



Improving Fish Passage by an Unstructured Block Ramp

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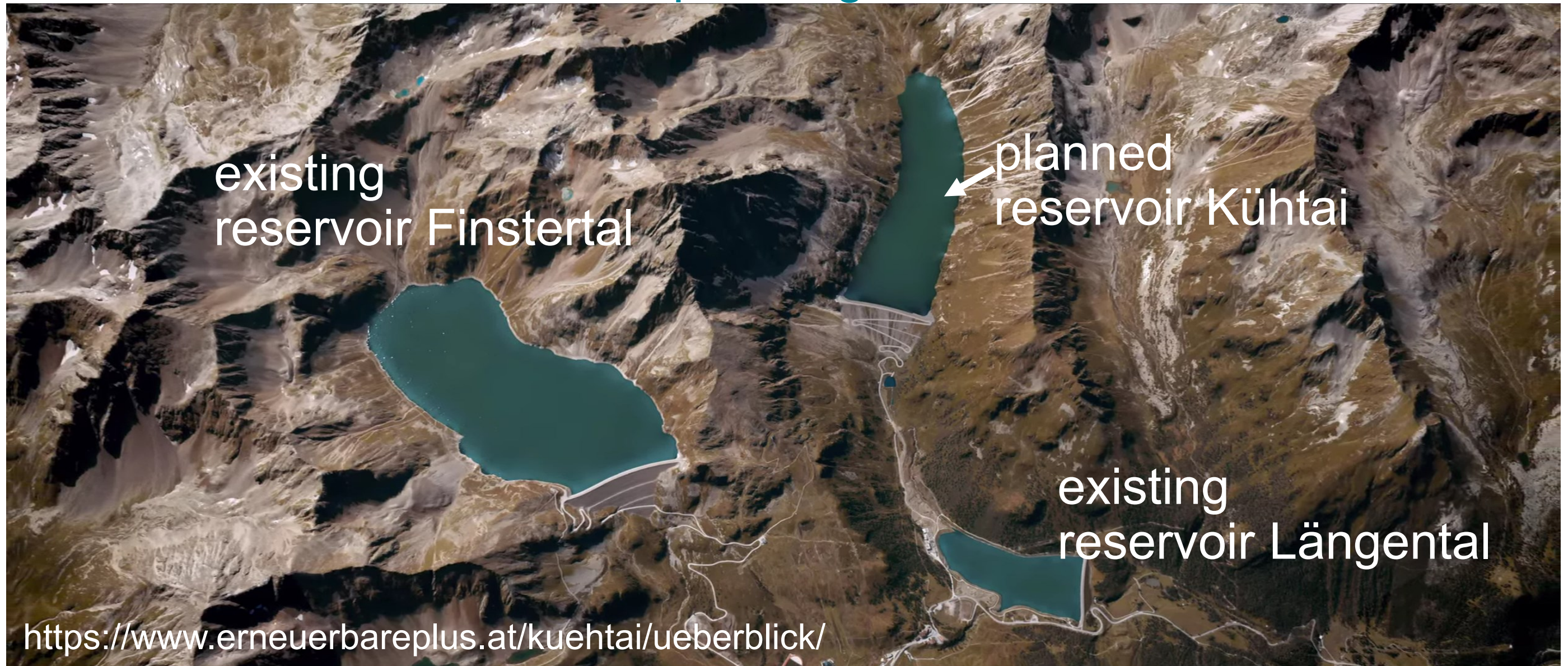
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Innsbruck, Austria

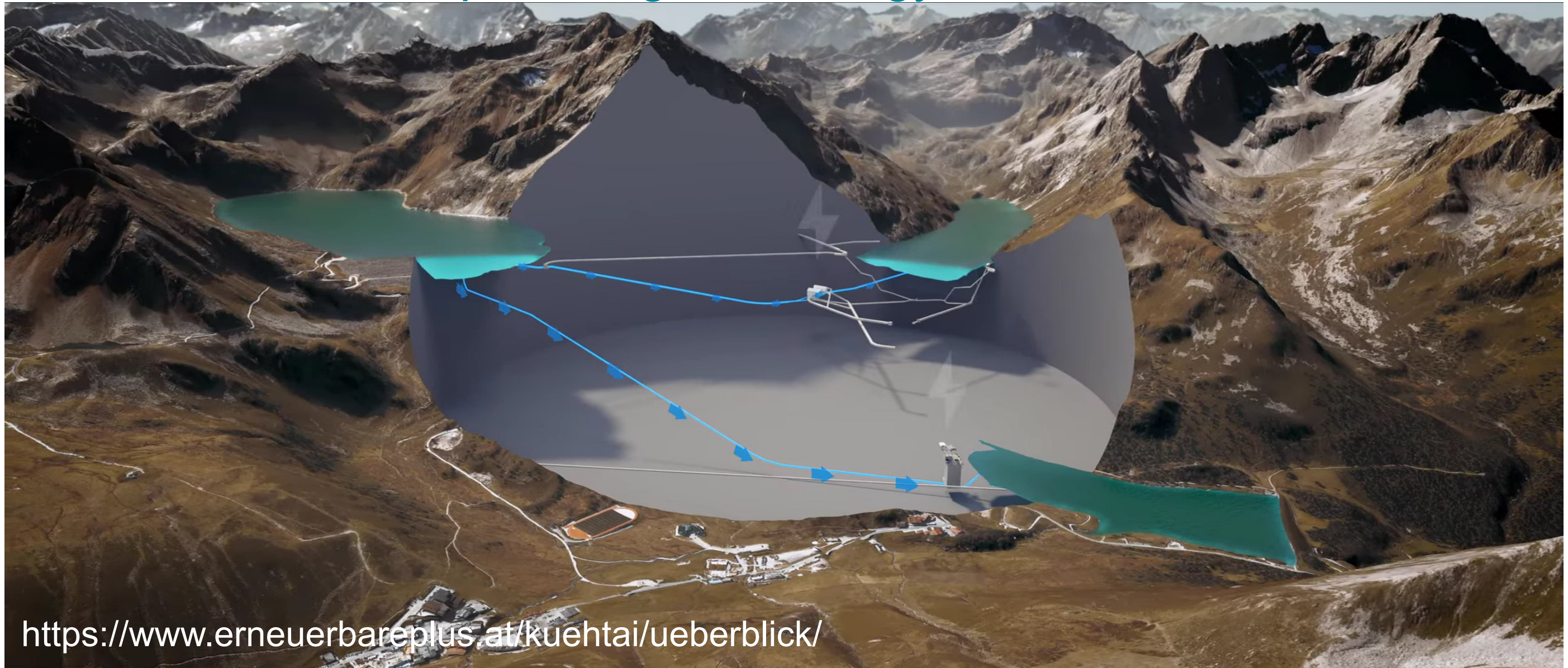
Project background

- Reservoir Kühtai and Pump Storage HPP Kühtai 2



Project background

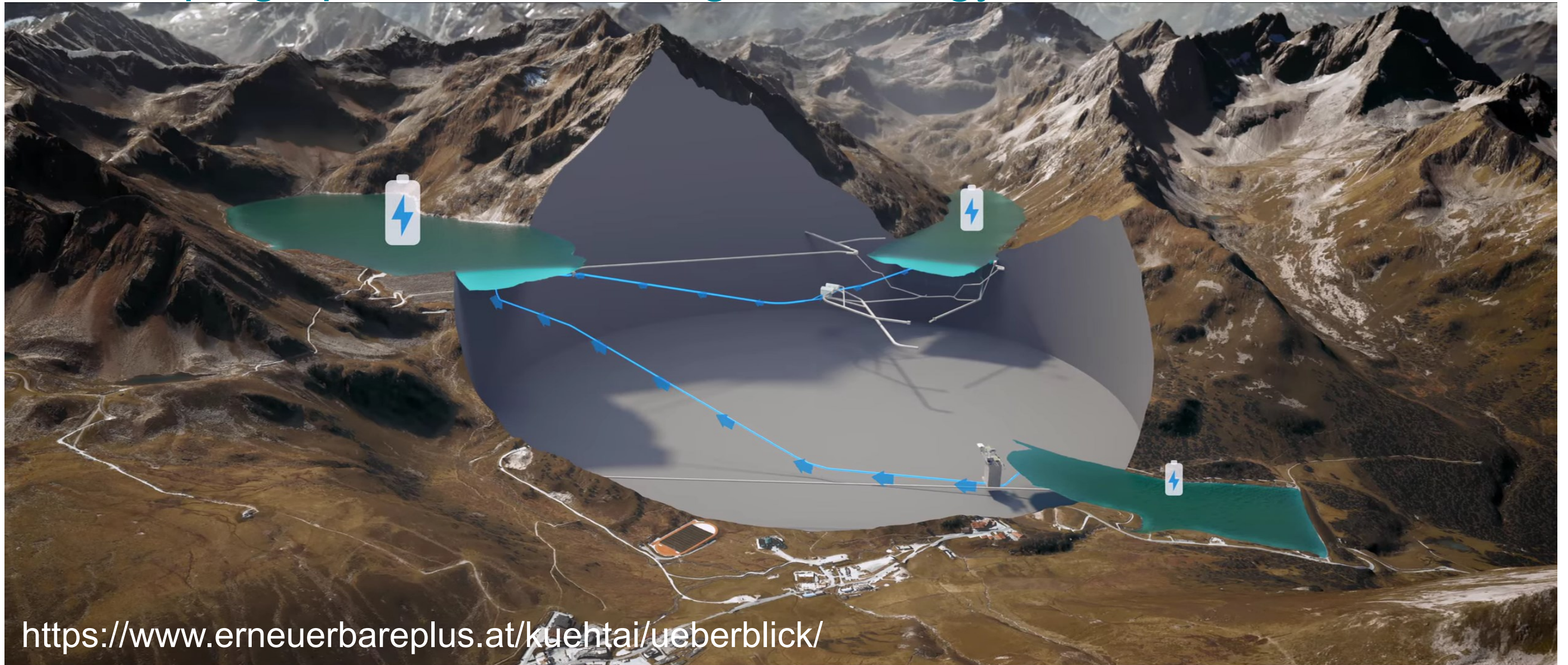
- Turbine mode to provide green energy



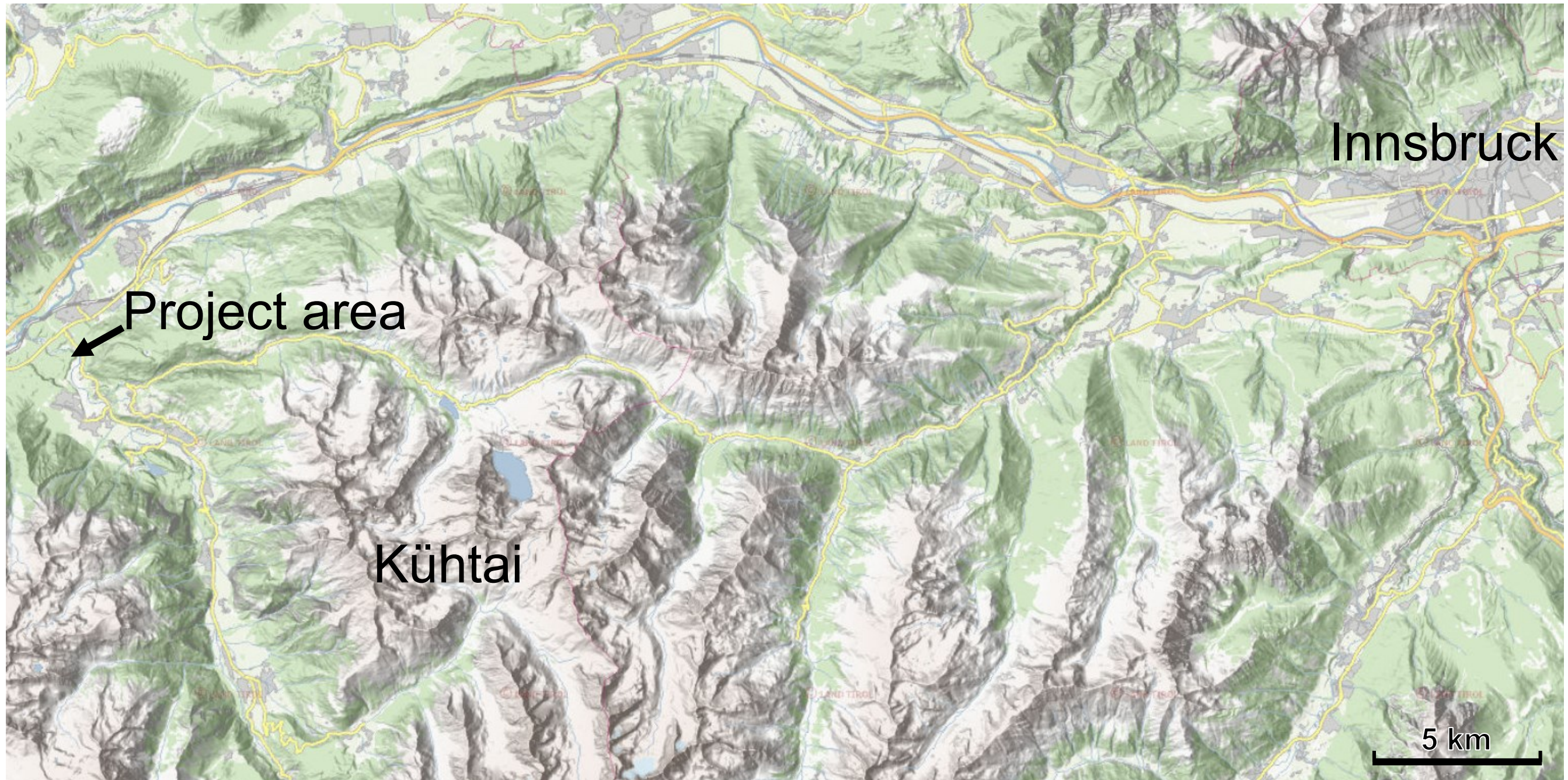
<https://www.erneuerbareplus.at/kuehtai/ueberblick/>

Project background

- Pumping operation to store green energy

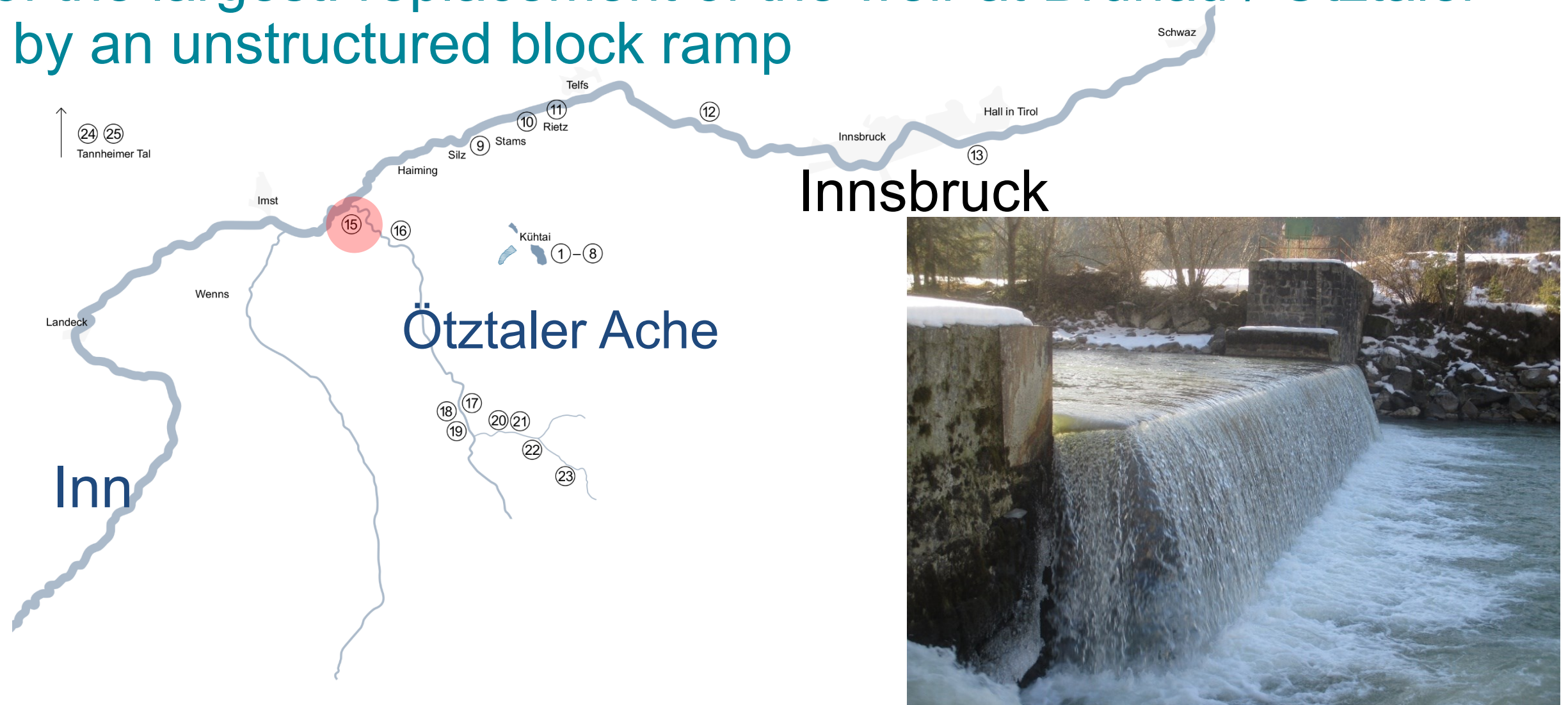


Project area - Tyrol, Austria



Project background

- 25 ecological measures to compensate impact of HPP extension
- One of the largest: replacement of the weir at Brunau / Ötztaler Ache by an unstructured block ramp



Weir / unstructured block ramp - Brunau

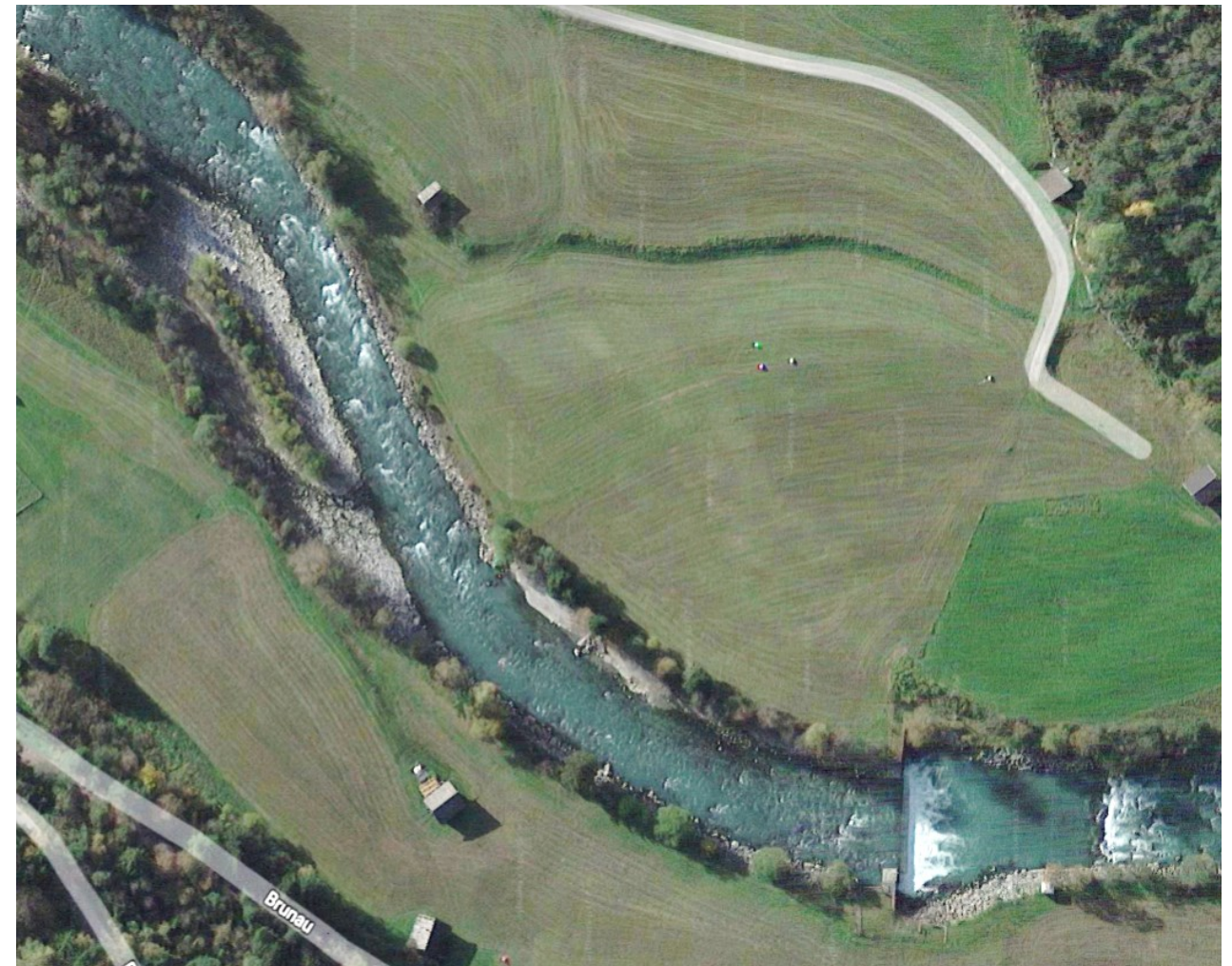
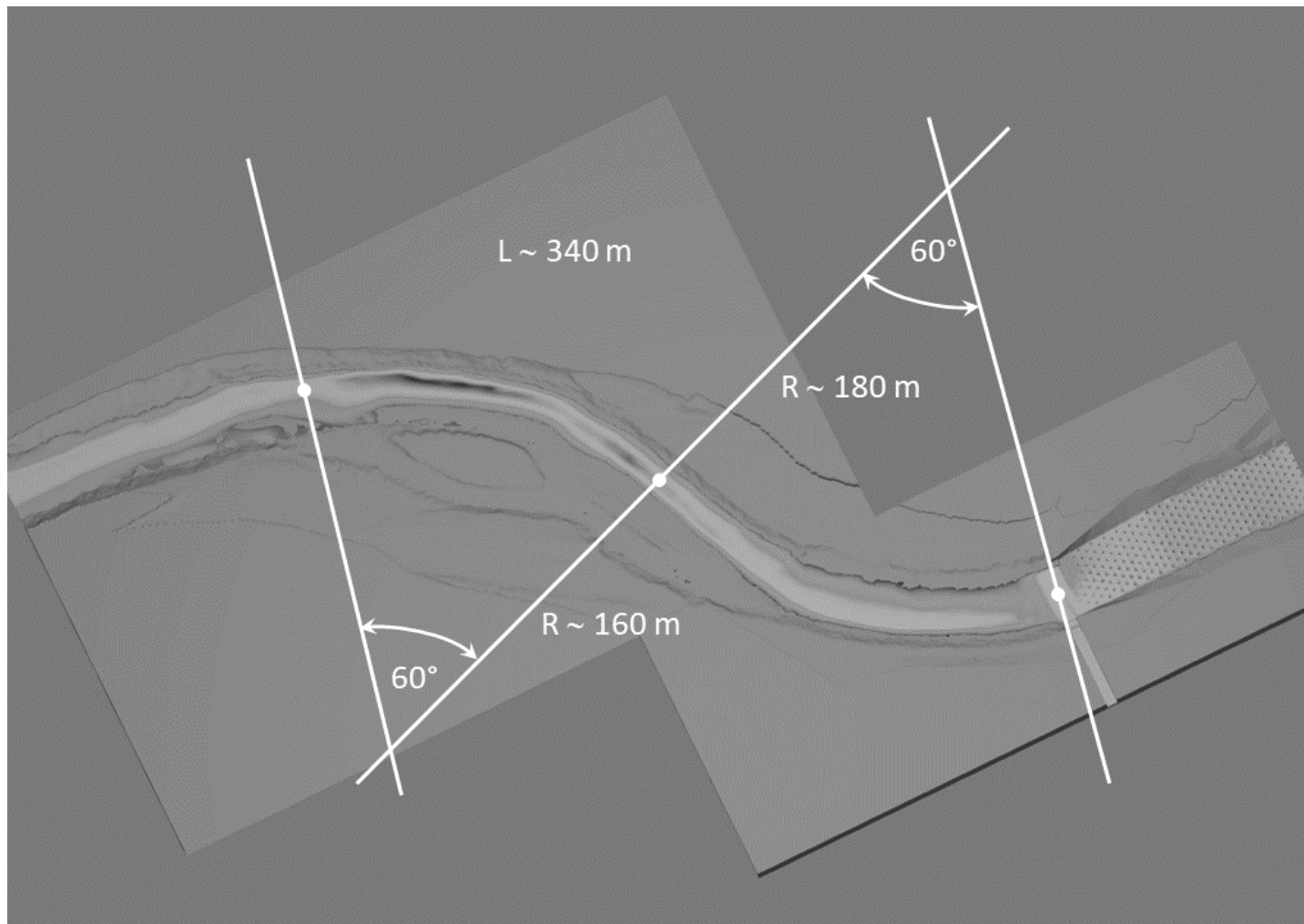
- Built: 1948
- Latest modification: 1974
- Side intake for agricultural irrigation:
1.5 m³/s



- Main fish species: trout
- Located at the end of a river bend

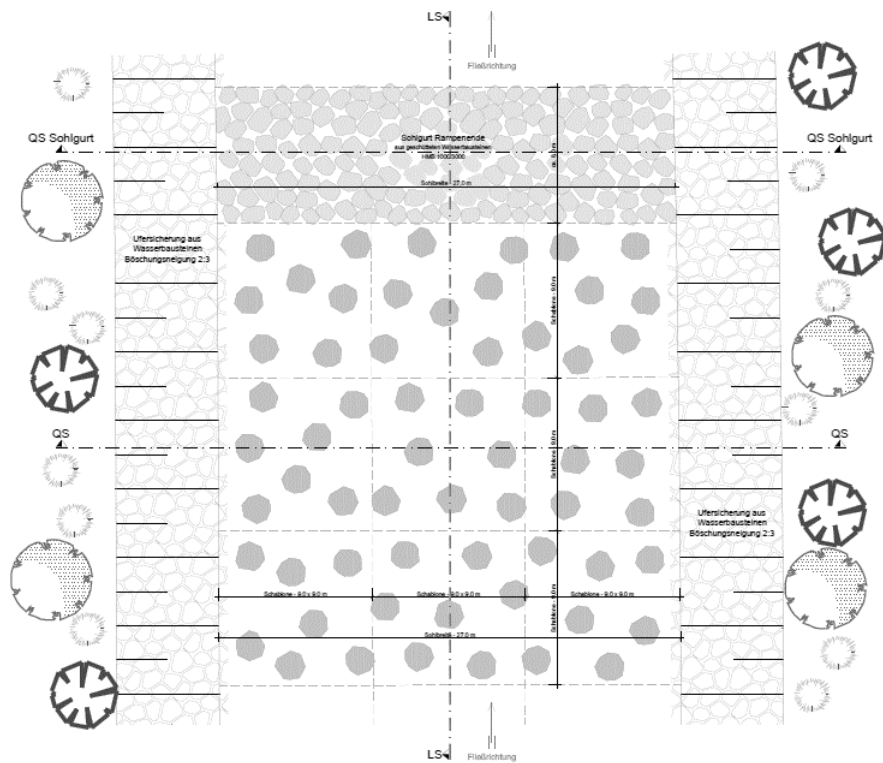
Weir / unstructured block ramp - Brunau

- The geometric features of the approaching river represent a typical Alpine river bend

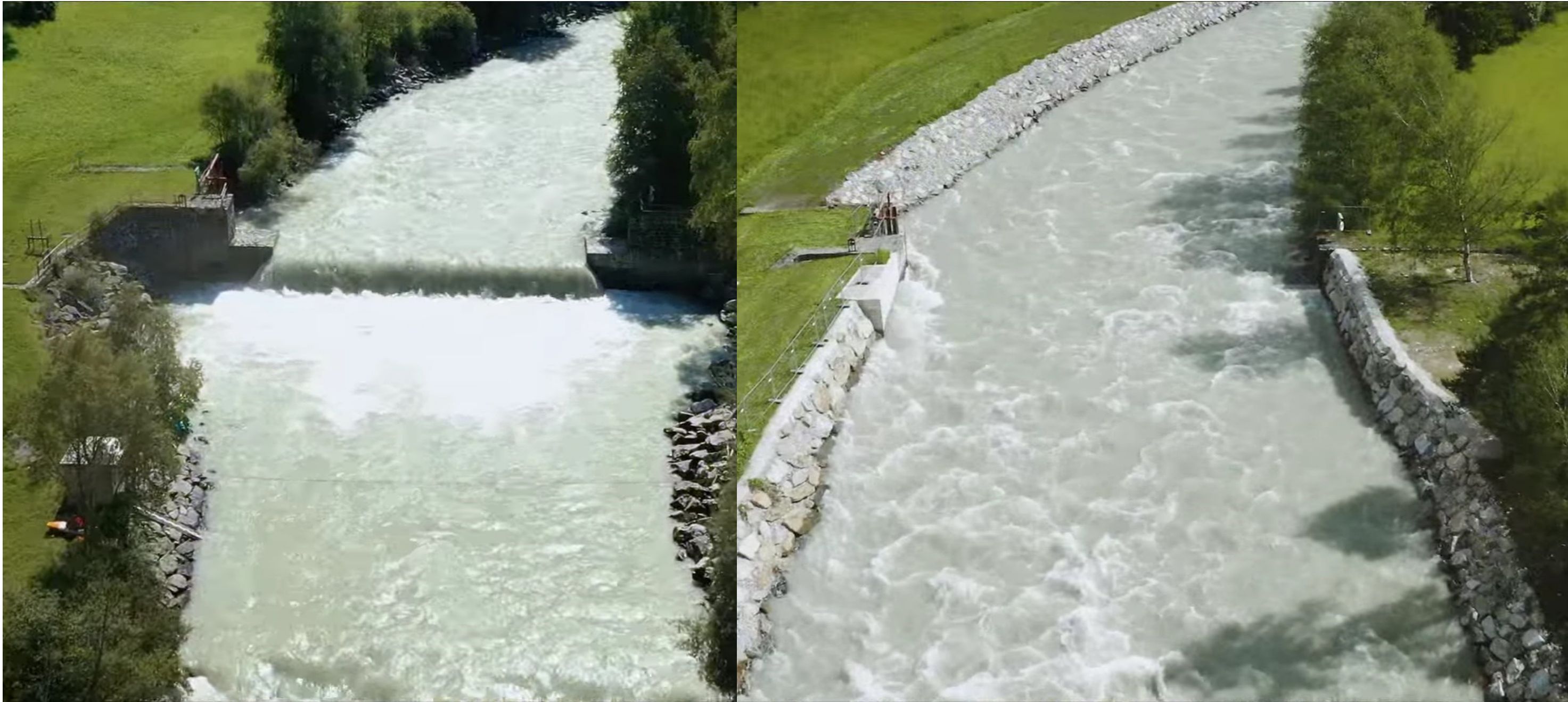


Weir / unstructured block ramp - Brunau

- Replacing the weir by an unstructured block ramp, regarding design guidelines, VAW 240 (2017)
- Stabilising the riverbed, app. 300 m downstream, 1.9%, 1.6 m diameter
- Possibility of upstream migration for fish and macrobenthos



Weir / unstructured block ramp - Brunau



Numerical investigation - FLOW-3D[®] HYDRO

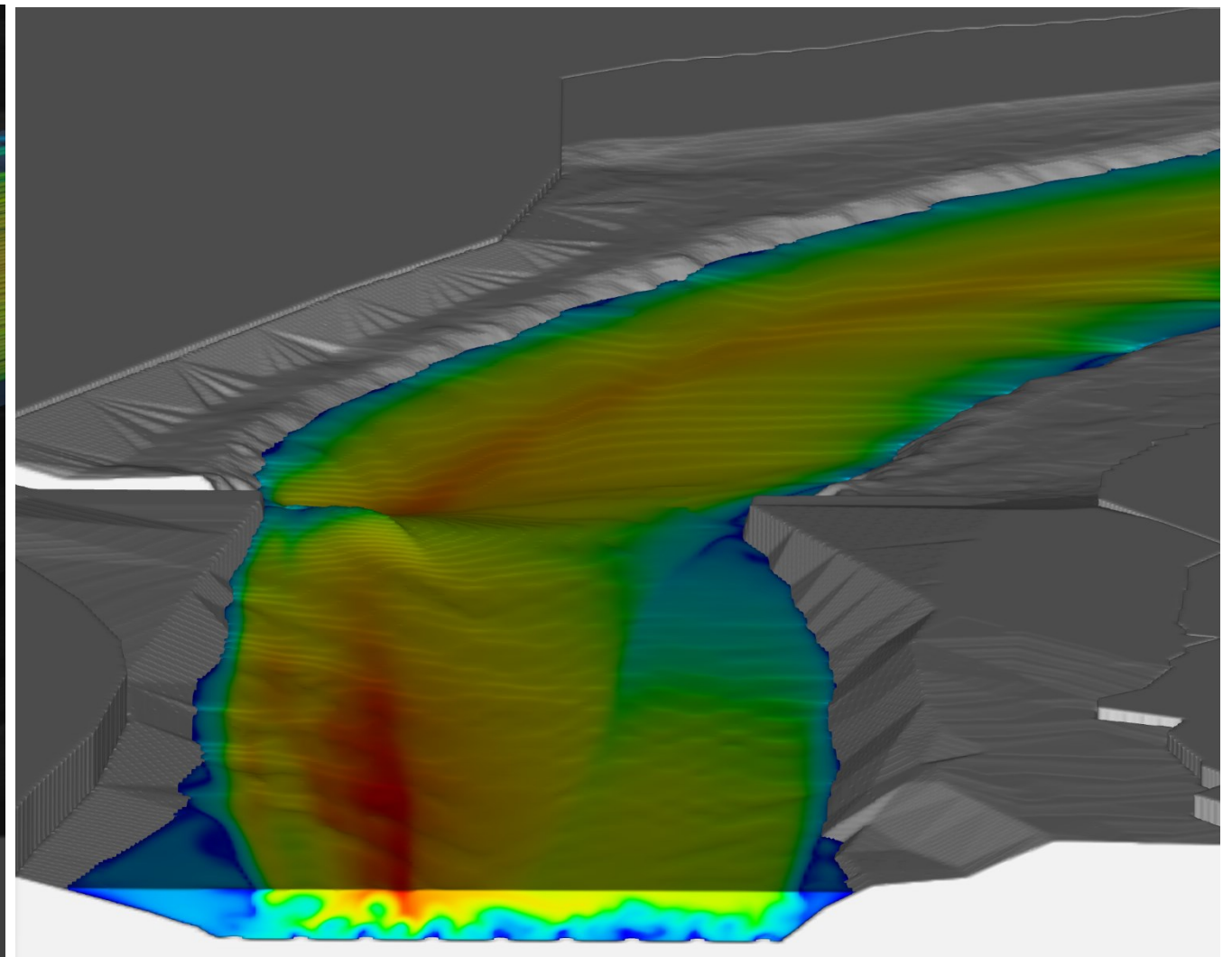
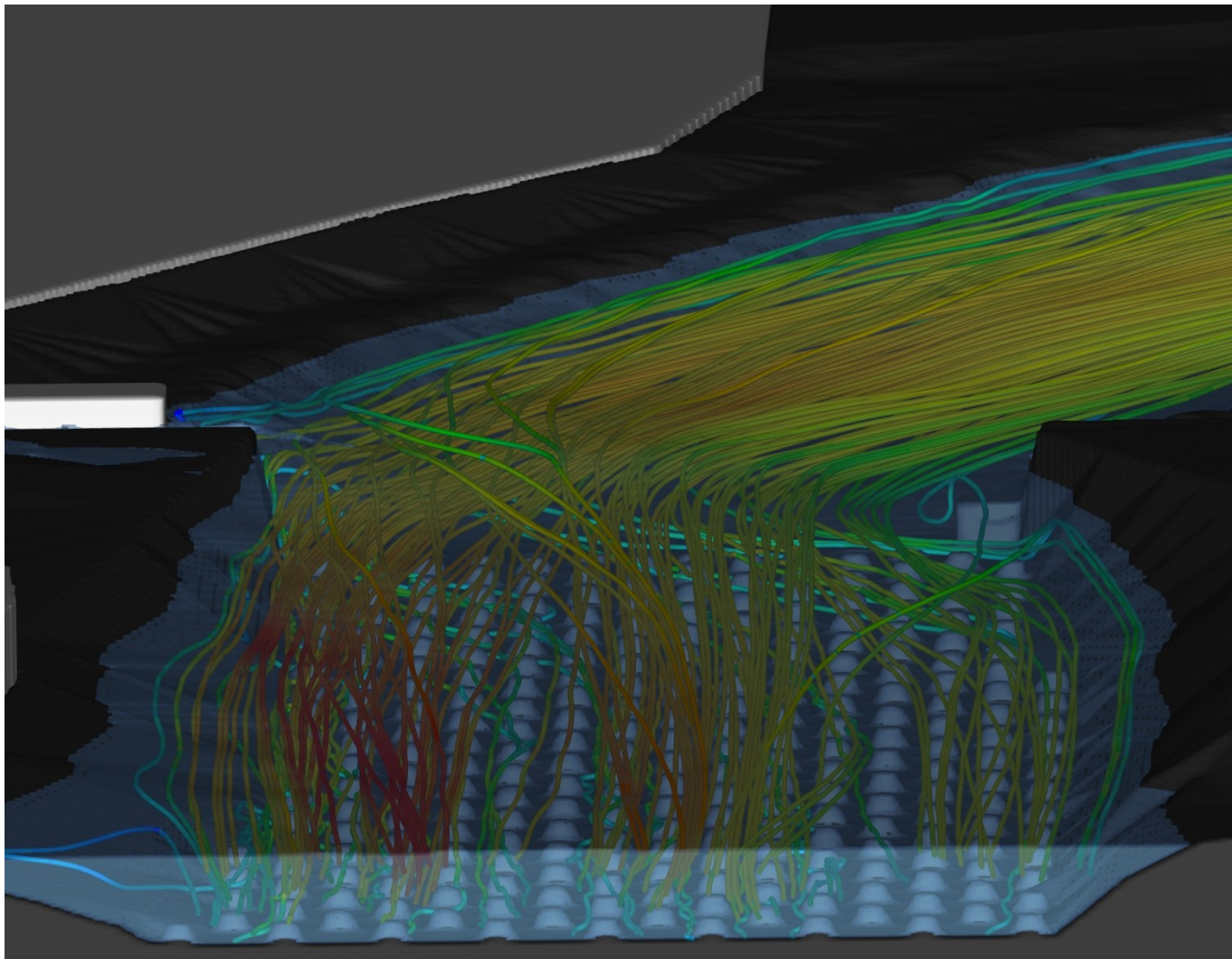
- 3D-CFD Code for all kinds of flow scenarios
- Easy to use for efficient setup
- Additional models for special tasks
- Free surface (TruVOF[®]) and pressured flows
- Sediment
- Air entrainment
-



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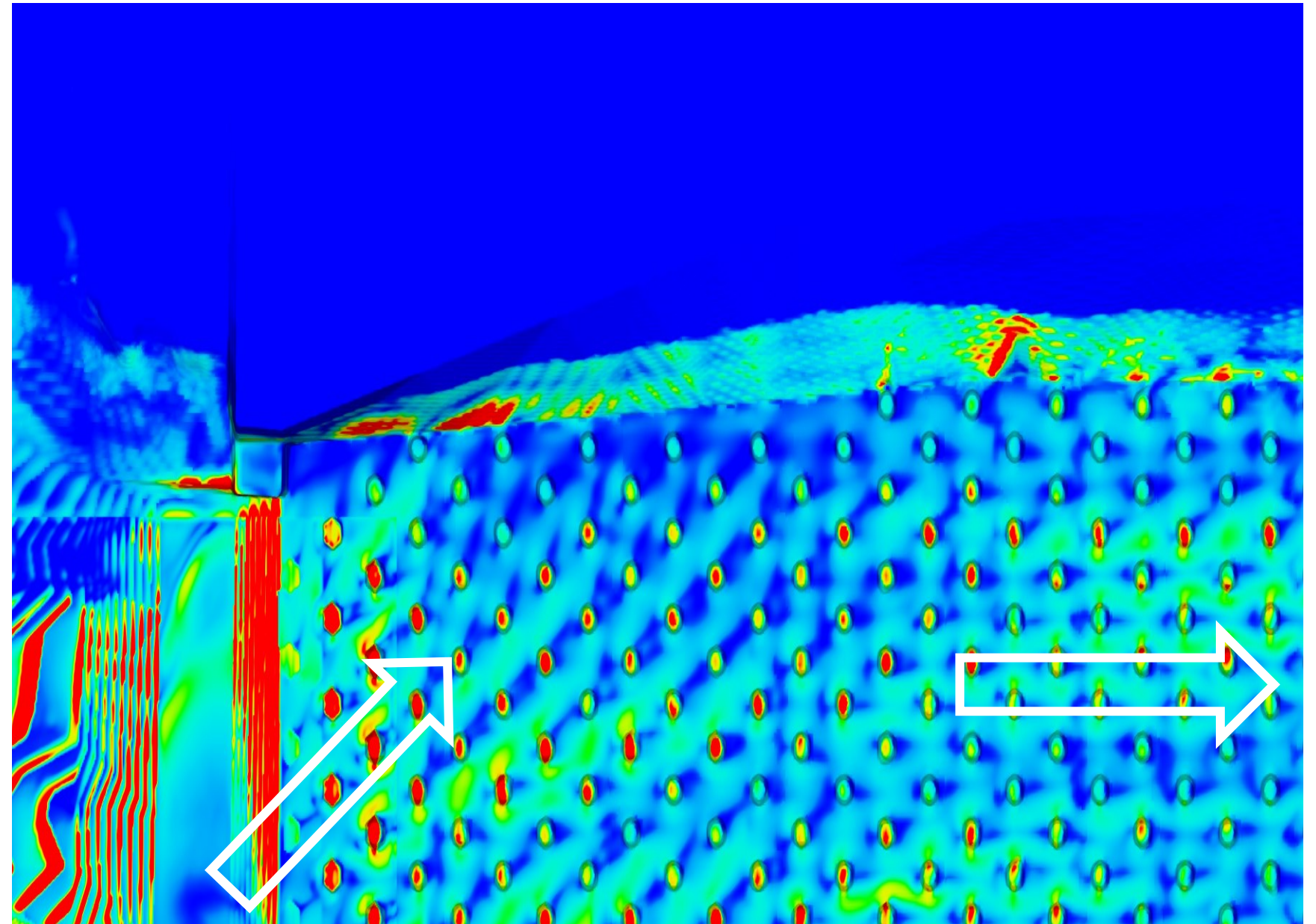
Numerical investigation

- Spiral flow and flow concentration on the outer side at the end of the bend affect the beginning of the ramp



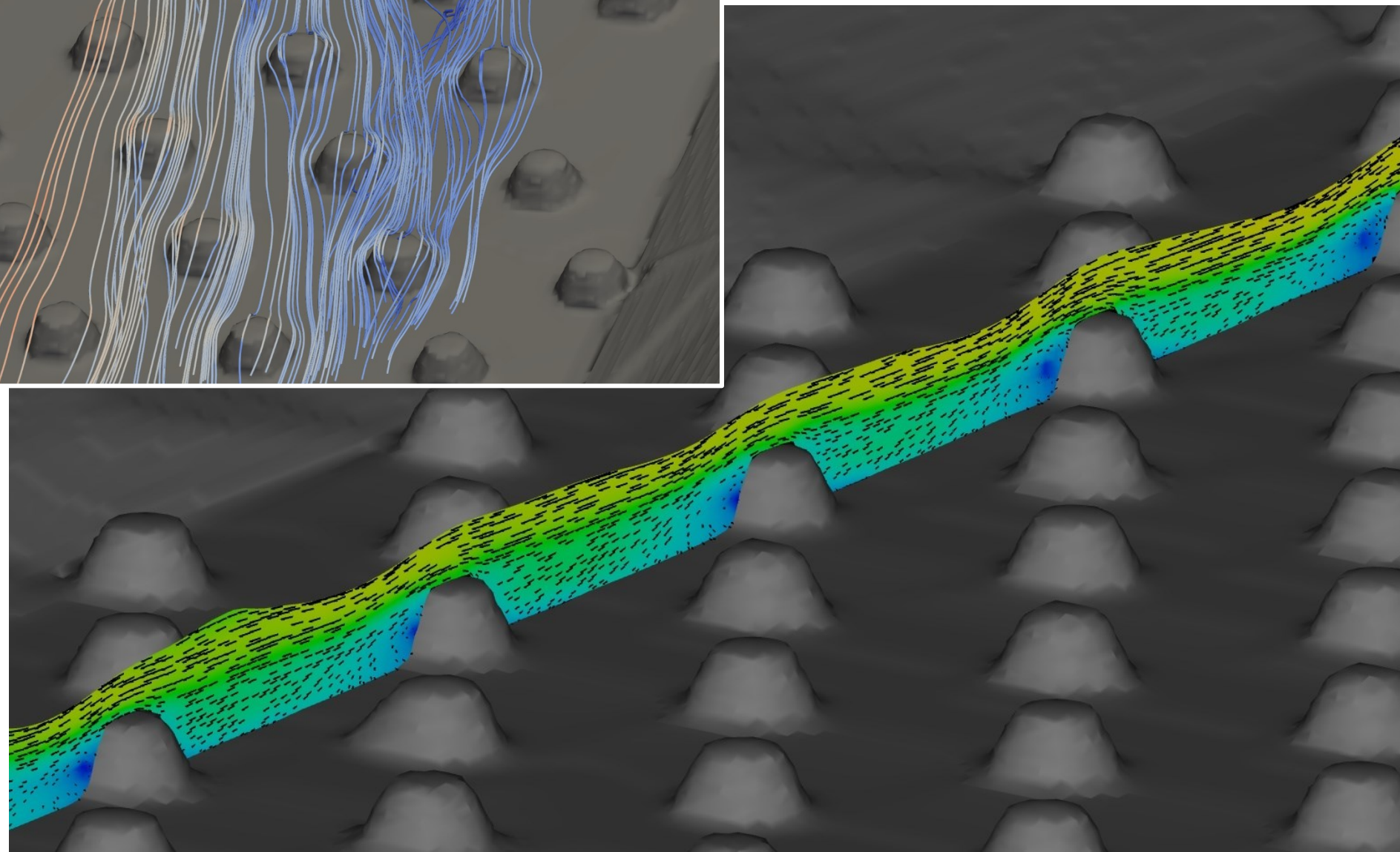
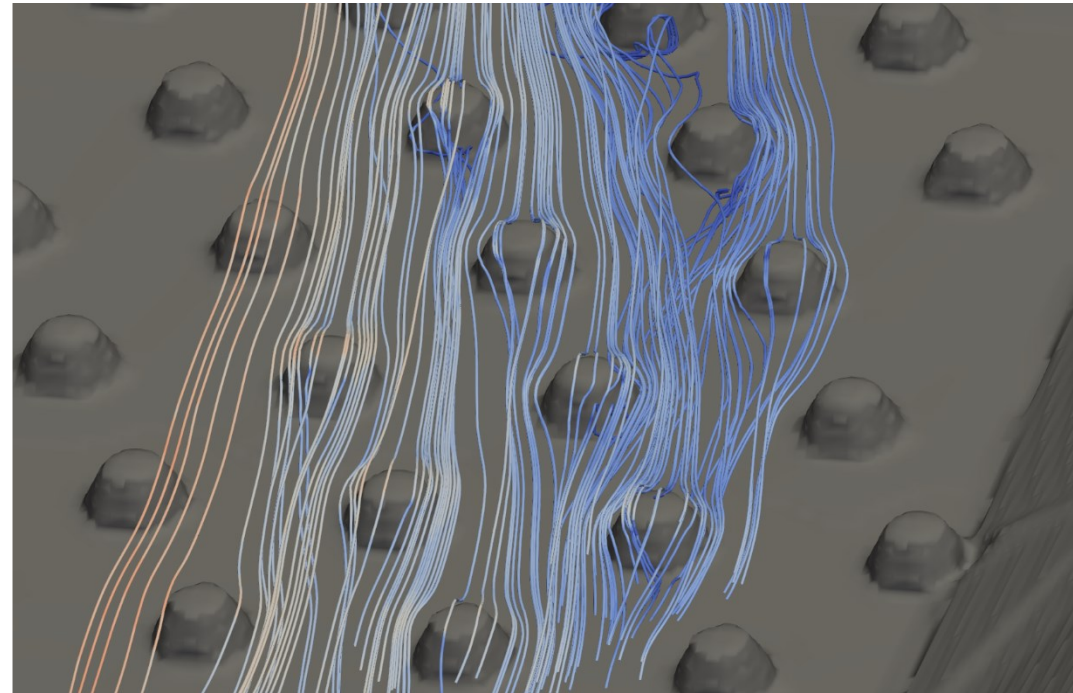
Numerical investigation

- Bed shear stress distribution at the beginning of the ramp
- Shows effect of the spiral flow coming out of the bend
- Blocks must be shifted to “break” the actual forces on the bed
- Required according to guideline



Numerical investigation

- Velocity between the blocks
- Provides all the details needed to check whether a flow situation is acceptable for fish

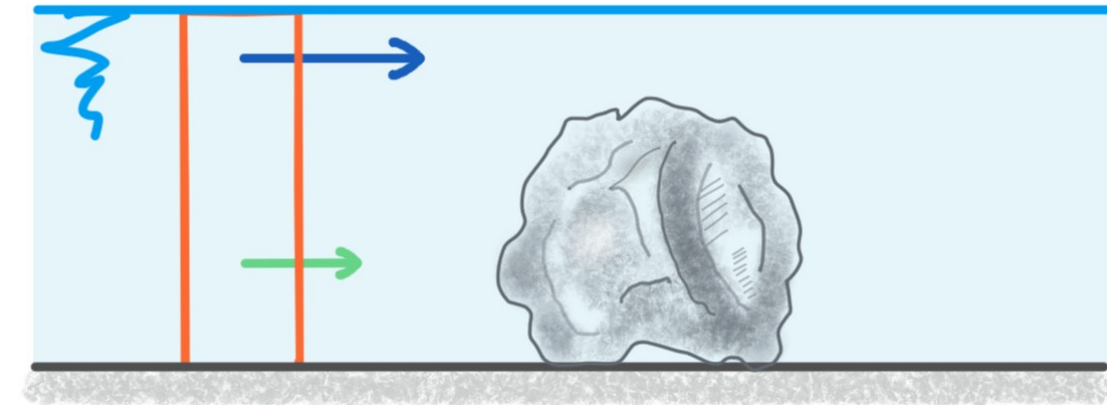


Why using 3D code for this projects 3D flow situation

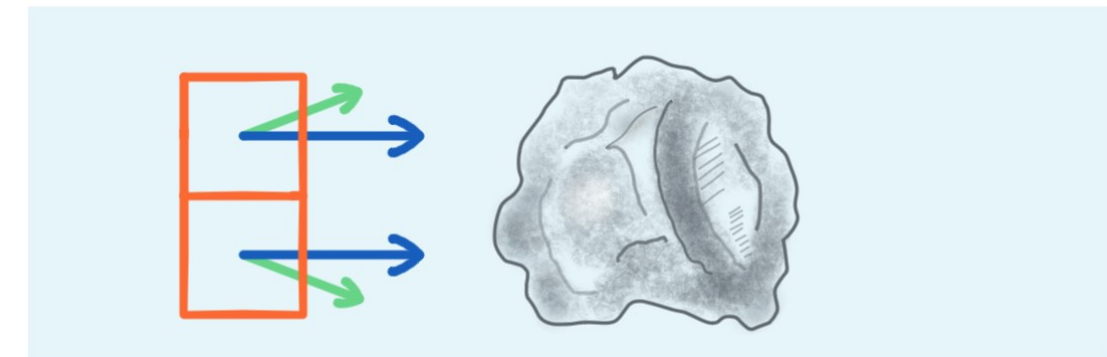
Basic preconditions for 2D codes

- $x, y \gg z$ & $u, v, \gg w$
- Constant conditions in z-direction

side view →

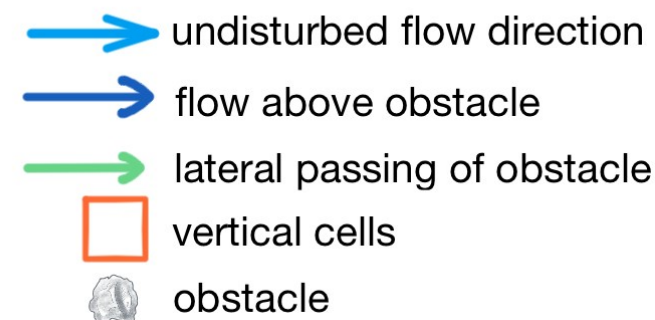


top view →



In many real situations we have

- Gradients in vertical direction
- Non hydrostatic pressure
- Velocities have directions

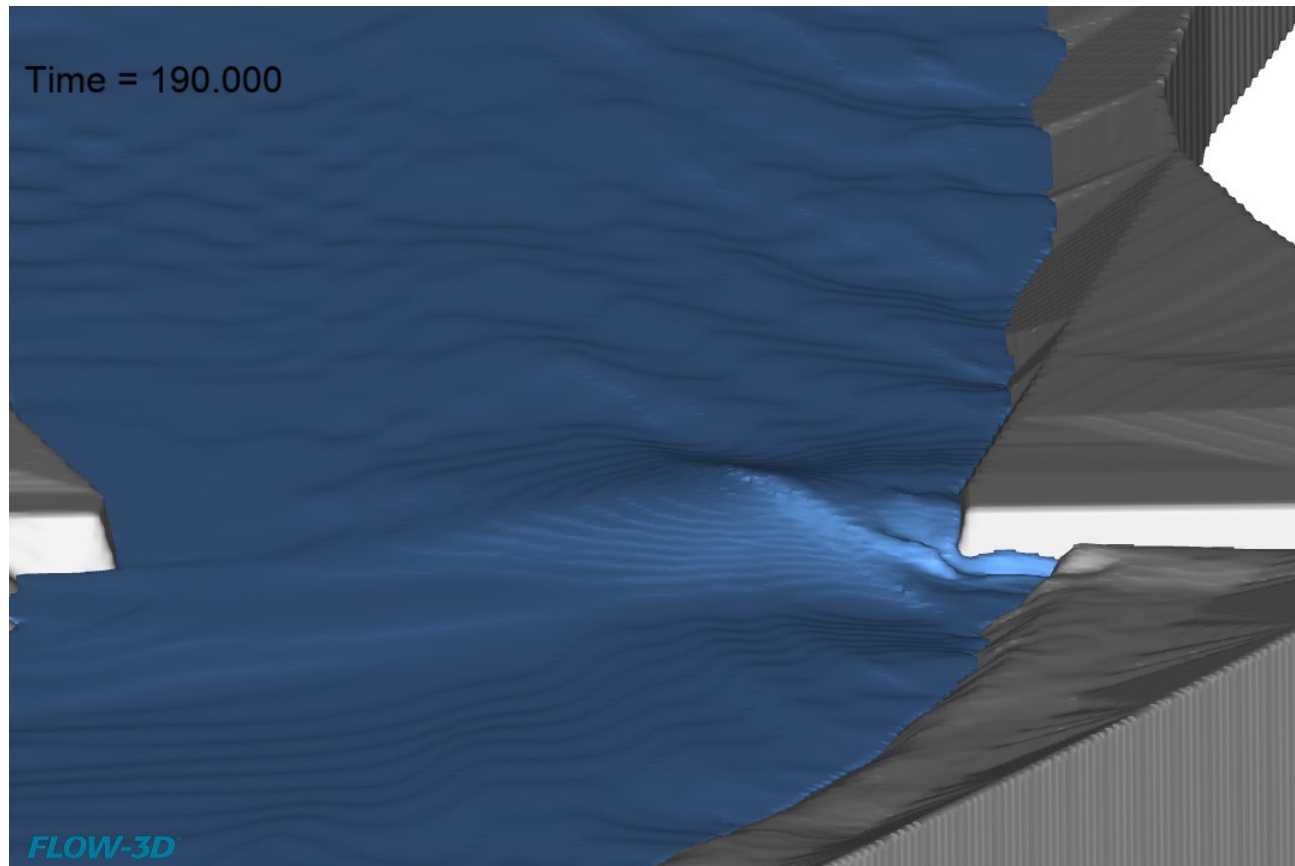


Numerical investigation

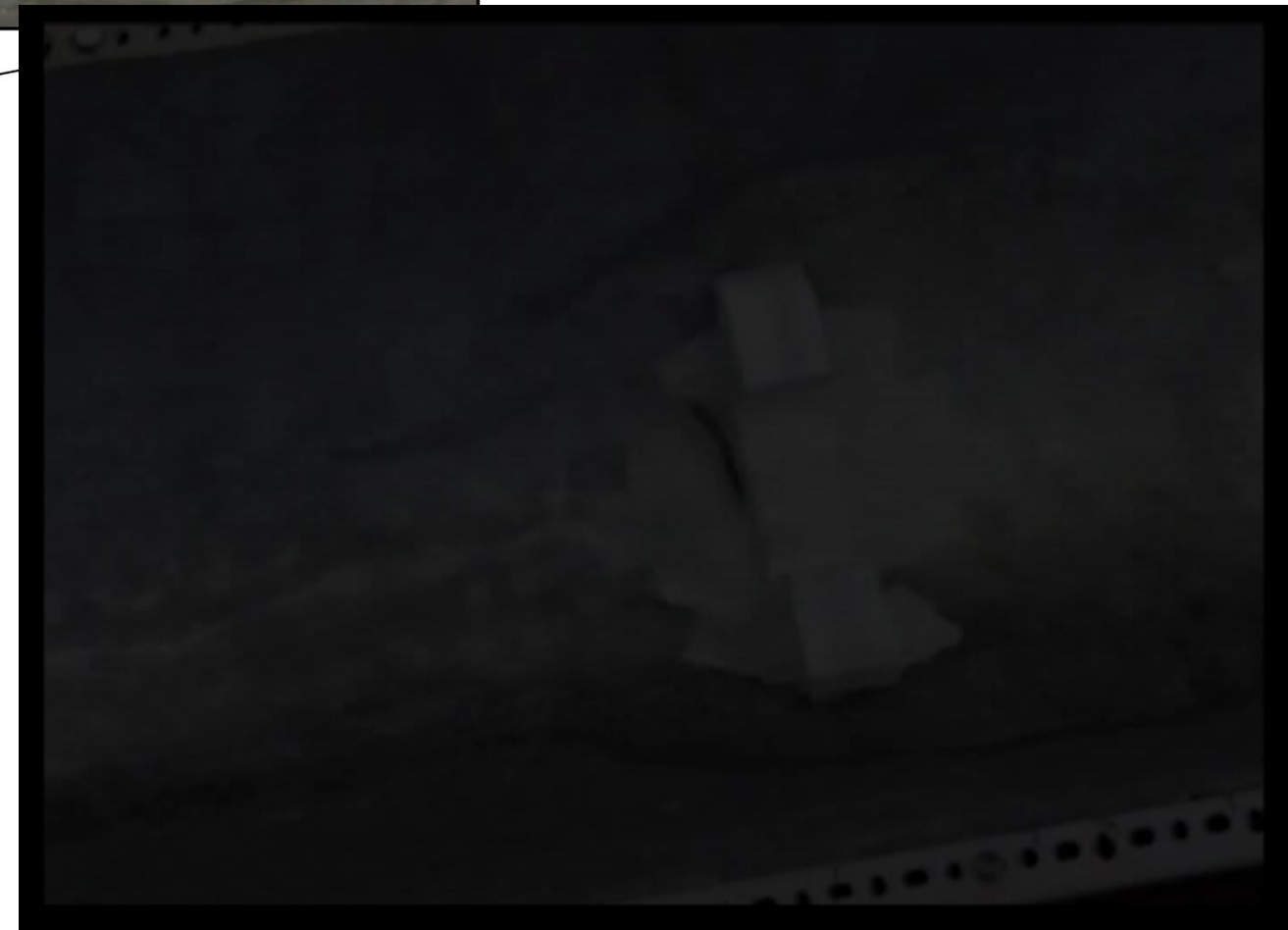
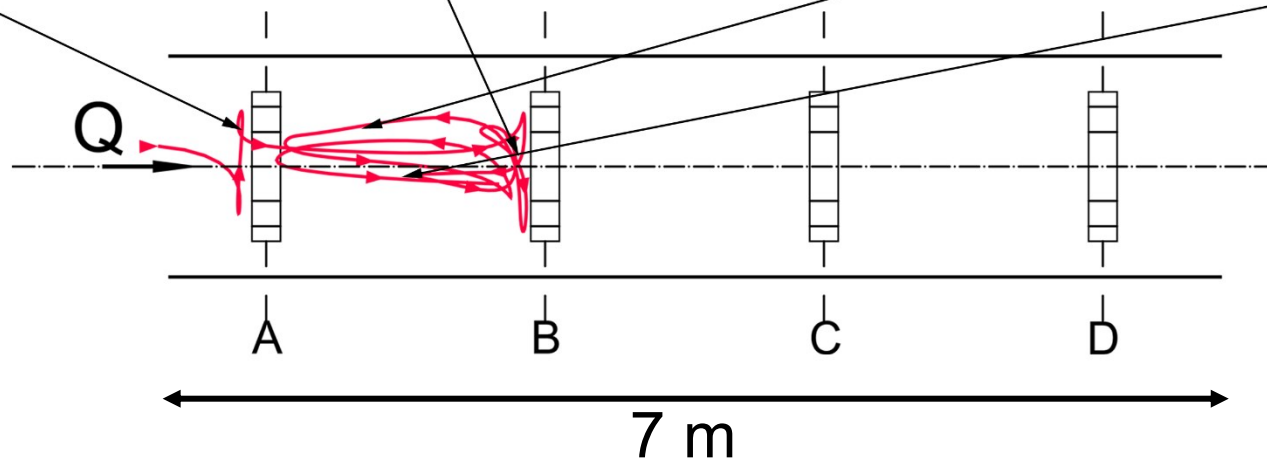
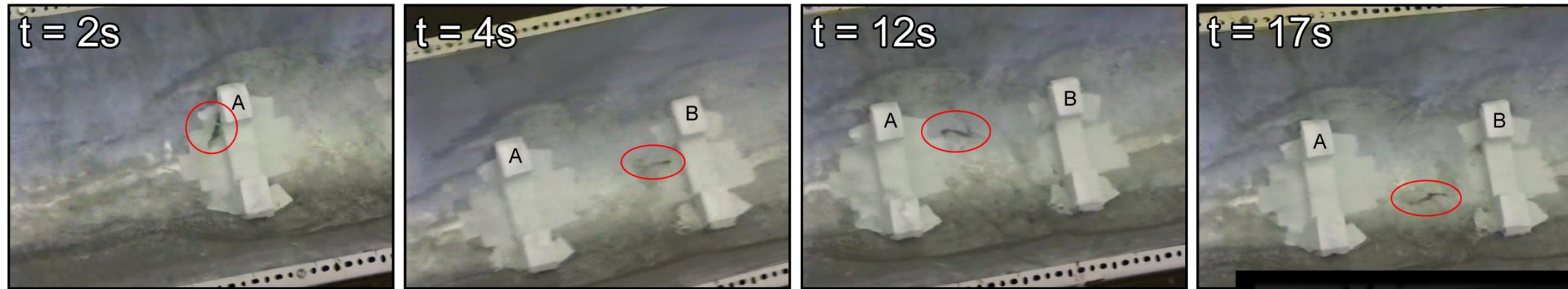
- Video comparison - flood event

350 m³/s looking downstream

400 m³/s looking upstream

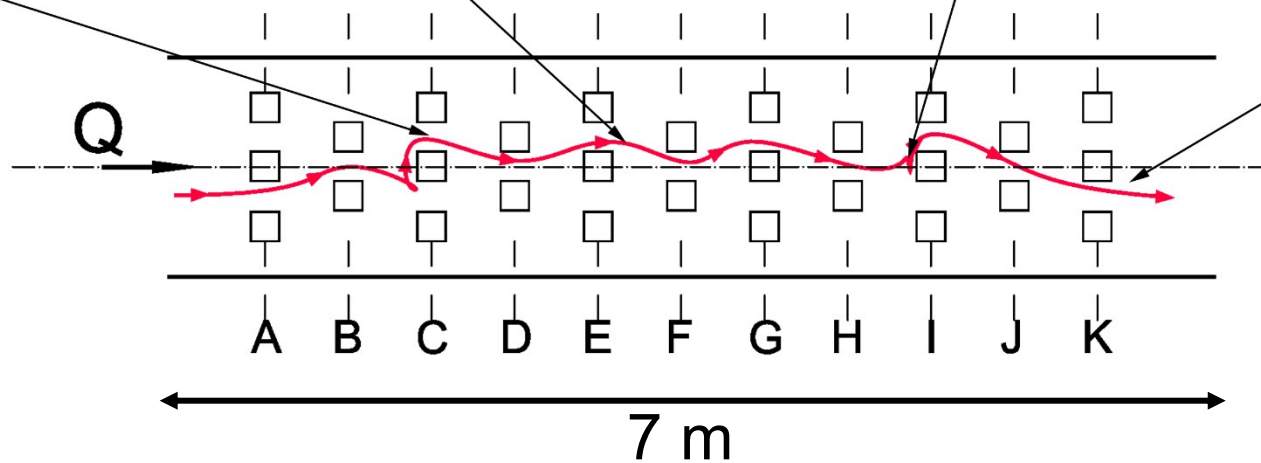
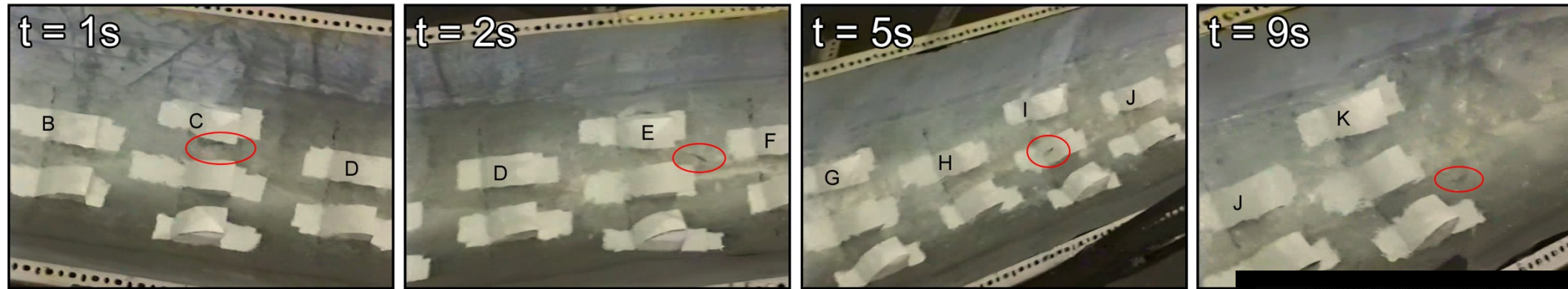


Are irregular blocks usable for upstream migration?



- Test pilot: *Galaxias maculatus* (inanga)
- Test environment: Alberta fish weir

Are irregular blocks usable for upstream migration?



- Test pilot: *Galaxias maculatus* (inanga)
- Test environment: spoiler baffle

Summary

- 2D simulations are not made for looking at the details of local flow situations
- Depth averaging is doubtful for different flow directions in vertical direction
- Vertical flow distribution essential for fish
- 3D simulations deliver exactly the data needed to explore the most diverse flow situations for fish and macrobenthos
- “Baffle system” provides a usable bed environment for migration
- What helps fish to migrate upstream helps humans to migrate downstream (rafting)



THANK YOU