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Ecological flow estimation in Latvian – Lithuanian transboundary river basins (ECOFLOW) LLI-249

FINAL REPORT

2019

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ABBREVATIONS

CIS	Common Implementation Strategy
E-flow	Ecological Flow
ECOSTAT	WFD CIS working group on Ecological Status
EU	European Union
FFS	First Field Survey
GU	Geomorphic Unit
HMWB	Heavily Modified Water Body
HPP	Hydropower Plant
LT	Lithuania
LV	Latvia
RBD	River Basin District
SFS	Second Field Survey
WFD	Water Framework Directive

INTRODUCTION

Development of the efficient joint management activities in the trans-boundary river basins is the main aim of the common strategy of neighbouring countries for supporting a coherent and harmonious implementation of the Directive 2000/60/EC. There is no joint management established for the Latvian-Lithuanian international river basin districts and effective target actions are needed to improve current situation for better compliance with the Water Framework Directive. The project objectives are related to integrated management activities with regards to strengthening institutional cooperation and to providing joint harmonised assessment and analysis of anthropogenic impact on the aquatic ecosystems.

According to River Basins Management Plans the flow regime regulations by Hydropower Plants (HPP) is one of the most significant pressures in Latvian-Lithuanian transboundary river basin districts, where about 100 small HPP are installed. Role of hydrological regime in determining physical habitats, which in turn defines the biotic composition and supports production and sustainability of aquatic ecosystems, is essential. Ecological flows (E-flow) support the achievement of the Water Framework Directive’s (WFD) environmental objectives by improving the biological, morphological and hydrological parameters related to quantitative water management, addressing pressures affecting the hydrological regime (e.g. abstractions and impoundments). Evaluation of E-flow that should be provided downstream of HPP dams (this information is included in their permits) until now was done only on the basis of water flow statistics regardless of biological parameters.

Estimations of ecological flow (E-flow) have been carried out neither in LV, nor in LT. The overall objective of the project is to establish cooperation among the project partners in order to encourage development of new methodology for estimation of E-flow, in compliance with standards and goals for protected areas under the WFD, Birds and Habitats Directive in Latvia-Lithuania border region. The main project outputs are the Methodology for E-flow estimation and Recommendations for the amendment to national water legislations in order to ensure effective implementation of E-flow, binding the strategic planning for water uses and the permitting process. In Guidance document No.31 “Ecological flows in the implementation of the Water Framework Directive" based approach is used for the identification of insufficient water flow downstream HPPs and E-flow estimation in LV-LT trans-boundary rivers. This approach includes hydromorphological and fish measurements, and meso-scale habitat modelling (MesoHABSIM). For the project implementation the special databases will be developed: long-term series of water flow data and lists of fish species for rivers in Venta and Lielupe RBD. These databases should be created for non-affected river stretches, and after that the field surveys should be carried out on the river sections affected by HPPs to evaluating the habitat changes. LV-LT new common activities are designation of habitat changes due to flow regulation and planning of ecological status improving by E-flow control. A new approach in the evaluation of ecological flow after the project will be proposed to implement in the practice for environmental authorities in LT and LV.

Final report provides information on achievements of specific project objectives: evaluation of the water diversion for the hydropower, E-flow estimation for regulated cross border rivers, development of new Methodology and Recommendations.

The main project outputs (T3.1 Methodology for E-flow estimation and T3.2 Recommendations for the amendment to national water legislations) were prepared using project results which are presented in deliverables: T1.1.1 Review of hydropower plants influence on water quantity and quality, T1.2.1 Review of national legislation, T1.3.1 Hydrographs for selected case-study rivers in Venta RBD, T1.4.1 List of specific species for Venta RBD, T1.5.1 Hydrographs for selected case-study rivers in Lielupe RBD, T1.6.1 List of specific species for Lielupe RBD, T2.1 Training Course Report, T2.2.1 First Field survey Report, T2.4.1 Second Field survey Report, T2.3.1 Modelling Report.

1. EU LEGISLATIVE REQUIREMENTS WITH REGARD TO E-FLOW AND NATIONAL LEGISLATIONS IN THE FIELD OF WATER USES

The legal framework for implementation of Ecological flow in the EU is set out in the WFD and in the Birds and the Habitats Directives. WFD main objective is to prevent deterioration of the status of water bodies and to protect, enhance and restore all water bodies, with the aim to achieve good ecological status [1]. The aim of the Birds and Habitats Directives is to conserve important habitats and species [2, 3]. Flow regime is critical for most of the aquatic ecosystems, having strong impact on the conservation status of water-dependent habitats and species. The WFD and the Birds and Habitats Directives set binding objectives on protection of water-dependent ecosystems. These objectives can only be reached if supporting flow regimes are guaranteed. Therefore, consideration of Ecological flow has to be included in the national legal frameworks of the EU Member States. Aside from the WFD and the Birds and the Habitats directives, main pieces of EU legislation, describing and explaining in detail the necessity and the concept of Ecological flow, are: the Blueprint to Safeguard Europe's Water Resources; WFD CIS Guidance Document No. 31 "Ecological flows in the implementation of the Water Framework Directive"; and WFD CIS Guidance Document No. 34 "On the application of water balances for supporting the implementation of the WFD" [4, 5].

The analysis of the requirements specified in Latvian legislation with regard to E-flow definition, and the comparison of these requirements with the obligations posed by EU legislative framework, enable to draw the following main conclusions:

- Definitions of ecological flow and minimum guaranteed flow are sometimes contradictory in different legislation acts. It is stated in Regulation No. 329 / Construction standard LBN 224-15 [6] that ecological flow has to be guaranteed downstream of hydrotechnical constructions. At the same time, Regulation No. 736 [7] gives the same definition for the minimum guaranteed flow and specifies particular cases when ecological flow has to be ensured. The latest is in contradiction with the requirements of the WFD and the Guidance Document No. 31, because E-flow is a necessary component for the achievement of good ecological status in natural water bodies (and small HPPs are, according to the information provided by ECOSTAT, generally of insufficient importance to be designated as HMWB). Ecological flow has to be a binding requirement to all water uses – in particular, for water abstraction, impoundment, and flow regulation.

- Although, according to the information provided by State Environmental Service, ecological flow for the hydropower plants has to be calculated obligatory, in practice there are examples where ecological flow is defined equal to minimum guaranteed flow.
- Instructions for the calculation of minimum guaranteed flow are provided in legislation but have differences, namely, average or minimum summer 30-days period low flow with 95% probability? It also has to be taken into account that "Q min 30d. 95%" is a low value.
- On the other hand, instructions are less clear for ecological flow, e.g. "value up to minimum summer 30-days period low flow with 50% probability" is given just for the watercourses important for fishery, and it seems that in other cases ecological flow has to be estimated based on expert judgement.
- The definition of ecological flow in LV legislation is based on the minimum flow and does not include different components of the natural flow regime. New conceptual definition of ecological flow is needed, with a clear reference to both flow quantity and dynamics and to their consistency with the environmental objectives.
- No clear evidence is provided that values of the minimum guaranteed flow and ecological flow are set high enough to ensure good hydromorphological status – that is sufficient to maintain biological quality elements at good status.
- Ecological flow has to be a necessary component in the delivery of new water use permits, and in the review of existing ones.
- There has to be clear responsibility for validating the definition of ecological flow and the inspection of its achievement, as well as clear penal provisions when regulatory requirements are breached.

ECOFLOW project activities will make it possible to evaluate if the definition of environmental flow within Latvian legislative framework ensure protection of good ecological status of surface waters as specified in the Water Management Law and Regulation No. 858 [8], according to the requirements posed by the WFD.

Many legislative documents related to planning, use and maintenance of HPPs and HPP dams exist in the Republic of **Lithuania** [9-11]. However, they do not protect fully river ecosystems from these anthropogenic activities. Although water users must ensure that hydrotechnical structures release not less water than so called environmental discharge, this is not sufficient for river ecosystem.

The term “environmental discharge” (*gamtosauginis debitas* in Lithuanian) that emerged in “Procedure for Environmental Discharge Calculation” in 1997 [11], is not environmentally friendly because it is designed to ensure only minimum conditions for ecosystem survival. The established environmental discharge is related to probability of multiannual runoff reoccurrence, whereas constant flow cannot fulfil requirements of river ecosystem. Moreover, definition of environmental discharge allows high water level fluctuations - artificial repeatable floodings (i.e. hydropeaking) downstream from the HPPs. Lastly, the minimum water discharge called environmental discharge is declared as ensuring minimum conditions for ecosystem survival; however, any substantial justification of this - like scientific background - does not exist.

A current conception of environmental discharge in Lithuanian legislation should be re-evaluated. Environmental flow (E-flow) in the downstream regulated river has to: (i) be based on scientific criteria; (ii) encompass and/or repeat a full range of flow natural regime variability (i.e. no artificial droughts, hydropeaking, etc.); (iii) comply with biological / habitat requirements of a certain regulated river; (iv) be constantly supervised and monitored by environmental authorities.

ECOFLOW project aims at estimation of environmental flow (E-flow) in compliance with CIS guidance document No. 31 for improving of ecological status of water bodies in the selected river basins. More information on national legislations with regard to E-flow is provided in Deliverable T1.2.1. “Review of national legislation in the field of water uses”.

2. REVIEW OF THE MAIN ANTHROPOGENIC PRESSURES IN VENTA AND LIELUPĖ RBD

Venta River Basin District (Venta RBD) consists of Venta, Bartuva and Šventoji river basins in Lithuania and of Venta as well as of small rivers basins entering both the Baltic Sea and Gulf of Riga including basins of Bārta and Irbe rivers in Latvia (Fig. 2.1). The total area of Venta RBD in Lithuanian territory is 6277 km^2 and in Latvian territory - 15625 km^2.

Lielupe River Basin District (Lielupe RBD) consists of the Lielupe River basin entering Gulf of Riga. The Lielupe River basin comprises large river sub-basins such as Mūsa/Mūša, Mēmele/Nemunėlis, Svēte/Švėtė in Latvia and Lithuania, Lecava and Veciecava in Latvia as well as numerous medium large and small sub-basins entering the Lielupe River (Fig. 2.1). The total area of Lielupe RBD in Lithuanian territory is 8938 km^2 and in Latvian territory - 8800 km^2.

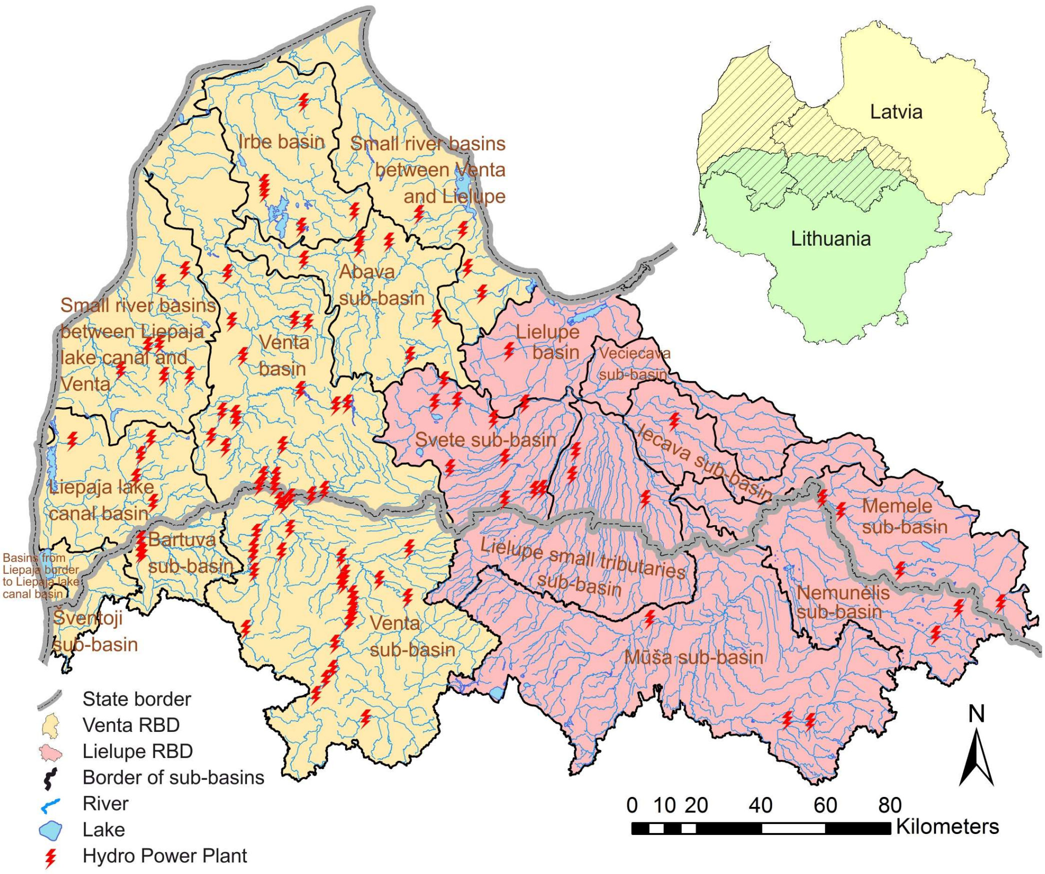

Figure 2.1. Sub-basins of Venta RBD and Lielupė RBD

In a number of Latvian-Lithuanian (LV-LT) transboundary river basins, the natural hydrological regime is destroyed due to various anthropogenic activities that may dramatically affect the biotic composition, production and sustainability of river ecosystems. The following main hydromorphological pressures in Venta and Lielupė RBDs were identified: river drainage and water regulations (deepening of river bed, shortening or changing of bank profile); polders (flood protected dams, water pumping); multiple morphological pressures (seaports location in river mouth stretches); hydropower plants (barrier to fish and sediment migration, hydrological regime regulation). One of the main pressures on river ecosystems is hydropower impact. The negative effects of HPP dams are: disruption of the continuity of the river, altering natural flow fluctuations, altering water quality and modifying channel morphology, as well as bed structure by increasing siltation upstream and erosion downstream.

There are 30 HPPs (in LT side) and 48 HPPs (in LV side) in Venta RBD. Larger hydropower dams with considerable reservoir storage capacity are able to capture high water flows and store them for later use. Fig. 2.2 shows that stream flow in the first half of the year has a tendency to decrease after the construction of HPP. In the second half of the year, natural flow and dam-controlled flow are usually changeable. Fig. 2.3 shows the Durbe River water level fluctuations compared to the Riva River water level over 3 months period. These fluctuations of the Durbe River flow are related to operation of Ciecere HPP that is located on the Cepuļupe River - tributary of the Durbe River, 330 m upstream of monitoring station.

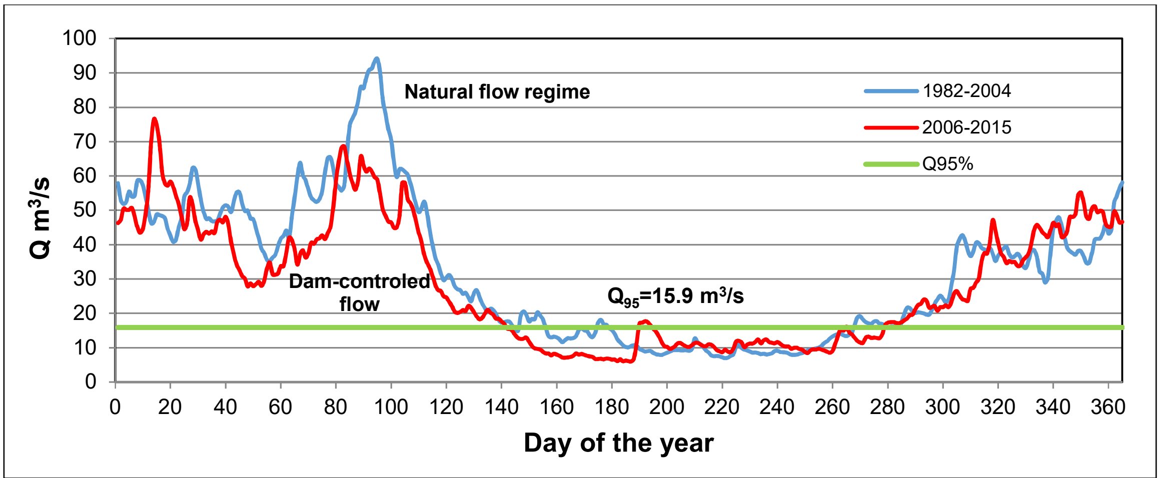

Figure 2.2. Hydrographs of Venta River at Leckava WGS (downstream of Kuodžiai HPP) for the natural flow period (1982-2004) and dam-controlled flow (2006-2015)

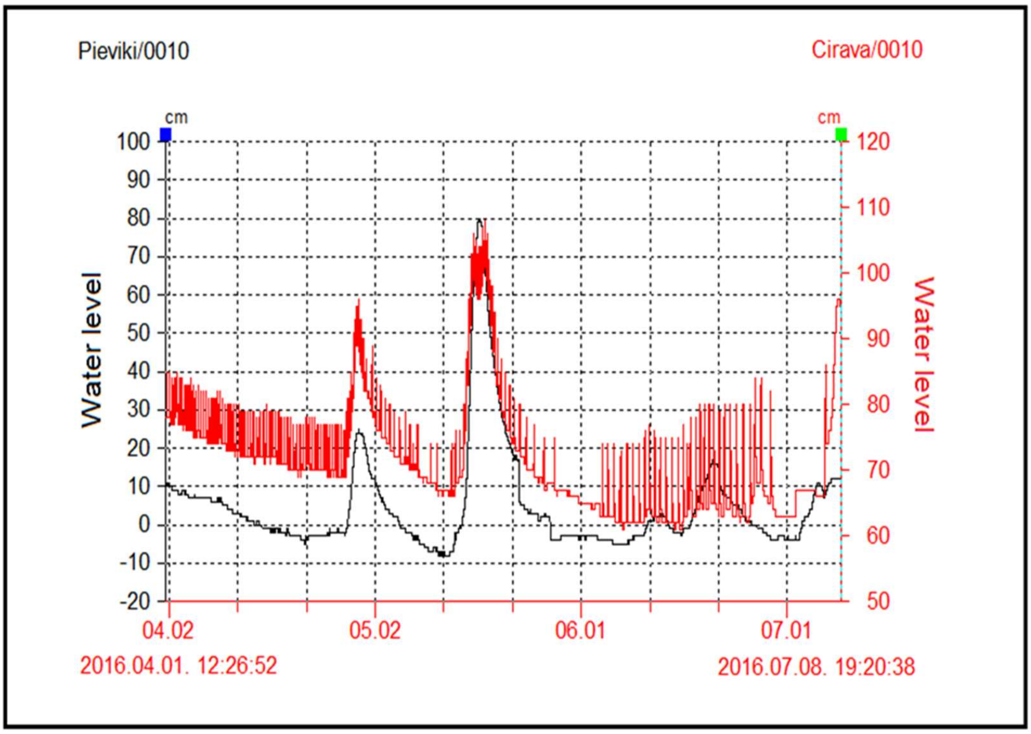

Figure 2.3. The Durbe River water level downstream Cirava HPP (in red) vs the Riva River water level at Pieviķi (in black).

Five small HPPs (in LT side) and 19 HPPs (in LV side) were constructed on the rivers of Lielupė RBD. Larger hydropower dams can result in lowered spring flood peak downstream hydropower dam. Fig. 2.4 shows that during winter, stream flow in the river is higher after the construction of HPP. Meanwhile spring stream flow has a tendency to decrease. In the second half of the year, natural flow and HPP-controlled flow are usually changeable.

Figure 2.5 shows water level fluctuations related with activity of HPP. These fluctuations of the Bērze River flow are related to operations of HPP Bērze, which is located 6 km upstream from a hydrological monitoring station Baloži.

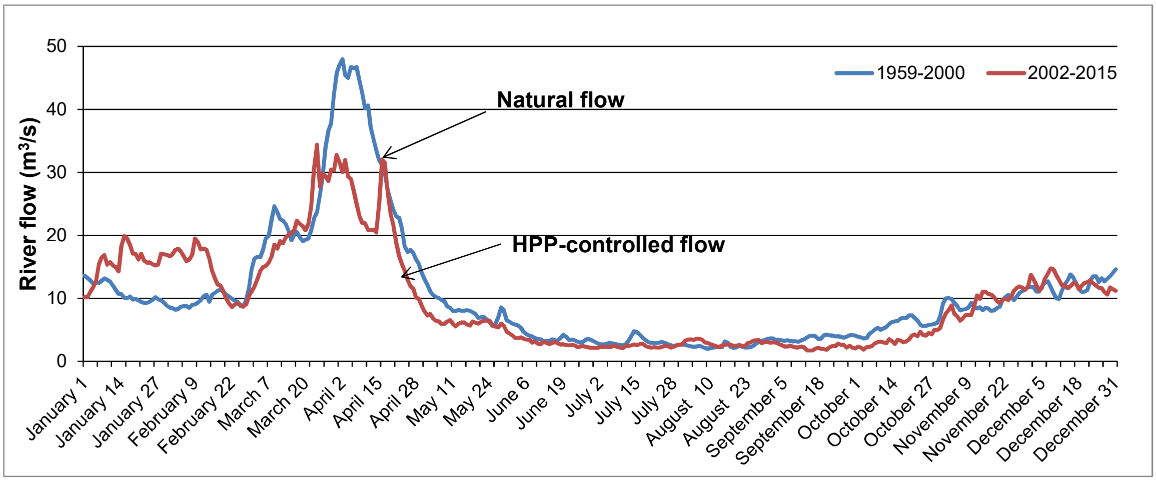

Figure 2.4. Hydrographs of the Mūša River at Ustukiai WGS (downstream of Dvariukai HPP) for the natural flow period (1959–2000) and HPP-controlled flow (2002–2015)

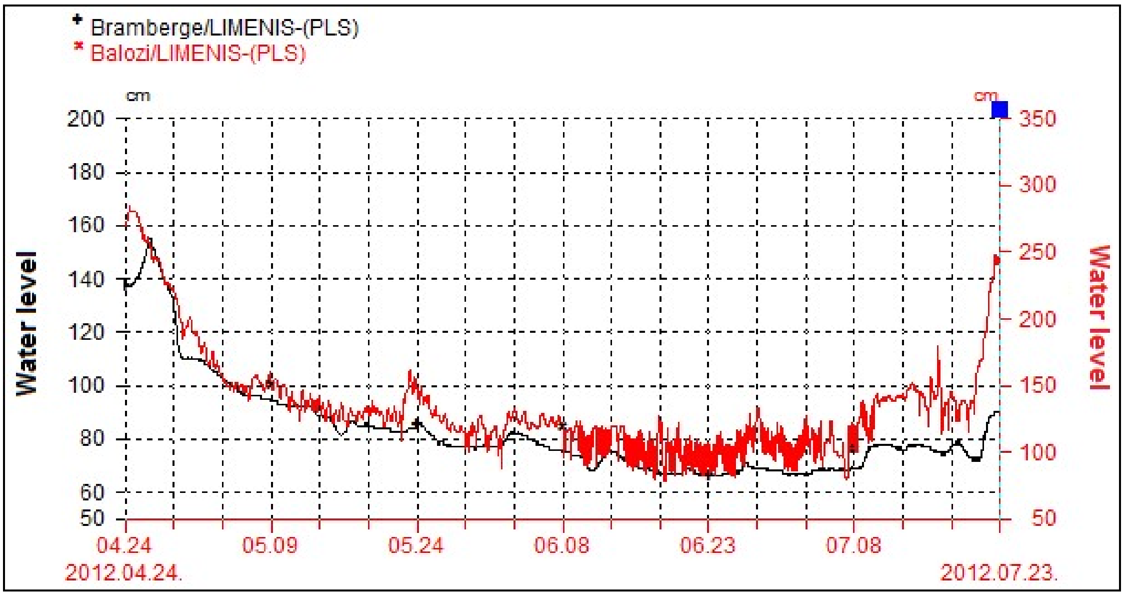

Figure 2.5. The Bērze River water level downstream of HPP Bērze (in red) vs. the Tērvete River water level nearby Bramberģe (in black)

However, it must be noted that changes in river hydrological regime as well as hydromorphological alterations not always can be the only factors which affect natural habitat structure. Moreover, limited number of the existing hydrological monitoring stations does not allow evaluating the influence of HPPs on aquatic ecosystems. Systematised information on river hydromorphology and the main pressures is necessary in further study, when case studies will be selected for more detailed investigation.

More detailed information on topography, hydrography, climate, hydrological regime and other significant pressures (river straightening, drainage reclamation, polders) is given in D.T1.1.1 “Review of hydropower plants influence on water quantity and quality in Venta River Basin District” and D.T1.1.1a “Review of hydropower plants influence on water quantity and quality in Lielupe River Basin District”.

3. CASE STUDY SELECTION IN VENTA AND LIELUPE RBD

Out of 78 small HPPs are constructed on rivers of Venta RBD. The six river sites with operating small HPPs were selected as the case studies based on the level of their investigation (Fig. 3.1, Table 3.1). The case study 1 is related to Rudikiai HPP (Table 3.1) on the Venta River (Papilė WGS), the case study 2 – Kuodžiai HPP on the Venta River (Leckava WGS), the case study 3 – Pakuli HPP on the Ciecere River (Pakulu HES WGS), the case study 4 – Skede HPP on the Eda River, the case study 5 – Edoles HPP on the Vanka River and the case study 6 – Skuodas HPP on the Bartuva River (WGS – Bartuva-Skuodas).

Table 3.1. Small HPPs on the rivers selected for case studies

No	HPP	River	Distance from the mouth, km	Basin area, km²	HPP construction year	Installed capacity, kW
1	Rudikiai	Venta	261.2	1538	2002	70
2	Kuodžiai	Venta	188.9	4021	2005	600
3	Pakuli	Ciecere	32.0	445	1996	250
4	Skede	Eda	15.7	121	1999	97
5	Edole	Vanka	12.0	79.0	1999	48
6	Skuodas	Bartuva	52.8	259.6	2000	220
7	Dvariukai	Mūša	81.5	1927	2001	494
8	Akmeniai	Lėvuo	85.9	873.3	1999	35
9	Stirniškiai	Suosa	1.8	95.1	2006	60
10	Rundale	Islice	17.1	585	1999	165
11	Benes	Auce	70.4	110	2012	190
12	Bikstu-Paleja	Berze	40.8	280	2011	120

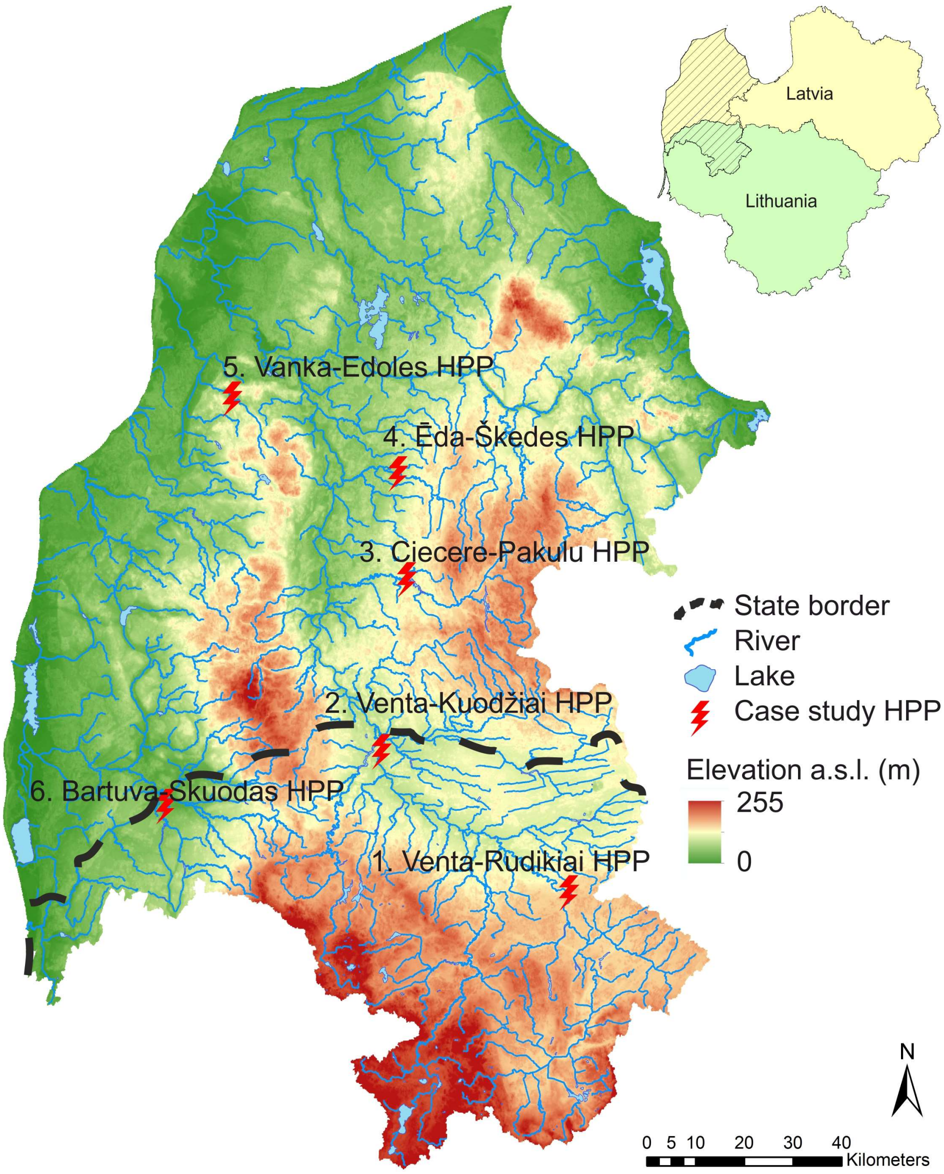

Figure 3.1. Case study sites in Venta RBD

In Lithuania, all hydropower plants on the rivers Venta and Bartuva were built after 2000. There are WGS below each investigated HPP. Therefore, the multi-year data sets of water discharge of 3 WGSs for the period of 1961-2016 were available for description of hydrographs of reference period to assess the natural river runoff. These hydrographs are going to be used for an assessment of E-flow patterns in Venta RBD.

The only one hydrological monitoring station (Pakulu HES downstream Pakuli HPP) is located in the study rivers. For calculation of flow time series in reference conditions the flow data of Pieviki WGS on analogue Riva River (daily mean specific water discharge) has been used for all study rivers in Venta RBD. Flow data series of Pakuli HES WGS has been used for modelling of altered conditions in the site “Ciecere River – downstream Pakuli HPP”. For calculation of Vanka and Eda rivers’ water flow in altered conditions daily energy production values of Edole HPP and Skede HPP correspondingly were used.

More information on case study selection and prepared river hydrographs is provided in D.T1.3.1 “Hydrographs for selected case-study rivers in Venta RBD”.

24 small HPPs are constructed on the rivers of Lielupė RBD. For assessment of HPP impacts on flow regime alteration and on fish communities, six river sites were selected as the case studies (Fig. 3.2, Table 3.1). The case study 7 is related to Dvariukai HPP (Table 3.1) on the Mūša River (Ustukiai WGS), the case study 8 – Akmeniai HPP on the Lėvuo River (Bernatoniai WGS), the case study 9 – Stirniškiai HPP on the Suosa River, which is not investigated, the case study 10 – Rundale HPP on the Islice River (Tiltsargi WGS), the case study 11 – Benes HPP on the Auce River (Brakski WGS) and the case study 12 – Bikstu-Paleja HPP on the Berze River (Balozi WGS).

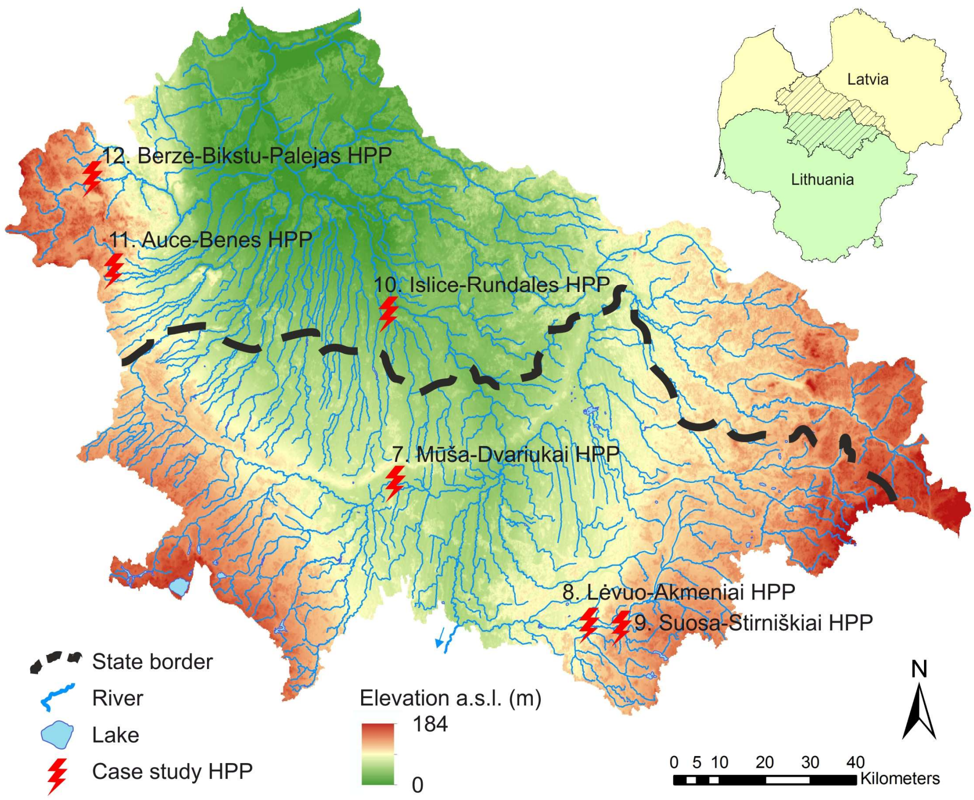

Fig. 3.2. Case study sites in Lielupė RBD

In order to assess the natural river runoff, i.e. without anthropogenic (HPP) impact, the data sets of water discharge of two WGSs (for case studies 7 and 8) for the period of 1960-2016 were used. Hydrographs of the Suosa River (case study 9) for reference period were created according to the discharges of analogue river (the Virinta River at Viliaudiškis).

Balozi WGS on Berze River with flow data series for period of 1961-1984 and Bramberge WGS on Tervete River as analogue with data series for period 1985-2017 were used for calculation of Berze' streamflow series upstream Bikstu-Paleja HPP (reference conditions). Balozi WGS flow data series was used for calculation of flow in altered conditions.

Water runoff data series upstream Bene HPP was calculated using flow data of Brakski WGS on Auce River for period 1975-1987 and flow data of Bramberge WGS on Tervete River as analogue for period 1988-2017 as Balozi WGS data series for period 1961-1974 were used for calculation of Auce River' streamflow series upstream Bene HPP. Flow data in altered conditions was calculated using energy production data of Bene HPP.

Water runoff data of hydrological monitoring station 'Islice River, nearby Tiltsargi' for the period 1961-1987 and data of Bauska WGS on Musa River as analogue for the period 1988-2015 were used for calculation of water flow data series in reference conditions. Flow data in altered conditions was calculated using energy production data of Rundale HPP.

More information on case study selection and prepared river hydrographs is provided in D.T1.5.1. "Hydrographs for selected case-study rivers in Lielupė RBD".

4. DATA COLLECTION FOR MODELLING

4.1. MESOHABITAT MODEL DESCRIPTION

Due to a negative impact of flow regime regulation on sustainability of river ecosystems, there is a need to improve the efficiency of regulated rivers management using ecological flow (E-flow) approach. The concept of mesohabitat modelling provides the necessary link between the amount of water flow and the living organisms in a river, which is crucial for the estimation of flow that is needed for the biological quality elements to be in a good status [12]. The main principle of habitat models is to combine physical conditions and biological requirements, to evaluate habitat availability and quality. Habitat modelling is composed of four parts. First of all, there is a need to obtain physical spatial measurements - hydraulic attributes (velocity, depth…), sediments, boulders, etc. This can be done on a scale of river segment, reach, mesohabitat. Mesohabitats are linked with hydromorphological units: pools, glides, etc. The second step is hydraulic modelling, which can be zero models (multiple measurements combined with interpolation), 1, 2 or 3-dimensional numerical models, or statistical models (based on measurements in many rivers). The third, biological measurements are needed (diver observations, electrofishing). The last step is establishment of biological models that define the relationship between fish distribution and physical environment. Time series analysis can be added to monitor habitat availability changes during different time periods.

A meso-scale habitat simulation model MesoHABSIM is applied to estimate the ecological flow through the survey of habitat changes due to flow regulations, and evaluation of the necessary ecological flow for regulated rivers. MesoHABSIM model is based on the concept of hydromorphological units and target fish communities. The main idea is that hydromorphological units change with the flow. Form of the channel has an impact on the stability of habitat. The model gives possibility to simulate fish abundance under different circumstances. For the biological part, the first step is to define the bioperiod – spawning, growing, etc., since bioperiods for different fish species are associated with different amounts of water.

SIM-STREAM is a user-friendly interface software that can easily organize many records, describe river features relevant for aquatic species and calculate habitat suitability. Collecting hydromorphological data is performed at the mesoscale. Good practice is to have >10 GUs in a surveyed river reach. This is a problem with homogeneous reaches. Survey has to be representative in terms of annual hydrological variability. At least 4 discharges have to be surveyed: minimum to low flow; low to median; median/mean; mean to high flow. MesoHABSIM model runs through SimStream plugin for QGIS.

Results of MesoHABSIM model are provided in separate graphics: habitat integrity scenarios, maps of habitat suitability (optimal, suitable, not suitable habitats under different flows) and habitat flow rating curves (built for the entire surveyed reach). More information on E-flow approach and MesoHABSIM model is provided in D.T2.3.1 ”Report on modelling results”.

The main objective of the habitat surveys was collection of the data for habitat modelling. Three groups of data are necessary for this modelling in the selected case study sites: hydromorphological and hydrological data, fish data and conditionals fish models. The detail descriptions of mentioned data in first (Venta RBD) and second (Lielupė RBD) habitat surveys are presented in D.T2.2.1 “First Habitat Survey Report” and in D.T2.4.1 “Second Habitat Survey Report”.

4.2. FIRST FIELD SURVEY IN VENTA RBD

First field survey was carried out during summer – autumn season of 2017 – 2018 and winter of 2019 (due to weather conditions, not all planned surveys have been accomplished in 2017). Four field measurements during two phases of hydrological regime (minimum, average and maximum of low flow, and average flow periods) have been carried out for each case study.

4.2.1. Mapping of geomorphic units and hydrological measurements

Lithuania

During the first field survey (FFS), in the Lithuanian part of Venta RBD the geomorphic units were mapped 12 times: 4 times in each case study (Venta at

Rudikiai, Venta at Kuodžiai and Bartuva at Skuodas) (Fig. 4.1). According to the MesoHABSIM model requirements (reach length > 10 river widths), the surveyed reach lengths varied from 294 m in the Bartuva River to 418 m in the Venta River (at Kuodžiai). During each field survey, the mapped area varied from 3705 m^2 to 12722 m^2 in the Venta at Rudikiai, from 11354 m^2 to 14690 m^2 in the Venta at Kuodžiai and from 1766 m^2 to 2650 m^2 in the Bartuva at Skuodas.

Figure 4.1. Hydromorthological measurements in Venta RBD

Distributions of geomorphic units (GU) surveyed within Venta RBD (LT side) are illustrated in Fig. 4.2. At least 7 GUs (aquatic vegetation, cascade, flood lake, glide, pool, rapid and secondary channel) were mapped only in one site (Venta at Rudikiai). The most frequent geomorphic unit was glide. Glides occupied from 47.5% to 70.9% of a total mapped area in the Venta at Kuodžiai, from 46.9% to 100% in the Bartuva at Skuodas and from 0.0 % to 18.8% in the Venta at Rudikiai. The second most frequent GU was rapid (indicated in 10 out of 12 field surveys), the third was pool (in 9 out of 12 field survey) and the fourth was aquatic vegetation (in 6 out of 12 field surveys). Cascade was identified during the FFS only 2 times in the Venta at Rudikiai. According to the number of geomorphic units, the most homogeneous was the Bartuva at Skuodas, where 1-3 (in average 2.5) different units per site were found, 2-5 different GUs were observed in the Venta at Kuodžiai (in average 3.3) and 4-7 GUs in the Venta at Rudikiai (in average 5.8).

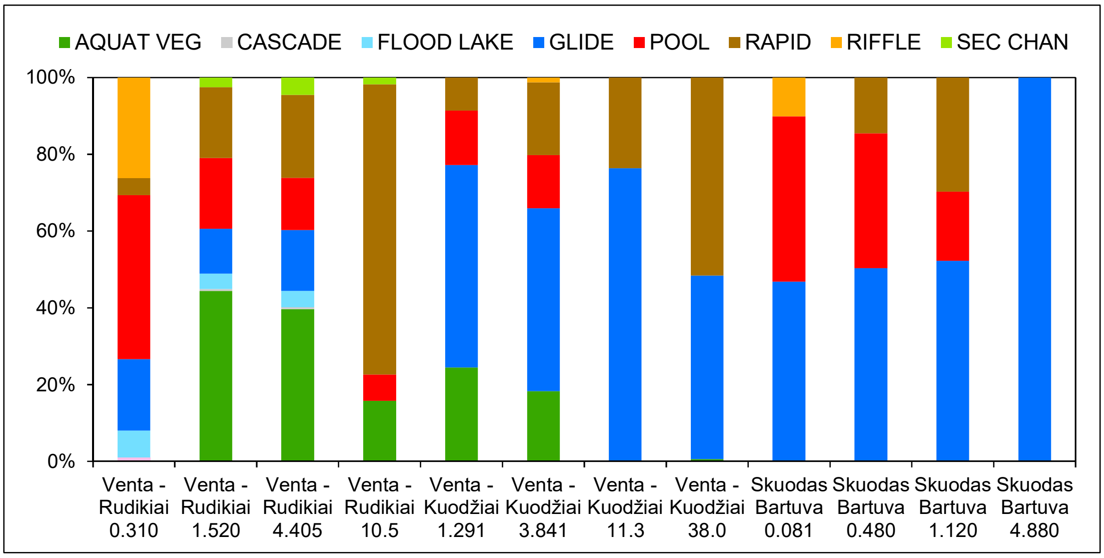

Figure 4.2. Distribution of geomorphic units in surveyed sites in Lithuanian side of Venta RBD (a number after case study corresponds to discharge)

The maps of GUs in Venta RBD (LT side) are presented in D.T.2.2.1 “First Habitat Survey Report” (Annex III, Fig. 1 – 12). As example of GUs map, the distribution of geomorphic units in the Venta at Rudikiai is presented in the conditions of four different discharges (Fig. 4.3).

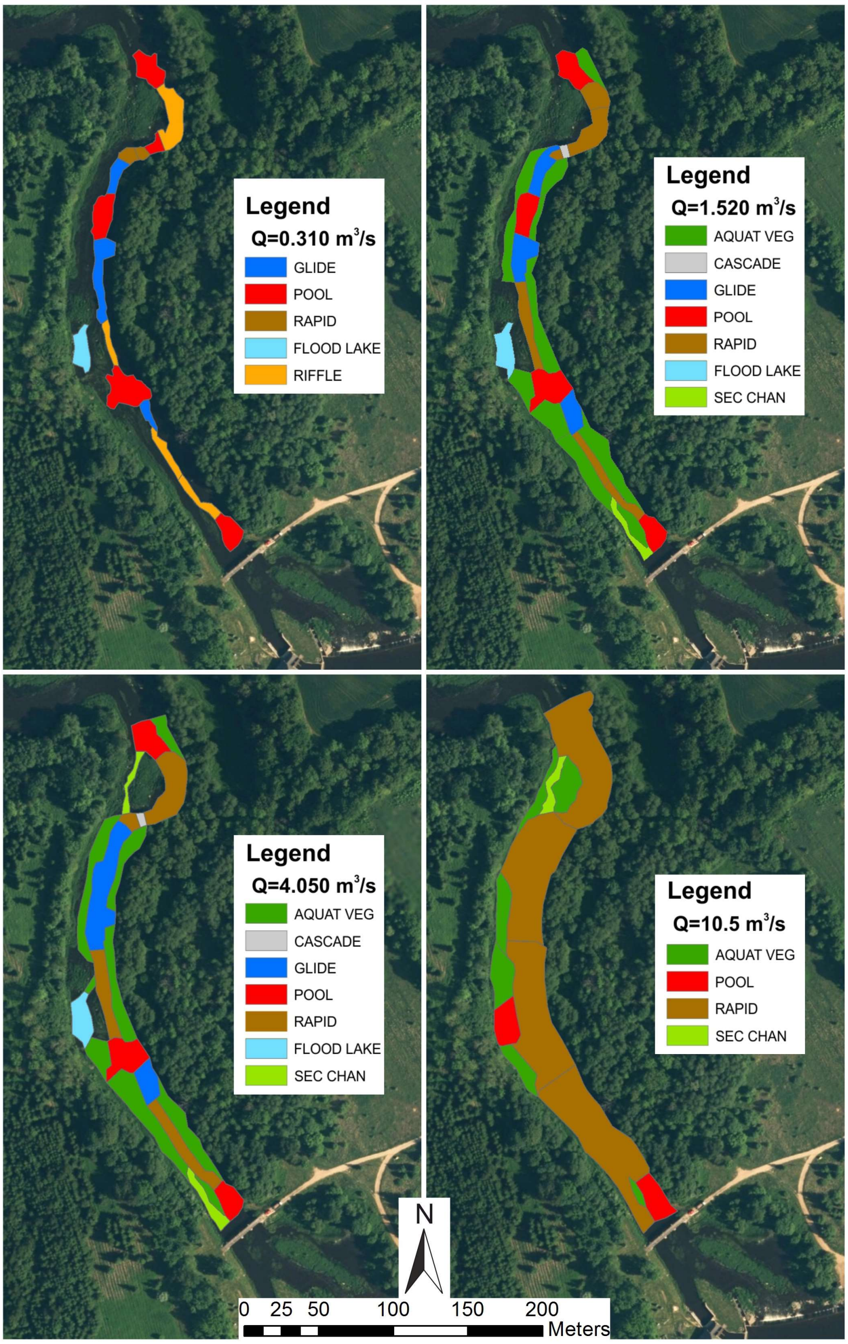

Figure 4.3. Geomorphic unit maps of the Venta (at Rudikiai) River directly below HPP in the conditions of four different discharges

In addition to the GU mapping, the hydrometric measurements have been carried out in selected case study rivers during FFS. The hydrometric part of surveys consisted of measurements of water depth, flow velocity and discharge as well as determination of substrate type (granulometry). These measurements were made in representative points of each GU. In selected cross-sections, the measurements of water discharge were carried out once in each site per survey. The measured water depths and flow velocities in representative points of each geomorphic unit can be found in D.T2.2.1 “First Field Survey Report” (Annex IV).

Latvia

Geomorphic units in the Latvian side of Venta RBD were mapped altogether in 10 sites: 4 in the Vanka River, 4 in the Eda River and 2 in the Ciecere River (Fig. 4.4). Each river stretch was assessed four times during different flow conditions. Due to changes in methodological approach Eda_4 (experimental site upstream HPPs) was not surveyed in summer 2018 and data from this site were not used in modelling. Surveyed reach length varied from 73 m in Eda River to 420 m in Ciecere River in accordance with MesoHABSIM model requirements (reach length > 10 river widths). Total mapped area depends on the length of the reach and river width. On average, mapped area varied from 2465 m^2 to 5620 m^2 in Ciecere River, from 419 m^2 to 1106 m^2 in Eda River and from 440 m^2 to 947 m^2 in Vanka River.


Figure 4.4. Hydromorthological measurements in Venta RBD

The most frequent geomorphic units within Latvian rivers are glides and runs (Fig. 4.5). High water levels during late autumn led to increase of riffles (mostly forced riffles downstream woody debris or large emergent boulders) and decrease of pools. Riffles occupy from 2.7% to 40.6% of a total mapped area in Vanka River, 22.7% - 36.4% in Ciecere River and 37% in Eda River (found only in site 3). River bed changes, new pools (behind logs or large boulders) and bars were distinguished during different surveyed periods. Maps of GUs for each case study can be found in D.T.2.1.1. “First Field Survey Report” (Annex VI, Fig. 1 – 12).

Water depths and flow velocities measured in representative points in each geomorphic unit can be found too in D.T.2.1.1 (Annex VII).

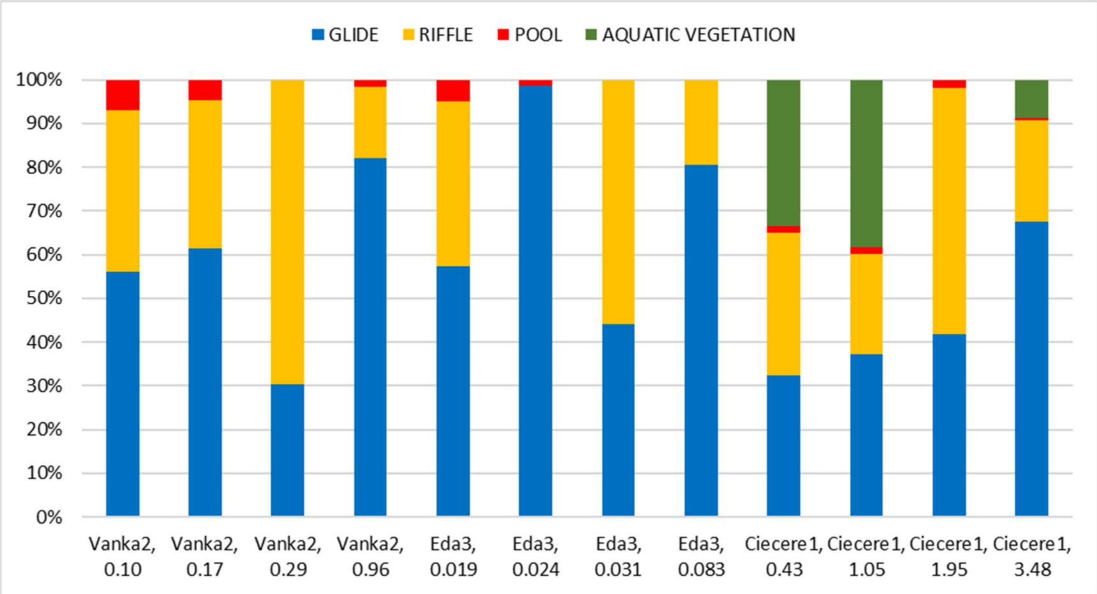

Figure 4.5. Distribution of geomorphic units in surveyed sites of Latvian side of Venta RBD (first number after river name corresponds to site number)

4.2.2. Fish data collecting

In Lithuania fish sampling was accomplished in accordance with EU standard EN 14011 (CEN, 2003), using pulse current electric fishing gear IG200/2B. Electric fishing has been performed by wading. Fish samples were collected separately in each of geomorphic units (GU), identified in a river stretch on a mesohabitat scale (Fig. 4.6). In total, 21 fish species were caught (14-18 species per river stretch). Densities of typical rheophilic fish were the highest in the GUs which are characterized by higher water flow velocities (riffle, rapid), while eurytopic and lentic fish species were most abundant (or were recorded) in GUs characterized by low or no flow (glide or pool). Cascades were inhabited purely by rheophilc fish species and dominated by Bullhead (*Cottus gobio*). River stretches, covered by dense emerged aquatic vegetation were dominated by Roach (*Rutilus rutilus*) and Bitterling (*Rhodeus amarus*), while Bleak (*Alburnus alburnus*) was the most abundant species in the pools.

Figure 4.6. Fish data collection in Venta RBD

In Latvia, fish sampling was carried out in accordance with standard LVS EN 14011:2003 (Water quality – Fish sampling with electricity), derived from the EU standard (EN 14011; CEN, 2003). Direct current electrofishing gear SAE300 was used for fish sampling. In total 20 fish species represented by 2668 adults were caught in the rivers Ciecere, Eda and Vanka. Most frequently occurred and abundant species were roach (69%), minnow (46%), ground ling and stone loach (38%). Composition of fish species corresponded to water biological and hydro-morphological conditions. Presence of bream, silver bream and other standing water species indicated the impact of HPP reservoirs while big quantity of roach pointed to the effect of eutrophication. Presence of sentinel species like a riffle minnow, bullhead, bitterling, trout and high number of gravel spawners (especially minnow) was an evidence of good ecological conditions at least in some river stretches below HPP. Presence of a trout, eel and vimba bream showed the accessibility for migratory fish in some river stretches below HPP. More information on fish data collecting is given in D.T2.2.1 "First Field survey report".

4.3. SECOND FIELD SURVEY IN LIELUPE RBD

Second Field Survey (SFS) was carried out during spring – autumn seasons of 2018 and winter season of 2019. Four field measurements during two phases of hydrological regime (minimum, average and maximum of low flow, and average flow periods) had to be performed for each case-study. In Lithuania, fish data collection for the Fish Model validation was carried out by Nature Research Centre (NRC) on 16–17 July 2018 in the Mūša, Lėvuo and Suosa rivers. In Latvia, fish data collections for the Fish Model validation were carried out by BIOR on 18–20 July 2018 in the Auce, Berze and Islice rivers.

4.3.1. Mapping of geomorphic units and hydrological measurements

Lithuania

In Lithuania, during the second field survey (SFS), the geomorphic units were mapped 10 times in three selected case studies of Lielupe RBD: 4 in the Mūša River at Dvariukai HPP, 4 in the Lėvuo River at Akmeniai HPP and 2 in the Suosa River at Stirniškiai HPP (Fig. 4.7). The length of surveyed reaches varied from 238 m in the Lėvuo River to 335 m in the Mūša River (at Dvariukai HPP). The total mapped area depended on measured discharge and geometry of the river bed. In average, the total mapped area varied from 4309 m^2 to 6325 m^2 in the Mūša at Dvariukai HPP, from 3106 m^2 to 4465 m^2 in the Lėvuo at Akmeniai HPP and from 1734 m^2 to 1826 m^2 in the Suosa at Stirniškiai HPP.

Figure 4.7. Hydromorthological measurements in Lielupė RBD

Distributions of geomorphic units (GU) surveyed within Lielupe RBD (LT side) are illustrated in Fig. 4.8. At least 6 GUs (aquatic vegetation, cascade, glide, pool, rapid and riffle) were mapped in case studies of the rivers of Muša and Lėvuo. The most frequent hydromorphic unit was glide in the Lėvuo River at Akmeniai HPP. Meanwhile, in the Mūša River downstream Dvariukai HPP, at low minimum and low average situations the glide dominated together with pool GU – 40 and 35% respectively. In the Suosa River below Stirniškiai HPP at low flow situations pool was the most dominant GU (65%). The maps of GUs for all three case studies can be found in D.T2.4.1 “Second Field Survey Report” (Annex III, Fig. 1-12).

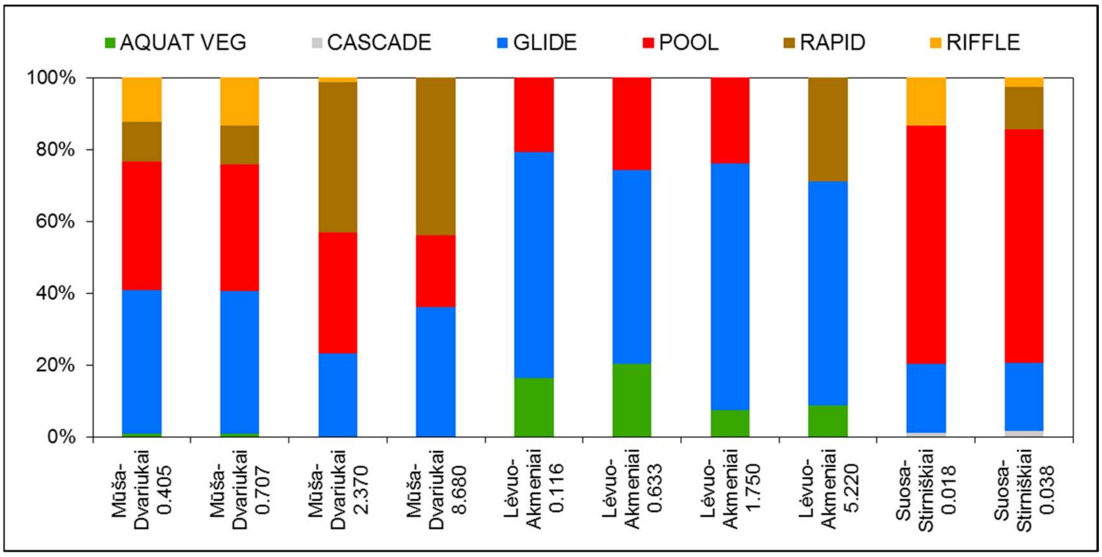

Figure 4.8. Distribution of geomorphic units in LT case studies of Lielupe RBD (a number after case study corresponds to discharge)

Hydrometric measurements in the Mūša and Lėvuo were carried out in at least 10 representative points of each GU.

Water levels and discharges in the Suosa River have never been monitored. Therefore for this reason in this case study, the water leveloggers and barologgers were applied. One levelogger was installed at the inlet of the reservoir, the second - in the reservoir, the third - at the outlet of the reservoir (185 m downstream Stirniškiai HPP). The data of recalculated discharges of inflow and outflow of reservoir as well as data of water level fluctuations in the reservoir of Stirniškiai HPP (case study of the Suosa River) are shown in Figure 4.9. Due to distinctive climatic conditions of 2018 (very dry summer) and a certain management of reservoir resources, the inflow was lower than outflow and in some cases the values got closer to 1 l/s. Outflow discharge was recorded during the whole observation period (18-21 l/s), and only several times HPP was in operating mode. Due to absence of discharges of low maximum and annual mean values below HPP the project experts were not be able to finish hydromorphological and hydrological surveys as well as habitat modelling in the case study of the Suosa River.

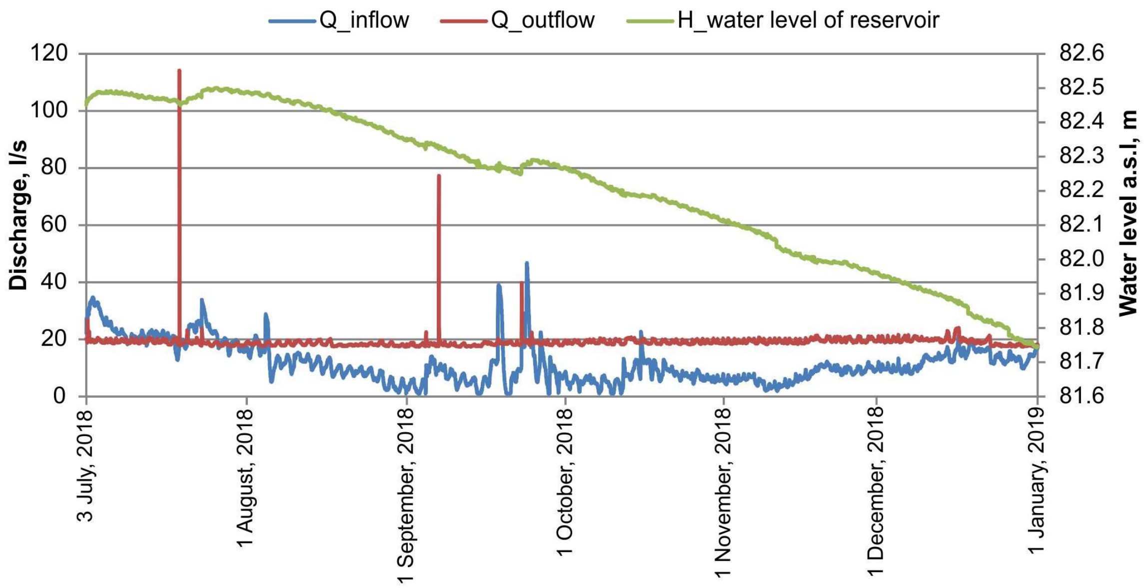

Figure 4.9. Discharges of inflow to reservoir and outflow from reservoir, and water level fluctuation in reservoir of Stirniškiai HPP

The measured water depths, flow velocities and substrate of river bed in representative points of each geomorphic unit can be found in D.T2.4.1 "Second Field Survey Report" (Annex IV).

Latvia

In Latvia, geomorphic units were mapped totally in 5 sites - 2 in the Auce and the Berze and 1 in the Islice River (Fig. 4.11). The reach length varied from 192 m in the Berze River (site 2) to 457 m in the Islice. Total mapped area was dependent from length of the reach and river width. On average mapped area varied from 1582 m^2 to 2208 m^2 in the Berze River, from 1580 m^2 to 2520 m^2 in the Auce River and from 5042 m^2 to 5423 m^2 in the Islice River.

The most abundant hydromorphic units were glides and aquatic vegetation (Fig. 4.10). There were no large differences between field surveys, probably because water level was very low. Glides occupied from 25% to 38% of a total mapped area in the Islice River, 60% - 72% in the Berze River and 66%-84% in the Auce River (only in site 3).

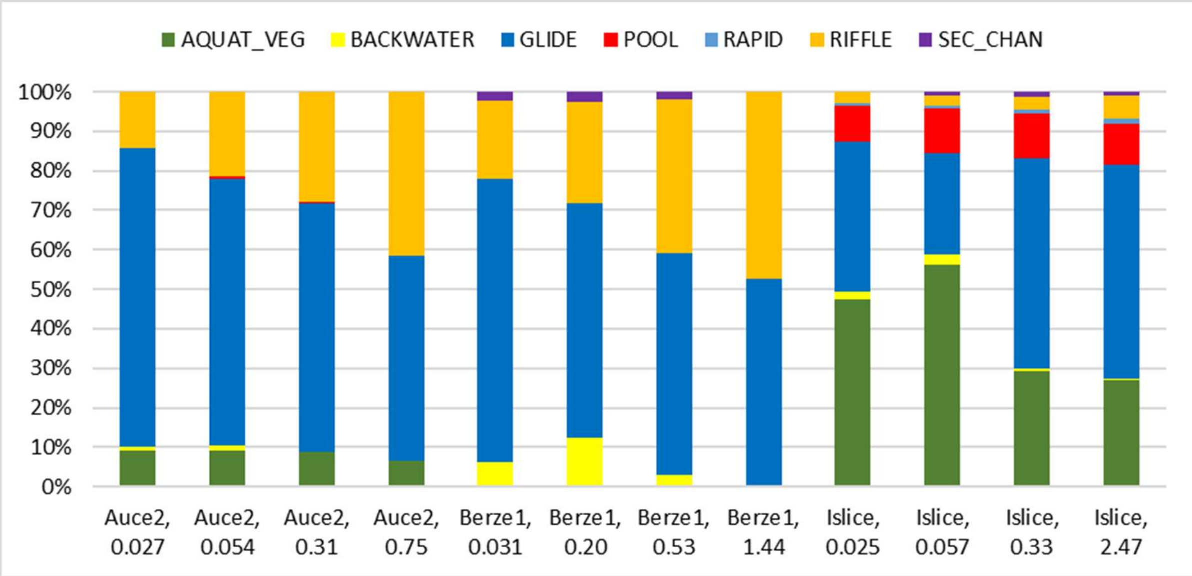

Figure 4.10. Distribution of geomorphic units in surveyed LV sites of Lielupe RBD (first number after river name corresponds to site number)

Area of aquatic vegetation varied from 9% in the Auce River (site 2) to 56% in the Islice river. Typically, rivers in Lielupe RBD can be characterized as having low slopes and sandy/silty substrate and occurrence of riffles or rapids are very low. It also means that rivers have relatively high water temperature, especially during summer, and reaches are not very suitable for salmonid fishes. Maps of different geomorphic elements within surveyed sites directly below HPP are shown in D.T2.4.1. “Second Field Survey Report” (Table 1, Annex II).

Figure 4.11. Hydromorphological measurements in Lielupe RBD (Islice River)

Additionally, to the habitat mapping the point measurements have been carried out in 3 case study sites in the Latvian rivers during SFS. More information related with hydrological measurements in the Lielupė RBD could be found in D.T2.4.1 "Second Field Survey Report".

4.3.2. Fish data collecting

In Lithuania, fish samples were collected separately in each of geomorphic units (GU), identified in a river stretch on a mesohabitat scale (Fig. 4.12). In total, 18 fish species were caught (10-13 species per river stretch). In general, the sampling results confirmed that fish species composition largely depends on the diversity of habitats, and typical rheophils prefer river stretches with a higher flow velocity. But depth, which in turn is a function of flow, becomes increasingly important at low flow conditions. The presence of artificial barriers to migratory fish in the lower reaches of studied rivers (or catchment), as well as diffused pollution from agricultural areas were additional pressures responsible for the absence of certain fish species, such as vimba (*Vimba vimba*) or spirlin (*Alburnoides bipunctatus*).


Figure 4.12. Fish data collection in Lielupė RBD

In Latvia, fish sampling was carried out in one reach in each of the project rivers – Auce, Bērze and Īslīce. In total, 2377 specimens representing 17 fish species were caught in the studied rivers: 17 species in the Īslice River, 11 species in the Bērze River and 8 species in the Auce River. Most widespread species were Eurasian minnow, European perch, gudgeon, roach, spined loach and stone loach, which were caught in all three rivers. Most abundant species were stone loach, chub and gudgeon (share 29.4%, 22.3% and 14.3% respectively). Species composition of all three rivers is typical for medium sized warm-water streams. More information related with fish data collecting in the Lielupė RBD could be found in D.T2.4.1 “Second Field Survey Report”.

Figure 4.13. Fish data collection in Lielupe RBD

4.4. FISH LISTS AND CONDITIONAL MODELS

The influence of HPP on fish communities can be assessed by modelling dependence of the distribution of fish species upon changes in water depth and flow velocity at various sites of the river channel. The composition of the bottom substrate, the presence of aquatic vegetation and other morphological characteristics that can determine the presence of a species or the number of individuals should also be taken into account. However, for the development of equations that relate biology with hydromorphology, hundreds of hydro-morphological measurements and fish samplings should be performed in different geomorphic units of undisturbed rivers. As an alternative requiring less time and attempt, conditional modelling can be used. It is based on characterization of a species-specific habitat using available fish survey data and fish lists which are prepared by expert assessments. Conditional models allow predicting the presence and/or abundance of a certain species in GU of a certain characteristics.

At nowadays the reference status river sites are absent in Venta and Lielupė RBDs in the territory of Lithuania. The list of fish species that should be theoretically present in the studied river stretches at reference status was developed based on data, collected in the reference sites of the neighbouring Nemunas river basin, taking into account the natural absence of several fish species, which are quite common in the Nemunas River (the barbel, grayling, brown trout and salmon). The list of type specific fish species in the studied rivers in the territory of Latvia was developed by using data, collected in the reference sites of the Venta and Lielupe RBDs. The lists of fish species that should be present at reference conditions in the studied stretches of the rivers are presented in D.T1.4.1 “List of specific species for Venta RBD” and D.T1.6.1 “List of specific species for Lielupe RBD”. Atypical and non-native fish species, which can occasionally occur (e.g. lake dwellers, common carp, etc.) are excluded.

In the course of this project, conditional models were developed for fish species that should theoretically reside in the analysed rivers and for which sufficient information on habitat preferences were collected. In total, conditional models were developed for 14 fish species (among them for adults and juveniles of 7 species, only for adults of 5 species and only for juveniles of 2 species). The models were developed by joint efforts of LT and LV experts, using the data available in both countries, and used in habitat modelling of the selected case studies.

4.5. HYDROGRAPHS FOR MODELLING

The daily water flow data is used for description of river hydrological regime in reference (upstream the HPP) and altered conditions (downstream HPP). Data series have been created for 3 different years (wet, average and dry) in order to describe the habitat suitability in all possible hydrological conditions. In the absence of flow data in reference conditions, the data series of river-analogue were used for modelling.

In Lithuania almost all (5 of 6) case-study sites have hydrological monitoring stations below HPPs. However, only 2 of Latvian case-study sites have hydrological monitoring stations downstream the determined small HPPs (Ciecere River – Pakuli HPP and Berze River – Bikstu-Paleja HPP). Three small HPPs are located downstream the Bikstu-Paleja HPP. It leads to additional difficulties in calculation of flow data for altered conditions. The energy production data series and turbines technical specifications have been used for these purposes.

Hydrographs for reference and altered conditions are prepared for all case study sites and used for habitat modelling. More information concerning hydrographs is presented in D.T2.3.1 “Report on modelling results”.

5. MODELLING RESULTS

The main objective of the River habitat modelling is to calculate the habitat suitability for aquatic species (fish) in different hydro-morphological conditions. Modelling results analysis leads to the E-flow values estimation in regulated rivers of Venta and Lielupe RBDs, based on the principles and approaches defined by the EU Water Framework Directive (WFD) and Guidance document No.31 “Ecological flows in the implementation of the Water Framework Directive”.

The River habitat modelling has been carried out for the 11 case-study sites within Venta and Lielupe RBDs in project countries (description of case study sites are presented in Chapter 3). In project SIM-STREAM software (as a tool that supports the Mesohabitat Simulation approach) was used for habitat modelling in the selected case study sites. Input data for habitat modelling (hydromorthological and fish measurements, fish lists and conditional models, hydrographs) are presented in Chapter 4.

The main results of habitat modelling for each case study are Habitat-flow rating curves, Habitat suitability maps, Time series of habitat availability at reference and altered conditions. Modelling results for all case study sites in Venta and Lielupė RBDs are presented in D.T2.3.1 “Report on modelling results”.

Analysis of habitat modelling results from all case study sites was done. For each study river the List of species of interest has been prepared, and according with it modelling results have been performed in the Modelling Report. The Habitat – Flow rating curves (Fig. 5.1.) show the relationship between water flow values and suitable habitat area. The habitat suitability maps (Fig. 5.2.) illustrate the changes of habitat suitability in a flow range.

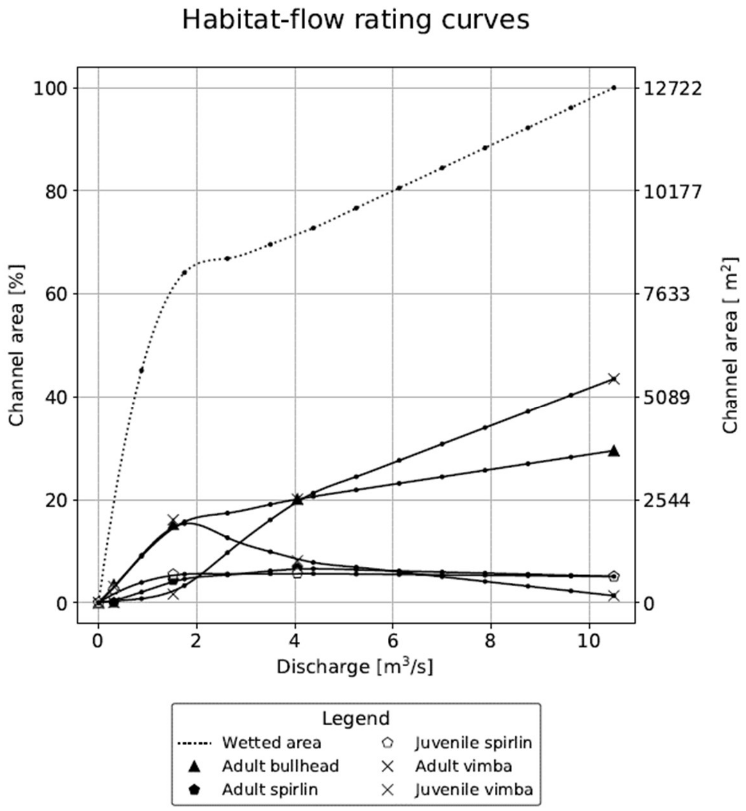

Figure 5.1. Habitat-flow rating curve of the Venta River downstream Rudikiai HPP

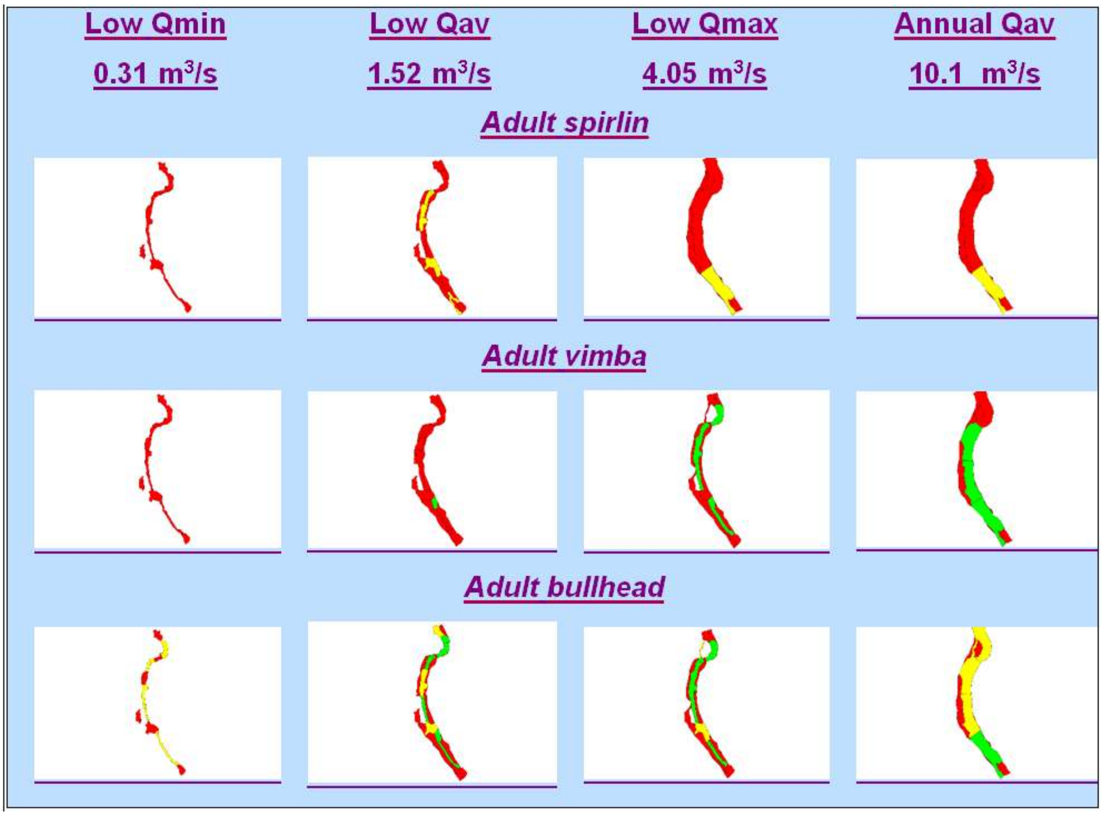

Figure 5.2. Habitat suitability for fishes at different runoff in the modelled stretch of Venta River below Rudikiai HPP (Not suitable Suitable Optimal).

The difference between habitat area at reference and altered conditions is presented by Habitat availability graphs (Fig. 5.3), were the red line is the threshold corresponding to the habitat area with a probability of 97% and the blue line is the average habitat area.

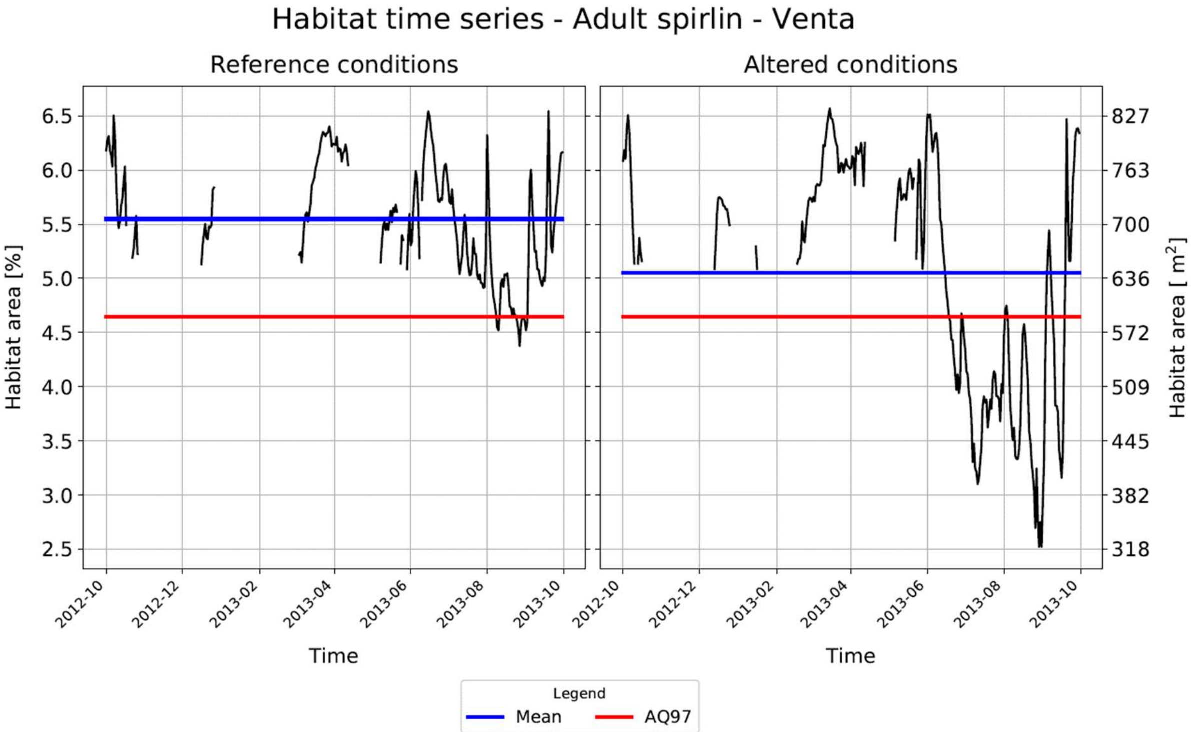

Figure 5.3. Time series of habitat availability for Spirlin at reference and altered conditions (the year with average flow), Venta River below Rudikiai HPP.

Habitat – Flow rating curves vary: 1) from rapid increasing during minimum flow till almost maximum value of habitat area and slowly increasing or decreasing later on, to 2) continuous increasing. The first case is common for the cyprinid fish species. Herewith the maximum value of habitat area for juveniles is smaller than for adults and corresponds with smaller water discharge (Fig. 5.4). The second case is usual for the salmonid fish species. The conditional maximum value of habitat area might be corresponded with annual mean flow (Fig. 5.5).

The maximum habitat area and the water discharge related to this area is a critical point for evaluation of E-flow. 60% of it is the optimal value for existing and development of aquatic fauna including fish. Table 5.1. shows the Opimal water discharge value for project case studies in comparing with guaranteed and ecological water discharge of HPPs.

Table 5.1. Optimal and existing ecological/guaranteed water flow

River	Site	Optimal water discharge		Required water discharge by Permission Act	
		Adult fish	Juvenile fish	Ecological	Guaranteed
Venta	Papile WGS	4.41	1.80		0.39
Venta	Leckava WGS	13.38	4.20		1.75
Bartuva	Skuodas WGS	1.24			0.22
Vanka	downstream Edole HPP	0.58	0.29		0.058
Eda	downstream Skede HPP	0.50	0.25	0.18	0.049
Ciecers	downstream Pakuli HPP	2.10	1.05		0.32
Musa	Ustukiai WGS	2.60			0.38
Levuo	Bernatoniai WGS	1.74	0.56		0.139
Berze	downstream Bikstu-Paleja HPP	0.43	0.22		0.031
Auce	downstream Bene HPP	0.19	0.09		0.007
Islice	downstream Rundale HPP	0.25	0.12		0.16

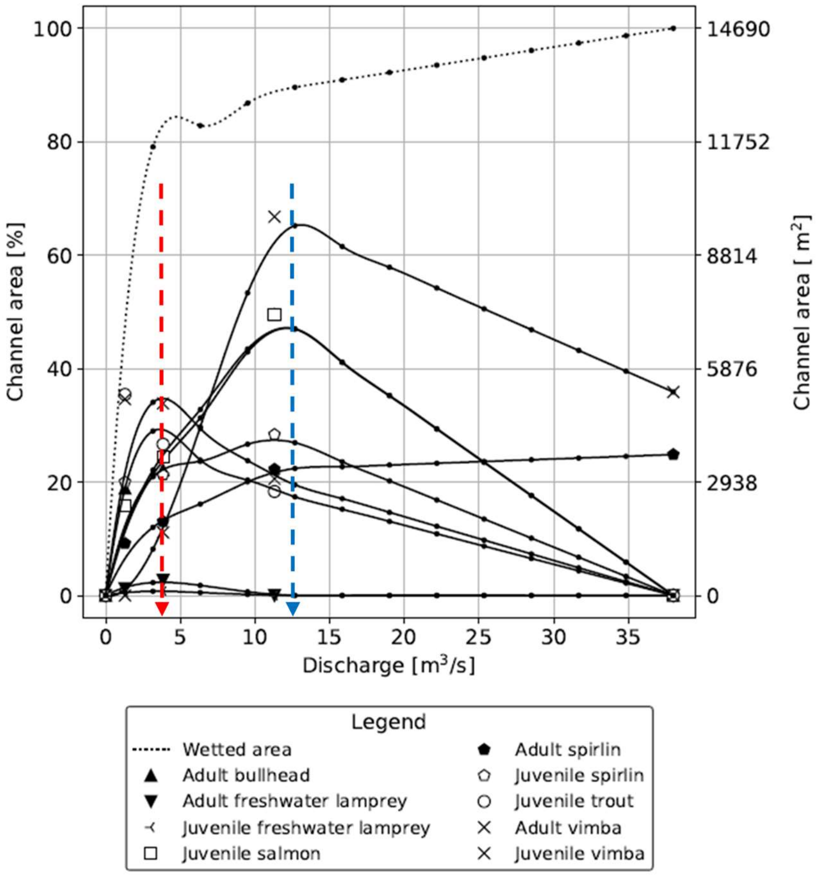

Figure 5.4. Habitat-Flow rating curve of the Venta River downstream Kuodžiai HPP (red arrow shows the optimal water discharge for juveniles and blue arrow – for adults)

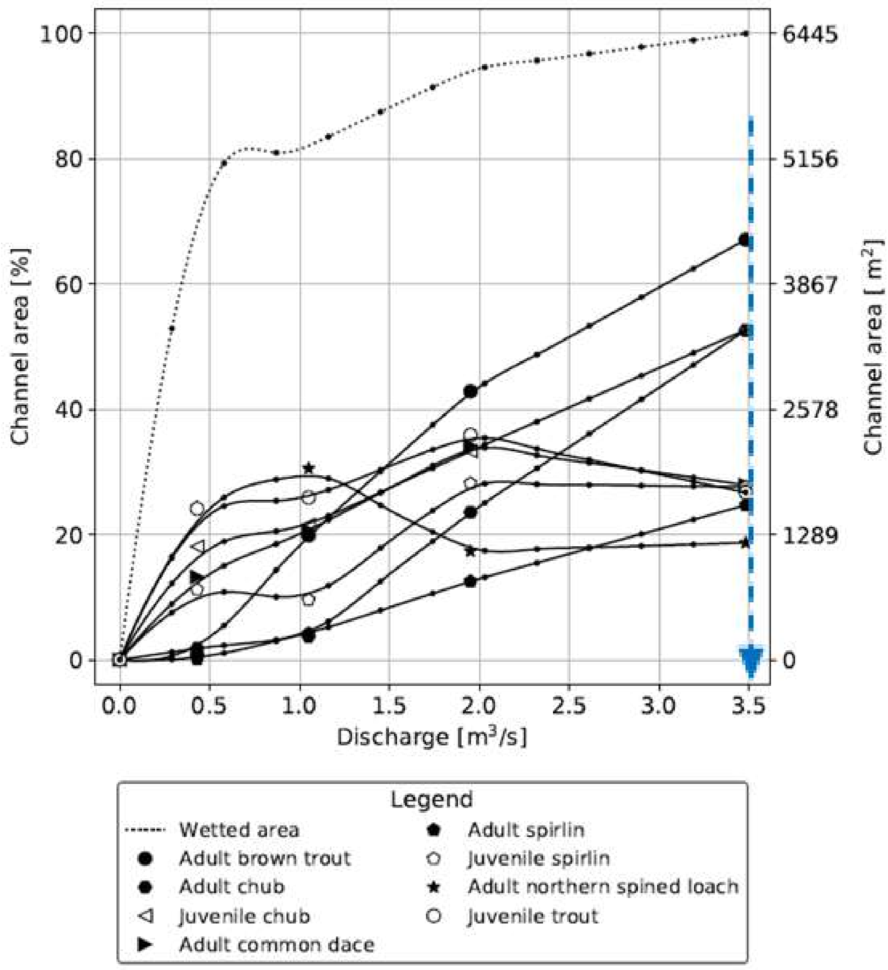

Figure 5.5. Habitat-Flow rating curve of the Ciecere River downstream Pakuli HPP (blue arrow shows the optimal water discharge for adult brown trout)

Presence of the different optimal flow for adults and juveniles implies the E-flow variations during a year depending on fish life stage and fazes of hydrological regime. Therefore, the *ecological flow regime* (not the constant E-flow) should be provided by HPPs in order to ensure the *Good ecological status* of water bodies. There is the necessity to provide the "ecological regime" in regulated rivers, and allow to estimate "winter E-flow" for fish spawning periods (from November to May) and "summer E-flow" for growing of juveniles (from June to October).

MesoHABSIM is a biologically sound method for E-flow evaluation. However, it contents huge amount of works and is resource-consuming for applications on country scales. Therefore, on the base of modelling results some formula for E-flow calculation would be proposed. Taking into account the restricted number of case studies during the project (only 6 sites within 2 river basins), the main project results concerning ecological flow should be validated in different rivers in order to estimate the country-wide E-flow values.

Modelling results show the closed relations between water flow and habitat availability as well as fish species presence and abundance in altered conditions. Existing guaranteed and ecological flow values regulated by LT/LV Permission Acts are not supporting sustainability of aquatic ecosystem.

6. METHODOLOGY FOR E-FLOW ASSESSMENT IN LATVIA AND LITHUANIA

According to CIS Guidance Document No. 31 “Ecological flows in the implementation of the Water Framework Directive”, each EU country has to develop national methodologies for ecological flow implementation. Therefore, methodology to determine ecological flows in Latvia and Lithuania are prepared on the base of Latvian-Lithuanian transboundary river basins (Venta and Lielupė RBDs). This methodology can be used by institutions which are involved in issuing permits for the use of water resources, environmental NGOs and other interested stakeholders. Data from 11 case studies in 10 rivers within Venta and Lielupe transboundary river basin districts were used. As both catchments belong to the same ecoregion (Baltic lowland province), one methodology for both countries can be developed.

E-flow calculation method, input data and results are described in Methodology. Estimating ecological flow, the SIM-STREAM tool of QGIS is used for implementation of the MesoHABSIM Simulation. The mentioned tools required different kind of information as input data, such as fish conditional models, hydro-morphological data and hydrological data. The software integrates hydro-morphological data collected during field surveys with fish data. This physical habitat simulation model describes river features that are relevant for aquatic species, calculates habitat suitability, and reports on the actual and projected status of the investigated river.

To establish the E-flow in the modelled river stretches, the Optimum flow (thereafter $Q_{OPTIMUM}$) should be chosen as a baseline. The $Q_{OPTIMUM}$ is a flow value, at which the area of suitable habitat reaches its maximum, or continues to increase, depending solely on the surface area of the water. The optimum flow is determined using a modelled relationship between runoff and area of habitat suitable for certain fish species. The $Q_{OPTIMUM}$ values for different fish species, as well as adults and juveniles, can be different. In view of existing relations between habitat availability and water ecological quality, it is possible to conclude that 60% of the $Q_{OPTIMUM}$ is sufficient value for presence and development of fish fauna during spawning and rearing period (mid October – June). For the rest of a year

30% of the $Q_{OPTIMUM}$ is necessary to protect the aquatic fauna and flora during the dry season.

The Roadmap of E-flow evaluation includes the following major steps:
1) collecting water flow data in reference and altered conditions;
2) collecting fish (species of interest) data;
3) carrying out field measurements and habitat mapping using the “Habitat Survey datasheet” (D.T 3.1.1 “Methodology for minimum E-Flow estimation”, Annex I) and the “Geomorphic units and macro-units list” (Annex II);
4) habitat modelling by SIM-STREAM Model;
5) developing $Q_{OPTIMUM}$ using Habitat – Flow Rating curve;
6) calculation of E-flow values.

The Methodology of E-flow calculation using Roadmap steps requires a lot of hydromorthological and fish data, field surveys and modelling experience. Therefore, E-flow calculation simplification routine has been developed using habitat modelling results in 11 case study sites in Venta and Lielupė RBDs. Comparison of the modelling results with annual characteristics of the studied rivers stretches indicates that different ecological flows should be used for the low flow season, and another part of the year to mitigate the impact of HPPs. These E-flows are: Winter E-flow = min $Q_{50\%\ winter}$*0.65; Summer E-flow = min $Q_{50\%\ summer}$.

Latvia and Lithuania have different legislation and regulations in the field of environmental protection. Therefore, the role of state authorities and other institutions involved in setting environmental requirements for water use is also different. For this reason, the recommendations on the approach for determining ecological flows are specific for each country. Detailed methods of practical applications for E-flow evaluation methodology in Latvia and Lithuania are presented in D.T 3.1.1 “Methodology for minimum E-Flow estimation”.

7. RECOMMENDATIONS FOR CHANGES IN LEGISLATION

Recommendations for changes in legislation due to evaluation of E-flow are based on the analysis of the requirements specified in LV and LT legislation with regard to E-flow definition, their comparison with the EU legislative framework obligations, as well as the project results.

In Latvia, although Ecological flow for the hydropower plants has to be calculated obligatory, in practice there are many examples where ecological flow is defined equal to minimum guaranteed flow, as the Definitions of ecological flow and minimum guaranteed flow in different legislation acts are sometimes contradictory. The term “minimum guaranteed flow” in Regulations of the Cabinet of Ministers of Latvia should be abandoned and replaced with correct application of Ecological flow.

In Lithuania, the term “environmental discharge” (“gamtosauginis debitas” in Lithuanian) that emerged in “Procedure for Environmental Discharge Calculation” in 1997, is not environmentally friendly because it is designed to ensure only minimum conditions for ecosystem survival. The established environmental discharge is related to probability of multiannual runoff reoccurrence (Q_{30} of 95% or 80% probability). This definition of environmental discharge allows high water level fluctuations (i.e. hydropeaking) downstream from the HPPs. The term “environmental discharge” in Lithuanian legislation documents should be abandoned and replaced with correct application of Ecological flow.

New conceptual definition of Ecological flow, with a clear reference to both flow quantity and dynamics and to their consistency with the environmental objectives needs to be developed and consistently used by all involved parties, harmonizing ecological flow calculation methods and necessary data, procedures according to water use and river type, as well as responsible authorities need to be incorporated in the legislation.

The ecological flow rate has to be calculated for each separate hydropower plant according to the WFD Guidance Document No. 31 “Ecological flows in the implementation of the Water Framework Directive”:

- based on scientific criteria and monitoring data;

- encompass and/or repeat a full range/complexity of flow natural regime variability (i.e. no artificial droughts, hydropeaking, etc.);
- comply with biological/habitat requirements of a certain regulated river, especially during spawning and migration seasons;
- be constantly supervised and monitored by environmental authority.

All text of Recommendations is presented in D.T 3.1.1 “Recommendations for the amendment to national water legislations”.

8. DISSEMINATION OF THE PROJECT RESULTS

Starting the project, Communication plan was elaborated with the aim to disseminate information on the project activities, results achieved and good practices implemented to the general public and stakeholders. Important information regarding project activities, achievements, events and overall project is published in several webpages:

1. Latvian Environment, Geology and Meteorology Centre (LEGMC, www.meteo.lv);
2. Lithuanian Energy Institute (LEI, www.lei.lt);
3. Institute of Food Safety, Animal Health and Environment BIOR (BIOR, www.bior.lv);
4. Latvia-Lithuania transboundary cooperation programme 2014-2020 (Project webpage, https://latlit.eu/supported-projects/).

During the project also social media was used to inform stakeholders about activities within the ECOFLOW project: the project partners LEGMC and LEI actively published posts in their Facebook and Twitter accounts, the information was disseminated in 7 newsletters and 6 press releases. For example, in Lithuanian media (Aina -*10 September 2018*, Elektronika - *4 September 2018)* two papers ("*Ar mažosios hidroelektrinės draugiškos aplinkai?"*) were published about the project results. Latvian media actively reacted after publishing the final press release. For example, the information was included in national TV newscast (23 March 2019), and also in radio broadcasts (LVR1/Pēcpusdiena - 14 March 2019), as well as in many other sources (Kurzemnieks - 29 March 2019, skaties.lv - 23 March 2019), etc. The information about surveys provided by the project are essential for general public and main stakeholders because such detailed investigation has not been made in the last decade. Taking into account the newest approach from European scientists and guidelines elaborated for successful implementation of requirements under Water Framework Directive 2000/60/EC, such surveys were necessary and will improve status of common water resources.

To acquaint stakeholders with progress achieved in the project, in 27 September 2018 workshop for stakeholders was organized in Panevėžys (Lithuania). The work was organized in separate sessions – two parallel sessions in national languages

(Latvian and Lithuanian) and the third joined session, where learned lessons and expected outcomes were discussed. The main issues of this meeting were mapping of hydro-morphological units in Venta and Lielupe river basin districts, habitat modelling results and E-flow concept. Flyers/brochures in national languages (LT and LV) were given for each participant. More than 50 participants took part in this meeting from Lithuania and Latvia (Figure 8.1), including representatives from regional environmental authorities from both countries, Ministry of Environment of Republic of Lithuania, Ministry of Environmental Protection and Regional Development of Republic of Latvia, Environmental Protection Agency of Lithuania, Lithuanian Hydropower association, Lithuanian member committee of the World energy council, Latvian Anglers association, State environmental service of Latvia and other organisations. Flyers in Latvian and Lithuanian languages with project results were distributed between participants of Stakeholder workshop. At the end of the workshop stakeholders were asked to fill the questionnaire in order to assess the event. The following questions were as: this workshop was well organised; the material presented was relevant and helpful; the purpose of the workshop was met; my expectation of the workshop was met. Overall assessment was excellent/good. Some of participants gave also remarks/comments to this event, for example, that “it would be also good to have a longer common session and have a bit more overview of how each country is dealing with the issue, project, etc”, some were disappointed that common session was in English.

Figure 8.1. Stakeholder workshop in Panevėžys (Lithuania), 27.09.2018

On February 26, 2019 the Final conference of the project “Ecological flow estimation in Latvian-Lithuanian trans-boundary river basins” (LLI-249, ECOFLOW) was held in Riga (Latvia). Project experts from three partner organisations and many stakeholders participated in this conference. During this event participants were informed about meso-scale habitat modelling, results of habitat surveys in transboundary Venta and Lielupe river basin districts, as well as results of fish data collection and analysis. The recommendations for possible amendments to the national water laws were also presented. Brochures for the Final conference were prepared in Latvian, English and Lithuanian languages and distributed to each participant, as well as poster with general information about the project ECOFLOW. More than 60 participants took part in this event from Lithuania and Latvia (Figure 8.2).

Figure 8.2. Final conference in Riga (Latvia), on 26.02.2019

In total, approximate number of persons reached by different activities distributing the information about the project and achieved results is more than 800 000 persons. It includes both social networks (newspapers, ethernet, radio, television etc.) and direct discussions during official events.

9. SUMMARY

One of the specific objectives of the Interreg V-A Latvia – Lithuania Programme is to increase integration and efficiency of environmental resource management. The main objective of the project - to improve the efficiency of regulated rivers management using E-flow approach - is closely related to sustainable development and environment. There were three specific tasks in the project: a) evaluation of the water diversion for the hydropower production; b) E-flow estimation for regulated cross border rivers; c) development of the new Methodology and Recommendations. All mentioned tasks were implemented during the project period.

Ecological status of Latvian and Lithuanian rivers was evaluated according to the hydromorphological quality elements: hydrological regime (water discharge and dynamics), river continuity and morphological conditions (bank and riverbed structure; runoff amount and character; condition of riparian vegetation; soil composition). Construction and operation of 78 HPPs in Venta RBD and 24 HPPs in Lielupė RBD have negative impact on river ecological status because of river connectivity disruption (changes of hydrological regime), impact of flow regulation on biological elements (minimum flows, hydropeaking), and modifications of sediment transport. Hydropower dams alter natural flow regime and harm riverine ecosystems. River continuity is a vital part of a healthy ecosystem and dry periods, caused by natural or man-made alterations, may lead to irreparable damage of aquatic ecosystems. Fish fauna in particular is the most sensitive to hydrological alterations, mainly because of it's inability to overcome artificial obstacles and getting to their feeding and spawning areas.

Evaluation of the impact of HPP dams and reservoirs on the ecological status of waters downstream was performed through targeted habitat surveys and simulations by MesoHABSIM model. In Venta and Lielupė RBDs, 12 river reaches with operating small HPPs were selected as the case study sites for habitat surveys. First and Second field surveys were carried out in Venta RBD and Lielupė RBD, accordingly. Hydromorthological and fish measurements were done in the situations of different discharge in the rivers (minimal, average and maximal low discharge, average discharge). These data and conditional fish models were used as an input data for habitat modelling. Modelling results in two transboundary river basin districts showed the close relations between water flow and habitat availability as well as fish species presence and abundance in altered conditions. The project results show the necessity to provide the “ecological regime” in regulated rivers, and allow to estimate “winter E-flow” for fish spawning periods (from November to May) and “summer E-flow” for growing of juveniles (from June to October).

Methodology of E-flow evaluation is created on the base of Latvian-Lithuanian transboundary river basins (Venta and Lielupe RBDs). E-flow calculation method, based on MesoHABSIM model, contents huge amount of works and is resource-consuming for applications on country scales. Therefore, on the base of modelling results some formulas for E-flow calculation are proposed as E-flow calculation simplification method. Taking into account the restricted number of case studies during the project (only 6 sites within 2 RBDs), the main project results concerning ecological flow should be validated in different rivers in order to estimate the country-wide E-flow values.

Recommendations for changes in legislation are prepared according to the analysis of the requirements specified in LV and LT legislation with regard to E-flow definition, their comparison with the EU legislative framework obligations, as well as project results. Currently existing “guaranteed water discharge” or “environmental discharge” definitions in Latvian and Lithuanian legislation should be changed by new conceptual definition of ecological flow, with a clear reference to both flow quantity and dynamics and to their consistency with the environmental objectives. The ecological flow rate should be an integral part of the issuing of new water use permits and extending the term for existing permits.

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