

A critical review of best practice mitigation

- towards low ecological impacts from large hydropower in Europe and the US



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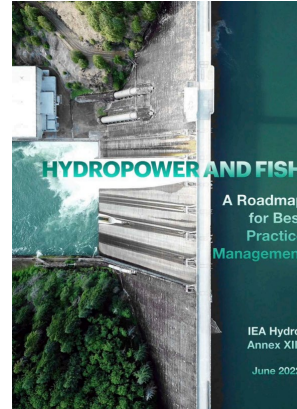
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⁶ Kraftwerke Oberhasli AG (KWO), Switzerland

Work in progress....suffering a bit by Sus HP chair tasks....

Outline

1. The low impact HP challenges
2. Best management practises for boosting mitigation
3. Sustainability standards
4. Emerging cases
5. Prelim key messages



Upgrading or low utilisation

- Closed loops (circular HP?)



SUSTAINABILITY

- Water wheels
 - x % of mean flow (with no storage)

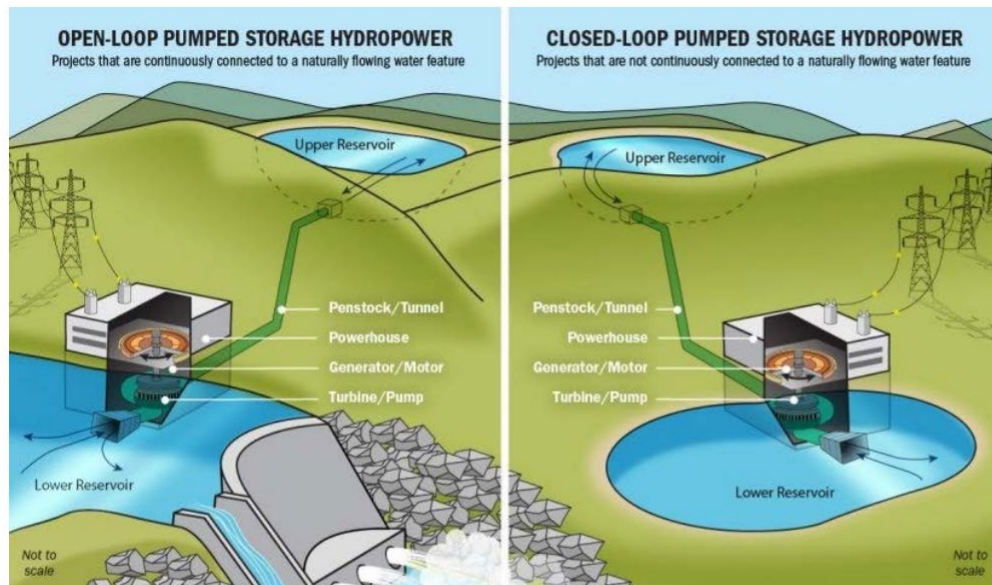


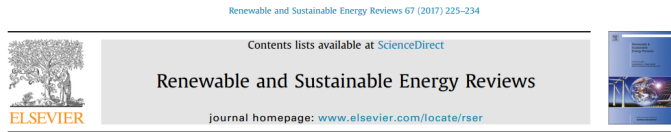
Figure 3.4 *Open vs closed pumped storage hydropower scheme* (Source: [U.S. DoE](#))

Ecosystem based HP management



SUSTAINABILITY

- The main objectives of this study
 - i) **highlight modern solutions** for mitigating HP impacts,
 - ii) **compare environmental performance** of new mitigation measures to current standard practice and
 - iii) discuss if the compiled cases are all likely to **meet sustainability standards**.
- *Halleraker, Jo Halvard; Bakken, Tor Haakon; Larsen, Tine. (2022) [Økosystembasert forvaltning og miljøforsvarlig drift av vannkraftanlegg i et EU-perspektiv.](#) Cappelen Damm*

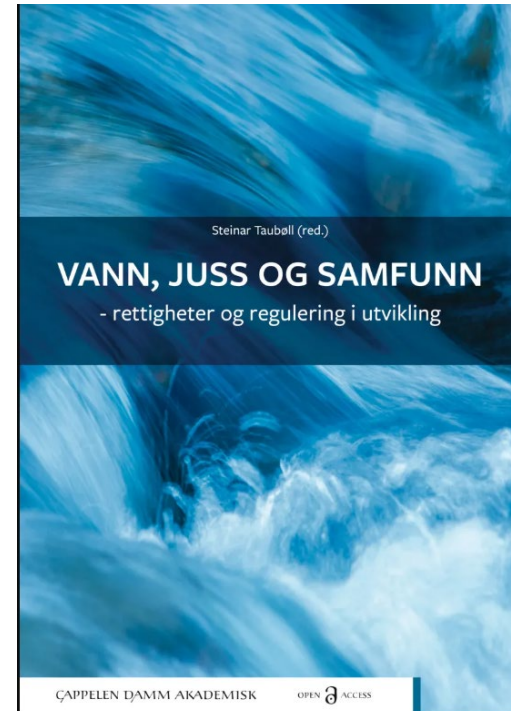


Reviewing and critiquing published approaches to the sustainability assessment of hydropower



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Ranking of modernised HP (NO)



HPP	Decision	First	Capacity /Power	Key species	Dam/barrier		Bypass	River section	(Minimum flow sections)	
					Upstream migr.	Down-stream migr.			Ratio of	Red.
River basin	yr	prod.	MW/GWh			rivers	Min-Q	max Q (%)	GWh (%)	
	yr					(No)	[m ³ /s]			
Trollheim/ <i>Suma</i> (1)	Kgl.res., 2021	1968	400 MW/ < 893	National salmon river	Upstream of natural barrier		> 10km (4)	Yes, past two intakes	0.46/45m ³ /s (1.02 %)	Ca. 35 GWh (3.9 %)
<i>Alta</i> (2)	2010 (trial regime)	1987	150 MW/ 762	National salmon river	Upstream of natural barrier		1-2 km (1)	No, but short section		0
Straumsmo/ <i>Bardu</i> (3)	Kgl.res. 2021	1966	130 MW/ < 704	Trout	Upstream of natural barrier		> 10km (5)	Yes, 0.5-2 m ³ /s (from dam)	0.5-2/70 m ³ /s 0,70 %	Ca. 20 GWh (2.8 %)
Lovik/ <i>Storelva</i> (4)	Kgl.res. 2019	1952	1.2 MW/ 4.7	Anadromous (Sea char) Catadromous	No	No	1-2 km (1)	No	No	0
Laudal/ <i>Mandal</i> (5-#)	2013/ 2020 (trial regime)	1981	32 MW/ 185	Anadromous (NLV), catadromous	Ladder, environmental design	Guiding fence (2021)	2-5 km (1)	Yes, 6-25 m ³ /s #(5)	6-25/110 m ³ /s (4.5-11 %)	15-26 GWh # (8-14%)
Kolsvik/ <i>Åbjøra</i> (6)	Revised 2014	1979	128 MW/ 549	Anadromous	Upstream of natural barrier		> 10 km (9)	Yes, 7 m ³ /s (1 Jul – 15 Sep)	0-7/31 m ³ /s (0-23 %)	No <0.04%

Transformative changes....



- IPBES, 2019
Transformative changes
– doing things **differentl**y—not just a little more or less of something we’re already doing.

EU taxonomy for sustainable activities

What the EU is doing to create an EU-wide classification system for sustainable activities.

PAGE CONTENTS

[What the EU is doing and why](#)

[EU taxonomy navigator](#)

[Commission expert groups on sustainable finance](#)

[Policy making timeline](#)

[Relevant legislation](#)

[Frequently asked questions](#)

[Related links](#)



Commission takes further steps to boost investments in a sustainable future

The Commission has today adopted a new package that builds on and strengthens the foundations of our sustainable finance agenda.

For more information, please also consult the page about [taxonomy delegated acts](#) EN

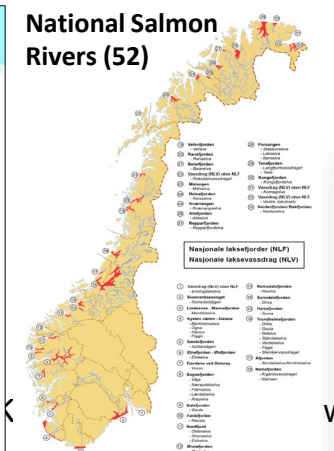
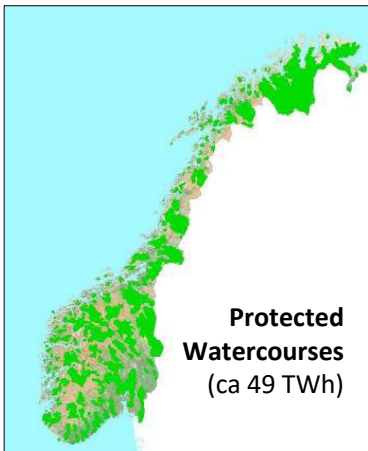
[Sustainable finance package](#) >

What the EU is doing and why



Half-full or half empty?

- Management tools
- Emerging good/best examples
- Addressing measures for all impacts



Mardøla i Eikesdalen
Foto: Bård Bredesen, Naturarkivet.no

Intercomparison of ecological potential: towards common mitigation practices (feasibility studies)

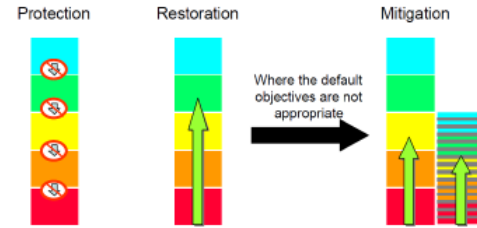
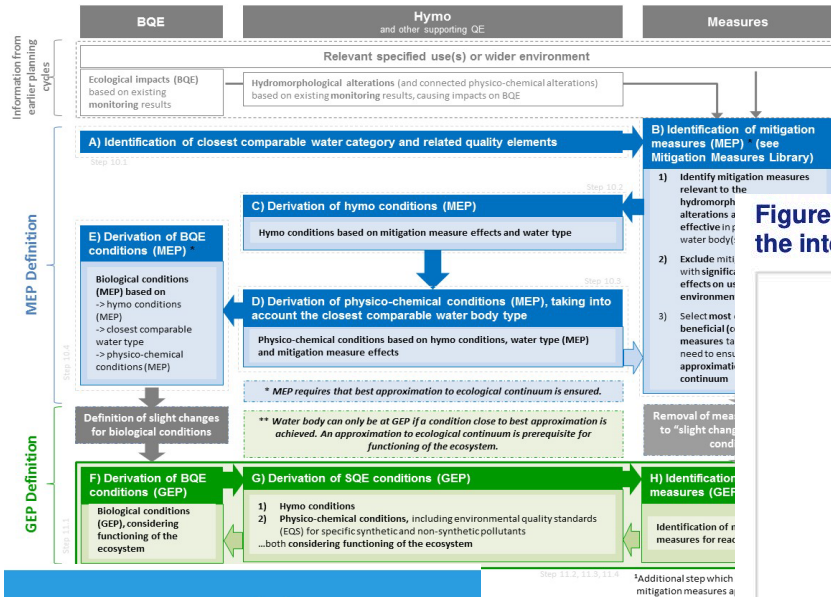
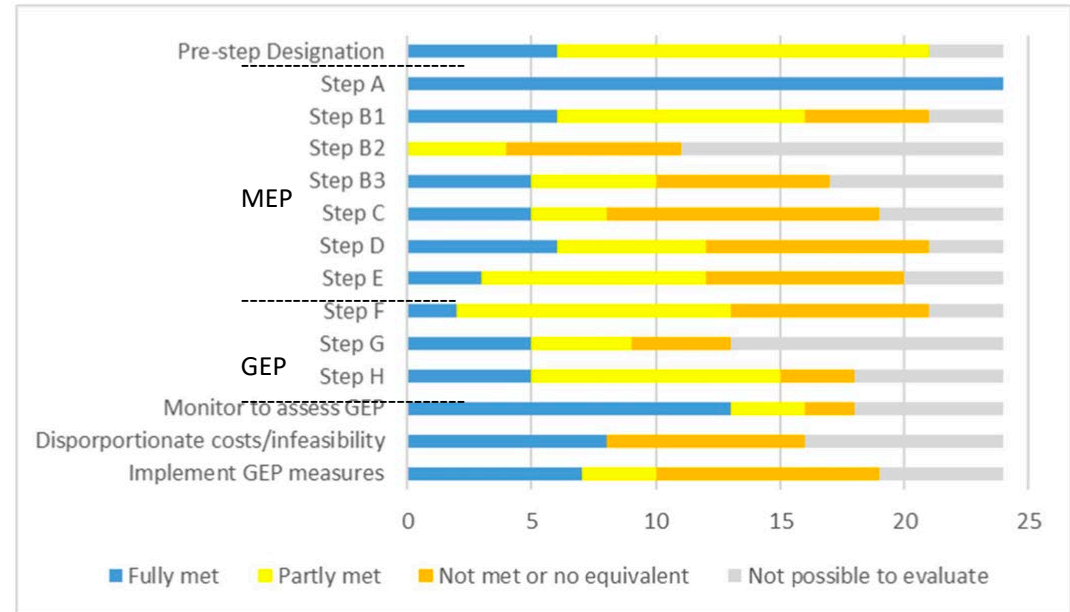


Figure 5 Numbers of countries which fully meet, partly meet or do not meet the criteria set for the intercomparison of methods for each step



JRC TECHNICAL REPORTS

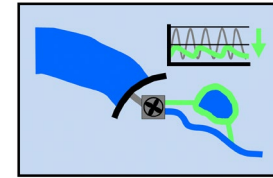
Working Group ECOSTAT report on common understanding of using mitigation measures for reaching Good Ecological Potential for heavily modified water bodies

Part 1: Impacted by water storage

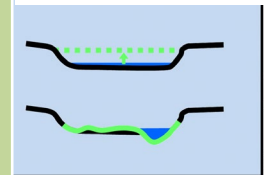
for a better world

Measure options – hydropeaking /rapid flow fluctuation in the European mitigation library

Hydromorphological alteration	Main ecological impact*	Mitigation measures options
Rapidly changing flows (including hydro peaking)	Reduction in animal & plant species abundance due to stranding & wash out	<ol style="list-style-type: none"> 1. Balancing reservoir(s) (internal) 2. Relocate tailrace 3. Reduce rate 4. Modify river morphology 5. Balancing reservoir(s) (external) 6. (Fish stocking – some countries)



Mitigation for rapidly changing flows



3. Mitigation low flow

SUSTAINABILITY



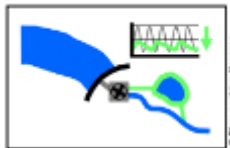
Omllopsventiler i kraftverk

Þessi flokkun er aðal skilgreiningin á þessum sviði og er hún byggð á þessum tveimur meginreglum: 1. Það er umhverfislega og atvikaframtíðarkennd og 2. Það er umhverfislega og atvikaframtíðarkennd.

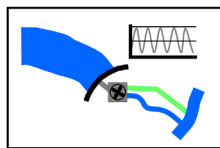


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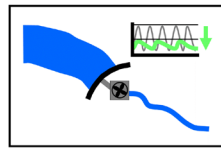
GOD PRAKIS



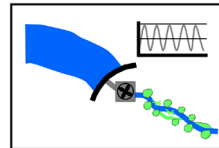
Constructing external balancing reservoir



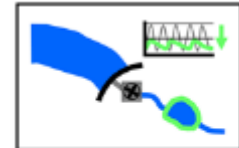
Relocating tail race



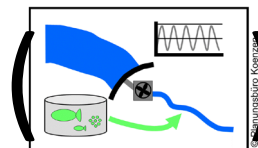
Reducing hydropeaking rate



Improving river morphology



Constructing balancing reservoir(s)



Compensating with fish stocking

Need to mitigate episodic and long lasting impacts *(if significant)*

Acknowledge «new impacts» and innovative solutions

- Gas supersaturation
- Thermopeaking
- Accidental HP turbine shut down
- Sediment degradation

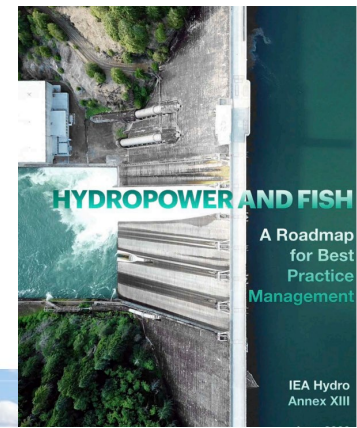


Figure 3.10 *Near-surface supersaturated “white-w”*
(Source: Pi-Lens/shu)

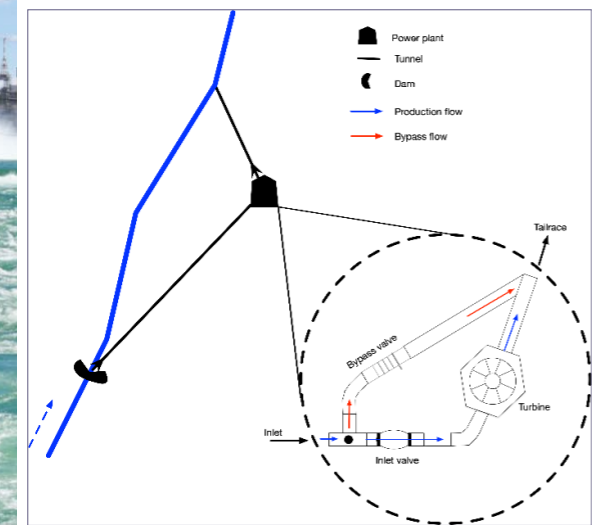


Figure 4.28 *By-pass valve allows constant flow release downstream in case of emergency*
(modified from: [4.85])

Some relevant HP sustainability standards



	Type	Scale	3rd part	Env obj	Indicator
EU taxonomy for HP	Promote holistic sustainability - investors	Water body or HP scheme...	Yes	Not yet, but evident based	(yes), also terrestrial
WFD principles	International framework	Water body	Yes	Yes, monitoring	Yes - aquatic
Low impact HP	Volunteerly	Reach	Yes	Endangerd spp.	
IHA Sust tool	Volunteerly	Unclear	Yes	More process bases	
Swizz water law	National law	Reach	Yes	Very specific – eg. hypeak	
IEA Best Practise	Uodated overview of r	Not specified	Not specified	Evaluation by montiroin cruisial	

Key impact from large HP

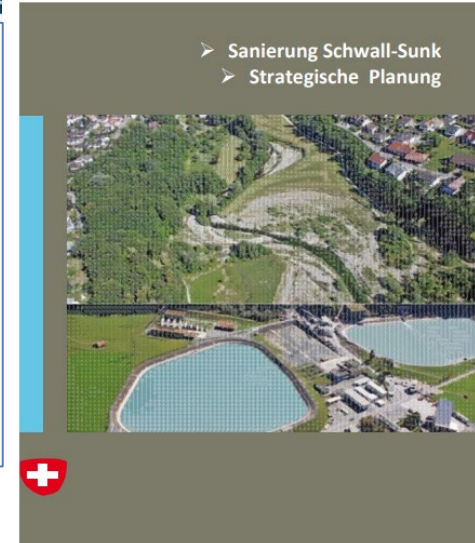
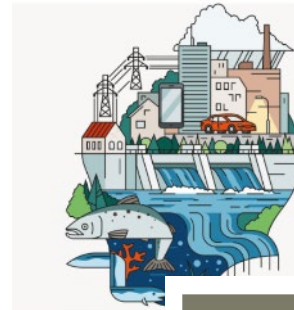


- Addressing significant ecological impacts
- Mitigation feasibility study

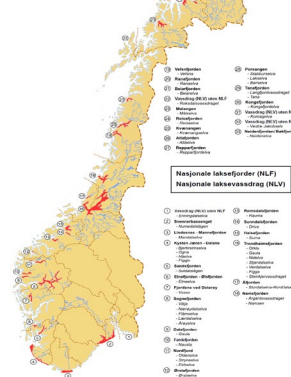
Key HP types	e-flow	hydropowering	Fish migration upstream	Fish migration downstream	Connectivity (fauna passage)	Hydromorphology (habitat improvements)	Water temp.	Bedload bypass	Sediment bypass
Diversion HPP	<u>X</u>		<u>X</u>	<u>X</u>	<u>X</u>	<u>X</u>		<u>(x)</u>	<u>(x)</u>
Run-of-HPP (instream, impoundment)	<u>X</u>		<u>X</u>	<u>X</u>	<u>X</u>	<u>X</u>		<u>(x)</u>	<u>(x)</u>
Storage HPP	<u>X</u>	<u>X</u>	<u>(x)</u>	<u>(x)</u>		<u>X</u>	<u>X</u>	<u>X</u>	<u>X</u>
Pump-Storage HPP	<u>X</u>	<u>X</u>				<u>X</u>	<u>X</u>	<u>X</u>	<u>X</u>

Strategic governance

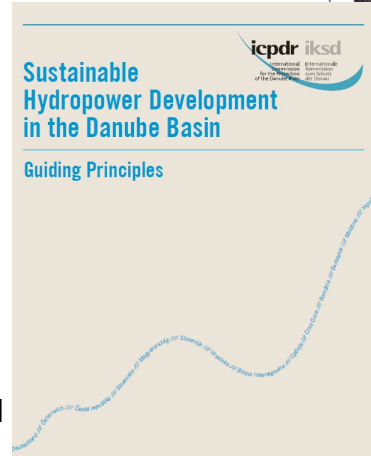
- HP fund to finance mitigation (SE)
- Mitigation fee - electricity bill (CH)
- PP-principle; NO, AT
- International /national guidelines
- Planning tools



National Salmon Rivers (52)



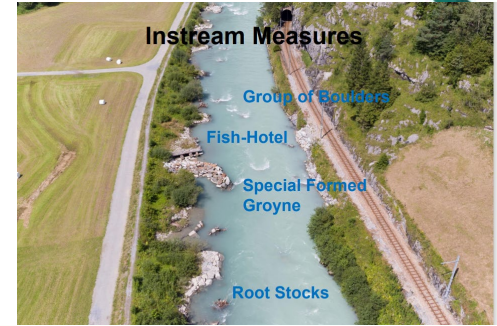
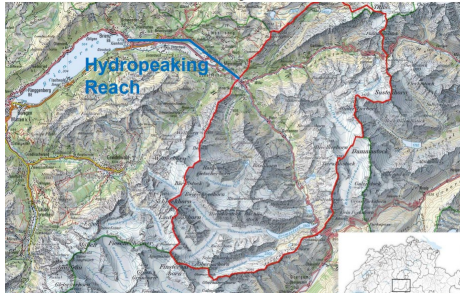
world



Case Hasliaare (KWO) - Switzerland



ABILITY



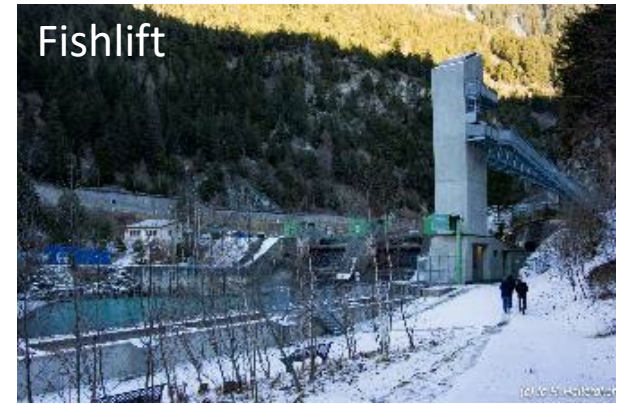
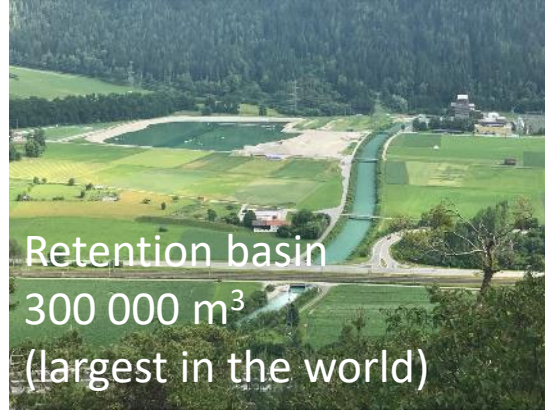
© Markus Zeh

«Rolls Royce Mitigation» of Hydropeaking in the alps ↓

Adressing cumulative impacts – biodiversity offsetting



SUSTAINABILITY



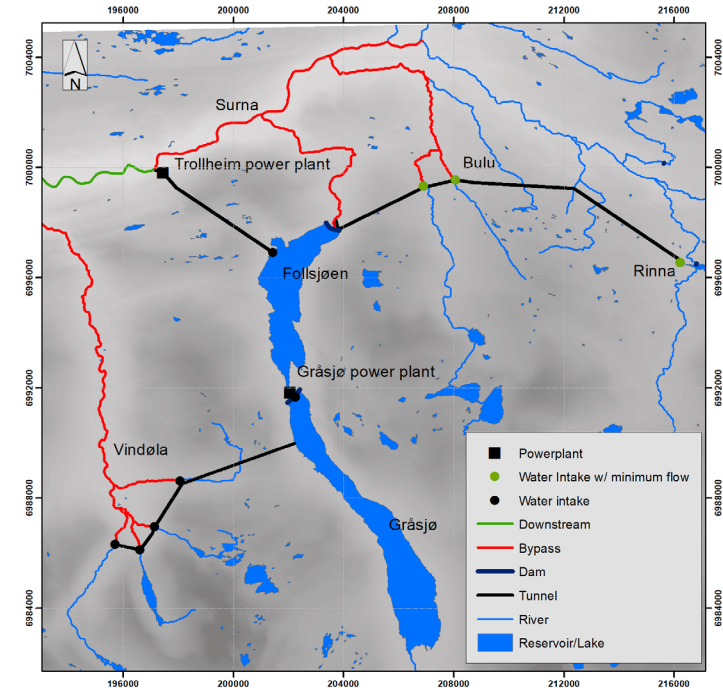
Surna /Trollheim HP

- New mitigation ongoing (relicensed, 2021)

- ✓ High base flow (downstream tailrace)
- ✓ Restricted downramping
- ✓ Thermal mitigation
- ✓ By-pass Eflow



SUSTAINABILITY



Alta HP

- ✓ **High base flow (downstream tailrace)**
- ✓ **Very restricted sub daily variability**
 - ✓ «Turbine Q 16-33 m³/s < 2 m³/s pr day »
- ✓ **By-pass valve (BPV)**
- ✓ **Thermal mitigation**
- «One of the best salmon rivers in the world»
- Still habitat for tiger beetle (northernmost location in the world)
- Loss of endemic species habitat (Innundated land)
- No residual flow from the dam (although short bypass reach)

Finnmarksjonsokblom
Silene involucrata ssp. tenella

Rødlistet art



Finnmarksjonsokblom er kjent fra Reisadalen i Troms og Alta-Kautokeinodalen i Finnmark og vokser på sand og grus på elveører og i



NTNU

Knowledge for a better world

Discussed in the group: How to target what is best practise cases?



- **Qualitative expert judgement** is "allowed"
 - (we are searching for THE best ones, more than the most representative one)
- Mitigation practise may have **pilot character** (the first, or the most promising examples)
- Some cases may be best "only"/mainly for one of the mitigation categories
- HP project aiming at low ecological impact/well mitigated by relevant measures
- Should much more severe ecological impacts be allowed in older schemes?

Ecosystem based management

“An integrated management approach that recognizes the full array of interactions within an ecosystem, ... rather than considering single issues, species, or ecosystem services in isolation.”

Peter Rutschmann · Eleftheria Kampa · Christian Wolter · Ismail Albayrak · Laurent David · Ulli Stoltz · Martin Schletterer · Editors

Novel Developments for Sustainable Hydropower

Springer

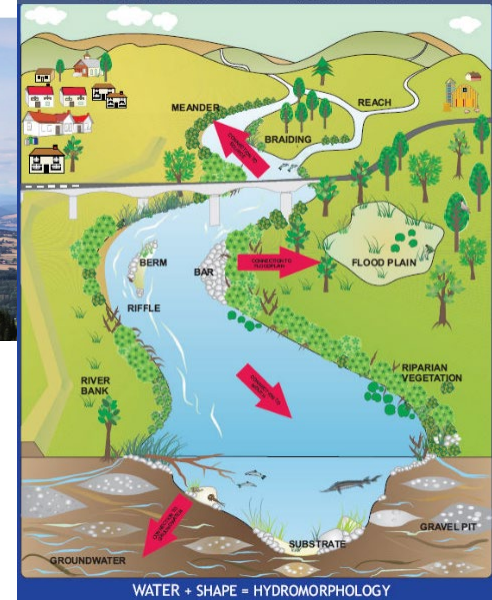
1802

Ecosystem-based management: Miracle or Mirage?

Mapping and rapid evidence assessment of international and Nordic research literature on ecosystem-based management

Oystein Aas, Marthe Indset, Christian Prip, Froukje Maria Platjouw & Frode Thomassen Singaas

NINA Report



Antall
2500
2000
1500
1000
500
0

HABITAT LOSS

Arealendringer Forurensning Høsting Fremmede arter Klimatiske endringer Andre og ukjent

Number of endangered species in Norway and dominating pressure.



All climate friendly HP - 100% sustainable with no significant harm for ecology..



SUSTAINABILITY



Welcome to
Sustainability in Hydropower 2023
-Ecological mitigation, best practises and governance

Trondheim, Norway 13-15 June 2023



SUSHP 2023
The 2nd International Conference on
Sustainability in Hydropower

Key messages

- Best practise mitigation (BPM) is possible
- Several impacts have **mature** measures
 - Continuity for fish/biota
 - Hydropeaking mitigation
- Innovative measures
 - Mitigation evolves
- Drivers towards best practises
 - Innovation (R&D)
 - Policies, common understanding & incentives
 - Knowledge sharing like **the IEA Roadmap & this conference are important arenas**

