Evaluation of available research on salmonids in the river Þjórsá in S-Iceland and proposed countermeasures and mitigation efforts in relation to three proposed hydroelectric power plants in the lower part of the river

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October 2013

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The project and terms of reference

In July 2013 following request by the Steering committee of the Icelandic Master Plan for Conservation and Development of Hydro- and Geothermal Energy Sites (*verkefnisstjórn rammaáætlunar 3*, short RÁ3*)* the first author of this report agreed to conduct an independent evaluation of available research on the ecology of Atlantic salmon (*Salmo salar*) in the river system Þjórsá in relation to the proposed hydro electric power plants and dams in the lower part of the river, and also to evaluate the proposed countermeasures and mitigation efforts (see project description/terms of reference in attached document). The proposed evaluation was framed in the form of the following four questions:

Question 1: Does available research along with other sources provide satisfactory information on the potential impact on the salmonid populations? If not, what additional research is needed?

Question 2: What are the effects of particular hydroelectric power plants, i.e. Hvammur, Holt and Urriðafoss power plants, on the salmonid population? Is any one power plant more desirable than the others?

Question 3: Are the proposed countermeasures and mitigation efforts satisfactory? If not, which additional efforts should be considered?

Questions 4: To what extent are negative effects acceptable? How is that evaluated?

Considering the focus on the biology of salmonid fish species and populations in our evaluation, we emphasize natural values on the basis of the needs and "interests" that these fish have, or may have, considering the proposed hydroelectric power plants and dams as well as proposed countermeasures and mitigation efforts. We also appreciate the human values involved, as they are reflected in the compromises made when making decisions about projects like this (see reply to question 4 below).

In the Icelandic work description the four questions were orientated towards Atlantic salmon. In subsequent communication with the Steering committee of RÁ3 it was decided to focus on salmonid species, not just Atlantic salmon.

Approach to the work

At the start the first author was provided with a list of documents, especially regarding research and information on the ecology of the system and of salmonids (mainly Atlantic salmon). Authors also collected other documents and international literature on the subject. After reviewing the documentation regarding research and proposed countermeasures and mitigation efforts the first author requested (mid August 2013) more detailed information about the updated design and capacity of each individual power plant as well as more information about the proposed countermeasures and mitigation efforts, especially concerning up- and down-stream fish passage. Such information was received the second week of September. Considering the pressure at this time to provide the report as soon as possible, additional expertise was recruited, i.e. the second author of this report. On September 25th 2013 the first author met with the board of RÁ3 and presented preliminary conclusions of the work. Information, suggestions and discussions during this meeting were very useful to the preparation of this report.

As part of the evaluation, the following researchers at the Institute of Freshwater Fisheries were interviewed: Dr. Sigurður Guðjónsson (Director); Mr. Magnús Jóhannsson Division Leader and Mr. Benóný Jónsson Biologist, who are well known scientists for their research on the biology of the Þjórsá system for a number of years. International experts were also consulted during this process: David L.G. Noakes Professor and Guillermo Giannico Associate Professor and Extension Fisheries Specialist in the Department of Fisheries and Wildlife, Oregon State University U.S.A.; Dr. Allen Curry Science Director, Canadian Rivers Institute, Professor of Biology, Forestry, and Environmental Management and Recreational Fisheries Research University of New Brunswick, and Dr. Tommi Linnansaary, Research Associate, Canadian Rivers Institute, University of New Brunswick, Canada; Mr. Geoffrey McMichael Senior Research Scientist Earth Systems Division/Ecology Group and Mr. Mark A. Weiland Senior Scientist Energy and Environment Directorate/Ecology Group, Pacific Northwest National Laboratory U.S. Department of Energy, North Bonneville U.S.A. These experts provided important advice, information, papers and reports; and the first four also critically read drafts of this report. We are grateful to them all for a very valuable assistance.

Brief description of the Þjórsá system and the proposed power plants

Þjórsá is one of the largest rivers in Iceland. It is 230 km long and its watershed covers 7,530 km^2 (Figure 1A,B). The average discharge at Urriðafoss in the lower part of the river is 368 m^3/sec, which is the second largest in Iceland. The river is a direct-runoff river with considerable mixing of glacial waters and some spring waters (Rist 1969) and it has a number of tributaries (Jóhannsson et al. 2002). It has been estimated that the Þjórsá system constitutes about 27% of harvestable hydro power in Iceland. Currently there are six hydro electric power plants in the upper parts of the system, and the oldest one at Búrfell started operating in 1969 (Jóhannsson & Guðjónsson 1989). Búðarháls power plant is the youngest and is not operating yet (Figure 1A). These plants are operated by the National Power Company of Iceland, Landsvirkjun (LV, this abbreviation is used hereafter).

There are three salmonid species in the river system, Arctic charr (*Salvelinus alpinus*), brown trout (*Salmo trutta*) and Atlantic salmon (*Salmo salar*). All three species occur as anadromous (i.e. migratory) populations that depend on sea run migration. There are also resident populations of Arctic charr and brown trout throughout the Þjórsá river system which in some cases migrate within the freshwater system. The other fish species in the system are threespine stickleback (*Gasterosteus aculeatus*) and European eel (*Anguilla anguilla*) (Jóhannsson et al. 2002, 2008). The Atlantic salmon population is among the largest in Iceland, and may constitute up to 20,000 adults (Jóhannsson et al. 2012; Jóhannsson 2013). There are interesting local adaptations in the salmon, e.g. in terms of body morphology and migration patterns of seamigrating juveniles (i.e. smolts) which appear to relate to the glacial environment, water temperature and flow rate patterns of the river but this has been little studied (Jóhannsson & Jónsson, personal communication). A survey of the population genetic structure of Atlantic salmon populations in Iceland confirms that the salmon population in Þjórsá/Kálfá is genetically distinct from populations elsewhere in Iceland (Ólafsson & Guðjónsson, personal communication).

In the years 1999 and 2000 LV started primary designing of potential hydroelectric power plants in the lower Þjórsá system. At present three power plants are proposed (Figure 2).

<u>Urriðafoss power plant</u>: This power plant would be about 140 MW and produce 980 GWh/year (NN 2009, 2013a). The power plant is the lowest of the three and the name of the expected reservoir is Heiðarlón. More information about this power plant will be provided in relation to discussion on specific issues in later chapters.

<u>Holt power plant</u>: This power plant would be about 55 MW and produce 420 GWh/year (NN 2013a,c). The power plant is the second lowest of the three and the name of the expected reservoir is Árneslón. More information about this power plant will be provided in relation to discussion on specific issues in later chapters.

<u>Hvammur power plant</u>: This power plant would be about 95 MW and produce 640 GWh/year (NN 2013a,b). The power plant is furthest upstream of the three and the name of the expected reservoir is Hagalón. More information about this power plant will be provided in relation to discussion on specific issues in later chapters.

Regarding the construction strategy, the Hvammur power plant would have to be constructed first and the other two later (NN 2013). Further information about these plans for hydroelectric power plants and dams in the lower Þjórsá can be found in http://thjorsa.is/.

During the designing process of these hydroelectric power plants, various changes have been made on individual structures such as dams and powerhouses (e.g. NN 2009, 2013a,b,c). This work is still ongoing, e.g regarding the design of various countermeasures and mitigation efforts. These changes have among other things affected proposed size of reservoirs, but information on the effects of these changes on salmonid habitats has not been provided. Therefore, all data in this report, e.g. of reservoir size and effects on salmonid habitats are based on the original report from

Jóhannsson et al. (2002).

The effects of power plants on salmonid populations

The knowledge of the effects of hydroelectric power plants and dams on the biology of salmonid species and populations is considerable (Rosenberg et al. 1997; Marmulla 2001; Thorstad et al. 2008; Ugedal et al. 2008; Ferguson et al. 2011; Muir & Williams 2012). Jóhannsson et al. (2002, p 11) provide detailed coverage of this issue in Icelandic. For example, hydropower dams a) block upstream migration of spawning adults and block downstream migration of adults and smolts (sea run juveniles); b) change the absolute and/or seasonal pattern of water discharge (so it is often inappropriate for fish migration, spawning, incubation of embryos and juvenile nursery habitat); c) trap suspended sediment and organic matter (thus reducing downstream productivity); d) change habitat upstream – by creating a reservoir or lake impoundment - so they change fish community composition (this is very likely to increase predation on juvenile fish migrating downstream through the reservoir); e) alter river hydrograph and thermal regimes (which has strong impacts on invertebrate production, fish life histories and many ecosystem processes, such as gravel recruitment and sediment transport); and f) affect fish migration (i.e. its timing, direction and extent) by replacing the river channel with a "lake" like system (Thorstad et al. 2008; Keefer et al. 2012).

The above issues are examples of the impacts that need to be considered and examined in great detail when planning and designing hydroelectric projects that involve dams. The above mentioned problems have been documented by many studies, especially on river systems that have already been greatly affected by dams like the Columbia River system in the USA (Ferguson et al. 2011; Muir & Williams 2012; Ploskey et al. 2012). Those studies have improved our understanding of hydroelectric dam impacts on migratory and resident populations of salmonids, and have informed the design and implementation of countermeasures and mitigation efforts (Ferguson et al. 2011). The extensive experience from the power plants on the west coast of North America (the Pacific Northwest) can also be used to predict and understand the ecological consequences of hydropower development projects elsewhere and assist in the decision making and design of future projects (Ferguson et al. 2011). Therefore, there is a significant body of evidence from research conducted at hydroelectric dams around the world that reveal the many major negative effects these structures have on important fluvial processes (e.g. sediment transport, seasonal floodplain connectivity, channel migration etc.) and, especially, on the life cycle and viability of migratory and resident fish populations (Marmulla 2001). Consequently, in cases where such projects are considered desirable, comprehensive research of the ecosystems to be affected prior to their disturbance is needed and numerous countermeasures and mitigation efforts, e.g. regarding migration routes for fish, habitat preservation and construction and fishways across dams, will have to be considered, examined and, if projects are launched, implemented (Schilt 2007, Ferguson et al. 2011; Russon & Kemp 2011; Cooke & Hinch 2013). In this context it should be emphasized that numerous cases confirm that such actions are often unsuccessful. Nothing is given when it comes to countermeasures and mitigation efforts, and they require long term attention and substantial financial resources (Noonan et al. 2012; McLaughlin et al. 2012; Hatry et al. 2013). Thus, it is important to exercise highly professional and adaptive approach to their development and implementation.

Question 1: Does available research along with other sources provide satisfactory information on the potential impact on the salmonid populations? If not, what additional research is needed?

Research on the biology of salmonids in the Þjórsá river system has been ongoing since 1973 (Ísaksson 1973) and has been primarily conducted by the Institute of Freshwater Fisheries (IFF) for LV. Since 2006 this research has been formally conducted by LV through contracts with IFF (Aðalsteinsson et al. 2012). The research has been aimed primarily at understanding migratory patterns of salmonids (Jóhannsson et al. 2008). Furthermore, in 2001 a comprehensive survey was conducted covering various aspects of salmonid biology, as well as invertebrate ecology and habitat parameters (Jóhannsson et al. 2002). All this work has been aimed at assessing the effects of potential hydroelectric power plants and dams on the system and after the year 2000, the emphasis has been on the power plants and dams proposed in the lower Þjórsá system. A special objective of this research has been to propose and design suitable countermeasures and mitigation efforts (Jóhannsson et al. 2002, 2008).

There are three salmonid species in the river system, Arctic charr, brown trout and Atlantic salmon. All of them occur as migratory populations which depend on sea run migration. There are also resident populations of Arctic charr and brown trout throughout the Þjórsá river system which in some cases migrate within the freshwater system (Jóhannsson et al. 2002, 2008).

Migratory populations

The salmon in the Þjórsá system all depend on annual sea run migration. Adult salmon are returning to spawn from the end of May until October and smolts migrate to the ocean from mid-May until mid-June (Jóhannsson et al. 2008). Research has demonstrated that considering Atlantic salmon (hereafter salmon) the proposed hydroelectric power plants, through combined effects of habitat changes and dams (primarily the Urriðafoss dam), would eliminate 78% of the spawning areas of adults and of the incubation and nursery habitats for juveniles in the natural distribution areas of the salmon in the system. Considering also the more recent spawning and nursery habitats above the waterfall Búði, which was made available to salmon by a fishway in 1991 and subsequent stocking (Jóhannsson et al. 2002), an additional 10% spawning and nursery habitat areas would be eliminated. This leaves 12% of the spawning and nursery habitat potentially available to salmon in the system as of today, all below the Urriðafoss dam (Jóhannsson et al. 2002). This finding is based on broad but reliable habitat evaluation (see methodology in Jóhannson et al. 2002).

Much less information is available regarding sea-run brown trout, but the effects of the power plants on them can be expected to be considerable (Jóhannsson et al. 2002).

Even less is known about sea-run Arctic charr, but they appear to be very scarce and may possibly only exist below the Urriðafoss waterfall. In general, the effects of the power plants on them can be predicted to be considerable, and considering the apparently small size of the population (Jóhannesson et al. 2002) it could experience rapid decline and extinction.

Thus, it is clear that without any countermeasures or mitigation efforts sea-run salmonids, including Atlantic salmon, in the Þjórsá system would, in terms of population size and ecology, clearly face extinction risk from the proposed power plant plans. It should also be emphasized that necessary countermeasures and mitigation efforts require a lot of work and financial resources (Noonan et al. 2012; McLaughlin et al. 2012; Cooke & Hinch 2013; Hatry et al. 2013).

Resident populations

Angling data and studies on juvenile habitats (electrofishing at selected locations) suggest that below the waterfalls Búði and Hestfoss (in Árneskvísl) resident population(s) of brown trout exist, for example in the river Kálfá and also in Þjórsá proper. Above these waterfalls respectable populations of resident brown trout are also found, e.g. in Þjórsá and a population in the river Minnivallalækur which is found to be quite special because of the size of the fish (Jóhannsson et al. 2002). It is clear that in cases where habitats are eliminated or affected by the hydropower plants the ecology of resident brown trout could be negatively affected. It is difficult to be more detailed about this, e.g. considering also that potential local migration patterns can be complex and are not well understood.

Angling data and studies of juveniles confirm that resident Arctic charr are primarily found in the upper part of the Þjórsá system. For example, Arctic charr have been numerous in the river Fossá (Jóhannsson et al. 2002). However, numbers of Arctic charr appear to have been going down in recent years possibly because of increased competition following recent presence of salmon above Búði, from stocking and migration through the fishway there (Jóhannsson personal communication). As with resident brown trout, it is clear that in cases where habitats are eliminated or affected by the hydropower plants the ecology of resident Arctic charr could be negatively affected. However, predicted absence of salmon above the Urriðafoss dam would likely increase opportunities of resident Arctic charr in that area.

Considering both resident brown trout and Arctic charr it is likely that the potential creation of reservoir „lakes" above the three proposed dams could result in growth of populations of both species in such reservoirs (Jóhannsson et al. 2002; Jónsson & Magnúsdóttir 2011). This is well known from other reservoirs in Iceland (Guðbergsson & Njarðardóttir 2010).

The available research results concerning salmon migratory patterns and distribution of salmon juvenile habitats give satisfactory information to confirm that the overall impact of the hydroelectric power plan in the lower Þjórsá system would have significant and irreversible negative effects on their populations (see above). Information regarding migratory and resident Arctic charr and brown trout is much more limited however and further studies are strongly recommended. In general, research from other systems and data from earlier studies in this basin indicate that the proposed hydroelectric power plants and dams will completely alter the ecology of salmonids in the whole river system and, almost certainly, cause major reductions or extinctions of some fish populations unless countermeasures are taken. It should be noted that the effectiveness of countermeasures and mitigation work applied to hydroelectric projects is often less than expected and require considerable expenses and continuous commitment by all stakeholders.

In the rest of this report, we evaluate the potential effects each individual power plant and dam may have on salmonid ecology and evaluate the proposed countermeasures and mitigation strategies. In the subsequent chapters we also present our further concerns and suggestions regarding further information and research needs, especially as they relate to countermeasures and mitigation.

Question 2: What are the effects of particular hydroelectric power plants, i.e. Hvammur, Holt and Urriðafoss power plants, on the salmonid populations? Is any one power plant more desirable than the others?

Urriðafoss power plant

In the case of the Urriðafoss power plant (Figure 2), a dam will be constructed at Heiðartangi and water directed from the resulting reservoir to the power plant in a tunnel and from there through opening below the Urriðafoss waterfall. The reservoir will extend about 15 km up-river (but see information on page 3) and flow will be significantly reduced in approximately 3.8 km in the canyon above and below the Urriðafoss waterfall (Jóhannsson et al. 2002).

The dam at Heiðartangi would, if no countermeasures are effected, prevent all migration of salmonids to the areas of the Þjórsá system above the dam. The disturbed part of the river below the dam and the area of the system closed for migratory salmonids above the dam is estimated to constitute about 78% of the natural spawning, incubation and juvenile habitat in natural distribution range of migratory salmonids in the system (i.e. below the waterfall Búði), and 88% of the total area available to migratory populations today (i.e. including the area above Búði, Jóhannsson et al. 2002). This information applies primarily to salmon since knowledge on brown trout and Arctic charr is limited (see reply to question 1).

Regarding seaward migration of juveniles (smolts) and adults (primarily brown trout), there would be, given no countermeasures, high mortalities due to passing through turbines and experiencing high pressure in the water passage of the power plant (Jóhannsson et al. 2002, Ferguson 2008; Guðjónsson 2012).

In the part of the river below the dam where flow will be disturbed there are currently good habitats for juvenile salmonids, especially salmon. However, it is difficult to estimate the carrying capacity of this river reach accurately due to its depth and high flow rate. Significantly reduced flow rates in this river section will affect the passage of migratory salmonids; whereas disturbed and irregular discharge patterns will significantly reduce the quality of nursery habitats for juvenile fish (Jóhannsson et al. 2002).

The reservoir above Heiðartangi will alter river habitat to a more lake-like environment, covering 15 km above the dam and about 25% of salmonid habitats in the natural distribution area of migratory salmonids. Thus, spawning, incubation and juvenile habitat for migratory salmonids will cease to exist in this area and invertebrate communities will be greatly altered. In contrast, resident Arctic charr and brown trout could make use of the reservoir habitats and, as a result, experience some level of population size increase (Guðbergsson & Njarðardóttir 2010; Jónsson & Magnúsdóttir 2011). The reservoir could also delay or halt smolt seaward migration and thus increase their mortality risk during this critical life cycle phase (Carr 1999, 2001). The potentially larger reservoir-dwelling populations of brown trout and Arctic charr would likely contribute to the higher salmon smolt mortality through direct predation (Jepsen et al. 1998; Thorstad et al. 2012).

Effects on fishing activities would be dramatic. All fishing for migratory salmonids (primarily salmon) above the dam would be eliminated and current gill-netting of salmon below the Urriðafoss waterfall would be much less and more difficult to conduct than at present (Jóhannsson et al. 2002).

Holt power plant

The proposed 3.2 km^2 reservoir above the power plant and dam at Akbraut would cover much of the Árneskvísl section (Figure 2) and, without countermeasures, this would significantly affect flow in the 2.6 km section below the dam. Flow in the 8.6 km section of Þjórsá below the proposed dam at Búði down to where Árneskvísl joins the main river would be very much reduced and unstable (Jóhannsson et al. 2002), which could also influence water temperature affecting salmonid distribution (Bradford et al. 2011). These areas represent the main contemporary spawning, incubation and nursery habitats in the natural distribution range of migratory salmonids in the Þjórsá system below the waterfall Búði (Jóhannsson et al. 2002).

The reservoir at the Holt power plant would alter invertebrate and fish communities in a similar way as the Urriðafoss reservoir and would cause similar negative effects on migratory salmonids moving upstream and downstream (see above). This area is currently a very important nursery habitat for juvenile salmonids (Jóhannsson et al. 2002).

The 8.6 km affected section of Þjórsá below Búði is the main spawning- and nursery habitat for salmon juveniles in the system. Severely restricted, unpredictable or no flow in this channel section could, firstly, prevent migratory salmonids from passing through (including those migrating to the tributary river Kálfá) and, secondly, reduce to a great extent or destroy salmonid spawning and nursery habitats. Consequently, we would anticipate the elimination of salmon production from 46% of its current habitats below Búði, including Kálfá/Tungná, and in all the area above Búði. When we combine the areas above the waterfalls Hestfoss in Árneskvísl and Búði in Þjórsá it is likely that, without countermeasures, the Holt power plant would eliminate production in 72% of habitats used by migratory salmonids in Þjórsá and its tributaries (Jóhannsson et al. 2002). Habitat changes due to reduced and irregular flow, would also affect resident populations of brown trout and Arctic charr.

Hvammur power plant

The Hvammur power plant is located above the natural distribution area of migratory salmonids in the Þjórsá system (Figure 2). The reservoir above the dam at Viðey would be about 4 km^2 and extend 7.2 km upstream. Since 1991 the fishway at Búði, along with stocking efforts of salmon, has allowed migratory salmonids to settle this area (Jóhannsson et al. 2002).

Together, the section with disturbed flow below the dam (approx. 3 km) and the area altered by the reservoir would constitute 68% of habitats supporting production of migratory salmonids above Búði. the Hvammur power plant would influence resident populations of brown trout and Arctic charr through these effects on habitats. The reservoir at the Hvammur power plant would alter communities in a similar way as the Urriðafoss and Holt power plant reservoirs and would cause similar negative effects on migratory salmonids moving upstream and downstream (see above). This area is currently a very important habitat for feeding juvenile salmonids (Jóhannsson et al. 2002).

Comparison of the effects of hydroelectric power plants

If no countermeasures are implemented, the Urriðafoss power plant and dam will clearly have the greatest effects on migratory salmonids because it will prevent any upstream passage of migratory salmonids. This will eliminate production of migratory salmonids in 78% of habitats in their natural distribution range, and in 88% of their total range (Jóhannsson et al. 2002).

Holt power plant will, if no countermeasures occur, through changes in flow pattern and rate, and potentially temperature regime, negatively impact salmonid migratory routes, as well as spawning, incubation and nursery habitats in the natural distribution area of migratory populations.

It is clear that the Hvammur power plant has the least impact on migratory fish. This applies to the total effect on the system, but it should also be considered that this power plant is located beyond the natural distribution range of salmon and other migratory species in Þjórsá. It will, however, be important to carefully manage disturbance on natural flow rate (see discussion on page 10) downstream of this location during the construction phase (this applies to all potential power plants). If this power plant is built it may provide valuable experience regarding the success of countermeasures and mitigation efforts, especially concerning juvenile fish passage. Lessons learned from this project could be used to re-evaluate the potential impacts of the other two dams proposed for the lower Þjórsá river.

Question 3: Are the proposed countermeasures and mitigation efforts satisfactory? If not, which additional efforts should be considered?

LV has formally proposed official counter measures and mitigation efforts regarding the potential effects of the proposed hydro electric power plants and dams in the lower Þjórsá river system (Landsvirkjun 2011; Aðalsteinsson et al. 2012). This is to a great extent based on research and suggestions by the IFF (see also Skipulagsstofnun 2003a,b). We will list the proposed measures and efforts and evaluate each of them separately.

Proposal A: Tryggt verður að farvegir Þjórsár munu hvergi þorna upp. Lágmarksrennsli neðan lóna verður 10 m^3/s neðan Hagalóns, 15 m^3/s neðan við Árneslón og 10 m^3/s neðan við Heiðarlón. Lágmarksrennsli á sumrin verður *töluvert hærra, eða í kringum 60 m³/s í meðalvatnsári. Með þessu er tryggt lágmarksrennsli um mikilvæg uppeldis- og hrygningarsvæði og fyrir uppgöngu fisks, auk þess sem búast má við að aðstæður til stangveiða á þessum köflum batni mikið frá því sem nú er.*

English: It will be guaranteed that no river beds in the river Þjórsá will dry completely. The minimum flow rate below the reservoirs will be 10 m³/sec below Hagalón, 15 m³/sec below Árneslón and 10 m³/sec below Heiðarlón. The minimum flow rate in the summer will be considerably higher, or about 60 m³/sec in average-flow-year. These measures will ensure a minimum flow rate through important nursery- and spawning areas and for fish migrating upstream. Besides, conditions for angling in these sections are expected to improve greatly compared to the present conditions.

It is essential that flow rate through sections of the river system that are affected by the dams is regulated in order to: 1) allow salmonid fish to pass through; 2) ensure sufficient spawning grounds; and 3) secure necessary incubation- and nursery habitats for embryos and juveniles. We are particularly concerned with the section of the system from Búði to Árnesflúðir, which represents an important part of the historical natural distribution of the Þjórsá salmon and is also important as migration route for the salmon population in Kálfá. As we interpret the above proposal (wording of the proposal needs to be clearer on this, see below) it seems to be proposed that flow rate through this area be a minimum of 15 m³ in the winter and up to 60 m³ during summer in an average year. We have several concerns and suggestions regarding this.

Firstly, based on its own research, the IFF has proposed that minimum flow rates in this area should be 30 m³/sec to ensure that this section functions properly for passing adult salmon (including the salmon migration to Kálfá) and as spawning grounds and nursery habitat for juveniles. The IFF has emphasized that it would be essential to avoid rapid and unpredictable fluctuations in flow and maintain flow rate as stable as possible (Jóhannsson et al. 2002; 2008; Saltveit et al. 2001). The IFF also recommends to maintain the present flow rate in Murneyrarkvísl. We recommend that, at a minimum, the three suggestions by the IFF be taken more seriously into account and dealt with clearly in the proposed countermeasures. In particular, rapid and unstable fluctuations in flow need to minimized and/or properly managed; especially during critical life stages of salmon, such as during spawning, embryo incubation period in redds, when juveniles are starting to feed and during the early nursing period of juveniles. Such flexibility in flow operation approach has been successful for chinook salmon (*Oncorhynchus tshawytscha*) in the Columbia river U.S.A., where altering the timing and magnitude of discharge fluctuations can minimize the adverse effects of operating hydroelectric dams on the productivity of downstream salmon populations (Harnish et al. 2013). Furthermore, the natural seasonal fluctuations need to be maintained as much as possible as they control many habitat related factors. Thus, it is very important, e.g. considering the different life stages of salmon, to maintain and regulate seasonal flow regime (not just guarantee minimum flow) as much as possible (Alfredsen et al. 2012). Developing such operation guidelines will obviously involve more research in Þjórsá.

Secondly, the IFF conducted habitat evaluation throughout the system using standard methods (Antonsson 2000, based on Caron & Talbot 1993 and Klemm & Lazorchak 1994; Jóhannsson et al. 2002) and based on the findings suggests that following the construction of the proposed dam at Búði measures be taken to restore and/or create habitats for spawning, incubation and juvenile rearing in the section below (Jóhannsson et al. 2002). This is also recognized in the report from LV where the formal countermeasures and mitigation efforts are listed (Aðalsteinsson et al. 2012). However, the appropriate actions are not included in the formal countermeasures and mitigation efforts proposed, but discussed less formally later in the report. Given the great significance of ensuring such habitats and that the knowledge exists to organize and design them (e.g. Einum et al. 2008; Koljonen et al. 2013; Sternecker et al. 2013) we find it necessary that further research and more detailed plans for such countermeasures will be undertaken and included in the formal countermeasure/mitigation proposal and as part of the proposed construction plans. Our conclusion on this issue is substantiated by the fact that despite these actions vast amount of habitat is lost in the system, e.g. due to reservoirs (Jóhannsson et al. 2002, 2008, Aðalsteinsson et al. 2012) and, therefore, it is important to ensure the viability of migration routes and the long term preservation of habitats for spawning, incubation and juvenile rearing in the river reaches that currently support salmonids after the construction of Holt power plant is completed.

Thirdly, we find the present information regarding spawning locations of salmon in the section of the river from Búði downstream to the proposed location of Heiðarlón to be too limited and unclear (see Jóhannsson et al. 2002, 2008). Such information is necessary to be able to properly construct and execute plans regarding seasonal discharge patterns, habitat preservation and restoration (see last point).

In a new version of proposal A, the expected flow rate below Árneslón and the expected flow-rate in the section of Þjórsá to the west below Búði needs to be stated separately and more clearly, and the process of minimum flow determination and seasonal plans for discharge regulation thoroughly explained.

Furthermore, in a new version of proposal A, the expected flow rate in Murneyrarkvísl needs to be presented, and the process of minimum flow determination thoroughly explained.

The other section of the natural distribution range of salmon that we are concerned with is the disturbed part of the system below the proposed Urriðafoss power plant project. LV proposes that flow rate below Heiðarlón will not be less than 10 m^3/sec. This proposal has to be justified and explained very clearly in the context of the proposed countermeasures and mitigation efforts.

In a new version of proposal A, the flow rates and seasonal discharge patters proposed below each dam have to be explained and justified with respect to the goals to be met regarding migration, and habitats for spawning, incubation of embryos and juvenile feeding for salmon and if possible for brown trout and Arctic charr.

<u>Proposal B</u>: Fiskistigar verða gerðir við stíflur Urriðafossvirkjunar og Hvammsvirkjunar. Reynsla frá núverandi fiskistiga við Búðafoss sýnir að hann hefur gert fiski kleift að nema land fyrir ofan fyrirhugaða Holtavirkjun.

English: Fishways will be constructed at the dams at Urriðafoss and Hvammur hydroelectric plants. Experience from the fishway at Búðafoss waterfall demonstrates that fish have been able to migrate into new territories beyond the planned Holt hydroelectric plant.

We want to emphasize that the fishway at Urriðafoss will need to service all migratory (sea-run) populations of salmonids (and possibly eels) in the Þjórsá system. Thus, its design needs to take the needs of both juvenile and adult Atlantic salmon, brown trout and Arctic charr into account. Furthermore, access of all populations to the fishway needs to be optimized. If this construction and related measures fail it will inevitably result in destruction of migratory populations of salmonids in the system above Urriðafoss. Special precautions need to be taken during the construction phase.

Considerable effort has been made by LV to define the approach to designing and constructing successful fishways for adult upstream migration at the Urriðafoss and Hvammur power plants (Pálmason 2008; Káradóttir & Guðjónsson 2013; Júlíusson & Guðjónsson 2013a). Furthermore, the fishway at Búði, which was constructed in 1991, has proven to be successful (e.g. Jóhannsson & Jónsson 2011) and is expected to continue to serve as a passage beyond the dam at Búði (part of Holt power plant) in the present or improved form (Júlíusson & Guðjónsson 2013b). In general, major international experience exists when it comes to designing and constructing successful fishways for upstream migration of adult salmonids (e.g. Hatry et al. 2013).

Concerning this proposal it should be clearly explained what countermeasures are planned to ensure the functionality of the fishway at Búði regarding the construction of Holt power plant.

In a new version of proposal B it has to be explained what exact goals are to be met with the design of each fishway, e.g. regarding the needs of each salmonid species (salmon, brown trout and Arctic charr). Such goals are important to ensure functionality of the fishway and to avoid long term effects of selection, e.g. if only certain size-classes of fish manage to use the fishway successfully (Schilt 2007; Pelicice & Agostinho 2008; Ferguson et al. 2011; Russon & Kemp 2011; Cooke & Hinch 2013). It is important that the design of each fishway and the respective goals refer to important experience elsewhere (e.g. Noonan et al. 2012; McLaughlin et al. 2012; Fjeldstad 2012; 2013; Hatry et al. 2013).

<u>Proposal C</u>: Við Urriðafoss er gert ráð fyrir sérhannaðri seiðafleytu. Þar er fallhæð mest og öll seiði í ánni þurfa að fara fram hjá virkjuninni. Í lituðu vatni halda seiðin sig nálægt yfirborði. Á niðurgöngutíma seiðanna veitir fleytan efsta lagi vatns í inntaki Urriðafossvirkjunar um sérstaka rás niður í farveg Þjórsár. Gert er ráð fyrir að virkni seiðafleytunnar sé um 90-95% og að lífslíkur seiða sem um hana fara séu nánast 100%. Dæmi um staði þar sem slíkar seiðafleytur hafa gefist vel í lituðu vatni eru Bonneville Dam og Lower Granite Dam í Columbia ánni á vesturströnd Bandaríkjanna þar sem líflíkur seiða sem fara um seiðafleytur virkjananna eru 98-99% samkvæmt mælingum.

English: At Urriðafoss a specially designed juvenile passage is planned. This is where the hydraulic head is greatest and all juveniles will have to pass this power plant. In murky waters juveniles tend to locate themselves close to the surface. During seaward migrations of juveniles the juvenile fish passage directs the surface layer of the water at the entrance of Urriðafoss hydroelectric plant through a special channel into the river bed of river Þjórsá. The efficiency of the juvenile fish passage is expected to be 90-95% and the survival of juveniles passing through it almost 100%. Examples of places where juvenile fish passages have been successful in murky waters are the Bonneville Dam and the Lower Granite Dam in the Columbia river on the west coast of the U.S.A. where the measured survival of juveniles passing through the juvenile fish passages of the hydropower plants is 98-99%.

LV has made a significant effort to evaluate juvenile fish passage systems for the Urriðafoss dam, which involved engineering and testing a model (Tómasson et al. 2013a,b). Detailed knowledge regarding juvenile salmon (smolt) migration in spring and early summer as well as information about migratory patterns of sea-run brown trout from research by the IFF (Jóhannsson et al. 2002, 2008) should significantly help in optimizing operation time for the proposed juvenile fish passages. However, a certain amount of uncertainty will always exists regarding the actual behaviour of the migrating juvenile fish (Guiny et al. 2003; Pavlov et al. 2008).

The proposals for juvenile fish passage systems in Þjórsá are encouraged by positive experience of juvenile fish passage over dams in the Columbia River system (Weiland et al. 2009; Muir & Williams 2012; Ploskey et al. 2012; Rayamajhi et al. 2013). In a new version of proposal C all the optimistic survival numbers presented and the comparisons made with the Columbia river experience need to be explained and justified. Thus, the comparison between passage installations in both systems needs to be made very clear (the pertinent data should be included in an appendix to the proposal) so the conclusions and predictions of the project proponents can be appropriately assessed and verified. It will also be important to explain when the juvenile passage system at the Urriðafoss power plant, as well as at the other dams, will be operating during the year to ensure there is consideration for the patterns of flow in the river (Káradóttir & Guðjónsson 2013; Júlíusson & Guðjónsson 2013a,b) and the timing of seaward migration of salmon smolts and adult brown trout (Jóhannsson et al. 2008).

Considering the numerous obstacles to adult and smolt migration in the proposed hydroelectric project in lower Þjórsá we recommend that an overall population viability analyses (PVA) be conducted. PVA estimates the probability of a population to obtain a certain size sometime in the future to avoid extinction risks (Gilpin & Soulé 1986; Morris et al. 2002; Legault 2005; Bowlby & Gibson 2012). It is important to consider that smolts surviving travel through passage structures may suffer damage that causes delayed mortality, which occurs by the time they reach the estuary or move into coastal waters (Welch et al. 2008; Petrosky & Schaller 2010; Muir & Williams 2012). Therefore, regarding future assessments of the salmon population it is necessary to carefully estimate smolt-to-adult return rates, SAR (Sandford & Smith 2002). Given that this is unclear at present, any estimates of survival associated with downstream passage structures must be interpreted with caution.

It is unclear why LV does not include its current plans to construct juvenile fish passage systems for the other two power dams at the Holt- and Hvammur power plants (see Káradóttir and Guðjónsson 2013; Júlíusson and Guðjónsson 2013a,b). We recommend that this is effected for future evaluations of the project.

LV explains in a memo (Guðjónsson & Jóhannesson 2009) that Kaplan turbines (Ferguson 2008) will be used in all the potential hydro power plants. These turbines are known to minimize mortality of salmon smolts passing through the turbines (Guðjónsson and Jóhannsson 2009). We suggest that LV includes this plan in its proposed countermeasures. This information could be easily added to proposal C.

<u>Proposal D</u>: Lónhæðir við Urriðafossvirkjun og Holtavirkjun hafa verið lækkaðar um 1 m í hvoru lóni frá því að mat á umhverfisáhrifum fór fram. Með því móti eykst rennslishraði um lónin sem hefur jákvæð áhrif á göngur og lífsskilyrði laxfiska sem og á niðurgöngu seiða.

English: The elevation of the reservoirs at Urriðafoss hydropower plant and Holt hydropower plant has been lowered by 1 m in each reservoir since environmental impact assessment was carried out. This increases the flow rate through the reservoirs and thus stimulates migrations and improves living conditions for salmonids, as well as conditions for the seaward migration of juveniles.

In relation to proposal D it is especially important that adequate flow exists in the reservoir at Urriðafoss power plant for salmon smolts to easily orient themselves downstream as they travel through it during their ocean migration (Jóhannsson et al. 2002). It is important to monitor behaviour of smolts through all the project reservoirs. Significant delays of smolts in the reservoirs can reduce their probability of successful seaward migration and increase their mortality rates as a result of increased risk of predation by resident brown trout and Arctic charr (Jepsen 1998; Aarestrup 1999). The same applies to the reservoirs at the Holt and Hvammur power plants. The above comments are closely related to our recommendations regarding proposal C, since flow through the reservoirs is an important part of proper function of juvenile fish passages.

In a revised version of proposal D the expected changes in water flow after the lowering of water level in these reservoirs and how this will stimulate migrating fish will have to be clarified and justified.

<u>Proposal E</u>: Landsvirkjun hyggst kaupa upp netaveiði á þeim jörðum er verða fyrir mestri skerðingu á veiði. Búist er við að með því dragi úr veiðiálagi á laxastofninn og hann eigi möguleika á að eflast. Stangveiði muni líklega aukast og þar með tekjur af veiði.

English: Landsvirkjun intends to buy the rights to gill-netting from those farms that will suffer most from reduced fishing. This is expected to reduce the fishing strain on the salmon population and it will have the potential to grow. Angling is likely to increase and thus bring in more income.

This proposal should be considered in close consultation and collaboration with the local community and fishing association (Veiðifélag Þjórsár). We recommend that the statement that angling will likely increase is justified, e.g. with actual numbers and by referring to experience elsewhere.

<u>Proposal F</u>: Fyrirhugaðar virkjanir í neðri hluta Þjórsár eru rennslisvirkjanir og munu ekki hafa áhrif á ferskvatnsstreymi til sjávar umfram þau áhrif sem þegar eru til staðar vegna núverandi virkjana og miðlunarlóna fyrir ofan Búrfell.

English: The proposed hydroelectric power plants in lower Þjórsá are run-of-the-river power plants and will not influence the flow of freshwater to the ocean in addition to that due to existing power plants and reservoirs beyond Búrfell.

It is unclear how this qualifies as a countermeasure with regards to the protection of salmonid populations in the system. We recommend that this will be clarified.

In general, LV should in revised formal proposals for countermeasures and mitigation efforts include plans for monitoring the salmonid populations following the potential construction of the proposed power plants (Jóhannsson et al. 2002; Skipulagsstofnun 2003a,b). Also, reaction plans if countermeasures and mitigation efforts fail to provide expected results need to be articulated (see Jóhannsson et al. 2002; Skipulagsstofnun 2003a,b)

We agree with LV not to include stocking plans and opening of more new (currently not accessible for migratory fish) sections of Þjórsá for salmon in their proposed countermeasures and mitigation efforts.

General conclusion regarding the proposed countermeasures and mitigation efforts (Proposals A-F)

In the documentation available to us, the official list of proposed countermeasures and mitigation efforts (A-F) first appeared in the reply from LV concerning the conclusions of RÁ2 (Landsvirkjun 2011) and then were presented again (exactly the same proposals) in the official report written by Aðalsteinsson et al. (2012).

Discussions, thoughts and ideas regarding possible countermeasures and mitigation efforts have also appeared less officially in reports, replies, memos and notes from LV (see list of references). Furthermore, as is to be expected, plans regarding the Urriðafoss, Holt, and Hvammur power plants and dams have evolved over the years causing related changes to ideas and discussions about countermeasures and mitigation efforts. Therefore, several cases of new and/or updated suggestions of countermeasures and mitigation efforts have been presented by LV after 2011, but these have not been included in the official proposals (A-F) that were presented officially in 2011 and then again in 2012 (see above). This applies most obviously to plans regarding juvenile passage systems which in the official proposal is listed only for Urriðafoss power plant, but have now also been considered for Holt and Hvammur power plants (Káradóttir & Guðjónsson 2013; Júlíusson & Guðjónsson 2013a,b). Thus, we recommend that updated official proposals of countermeasures and mitigation efforts and all the necessary supporting material will be pulled together into a single comprehensive document. Furthermore, it should be required that all information regarding the final design of all major structures of the proposed hydroelectric power plants, including their effects on salmonid habitats, are clear and included in the final proposals of countermeasures and mitigation efforts provided by LV.

Considering the above, we find it necessary that LV provides the Steering committee of RÁ3 with an official document where proposed countermeasures and mitigation efforts are updated, clearly explained and justified. The updated proposals should firstly, take into account the latest developments regarding countermeasures and mitigation efforts as presented by LV (see above). Secondly, the updated proposals should take into account the recommendations and comments provided earlier in this report as well as addressing other justified comments/criticisms that have been made in relation to, or after, the conclusion of RÁ2. Thirdly, the wording of each proposal should be as transparent and clear as possible to avoid misunderstanding (see earlier example about interpretation of proposal A regarding flow rate below Búði). Finally, each statement of proposed countermeasure and mitigation effort should be accompanied by a separate explanatory text (*greinargerð*) stating how each proposal will be executed, monitored and potentially adapted. This text should include a summary of the technical details (including explanations of any numbers and statistics presented in the proposal) and explain in what way the respective proposal fits into the execution/construction plan for each power plant (Urriðafoss, Holt- and Hvammur power plants). Furthermore, detailed plans for monitoring and adaptive management plans need to be presented, e.g. considering that initial results of countermeasures and mitigation efforts may be different from what is proposed. In cases where statements and numbers have to be supported by necessary data, modeling results, diagrams, maps etc. this should be provided in appendices. Considering the scope and seriousness of the proposed project and the stakes involved in it, we consider such official document to be necessary and very timely.

Questions 4: To what extent are negative effects acceptable? How is that evaluated?

When dealing with these questions, we make a clear distinction between what can be considered <u>basic natural values</u>, in this case related to the biology of salmonids, and what kind of <u>compromises</u> potential decisions regarding the system will involve. The basic natural values aspect implies ultimate values while the compromises relate to more proximate values (i.e. based on social decisions and strategies in dealing with nature). This also dictates how we judge how much research is “sufficient” to minimize the uncertainties associated with the proposed construction project (see question 1, and indeed how issues are dealt with in this report).

Considering basic natural values, when it comes to migratory (sea-run) populations (primarily salmon) we place stronger value on the parts of the Þjórsá river system which represent historical natural distribution (i.e. the area below the waterfall Búði) as compared with the man-made distribution area for migratory fish above Búði (created by the fishway at Búði and related stocking efforts). However, we realize that this natural distribution area has already been affected by previous hydro power plants and dams in the upper parts of the Þjórsá system. Thus, conditions for salmon in the natural distribution area have been improved by more regular flow rates and less murky waters (Guðjónsson 2012). We also recognize that the numbers of salmon in the Þjórsá system are very high, as compared with other salmon populations in Iceland (Jóhannsson 2013) which adds to their natural value. This is substantiated by the fact that Atlantic salmon populations have been threatened and/or are declining in a number of locations throughout their distribution range (e.g. Mills et al. 2013; http://www.nasfworldwide.com/). In the particular case of the Þjórsá and Kálfá salmon, it is important to highlight that many of the local phenotypic adaptations of these fish, for example in migration patterns and body shape (related e.g. to living in glacial waters and at different temperatures) also contribute to their unique and irreplaceable natural value. Regarding natural values, we know very little about brown trout and Arctic charr in the Þjórsá system, but in Iceland we find numerous populations of both species displaying a variety of local adaptations (Guðbergsson & Antonsson 1996; Skúlason et al. 1999). In recent years some Icelandic populations of Arctic charr have been declining and this has been related to climate change (Kristmundsson et al. 2011; Jeppesen et al. 2012).

Considering the more proximate approach involving compromises, this reflects upon our human values and tolerance for irreversible consequences in the face of uncertainty. We evaluate different options against each other and make our decisions based on what we judge as relatively more or less important (e.g. how much damage is acceptable to a particular fish species or freshwater system as compared with another fish species or freshwater system). Such process considers the economic aspects of development plans. Thus, in all documentation available to us regarding the Þjórsá system, when it comes to ecological research, much greater relative value is placed on salmon than on brown trout and Arctic charr. This reflects general views about these fish, at least in Iceland, and is obviously related to the relatively high economic significance of Atlantic salmon in the Þjórsá system (Aðalsteinsson et al. 2012). In this basin, human appreciation or "valuation" of salmon is to some extent complemented by what we identify above as natural values for salmonids in the system and this is understandable. Nevertheless, we are concerned about the lack of information available on brown trout and Arctic charr and the fact that relatively little attention is being given to them in the decision-making process related to the proposed power plants for the lower parts of the basin.

Final remarks

We want to close with two points that are among the take home messages resulting from our experience with this project.

Firstly, when planning a hydroelectric power project like the one in the lower Þjórsá, it is important to consider countermeasures and mitigation efforts jointly with other planning and design of the plants and dams from the beginning of the process. This has been the objective of present power project and should be commended. It is important that the culture of such work acknowledges the need for scientific professionalism at all stages and that all counteractions are clear, transparent and in all cases carefully valued, explained and justified with data and references.

The second point concerns a general problem facing work of this kind everywhere, especially in small countries like Iceland. This is the need for independent and objective research regarding the ecological resources that will be affected by hydroelectric power plants and dams. All stakeholders will at the end of the day benefit if this is emphasized and/or the limitations of the process in this respect clearly acknowledged.

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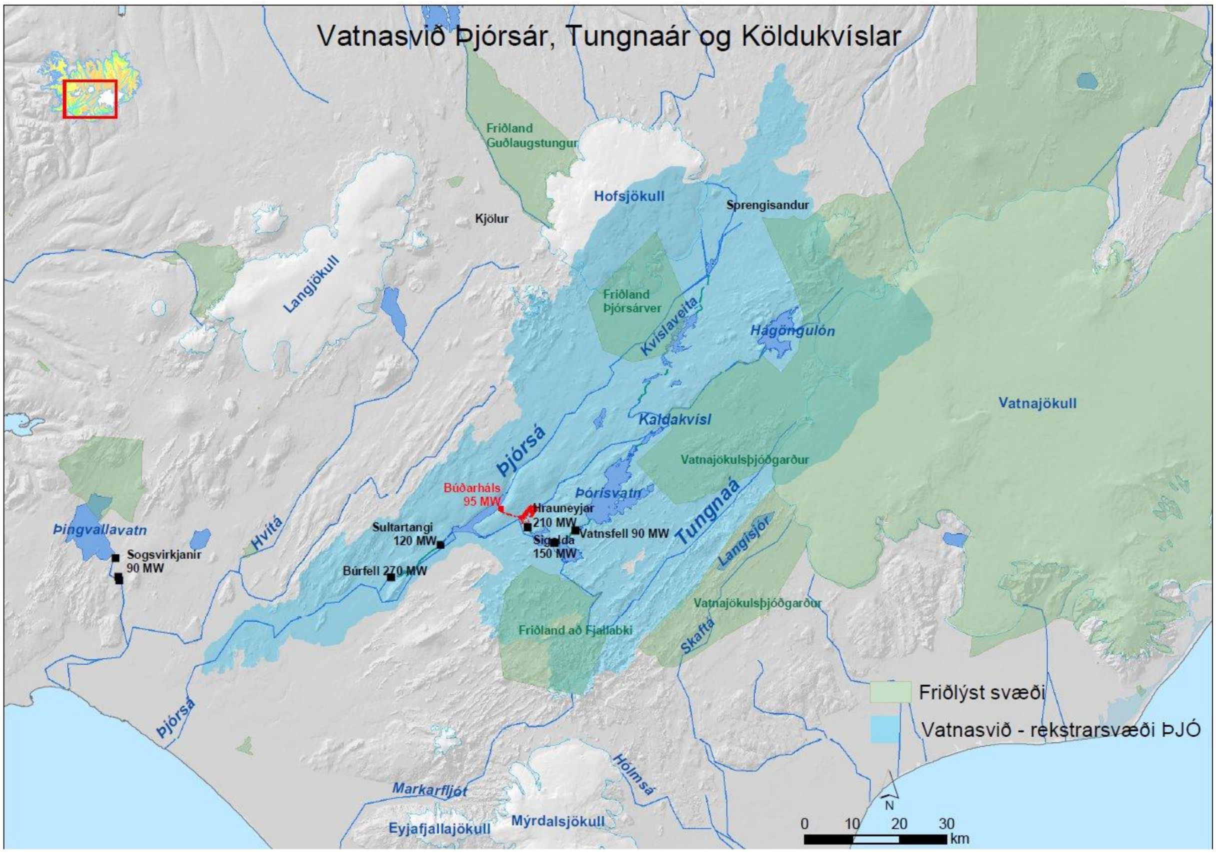

Figure 1. A)

A map of the watershed of Þjórsá, with older power plants in the system indicated (kindly provided by Landsvirkjun).

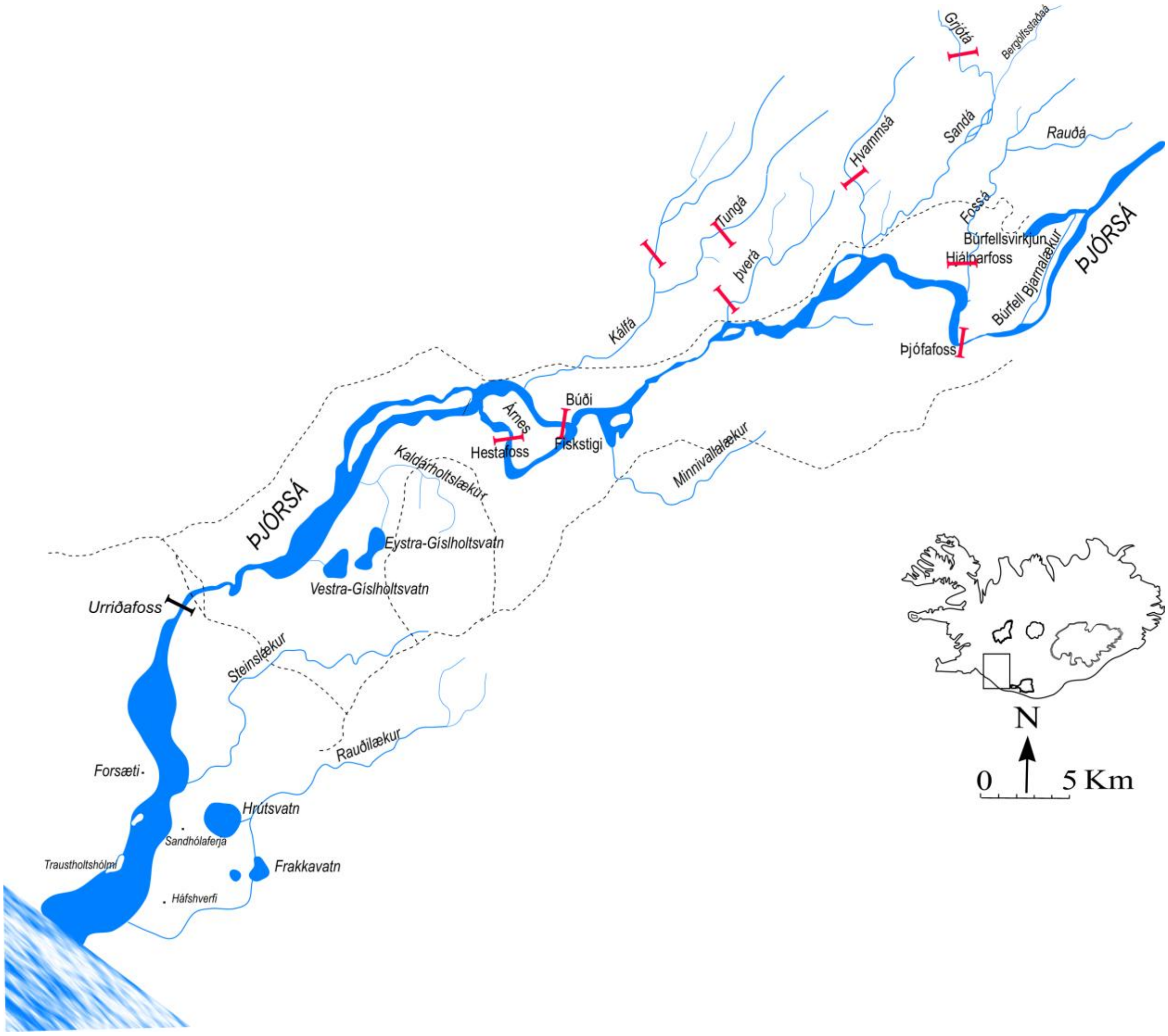

Figure 1. B)

A drawing of the Þjórsá system with important tributaries and locations indicated. Red bars indicate waterfalls that migratory fish cannot pass and black bars indicate waterfalls that migratory fish can pass (kindly provided by the Icelandic Institute of Freshwater Fisheries).

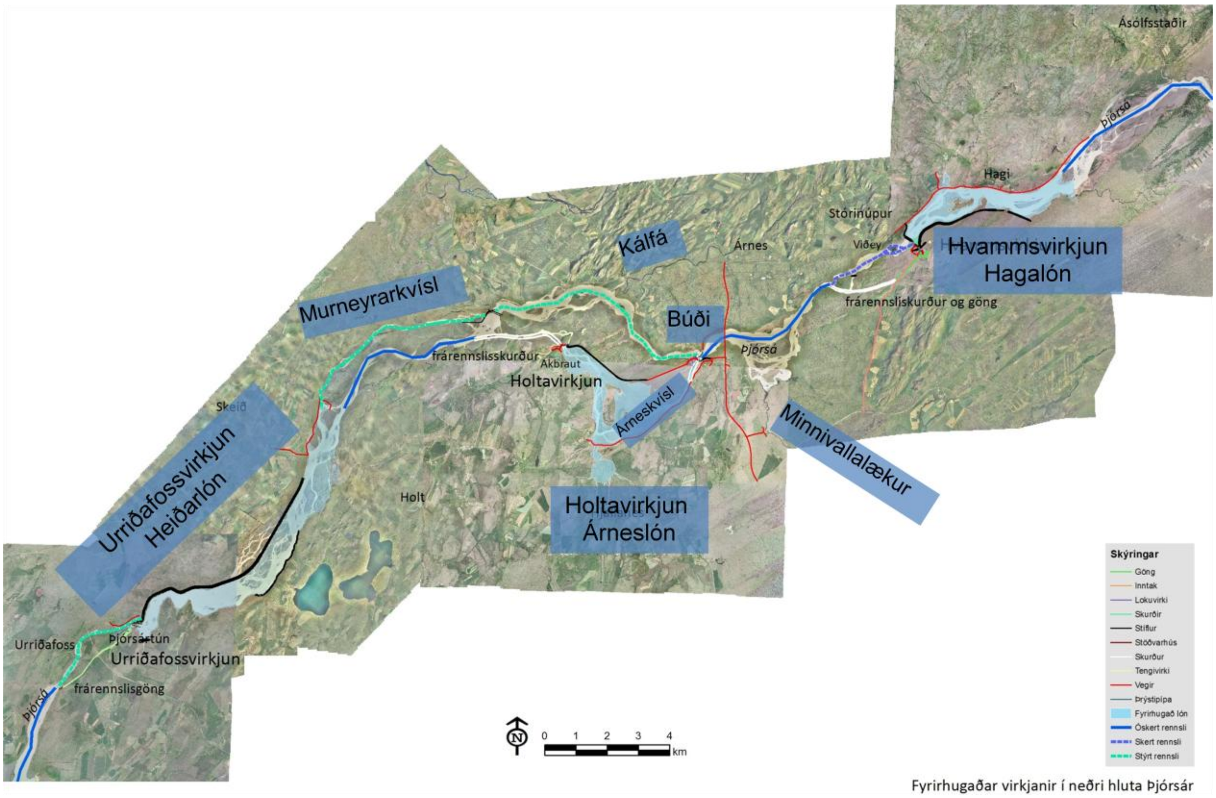

Figure 2.

An aerial picture with the proposed hydro electric plants and dams and names of important features in the lower Þjórsá superimposed (kindly provided by Landsvirkjun).

Attachment: Project description / terms of reference (verkefnislýsing)

Laxastofninn í Þjórsá – greining á fyrirliggjandi rannsóknum

Af hverju núna: Þrír orkukostir í neðri Þjórsá, Hvammsvirkjun, Holtavirkjun og Urriðafoss eru í biðflokki rammaáætlunar vegna óvissu um áhrif framkvæmdanna á laxastofninn í ánni. Í meðferð verkefnisstjórnar RÁ2 voru þessi orkukostir settir í nýtingarflokk. Eftir umsagnarferli sbr. lögin um RÁ var niðurstaða Alþingis sú að þessi kostir færu í biðflokk og áhrif á laxastofninn/-ana yrðu skoðuð frekar. Fyrir liggja verulega rannsóknir á áhrifum framkvæmdanna á laxastofninn og tillögur um mótvægisaðgerðir. Því telur verkefnisstjórn RÁ 3 nauðsynlegt að fá óháða sérfræðiaðila til að fara yfir þetta mál til að reyna að fá úr því skorið hver séu áhrif hverrar virkjunar fyrir sig á laxastofninn.

Verkefnisstjórnin hyggst nýta þessa vinnu við tillögugerð sína um hvernig ráðstafa skuli þessum þremur virkjunarkostum sbr. lög nr. 48/2011, þ.e. áfram í bið til frekari skoðunar eða flokka í verndar- eða nýtingarflokk.

Verkefni: Framkvæma greiningu á öllum tiltækum rannsóknum um vistfræði laxins í Þjórsá og fyrirhuguðum mótvægisaðgerðum vegna umræddra vatnsaflsvirkjana. Hér er fyrst og fremst um að ræða rannsóknir og önnur gögn Veiðimálastofnunar og Landsvirkjunar, svo og aðrar rannsóknir og athugasemdir sem fram komu í vinnunni við 2. áfanga rammaáætlunar. Þessi greining á að leitast við að gefa svör við eftirfarandi spurningum varðandi áhrif Hvamms-, Holta- og Urriðafossvirkjana á laxastofninn í Þjórsá:

1. Nægja rannsóknir þær og önnur gögn sem fyrir liggja til að svara því á fullnægjandi hátt hver áhrif virkjananna þriggja verði á laxastofna? Sé svo ekki, hvaða frekari rannsóknir gæti þurft að ráðast í?

2. Hver eru áhrif einstakra virkjana, þ.e. Hvamms-, Holta- og Urriðafoss á laxastofna?
   Er einhver virkjanakostur ákjósanlegri en annar m.t.t. þessa?

3. Eru fyrirliggjandi hugmyndir að mótvægisaðgerðum fullnægjandi? Ef ekki, hvaða aðgerðir ætti að skoða frekar?

4. Hversu mikil neikvæð áhrif eru ásættanleg? Hvernig má meta slíkt?

Afmörkun verkefnis: Gert er ráð fyrir að afmörkun verkefnisins verði ákveðin í samráði við formann og starfsmann verkefnisstjórnar rammaáætlunar (V-RÁ3) eftir því sem verkinu vindur fram, enda erfitt að skilgreina afmörkunina nákvæmlega fyrirfram. Landfræðileg afmörkun ræðst væntanlega af því hvar í ánni og þverám laxarnir halda sig og lifa, og tímaafmörkun ræðst væntanlega af því hve langt aftur rannsóknirnar ná og e.t.v. líka af lífsskeiði laxins. Einnig verða væntanlega einhver afleidd áhrif af virkjununum á búsvæði og lífsskilyrði laxanna – þeir þættir eru væntanlega best skilgreindir af fagaðilum. Mikilvægt er að hafa í huga að framkomnar athugasemdir snerust ekki bara um seiðaveitur og fiskavænar túrbínur heldur einnig vatnsmagn í náttúrulegum farvegi árinnar eftir virkjun, upphlutun búsvæða, truflanir á sundleiðum vegna ósamhangandi straums (lítið vatn í stórum farvegi) o.s.frv.

Framkvæmd: Óháðum sérfræðingi verði falið að vinna verkefnið sumarið 2013. Viðkomandi aðili yfirfari öll fyrirliggjandi rannsóknagögn og skýrslur og afli sér upplýsinga hvaðanæva sem hann telur þurfa. Niðurstöðum sínum skili hann í skýrslu til V-RÁ3 í síðasta lagi 30. ágúst. V-RÁ3 mun fá 2-3 fagaðila til að ritrýna skýrsluna og koma með ábendingar áður en skýrslan verður tekin til lokaafgreiðslu í verkefnsstjórn.

Samningur: Gerður verði skriflegur verksamningur milli umhverfis- og auðlindaráðuneytisins f.h. V-RÁ3 annars vegar og viðkomandi sérfræðings hins vegar, þar sem fram koma framangreind tímamörk ásamt ákvæðum um fjárhæðir og greiðslur fyrir verkið.

Verkefnisstjórn 3. áfanga áætlunar um vernd og nýtingu náttúrusvæða (rammaáætlunar)
5. júlí 2013