wien.

11. Environment Agency (2003): River Habitat Survey in Britain and Ireland. Field Survey Guidance Manual: 2003. Bristol.uropean forest types, categories and types for sustainable forest management reporting and policy, EEA Tehnical report, No 9/2006.

12. European Commission (EC) (2021): Nature and Biodiversity. Official website. Available on: https://ec.europa.eu/environment/nature/index_ en.htm. Accessed on: 1 October 2021

13. European Environmental Agency (2006): European forest types, categories and types for sustainable forest management reporting and policy, EEA Technical Report, No. 9/2006.

14. European Environment Agency (EEA) (2022): Natura 2000 Barometer. Official website. Available on: https://www.eea.europa.eu/data-and-maps/ dashboards/ natura-2000-barometer. Accessed on: 20 October 2022

15. Grubešić M. (2008): *Dabar u Hrvatskoj* (Beavers in Croatia), Faculty of Forestry of the University of Zagreb, Zagreb.

16. Guttmann S. (2015): Stručne smjernice – Upravljanje rijekama (Professional Guidelines – River Management); EU IPA Programme for Croatia, Twinning Light Project, EU HR/2011/IB/EN/02 TWL *Jačanje stručnih znanja i tehničkih kapaciteta svih relevantnih ustanova za Ocjenu prihvatljivosti zahvata za ekološku mrežu (OPEM)* (Strengthening the Professional Competence and Technical Capacity of all Relevant Institutions for Conducting the Appropriate Assessment Procedure). Available on: https://www.haop.hr/hr/publikacije/strucne-smjernice-upravljanje-rijekama

17. Hahn E. (2015): Stručne smjernice – Prometna infrastruktura (Professional Guidance – Tra*nsport Infrastructure), EU IPA Programme for* Croatia, Twinning Light Project, EU HR/2011/IB/EN/02 TWL Jačanje stručnih znanja i tehničkih kapaciteta svih relevantnih ustano*va za Ocjenu prihvatljivosti zahvata za ekološku mrežu (OPEM) (Strengthening the Professional Competence and Technical Capacity of al*l Relevant Institutions for Conducting the Appropriate Assessment Procedure). Available on: https:// www.haop.hr/hr/publikacije/strucne-smjernice-prometna-infrastruktura

18. Horwitz F. J., Johnson T. E., Overbeck P. F., O'Donnell T. K., Hession W. C., Sweeney B. W. (2008): Effects of riparian vegetation and watershed urbanization on fishes in streams of the mid-Atlantic Piedmont (USA). J Am Water Resour Assoc. 44(3):724–741.

19. Illies J. (1978): Limnofauna Europaea. Stuttgart, Gustav Fischer Verlag.

20. Jelić M. (2010): *Vidra - Priručnik za inventarizaciju i praćenje stanja (The Otter – A Manual for* Inventarisation and Condition Monitoring, State Institute for Nature Protection, Zagreb.

21. Jelić M. (2013): *Nacionalni programi za praćenje stanja očuvanosti vrsta u Hrvatskoj: Vidra (Lutra lutra)* (National Programmes for Monitoring the Conservation Status of Species in Croatia – Otter (Lutra lutra)), State Institute for Nature Protection, Zagreb.

22. Jelić D., Kuljerić M., Koren T., Treer D., Šalamon D., Lončar M., Podnar-Lešić M., Janev Hutinec B., Bogdanović T., Mekinić S., Jelić K. (2015): *Crvena knjiga vodozemaca i gmazova Hrvatske* (Red Book of Amphibians and Reptiles of Croatia), State Institute for Nature Protection, Zagreb.

23. Lončar G., Vranješ D., Tomašević I., Čović K., Buj I., Dašić G., Korica L. (2017): *Mogućnosti ublažavanja utjecaja regulacijskih i zaštitnih vodnih građevina na vodene ekosustave, Inženjerstvo okoliša (2017) / Vol 4., No. 2.* (Possibilities for Mitigating the Impact of Water Regulation and Protection Structures on Aquatic Ecosystems, Environmental Engineering (2017) / Vol 4., No. 2.

24. Nikolić T. ur. (2005): *Flora Croatica baza podataka* (The Flora Croatica Data Base), Faculty of Natural Sciences and Mathematics, University of Zagreb. Available on: http://hirc.botanic.hr/fcd. Accessed on: 5 October 2021

25. Nikolić T., Mitić B., Boršić, I. (2014): *Flora Hrvatske – Invazivne biljke* (Croatian Flora – Invasive Plants); Alfa d. d., Zagreb.

26. Ministry of Economy and Sustainable Development (MESD) (2021): *Održivo korištenje prirodnih dobara i ekološka mreža* (Sustainable Use of Natural Resources and the Ecological Network); Natura 2000. Available on: http://www.haop.hr/hr/tematska-podrucja/odrzivo-koristenje-prirodnihdobara-i-ekoloska-mreza/ekoloska-mreza/natura-2000. Accessed on: 27 September 2021

27. Office of Public Works (2021): Design Guidance for Fish Passages on Small Barriers. Environment Section, Office of Public Works, Headford, Co. Galway, Ireland. Available on: https://www.gov.ie/en/policy-information/5fc871-environmental-activities/

28. *Plan upravljanja vodnim područjima Republike Hrvatske, Dodatak I: Analiza značajki vodnog područja rijeke Dunav* (River Basin Management Plan for the Republic of Croatia, Annex I: Analysis of the Characteristics of the Danube River Basin), 2016.

29. Riisgård, H. U., Larsen P. S. (2000): Comparative ecophysiology of active zoobenthic filter feeding, essence of current knowledge. J. Sea Res., 44(3): 169-193.

30. Sabolić M., Topić R., Duplić A., Lunko P., Schneider D., Trenc N. (2019): *Vodno gospodarstvo i zaštita prirode: zajedničko očuvanje vodenih ekosustava. Zbornik radova 7. hrvatske konferencije o vodama* (Water Management and Nature Protection: Joint Water Ecosystem Conservation Efforts, 7th Croatian Water Conference Proceedings Book); Opatija 2019, Croatian Waters, Zagreb.

31. Scottish Environment Protection Agency (2010): Engineering in the water environment – Good practice guide: River crossings. SEPA, Stirling, Scotland, UK. Available on: https://www.sepa.org.uk/regulations/water/engineering/engineering-guidance/

32. Sundseth K. (ur.) (2013): Case studies on the Article 6.3 permit procedure under the Habitats Directive. European Commission.

33. Sundseth K., Roth P. (2013): Study on evaluating and improving the Article 6.3 permit procedure for Natura 2000 sites. Final Report. European Commission.

34. Šimundić N. (2008): *Opis poslova održavanja u području zaštite od štetnog djelovanja voda* (Description of Maintenance Works Aimed at Ensuring Protection from the Harmful Effects of Water), Croatian Waters, Zagreb.

35. Topić J., Ilijanić L., Tvrtković N., Nikolić T. (2006): *Staništa. Priručnik za inventarizaciju, kartiranje i praćenje stanja* (Habitats, A Manual for Inventarisation, Mapping and Condition Monitoring), State Institute for Nature Protection.

36. Tutiš V., Kralj J., Radović D., Ćiković D., Barišić S. (ur.) (2013): *Crvena knjiga ptica Hrvatske* (Red Book of Birds of Croatia), Ministry of Enviromental and Nature Protection, State Institute for Nature Protection, Zagreb.

37. Vukelić J. (2012)*: Šumska vegetacija Hrvatske* (Croatian Forest Vegetation), Faculty of Forestry, State Institute for Nature Protection, Zagreb.

38. Wilkerson E., Hagan J. M., Siegel D., Whitman A. A. (2006): The effectiveness of different buffer widths for protecting headwater stream temperature in Maine. Forest Sci. 52(3):221–231

HANDBOOKS ON WOODY DEBRIS AND SEDIMENT REMOVAL

1. Macomb County Public Works Office (n.d.): Field Manual on Maintenance of Large Woody Debris for Municipal Operation and Maintenance Crews, Macomb County, USA. Funding provided by the U.S. Army Corps of Engineers. Input provided by Macomb County (Public Works Office, Department of Planning and Economic Development), Clinton River Watershed Council, Tetra Tech. Available on: http://www.savebuffalobayou.org/wp-content/uploads/2021/05/LWDManualFinal-1.pdf. Accessed on: 27 September 2021

2. Paulus T. (2015.): Die Bedeutung von Totholz für Fließgewässer, presentation. Available on: https://aller-projekt.de/fileadmin/user_upload/aktion_fischotterschutz/desktop/hauptnavigation/Unsere_Projekte/Aller-Projekt/PDF.Vortraege.2015/Bedeutung.von.Totholz.fuer.Fliessgewaesser.Dr.Thomas.Paulus.pdf. Accessed on: 27 September 2021

3. Scottish Environment Protection Agency (2010a): Engineering in the water environment – Good practice guide: Sediment management. SEPA, Stirling, Scotland, UK. Available on: https://www.sepa.org.uk/regulations/water/engineering/engineering-guidance/

4. Siemens M. von, Hanfland D., Binder W., Herrmann M., Rehklau W. (2009): Totholz bringt Leben in Flüsse und Bäche. Bayerisches Landesamt für Umwelt (LfU), Augsburg.

HANDBOOKS ON VEGETATION MAINTENANCE (MOWING, CLEARING AND CUTTING)

1. Buisson R. S. K., Wade P. M., Cathcart R. L., Hemmings S. M., Manning C. J., Mayer L. (2008): The Drainage Channel Biodiversity Manual: Integrating Wildlife and Flood Risk Management. Association of Drainage Authorities and Natural England, Peterborough. Available on: https://www.wlma.org.uk/uploads/NE121_Drainage_Channel_Biodiversity_Manual.pdf

2. Bentley S., Brady R., Cooper J. Davies K., Hemsworth M., Robinson P., Thomas L. (2014): Aquatic and riparian plant management: controls for vegetation in watercourses. Technical guide. Environment Agency, Bristol. Available on: https://assets.publishing.service.gov.uk/media/6034e181d3bf7f26576beefa/SC120008-R2_Technical_guide.pdf

3. Derigon J., Dechavann C. (2013): Manuel du riverain et des usagers de la rivière. Recueil de connaissances et conseils sur les bonnes pratiques de gestion et d'entretien des cours d'eau du Sornin, SYMISOA, Charlieu

4. Scottish Environment Protection Agency (2009): Engineering in the water environment – Good practice guide: Riparian vegetation management. SEPA, Stirling, Scotland, UK. Available on: https://www.sepa.org.uk/regulations/water/engineering/engineering-guidance

5. Shilla D. J., Shilla D. A. (2012): Effects of riparian vegetation and bottom substrate on macroinvertebrate communities at selected sites in the Otara Creek, New Zealand, Journal of Integrative Environmental Sciences, 9:3, 131-150

6. Wasserverbandstag (2015): Das Geheimnis der modernen Gewässerunterhaltung. Available on: https://www.youtube.com/watch?v=etBMBG2VZ6I. Accessed on: 27 September 2021

Internet Sources of Photographs

PLANT AND ANIMAL SPECIES

1. A stand of clasping-leaf pondweed (NHC A.3.3.1.5.) (*Potamogeton perfoliatus*): Krzysztof Ziarnek, Kenraiz, 2017, Creative Commons License. Available on: https:// commons.wikimedia.org/wiki/ File:Potamogeton_perfoliatus_kz01.jpg. Accessed on: 1 October 2021
2. The thick-shelled river mussel (*Unio crassus*) in a watercourse: Alexander Mrkvicka, 2009, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/ File:Unio_crassus3_A_MRKVICKA.JPG. Accessed on: 1 October 2021
3. The Carabus variolosus beetle (*Carabus variolosus*): Jacek Proszyk, 2018, Creative Commons License. Available on: https://commons.wbeikimedia.org/wiki/ File:01_ Carabus_variolosus.jpg. Accessed on: 1 October 2021
4. The sand martin (*Riparia riparia*): Frank Vassen, 2015, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/File:Sand_martin_ (Riparia_riparia), Guidel-Plage, Brittany,_France_(19765483180).jpg. Accessed on: 1 October 2021
5. A colony of sand martins: Shkumbin Saneja, 2008, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/File:Riparia_riparia_ colony.jpg. Accessed on: 1 October 2021
6. The European roller (*Coracias garrulus*): Zeynel Cebeci, 2020, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/File:Coracias_ garrulus_-_ European_roller_07.jpg. Accessed on: 1 October 2021
7. The corncrake (*Crex crex*): Ron Knight, 2013, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/Crex_crex#/media/ File:Crex_crex,_ Beachy_Head_1.jpg Accessed on: 1 October 2021
8. The spiny-cheek crayfish Faxonius limosus (formerly Orconectes limosus),: Magnus Hagdorn, 2014, Creative Commons License. Available on: https:// commons.wikimedia. org/wiki/File:Eastern_Crayfish_(Orconectes_limosus) _(14525699628).jpg. Accessed on: 1 October 2021
9. The marbled crayfish (*Procambarus virginalis*): Chucholl C., 2012, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/ File:Marmorkrebs_Procambarus_fallax_forma_virginalis.JPG. Accessed on: 1 October 2021
10. The blue crab (*Callinectes sapidus*): LoriLee, 2011, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/File:The_Childrens_ Museum_of_ Indianapolis_-_Atlantic_blue_crab.jpg. Accessed on: 29 March 2022

11. The zebra mussel (*Dreissena polymorpha*): Bj.schoenmakers, 2016, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/File:Dreissena_polymorpha_(Zebra_mussel),_Arnhem,_the_Netherlands.jpg. Accessed on: 1 October 2021

12. The Asian freshwater clam (*Corbicula fluminea*): Björn S., 2018, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/File:Asian_Clam_-_Corbicula_fluminea_(25935358507).jpg. Accessed on: 1 October 2021

13. The Chinese pond mussel (*Sinanodonta woodiana*): Albarubescens, 2019, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/ File:Sinanodonta_woodiana_mollusk _shells,_from_Arno_river_(Rovezzano),_Florence.jpg. Accessed on: 1 October 2021

14. The broadleaf watermilfoil (Myriophyllum heterophyllum): Stefan.lefnaer, 2020, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/ File:Myriophyllum_heterophyllum_sl36.jpg. Accessed on: 1 October 2021

15. The Canadian pondweed (*Elodea canadensis*): Christian Fischer, 2011, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/ File:ElodeaCanadensisFlowering.jpg Accessed on: 1 October 2021

16. Nuttal's waterweed (*Elodea nuttallii*): Christian Fischer, 2011, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/ File:ElodeaNuttalli i2.jpg Accessed on: 1 October 2021

17. The Brazilian waterweed (*Egeria densa*): Lamiot, 2015, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/File:Egeria_ densa_%C3%A9tang_de_Saint-Nolf_14_ao%C3%BBt_2015a8.JPG. Accessed on: 1 October 2021

18. The water lettuce (*Pistia stratiotes*): Krzysztof Ziarnek, Kenraiz, 2018, Creative Commons License. Available on: https://commons.wikimedia.org/wiki/File:Pistia_stratiotes_kz01.jpg. Accessed on: 1 October 2021

OTHER PHOTOGRAPHS

1. A clipper used for cutting herbaceous vegetation: Stihl, website. Available on: https:// www.stihl.com/products.aspx. Accessed on: 12 October 2021

2. A chainsaw used for cutting trees: Agroklub d. o. o., website, 2015. Available on: https://www.agroklub.com/sumarstvo/vrijeme-je-za-sjecuogrjevnog-drveta/15782/#images. Accessed on: 13 October 2021

3. Selective cutting carried out using a hand chainsaw along theOđenica watercourse: Virovitica – Podravina County, website 2021. Available on: http:// www.vpz.hr/2021/03/15/ureduje-se-vodotok-odenice-drzavnu-cestu-d-5-kodvirovitickih-ribnjaka/. Accessed on: 13 October 2021

4. An example of good practice: mowing the slope with a sickle bar mower: Briliant d. o. o., website. Available on: https://briliant.hr/proizvod/bcs-duplex-strizna-kosa/. Accessed on: 15 July 202

5. An example of good practice: the planting of vegetation on the slope using biodegradable geotextile as an underlay to increase erosion resistance: AquaTerra Solutions, website. Available via link: http://www.genievegetal.eu/produit/fiche/72/geofilet-jute.htm. Accessed on: 15 July 2021

6. An example of mechanical equipment with a sickle bar attachment for mowing floodplains and embankments: Wasserverbandstag, website, Das Geheimnis der modernen Gewässerunterhaltung. 2015, Available on: https://www.youtube.com/ watch?v=etBMBG2VZ6I. Accessed on: 6 October 2021

7. An example of mechanical equipment for mowing aquatic macrophyte vegetation in the bed of a watercourse with a sickle bar placed in a grab bucket: Wasserverbandstag, website, Das Geheimnis der modernen Gewässerunterhaltung. 2015, Available on: https://www.youtube.com/ watch?v=etBMBG2VZ6I. Accessed on: 6 October 2021

8. An example of mechanical equipment for mowing aquatic macrophyte vegetation in the bed and on the banks (slopes) of a watercourse with a cikle bar attachment without a grab basket: Wasserverbandstag, website, Das Geheimnis der modernen Gewässerunterhaltung. 2015, Available on: https:// www. youtube.com/ watch?v=etBMBG2VZ6I. Accessed on: 6 October 2021

9. An example of mechanical equipment for mowing the banks and sloped with a sickle bar attachment: The Berky Company, website. Available on: https:// www. berky.de/. Accessed on: 13 October 202

10. An example of mechanical equipment for mowing aquatic macrophyte vegetation on the banks (slopes) with a sickle bar attachment: Wasserverbandstag, website, Das Geheimnis der modernen Gewässerunterhaltung. 2015, Available on: https:// www.youtube.com/ watch?v=etBMBG2VZ6I. Accessed on: 6 October 2021

11. A photo of a floating dredger removing macrophyte vegetation and silt from the bed of a watercourse: Aquamec, Ltd., website. Available on: https:// watermaster. fi/pictures. Accessed on: 13 October 2021

12. Removal of macrophyte vegetation from the bed of a watercourse operating a floating mower: Aquamec, Ltd., website. Available on: https://watermaster.fi/ pictures. Accessed on: 13 October 2021

13. Placement of logs at an angle in relation to the bank: Verein zur Revitalisierung der Haseauen e.V., website. Available on: https:// haseauenverein.de/ strukturvielfalt-fuer-die-hase-und-ihre-aue-in-haseluenneandrup/. Accessed on: 2 November 2022

6 Annexes

6.1 Invasive Alien Species of Freshwater Invertebrates and Aquatic Plants Found in Croatia

Invertebrates - Decapods

The spiny-cheek crayfish

(Orconectes limosus = Faxonius limosus)

Source: Magnus Hagdorn, Creative Commons License 2014

The marbled crayfish

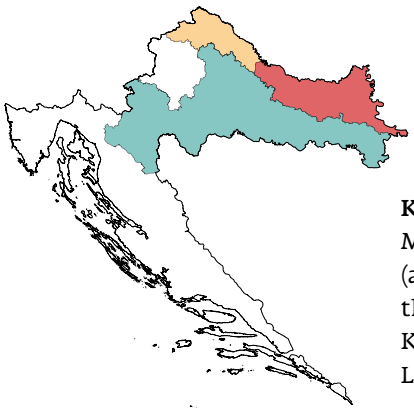
(Procambarus virginalis)

Source: Chucholl C., Creative Commons License 2012

The signal crayfish

(Pacifastacus leniusculus)

Source: LoriLee, The Children's Museum of Indianapolis, Creative Commons License 2011



Known distribution:
Mura, Korana, Radonja, Bednja, Plitvica and Drava rivers (almost the entire watercourse) and downstream sections of their tributaries, canals, reservoirs and gravel pits; the Vuka, Karašica and Dunube rivers, the Kopački rit area, the Šoderica Lake (near Koprivnica, only the marbled crayfish)

The blue crab

(Callinectes sapidus)

Known distribution:
Neretva River delta, surroundings of Split and Trogir, Krk Island, Vransko Lake near Biograd

WATER MANAGEMENT DEPARTMENTS (WMD):

- *WMD for the Danube River and the Lower Drava River*
- *WMD for the Upper Sava River*
- *WMD for the Mura River and the Upper Drava River*
- *WMD for the Southern Adriatic River Basins*
- *WMD for the Northern Adriatic River Basin*
- *WMD for the Central and Lower Sava River*

Invertebrates – Molluscs - Shellfish

The zebra mussel

(Dreissena polymorpha)

Source: Bj.schoenmakers, Creative Commons License 2016

Known distribution: the entire course of the Danube and Sava rivers and its small tributaries, the entire course of the Drava River and the associated reservoirs, gravel pits, tributaries and derivation canals; Mura River, Lake Jarun in Zagreb, Dobra River, Lešće Reservoir, Bukovnik and Sabljaci Reservoirs

The Asian freshwater clam

(Corbicula fluminea)

Source: Björn S., Creative Commons License 2018

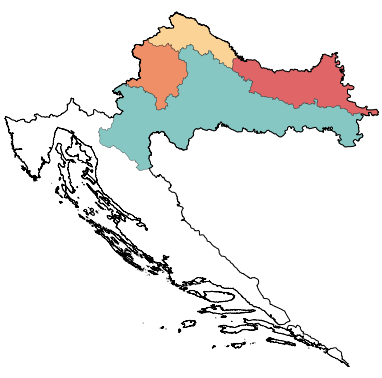
Known distribution: the entire course of the Danube River and its small tributaries, the entire course of the Sava River and its small tributaries and lakes, the entire course of the Kupa, Una and Glina rivers and their tributaries, the entire course of the Drava River and the associated reservoirs, gravel pits and tributaries (Karašica, Vučica, Županijski kanal rivers), Savica Lake in Zagreb, Tribalj Reservoir, Lika River and Krušćica Reservoir, Butoniga Reservoir

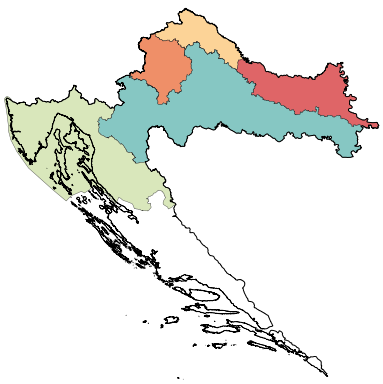
The Chinese pond mussel

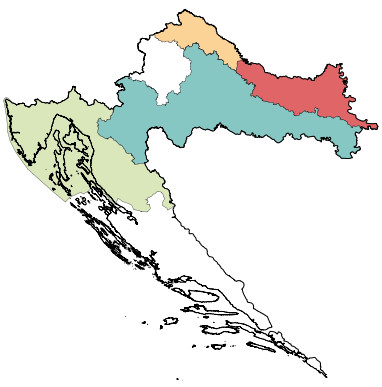
(Sinanodonta woodiana)

Source: Albarubescens, Creative Commons License 2019

Known distribution: Danube River and its small tributaries, Sava River and its small tributaries and lakes, Drava River and the associated reservoirs and tributaries, Draganići River and Konopljište Fishpond, Ilova River, Vransko Lake near Biograd, Karašica, Spačva , Vuka, Vučica, Mrsunja, Londža, Županijski kanal, Orljava, Česma, Pakra and Tolica (Daruvar) rivers, Voćin- Drava canal, Kopački rit, Lapovac Lake (Našice), Vidrenjak Lake, Bajer Fishpond (Novi Marof), Borza River (Topolje), Bistra Spring (Kaptol), Mali Strug canal (Gornji Varoš), and Tribalj Reservoir







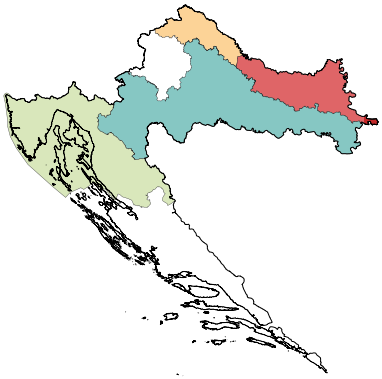
WATER MANAGEMENT DEPARTMENTS (WMD):

- *WMD for the Danube River and the Lower Drava River*
- *WMD for the Upper Sava River*
- *WMD for the Mura River and the Upper Drava River*
- *WMD for the Southern Adriatic River Basins*
- *WMD for the Northern Adriatic River Basin*
- *WMD for the Central and Lower Sava River*

Invertebrates – Molluscs - Gastropods

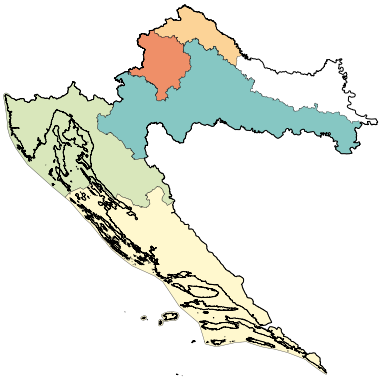
The New Zeland mudsnail
(Potamopyrgus antipodarium)

Known distribution: the entire course of the Drava River, reservoirs on the Drava River, Bednja River, the course of the Mirna River, including the Boljunčica and Pazinski potok streams, Butoniga Reservoir, Arđile stream, Raša River, Rečina River, Dragonja Ri



Physella acuta

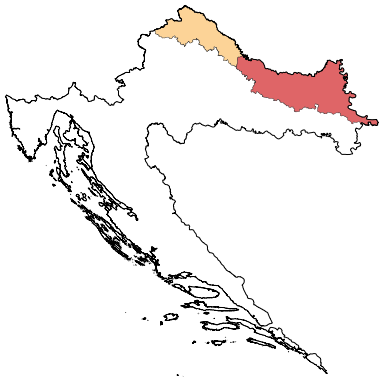
Known distribution: Raša River, Dubračina Stream, Njivice Reservoir, Muškovci Reservoir, Zrmanja River, Ličanka Stream, Bajer Reservoir, Lepenica River, Omladinsko jezero Lake, Lokvarka Stream, Lika River, Štikada Lake, Ričica Stream, Prološko Blato, Ričice Reservoir, Cetina River, Peruča Reservoir, Visovac Lake, Brljansko Lake, Kozjak Laka, Prošćansko Lake, Drava River with its tributaries and reservoirs, Sava River with its tributaries, Bednja River, Plitvica River, Lepenica Reservoir, Krapina River



Invertebrates – Mysidacea i Isopoda

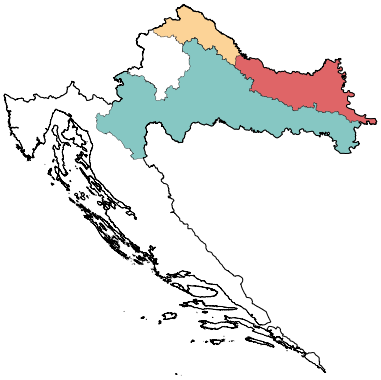
Hemimysis anomala

Known distribution:
Drava River, Danube River and its small tributaries



Jaera istri

Known distribution:
Sava River downstream from the Una River estuary, Drava River and Karašica River, Danube River and its small tributaries



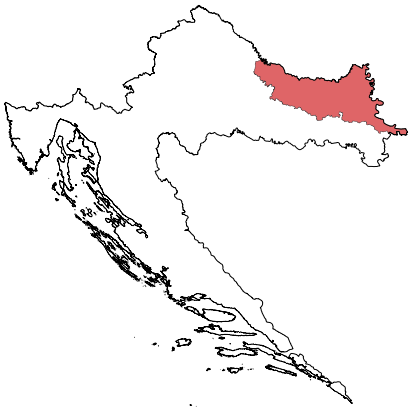
WATER MANAGEMENT DEPARTMENTS (WMD):

- *WMD for the Danube River and the Lower Drava River*
- *WMD for the Upper Sava River*
- *WMD for the Mura River and the Upper Drava River*
- *WMD for the Southern Adriatic River Basins*
- *WMD for the Northern Adriatic River Basin*
- *WMD for the Central and Lower Sava River*

Invertebrates – Mysidacea i Isopoda

Katamysis warpachowskyi

Known distribution:
Danube River and its small tributaries



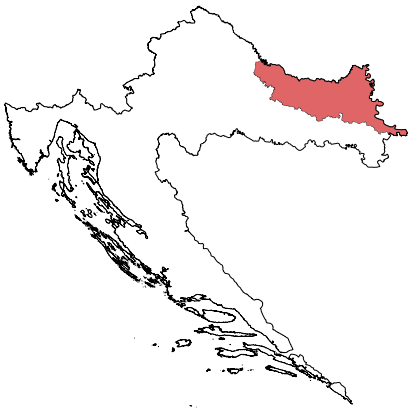
Limnomysis benedeni

Known distribution:
Županijski kanal River, Drava River estuary, Danube River and its small tributaries

Invertebrates – Amphipoda (Crustaceans)

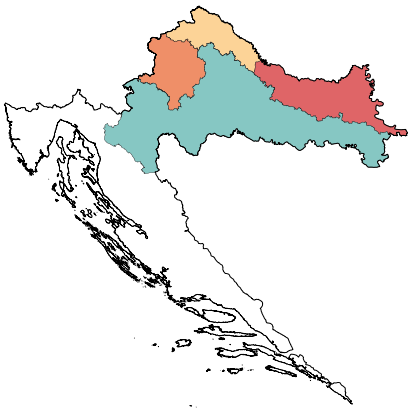
Echinogammarus ischnus

Known distribution:
Drava River downstream from Terezino polje, Danube River (Batina, Borovo, Ilok)



Dikerogammarus villosus

Known distribution:
Drava River with the associated canals, tributaries and reservoirs; Danube River and its small tributaries, Sava River (entire course in Croatia), Odra River, Sutla River



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- *WMD for the Northern Adriatic River Basin*
- *WMD for the Central and Lower Sava River*

Dikerogammarus bispinosus

Known distribution:
Danube River and its small tributaries

Obesogammarus obesus

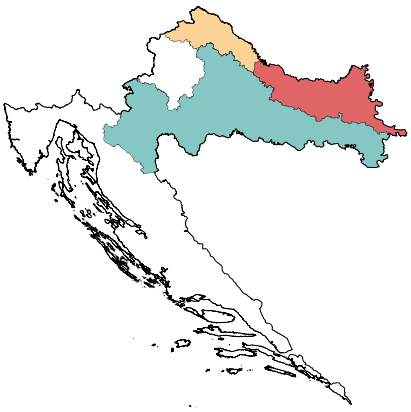
Known distribution:
Danube River and its small tributaries

Dikerogammarus haemobaphes

Known distribution:
Danube River and its small tributaries, Sava River downstream from Bobovac

Chelicorophium curvispinum

Known distribution:
Drava River with its tributaries and the Šoderica gravel pit, Mura River and its tributaries, Danube River and its small tributaries, Sava River and Una River



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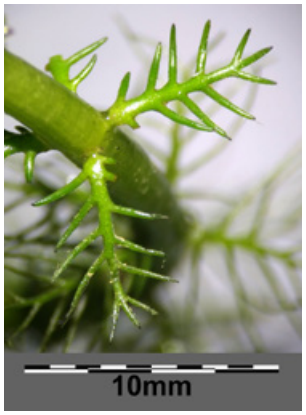
Aquatic Plants



The broadleaf watermilfoil

(Myriophyllum heterophyllum)

Source (both photos): Stefan.lefnaer, Creative Commons License 2020

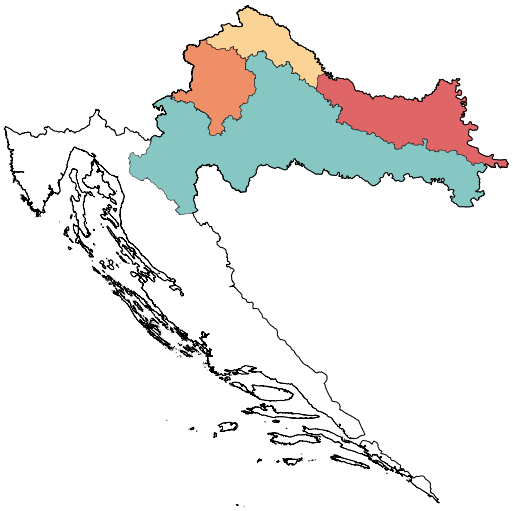
Known distribution:
The records so far refer only to the Neretva River Delta (Desne Lake, Bijeli vir), with only one mention in literature of its presence on the Krk Island

The Canadian waterweed

(Elodea canadensis)

Source: Christian Fischer, Creative Commons License 2011

Known distribution:
Sava, Mura, Drava, Lonja and Odra rivers and small standing and running waters of Northern and Eastern Croatia



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- *WMD for the Southern Adriatic River Basins*
- *WMD for the Northern Adriatic River Basin*
- *WMD for the Central and Lower Sava River*

Aquatic Plants

The Brazilian waterweed

(Egeria densa)

Source: Lamiot, Creative Commons License 2015

Known distribution:
So far, the species has only been recorded in the Neretva River Delta (Modro oko, Bijeli vir, Metković)

The water lettuce

(Pistia stratiotes)

Source: Krzysztof Ziarnek, Kenraiz, Creative Commons License 2018

Known distribution:
So far, the presence of this species has only been confirmed in lakes within the Sava – Strmec Special Ornithological Reserve (the surroundings of Zagreb)

WATER MANAGEMENT DEPARTMENTS (WMD):

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- *WMD for the Northern Adriatic River Basin*
- *WMD for the Central and Lower Sava River*

Aquatic Plants

Nuttall's waterweed
(Elodea nuttallii)

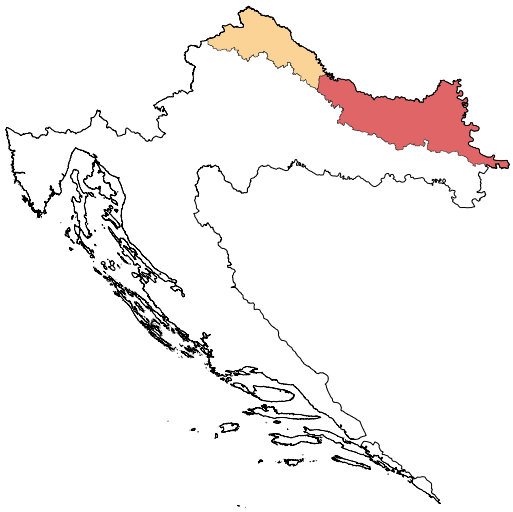
Source: Christian Fischer, Creative Commons License 2011

Known distribution:
So far, the presence of this species has been recorded in several location in Continental Croatia, the Drava and Danube regions, Kopački rit, Drava River near Varaždin and Čakovec, the surroundings of Virovitica

Floating primrose-willow
(Ludwigia peploides)

Source: Oikon Ltd.

Known distribution:
three locations in Central Croatia have been identified: one sighting in the Ilova River and two in the Česma River (Obedišće and Sišćani)



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- *WMD for the Northern Adriatic River Basin*
- *WMD for the Central and Lower Sava River*

6.2 Proposed Mechanical Equipment for Undertaking Watercourse Maintenance Works

1. Hand mechanical equipment

The recommended equipment for cutting herbaceous and small woody vegetation (shrubs) in the watercourse bed as well as for cutting the overhanging branches of large trees entering the bed includes **clippers or hand chainsaws**.

A clipper used for cutting herbaceous vegetation
(Source: Stihl, mrežne stranice 2021)

A chansaw used for cutting trees
(Source: Agroklub Ltd., website 2015)

Selective cutting carried out using a hand chainsaw alongside the Ođenica watercourse
(Source: Virovitica-Podravina County, website 2021)

2. Mowing Machinery (Mechanical Equipment)

The recommended equipment for mowing floodplains and embankments includes various machines with sickle bar attachments.

Sickle bars can be attached to various machines used in the execution of works.

An example of mechanical equipment with a sickle bar attachment used for mowing floodplains and embankments
(Source: Briliant Ltd., website 2021)

The recommended equipment for **mowing banks** (**and slopes**) performed within the scope of maintenance works includes various machines with a sickle bar attachment used either separately or in combinations with a grab basket.

An example of mechanical equipment for mowing aquatic macrophyte vegetation in the bed and on the banks (slopes) of a watercourse with a sickle bar attachment, without a grab basket
(Source: Wasserverbandstag 2015)

An example of mechanical equipment for mowing the banks and slopes with a sickle bar attachmen
(Source: Berky Company, website 2021)

An example of mechanical equipment for mowing aquatic macrophyte vegetation on the banks (slopes) with a sickle bar attachment
(Source: Wasserverbandstag 2015)

An example of mechanical equipment for mowing the banks and slopes with a sickle bar attachmentkosom
(Source: Wasserverbandstag 2015)

When removing the **accumulated silt and macrophyte vegetation from the bed of canals and watercourses**, the works should, whenever possible, be carried out using such **mechanical equipment that minimally affects the bottom of the canal or watercourse** (e.g. **floating dredgers**).

A floating dredger removing macrophyte vegetation and silt from a watercourse bed
(Source. Aquamec Ltd., website 2021)

Removing macrophyte vegetation from a watercourse bed with a floating dredger
(Source. Aquamec Ltd., website 2021)

REPUBLIC of CROATIA
Ministry of Economy and
Sustainable Development

EUROPEAN STRUCTURAL
AND INVESTMENT FUNDS

Operational programme
COMPETITIVENESS
AND COHESION

European union
together to EU funds