Rivers ranked according to the available potential for spawning of river lamprey and proposed improvement measures to secure river connectivity, Kurzeme Region

Project: Cross-boundary evaluation and management of lamprey stocks in Lithuania and Latvia
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AUTORS: Kaspars Abersons, Jānis Bajinskis

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Introduction

River lamprey *Lampetra fluviatilis* is an anadromous species which spawns and spends most of its life in freshwater. Therefore, the availability and quality of spawning and rearing habitats is a crucial factor determining the status of this species. River lamprey spawn in running freshwater but their larvae spend several years buried in the substrate of riverbed in calmer sections of the same stream. As for other anadromous species, the availability and quality of spawning and rearing habitats of river lamprey in rivers of Latvia has been reduced mostly by impoundment, dredging and other human activities. In addition to anthropogenic factors, the reproduction of river lamprey is hampered in many Latvian rivers also by natural circumstances such as waterfalls or beaver activities.

One of such measures for improvement of the status of river lamprey population is the facilitation of use of river lamprey reproduction potential in sections of rivers located upstream of the barriers for natural migration. Activities needed for this goal may be different for each river and nature of activity depends mostly on parameters and location of the river as well as size, location and usage of the barrier. Aim of this document is to elaborate the list of 20 rivers in Kurzeme Region with the greatest lamprey reproduction potential upstream of the barriers for anadromous migration, and to list these rivers in priority order and propose the most suitable measures to secure the river connectivity.

Elaboration of this document started only in winter 2020 when detailed mapping of rivers was not possible. Some of rivers included in this document were mapped within other projects yet for many other rivers alternative sources of information (electrofishing, monitoring of lamprey larvae, information on general parameters of this river or other) had to be used. For some of the rivers and barriers included in this document very little information is publicly available therefore the reliability of our conclusions was also evaluated.

Materials and methods

Sources of information

Several sources of information were used. Information on barriers for upstream migration was obtained from database of small HPS (made in 2007 by State Environmental Service) and other databases containing information of old mill dams, bad culverts and others. There are two most important such databases. One was made by institute BIOR in 2008 as a part of eel management plan and second, the more sophisticated – in 2019 by Latvian Environment, Geology and Meteorology Centre to be used for evaluation of ecological quality of water objects. Where possible also additional data (results of mapping of salmonid rivers or *Natura 2000* sites, literature, etc. was used).

Several data sources were also used to determine if river lampreys enter particular river for spawning and to assess the existence of lamprey reproduction potential upstream of each barrier. Quantitative data of abundance of lamprey larvae is compiled in database of annual monitoring of lamprey larvae hosted by BIOR. Unfortunately, only few sampling sites have been located upstream of migration barriers and this database was used mostly to ensure that migrating river lampreys enter river below the barrier. Another data source used for this purpose was electrofishing database which is also hosted by BIOR and contains information of electrofishing results in more than 100 rivers in Kurzeme region and in many rivers sampling sites are located both upstream and downstream of several barriers. To evaluate the potential of rivers upstream the barriers also the register of rivers converted to drainage channels, public orthophoto maps from sites www.balticmaps.eu and https://kartes.lgia.gov.lv/karte/ and other available sources of information were used.

Ranking of rivers for spawning potential above barriers

Rivers were ranked based on combination of a simple decision tree and calculation of index of potential for lamprey reproduction.

In the first step rivers were grouped by use of simple decision tree with two questions and three potential answers to each question. Questions were as follows: “Do migrating lampreys reach the barrier?” and “Is catchment upstream the obstacle suitable for reproduction of lampreys?” And three answers were “Yes”, “No” and “Maybe”, however it should be noted that “Maybe” was closer to denial than to acknowledging an unknown situation. Reliability of answers of each of these questions was also estimated by dividing answers in three groups – “high” (larvae of river or brook lampreys has been caught downstream or upstream the barrier), “medium” (answer is confirmed by indirect data such as known parameters of river, existing population of bullhead *Cottus gobio*, trout *Salmo trutta* and other species often found in same rivers as lamprey larvae) and “low” (best guess or common sense decisions which are

not backed by any direct or indirect data). In total 31 rivers bearing an obstacle for river lamprey upstream migration were evaluated in this step.

Second step was a calculation of index of importance of the migration barriers for each identified barrier located in 20 most suitable rivers chosen in step 1. Index was calculated by specially developed formula: $II_{barrier} = ((AL_{river} \times CS_{river}) + (AL_{trib} \times CS_{trib})) \times IF_{barrier} \times \sqrt{CA} \times Ind_{hab\%} + IF_{barrier} \times II_{nextbarrier} \times (1 - IF_{nextbarrier})$, where:

$II_{barrier}$ – index of importance for each barrier;

AL_{river} – available length of river upstream the barrier, km;

CS_{river} – coefficient of suitability of river upstream the obstacle, from 0 (unsuitable) to 1 (perfect);

AL_{trib}– available length of tributaries upstream the barrier, km;

CS_{trib} – coefficient of suitability of tributaries upstream the obstacle, from 0 (unsuitable) to 1 (perfect);

$IF_{barrier}$ – impact factor of barrier, from 0 (no impact) to 1 (unpassable)

CA – catchment area upstream the obstacle, km^2;

$Ind_{Hab\%}$ - index of share of habitats upstream the barrier (calculated by dividing the multiplication of sum of total length of river and its tributaries upstream exact barrier with the square root of catchment area upstream the same barrier with the multiplication of sum of total length of all river and its tributaries with square root of total catchment area);

$II_{nextbarrier}$ – calculated index of importance for barrier located upstream the next barrier;

$IF_{nextbarrier}$– impact factor for barrier located upstream, from 0 (no impact) to 1 (unpassable).

To rank the rivers in priority order, the indexes of individual barriers were summed up to get a total index of unused lamprey reproduction potential of all river. Rivers were then listed in accordance to calculated value of this index. In almost all rivers individual indexes for all identified noteworthy barriers were calculated and included in calculation of the total index. Only exclusion is River Venta where index was calculated only for Ventas Rumba Waterfall. River Venta is the largest river in Kurzeme Region and It is self-evident that it also has the greatest unused lamprey reproduction potential which was also confirmed by calculation of index for the Ventas Rumba Waterfall only.

1. Rank of rivers

20 rivers of Kurzeme region with the greatest unused lamprey reproduction potential above the migration barriers are (in priority order): Venta, Rīva, Roja, Riežupe, Alokste, Grīva, Vārtāja, Virga, Pāce, Durbe, Tebra, Kauliņa, Dzirnavupe, Dakterišķe, Rudupe, Padure, Īvande, Svente, Vanka, Alekšupīte (Table 1). Answers to questions of the decision tree for all of rivers are added in Annex 1. More information on each river and identified barriers can be found in the next chapter.

Table 1. Rivers with the greatest unused lamprey reproduction potential in Kurzeme Region

Rank	River	Accessible	Suitable	Index value	Priority class	Reliability
1	Venta	Yes	Yes	11 260.1	-	Excellent
2	Rīva	Yes	Yes	495.6	1 (high potential)	Excellent
3	Roja	Yes	Yes	213.2	1 (high potential)	Excellent
4	Riežupe	Yes	Yes	153.3	1 (high potential)	Moderate
5	Alokste	Yes	Yes	119.3	1 (high potential)	Good
6	Grīva	Yes	Yes	62.9	2 (good potential)	Moderate
7	Vārtāja	Yes	Yes	51.6	2 (good potential)	Very low
8	Virga	Yes	Yes	51.1	2 (good potential)	Good
9	Pāce	Yes	Yes	44.4	2 (good potential)	Low
10	Durbe	Yes	Yes	41.9	2 (good potential)	Good
11	Tebra	Yes	Yes	41.4	2 (good potential)	Excellent
12	Kauliņa	Yes	Yes	30.7	3 (moderate potential)	Low
13	Dzirnavupe	Yes	Yes	29.7	3 (moderate potential)	Very low
14	Dakterišķe	Yes	Yes	29.0	3 (moderate potential)	Very low
15	Rudupe	Yes	Yes	25.8	3 (moderate potential)	Very low
16	Padure	Yes	Yes	21.1	3 (moderate potential)	Low
17	Īvande	Yes	Yes	20.3	3 (moderate potential)	Low
18	Svente	Yes	Yes	15.1	4 (low potential)	Moderate
19	Vanka	Yes	Yes	11.6	4 (low potential)	Low
20	Alekšupīte	Yes	Yes	11.6	4 (low potential)	Good

Judging by the value of Index of potential for lamprey reproduction, the rivers ranked can be divided into five classes. Class 1 (value of index >100) incudes rivers with high unused lamprey reproduction potential upstream of the barriers. Mitigation measures in these rivers will greatly increase the river lamprey reproduction potential and they should be implemented in priority order. Class 2 (index from 40 to 65) unite rivers with a good lamprey reproduction potential upstream of the barrier. It is expected that mitigation measures in these rivers will improve the reproduction of river lamprey but in smaller extent than Class 1. Class 3 unites rivers with a moderate priority (index value from 20 to 31). These rivers in general are suitable for lamprey reproduction, yet due to a relatively small size or other reasons the potential effect of the mitigation measures is relatively small. Class 4 (index <20) represents rivers with a small priority. Mitigation measures in these rivers may still have some effect while for rivers in Class 5

(failed to score two positive answers in decision tree, not shown in table 1) mitigation measures would not facilitate lamprey reproduction at noteworthy extent. River Venta due its exceptionally high index value and the fact that most important migration barrier in this river is a natural waterfall was not included in any of these classes.

Planning of mitigation measures in accordance to this ranking and suggestions from the next chapter can increase the efficiency of implemented measures. However, if it comes to such mitigation measures as removal of migration barriers or construction of fish passes we suggest the opportunistic approach. I.e., if for some reasons (lack of funding, opposition from stakeholders etc.) the mitigation measures for the high priority or Class 1 barriers cannot be implemented, we suggest to aim for Class 2 or lower. And the same can be said regarding measures. In general, if the migration barrier is a manmade dam, the most beneficial measure from the lamprey perspective will always be the complete removal of this barrier and the second-best option will be construction of bypass channel. But in reality such solutions often are not possible for different reasons, therefore, in such situations it is recommended to choose the best suitable measure which can be implemented.

2. Description of each river and proposed measures

2.1 River Venta

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
-	11 260.1	Natural waterfall	11 260.1	Excellent

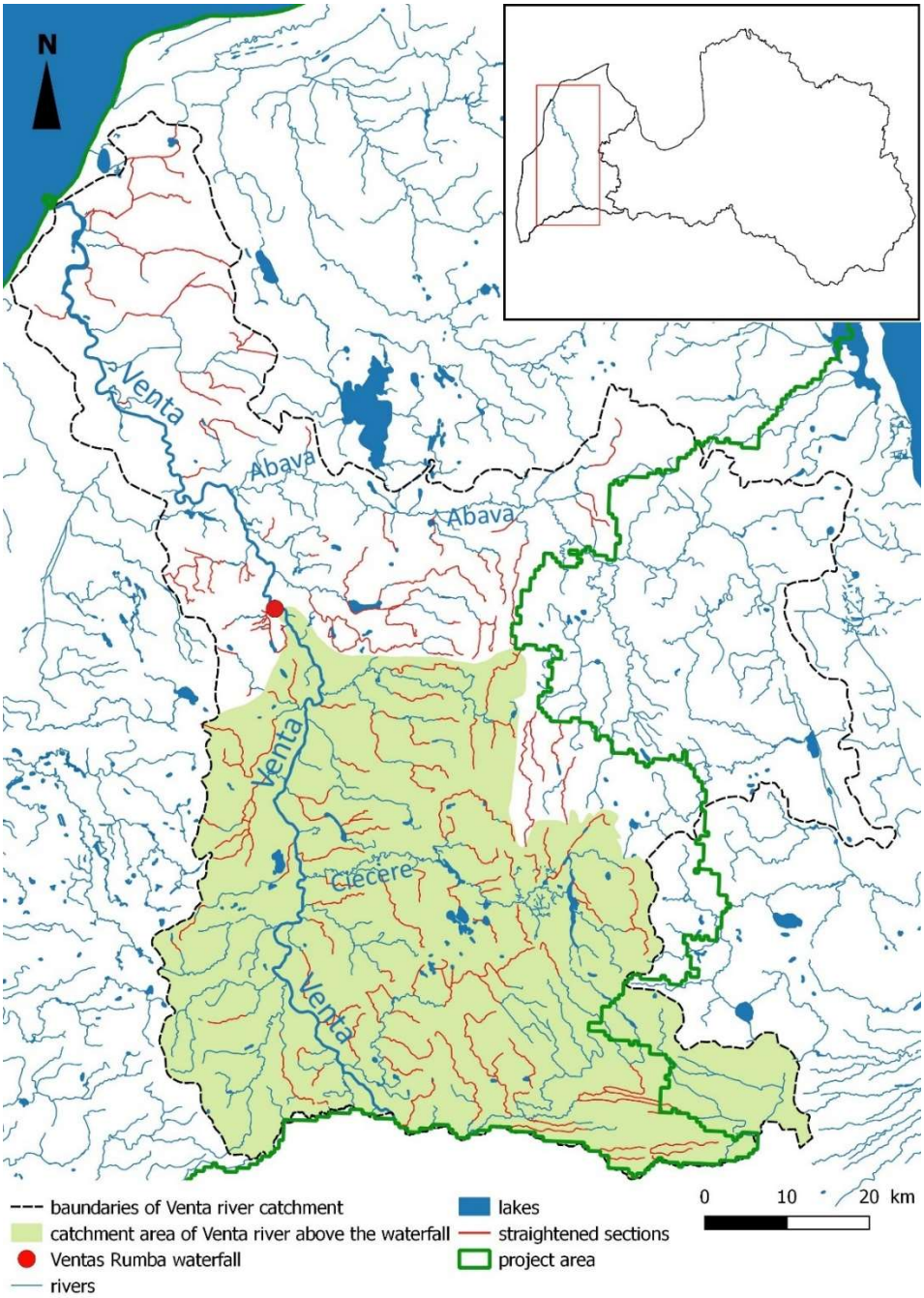

Figure 2.1.2 Catchment of River Venta and location of barrier

River Venta is the largest stream in Kurzeme region. It sources in Lithuania, crosses Kurzeme and empties into Baltic Sea in territory of Ventspils City. River Venta is natural salmon *Salmo salar* spawning river, great part of its riverbed is included in two Natura 200 territories – "Ventas ieleja" (The Valley of River Venta) and "Ventas un Šķerveļa ieleja" (The Valley of rivers Venta and Šķervelis) which among other is designated for protection of anadromous species. Hydromorphological alterations of riverbed of River Venta in territory of Latvia are minor. Greatest changes can be found next to river mouth where river is embanked and deepened to meet the needs of Freeport of Ventspils. There are almost no noteworthy man-made changes in other parts of this river but such alterations as straightening of riverbed, exploitation of small HPS and presence of other man-made barriers can be found in many tributaries of this river and also in its upper reach in territory of Lithuania. Most important barrier in this river is waterfall Ventas Rumba located in Kuldīga Town. There are also a large number of small HPS and other barriers in many tributaries of this river both above and below of this waterfall. Most important barriers located in rivers downstream this waterfall will be viewed in separate chapters.

Suitability for lamprey reproduction

Detailed information on fish habitats in River Venta is not available. However, results of annual lamprey monitoring allow to conclude that Venta is one of the most important lamprey reproduction rivers in Latvia. Monitoring has started in 2005 and since 2013 the average density of lamprey larvae has been fluctuating from 20 to 40 individuals per square meter depending on sites sampled and other factors. Existence of large lamprey reproduction potential in rivers upstream the Ventas Rumba waterfall was first noted already in middle of 20th century. Suitability of Venta and its tributaries upstream the waterfall for lamprey reproduction is also confirmed by experimental translocation of spawners in 2014., 2015. and 2017 followed by monitoring of lamprey larvae (results of survey can be found in internet page of institute "BIOR").

Description of barrier and proposed measures

Waterfall Ventas Rumba is located 86 km upstream the river mouth in Kuldīga town. Its average height is ~2 m and it is the widest waterfall in Europe (Figure 2.1.1.). Waterfall and its surrounding area have a status of protected geomorphological object, it is located in territory of Natura 2000 site "Ventas ieleja". In 17th century and repeatedly in 19th century there were attempts to build a bypass channel for shipping purposes around this waterfall on the right bank of River Venta. Unfortunately, these plans did not succeed yet the remains of the unfinished channel may occasionally be flooded and serve for some sort of fish pass. Nevertheless, in general Ventas Rumba waterfall is not passable for migrating lampreys with the exception of periods of very high water levels.

Figure 2.1.2. View on Ventas Rumba Waterfall

Possibility of building artificial structures to facilitate the lamprey migration over this barrier is limited due to its status. Theoretically it may be possible to modify the unfinished bypass channel to adapt it for fish migration yet realisation of this activity would require a large investment of time, engineering and money and would not grant the results. The most suitable mitigation measure for this barrier is stocking of larvae. Translocation of spawners has also proved its utility yet it needs to be taken into account that lamprey population upstream the barrier is genetically distinct from lamprey population of Latvia and Lithuania and may provide important information for the study of lamprey evolution and evolution in general. It is possible that large-scale translocation projects may affect the genetical structure of lamprey population upstream of the barrier, therefore such actions should be avoided.

There are number of other barriers in several tributaries of River Venta. From lamprey perspective specific mitigation measures for these barriers has a low priority. Taking into account the large area of potential habitats already available upstream the Ventas Rumba and status of this barrier there is a very small possibility that mitigation actions in this barrier will result in shortage of spawning and rearing habitats for river lamprey upstream this waterfall. However, it needs to be taken into account that salmonids and vimba bream can overcome this barrier and mitigation measures of dams located in tributaries emptying upstream the waterfall may be beneficial for these species.

2.2 River Rīva

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
1	495.6	Dam of cardboard factory	495.6	Excellent

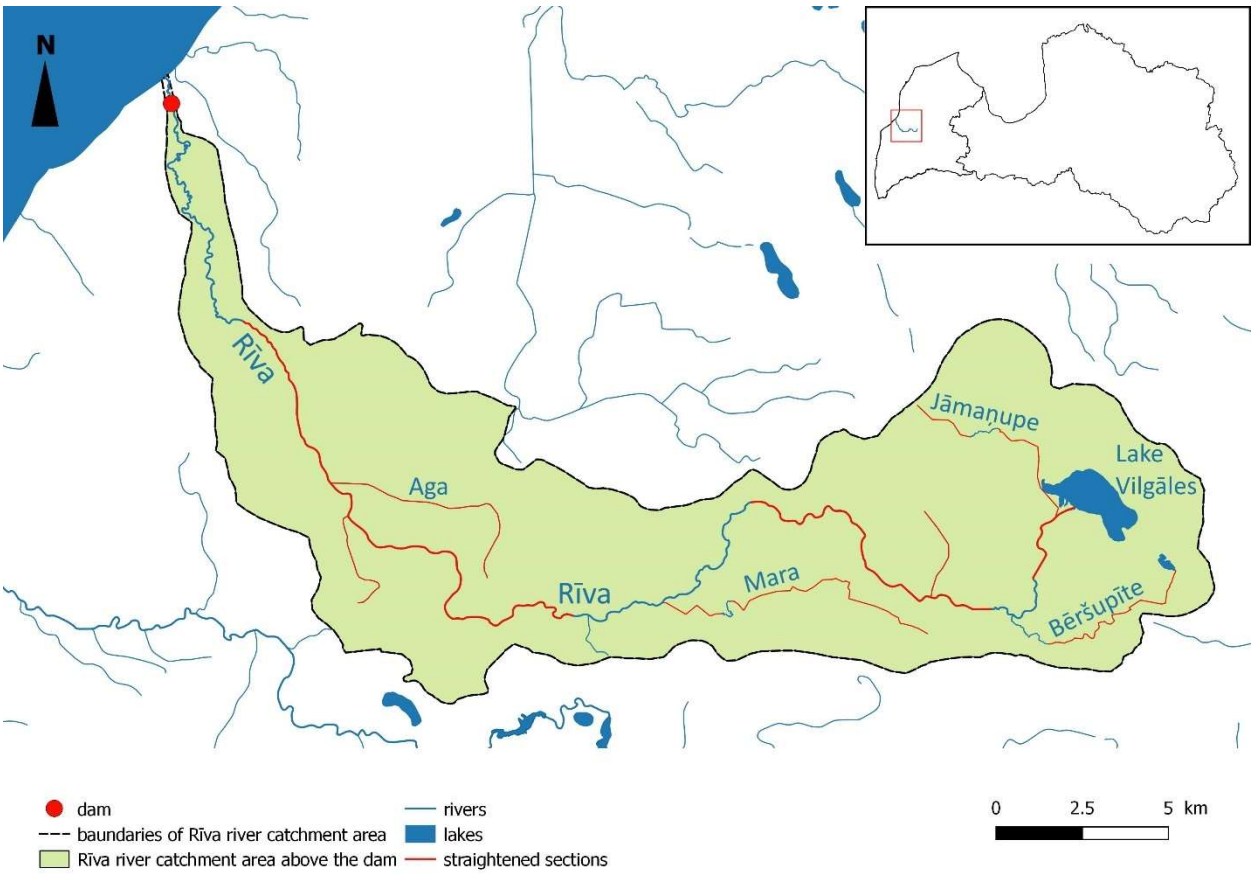

Figure 2.2.1 Catchment of River Rīva and location of most important barrier

River Rīva sources from Lake Vilgāles and empties into Baltic Sea main proper (Figure 2.2.1). This river is 61 km long; its narrow catchment area covers 230,4 km^2 and average slope of the riverbed is 1,17 m/km. Approximately half of the total length of riverbed is straightened. Straightening was started already in 1920s and 1930s and continued throughout 1960s and 1970s. Most of riverbed of all noteworthy tributaries of River Rīva are also straightened and natural riverbed can be found in only few places. Most important migration barrier in this river is remains of unfinished cardboard factory dam close to river mouth. Other barriers (water level regulator of Lake Vilgāles located close to the lake and a few more barriers located in minor tributaries) are not important from lamprey perspective since they limit access to very small straightened streams with no noteworthy lamprey reproduction potential.

Suitability for lamprey reproduction

Detailed information on fish habitats in River Rīva is not available. A walk-by survey in 2018 has been performed only in approximately 10 km long lower section of River Rīva. Results of this survey showed that hydromorphological parameters of unregulated part of River Rīva upstream of the barrier is well suited for lamprey reproduction (Figure 2.2.2). Suitability for lamprey reproduction is confirmed also by the capture of brook lamprey *Lampetra planeri* larvae, brown trout and other gravel spawning species in electrofishing surveys in this part of river. Brown trout has been captured also in some electrofishing sites located in upper reach of this river, in one of these sites presence of lamprey larvae has also been registered.

Figure 2.2.2 Unregulated downstream section of River Rīva upstream the migration barrier

Very little is known about tributaries of River Rīva. In fact, all of them are relatively small and straightened and thus most probably not suitable for lamprey reproduction. Electrofishing survey has been performed only in River Jāmaņupe emptying in River Rīva just downstream the water regulator of Lake Vilgāles. Electrofishing results in this river (few specimens of roach *Rutilus rutilus*, perch *Perca fluviatilis* and sunbleak *Leucaspius delineatus*) confirms the assumption that today the tributaries of River Rīva in general are not suitable for lamprey reproduction.

Description of barrier and proposed measures

Barrier is located in lower reach of the river and consists of three parts. In downstream part there is approximately 1,2 m high waterfall (Figure 2.2.3), in upstream direction followed by ~ 1.2 m high concrete wall with narrow (approximately 30 cm opening in right coast side) and by ~1,5 m high concrete block with integrated 1 m diameter pipe in the centre and half-pipe in upper right corner. This construction is remains of unfinished cardboard factory dam built in 1920, however there is information that watermill in this site existed already in 18th century and later was replaced by papermill destroyed during the World War I. Today dam is a tourist attraction for visitors of the nearby cafe and a wooden bridge. Barrier might be passable for river lamprey at very rare and specific conditions.

Figure 2.2.3 Remains of unfinished cardboard factory dam in River Rīva

Best mitigation measure would be the complete removal of the barrier. It would not only ensure the migration for river lamprey, sea trout, European eel *Anguilla anguilla* and other fish species but also lower the water level in section upstream of the barrier. Yet complete removal of this object faces strong opposition from the local community and other stakeholders and therefore is currently not possible. Second best option is building of bypass channel/fauna passage which is planned within Interreg project "Development, Promotion and Sustainable Management of the Baltic Sea Region as a Coastal Fishing Tourism Destination" RETROUT. Potential of river lamprey reproduction both in the main river and its tributaries can also be increased by restoration of riverbed.

2.3 River Roja

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
1	213.2	Former Lube watermill	213.1	Excellent
		Former Siladzirnavu watermill	0.05	Very low

Figure 2.3.1 catchment of River Roja and location of most important barriers

River Roja is the largest river emptying into western part of Gulf of Riga (Figure 2.3.1). Roja is approximately 80 km long; its catchment area covers 480 km^2 and average slope of the riverbed is 0.61 m/km. Upper and middle reaches of River Roja together with most of its tributaries as well as some

sections and most of tributaries downstream of the barrier are straightened. Total length of straightened parts is 38.4 km, there is some information stating that straightening started already in 19th century, however most of large-scale straightening was done in 1957 and 1964 and repeated in 2018. Most important migration barrier in this river is a dam of former Lube watermill on River Roja while second barrier is located in – dam of former Siladzirnavu watermill – is located in River Greimica which is left side tributary of River Roja. Other known barriers are blocking access to a very small straightened streams with no potential for lamprey reproduction.

Suitability for lamprey reproduction

Detailed information of fish habitats in River Roja is not available. However, monitoring of lamprey larvae confirms that downstream the barrier River Roja is well suited for river lamprey reproduction (Figure 2.3.2) and reproduction of brook lamprey happens also upstream the barrier.

Figure 2.3.2 River Roja downstream of the dam

In section downstream of the barrier monitoring of lamprey larvae is being performed since 2013 and average density of lamprey larvae since then has been approximately 30 ind./m^2. Upstream of the dam monitoring of lamprey larvae was performed in 2018 and 2019 with the aim to evaluate the success of translocation of lamprey spawners within the LAMPREY project. Results of monitoring of lamprey larvae show that lamprey reproduction upstream of the dam occurs both in natural section of riverbed (density from 10 to 15 ind./m^2) and also in downstream part of straightened section (average density 7.7 ind./m^2).

Very little is known about River Greimica. Greatest part of riverbed upstream the barrier is straightened, however approximately 2 km long part of riverbed still has its natural shape thus suggesting that lamprey reproduction is still possible in this river.

Description of barriers and proposed measures

Dam of former Lube watermill is located in middle section of River Roja approximately 32.5 km from the river mouth. It is a solid concrete dam with a regulator of water level and as such completely impassable for river lamprey or other migratory fishes (Figure 2.3.3). There is information that watermill in this place existed already in the end of the 16th century. Lube watermill during its existence was reconstructed several times and exploited as watermill until the second half of the 20th century. There were also plans to use mill dam for construction of small HPS yet luckily these plans were not realised. Today dam and reservoir are not directly used for economic activity. The most effective measurement for this barrier would bet the complete or partial removal of dam. Such action would not only ensure the migration of river lamprey, sea trout and other fishes but also improve the quality of river affected by impoundment. However, experience with other dams shows that complete removal of such barriers often face resistance from owners and other stakeholders and thus is very complicated or is not possible at all.

Figure 2.3.3 Dam of former Lube Watermill

If complete removal of this barrier is not possible, the second-best solution is to build a bypass channel/fauna passage. If building of such fish pass is not possible it can be replaced by technical fish pass targeted for ensuring the migration of lamprey and sea trout. However technical fish pass is a compromise solution with limited efficiency and should be replaced with natural fish pass or removal of dam when possible. As a short-term solution yearly translocation of river lamprey spawners from commercial fishery in River Roja is suggested. It needs to be taken into account that great part of River Roja and its catchment is straightened and lamprey reproduction potential can also be greatly increased by restoration of riverbed.

Siladzirnavu watermill is located 1.2 km from river mouth of River Gremica and was constructed in the beginning of 20th century. Mill was operated until the 1960s and later abandoned. Today the mill building is ruined, but mill dam was reconstructed in 1970 and is still impassable for upstream migration. From a lamprey perspective the most suitable solution is a complete removal of barrier but priority of this action is low. Building of expensive sophisticated fish pass in this barrier is not relevant due to the small lamprey reproduction potential upstream of this barrier.

2.4 River Riežupe

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
1	153.3	Culvert	21.7	Excellent
		Riežupe waterfall cascade	126.3	Moderate
		Veldze waterfall cascade	4.5	Very low
		Former Pusgaldiņu watermill	0.4	Moderate
		Former Upesmuižas watermill	0.4	Moderate

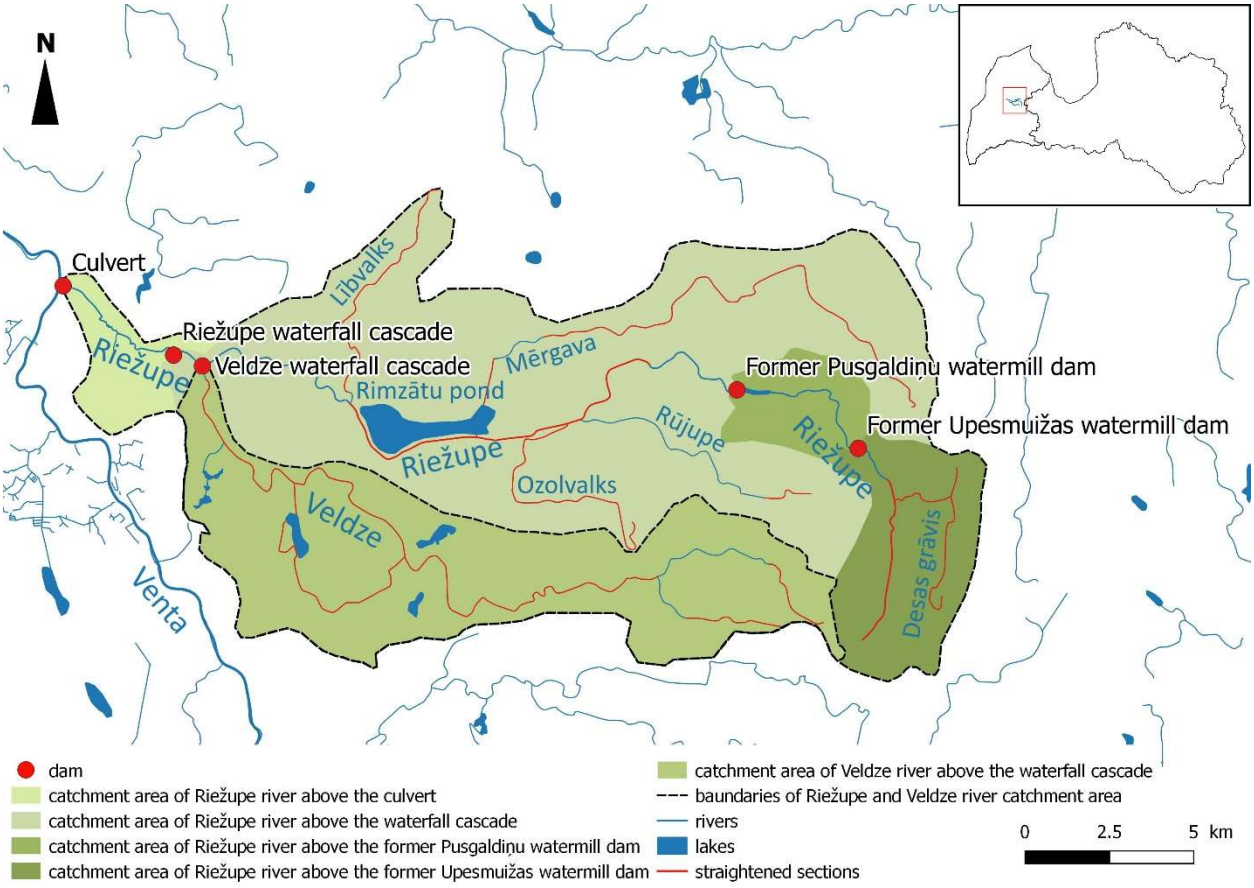

Figure 2.4.1 Catchment of River Roja and location of most important barriers

Riežupe is a left coast tributary of River Venta. It sources from Ēģenieku Swamp approximately 4 km southwards from Kabile Town and empties in River Venta only few kilometres downstream of Ventas Rumba waterfall. With a length of 43.7 km and catchment area 251 km^2 it can be listed among largest tributaries of River Venta downstream this waterfall. Upper reach and middle section of this river is straightened yet approximately half of its riverbed still has its natural riverbed. Approximately 5 km long downstream reach of this river is included in territory of Natura 2000 site “Riežupes dabas parks”, (The Nature Park of River Riežupe) among other designated also for protection of river lamprey. Riežupe has several relatively big tributaries, the largest of which – Veldze and Mergava – have a length of more than

20 km. Unfortunately, share of straightened riverbed in tributaries is much greater than its main river. Riežupe has several important migration barriers. The lowermost barrier which is a culvert of local road is located only approximately 100 m from the river mouth. Next barriers are two cascades of natural waterfalls. One of them is located in River Riežupe approximately 5.4 km from River Venta and the second one – in lower reach of River Veldze. Next two barriers are dams of former watermill located in upper reach of River Riežupe.

Suitability for lamprey reproduction

Evaluation of fish habitats has been done only in lower part of River Riežupe located between culvert and waterfall. Riverbed in this part of river is a mix of swift flowing and slower sections providing the river lamprey with a plenty of both spawning and rearing habitats.

Figure 2.4.2 River Riežupe upstream the culvert

Suitability of this section of river for river lamprey is also confirmed by monitoring of lamprey larvae which has been carried out since 2014 in one sampling spot located approximately in the middle of this section. Density of lamprey larvae in individual years in this site fluctuates between 10 and 33 ind./m^2 making an average value of 21.3 ind./m^2. Less data is available on next reaches and on River Veldze. In a section between waterfall and first dam only one electrofishing site and one lamprey larvae sampling site is located. Presence of brown trout, bullhead and other species in electrofishing as well as presence of lamprey ammocoetes in larvae monitoring confirms that in general this part of river is suitable for lamprey

reproduction. Density of lamprey larvae in only site sampled was small (only 1.4 ind./m^2) however it may be different in other sections of river. There is almost no information regarding river upstream of both dams. However, presence of bullhead in electrofishing upstream the furthermost dam suggests that this part of river may also be suitable for lamprey reproduction. Very little is known about tributaries of River Riežupe. There is no information on electrofishing, sampling of lamprey larvae or mapping of habitats in these rivers so far. Small size and great proportion of straightened reaches suggests that tributaries of River Riežupe in general are only partly suitable for lamprey reproduction.

Description of barriers and proposed measures

Culvert of the local road is located less than 100 m upstream of the river mouth. Culvert consists of two parallel square-shaped tunnels of reinforced concrete (Figure 2.4.3.).

Figure 2.4.3 Culvert of local road in downstream section of River Riežupe

Relatively wide and flat concrete bed induces hardly negotiable swift and monotonous current inside the tunnels. In addition, downstream side of this culvert has a relatively steep drop which is partly collapsed and followed by washed out riverbed thus making the entrance in culvert arduous for ascending lampreys. Difficult entrance and passage through the tunnels make this obstacle to be passable only during favourable conditions. Most convenient mitigation measure is to remove the present culvert and replace it with a culvert where bottom is covered by stones and gravel and resemble natural riverbed and

is on the same level as riverbed downstream the culvert. Since culvert is passable at specific conditions other measures such as building of a fish pass, translocation of spawners or stocking of lamprey larvae is not relevant in this case.

Cascade of several up to 0.5 m high waterfalls in River Riežupe is located approximately 5.2 km from river mouth. Initially there was one several meters high waterfall which in 1950s was destroyed and used as a raw material for lime production. Waterfalls and surrounding area have a status of protected geomorphological object. Ability of lampreys to negotiate this obstacle has never been evaluated, however most probably they may be passable at high water level or other specific conditions. These waterfalls are a natural object and potential measures are limited due to its status which does not allow to build objects that change the object itself. However, mitigation measures as such are not forbidden in this object and there is a possibility to find a solution (temporary lamprey-specific ramps or other) that does not contradict the status of barrier. Potential measures should be approved by Nature Conservation Agency. Temporary solution is translocation of lamprey spawners from River Venta or stocking of lamprey larvae. Before taking any of these actions additional survey of lamprey reproduction potential upstream the waterfalls are suggested.

Cascade of waterfalls in River Veldze is located close to its inflow in River Riežupe. Waterfalls in this cascade can reach height of approximately 0.7 m. Ability of lampreys to negotiate this obstacle has never been evaluated, however most probably it may be passable during high flow. The same as in River Riežupe the cascade of waterfalls in River Veldze also have a status of protected geomorphological object. Recommended measures are the same as in River Riežupe, i.e., looking for a way to facilitate the natural migration and performing the stocking of lamprey larvae or translocation of spawners until such possibility is found. In River Veldze additional survey of lamprey reproduction potential is also recommended before these actions.

Former Pusgaldiņu watermill and Upesmuižas watermill are locate 30 km and 36 km upstream the river mouth. They both are solid dams and thus impassable for lamprey migration. Most suitable solution would be the complete removal of these barriers. Building of expensive sophisticated fish passes in these barriers is not relevant due to the small lamprey reproduction potential upstream this barrier. Removal of barriers will not only open migration routes for river lamprey or other species but also allow to restore the riverbed in area currently flooded by reservoirs. Yet from a perspective of river lamprey any measures in these barriers have a low priority yet such actions may be more urgent for other species.

2.5 River Alokste

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
1	119.3	Baronu HPS	2.5	Low
		Apriķu HPS	96.3	Good
		Kazdanga HPS	20.2	Excellent
		Former Vecpils watermill	0.3	Low

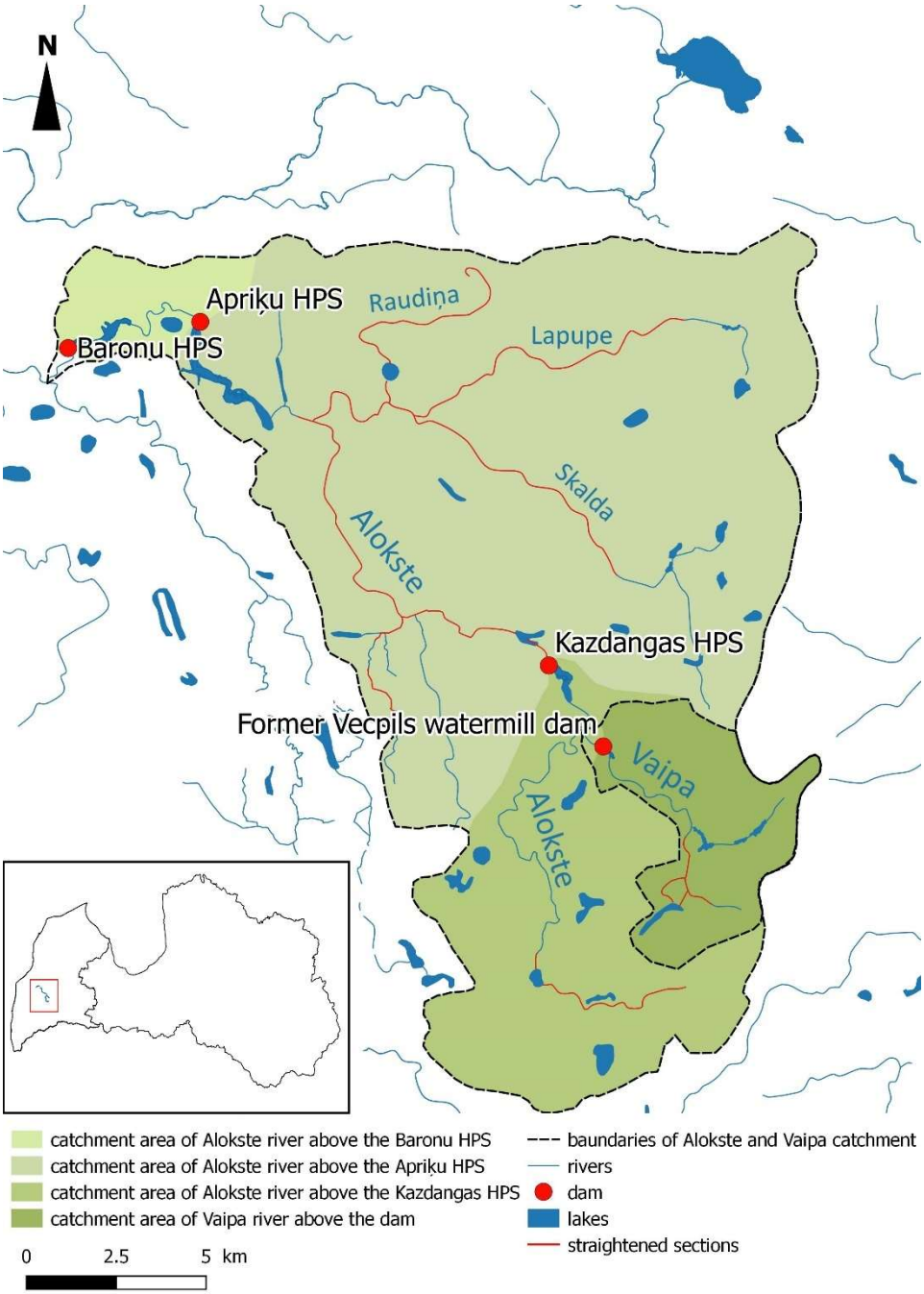

Figure 2.5.1 Catchment of River Roja and location of most important barriers

River Alokste is the largest tributary of River Tebra which is one of confluent river of River Saka and one of seven Latvian natural salmon reproduction rivers. Alokste is approximately 46 km long; its catchment area covers 291 km^2 and average slope of riverbed is 1,81 m/km. Great part of riverbed of this river as well as most of its tributaries is straightened, natural sections of riverbed have been preserved mostly downstream reach downstream all barriers and in upper reach upstream of Kazdangas HPS (Figure 2.5.1). Most important barriers for fish migration in this river are three HPS. Baronu and Apriķu HPS are located close to river mouth and currently less than two kilometres of lower reach of River Alokste are available for anadromous migration. Kazdangas HPS is located in the upper part of the middle reach and blocks access the unregulated section of this river. Man-made barrier with lesser importance is located on River Vaipa.

Suitability for lamprey reproduction

Detailed survey of habitats in River Alokste and its tributaries has not been performed. However, River Alokste along with its largest tributary River Skalda was included in LAMPREY project activities of translocation of spawners and stocking of ammocoetes and thus monitored for presence of lamprey before and after these actions. Also, several electrofishing surveys have been performed in recent years in these rivers. Average density of brook lamprey larvae in unregulated part of river upstream of Kazdanga HPS is approximately 10 individuals per square. Lamprey larvae has not been found in bottom sampling in straightened reach of River Alokste between Apriķu HPS and Kazdangas HPS. However, in general this part of River Alokste consists of swift flowing sections separated by slower sand-dominated parts of riverbed and thus in general meets the requirements of river lamprey and may be suitable for lamprey reconstruction. This assumption is indirectly confirmed by capture of several lamprey larvae in electrofishing survey in this part of river. In River Skalda presence of lamprey larvae has been recorded only in one electrofishing site located less than 100 m from River Alokste. In all other electrofishing and bottom sampling sites in this river the lamprey larvae or other fish species (bullhead, brown trout etc.) pointing on suitability of this river for lamprey larvae have not been found. Very little is known about River Vaipa. It is only 5 km long left coast tributary of River Alokste emptying upstream the Kazdanga HPS. Natural shape of riverbed has been kept in almost all River Vaipa thus suggesting that at least a part of this stream should be suitable for lamprey reproduction.

Description of barriers and proposed measures

Most significant barrier is the cascade of Baronu and Apriķu HPS. Baronu HPS which is the lowermost power station is located less than two kilometres from river mouth. It was constructed in a beginning of 20^{th} century partially using existing dam of fish pond cascade. Baronu HPS is followed by

Apriķu HPS located only 7.8 km from the river mouth. This powerplant was built already in 1950s yet later abandoned and partly collapsed. HPS was restored and production of electricity restarted in end of 20th century. None of these power stations is equipped with fish passes and they both are completely blocking the upstream migration. Although both power stations are located close to each other there is still approximately 3 km long natural-like free-flowing section of River Alokste preserved downstream the Apriķu HPS dam. Most beneficial solution would be the complete removal of dams of both power stations. This action would not only grant access to greatest part of Alokste and its catchment but also allow to restore the riverbed in sections currently flooded by reservoirs. Yet taking into account that both barriers are used for operation of HPS and are involved in maintaining of water level in several fish ponds such solution would be very resource consuming and, also, may face great resistance from owners of HPS and ponds. Therefore, the most suitable realistic solution to aim to is the construction of a fish pass. The preferable type of fish pass is a bypass channel but if its construction is not be possible due to lack of space or other circumstances, it can be replaced with technical fish pass aimed for river lamprey and sea trout. Monitoring of success of translocation of lamprey spawners performed within LAMPREY project so far has not confirmed successful reproduction of translocated lampreys in rivers Skalda and Alokste. Yet taking into account that River Alokste in general is suitable for lamprey reproduction it is possible that reproduction of translocated lampreys was not confirmed due to a small number of sampling sites and it will be confirmed in following years. Large part of available catchment upstream the Apriķu HPS is straightened leaving also the noteworthy space for river restoration activities. Monitoring of spawning success of translocated lamprey larvae in Alokste will be continued for several years and decision on usefulness of translocation of lamprey spawners to River Alokste should be taken after summing up these results.

Next barrier is Kazdanga HPS located approximately 28 km from river mouth. This powerstation is built next to former Kazdanga watermill (built in the middle of 19th century and operated until the second half of 20th century) and uses the same dam and water reservoir as watermill. Removal of this dam or building of fish pass will undoubtedly contribute to improvement of ecological status of River Alokste. However, from the perspective of river lamprey such measures would bring benefit only if there were effective measures for ensuring lamprey migration would first be implemented in Baronu and Apriķu HPS. Until such measures are taken only way to exploit the lamprey reproduction potential is translocation of spawners from commercial fisheries in River Saka or stocking of lamprey larvae.

Manmade barrier of least importance is former dam of Vecpils watermill on River Vaipa located one kilometre from river mouth. Precise date of construction of watermill is not known (must probably –

second half of 19th century). Mill was operated until the second half of 20th century and later used for filling up the fish ponds. Today this barrier is not used but it still makes unpassable barrier for upstream migration. Most perspective solution is complete removal of barrier. Construction of expensive sophisticated fish pass or fauna passage is not relevant due to small lamprey reproduction potential upstream this barrier. It must be taken into account also that this barrier is located upstream three HPS dams and any measures in this barrier will be beneficial only after implementing the effective measures in downstream barriers first. Due to small size of this river and lack of data confirming its lamprey reproduction potential the translocation of spawners or stocking of ammocoetes in River Vaipa is not recommended.

2.6 River Grīva

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
2	62.9	Former Uguņu watermill	59.7	Moderate
		Former Dārtes watermill	3.2	Very low

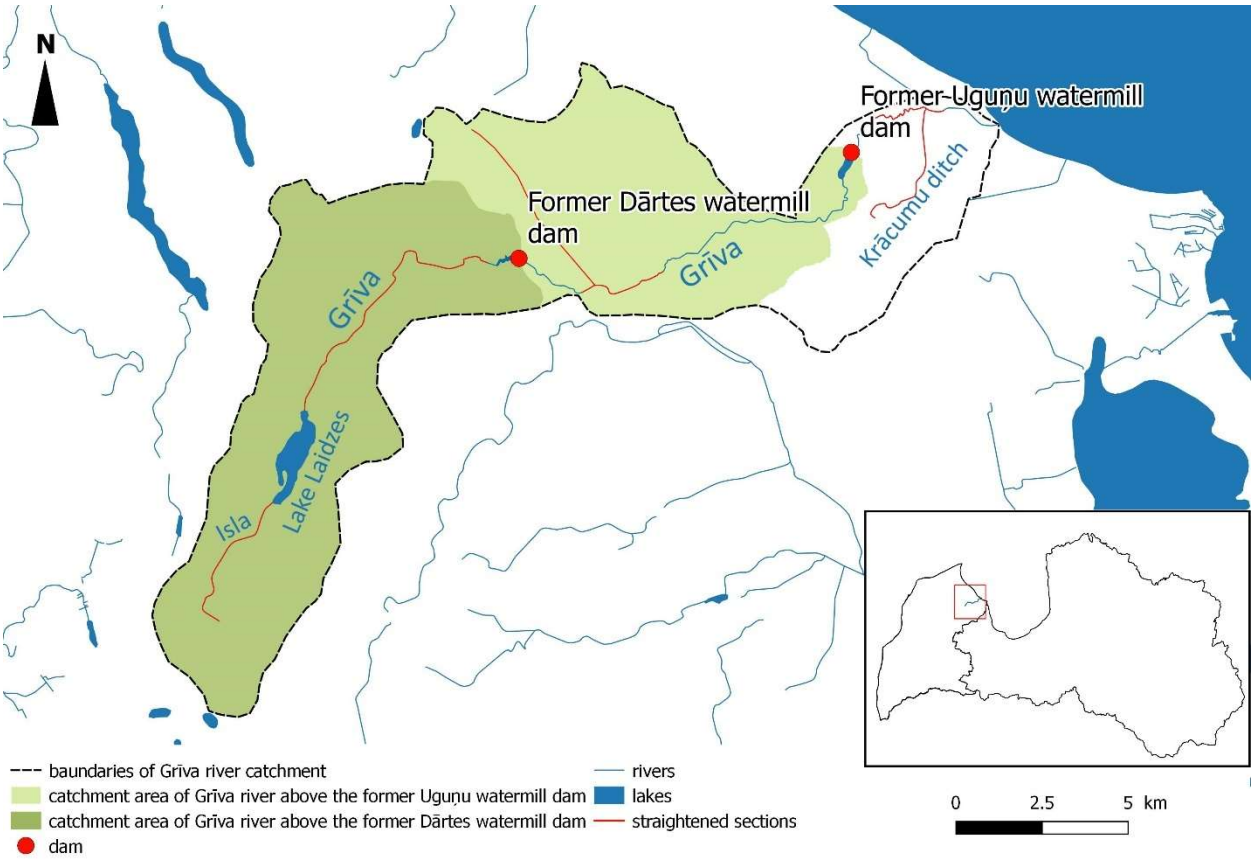

Figure 2.6.1 Catchment of River Grīva and location of most important barriers

River Grīva sources from Lake Laidzes and empties in western part of Gulf of Riga approximately 19 km southeast from river mouth of River Roja. Total length of this stream is 33.3 km and its catchment area cover territory of 142.8 km^2. Approximately half of riverbed of this river and most of its tributaries has been straightened. There are two manmade barriers in this river – the dam of former Uguņu watermill in lower reach and the dam former Dārtes watermill located in upper reach more than 20 km from the sea.

Suitability for lamprey reproduction

Bottom sampling of lamprey larvae has been performed only in 2019 in one site located approximately 0.5 km from the sea. Average density of lamprey larvae was relatively low (9 ind./m^2) yet in samples taken in optimal habitats density of lamprey larvae exceeded 30 ind./m^2. Importance of this

river for lamprey reproduction is also confirmed by annual commercial catch of 100–300 kg of lampreys in this river. Detailed survey of habitats or monitoring of lamprey larvae in other parts of this river has not been performed. Electrofishing results upstream the former Uguņu watermill confirms the existence of brook lamprey population and the suitability of this part of river for the lamprey reproduction is confirmed also by the presence of bullhead and brown trout.

Figure 2.6.2 River Grīva upstream the former Uguņu watermill

All riverbed upstream the Dārte watermill is straightened and it can be assumed that suitability of this section for lamprey reproduction is low. Only noteworthy tributary emptying upstream the barriers is River Mucupe. It is a relatively small river (length only 5.7 km) which is straightened in all of its length thus suggesting that in general the lamprey reproduction potential in this stream is very low.

Description of barriers and proposed measures

The most important migration barrier in River Grīva is former Uguņu watermill located only 6.6 km from the river mouth. It was constructed in 1920s and in the second half of 20th century converted to use of electricity instead of water power. Today the mill building hosts a shop and a guest house and its exploitation is not directly linked to usage of reservoir and water power. Nonetheless, this dam is not equipped with any device for fish upstream migration and is impassable for upstream migration. As in

many other cases the most beneficial mitigation measure would be the complete removal of this barrier. If it is not possible due to opposition of stakeholders or other reasons the construction of bypass channel/fauna passage is recommended. Temporary solution to ensure the usage of river lamprey reproduction potential in River Grīva upstream the Uguņu watermill dam is the translocation of lamprey spawners from commercial catch in this river or stocking of lamprey larvae.

Dārte watermill was constructed 1930s (in other sources – 1866) and destroyed during the second world war. In 1970s the water regulator, dam and adjacent bridge was reconstructed and completely blocks the upstream migration. This barrier is located in upper reach of River Grīva and all riverbed upstream of this barrier is straightened thus limiting the importance of this barrier from the river lamprey perspective. Due to limited river lamprey reproduction potential upstream this barrier such temporary measures as translocation of spawners or stocking of larvae is not recommended. From the lamprey perspective, the other measures such as removal of barrier or construction of fish pass should be considered only after such actions are implemented in Uguņu watermill. However, providing opportunities for migration may be beneficial for other species.

Due to relatively large proportion of straightened sections in River Grīva its lamprey reproduction potential can be greatly increased also by restoration of the riverbed.

2.7 River Vārtāja

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
2	51.6	Bunkas HPS	7.4	Very low
		Krotes HPS	0.02	Very low
		Velēkšņu pond	44.2	Very low

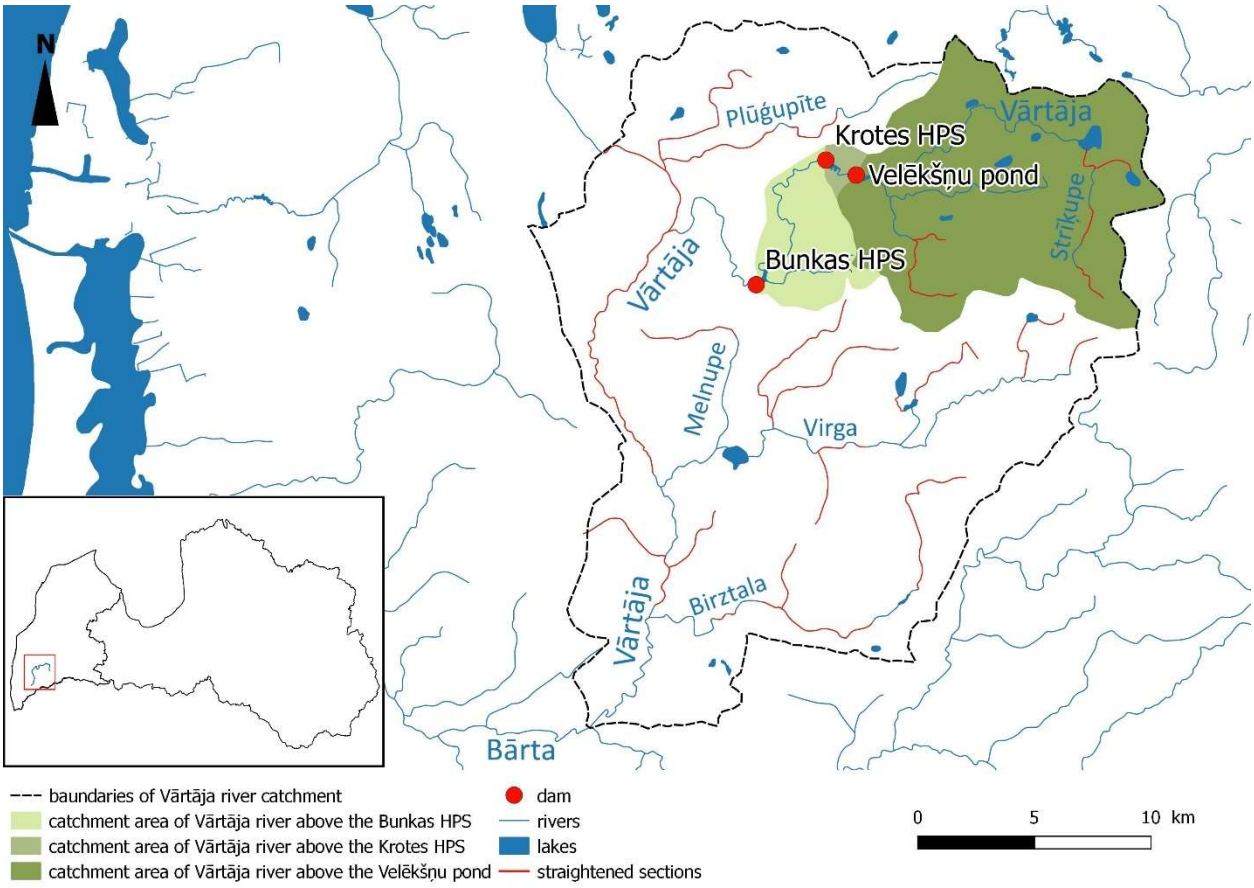

Figure 2.7.1 Catchment of River Vārtāja and location of most important barriers

River Vārtāja is the largest tributary of River Bārta which is one of Latvian wild salmon reproduction rivers. It sources from Sēpenes Lake and flows into River Bārta approximately 34 km from its inflow in Liepājas Lake. Total length of River Vārtāja is 81 km. Its catchment area covers 537 km^2 and average slope of riverbed of this stream is 1.3 m/km. Approximately one quarter or 20.1 km of lower section of riverbed of River Vārtāja has been straightened while three remaining quarters is still having its natural shape. Greatest proportion of straightened sections can be found in tributaries of this river. There are three man-made barriers for upstream migration in River Vārtāja– Bunkas HPS, Krotes HPS and dam of Velēkšņu pond, all of them are located in middle and upper reach of River Vārtāja.

Suitability for lamprey reproduction

There is relatively little data available for estimation of lamprey reproduction potential in River Vārtāja. Electrofishing survey has been performed in only two sampling sites (one time each) located downstream of all the barriers. In both surveys capture of lamprey larvae was not registered and also other species captured in electrofishing (few bullheads but also roach *Rutilus rutilus*, perch and bitterling *Rhodeus sericeus*) do not provide clear clue on suitability of this river for lamprey reproduction. However, judging by average slope exceeding 1 m/km and the fact that most of the riverbed of River Vārtāja still has its natural shape, it can be assumed that in most of its length this river most probably is suitable for river lamprey reproduction

Description of barriers and proposed measures

Lowermost barrier in River Vārtāja is the Bunkas HPS located 47 km from River Bārta. Watermill in this location was built already in first half of 19th century. After several reconstructions mill was operated until the 1970s while HPS in this place was constructed in the end of 20th century. Next two barriers – Krotes HPS and Velēkšnu Pond are located 13.8 km upstream Bunkas HPS ad only 2.1 km from each other. History of Krotes HPS in general is similar to that of Bunkas HPS. This power station was constructed in a beginning of 21st century and uses reservoir of the old watermill built in the middle of 19th century. There is little information on Velekšņu Pond. Most probably it was constructed during last decades of 20th century with a purpose of filling up adjacent fish ponds. All three barriers mentioned before are solid dams without fish pass and completely block the upstream migration of all fish species.

Highest lamprey reproduction potential in River Vārtāja is upstream the Velekšņu Pond which is the uppermost barrier in this river. Therefore, the mitigation measures in this river need to be implemented in all three barriers simultaneously. As in most other cases, the best mitigation measure from the perspective of lamprey and other fish species would be the complete removal of all three barriers. And the same as with another barriers, it can be expected that this measure will not be possible because of strong opposition from the owners of power stations and other stakeholders. The second most useful option is building a bypass channel or in worst scenario – the technical fish pass suitable for lampreys and Sea trout. Due to its distant location and small size of this river, the translocation of spawners or stocking of lamprey larvae is not recommended. It must be taken into account also that the decision of existing of lamprey reproduction potential in River Vārtāja is not reliable. Before taking any of the suggested actions the additional survey of lamprey reproduction potential upstream the barriers are suggested.

2.8 River Virga

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
2	51.1	Prūšu HPS	28.2	Good
		Remains of Priekules watermill	22.9	Good

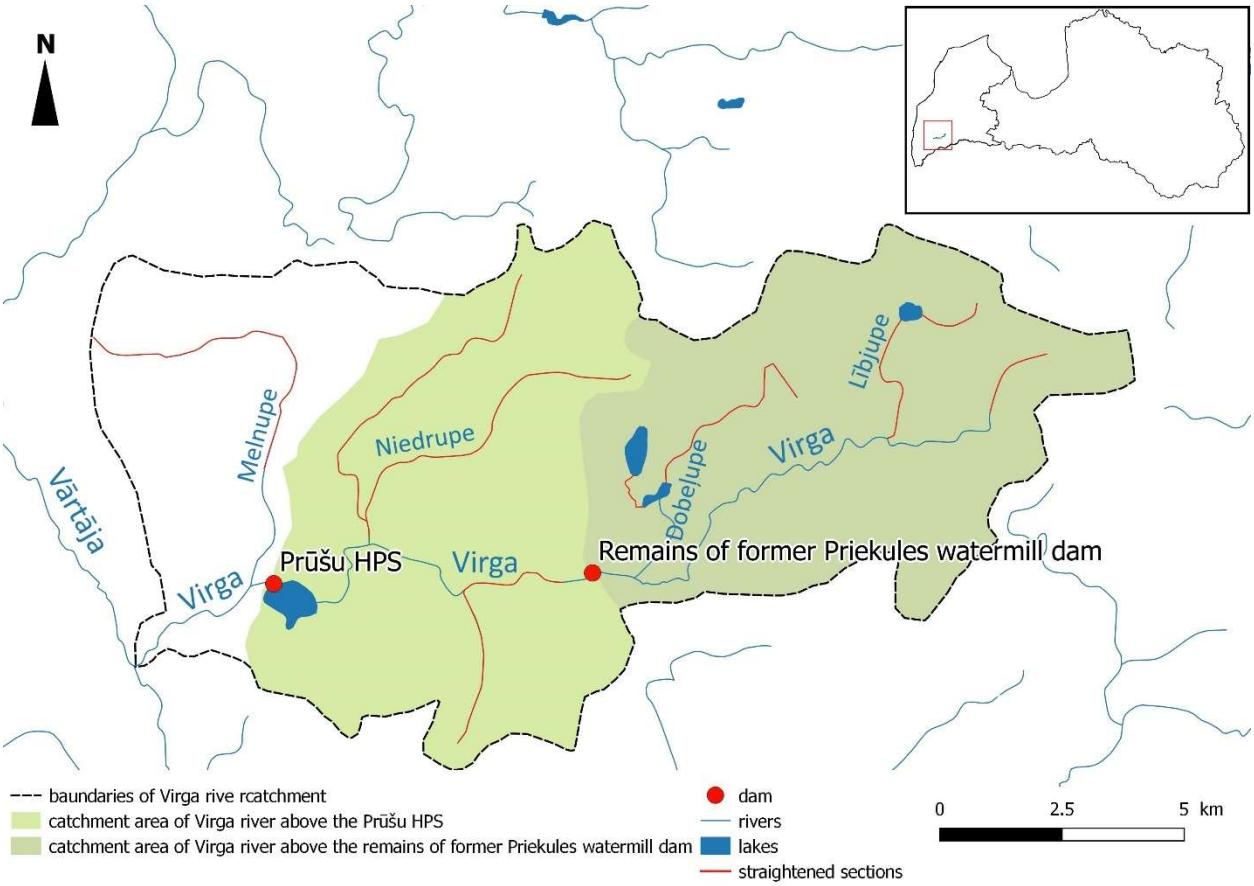

Figure 2.8.1 Catchment of rivers Virga and Vārtāja and location of most important barriers

River Virga is the left coast tributary of River Vārtāja, its total length is approximately 34 km while catchment area reaches 143,9 km^2. Unlike many other rivers in Kurzeme Region most of riverbed of River Virga has preserved its natural shape yet greater proportion of straightened sections is found in its tributaries (Figure 2.8.1). Most important barrier for fish migration is Prūšu HPS located only few kilometres from river mouth. In the past there were also two mill dams upstream this HPS. Today both of them are collapsed yet remains of dam of Priekule watermill is still a barrier for the upstream migration.

Suitability for lamprey reproduction

Detailed survey of habitats or monitoring of lamprey larvae in River Virga and its tributaries has not been performed. Electrofishing data are available from two sampling sites located in reach upstream of Prūšu HPS and upstream from the remains of dam of former Priekule watermill. Lamprey larvae were

captured only in lowermost electrofishing site located approximately 10 km from river mouth (Figure 2.8.2). However, presence of such species as brown trout and bullhead in electrofishing site located approximately 24 km from river mouth suggests that this part of riverbed is also suitable for lamprey reproduction. There are only two noteworthy tributaries emptying in River Virga upstream of the barriers. River Niedrupīte is 7.4 km long and most of its riverbed is straightened. In the same time River Dobeļupe is only 2.2 km long but has preserved natural riverbed in almost all its length.

Figure 2.8.2 River Virga upstream of the Prūšu HPS

Description of barriers and proposed measures

Most significant migration barrier in this river is Prūšu HPS. Dam and impoundment in this location was constructed in late 1980s and in the beginning of 21st century adapted to use for production of electricity. This HPS has a relatively large (66 ha) reservoir which is a popular recreational destination. Also, licenced angling is organised in this reservoir which means that angling is allowed only after purchase of special licence. The same as previously, most beneficial mitigation measure would be the complete removal of the dam. However, taking into account dam is used for production of electricity and reservoir itself – for angling and other recreational activities, the complete removal of this barrier would most probably be strictly opposed by different stakeholders and therefore would not be possible. The most suitable solution which potentially can benefit also the sea trout, is construction of natural-like fish pass

or, if it is not possible – the technical fish pass suitable for lamprey and sea trout. Most suitable temporary solution is a stocking of lamprey larvae. Due to its small size and the fact that the closest river with existing commercial lamprey fisheries is located more than 50 km away (in a straight line, on auto roads ~ 80 km), translocation of spawners is not recommended.

Second manmade barrier is the remains of Priekule water mill dam. Water regulatory device is collapsed in our days, but the remaining part of the dam forms approximately 1.5 m high waterfall which is unpassable for lampreys and most of other fishes. Most suitable mitigation measure is the complete or partial removal of this obstacle or, if it is not possible – construction of natural-like fish pass. From the lamprey perspective these actions would contribute to the reproduction of river lamprey only after passage over Prūšu HPS were granted. But on other hand it is very likely that mitigation of these measures would facilitate migration and reproduction of brown trout, brook lamprey and other species. Until the passage of Prūšu HPS is granted the most convenient way to utilise the lamprey reproduction potential upstream of the remains of Priekule watermill dam is the stocking of river lamprey larvae.

2.9 River Pāce

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
2	44.4	Pāce HPS	30.7	Low
		Former Dundagas HPS	13.7	Low

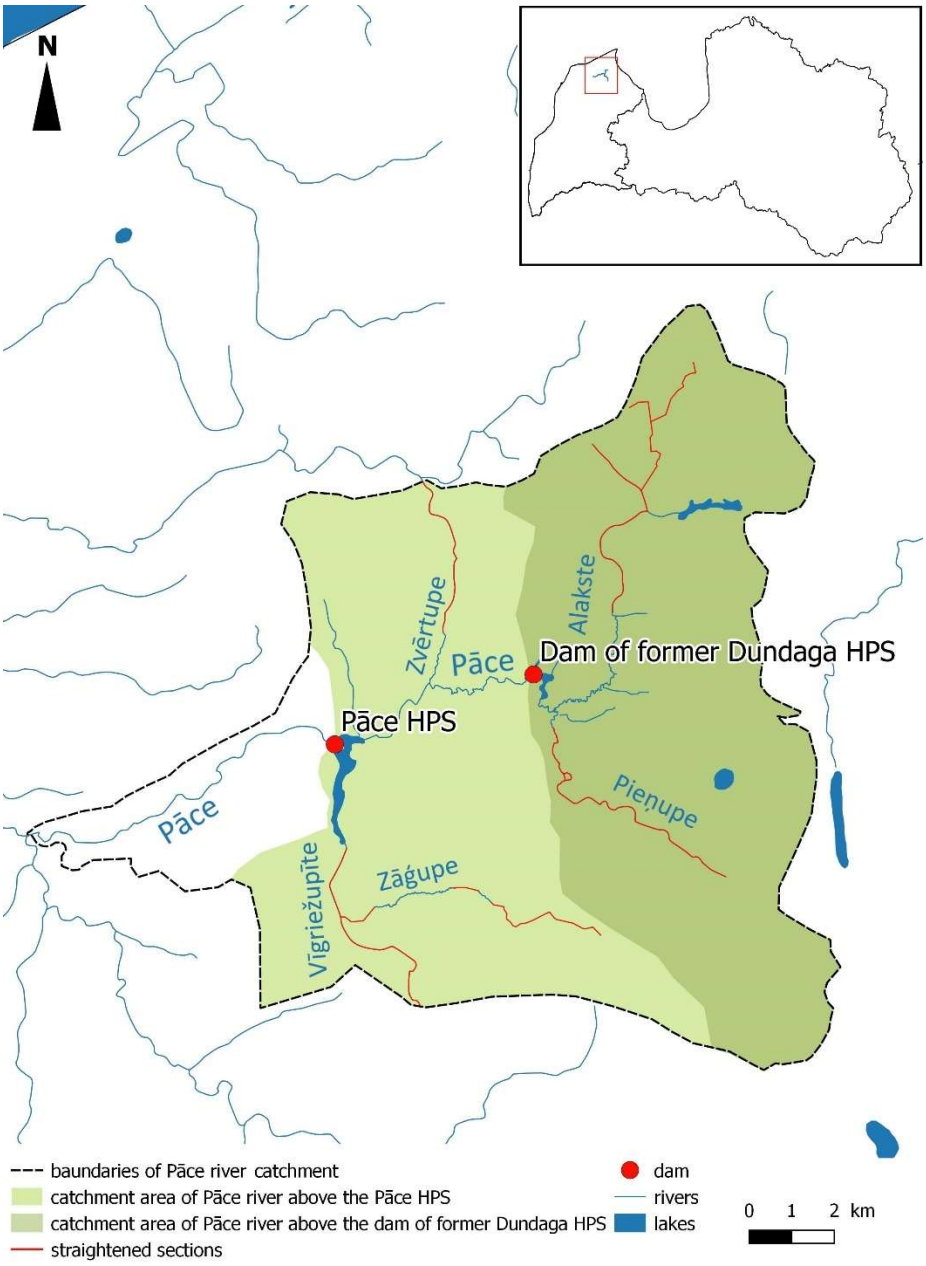

Figure 2.9.1 Catchment of River Pāce and location of most important barriers

River Pāce is one of confluent rivers of River Lonaste which later flows into River Stende that is one of two confluent rivers of River Irbe which is one of Latvian wild salmon spawning rivers. Total length of River Pāce is 24 km and; its catchment area covers 175 km^2. River Pāce has not been straightened yet

greater proportion of straightened sections can be found in its tributaries (Figure 2.9.1). Most important barriers are located in middle and upper reach of this river. These barriers are the dams of two watermills which were later converted to the production of electricity – Pāces HPS and former Dundagas HPS.

Suitability for lamprey reproduction

No detailed survey of habitats or monitoring of lamprey larvae has been performed in River Pāce or its tributaries. Known electrofishing sites are located downstream of both barriers and electrofishing results in these sites (lamprey larvae trout parr, bullhead etc.) confirm that downstream section of River Pāce is well suited for lamprey reproduction.

Figure 2.9.2 River Pāce downstream the Pāces HPS

Very few data is available from catchment upstream of the barriers. Electrofishing has been performed only in two sites in straightened section of River Alakste. Fish fauna (pike, perch, roach and stone loach) in this section confirms that straightened parts of tributaries of River Pāce are not suitable for lamprey reproduction. However, these results most probably do not illustrate the situation in unmodified downstream reach of River Alakste and in River Pāce between both barriers.

Description of barriers and proposed measures

Lowermost barrier in River Pāce is Pāce HPS. This power station was constructed in place of former watermill and uses the same dam and reservoir. Precise information of construction of mill cannot be

found, but most likely it dates back to at least the 18th century. Watermill was exploited until second half of 20th century, later water level in reservoir lowered due to defect of sluices. In the beginning of 20th century the dam and water regulator were reconstructed and converted to operation of small HPS. For this barrier also the most beneficial solution would be the complete removal of the dam in such way granting not only access to riverbed upstream of the barrier but also a further increase of the quality of currently flooded riverbed. Yet taking into account that this barrier is used for operation of HPS such solution would face great opposition from owners of HPS and may also be very resource consuming. Other solution is to build a bypass channel or in worst scenario – the technical fish pass suitable for lamprey and sea trout. River upstream of Pāce HPS can also be used for translocation of spawners from River Irbe and stocking of lamprey larvae.

Second barrier in River Pāce is dam of former Dundaga watermill. Impoundment in this location has a long history and most probably can be linked to Dundaga Castle building in the end of 13th century. In the first half of 20th century this impoundment was used for operation of the small HPS yet later production of electricity was discontinued. During flooding of 2013 the water regulator partly collapsed and water level dropped to some extent. As in most other cases the best mitigation measure would be the complete removal of barrier in such way granting not only free passage for migrating fish but also restoration of the flooded riverbed. Yet taking into account the long history of this impoundment and its location in centre of town this measure would most probably not be possible due to strong opposition by local population and other stakeholders. Therefore, the most convenient solution is construction of bypass channel. From the lamprey perspective these actions would contribute the reproduction of river lamprey only after passage were granted in Pāce HPS. But in the same time, it is very likely that these mitigation measures would facilitate the migration and reproduction of brown trout, brook lamprey and other species. It must also be taken into account that the decision of existence of the lamprey reproduction potential in River Pāce upstream barriers is not reliable. Before taking any of suggested actions it is recommended to take additional survey of lamprey reproduction potential upstream these barriers.

2.10 River Durbe

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
2	41.9	Cascade of beaver dams No 1	8.1	Excellent
		Cascade of beaver dams No 2	33.8	Moderate

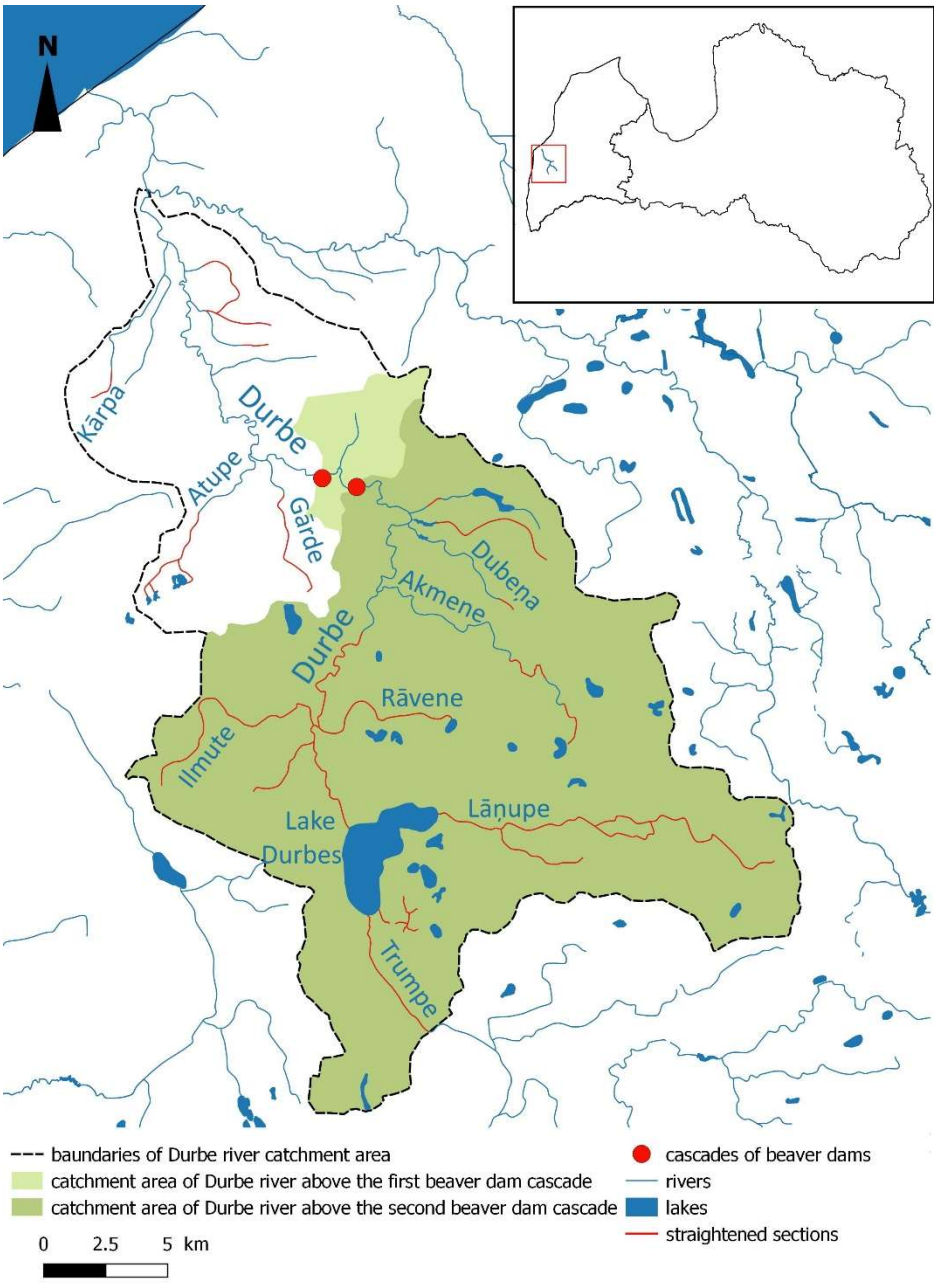

Figure 2.10.1 Catchment of River Durbe and location of most important barriers

River Durbe is one of two confluent rivers of River Saka. It sources from Lake Durbes and meets River Tebra approximately 6 km from the Baltic Sea. Total length of this river reaches 83 km and its

catchment covers territory of 479.9 km^2. 12.5 km long upper reach of this river just downstream of Lake Durbes is straightened but all other riverbed in general has kept its natural shape. There are no noteworthy man-made barriers in River Durbe. Some dams are built in several of its tributaries yet existence of noteworthy lamprey reproduction potential in these tributaries is doubtful. Most important migration barriers in River Durbe are two beaver dam cascades located in middle reach of this stream.

Suitability for lamprey reproduction

Riverbed of River Durbe was surveyed in 2019 in approximately 36 km long lower and middle section from the river mouth up to Cīrava Town. This part of river is dominated by potomal biotopes with several relatively short fast flowing sections (Figure 2.10.2).

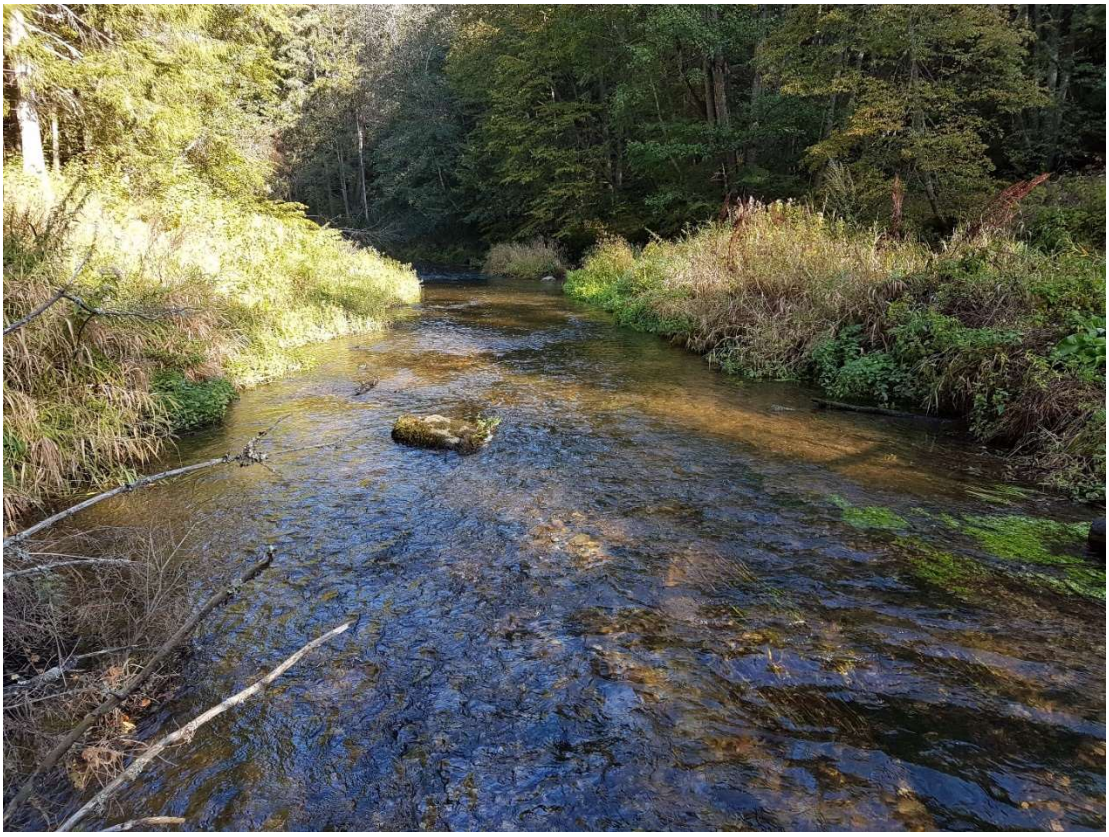

Figure 2.10.2 Fast flowing section in River Durbe

Part of River Durbe upstream the Cīrava Town has not been mapped but most probably in general it resumes the mapped section. Suitability of River Durbe upstream the barriers for reproduction of river lamprey is also confirmed by capture of lamprey larvae in several electrofishing sites and presence of trout population. Different situation can be found in upper reach close to Lake Durbes. Due to recent channel maintenance works which completely changed the riverbed the potential of lamprey reproduction in this section will be very limited. Very little is known about the tributaries of River Durbe. There are no habitats mapping, monitoring of lamprey larvae or electrofishing data available for these streams. Most of

noteworthy tributaries of River Durbe are straightened with limited lamprey reproduction potential. Only noteworthy exception is River Akmene. Total length of this river exceeds 18 km while length of straightened section is only 2.5 km.

Description of barriers and proposed measures

Both barriers are big beaver dams (Figure 2.10.3) and mitigation measures in both cases is removal of existing dams and regular survey of river to see if dams have not been rebuilt. It is also recommended to regulate the beaver population. Lamprey reproduction potential in upper reach of River Durbe and in several of its tributaries can be increased also by river restoration.

Figure 2.10.3 One of the beaver dams in the River Durbe

2.11 River Tebra

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
2	41.4	Cascade of beaver dams	8.2	Excellent
		Former Aizputes watermill	33.2	Excellent

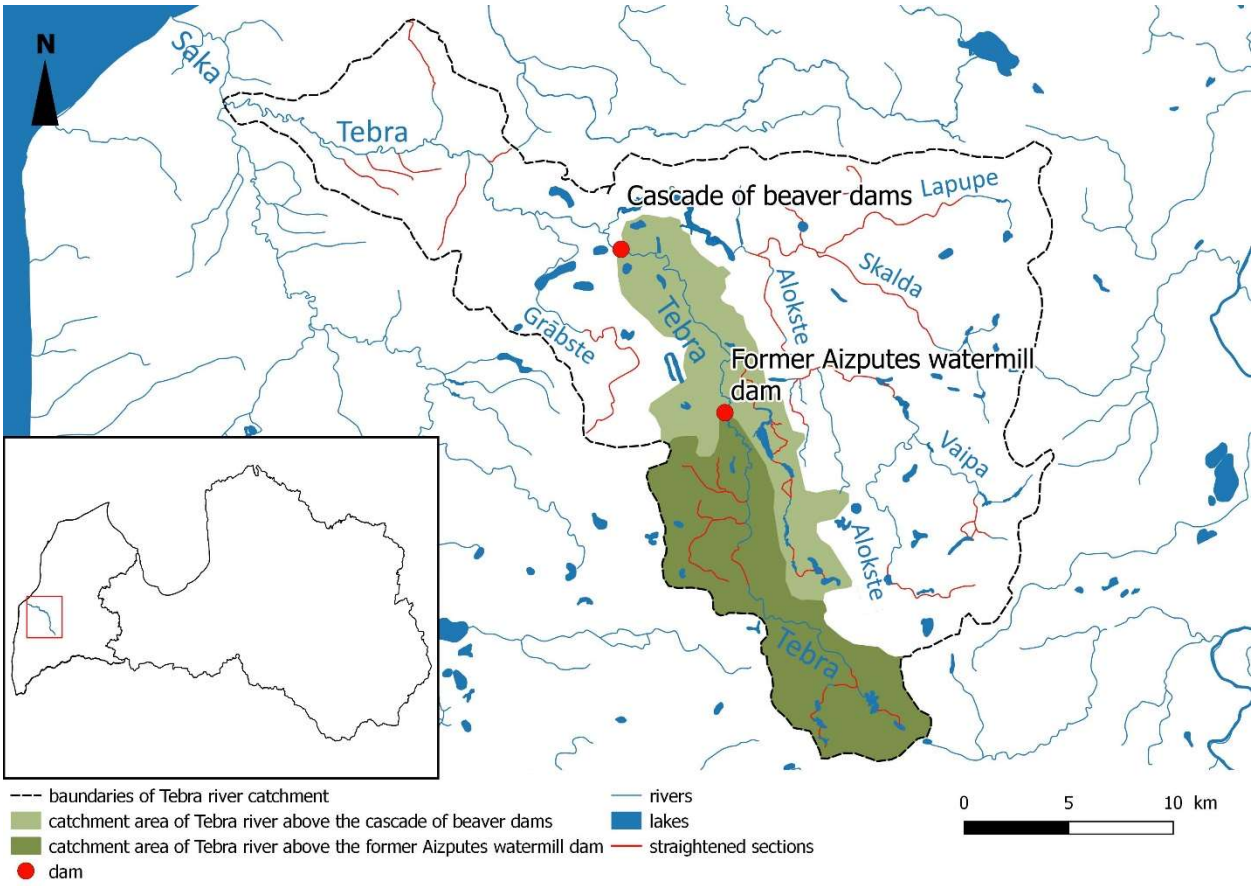

Figure 2.11.1 Catchment of River Tebra and location of most important barriers

River Tebra is one of two confluent rivers of River Saka, this is also one of Latvian wild salmon reproduction rivers. Tebra sources in Lake Tāšu Padures Dzirnavezers and approximately 6 km from the sea joins the River Durbe and starts River Saka. Total length of River Tebra is 85 km and its catchment area reaches 586.6 km^2. In most of its length River Tebra is still flowing in its natural riverbed. The only straightened section is just 1.2 km long and is located 70 km from the river mouth. Greater proportion of straightened sections can be found in tributaries of River Tebra but in general impact of straightening in catchment of River Tebra is smaller than in most other rivers in Kurzeme region. Greatest part of River Tebra is available for upstream migration from the sea. The only manmade dam in this river is located in Aizpute Town and blocks access to approximately one third of the total length of this stream

yet fish migration in River Tebra is hampered also by cascade of big beaver dams located in its middle reach (Figure 2.11.1).

Suitability for lamprey reproduction

Habitat mapping has been performed in approximately 50 km long middle and lower section of River Tebra. Mapping of riverbed confirms that in addition to the slow flowing sections suitable for rearing of lamprey larvae there are also more than 0.7 ha of fast flowing sections suitable for spawning of salmonid fishes and lampreys (Figure 2.11.2), and these rapids are separated by sections with a good rearing habitat for lamprey larvae.

Figure 2.11.2 section of River Tebra suitable for spawning of lampreys and salmonid fishes

Entrance of river lamprey in River Tebra is also confirmed by relatively high (5 to 10 tones) annual landings in commercial lamprey fisheries in River Saka and capture of lamprey larvae in electrofishing surveys. Lamprey reproduction potential upstream Aizpute Town is confirmed by monitoring of lamprey larvae performed within LAMPREY project. In 2019 average density of lamprey larvae was 16.3 ind./m^2 while in individual samples located in suitable biotopes it reached 40 ind./m^2. Almost no data on tributaries of River Tebra is available. Since most of them are relatively small and straightened it can be assumed that river lamprey reproduction potential is located mostly in Tebra itself.

Description of barriers and proposed measures

Most important man-made barrier in River Tebra is a dam of former Aizputes watermill located 56.9 km from conflux with River Durbe. First information on existence of watermill in Aizpute Town dates back to 16th century. Watermill was reconstructed several times and exploited until the 1960s. In the end of 20th century small HPS was constructed next to watermill but this power station has not been exploited at least since 2015. Dam of former Aizputes watermill is not equipped with the fish pass and is not passable for upstream migration of lampreys or any other species. Currently reservoir of Aizputes watermill is not directly used for commercial purposes but it is located in centres of Aizpute Old Town whose buildings are included in the European Cultural Heritage list. Complete removal of this barrier is very unlikely to be possible because of strong opposition from local population, therefore it is recommended to focus on the second-best option which is construction of bypass channel/fauna passage. Temporary solution is a translocation of spawners from commercial fisheries in River Saka or stocking of lamprey larvae.

Noteworthy impact on lamprey migration also lies with the cascade of large beaver dams located approximately 22 km downstream of the Aizpute watermill. These dams can be passed at high flow or other suitable conditions yet they slow down the pace of migration and increase the consumption of energy. Such dams also reduce the area of potential spawning biotopes (Figure 2.11.3). The only convenient solution is regular removal of the largest dams and if possible reduction of beaver population.

Figure 2.11.3 Section of River Tebra upstream the beaver dam

2.12 River Kauliņa

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
3	30.7	Alsungas HPS	27.4	Low
		Ponds next to Dārziņi	1.7	Low
		Cascade of fish ponds	1.6	Low

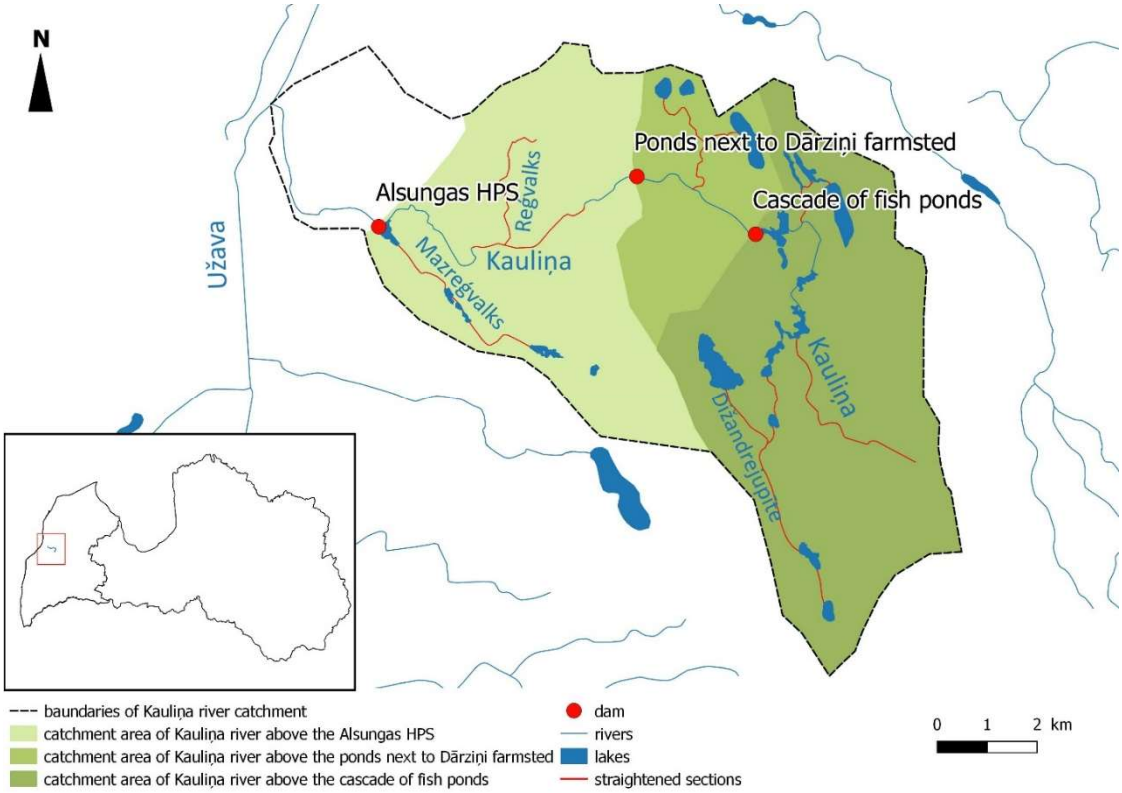

Figure 2.5.1 Catchment of River Kauliņa and location of most important barriers

River Kauliņa is a right coast tributary of River Užava which is one of Latvian natural salmon spawning rivers. This river starts approximately 12 km southeast from Alsunga Town and flows into River Užava 3 km northwest from this town. Total length of this stream reaches 24.6 km and its catchment area covers 85.9 km^2. Only 4 km long upstream reach of this river is registered as a part of drainage system of state importance but judging by the map several kilometres long middle reach upstream of Alsunga Town has obviously been straightened. In upper reach this river flows through of saccade of several natural lakes. River Kauliņa bears several manmade barriers. Lowermost barrier is Alsungas HPS located in Alsunga Town. This barrier is followed by two fish pond dams located in middle reach of River Kauliņa.

Suitability for lamprey reproduction

We do not possess direct data confirming the entrance of river lamprey in River Kauliņa for spawning. Indirectly it is confirmed by existence of commercial lamprey fisheries in River Užava and by capture of lamprey larvae in River Vanka which enters River Užava approximately 7 km downstream the River Kauliņa. Also, there is very little information available on River Kauliņa upstream the barriers. So far this river has not been mapped or electrofished or monitored during annual monitoring of lamprey larvae. Suitability of this river for reproduction of river lamprey is indirectly confirmed by its meandering riverbed and by the fact that in internet discussion portals anglers agree that this stream hosts a strong brown trout population.

Description of barriers and proposed measures

Lowermost barrier with the greatest lamprey reproduction potential index in river upstream of it is Alsungas HPS located in Alsunga Town just 4.6 km upstream of river mouth. This power station was constructed using an already existing dam and reservoir of old watermill dam. Precise time of construction of watermill is not known but its location next to medieval castle suggest that construction of first watermill in this location could be dated several centuries back. This barrier is not equipped with fish pass and is completely impassable for fish migrating upstream. If there is the opportunity for a complete removal of this barrier it should be used. Nonetheless, taking into account the use and location of this reservoir most convenient mitigation measure to aim for is construction of bypass channel/fauna passage. If such solution is not possible it can be replaced with construction of technical fish pass suitable for river lamprey and sea trout. Kaulina upstream of Alsunga watermill is also suitable for translocation of spawners from River Užava or stocking of lamprey larvae which may be good temporary measures.

Next barrier is a pond or reservoir located 7.6 km from the Alsungas HPS and the cascade of ponds located 11 km upstream the Alsungas HPS. Precise information on the construction time, purpose and parameters of these barriers is not known. Publicly available orthophoto maps suggest that lowermost reservoir was constructed between 2013 and 2018 while construction of pond cascade started in end of 20th century and continued for at least a decade. Both barriers are not passable for fish migrating upstream. Currently there is no need to take specific measures to ensure the realisation of lamprey reproduction potential upstream these barriers. Available reach of River Kauliņa upstream of the first pond is relatively short and small while riverbed upstream of the pond cascade flows through several natural lakes and lamprey reproduction potential in this part of river is small. Nonetheless such necessity of measures as removal of barrier or construction of fish pass in lowermost pond should be considered if in the future successful measures for ensuring lamprey migration are to be implemented in Alsungas HPS.

2.13 River Dzirnavupe

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
3	29.7	Dam of former Zlēku watermill	29.7	Very low

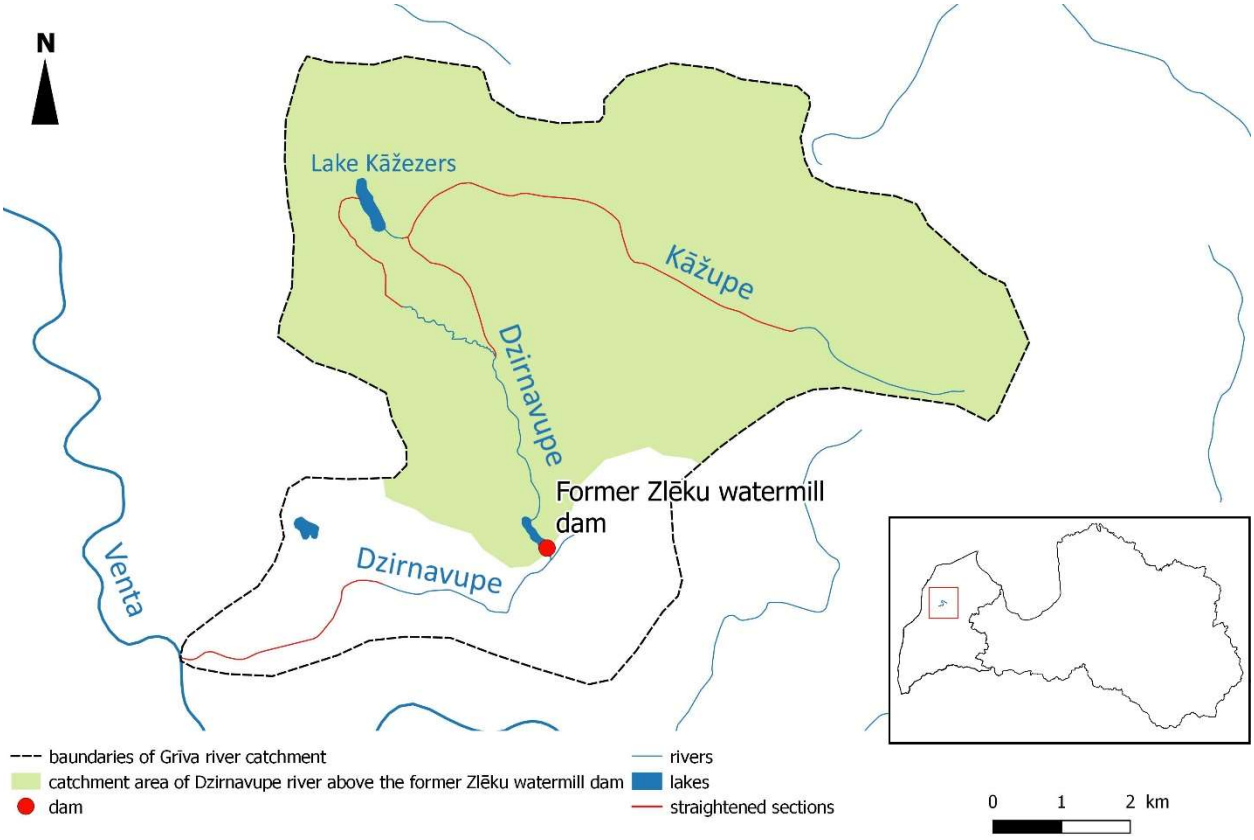

Figure 2.13.1 Catchment of River Dzirnavupe and location of most important barrier

Dzirnavupe is a right coast tributary of River Venta. It sources from Lake Kāžezers and flows into River Venta approximately 55 km from the sea. In some sources River Kāžupe which empties in Lake Kāžezers is referred as upper reach of River Dzirnavupe. Total length of Dzirnavupe is 16.2 km and catchment area reach 64 km^2. Unlike for most other small rivers in this region, a relatively large part of River Dzirnavupe upstream of the barrier has not been straightened. Unfortunately, the same cannot be said about River Kāžupe which has been straightened in almost all its length. A manmade barrier of greatest importance is dam of former Zlēku watermill located 8.4 km from River Venta.

Suitability for lamprey reproduction

Detailed information on fish habitats in River Dzirnavupe is not available. So far this river has not been mapped or surveyed by electrofishing or included in annual monitoring of lamprey larvae. However, electrofishing results in other small right cost tributaries of lower reach of River Venta show that these

rivers in most cases are dwelled by lamprey larvae, bullhead and trout parr thus indirectly confirming that River Dzirnavupe is suitable for lamprey reproduction as well. Very little information on River Kāžupe is available. Due to its relatively small size and the fact that riverbed of this stream is straightened, it can be concluded that suitability of River Kāžupe for lamprey reproduction is very limited.

Description of barrier and proposed measures

Most important manmade barrier for upstream migration is located 8.4 km from river mouth of River Dzirnavupe. Mill dam and mill was built in second half of 19th century and forms a complexly unpassable barrier. Exploitation of watermill stopped in second half of 20th century but the equipment of the mill, in general, is still operational until this day. Today the mill's building is used as a guest house and offers boat rides in reservoir as a tourist attraction and it is planned to also offer the demonstration of watermill equipment and its use to the tourists. Similarly to most other cases the best mitigation measure from the lamprey perspective would be the complete removal of this barrier, yet it is expected that this measure would face strong opposition from landowner and probably also other stakeholders. Other solution is construction of natural like fish pass or bypass channel/fauna passage. If building of such fish pass is not possible it can be replaced by technical fish pass targeted for ensuring the migration of lamprey and sea trout. Lamprey reproduction potential upstream of this barrier can also be utilised by translocation of spawners or stocking of lamprey larvae. Yet suitability of River Dzirnavupe for these measures is limited by its small size. It must also be taken into account that the decision of existence of the lamprey reproduction potential in River Dzirnavupe upstream of the barrier is not reliable. Before taking any of suggested actions it is recommended to take additional survey of lamprey reproduction potential upstream of the dam of former Zlēku watermill.

2.14 River Dakterišķe

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
3	29.0	Former Plepju watermill	29.0	Very low

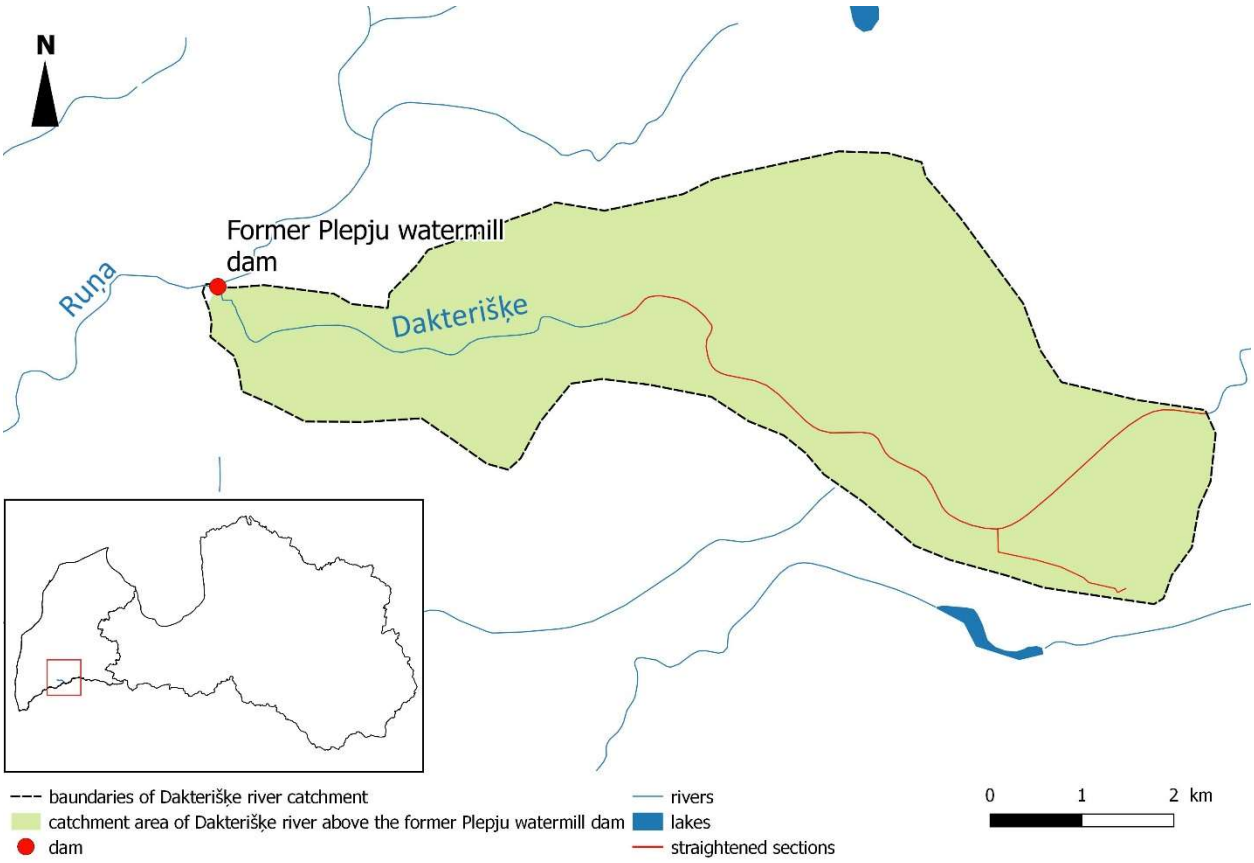

Figure 2.14.1 Catchment of River Dakterišķe and location of the most important barrier

Dakterisķe River belongs to the catchment of River Bārta. River Dakterišķe sources in a southern part of Kalšupurvs Swamp a few kilometres southwards from Vaiņode Town and empties into River Ruņa which later flows in River Apše which is a tributary of River Bārta. Daktarišķe River is 14.5 km long stream with a catchment area of 25.7 km. Upper and middle reach of this river has been straightened yet the approximately 8 km long downstream and middle section of this river still have its natural riverbed. Downstream reach of this river is included in Natura 2000 territory "Ruņas upes ieleja" (the Valley of River Ruņa). Most important manmade barrier in River Daktarisķe is a dam of former Plepju watermill located approximately 100 m from River Ruņa.

Suitability for lamprey reproduction

No actual information is available on fish fauna or hydromorphological parameters of River Dakterišķe. Entrance of river lamprey in River Ruņa in proximity of river mouth of River Dakterišķe

is mentioned in local media and indirectly confirmed by the capture of trout parr and bullhead in electrofishing surveys in this river. No survey data for evaluation of lamprey reproduction potential in River Dakterišķe upstream or downstream of the barrier is available. Existence of lamprey reproduction potential in this river was estimated by fact that at least part of this river is still flowing in its natural riverbed and most probably has a relatively large slope.

Description of barrier and proposed measures

Most important manmade barrier in River Dakterišķe is dam of Plepju watermill and adjacent small dams of fish ponds. Watermill was constructed in 1850s and destroyed during the World War II. This dam together with level regulator was partly reconstructed in second half of 20th century and at least until the 2009 reservoir was used for filling up the adjacent fish ponds. Information on recent use and current parameters of dam is not publicly available. Taking into account that this is a relatively large dam initially built for operation of watermill it can be concluded that this is an impassable barrier not only for lampreys but also for any other species.

The same as in most other cases, the best scenario from perspective of upstream migrating anadromous fish would be the complete removal of watermill dam and adjacent small fish pond dams. However, if reservoir and fish ponds are still used for fish farming this measure will face strong opposition from landowner and maybe also other stakeholders. Other solution is construction of fish pass. Priority should be given to construction of bypass channel but were it not possible this solution could be replaced with technical fish pass suitable for river lamprey and sea trout. Like in several other rivers it needs to be taken into account that entrance of river lamprey in River Dakterišķe and its suitability for lamprey reproduction is not confirmed by any survey data. To ensure that construction of fish pass is beneficial to the reproduction of river lamprey, an additional survey of this river and its fish fauna is recommended. Due to the remote location and small size of this river the stocking of lamprey larvae or translocation of spawners in this river is not recommended.

2.15 River Rudupe

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
3	25.8	Ķūķciema reservoir	25.4	Very low
		Korļu ponds	0.4	Very low

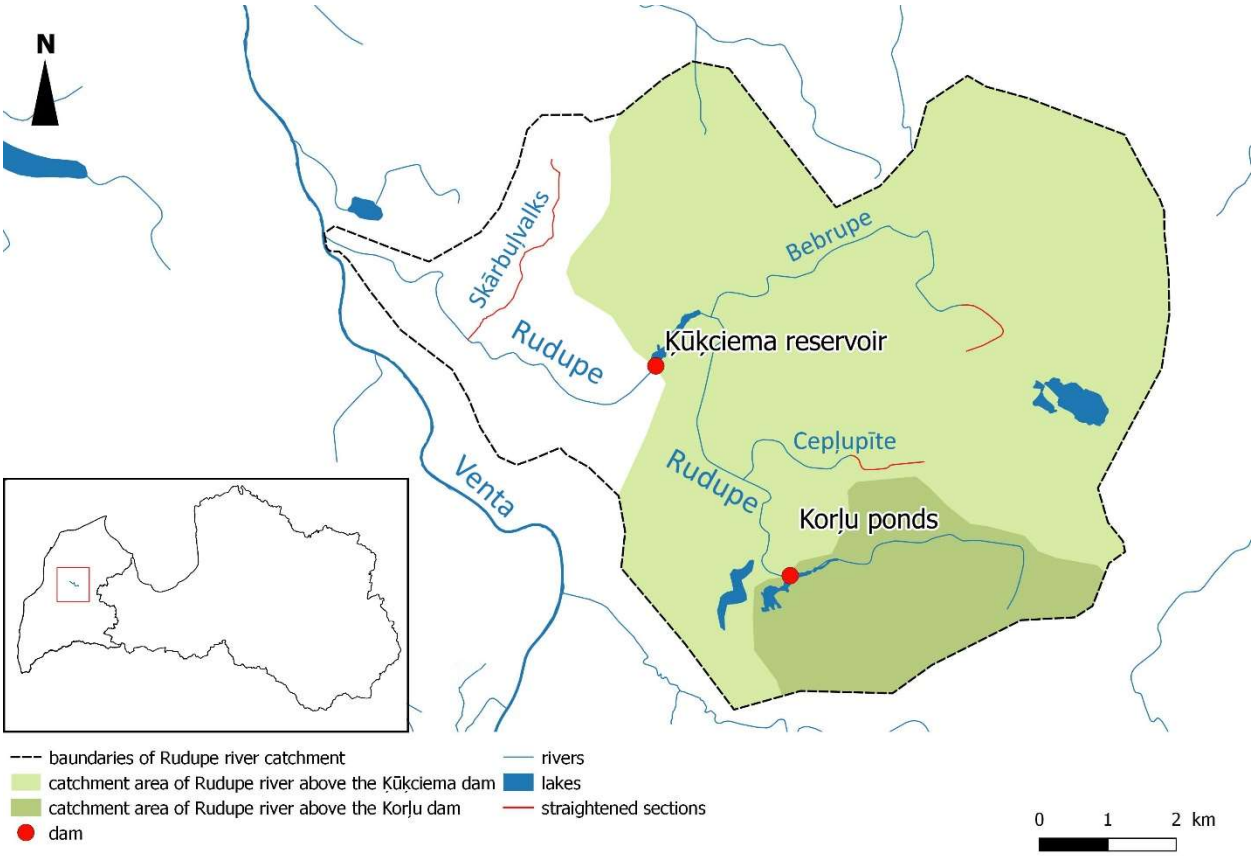

Figure 2.15.1 Catchment of River Rudupe and location of the most important barriers

River Rudupe is the right coast tributary of River Venta. River Rudupe sources in forested area approximately 8 km northeast from Kuldīga and flows into River Venta approximately 13 km downstream of this town. Total length of this river is 22.6 km and its catchment area reaches 71 km^2. River Rudupe is not included in the list of land drainage objects of state importance but judging by the map some of the sections of this river have historically been straightened. Most important manmade barriers in this river are dams of Ķūķu reservoir and Pond Korļu located in middle and upper reach of this river.

Suitability for lamprey reproduction

No actual electrofishing, bottom sampling or other data is available to confirm the entrance of river lamprey in this river or its suitability for lamprey reproduction. Indirectly it can be confirmed by location of this stream because the river lamprey spawns in River Padure and Riežupe River emptying in

River Venta a few kilometres away from river mouth of River Rudupe. The suitability of River Rudupe for lamprey reproduction upstream of the barriers is reduced by its small size and possible straightening of riverbed. The same can be said regarding rivers Briežupe or Zirgvalks which is the largest tributary of River Rudupe emptying upstream of the lowermost barrier.

Description of barrier and proposed measures

Most important barriers are located in middle and upper reach in 9.1 km and 15.2 km distance from mouth of river, both of them were constructed in the second half of 20th century. Very little information can be found on construction and purpose of these barriers yet most probably they were built for fish farming and are impassable for upstream migration.

Most convenient solution is a complete removal of both barriers. Impact of these barriers can also be reduced by construction of fish pass suitable for river lamprey and sea trout. On other hand it needs to be taken into account that the entrance of river lamprey in this river and suitability of river upstream of the barrier for lamprey and sea trout reproduction is not confirmed by any survey data. To ensure that construction of fish pass is beneficial the reproduction of river lamprey the additional survey of this river and its fish fauna is recommended. Due to the small size and limited lamprey reproduction potential in River Rudupe upstream of the barriers the stocking of lamprey larvae and translocation of spawners in this river is not recommended.

2.16 River Padure

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
3	21.1	Partly collapsed mill dam	0.7	Low
		Padures HPS	20.4	Very low

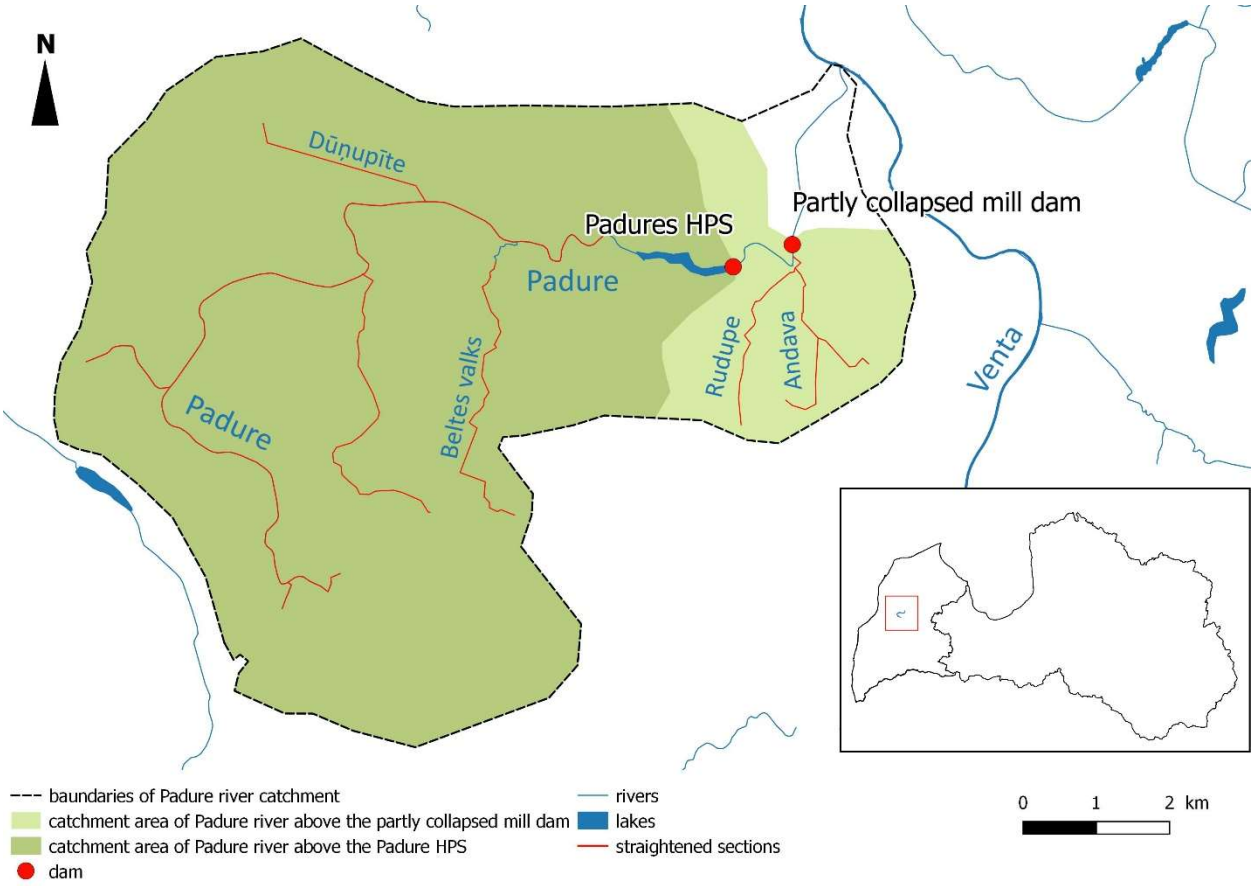

Figure 2.16.1 Catchment of River Rudupe and location of the most important barriers

River Padure is a left coast tributary of River Venta. It sources approximately 9 km westwards from Kuldīga and flows into River Venta approximately 10 km downstream of this town. Lower reach of River Padure is included in Natura 2000 site "Ventas ieleja" (Valley of River Venta). Total length of this river is 21.6 km and its catchment area reach 69 km^2. Lower reach of this river downstream of barriers has preserved its natural riverbed while almost all riverbed upstream the barriers has been straightened. Most important manmade barriers in River Padure is the remains of collapsed mill dam and Padures HPS located close to each other in lower reach of River Padure.

Suitability for lamprey reproduction

Ascending of river lampreys for spawning in River Padure is confirmed by results of monitoring of lamprey larvae in 2019. Average density of lamprey larvae in sampling site located 100 m downstream of the partly collapsed mill dam was only 5 ind./m^2 yet in a few samples it reached 16.6 ind./m^2. No river mapping, electrofishing or other precise information of river upstream of the barriers is available. Judging by the map and occasional visual observations while crossing this river, the reach between both barriers in general is suitable for lamprey reproduction. Meanwhile in River Padure and its tributaries upstream of the Padures HPS the lamprey reproduction potential is lowered due to the straightening of riverbed and partly also the small size of most of the streams.

Description of barrier and proposed measures

There are two most important man-made barriers in River Padure. Lowermost barrier is the remains of dam of former Padure Watermill located 4.4 km from River Venta. Precise information on the time of construction and collapse of mill dam is not available. Judging by publicly available historical maps dam was constructed in 19th century and partly collapsed in the middle of 20th century. Today water regulator is collapsed and its remains form approximately 1.5 m high artificial waterfall. Today mill building is abandoned and put on sale together with the remains of the dam and adjacent property. Normally this obstacle is insurmountable for lampreys migrating upstream yet theoretically it it can be passed during very high water level or other very specific conditions. Most suitable mitigation measure for this barrier is its complete removal from riverbed. Due to small available part of river until the next barrier building of fish pass should be considered only if there are plans to ensure upstream migration in Padures HPS as well. Due to the short distance between both barriers and potential impact of Padures HPS stocking of lamprey larvae or translocation of lamprey spawners upstream of remains of former Padures Watermill is not recommended.

Dam of Padures HPS is located only 1.8 km upstream the dam of Padures Watermill. This dam was constructed in middle of 20th century and designated for Padures HPS. After a few years dam partly collapsed and was reconstructed only in 1970s. Power station currently operating on this reservoir was constructed in the beginning of 21st century using the already existing dam and reservoir. Power station is not equipped with fish pass and upstream migration of any lamprey or fish species is not possible. Any mitigation measure in this barrier should be supplemented by efficient measures also in remains of dam of former Padures Watermill. This reservoir is used for operation of small HPS and it is also a popular recreation place for the local population therefore the most efficient solution, which is the complete removal of this barriers, is likely to face stakeholder resistance. Other solution is a construction of fish

pass. Priority should be given to construction of bypass channel but if it is not possible this solution can be replaced by technical fish pass suitable for river lamprey and sea trout. Like in several other rivers it needs to be taken into account that suitability of rivers upstream of the barrier for lamprey and sea trout reproduction is not confirmed by any survey data. To ensure that construction of fish pass beneficial the reproduction of river lamprey the additional survey of this river and its fish fauna is recommended. It is also possible that recreation of migration possibility of river lamprey and other species needs to be complemented by restoration of riverbed upstream the barriers.

2.17 River Īlande

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
3	20.3	Īvandes waterfalls	0.2	Low
		Rendas HPS	3.0	Low
		Upmaļi fish ponds	17.1	Very low

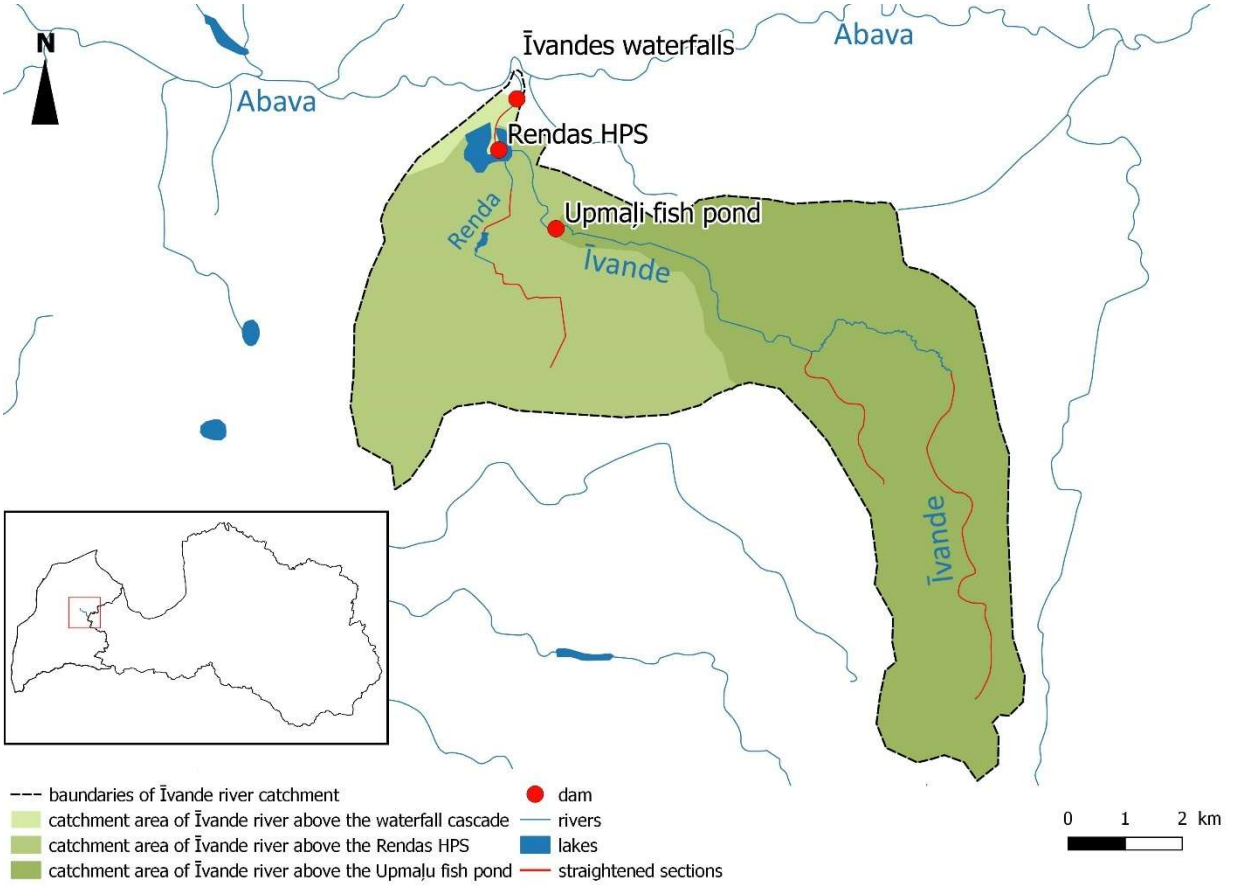

Figure 2.17.1 Catchment of River Īlande and location of the most important barriers

River Īlande is a left coast tributary of River Abava which is the largest tributary of River Venta. Īvande sources approximately 2 km northeast from Kabile Village and flows in River Abava in territory of Renda Village. Total length of River Īlande is 22 km and its catchment area cover 57.4 km^2. Only a small upstream section of this river has been straightened and most of its riverbed is still flowing in natural riverbed. Most important barrier for upstream migration in River Īlande is a cascade of natural waterfalls located close to river mouth. In addition, this river bears also two manmade barriers – dam of Rendas HPS which is also used for filling up the fish ponds and a small dam next to property "Upmaļi".

Suitability for lamprey reproduction

There are no direct data confirming the entrance of river lamprey for spawning in River Īlande. This assumption is supported by the fact that River Abava is an important lamprey reproduction site and it is

highly possible that migrating lampreys enter all of its tributaries. In addition, suitability of downstream reach for reproduction of river lamprey is indirectly confirmed by high abundance of bullhead in electrofishing site downstream the waterfalls (Figure 2.17.2).

Figure 2.17.2 River Īlande downstream of the waterfalls

There is almost no data regarding the parameters of River Īlande upstream of the waterfall and other barriers. Assumption of presence of lamprey reproduction potential upstream of the barriers was made by taking into account the relatively large catchment area of this river and a fact that only a small part of this river has been straightened.

Description of barrier and proposed measures

Most important barrier for upstream migration is cascade of two 1.5 m (Figure 2.17.3) and 2 m high waterfalls located only 0.5 km from the riverbed. Both of them have a status of protected geomorphological site and due to their size normally cannot be passed by migrating lampreys.

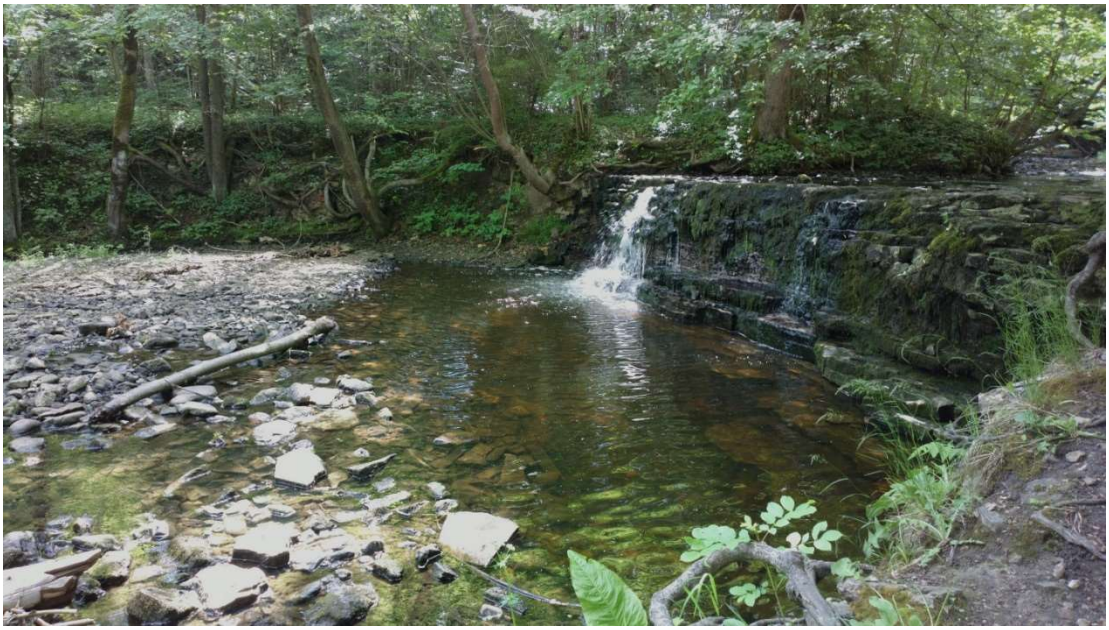

Figure 2.17.3 Lowermost of waterfall in River Īlande

Only after 1.1 km this barrier is followed by the Renda HPS. Originally this barrier was constructed in 1970s with a purpose to fill up the adjacent fish ponds. In the beginning of 21st century this dam was supplemented by the small HPS. Very little information is available on small pond next to property "Upmaļi". Precise construction time for this barrier is not known but publicly available orthophoto maps suggest that dam and small ponds in this location have existed at least since 1990s. Mitigation measures in this river need to focus not only on man-made barriers but also on natural waterfalls thus it is expected for self-sustainable measures to be complicated and expensive. Such measures may also be limited by the status of both waterfalls and opposed by stakeholders. The only purposeful measures in this river is translocation of lamprey spawners and stocking of lamprey larvae. However, the existence of lamprey reproduction potential upstream the barriers in River Īlande is not confirmed by any actual data, therefore before considering these measures additional survey of this river is required.

2.18 River Svente

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
4	15.2	Sendzirnavas HPS	1.3	Low
		Dzelzāmura HPS	9.4	Moderate
		Kalviņu dam	4.5	Low

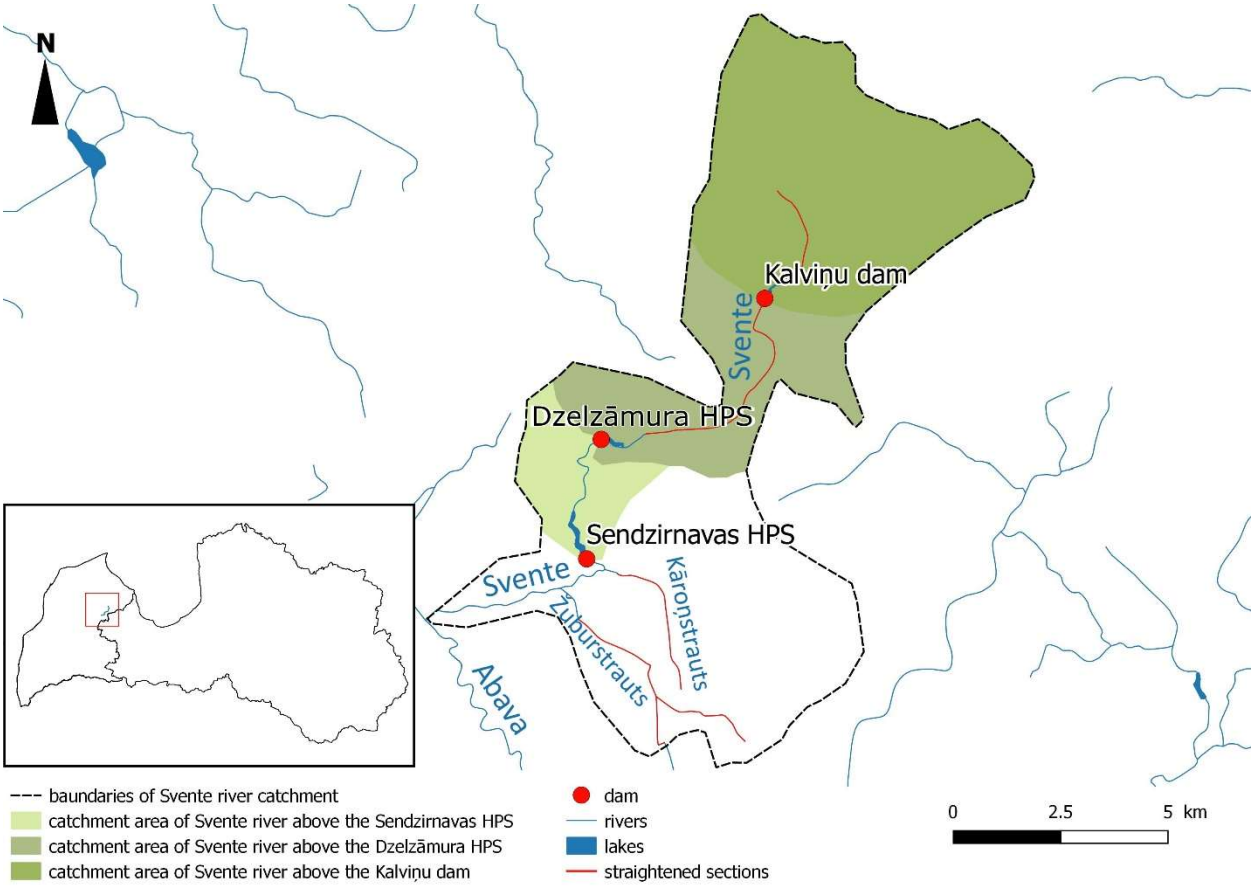

Figure 2.18.1 Catchment of River Svente and location of the most important barriers

Svente or River Virbupe is the right bank tributary of River Abava which is the largest tributary of River Venta. It sources approximately 3.5 km northwards from Jaunpagasts Village and flows into River Abava approximately 5 km downstream of the Sabile Town. Total length of this river is 20.2 km and its catchment area covers 92.7 km^2. Upper and middle reach of this river is straightened while in lover reach it still flows in its natural riverbed. There are three manmade barriers in River Svente. Two lowermost barriers are located in middle reach and hosts a small hydro power station while third barrier is cascade of fish ponds and is located in the upstream section close to source of this river. Historically there was additional dam upstream both HPS dams which today is collapsed and most probably can be negotiated by upstream migrating lampreys and other species.

Suitability for lamprey reproduction

Entrance or river lamprey for spawning in this river is confirmed by capture of lamprey larvae in electrofishing sites located downstream the barriers (Figure 2.18.2).

Figure 2.18.2 River Svente downstream of the Sendzirnavas HPS

Presence of lamprey larvae is also registered in electrofishing site located in section of River Svente between HPS and uppermost dam. Electrofishing has also been carried out in part of river located between both HPS. Electrofishing site was located close to reservoir and registered fish species (mostly roach, perch and pike) suggest that the results of this survey do not reflect the situation further upstream.

Description of barriers and proposed measures

Most downstream barrier in River Svente is dam of Sendzirnavas HPS. Watermill in this location was built in the middle of 19th century and was exploited until the second half of 20th century but in following decades dam and mill partially collapsed. HPS was constructed on turn of 20th century and included also the renovation of dam and increase of water level. This HPS is not equipped with fish pass and is impassable for upstream migrating lampreys and other fish species. Free flowing section of river between this and next barrier is very short and mitigation measures in Sendzirnavu HPS will benefit only if they are followed by the efficient measures in next barrier – the Dzelzāmura HPS – as well. Dzelzāmura HPS was

also constructed in place of old watermill and construction included renovation of partially collapsed dam and increase of water level in reservoir. This HPS also completely blocks the upstream migration.

Most beneficial solution from the perspective of reproduction of river lamprey and other anadromous fish species would be the complete removal of both HPS in River Svente. This measure would not only open free migrating rout but would also give opportunity to restore potential spawning habitats in parts of river currently flooded by both reservoirs. Situation can also be improved by construction of fish pass suitable for lamprey and sea trout. But to ensure the purposefulness of this action additional survey for estimation of area of potential spawning habitats must be done. Such actions as stocking of lamprey larvae or translocation of spawners in this river is not recommended.

Cascade of fish ponds is located in upstream reach of River Svente and existence of good spawning and rearing habitats for river lamprey upstream of this barrier is very questionable. From lamprey perspective the implementation of specific measures regarding this barrier is not necessary but such measures may be needed for other species.

2.19 River Vanka

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
4	11.6	Ēdoles HPS	7.9	Low
		Former Īvande watermill	3.2	Low
		Upīšu and Planīcas pond	0.5	Low

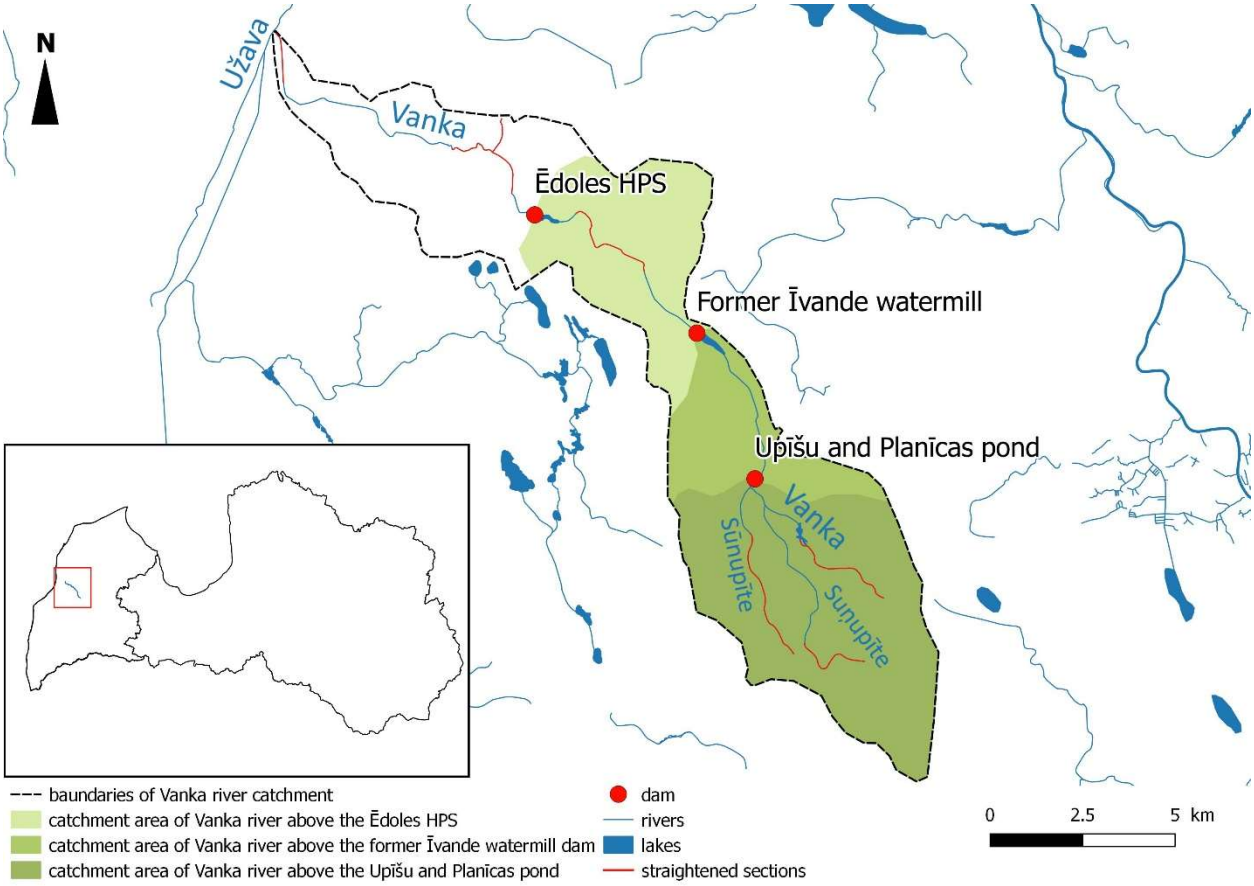

Figure 2.19.1 Catchment of River Vanka and location of the most important barriers

River Vanka is a right coast tributary of River Užava which is one of Latvian wild salmon spawning rivers. River Vanka sources southwest from Kuldīga Town and empties in River Užava approximately 31 km upstream of its river mouth. Total length of this stream is 35.3 km and its catchment area covers 88.5 km^2. Average slope of this river exceeds 2.5 m/km. Several downstream, middle and upper sections of River Vanka have been straightened, yet approximately two thirds of this stream are still flowing in its natural riverbed. There are four manmade barriers in River Vanka. Two lowermost barriers are old mill dams located in middle section in this river in Ēdole and Īvande towns. Uppermost barriers are two ponds located in upper reach just a few kilometres from the source of this river.

Suitability for lamprey reproduction

River Užava is among these 17 Latvian rivers where commercial fisheries for river lamprey are carried out. Annual landings in this river fluctuate between 600 and 1500 kg thus confirming that River Užava and its catchment has a noteworthy importance for lamprey reproduction. Reproduction of river lamprey in River Vanka downstream of the barriers (Figure 2.19.2) is confirmed by capture of lamprey larvae in electrofishing surveys.

Figure 2.19.2 Section of River Vanka with natural riverbed downstream of Ēdole HPS

Upstream of the barriers only the uppermost barriers have been surveyed. Hydromorphological features of this part of river as well as electrofishing results (roach, pike and sunbleak) suggest that upper reach in general is not suitable for lamprey reproduction. No mapping, electrofishing or lamprey larvae monitoring data is available regarding River Vanka upstream of Ēdole HPS and Īvande Watermill. The assumption of the existence of lamprey reproduction potential in this part of the river is based on the fact that this river has relatively large average slope and greatest part of these sections has preserved their natural riverbed.

Description of barriers and proposed measures

Lowermost reservoir in River Vanka is a dam of former Ēdoles Watermill which today is used for operation of Ēdoles HPS. It is located in middle reach of the river 14.5 km from the river mouth. Ēdoles HPS is constructed in last years of 20th century but watermill in this location has existed at least since 17th

century. Dam is not equipped with fish pass and it is an insurmountable barrier for upstream migration. The long history of the reservoir of former Ēdoles watermill and its exploitation for operating of small HPS make a complete removal of this barrier an unlikely measure. As the most convenient mitigation measure for this barrier the construction of bypass channel is recommended yet the technical fish pass suitable for lampreys and sea trout would also benefit the reproduction of anadromous species. River Vanka upstream of Alsunga watermill is also suitable for translocation of spawners from River Užava or stocking of lamprey larvae which may be a good temporary measure.

Īvande Watermill is located 7.7 km upstream of Ēdoles Watermill. This watermill was constructed in 1842, reconstructed in 1930s and is still operational now. Watermill and its equipment are included in the list of objects of cultural heritage of national importance. Dam is not equipped with fish pass and cannot be passed by fish migrating upstream. Due to location upstream of the Ēdoles HPS, from the river lamprey perspective currently there is no need for specific measures in this barrier. Until providing the migration opportunity in Ēdole HPS the only relevant measure for realisation of lamprey reproduction potential upstream of Īvandes watermill is translocation of lamprey spawners from River Užava or stocking of lamprey larvae. Nonetheless such measures as removal of barrier or construction of fish pass should be considered if in future successful measures for ensuring of lamprey migration are be implemented in Ēdoles HPS.

Other two barriers are located in upstream reach of River Vanka and they are blocking access to a part of river with a very limited lamprey reproduction potential. Implementation of specific measures in these barriers from the lamprey perspective is not purposeful but they might be needed for the benefit of other species.

2.20 River Alekšupīte

General information

Priority class	Total index value	Value for individual barriers		Reliability of data
4	11.6	Conrete step	<0.01	Low
		Weir	<0.01	Low
		Concreste step	0.05	Low
		Māras pond	11.5	Good

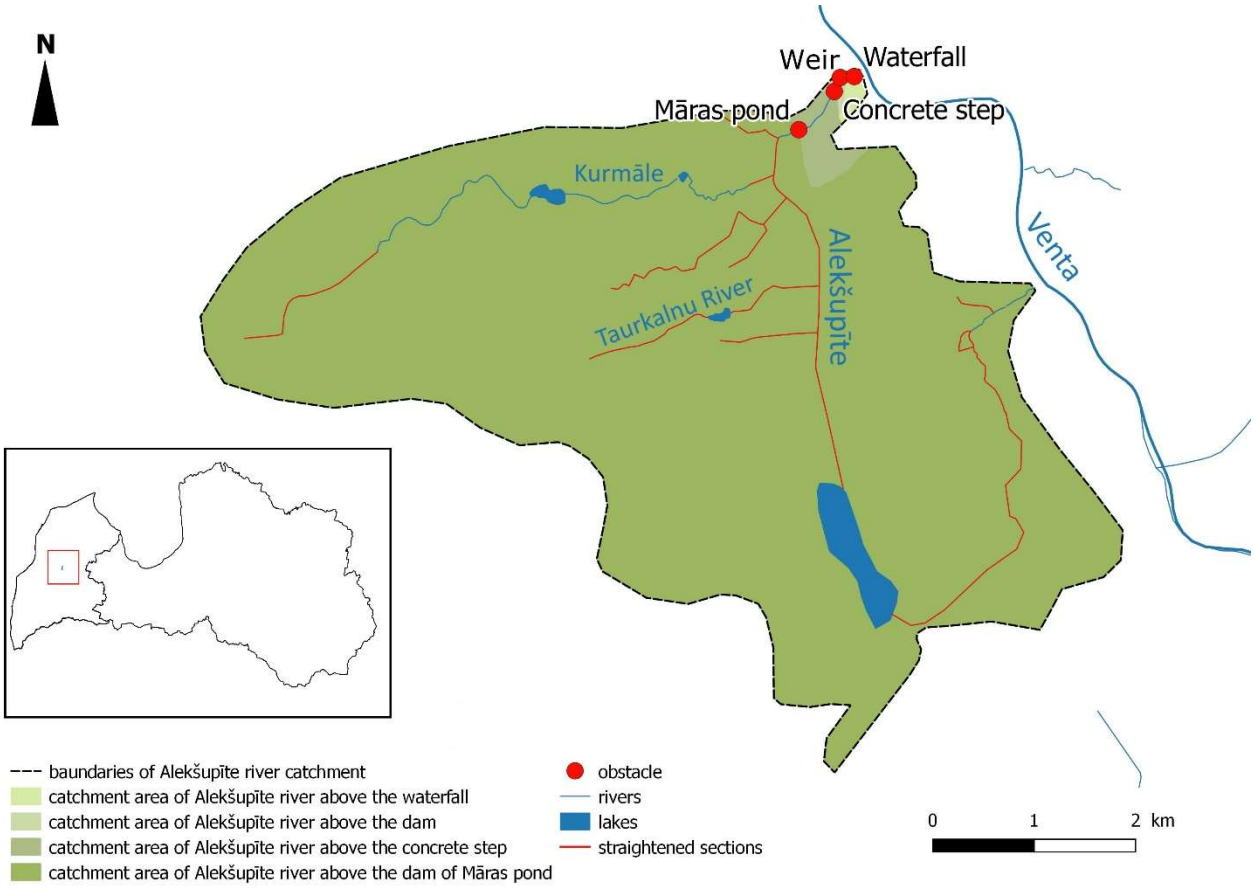

Figure 2.20 Catchment of River Alekšupīte and location of the most important barriers

River Alekšupīte is a small left coast tributary of River Venta. This stream sources a few kilometres southwards from Kuldīga then flows through centre of this town and empties in River Venta 250 m downstream of Ventas Rumba Waterfall. Its total length is only 5.6 km and catchment area barely exceeds 30 km^2. Riverbed of this stream in almost all of its length has been modified. Upper and middle reach of River Alekšupīte is straightened while in the lower reach the banks of this stream are reinforced and surrounded by buildings. River has several barriers for fish migration. Most notorious barrier is natural waterfall in proximity of river mouth which is followed by several small artificial steps in centre of Kuldīga Town. Upstream of these waterfalls in upstream reach of Alešupīte River there are also manmade dam of former fabric factory.

Suitability for lamprey reproduction

Commercial lamprey fisheries in River Venta takes place a few hundred away from river mouth of River Alekšupīte thus confirming that upstream migrating lamprey reach the river mouth of this stream. As it was found in monitoring of lamprey larvae within framework of LAMPREY project, the abundance of lamprey larvae in straightened section of River Alekšupīte fluctuates between 1.3 to 7.1 ind./m^2 thus confirming that this river is suitable for lamprey reproduction but suitability is reduced by straightening of riverbed and blocking of the upstream migration. There is no detailed information available on fish fauna in reinforced section of River Alekšupīte in Kuldīga Town. Assumption on suitability of this part of river for reproduction of lampreys are based on the fact that there are several rapids in this part of river and lampreys were found also in straightened section of this steam.

Description of barriers and proposed measures

Lowermost and most important barrier for upstream migration in River Alekšupīte is the natural waterfall located less than 100 m from the river mouth. With a height of more than 4 m this is the highest waterfall in Latvia and cannot be passed by fish migrating upstream. Mitigation measures are limited by large height of this waterfall and fact that this is a natural object. Construction of expensive fish pass in River Alekšupīte is not recommended also due to its relatively small size and limited lamprey reproduction potential in this stream. Most convenient solution in this river is translocation of spawners from commercial fisheries in River Venta or stocking of lamprey larvae in limited amount.

Translocation of lamprey spawners or stocking of lamprey larvae is the most convenient solution for other migration barriers in this river as well. Any other actions from perspective of reproduction of river lamprey are not purposeful since ensuring natural migration in lowermost waterfall is very unlikely. However, construction of bypass channel in dam of former fabric factory may be beneficial for local population of brown trout, brook lamprey and other species.

Annex I. Answers to decision tree questions, source of information and its reliability

No	River	Questions for decision tree					
		Does migrating lampreys reach the barrier?			Is catchment upstream the obstacle suitable for reproduction of lampreys?		
		Answer/reliability		Justification/source	Answer/reliability		Justification/source
1	Roja	Yes	High	Ammocoetes monitoring	Yes	High	Ammocoetes monitoring
2	Alokste	Yes	High	Electrofishing (ammocoetes)	Yes	High	Electrofishing (ammocoetes)
3	Riežupe	Yes	High	Ammocoetes monitoring	Yes	High	Ammocoetes monitoring
4	Ālande	Yes	Medium	Collapsed dam downstream	Maybe	Medium	Ammocoetes monitoring
5	Alekšupīte	Yes	Medium	Visual observation of river	Yes	High	Ammocoetes monitoring
6	Vārtāja	Yes	Medium	Electrofishing (other species)	Yes	Low	Map and orthophoto
7	Abava	Yes	High	Electrofishing (ammocoetes)	Maybe	Medium	Electrofishing (other species)
8	Grīva	Yes	High	Ammocoetes monitoring	Yes	High	Electrofishing (ammocoetes)
9	Rīva	Yes	High	Electrofishing (ammocoetes)	Yes	High	Electrofishing (ammocoetes)
10	Pāce	Yes	High	Electrofishing (ammocoetes)	Yes	Low	Map and orthophoto
11	Svente	Yes	High	Electrofishing (ammocoetes)	Yes	Low	Map and orthophoto
12	Vanka	Yes	High	Electrofishing (ammocoetes)	Yes	Medium	Map and orthophoto
13	Padure	Yes	High	Ammocoetes monitoring	Yes	Medium	Visual observation of river
14	Virga	Yes	Low	Judging from the map	Yes	High	Electrofishing (ammocoetes)
15	Rudupe	Yes	Medium	Visual observation of river	Yes	Low	Map and orthophoto
16	Tebra	Yes	High	Electrofishing (ammocoetes)	Yes	High	Electrofishing (ammocoetes)
17	Durbe	Yes	High	Electrofishing (ammocoetes)	Yes	High	Electrofishing (ammocoetes)
18	Īvande	Yes	Medium	Electrofishing (ammocoetes)	Yes	Low	Map and orthophoto
19	Venta	Yes	High	Ammocoetes monitoring	Yes	High	Ammocoetes monitoring
20	Engure	Maybe	Medium	Electrofishing (other species)	No	Medium	Visual observation of river
21	Elkupīte	Yes	Low	Map and orthophoto	Maybe	Low	Map and orthophoto
22	Sprēcele	Yes	Low	Map and orthophoto	Maybe	Low	Map and orthophoto
23	Dakterišķe	Yes	Low	Map and orthophoto	Yes	Low	Map and orthophoto
24	Malduguņu orga	Yes	Medium	Map and orthophoto	Maybe	Low	Map and orthophoto
25	Saļienas Orga	Yes	Medium	Map and orthophoto	Maybe	Low	Map and orthophoto
26	Mārgava	Maybe	Low	Map and orthophoto	No	Low	Map and orthophoto
27	Kauliņa	Yes	Medium	Visual observation of river	Yes	Medium	Visual observation of river
28	Dzirnavupe	Yes	Medium	Map and orthophoto	Yes	Low	Map and orthophoto
29	Veciere	Maybe	Low	Map and orthophoto	Maybe	Low	Map and orthophoto
30	Zemdegsupe	Yes	Low	Map and orthophoto	Maybe	Low	Map and orthophoto
31	Mazirbe	Maybe	Low	Map and orthophoto	No	Low	Map and orthophoto