Safe downstream migration of Atlantic salmon past hydropower intakes

– New research and technologies

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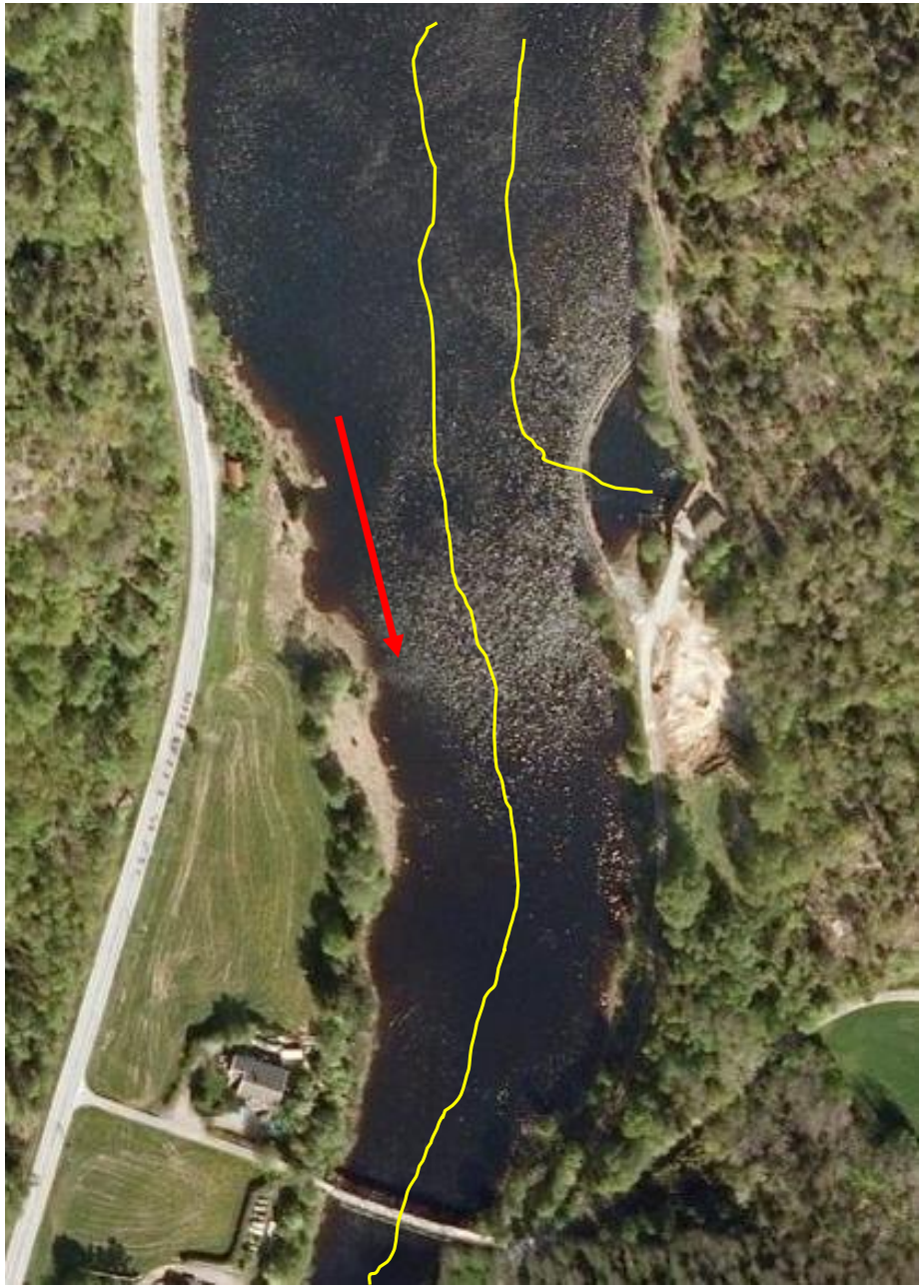
Hans-Petter Fjeldstad
SINTEF Energy
Hans-petter.fjeldstad@sintef.no

In collaboration with:

-Torbjørn Forseth and Ana T. Silva, NINA, Norway
-Henrik Baktoft, Danish Technical University
-Knut Alfredsen and Marcell Szabo-Meszaros, NTNU, Norway



We love jumping!


Safe bypass (90%)
Intake

Conducted studies

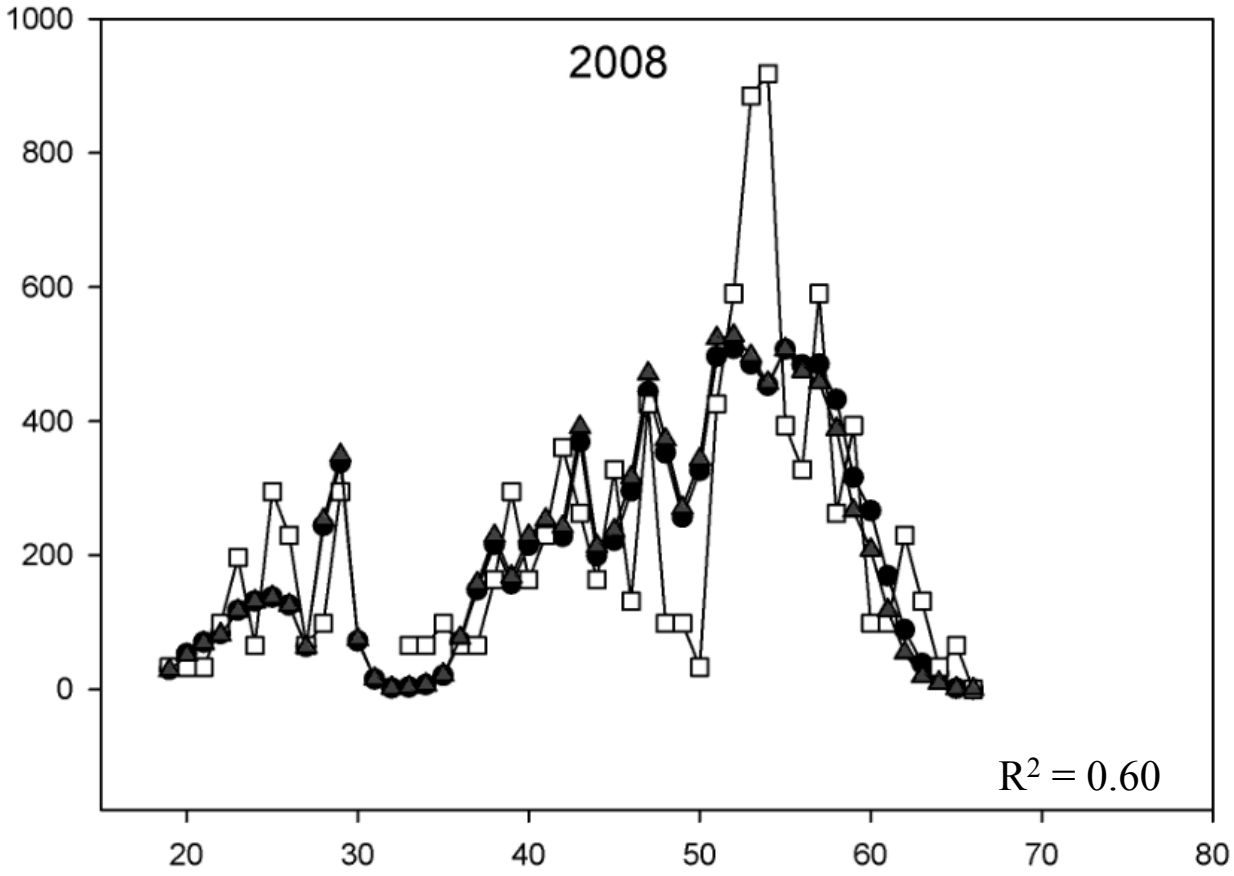
1. When do smolts migrate?
2. Where do the smolts migrate under a normal production regime (without flow mitigations)?
3. Can we influence the migration route through hydraulic and physical measures (strobe lights/ floating boom)?
4. 3D Telemetry linked with hydraulic modelling

Telemetry Experiments

Tagging of 450 smolt (2003-2015)

Smolt timing model

based on catches from an upstream rotary screw trap

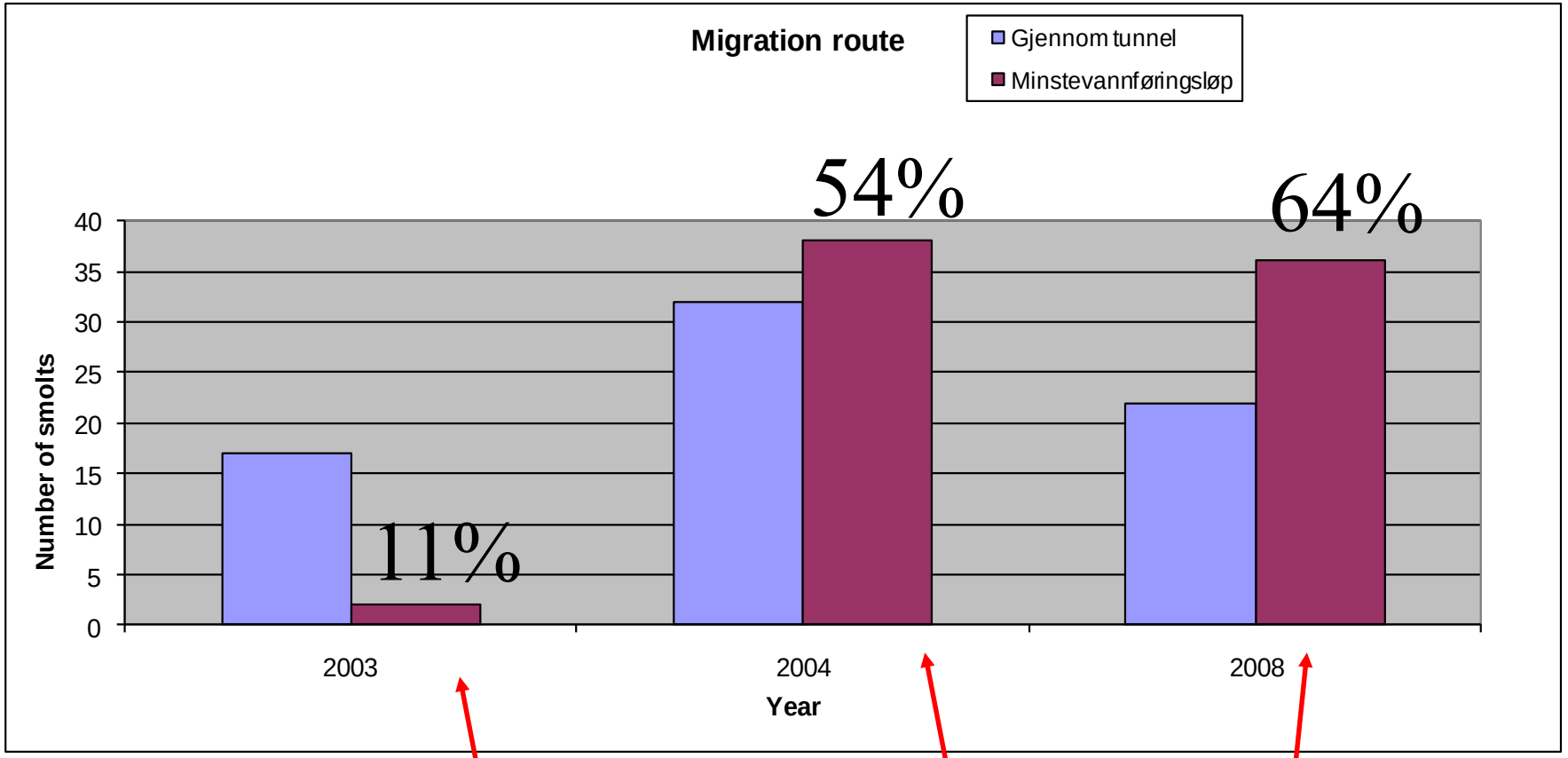


□ Observed smolt catches

● / ▲ Model predictions

Fjeldstad et al., 2012

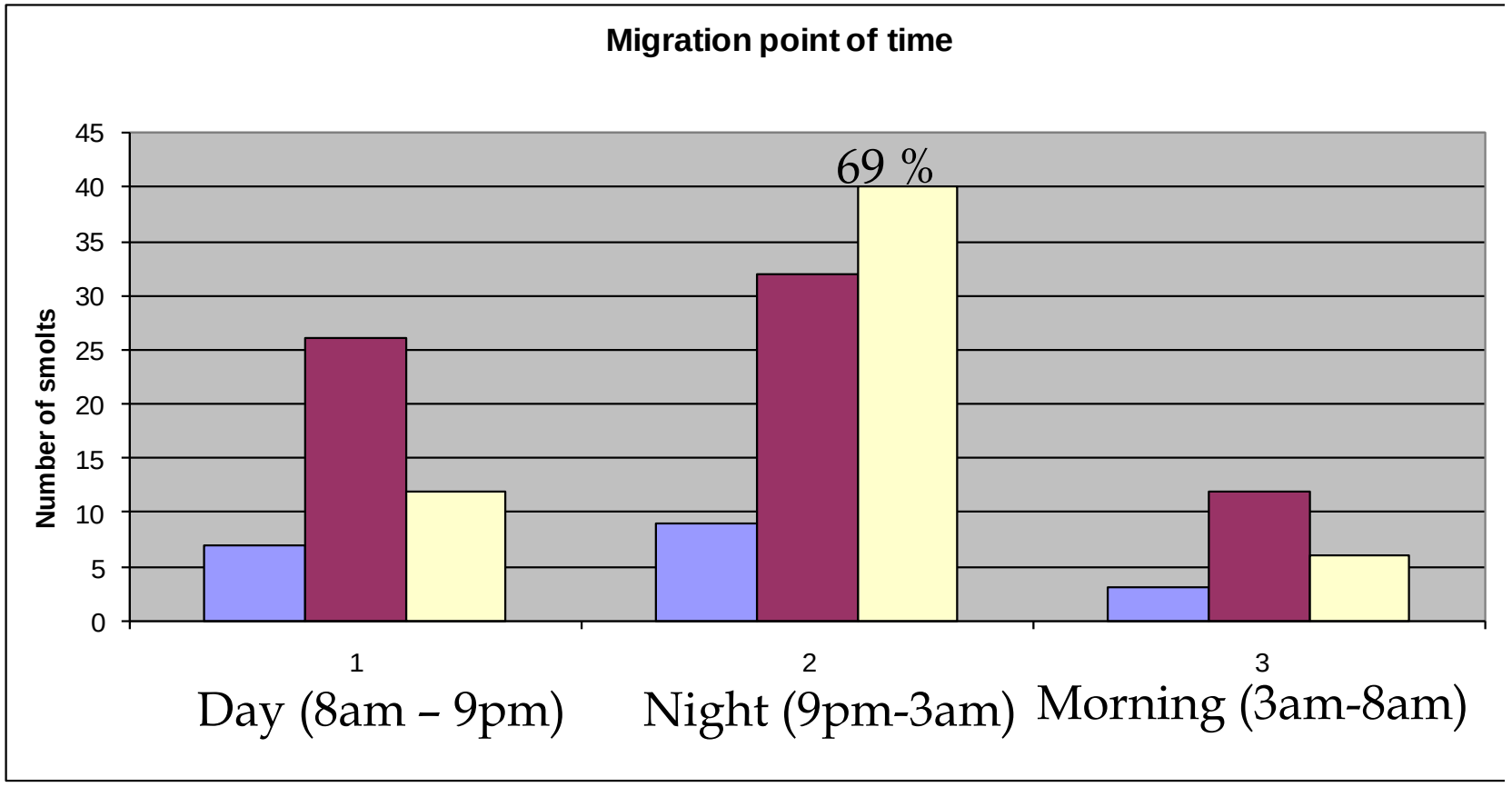
Impacts of increased bypass flow



Without targeted flood spill

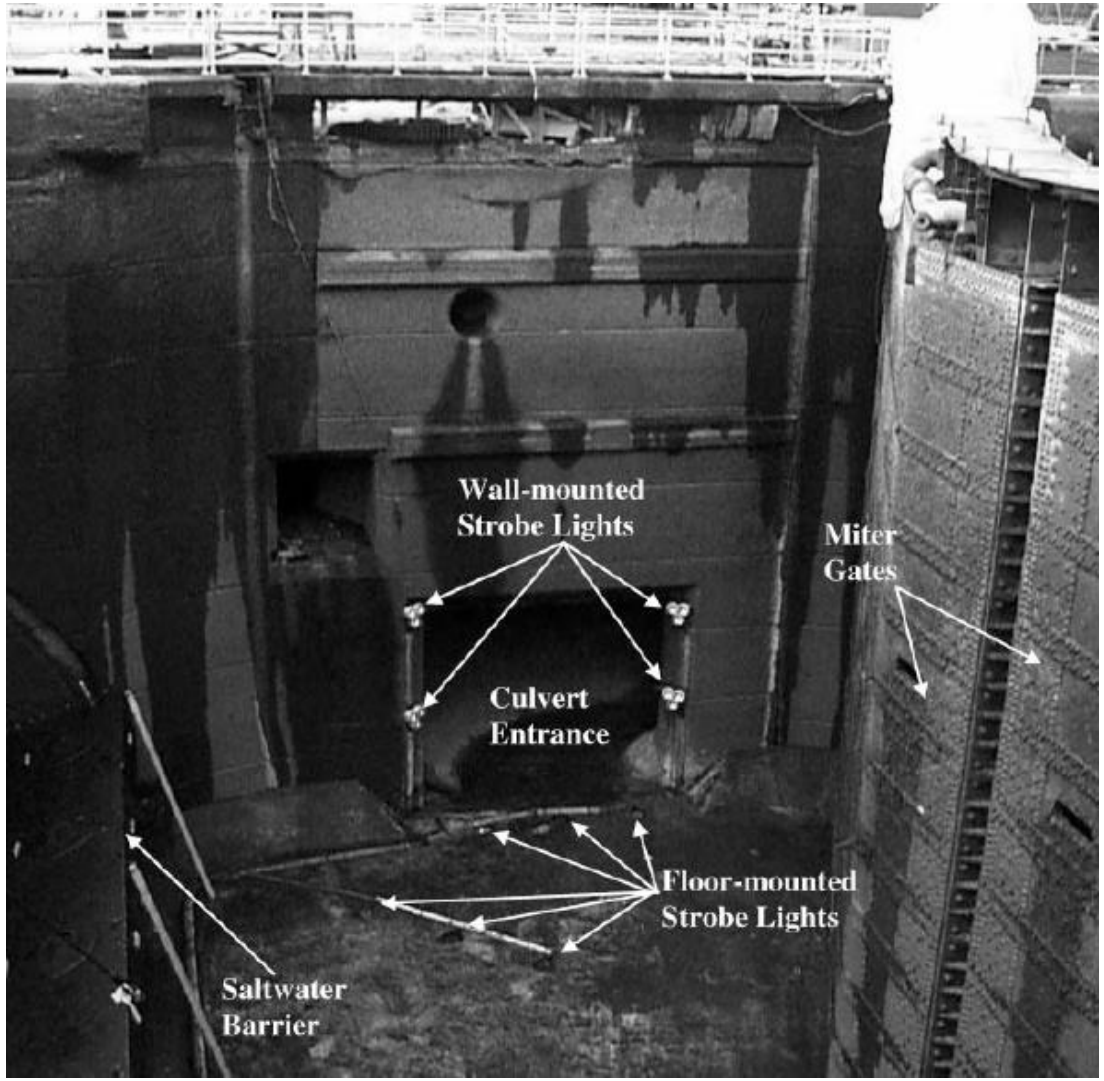
With extra bypass spill

Nightly reduction of power production seems to be successful

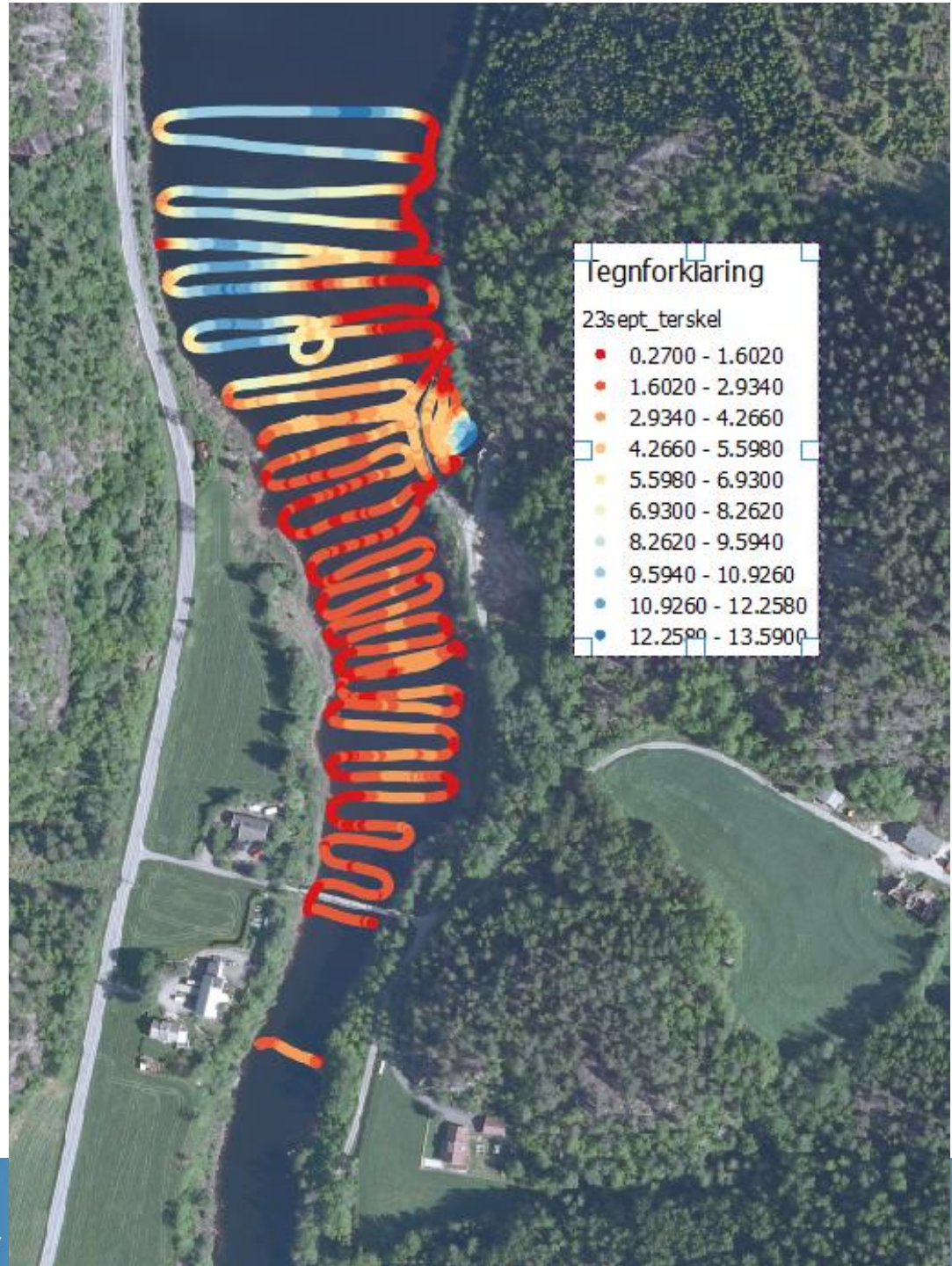


Strobe lights

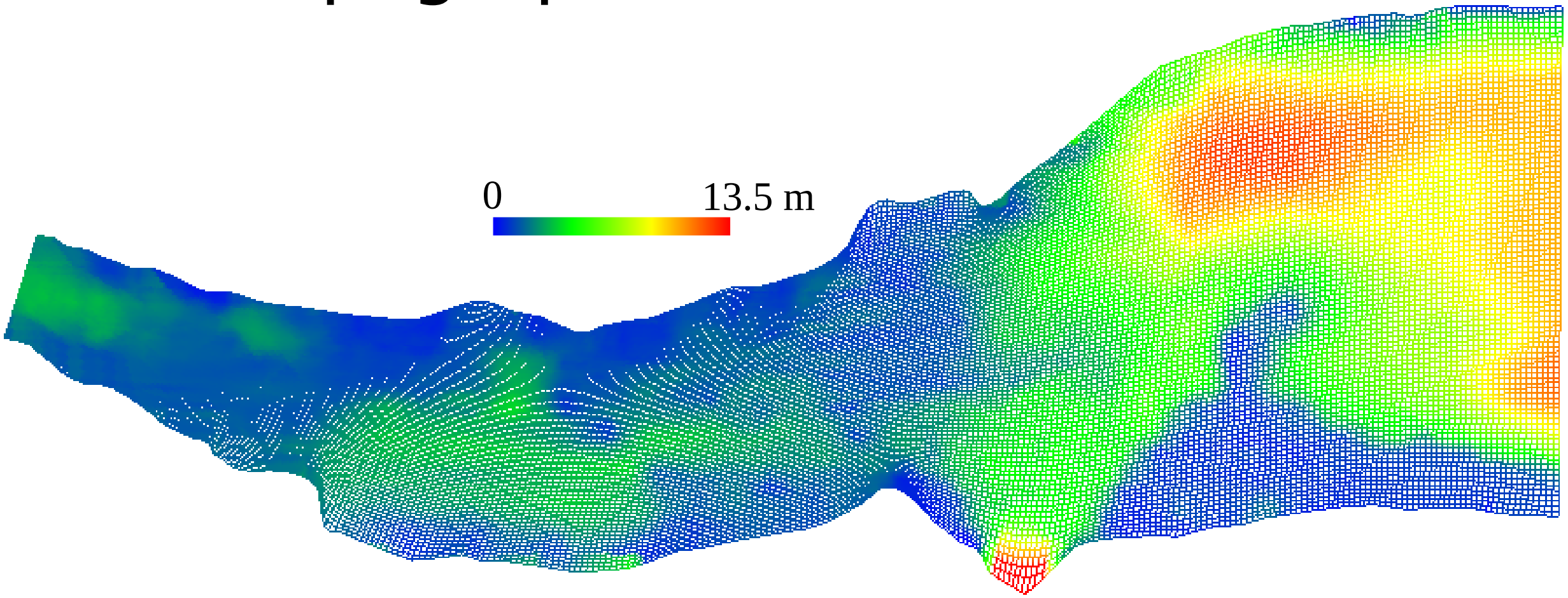
Significant impact in dark hours



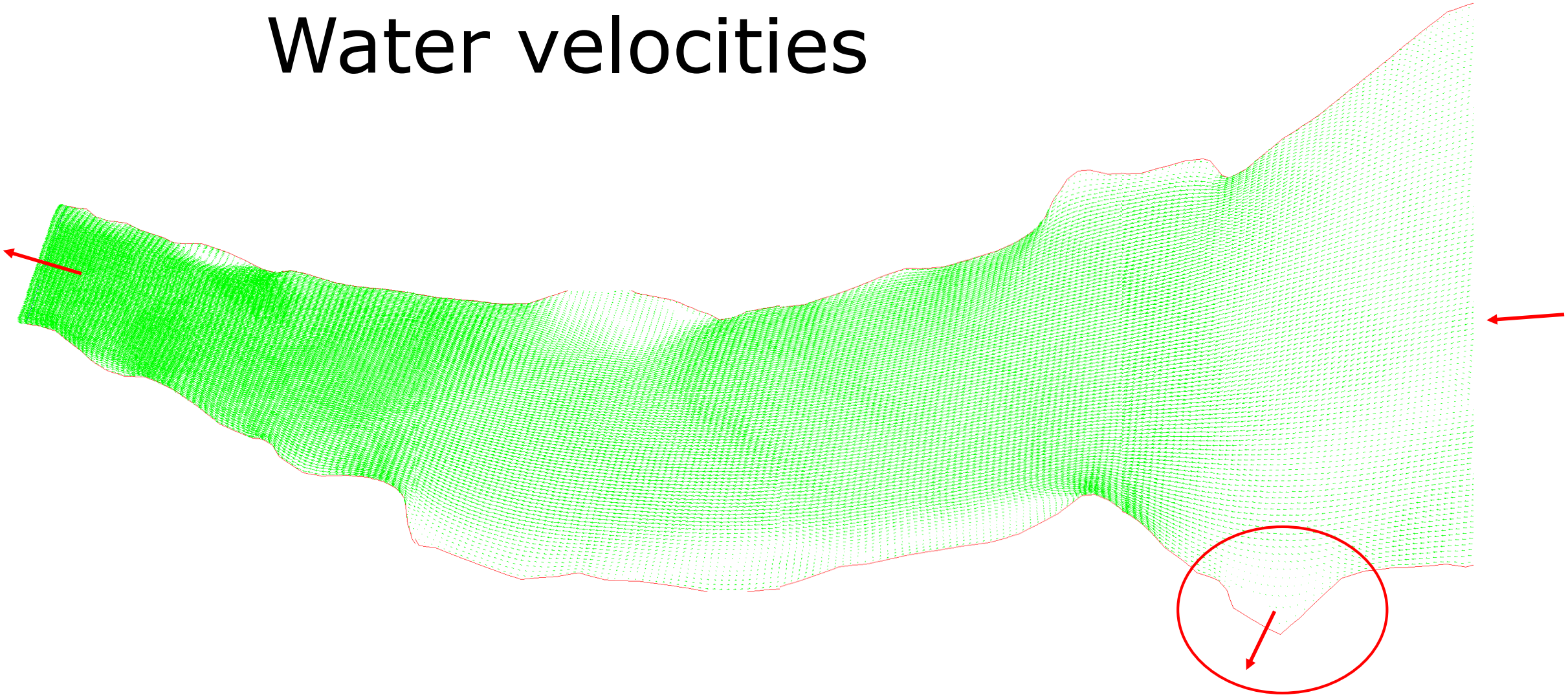
Surveying (RTK GPS combined with soundings and accoustic velocity measurements)

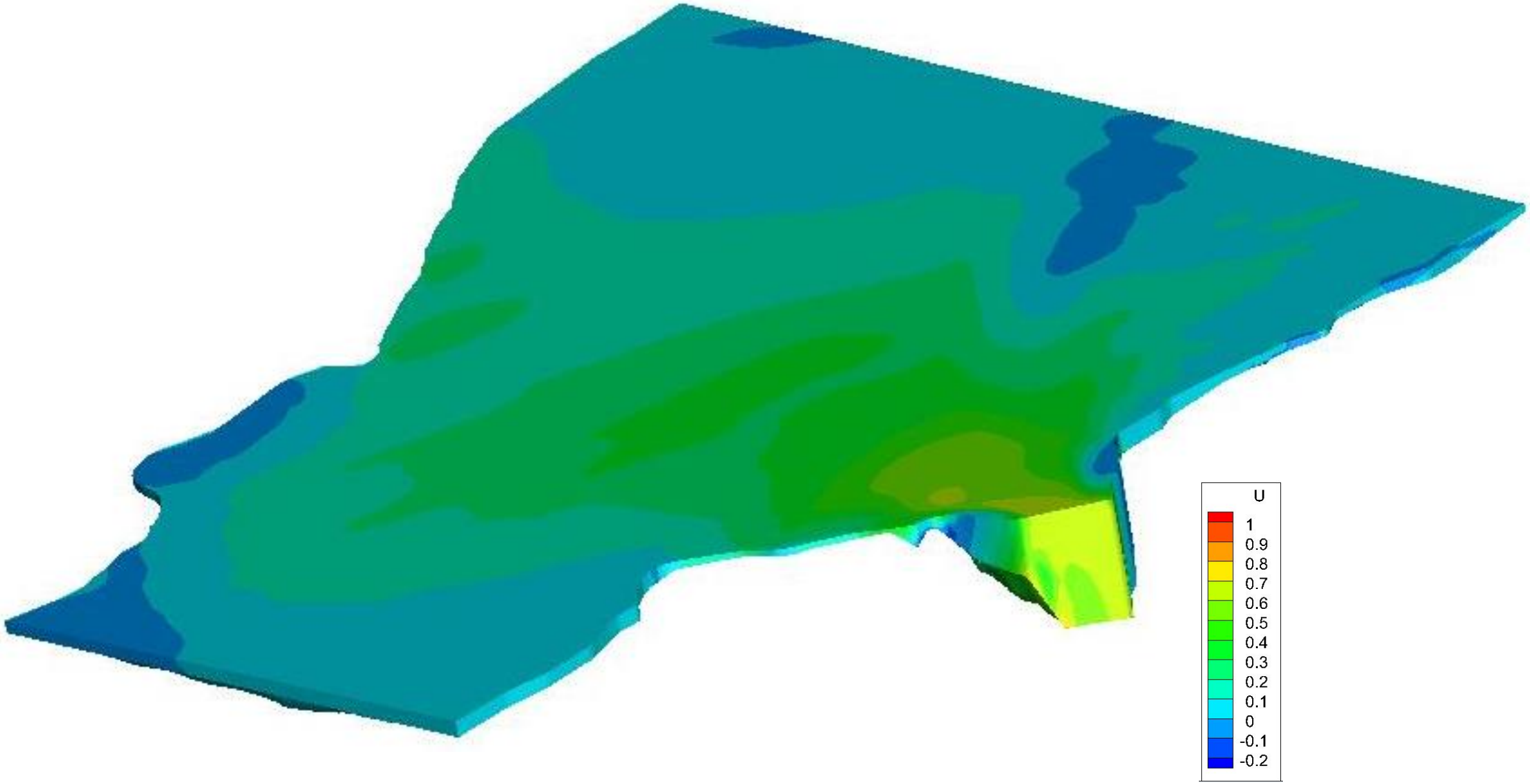


Topographic model



Water velocities

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0.1
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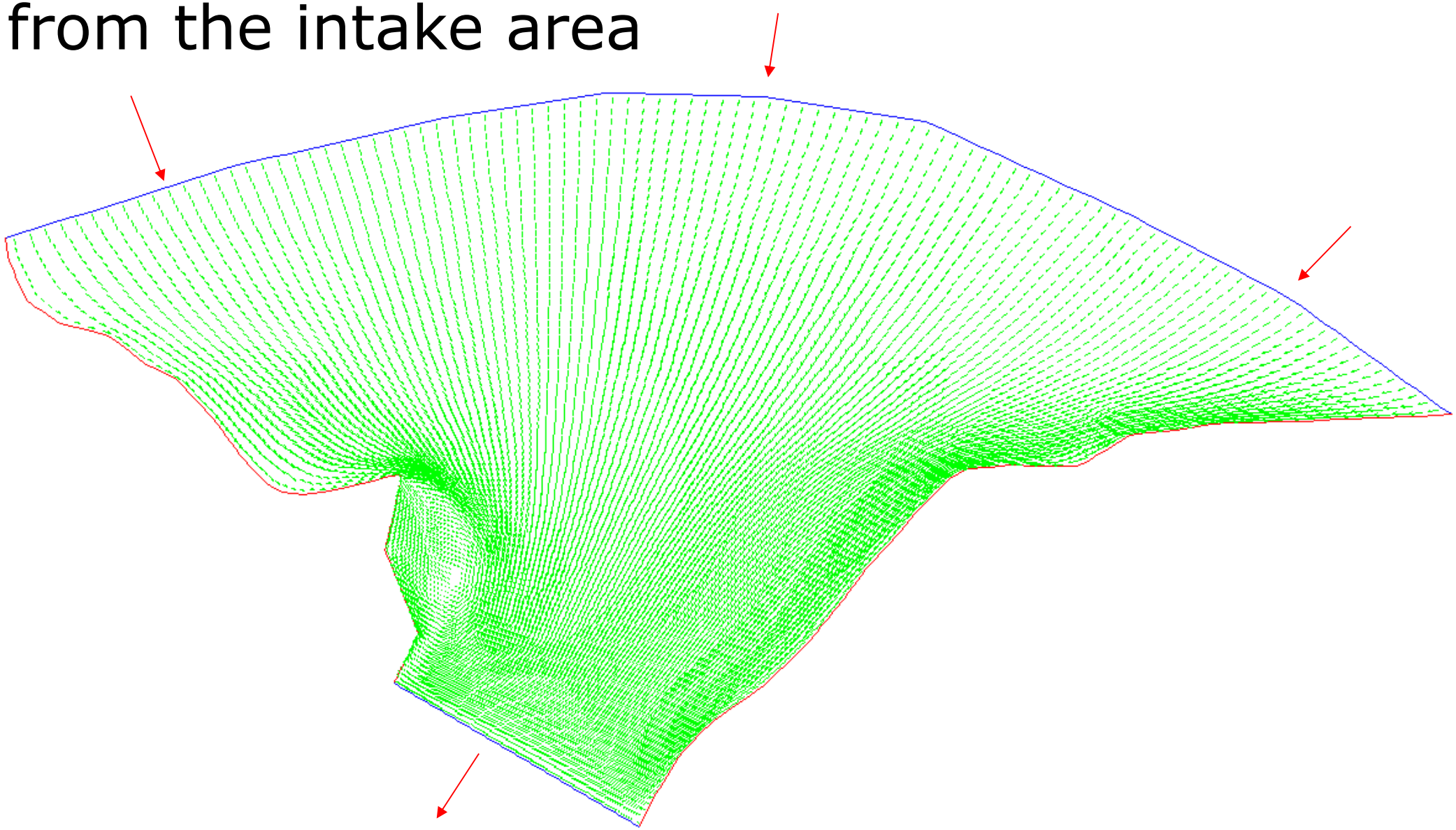
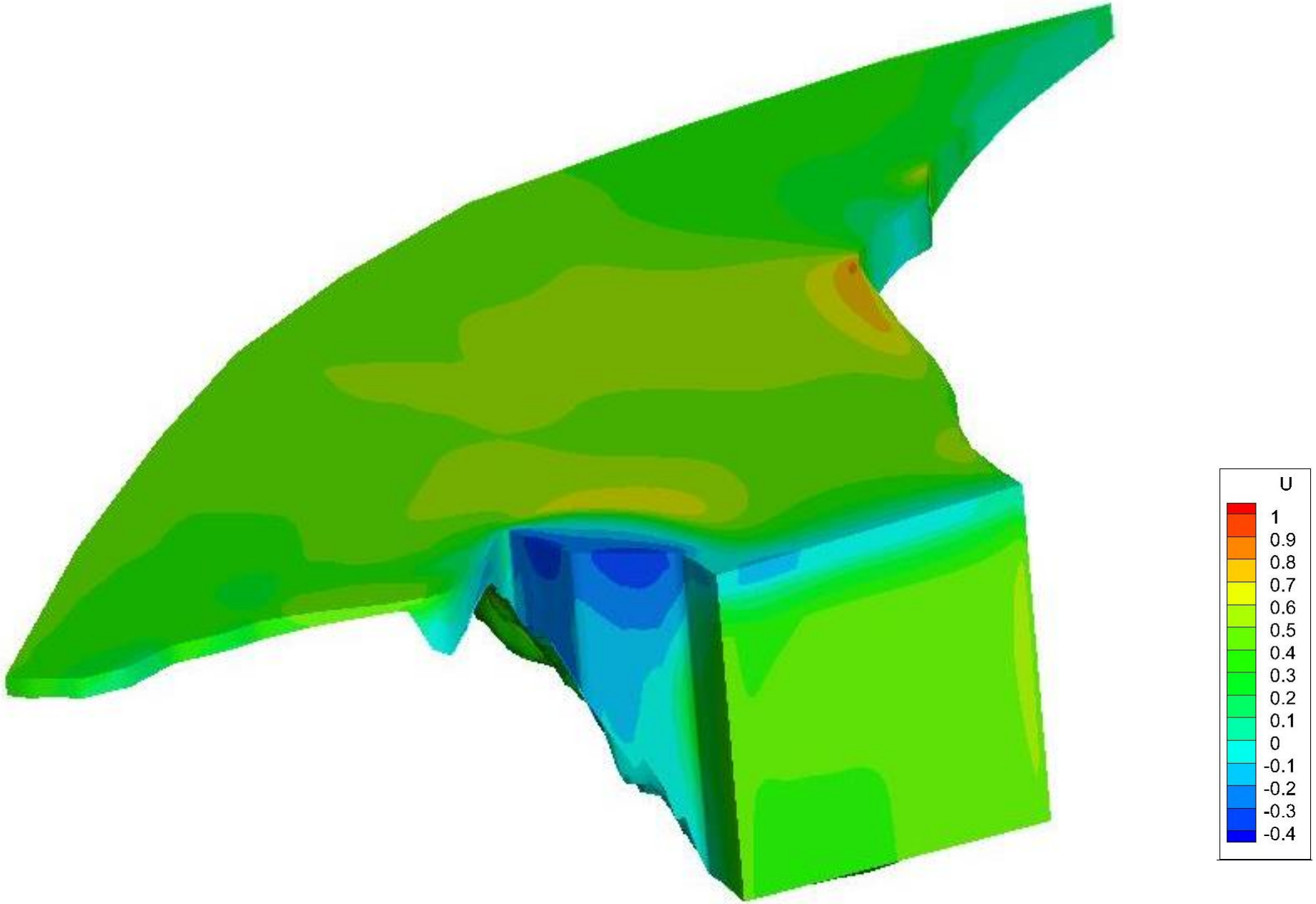
Details from the intake area

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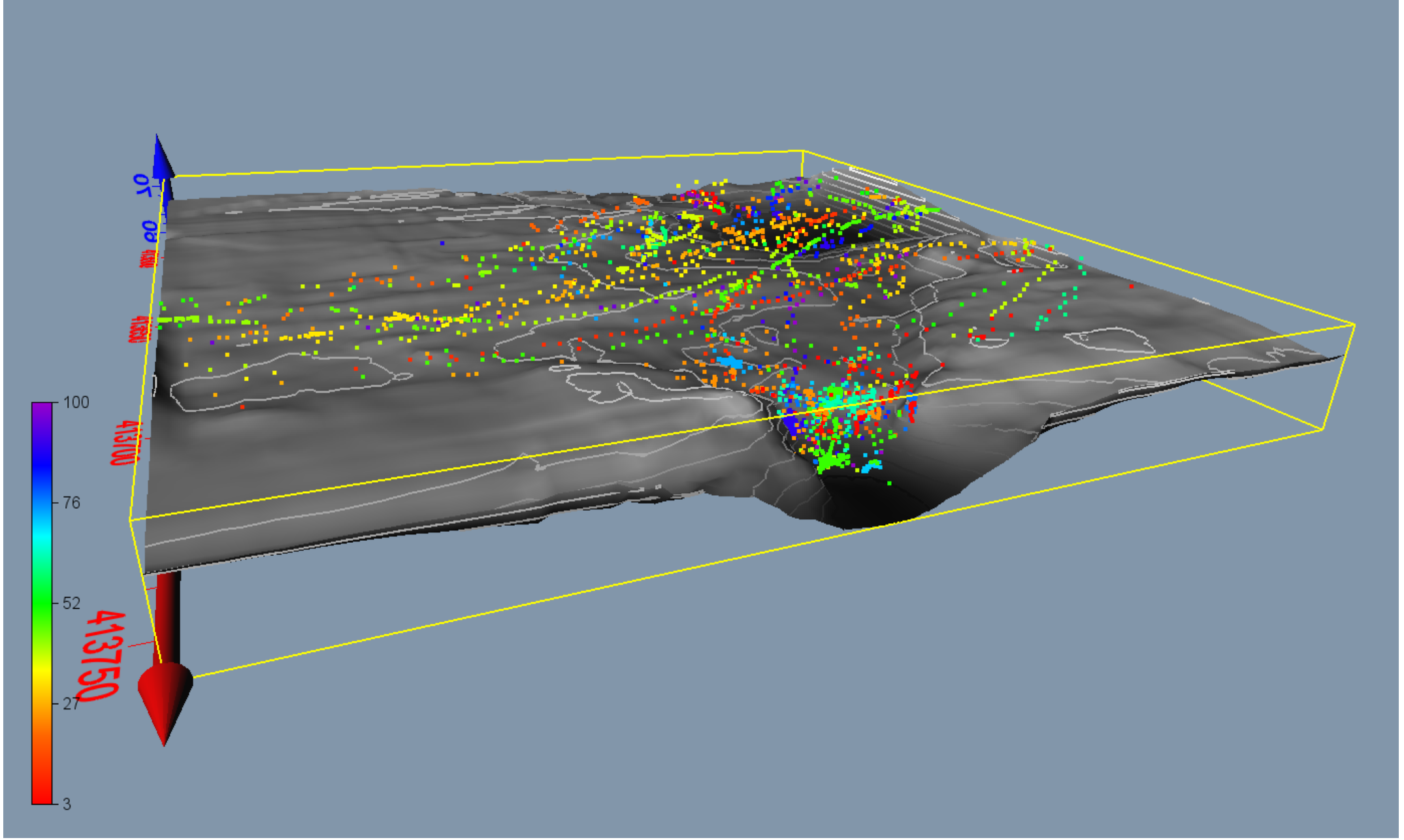
-0.3
-0.4

Monitoring of fish with acoustic 3D telemetry

1. 2D and 3D positioning using **200 kHz** acoustic telemetry with wireless hydrophones (Lotek).
2. Practically unlimited number of tags can be in the system at any time.
3. **Small tags (15x6.5 mm)** can be used with small smolts, and with a burst interval of 5 s **lasting for 45 days**.

Hydrophone allignment at the intake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3
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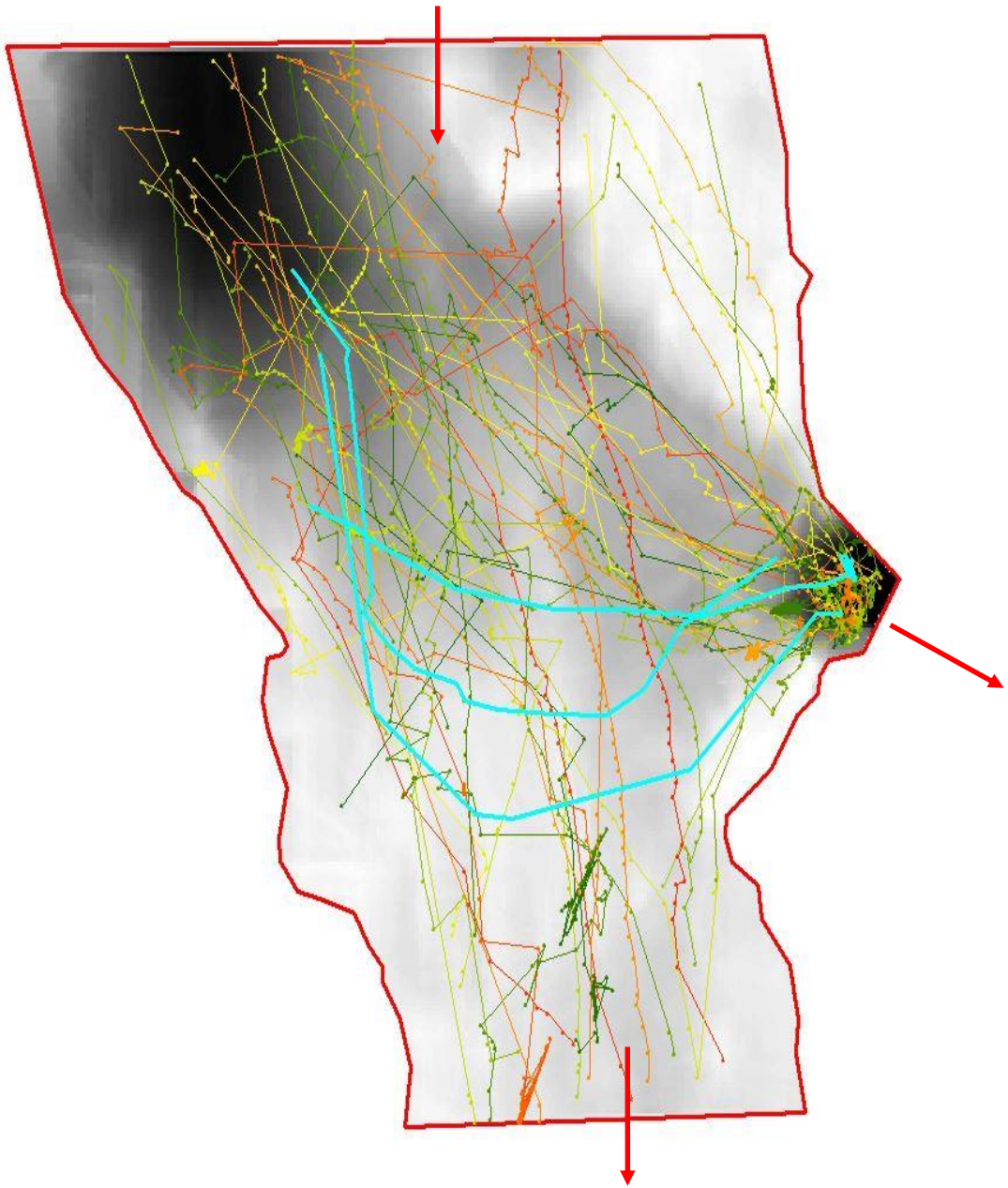
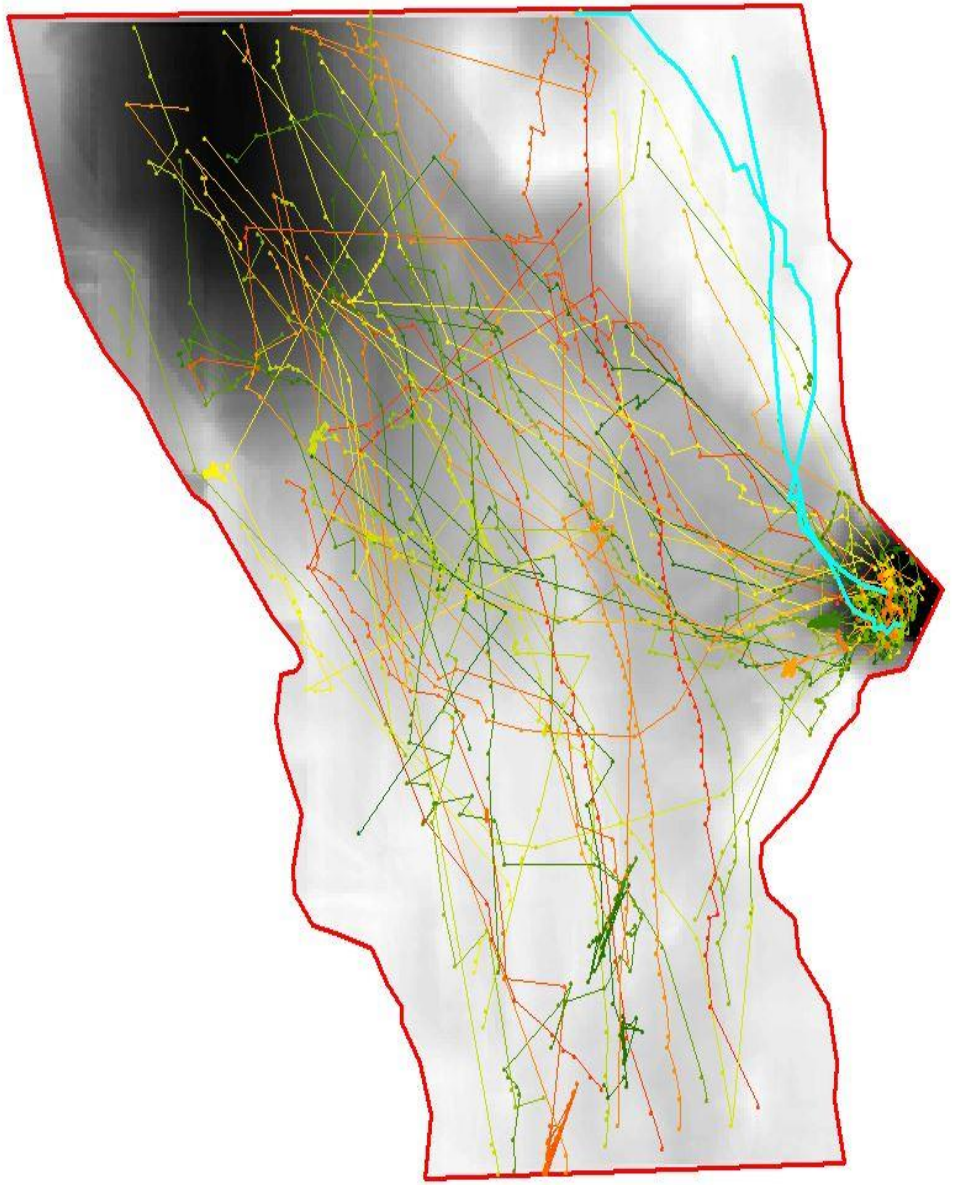


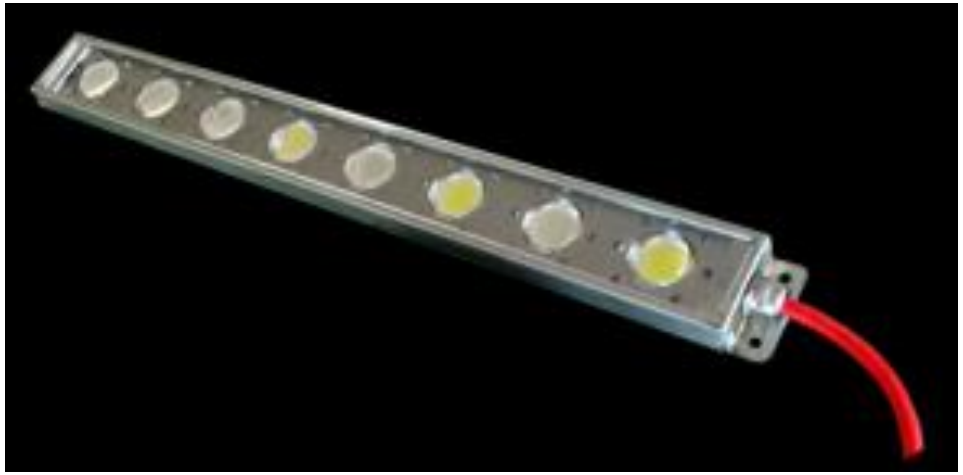


Alternative bypass corridors

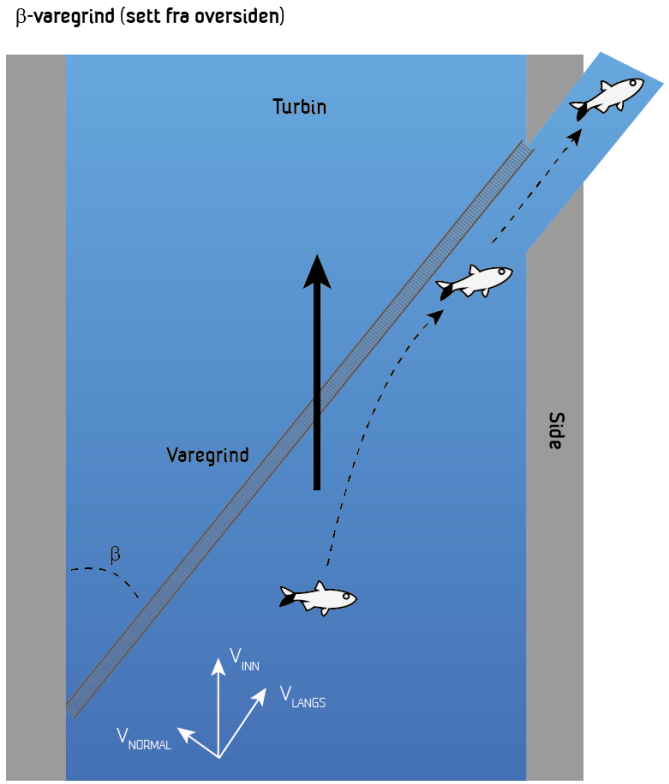
Photo: Anders Lamberg

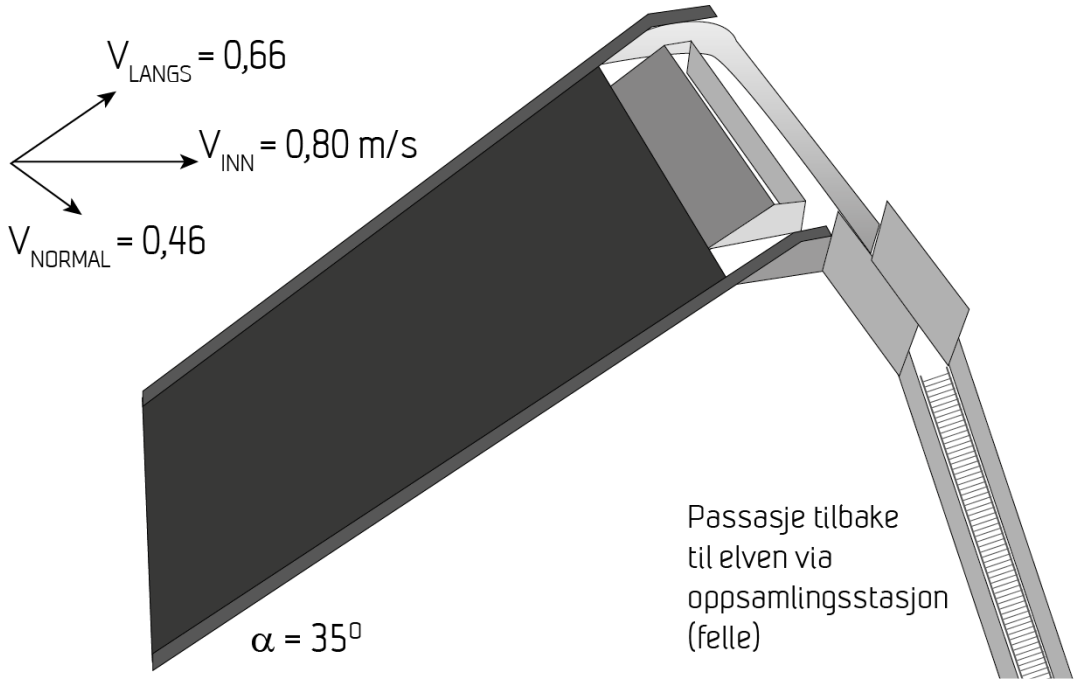
Repulsing measures

- LED-lights and infra sound (5-16 Hz)
- Electric fields
- Physical or hydraulic screens



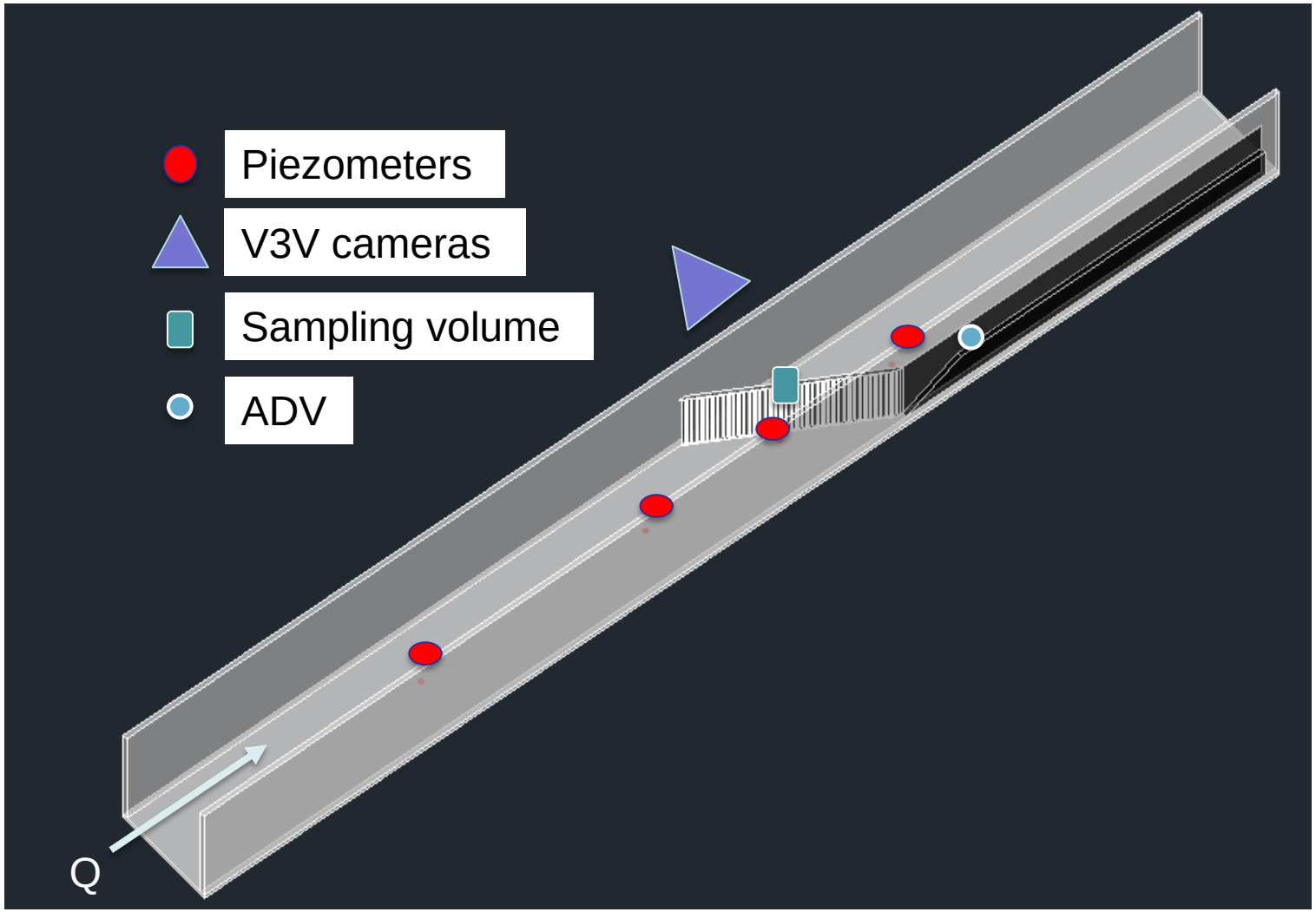
Fine mesh racks



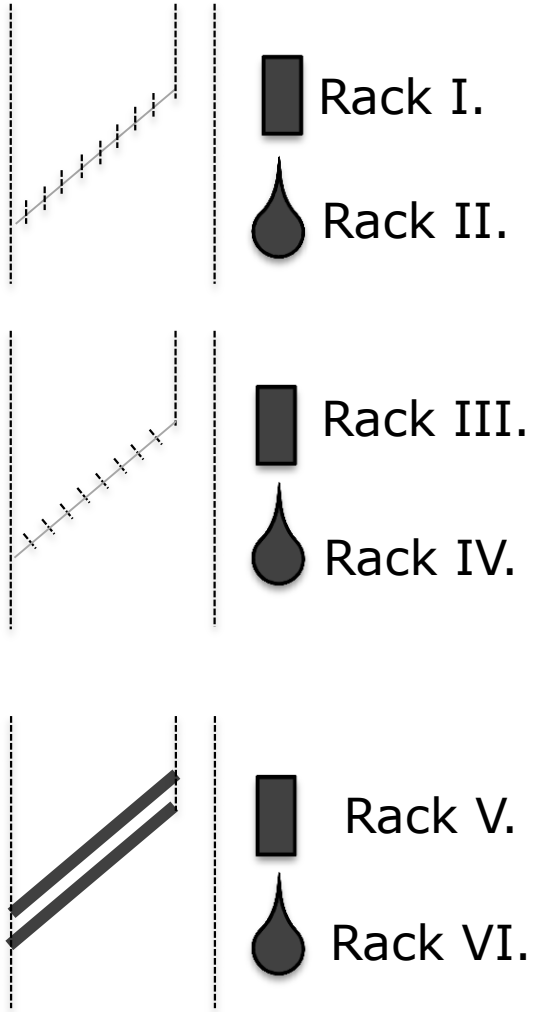


Images from Olle Calles, Karlstad University

Laboratory setup



Rack label



Head-losses

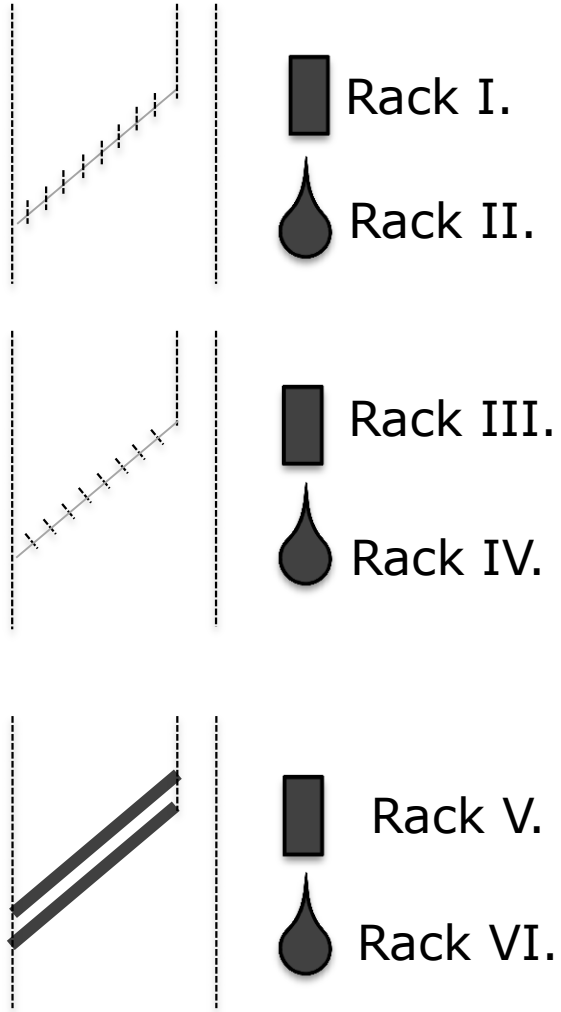
Volume based blockage ratio

Rack I.	Rack II.	Rack III.	Rack IV.	Rack V.	Rack VI.
0,18	**0,16**	**0,34**	**0,30**	**0,35**	**0,32**

Head-losses and head-loss coefficients

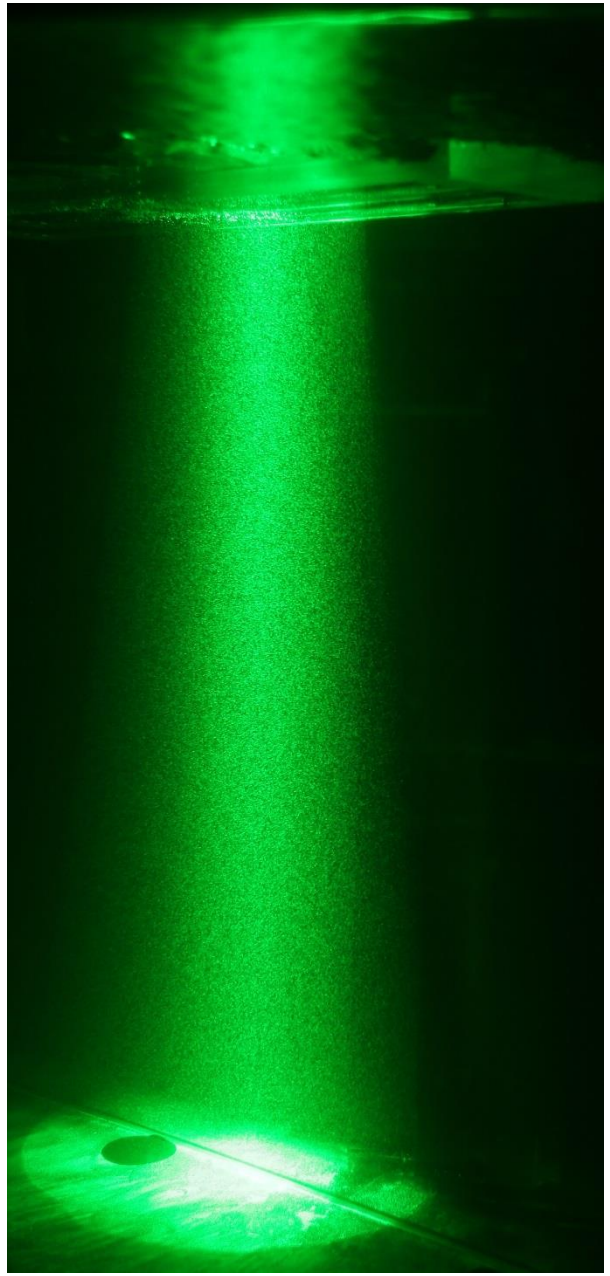
Q = 170 - 200l/s	Rack I.	Rack II.	Rack III.	Rack IV.	Rack V.	Rack VI.
ΔH [mm]	**9,8 - 14,2**	**3,4 - 4,9**	**30,9 - 43,8**	**25,7 - 37,2**	**6,6 - 8,7**	**3,1 - 5,1**
ξm [-]	**1,70 - 1,81**	**0,59 - 0,62**	**5,54 - 5,79**	**4,58 - 4,87**	**1,15 - 1,10**	**0,54 - 0,64**

Rack label



About the PIV - V3V system

- Volumetric 3-Component Velocimetry (V3V)
  - Based on the method of Particle Image Velocimetry (PIV)
  - 140x140x100 mm measured volume
  - Gives high resolution of 3D velocities
- Conditions:
  - Installed laser and camera system (3 high speed cameras)
  - 55 µm particles were mixed into the water
- Method:
  - Calibration in calm water
  - Capturing when firing the laser



Thank you!

hans-petter.fjeldstad@sintef.no