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**Joint management of Latvian – Lithuanian trans-boundary river and lake water bodies (TRANSWAT) LLI-533**

# Review of existing hydro-morphological data and HPPs technical specification

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LVĢMC

UNIVERSITY OF LATVIA

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**Abbreviation**

| | |
|---|---|
| ASPT | Average Score Per Taxon (macroinvertebrates); |
| $BOD_7$ | Biological Oxygen Demand (in 7 days) |
| $BOD_5$ | Biological Oxygen Demand (in 5 days); |
| DSFI | Danish Stream Fauna Index; |
| H' | Shannon Wiener Diversity Index |
| HEC-RAS | Hydrologic Engineering Center's River Analysis System |
| ind. | Individuums |
| HPP | Hydropower Plant; |
| LT | Lithuania; |
| LV | Latvia; |
| Ntot | Total nitrogen; |
| $NH_4$-N | Nitrogen content of the ammonium ion |
| $O_2$ | Oxygen; |
| Ptot | Total phosphorus; |
| $PO_4$-P | Phosphate phosphorus; |
| RBMP | River Basin Management Plan; |
| WGS | Water Gauging Station |
| WWTP | Waste Water Treatment Plant |

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# I INTRODUCTION

In the frame of the ECOFLOW project (Lat-Lit INTERREG, ECOFLOW LLI-249) some investigations in the field of ecological regime downstream hydropower plants have been carried out. During that project river habitats of 6 rivers in the Venta and 5 rivers in the Lielupe transboundary river basins were mapped and modelled. Results of those investigations allow to describe the impact of separate HPP on aquatic fauna and to calculate values of the ecological flow for different seasons. However ECOFLOW project didn't bring up the HPP cascade issue that is very important as far as water policy is concerned.

One of the aim of the "Joint management of Latvian – Lithuanian trans-boundary river and lake water bodies" project (TRANSWAT) LLI-533 financed by the Interreg V-A Latvia–Lithuania Programme 2014-2020 is modelling of the ecological regime for HPP cascade. An adoption of project results will help to avoid the insufficient amount of water downstream HPPs and the adverse effect of HPP cascades' operation on the ecological status of water bodies.

The hydro-morphological characteristics of pilot rivers (Ciecere and Losis rivers in Latvia and Varduva River in Lithuania), pressures and its impact on the ecological quality of water will be described in this Report. Data gaps in hydrological and ichthyological information as well as in technical construction will be identified for filling during the implementation of the TRANSWAT project.

# II RIVER BASINS OVERVIEW

All project pilot river basins belong to transboundary Venta River Basin the detailed description of that has been done in the Report of ECOFLOW project “Review of hydropower plants influence on water quantity and quality in Venta River Basin Districts” [1]. The present report includes wide information about tributaries of Venta River: Varduva River (LT), Ciecere and Losis rivers (LV) and their watersheds.

## 2.1. Ciecere River

The Ciecere River is a right tributary of the Venta River. It outflows from the Ciecere Lake and inflows to the Venta River in Brocēni, Saldus and Skrunda counties (Fig. 2.1.1.). The catchment area is mostly located in the Eastern Kurzeme upland.

The Ciecere River Basin area is 539 km$^2$. The river is 51 km long, the river bed gradient is 1.7 m/km in upper stretch and 1.0 m/km in down stretch. An elevationof the river basin varies from 23 to 101 m LAS. Largest tributaries of the Ciecere River are Vēršāda, Dīcmaņu and Krimelde (right bank), Bukupe and Paksīte rivers (left bank). The Ciecere River has 48 other tributaries shorter than 10 km. There is a risk of flooding in the Ciecere River.

River has small U- and V- shaped (in upper reach) valley, 150 – 200 m width. The valley slopes are moderate, formed by sandy loam, overgrown with brush. In some places, there are outcrops of bedrock. Floodplain is also formed by sandy loam, covered by brush and meadow vegetation, inundated. Channel is sinuous, 10 m width in average and 0.3-0.6 m depth. There are bars, artificial and natural riffles in the upper stretch near Saldus. River bed substrate: boulders, cobbles, gravel and silt [2]..

The Ciecere River in the section from Pakuļi Reservoir to the estuary has been identified as a priority fish water as a type of salmonid water.

The water body Ciecere_1 (*V105SP*) from the river source to the Nasa River is classified as a heavily modified water body due to hydromorphological pressures and as a water body of type 3 (medium – sized rithral river). The water body’ catchment area is 297.49 km$^2$. The stream gradient here is 1.37 m/km.

The Ciecere River Basin’ annual amount of precipitation is 500 - 650 mm. The growing season lasts 185 - 195 days. Forests cover about 33% of the basin area, agricultural land - 57%, lakes - 3.5%, bogs - 0.35%. Urban areas cover 6% of the watershed.

The water body Pakuli HPP reservoir (*Pakuļu HES ūdenskrātuve, E017SP*) is classified as a water body type 2 (very shallow brownwater lake with high water hardness). The water body' area is 442 km$^2$.

The water body Ciecere_2 (*V054*) from the Naša River to the estuary is classified as a water body of type 3 (medium – sized rithral river). The water body' area is 555 km$^2$. The stream gradient here is 1.2 m/km. Forests cover about 51%, agricultural land 43%, lakes 1%, bogs 3.5% and urban areas 1% of the catchment area.

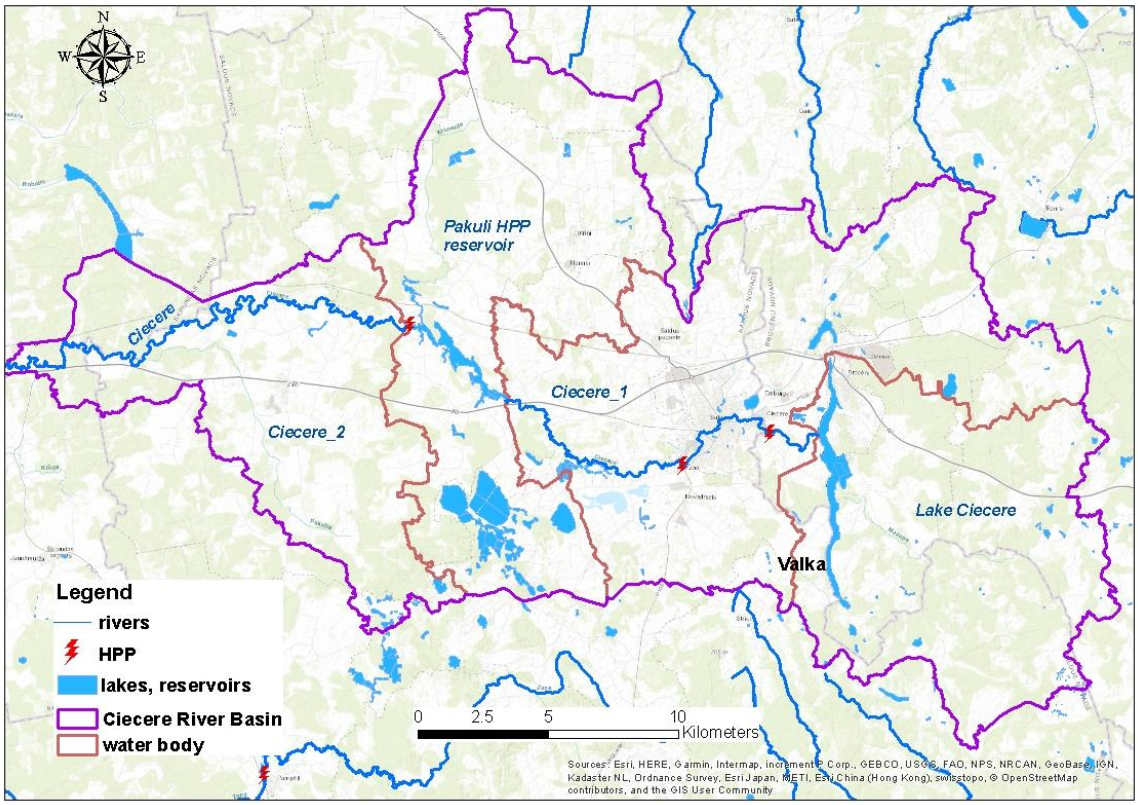


**Figure 2.1.1. Ciecere River catchment area**

## 2.2. Losis River

The Losis River (Lithuanian - Lūšis) is a 37.5 km long Latvian - Lithuanian transboundary river in the Venta River Basin District (Fig. 2.2.1.).

The Losis River that begins in Berztvu forest (LT), is a left tributary of the Venta River in Saldus and Vaiņode counties in Latvia. The catchment area is located in the Eastern and Western Kurzeme uplands. In the upper reach the river flows in a northerly direction to the Latvian border, then turns east and 22.1 km is the Latvian-Lithuanian border river. River turns north before Kalni village and after 7.2 km flows into the Venta River.

The riverbed is regulated in the upper reach, Kanavišķi Reservoir was built below Kalni village. The largest tributaries are Spinnis, Dargis, Zverupe rivers and the border river Janupite [3]. There is a specially protected nature territory in the catchment area - Nature Reserve “Nigrandes mezi”.

Grantini HPP and Lejnieki HPP are located on the Losis River. Grantini HPP is located in 6 km from the river mouth. Lejnieki HPP is located in 1.8 km from the river mouth and below Kanavisku Reservoir. The Losis River is at risk of flooding.

The water body Losis (*V059*) is classified as a river of the type 3 (medium – sized rithral river). The water body’ catchment area is 111 km$^2$. The stream gradient here is 2.14 m/km. The annual precipitation in Losis River basin area is 700 mm. The growing season lasts 185 days. Forests cover about 54.5%, agricultural land 43.9% and urban areas 1.6% of the catchment area.

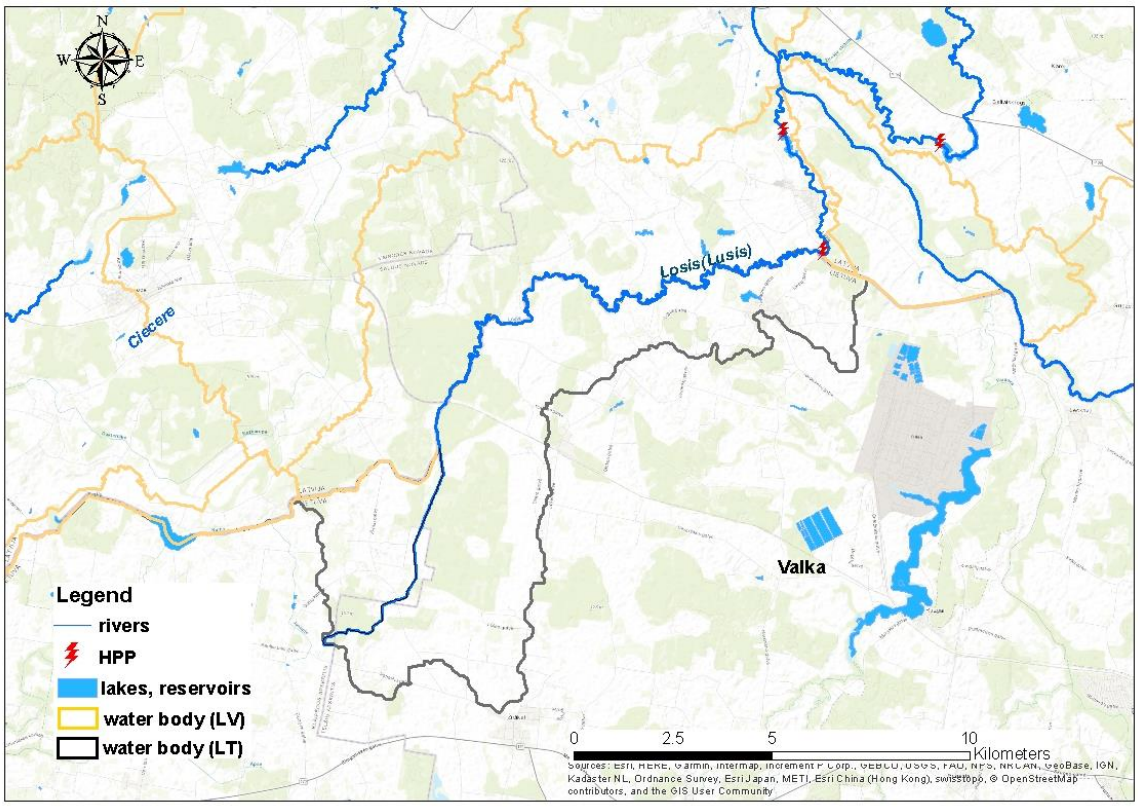


**Figure 2.2.1. Losis (Lusis) River catchment area**

## 2.3. Varduva River

The Varduva River flows through north western Lithuania. It is a left tributary of the Venta River joining the main channel at the Latvian-Lithuanian border. Rising in the dividing hills of Samogitian Highlads (at 122.5 metres above sea level), the Varduva River then flows through the Northern Samogitian Plateau and descends

into the low elevation Venta Middle-Course Lowland to its confluence with the Venta River (at 182.5 km from its mouth) (Fig. 2.3.1).

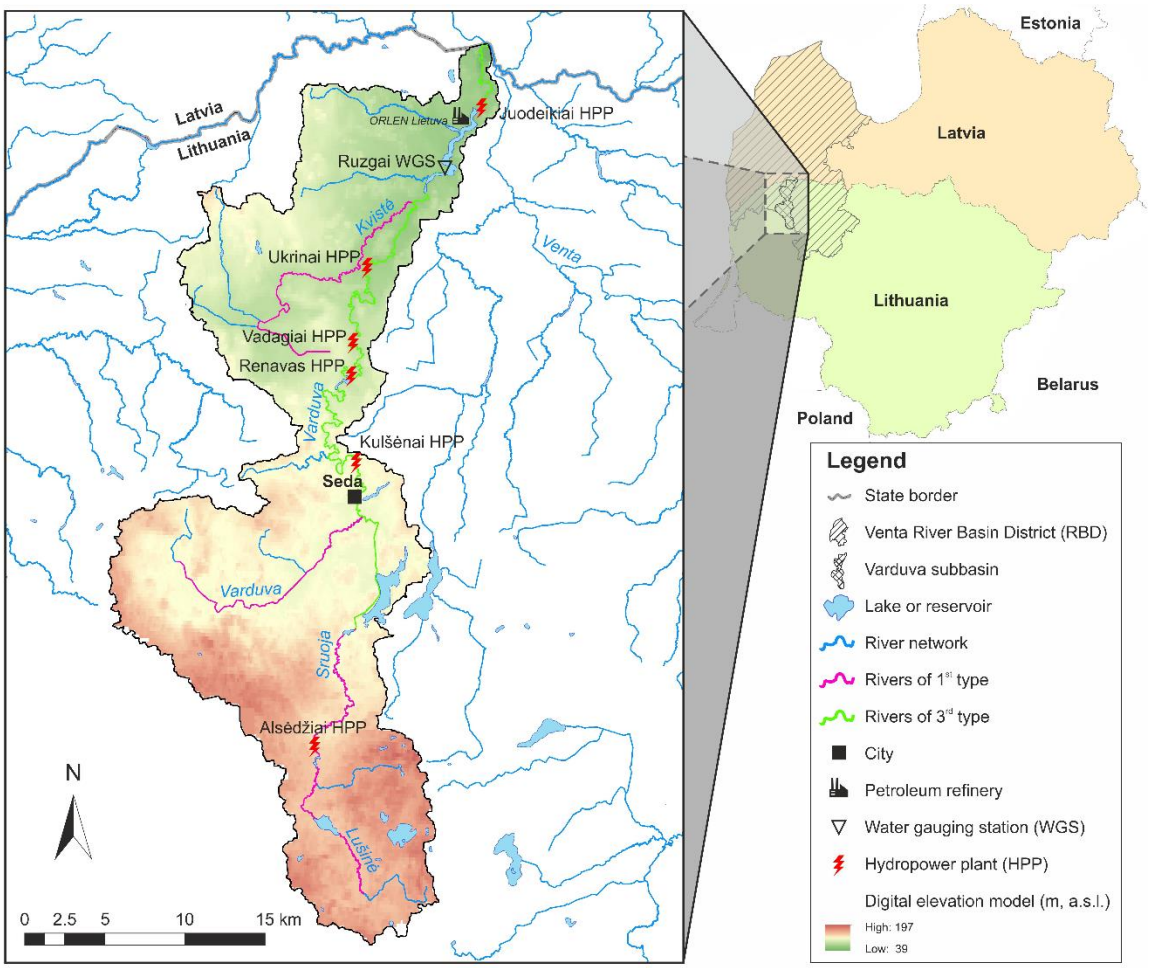


**Figure 2.3.1. Varduva River basin**

The Varduva River is the third largest tributary of the Venta River (in the territory of Lithuania), drainage area is 586.7 km$^2$. The length of the river is 90.3 km. The Varduva River has a high density drainage basin - 1.32 km/km² (total average drainage density in Lithuanian territory – 0.99 km/km²) [4]. The average stream gradient of the Varduva River is 0.94 m/km, while some stretches of the river, for example from 35 to 39 km from the mouth, this measurement reaches 1.75 m/km (Fig. 2.3.2). The Varduva is a relatively meandering river with the sinuosity index of 2.60.

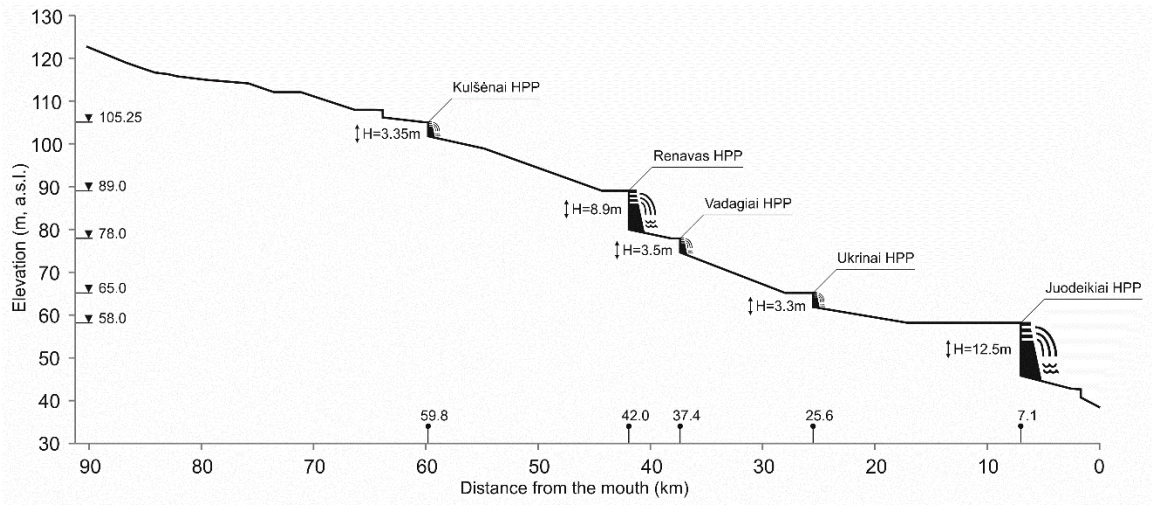


Figure 2.3.2. The longitudinal profile of the Varduva River

The major tributaries of the Varduva River are rivers Sruoja (right), Kvistė (left), Dubulis (left), and Eglynupis (left). The river also has 16 smaller tributaries with a length of less than 10 km. The length (30.0 km) and the catchment area (179.5 km²) of the Sruoja River at the confluence with the Varduva River (at 66.4 km from its mouth) are larger than those of the main river (23.9 km and 136.8 km², respectively). Water discharge of the Varduva River at confluence is about 1.42 m³/s, the Sruoja River – 1.77 m³/s.

The Varduva River valley is 0.5–1.7 km wide. The river floodplain is mostly one-sided, 50–120 m wide. The riverbed of the upper reaches of the river is regulated (from the source to 72.9 km). The width of the upper reaches is 5-8 m, the depth - 1.8-2.5 m.The width of the natural channel is 10–20 m, the depth is 0.8–1.5 m [5].

The annual precipitation in the Varduva River basin area is 750 mm. Most of the precipitation falls on the area of the upper reaches – 800 mm/year [4, 6]. Total evaporation exceeds 300 mm/year. Agricultural lands cover 70.2%, forests 24.1%, urban areas 3.2%, water bodies 1.8%, and swamps 0.7% of the Varduva River catchment area.

All the river types in the Varduva River basin are classed as low altitude (< 200 m) km² and stream gradient >0.7 m/km). The Varduva River from the 85.5 km (Degemė River mouth) to the 66.4 km (Sruoja River mouth) is classified as a water body of type 1, and from the confluence with the Sruoja River to the mouth is a water body of type 3. The headwaters of the Sruoja River (the right tributary of the Varduva) are classified as a water body of type 1 and its lower reaches as a water body of type 3. The lower reaches of the Lusinė River (a tributary of the lake Alsėziai) in the basin of the Sruoja River is classified as a water body of type 1. The lower reaches of the Kvistė River (the left tributary of the Varduva) are classified as water body of type 1 (Fig. 2.3.1).

Some stretches of the Varduva River are located in protected areas: the stretch from the Šarnelė River mouth (at 82.2 km) to Žemaičių Kalvarija town (at 75.9 km) is located in the territory of the Samogitia National Park (Žemaitija National Park), and the stretch from Kulšėnai HPP (at 59.8 km) to Renavas HPP (at 41.4 km) is located in the territory of the Varduva Landscape Reserve.

# III ECOLOGICAL QUALITY OF WATER BODIES, PRESSURES

## 3.1. Ciecere River

The Ciecere River is divided into two water bodies, both of which have surface water monitoring stations: “Ciecere, at river mouth” (*V054, Ciecere_2*) in downstream and “Ciecere, below Saldus” (*V105SP, Ciecere_1*) in upstream. According to River basin management plans [7], both monitoring stations belongs to the medium-sized rithral river type. The monitoring station “Ciecere, at the river mouth” is located in a natural, free-flowing river stretch ~ 28 km downstream from Pakuli HPP. The monitoring station “Ciecere, below Saldus” is located between two HPPs (upstream HPP ~3.4 km and downstream HPP ~ 8.5km), but in a natural stretch with free flow and no significant impoundment. Both Ciecere River’ monitoring stations are not suitable for determining the hydromorphological pressure, but they show more diffuse pollution from agricultural lands and point source pollution from the city of Saldus.

According to the 3rd RBMP (unpublished), the most significant pressures in the upstream water body Ciecere_1 is hydromorphological alterations due to HPP, point source pollution from WWTP and diffuse pollution from arable lands. The most significant pressure in the downstream water body Ciecere_2 is diffuse pollution from arable lands.

The Ciecere River upstream water body has moderate physico - chemical quality class and the downstream water body has good physico - chemical quality class. (Table 3.3.1). In general, a physico – chemical quality of the downstream water body is improving, but in the upstream water body it is decreasing. The main reason for decreasing of quality is phosphorus loads from Saldus WWTP.

**Table 3.1.1. Physico – chemical quality of the Ciecere river***

| Station | Year | $O_2$ | $BOD_5$ | N-NH4 | Ntot | Ptot | Total |
|---|---|---|---|---|---|---|---|
| Ciecere, at river mouth | 2006 | 7.3 | 1.8 | 0.18 | 2 | 0.088 | 4 |
| Ciecere, at river mouth | 2007 | 10.8 | 2 | 0.04 | 2.2 | 0.051 | 2 |
| Ciecere, at river mouth | 2008 | 9.7 | 1.6 | 0.06 | 1.9 | 0.071 | 2 |
| Ciecere, at river mouth | 2018 | 10.3 | 1.0 | 0.04 | 1.0 | 0.038 | 1 |
| Ciecere, below Saldus | 2013 | 7 | 1.8 | 0.12 | 1.3 | 0.071 | 2 |
| Ciecere, below Saldus | 2018 | 10.4 | 1.6 | 0.08 | 1.7 | 0.083 | 3 |

*Blue-high status class, green-good, yellow-moderate, orange-bad

The Ciecere River downstream water body has moderate biological quality, but the upstream water body has good biological quality (table 3.1.2). However, these results do not reflect true situation, because no fish have been monitored in the upstream water body monitoring station (located between two HPPs), which is likely to impair a biological quality.

**Table 3.1.2. Biological quality of the Ciecere River**

| Station | Year | Macroinvertebrates | Macrophytes | Fish | Total |
|---|---|---|---|---|---|
| Ciecere, at river mouth | 2006 | High | | | High |
| Ciecere, at river mouth | 2007 | High | | | High |
| Ciecere, at river mouth | 2008 | Good | | Moderate | Moderate |
| Ciecere, at river mouth | 2018 | High | Moderate | | Moderate |
| Ciecere, below Saldus | 2013 | Good | Good | | Good |
| Ciecere, below Saldus | 2018 | High | Good | | Good |

Total ecological quality (biological and physico - chemical) for both Ciecere River water bodies is moderate.

## 3.2. Losis River

The "Losis River" is a new water body (created in year 2019) and the surface water monitoring is wasn't carried out here. According to 3rd RBMP, the Losis River belongs to a medium-sized rithral river type. The only information available is from the Lat-Lit INTERREG project LLIV-230 "Monitoring of Rivers and environmental Survey of Farmers in Lielupe and Venta River Basin Districts". This project was implemented in years 2013-2014 and surface water samples were collected in the autumn, spring and summer.

According to River basin management plans, the most significant pressures in the Losis River' water body is point source pollution from Kalni village WWTP, hydromorphological alteration due to two HPPs and transboundary pollution from Lithuania.

The Institute of Biology of University of Latvia carried out the water quality monitoring of the Losis River in Kalni village between both HPPs (in ~ 2.9 km from the upstream HPP and ~1.4 km from the downstream HPP).

As shown in table 3.2.1., a physico- chemical quality of the Losis River is poor. The reason is the increased ammonia ion concentration. Other quality elements show high and good quality class. Water samples were not collected in all seasons and the obtained results must be treated with caution.

**Table 3.2.1. Pysico – chemical quality of Losis River (average from autumn, spring and summer samples) ***

| $O_2$ | $BOD_5$ | $NH_4$ -N | Ntot | Ptot | Total |
|---|---|---|---|---|---|
| 10.79 | 2.24 | 0.16 | 1.27 | 0.029 | Poor |

*Blue-high status class, green-good, orange-poor

A biological quality of the Losis River is moderate (table 3.2.2), but only macroinvertebrates and fish were sampled. Fish (Lithuanian Fish Index) corresponds to moderate ecological quality and in accordance with the *one out-all out* principle, total biological quality of the Losis River is moderate. According to hydromorphological survey results, the Losis River has a good habitat quality potential and this river is potentially suitable also for salmonids, but fish migration is not possible due to the HPPs cascade.

**Table 3.2.2. Losis river biological quality according to benthic macroinvertebrates and fish**

| T | ASPT | DSFI | H' | Macroinvertebartes, total | Fish | Biology, total |
|---|---|---|---|---|---|---|
| 49 | 6.23 | 7 | 2.68 | Good | Moderate | Moderate |

Total ecological quality (biological and physico - chemical) of the Losis River is moderate.

## 3.3. Varduva River

During the last decade (2010-2019) State monitoring was carried out in two sections of the Varduva River: in the lower reaches near the LT / LV border (by Griežė, below the lowermost Juodeikiai HPP) and in the middle reaches (below Renavas HPP). In the lower reaches, State monitoring was carried out annually, in the middle reaches - in 2012 and 2015. According to the 2nd River basin management plan (Venta RBDMP, 2015), both monitoring stations belong to a medium-sized rithral river type.

According to the information provided on the website of Lithuanian Environment Protection Agency, the water quality elements in the Varduva River met the good status criteria throughout the entire period (Table 3.3.1). According to $O_2$, $NH_4$-N, $PO_4$-P and Ptot, the ecological status of the Varduva below Juodeikiai HPP

corresponded to the criteria of high status, while measured values of $BOD_7$, NO3-N and Ntot corresponded to either high or good status criteria. Accordingly, in the Varduva below Renavas HPP, the status was high in terms of all quality criteria, except for $PO_4$-P. The measured values of the latter corresponded to either high or good ecological status.

Among the biological quality elements, the phytobenthos in the Varduva below Juodeikiai HPP was monitored in 2012-2015 and 2019, macrozoobenthos in 2010-2015 and 2019, and fish in 2011 and 2014. The phytobenthos and macrozoobenthos indices met the requirements for at least good ecological status throughout the entire period (Table 3.3.2). However, in terms of fish indicators, the status was classified as moderate.

In the Varduva below Renavas HPP, phytobenthos monitoring was carried out only in 2015, while zoobenthos and fish were monitored in both years (2012 and 2015). As in the Varduva below Juodeikiai HPP, the values of phytobenthos and macrozoobenthos indices met requirements for at least good ecological status, However, in terms of fish indicators, the status was classified as moderate or even poor.

Since the water quality metrics meet the criteria for at least good status, the impact of HPPs is.the only reason for the less than good status of fish assemblages in the Varduva River. According to the 2rd RBMP [8], hydromorphological alterations due to HPP is the most significant pressure in the water body Varduva.

**Table 3.3.1. The range of values of physico – chemical quality elements in the Varduva river***

| Quality element | Below Renavas HPP (2012 and 2015) | Below Juodeikiai HPP (2010-2019) |
|---|---|---|
| $O_2$, mg/l | 8,5-8,8 | 8,6-10,4 |
| $BOD_7$, mg/l $O_2$ | 1,9-2,1 | 1,3-2,5 |
| $NH_4$-N, mg/l | 0,04-0,06 | 0,04-0,08 |
| $NO_3$-N, mg/l | 0,53-0,72 | 0,69-1,83 |
| Ntot, mg/l | 1,24-1,54 | 1,39-2,38 |
| $PO_4$-P, mg/l | 0,019-0,064 | 0,017-0,030 |
| Ptot, mg/l | 0,036-0,044 | 0,036-0,058 |

*Blue-high status class, green-good

**Table 3.3.2. The range of values of biological quality elements in the Varduva River***

| Quality element | Below Renavas HPP | Below Juodeikiai HPP |
|---|---|---|
| Phytobenthos index | 0,73 | 0,63-0,83 |

| | | |
|---|---|---|
| Macrozoobenthos index | 0,72-0,86 | 0,66-0,79 |
| Fish index | 0,37-0,45 | 0,47-0,66 |

*Blue-high status class, green-good, yellow-moderate, orange-poor

# IV FISH COMMUNITY (SPECIES)

## 4.1. Ciecere River

Electrofishing surveys in the Ciecere River in last five years (2016 – 2020) has been performed within different projects [9] and in different stations. In total 25 fish species is recorded in the Ciecere River which is a large number for a middle size river (Table 4.1.1.). One of the most abundant species in all three parts of the river is roach (*Rutilus rutilus*) which belongs to eurytopic species often found in eutrophicated and slow flowing streams.

The lowest number of fish species was recorded in the upstream section of the Ciecere River downstream Ciecere HPP. Among such species as bullhead (*Cottus gobio*), stone loach (*Barbatula barbatula*) and gudgeon (*Gobio gobio*) which are typical for rhithral medium size streams the occurrence of bream (*Abramis brama*), perch (*Perca fluviatilis*), bleak (*Alburnus alburnus*), belica (*Leucaspius delineatus*) and ruff (*Gymnocephalus cernua*) was recorded, thus indicating the strong impact of nearby reservoirs and the town of Saldus. Salmonid and lamprey species has not been found in this part of the river.

**Table 4.1.1. Average abundance (ind./100 m$^2$) and frequency of occurrence (%) of fish species in different parts of Ciecere River**

| Species | Below Cieceres HPP | | Below Dzirnavnieku HPP | | Below Pakuļu HPP | |
|---|---|---|---|---|---|---|
| | ind./100m$^2$ | % | ind./100m$^2$ | % | ind/100m$^2$ | % |
| *Abramis brama* | 0.6 | 25.0 | 0.6 | 25.0 | 0.9 | 11.1 |
| *Alburnoides bipunctatus* | | | | | **25.5** | 77.8 |
| *Alburnus alburnus* | 2.2 | **100.0** | 2.1 | 62.5 | 5.5 | **88.9** |
| *Anguilla anguilla* | | | | | 0.3 | 33.3 |
| *Barbatula barbatula* | 0.3 | 75.0 | 1.2 | 37.5 | **28.4** | 66.7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Blicca bjoerkna* | | | 2.3 | 62.5 | 0.2 | 22.2 |
| *Carassius carassius* | | | 1.7 | 25 | 0.5 | 22.2 |
| *Carassius gibelio* | | | | | 0.6 | 12.5 |
| *Cobitis taenia* | **7.8** | 75.0 | 0.8 | **87.5** | 3.2 | **100.0** |
| *Cottus gobio* | 1.7 | 75.0 | 0.2 | 12.5 | 1.6 | 44.4 |
| *Esox lucius* | 0.3 | 25.0 | 0.3 | 25.0 | 0.8 | 11.1 |
| *Gasterosteus aculeatus* | | | 0.9 | 25.0 | 0.9 | 22.2 |
| *Gobio gobio* | **6.7** | **100.0** | **13.5** | **100.0** | **15.2** | **88.9** |
| *Gymnocephalus cernua* | 0.3 | 25.0 | 0.5 | 25.0 | | |
| *Lampetra planeri* | | | * | 25.0 | | |
| *Leucaspius delineatus* | 0.7 | 25.0 | 2.5 | 25.0 | 0.5 | 11.1 |
| *Leuciscus leuciscus* | | | 0.8 | 50.0 | 5.5 | 66.7 |
| *Perca fluviatilis* | **6.2** | **100.0** | 6.1 | **100.0** | 0.3 | 33.3 |
| *Phoxinus phoxinus* | | | 1.3 | 62.5 | **37.2** | 66.7 |
| *Rhodeus amarus* | | | 1.3 | 62.5 | 9.2 | 66.7 |
| *Rutilus rutilus* | **37.6** | **100.0** | **36.5** | **87.5** | **27.0** | **100.0** |
| *Salmo trutta* | | | 1.4 | 50.0 | 2.0 | 33.3 |
| *Sander lucioperca* | | | 0.9 | 12.5 | | |
| *Scardinius erythrophthalmus* | | | 0.2 | 12.5 | | |
| *Squalius cephalus* | 0.3 | 50.0 | 0.2 | 50.0 | | |

Downstream Dzirnavnieku HPP more than 20 fish species was recorded. Dominance of roach and high occurrence of perch well as presence of silver bream (*Blicca bjoerkna*), bream, bitterling (*Rhodeus amarus*), pikeperch (*Sander lucioperca*), crucian carp (*Carassius carassius*) and other species typical for slow flowing streams and reservoirs indicates that the fish assemblage in this part of the river is affected by nearby reservoirs. In the same time, the presence of such sensitive species as brown trout (*Salmo trutta*) and brook lamprey *(Lampetra*

*planeri*) confirms that at least in some reaches downstream Dzirnavnieku HPP the Ciecere River is still suitable for rheopar fish species intolerant to oxygen depletion.

Beside the roach the most abundant fish species downstream Pakuļu HPP are spirlin (*Alburnoides bipunctatus*), stone loach, gudgeon and minnow (*Phoxinus phoxinus*), thus is indicating that the fish assemblage in this part of the Ciecere River is closer to the typical fish fauna of a medium size rhithral river than the upstream parts of this stream. It is confirmed also by presence of trout, bullhead and other sensitive species. Capture of lampreys in electrofishing surveys downstream Pakuļu HPP is not registered yet their presence was confirmed during monitoring of lamprey larvae. In the same time the presence of crucian carp, Prussian carp *Carassius gibelio* and many other fish species typical for slow flowing or still waters indicates also the impact of eutrophication and impoundment.

As it was mentioned above previous electrofishing surveys in the Ciecere River has been performed within several independent projects. Since aims of these projects were different also the number and allocation of sampling sites as well as sampled habitats were different in each year and each part of the river. Getting a more accurate information on differences of fish fauna in each part of the Ciecere River using electrofishing surveys is one of the TRANSWAT project' objectives.

## 4.2. Losis River

During the last decade only three electrofishing surveys has been performed in the Losis River. One survey (in 2013) was peformed just downstream of Lejnieki HPP dam and two other surveys (in 2009 and 2013) - in the part of river between Grantini HPP and Lejnieki HPP. We do not possess the information on electrofishing surveys in upper and middle reach of the Losis River upstream Grantini HPP.

In total 29 fish species is recorded in the Losis River (Table 4.2.1.). Between both power plants 12 fish species were registered. Most abundant species in this part of the river was stone loac. An occurrence of such species as bullhead, burbot and brown trout indicates the suitability of this river part for ecologically sensitive fish species until the 2013.

In the same time, it should be noted that besides the sensitive fish species also such eurytopic species as roach and perch were registered in relatively large number. Great abundance of roach and perch as well as presence of crucian carp and bleak indicates the impact of nearby reservoirs and nearby village.

Species like bleak, three-spined stickleback (*Gasterosteus aculeatus*), bitterling and roach were dominated in lower stretch of the Losis River below Grantini HPP, These and also most of other recorded fishes belonged to ecologically tolerant species. However, it needs to be taken into account that electrofishing site was

located in highly affected site just downstream HPP dam. It is possible that in less disturbed downstream part of the Losis River structure of fish fauna is different and both abundance and proportion of ecologically sensitive species is higher.

**Table 4.2.1. Average abundance (ind./100 m$^2$) of fish species in different parts of Losis River**

| Species | Below Lejnieku HPP | Below Grantiņu HPP |
|---|---|---|
| | ind./100m$^2$ | ind./100m$^2$ |
| *Alburnus alburnus* | 0.4 | **121.5** |
| *Barbatula barbatula* | **10.1** | 3.0 |
| *Blicca bjoerkna* | | 3.0 |
| *Carassius carassius* | 0.2 | 2.0 |
| *Cottus gobio* | 1 | |
| *Esox lucius* | 0,5 | 1.5 |
| *Gasterosteus aculeatus* | | **48.0** |
| *Gobio gobio* | 2.7 | 7.0 |
| *Leucaspius delineatus* | | 1.0 |
| *Leuciscus aspius* | | 0.5 |
| *Leuciscus leuciscus* | | 9.0 |
| *Lota lota* | 0.2 | |
| *Perca fluviatilis* | **6.4** | 1.5 |
| *Phoxinus phoxinus* | 0.2 | 0.5 |
| *Pungitius pungitius* | | 4.5 |
| *Rhodeus amarus* | | **41.0** |
| *Rutilus rutilus* | **6.1** | **24.5** |
| *Salmo trutta* | 0.5 | |
| *Scardinius erythrophthalmus* | | 1.0 |
| *Squalius cephalus* | 2.7 | 13.5 |

Taking into account that last electrofishing survey in the Losis River was performed in 2013 and one of sampling sites was located in the highly affected river reaches, situation described above may not represent the actual status of fish fauna in this river. To get a more accurate information on fish fauna in the Losis River electrofishing survey in this stream should be repeated.

## 4.3. Varduva River

During the last decade (2010-2019) fish monitoring was carried out in two sections of the Varduva River: in the lower reaches near the LT / LV border (by Griežė, below the lowermost Juodeikiai HPP) and in the middle reaches (below the Renavas HPP). In both sections electrofishing surveys were conducted only twice: in 2011 and 2014 in the lower reaches, and in 2012 and 2015 in the middle reaches.

In total 19 fish species were recorded in the Varduva River, 13 species in each of the monitoring sites (Table 4.3.1). Although the species diversity is relatively high, non-specialized eurytopic phytolitophilic species roach (*Rutilus rutilus*) and bleak (*Alburnus alburnus*) predominate, as well as rheophilic species that are moderately resistant to habitat degradation, the stone loach (*Barbatula barbatula*) and gudgeon (*Gobio gobio*). The migratory species vimba (*Vimba vimba*), as well as the intolerant potamodromous species spirlin (*Alburnoides bipunctatus*) were recorded only in the lower reaches of the Varduva River, below the lowermost HPP. Two other sensitive species found in the Varduva River, the bullhead (*Cottus gobio*) and the minnow (*Phoxinus phoxinus*), have been recorded in both the lower and middle reaches of the river. However, the rest of typical riverine fish species that should be present in the natural rivers of a comparable type, the trout (*Salmo trutta*), grayling (*Thymallus thymallus*), barbel (*Barbus barbus*), and river and/or brook lamprey (*Lampetra fluviatilis* and *L. planeri*) where absent from the river. Instead, there were even 5 atypical fish species, such as bream (*Abramis brama*), silver bream (*Blicca bjoerkna*), ruff (*Gymnocephalus cernuus*), belica (*Leucaspius delineatus*) and nine-spined stickleback (*Pungitius pungitius*). All this indicates significant changes in the fish assemblages of the Varduva River.

**Table 4.3.1. Average abundance (ind./100 m$^2$) of fish species in different parts of Varduva River**

| Species | Below Renavas HPP | Below Juodeikiai HPP |
|---|---|---|
| | ind./100m$^2$ | ind./100m$^2$ |
| *Abramis brama* | 0.2 | |
| *Alburnoides bipunctatus* | | 0.7 |

| | | |
|---|---|---|
| *Alburnus alburnus* | **0.9** | **7.2** |
| *Barbatula barbatula* | 0.3 | 22.4 |
| *Blicca bjoerkna* | 0.6 | |
| *Cobitis taenia* | | 0.2 |
| *Cottus gobio* | 0.6 | 1.4 |
| *Esox lucius* | 0.7 | 0.4 |
| *Gasterosteus aculeatus* | | 0.2 |
| *Gobio gobio* | 1.5 | 8.4 |
| *Gymnocephalus cernua* | 0.2 | |
| *Leucaspius delineatus* | 1.1 | |
| *Leuciscus leuciscus* | 0.2 | |
| *Perca fluviatilis* | | 0.8 |
| *Phoxinus phoxinus* | 3.5 | 1.3 |
| *Pungitius pungitius* | 0.2 | |
| *Rutilus rutilus* | **5.0** | **9.6** |
| *Squalius cephalus* | | 1.3 |
| *Vimba vimba* | | 0.7 |

Taking into account that the last electrofishing survey in the Varduva River was performed in 2015, the situation described above may not represent the actual status of fish fauna in this river. In order to obtain more accurate information about the ichthyofauna in the Varduva River, the electrofishing survey will be repeated.

# V EXISTING DATA, DATA GAPS

Accurate and timely hydrological data are crucial for water policy making, especially in the field of hydropower production. Assessing the amount of limited information is essential to prioritize ways to fill data gaps.

## 5.1. Hydrological data

### 5.1.1. Ciecere and Losis rivers

The hydrological data is needed for the assessment of water use by each HPP in cascade during a different season and water flow as well as for the river habitat modelling. An existing of hydrological data is shown in the table 5.1.1.1.

Monitoring station “Pakuli HPP” on the Ciecere River is located downstream Pakuli HPP (Fig. 5.1.1.1.) and allows to evaluate the operational regime for only one of three HPPs on the Ciecere River (Fig.5.1.1.2, 5.1.1.3). For two other HPPs hydrological data is absent.

**Table 5.1.1.1. Existing hydrological data for pilot rivers**

| River | Monitoring station | Area, $km^2$ | Location, km from river mouth | Monitoring period | Water discharge monitoring | Water level monitoring |
|---|---|---|---|---|---|---|
| Ciecere | HES Pakuli | 445 | 29.0 | 1958 – 1987; 2008 - 2020 | 1959 – 1987; 2008 - 2020 | 1959 – 1987; 2008 - 2020 |
| Losis | - | | - | - | - | - |

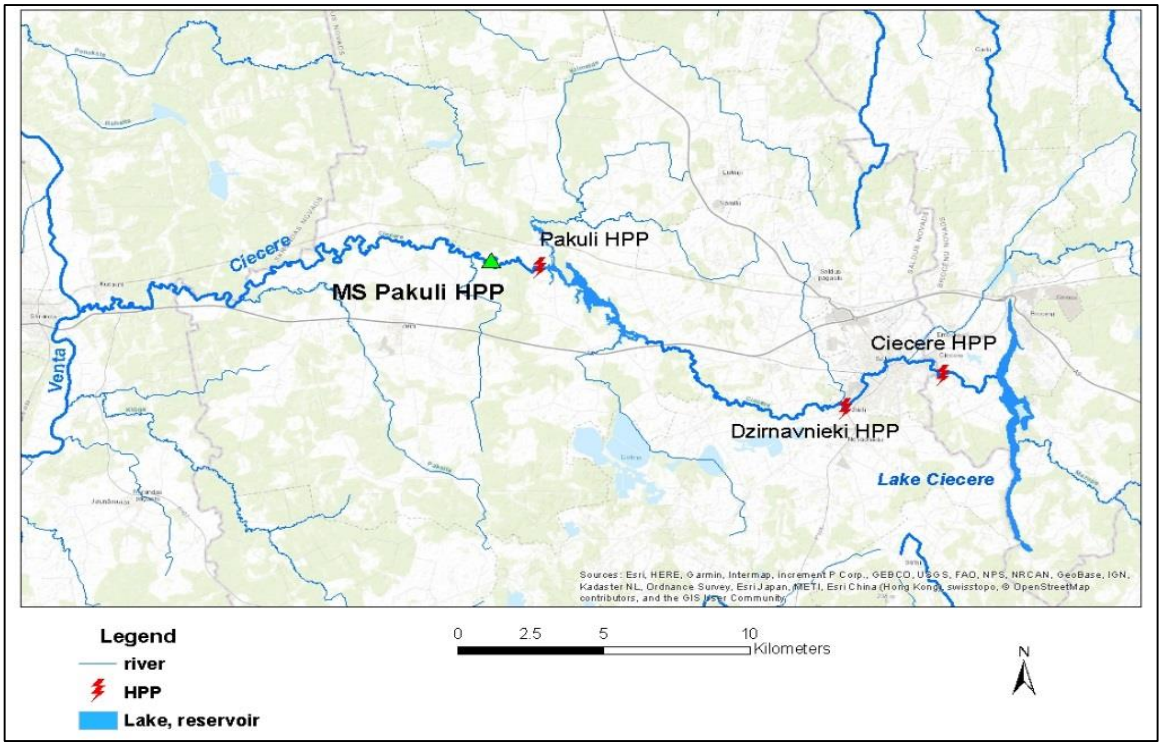


**Figure 5.1.1.1. Ciecere River, hydrological monitoring station**

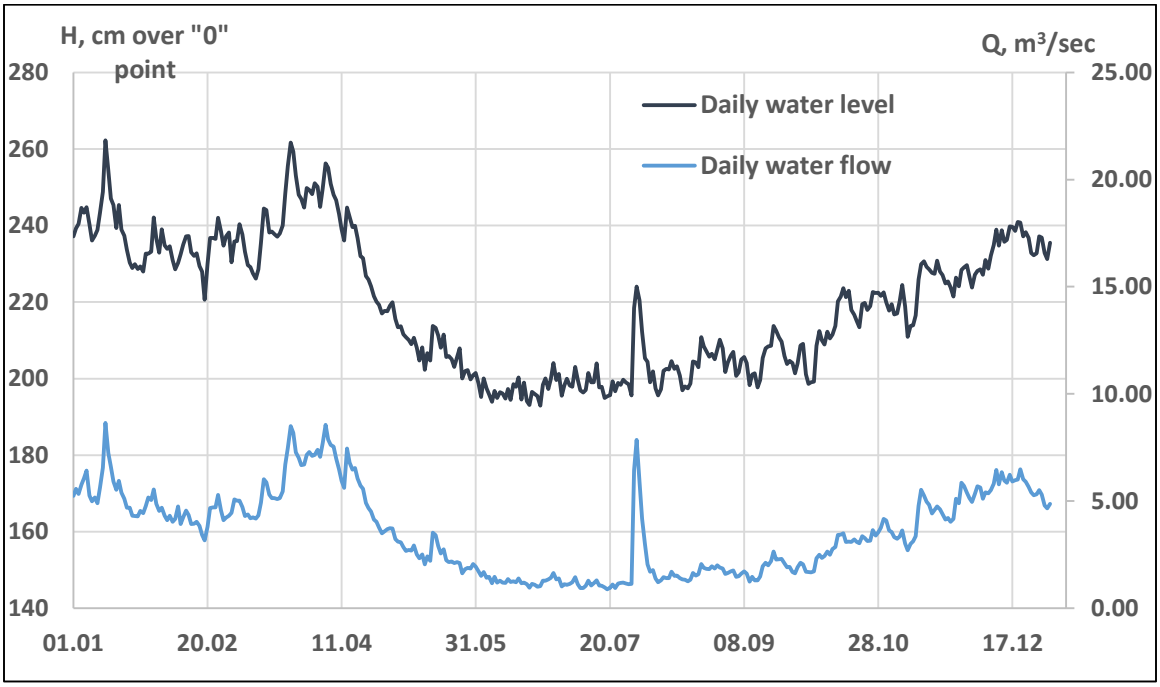


**Figure 5.1.1.2. Data series of station Ciecere – Pakuli HPP for period 2008-2019**

The hydrological regime of the Ciecere River characterizes by winter-spring flood, summer low flow period and autumn rain flood. The winter low flow period

is very short and not permanent. Table 5.1.2 shows flow values of the Ciecere River below Pakuli HPP for observation period 1959-1987, 2008-2019 (LEGMC database).

**Table 5.1.1.2. Water flow data of Ciecere River, $m^3$/sec**

| Observation period | Annual flow | Max of winter-spring flood | Low flow average | Low flow minimum |
|---|---|---|---|---|
| 1959-1987 | 3.35 | 42.1 | 0.76 | 0.60 |
| 2008-2019 | 3.60 | 27.4 | 0.80 | 0.44 |

The hydrological regime of the Losis River is very much the same as regime of the Ciecere River. There is now any hydrological monitoring station on the Losis River that goes 23 km along the LT-LV state border. Theoretical annual water flow in the river mouth is 1.10 $m^3$/sec.

### 5.1.2 Varduva River

There are no water gauging stations (WGS) currently operating in the Varduva River Basin. The only water gauging station that had ever been active in the basin was Ruzgai WGS on the Varduva River (Fig. 2.3.1). This WGS commenced to operate in 28 May 1948 and ceased to operate in 01 July 1973, when Mažeikiai oil refinery plant (currently ORLEN Lietuva) construction began and Juodeikiai Reservoir was formed on the river in order to supply water to the plant.

Ruzgai WGS was established in 14 km from the the Varduva River mouth. Initially, water level measurements were taken in this WGS, while water discharge measurements were carried out only since 1956. The average water discharge at Ruzgai water gauging station for the period of 1956-1972 was 5.16 $m^3/s$ (Table 5.1.2.1).

**Table 5.1.2.1. Existing hydrological data**

| Observation period | Annual flow | Max of winter-spring flood | 30-day low flow average | 30-day low flow minimum |
|---|---|---|---|---|
| 1956-1972 | 5.16 | 113 | 0.99 | 0.37 |

The Varduva River contains large amounts of water, the specific discharge being 10.4 l/s $km^2$. The hydrological regime of the Varduva River is characterized by winter-spring floods, summer low flow period and autumn rain flood (Fig. 5.1.2.1).

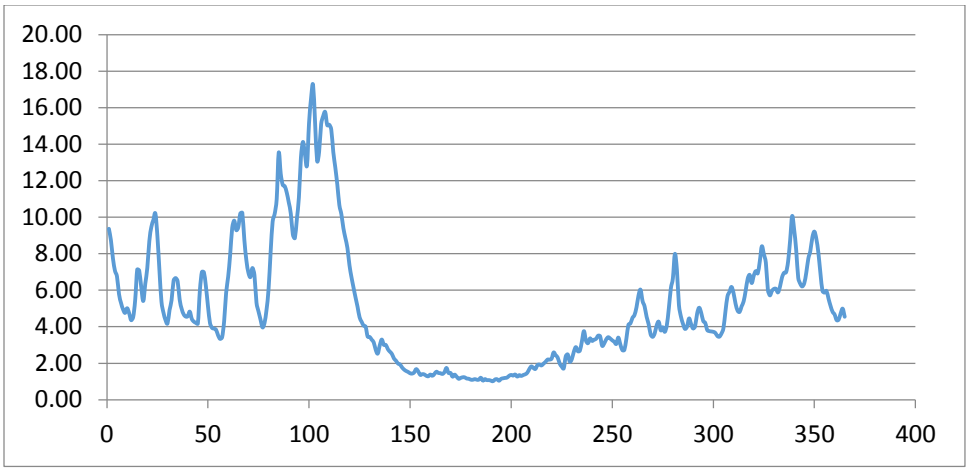


**Figure 5.1.2.1. Flow hydrograph of the Varduva River – Ruzgai WGS for 1956-1973**

The river has a rainfall dominated flow regime. The seasonal distribution of the river runoff shows that 35% of the annual runoff flows in spring, 33% in summer-autumn, and 32% in winter [10].

## 5.2. HPPs technical specification'

### 5.2.1. Ciecere and Losis rivers

Information about HPPs in pilot rivers [11] might be subdivided 2 main groups:

1. hydro-technical characteristics of HPP,

2. HPP constructions information.

Data of the first group is shown in the table 5.2.1.1.

**Table 5.2.1.1. Hydro-technical characteristics of HPPs in pilot rivers**

| HPP | River | Dam construction year | Distance from river mouth, km | Installed capacity, kW | Head, m | Reservoir area, ha | Reservoir normal water level |
|---|---|---|---|---|---|---|---|
| Ciecere | Ciecere | 1997 | 49.0 | 150 | 4.0 | 6.1 | 99.86 |
| Dzirnavnieki | | 1998 | 32.0 | 150 | 4.0 | 8.1 | 88.36 |
| Pakuli | | 2000 | 28.0 | 400 | 7.8 | 162 | 67.96 |
| Grantini | Losis /Lusis | 1997 | 6.0 | 92 | 3.6 | 7.40* | 55.46 |
| Lejnieki | | 1997 | 1.0 | 252 | 6.0 | 21.2 | 47.76 |

*Grantini HPP reservoir area is 2.4 ha in Latvian side and 5ha – in Lithuanian side.

Characteristic water discharges at the hydropower plants are presented in Table 5.2.1.2.

**Table 5.2.1.2. Characteristic water discharges (Q m³/s) at hydropower plants**

| | Name of HPP | Multi-year Q | | Spring flood max Q | | | Summer-autumn Q for 30 consecutive driest days | | E-flow / guaranteed flow, $m^3$/sec | Q releasing through the turbines max/min |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Q mean | Q 95% | Q mean | Q 95% | Q 1% | Q mean | Q 95% | | |
| 1 | Ciecere | 1.02 | 0.061 | - | - | 20.0 | - | 0.061 | 0.061 | 3.0/0.06 |
| 2 | Dzirnavnieki | 1.10 | 0.30 | - | - | 38.3 | - | 0.16 | 0.30 / 0.16 | 5.0/0.16 |
| 3 | Pakuli | 3.39 | 0.32 | - | - | 58.0 | - | 0.32 | 0.32 | 5.6/0.3 |
| 4 | Grantini | 1.45 | 0.20 | - | - | 51.5 | - | 0.029 | 0.20 / 0.029 | 2.6/0.4 |
| 5 | Lejnieki | 0.92 | 0.2 | - | - | 55.06 | - | 0.093 | 0.20 / 0.093 | 5.0/0.2 |

HPP construction information is necessary for flow modelling by HEC-RAS model. The spillway' geometry data of each HPP should be described as well as an elevation of spillways in the stream.

Ciecere HPP: concrete spillway of 6.0 m width with 5 sections (no information about elevation);

Dzirnavnieki HPP: mining type spillway with underwater discharge, elevation 84.16 m (no information about width and height);

Pakuli HPP: open-type iron-concrete practical profile spillway with metal shutter (no information about geometry and elevation);

Grantini HPP: gates with 3 sections of10 .5 m width and flat wood shutters (no information about elevation);

Lejnieki HPP: mining type spillway with underwater discharge and lifting shuttles, elevation 43.16 m (no information about width and height);

### 5.2.2 Varduva River

Information about 5 HPPs in the pilot river Varduva might be subdivided 2 main groups:

1. hydro-technical characteristics of HPP,

2. HPP constructions information.

Main hydro-technical characteristics of 5 HPPs in the Varduva River are presented in Tables 5.2.2.1 [12-17].

**Table 5.2.2.1. Hydro-technical characteristics of HPPs in pilot river Varduva**

| HPP | River | Dam construction year | Distance from river mouth, km | Installed capacity, kW | Head, m | Reservoir area, ha | Reservoir normal water level |
|---|---|---|---|---|---|---|---|
| Kulšėnai | Varduva | 1998 | 59.8 | 110 | 3.35 | 2.2 | 105.25 |
| Renavas | | 1955 | 41.4 | 300 | 8.9 | 29.1 | 89.05 |
| Vadagiai | | 2004 | 34.6 | 110 | 3.50 | 5.6 | 78.00 |
| Ukrinai | | 2002 | 23.8 | 110 | 3.3 | 9.6 | 65.00 |
| Juodeikiai | | 1979 | 7.1 | 820 | 12.5 | 261.4 | 58.00 |

Characteristic water discharges at the hydropower plants are presented in Table 5.2.2.2.

**Table 5.2.2.2. Characteristic water discharges (Q m³/s) at hydropower plants**

| | Name of HPP | Multi-year Q | | Spring flood max Q | | | Summer-autumn Q for 30 consecutive driest days | | E-flow / guaranteed flow, m³/sec | Q releasing through the turbines max/min |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Q mean | Q 95% | Q mean | Q 95% | Q 1% | Q mean | Q 95% | | |
| 1 | Kulšėnai | 3.6 | 1.8 | 56.5 | 58.7 | 76.3 | 0.45 | 0.20 | 0.20 | 6.0/0.5 |
| 2 | Renavas | 3.54 | 1.78 | 34.8 | 58.6 | 76.1 | 0.54 | 0.30 | 0.39 | 9.0/2.4 |
| 3 | Vadagiai | 3.70 | 1.86 | 36.4 | 61.2 | 79.5 | 0.56 | 0.32 | 0.41 | 5.7/1.2 |
| 4 | Ukrinai | 3.80 | 1.97 | 39.4 | 64.8 | 84.1 | 0.65 | 0.36 | 0.46 | 6.0/0.5 |
| 5 | Juodeikiai | 6.15 | 3.20 | 43.2 | 114.4 | 143.0 | 1.28 | 0.57 | 0.91 | 8.0/3.5 |

HPP construction information is necessary for the flow modelling by the HEC-RAS model. The spillway' geometry data of each HPP should be described as well as an elevation of spillways in the stream [12-16].

Kulšėnai HPP. Stone concrete overflow spillway, elevation - 101.90 m.

Renavas HPP. Ground dam (length of 192 m, height of 6 m, slope 1:2.5), elevation - 90.85 m. Iron concrete spillway - threshold with shutters, gates with 3 sections, the dimensions of one section - 3.20 × 2.50 m.

Vadagiai HPP. Ground dam (length of 72 m, height of 4 m, slope 1:3), elevation – 79.40 m. Iron reinforced concrete overflow spillway, gates with 5 sections, the dimensions of one section - 3.50 × 5.50 m.

Ukrinai HPP. Ground dam (length of 94 m, height of 2 m, slope 1:3), elevation – 66.40 m. Iron reinforced concrete overflow spilway, Gate with 1 section.

Juodeikiai HPP. Ground dam (length of 208 m, height of 16.30 m, slope 1:3,5), elevation – 59.80 m. Reinforced concrete spilway - threshold with shutters, gates with 2 sections, the dimensions of one section – 6.00 × 4.50 m.

# VI CONCLUSION

1. The most significant pressures in all selected rivers (Ciecere, Losis, Varduva) are the hydromorphological alteration due to activity of cascades of HPPs that is critical for the assessment of HPP impact on the flow regime of pilot rivers;

2. There are small hydrological investigations of selected rivers. Only one water gauging station was at the Varduva River (1956-1972). In Latvian rivers operated only one water discharge station (Pakuli HPP, 1958 – 1987; 2008 – 2020) as well.

3. In all HPPs the ecological water flow is not provided but flow rate by policy regulations requirements (“ecological/guaranteed” in LV and “environmental” in LT) is very matching to the summer 30-days low flow with 95% probability. Additional investigations for the E-flow calculation in the context of HPPs cascade is necessary.

4. There are different hydropower plant cascades on the selected rivers. This will allow better understanding of the impact of cascades on river hydromorphology and aquatic ecosystems.

5. Last electrofishing surveys in pilot rivers were performed some years ago, and collected information does not represent the actual status of fish fauna in these rivers now. In order to obtain more accurate information about the ichthyofauna there, the electrofishing survey should be repeated.

6. There is no all data which are required for hydrodynamic modelling by the HEC-RAS software. Special river’ profiling measurements will be carried out for the bathymetry data preparing. The relationships of water level – reservoir storage and the relationship of water level – discharge in river reaches below HPP will be prepared using field survey data of this project.

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