

Principles of Fish Passage Design

Martin Mallen-Cooper

Fishway Consulting Services

Charles Sturt University

OzFish Unlimited



Principles of Fish Passage Design

- Fishway types
- Principles of fishway design:
 - Biology, hydrology and hydraulics
 - Design
 - 1 Attraction (fishway entrance)
 - 2 Passage

Conclusion: It's a team approach!

Fishway Types

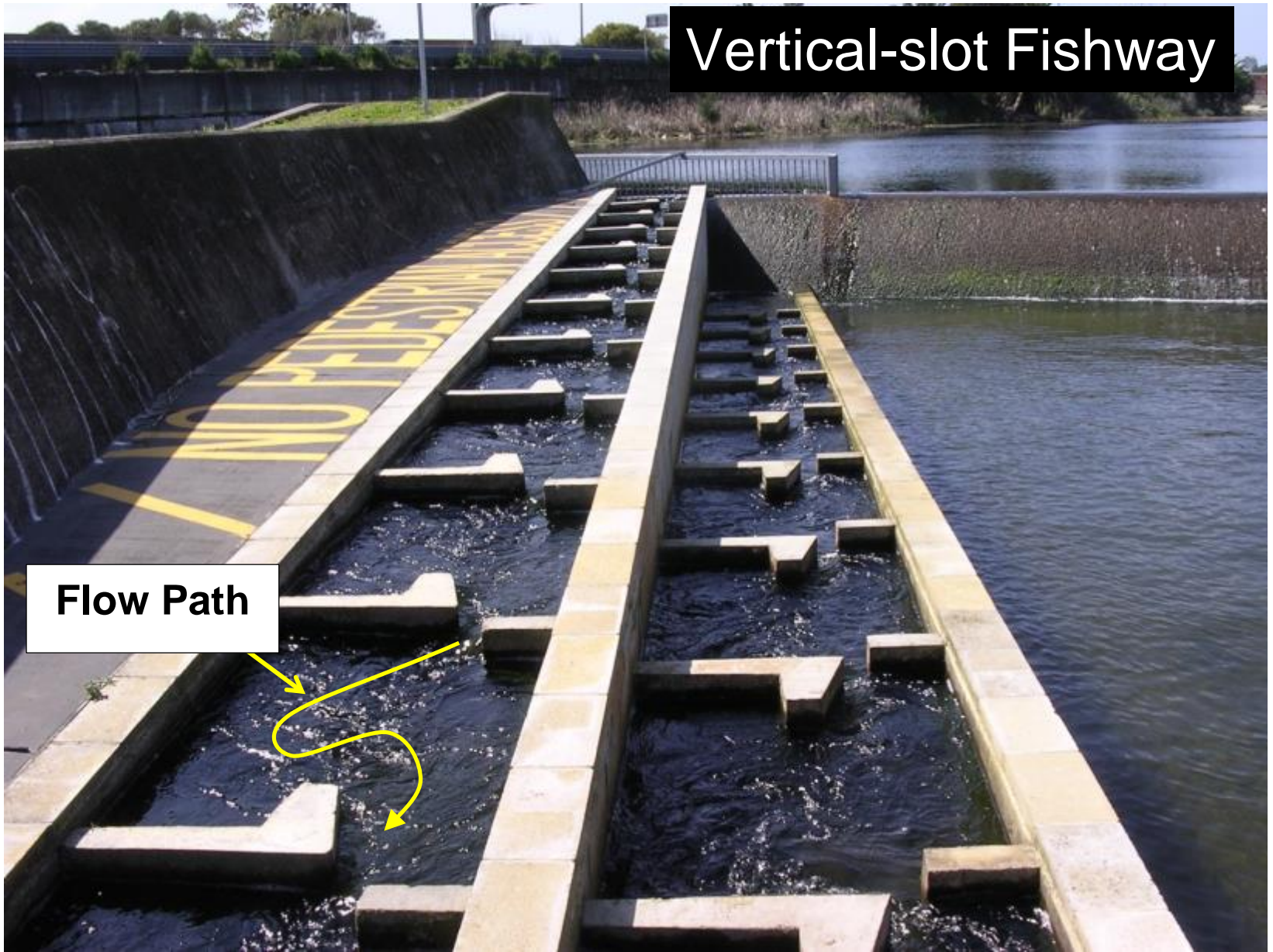
Pool-type
fishways

- Vertical-slot fishway
- Cone fishway
- Trapezoidal weirs
- Rock-ramp or Nature-like fishways
- Denil fishway
- Fish locks, fish lifts, trap and transport
- Downstream

Fishway Types

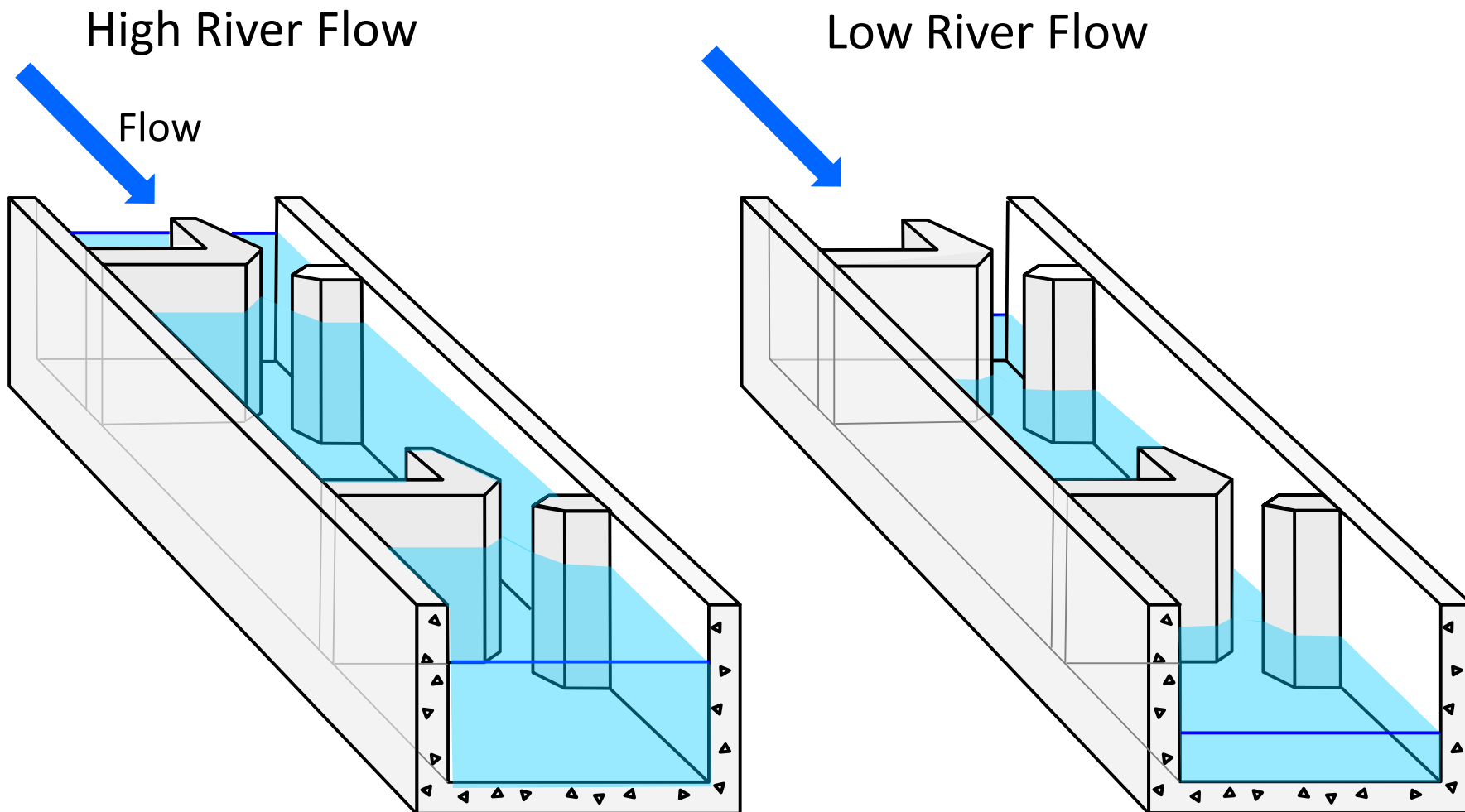
Vertical-slot Fishway

Flow Path



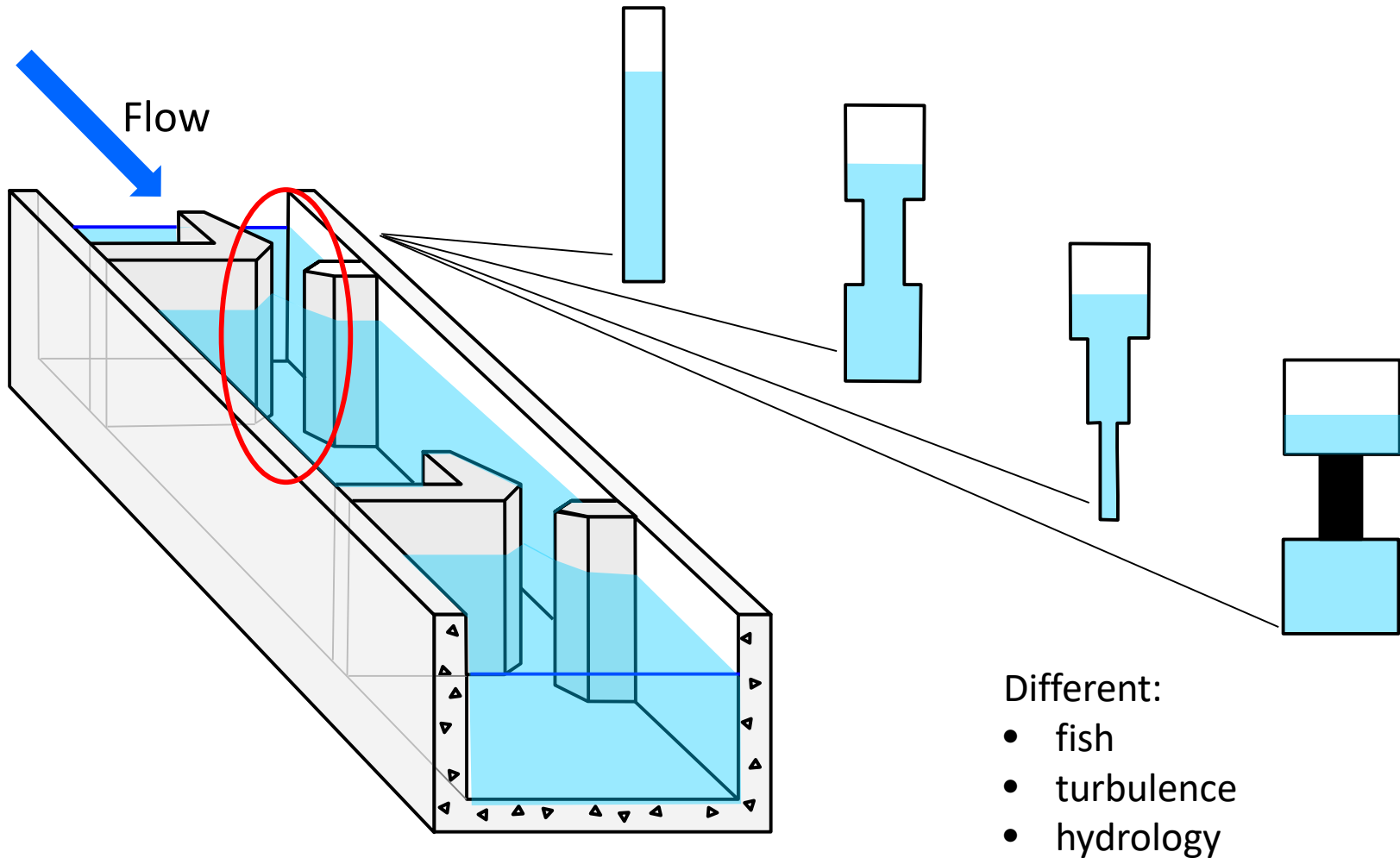
Fishway Types

Vertical-slot Fishway

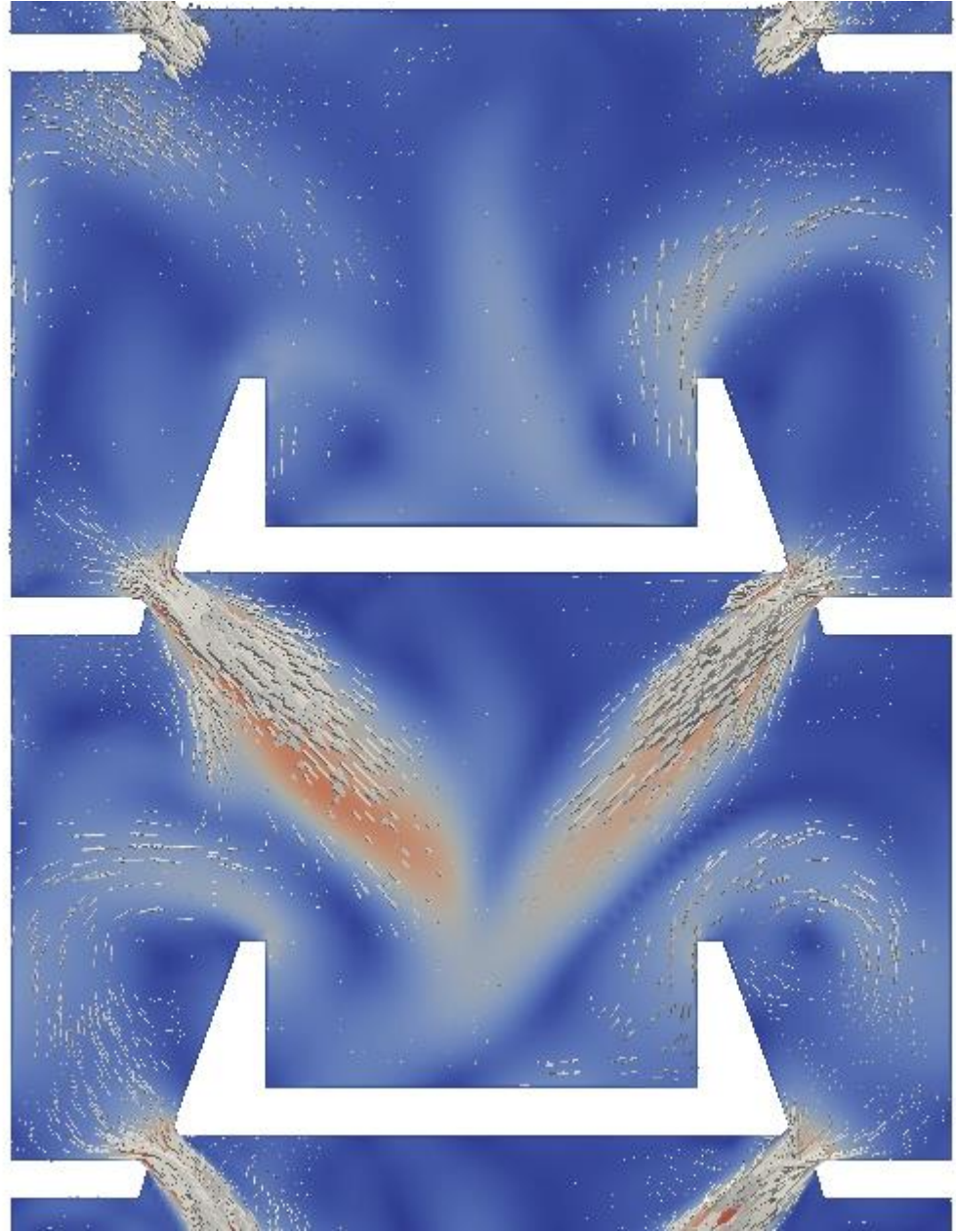


Fishway Types

Vertical-slot Fishway - variations



Dual Vertical-slot Fishway



Fishway Types



Cone Fishway



Trapezoidal weirs fishway



Trapezoidal weirs fishway



Fishway Types

Rock-ramp or Nature-like Fishways

- Full width
- Partial-width
- Bypass channels

Fishway Types



Full-width Rock-Ramp Fishway

Partial-width Rock-Ramp Fishway



Recessed Partial-width Rock-Ramp Fishway

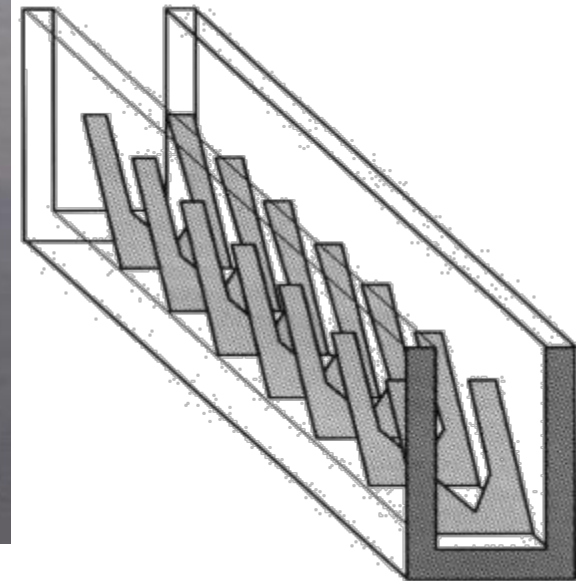
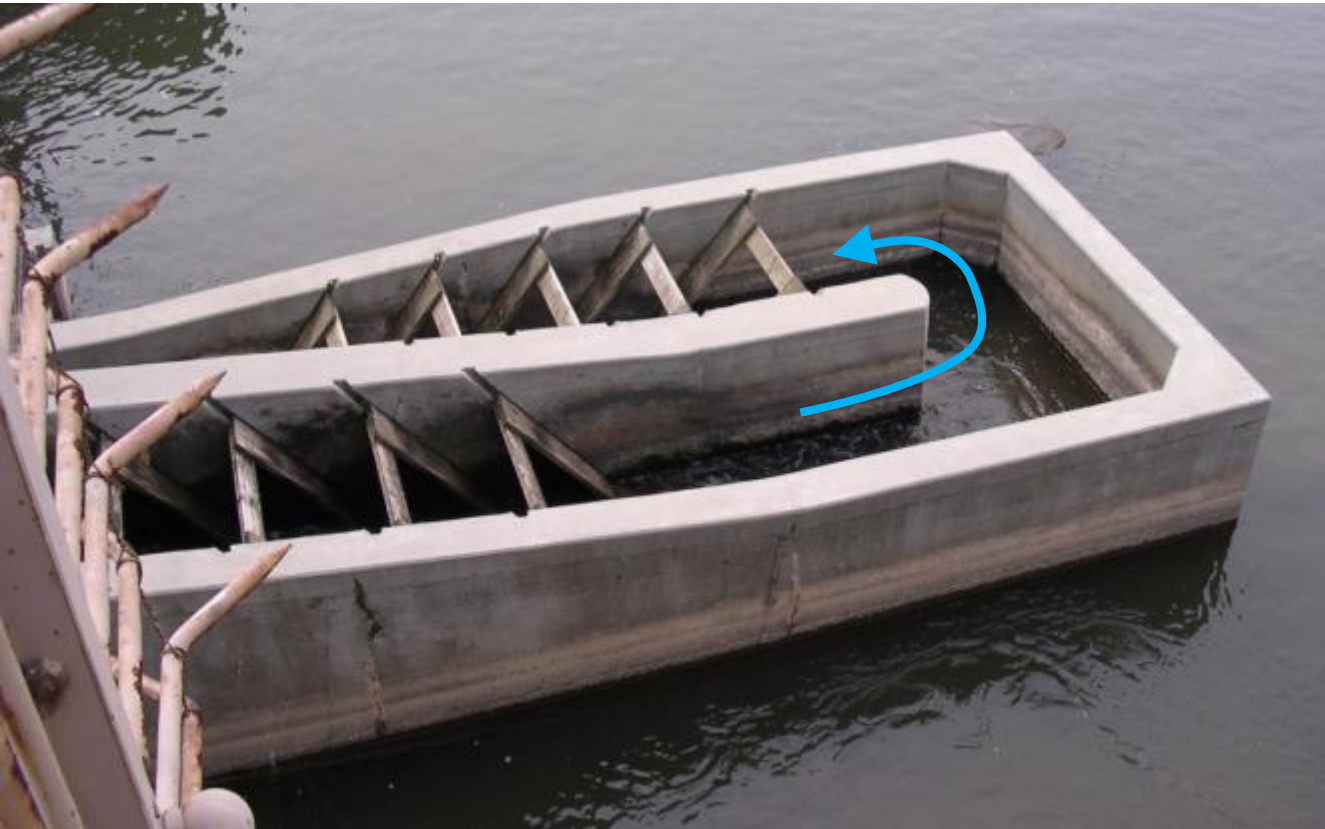


Nature-like bypass channel



Fishway Types

Denil Fishway



Fishway Types

Culverts



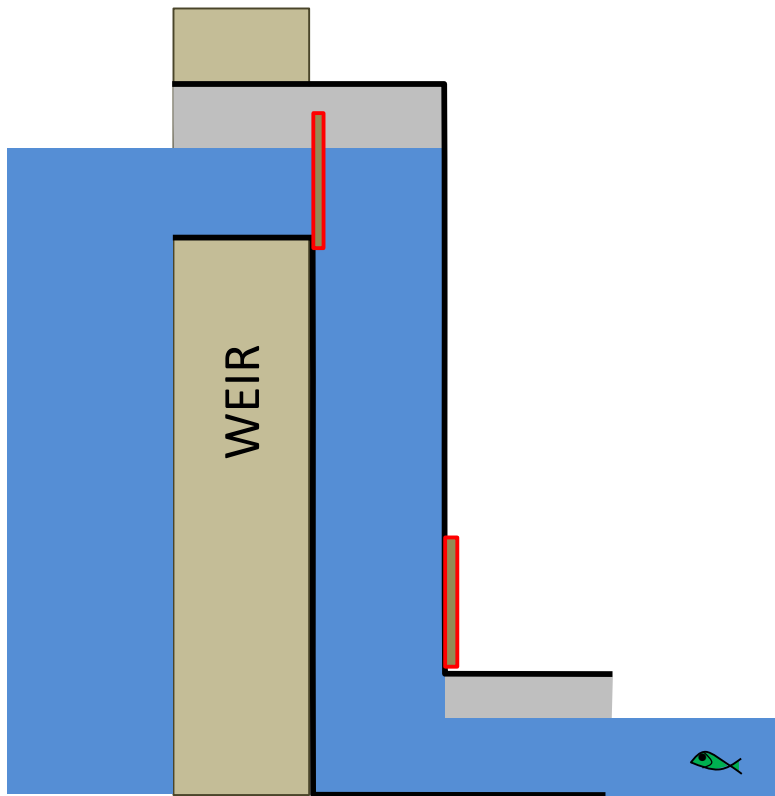
Fishway Types

Floodgates



Fishway Types

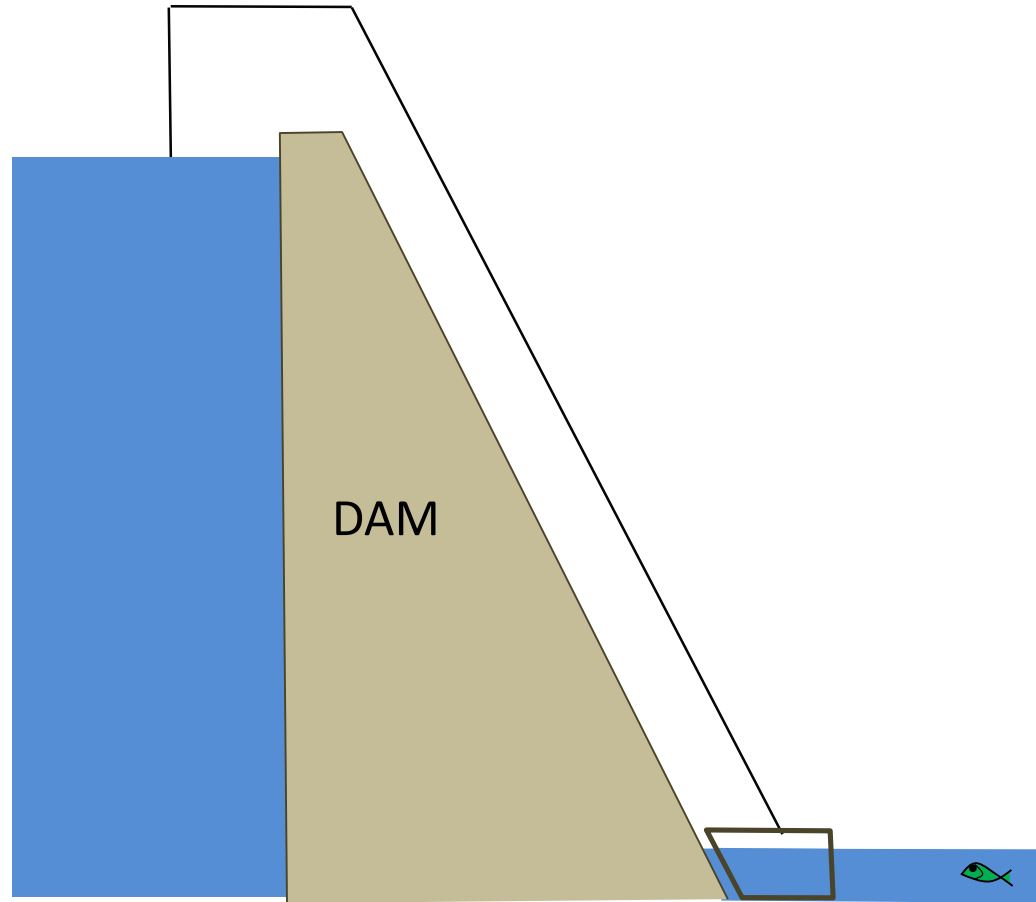
Fish Locks



8 high-level (> 7m) locks

7 low-level locks

Fish Lifts



3 fish lifts

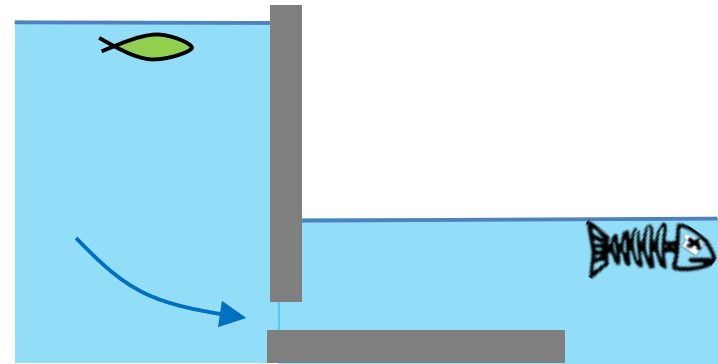
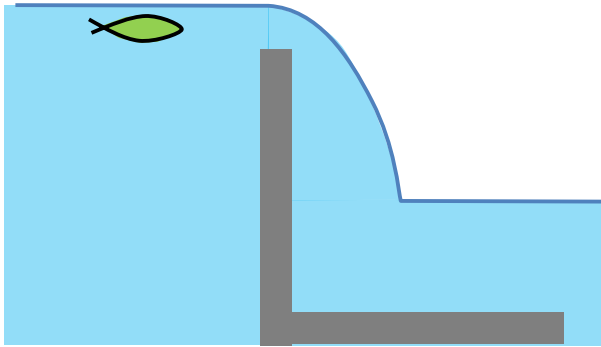
Fishway Types

Barrier removal

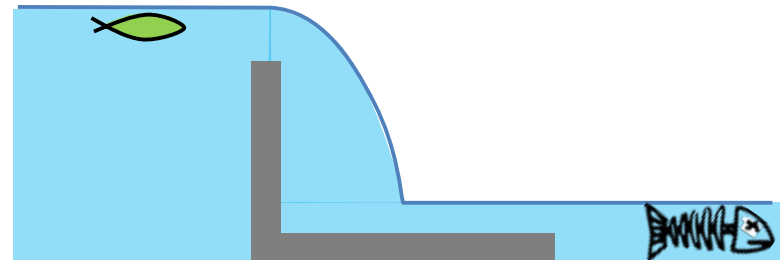
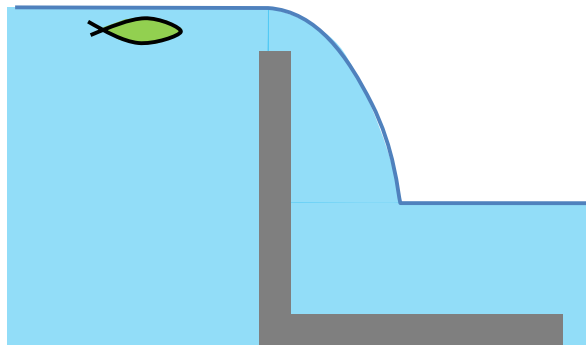


Downstream migration

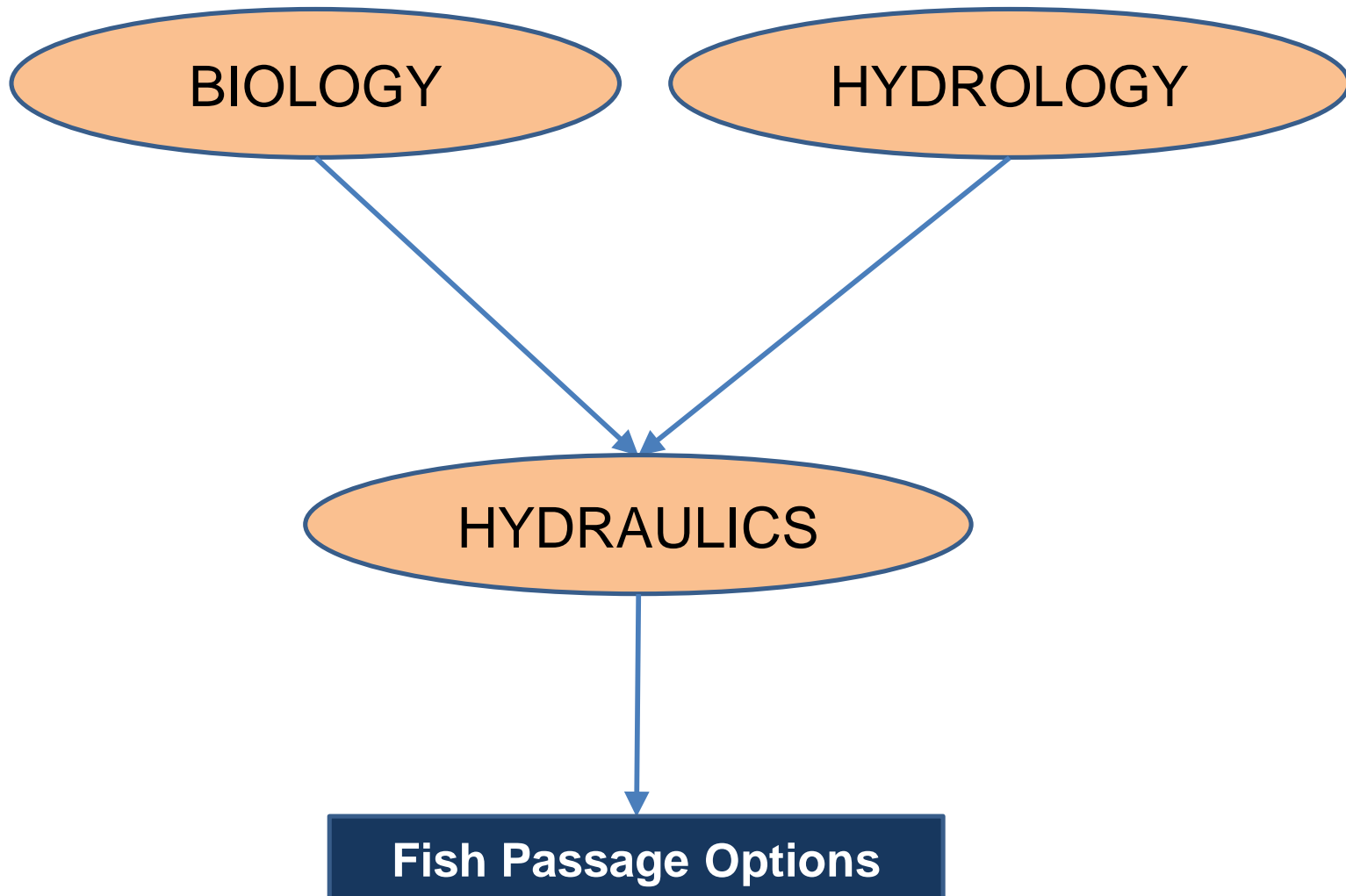
1. Overshot better than undershot



2. Deep downstream water better than shallow



Principles of Fish Passage Design

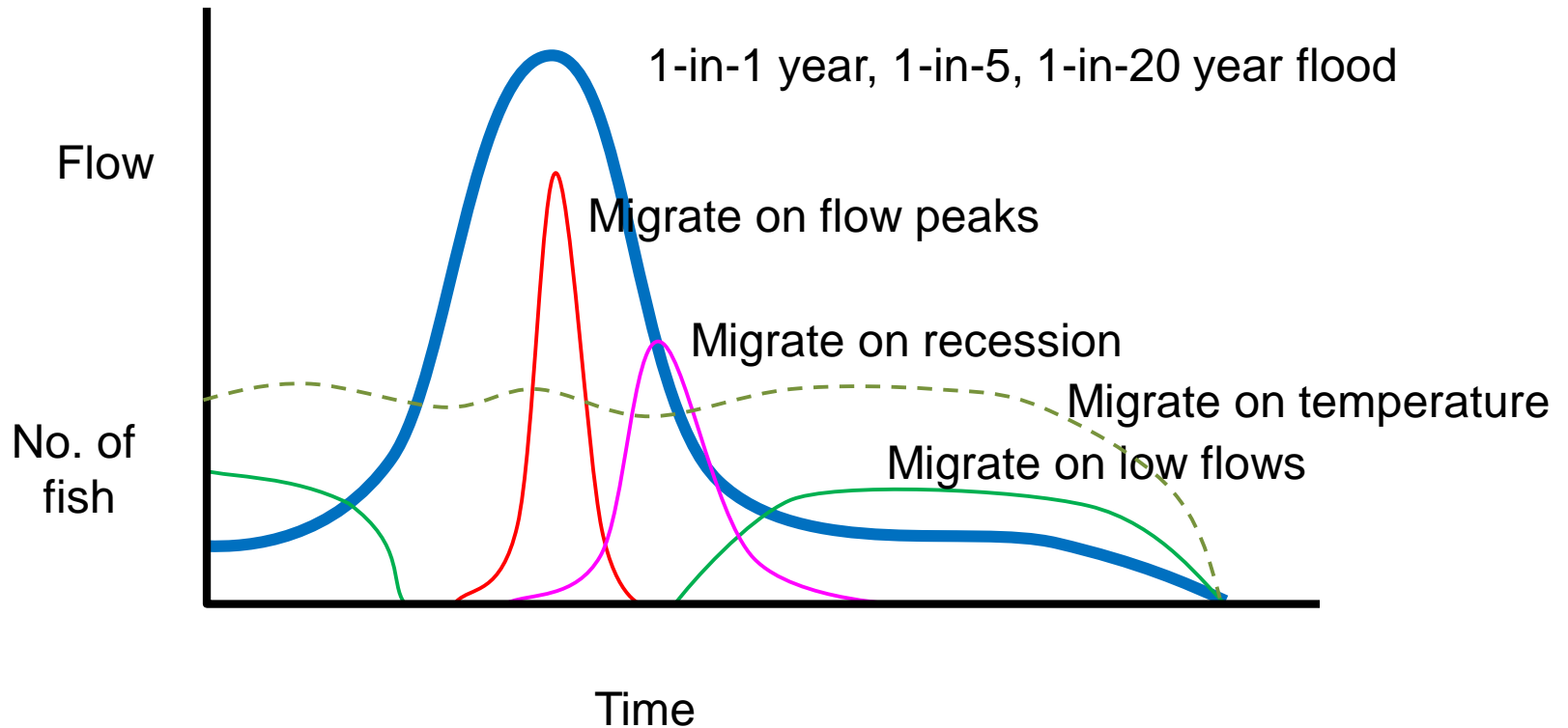


Biology

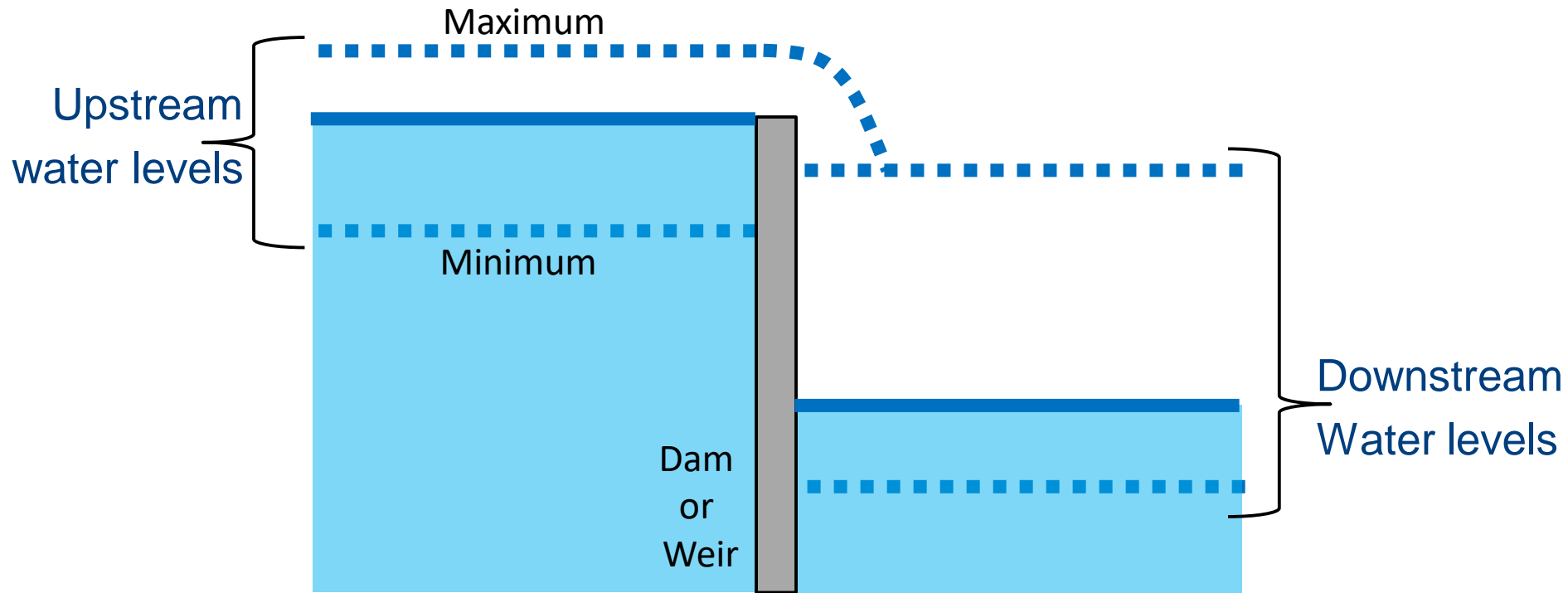
- Smallest fish
- Largest fish
- Biomass
- Upstream
& downstream
- Migration & Flow



Biology & Hydrology



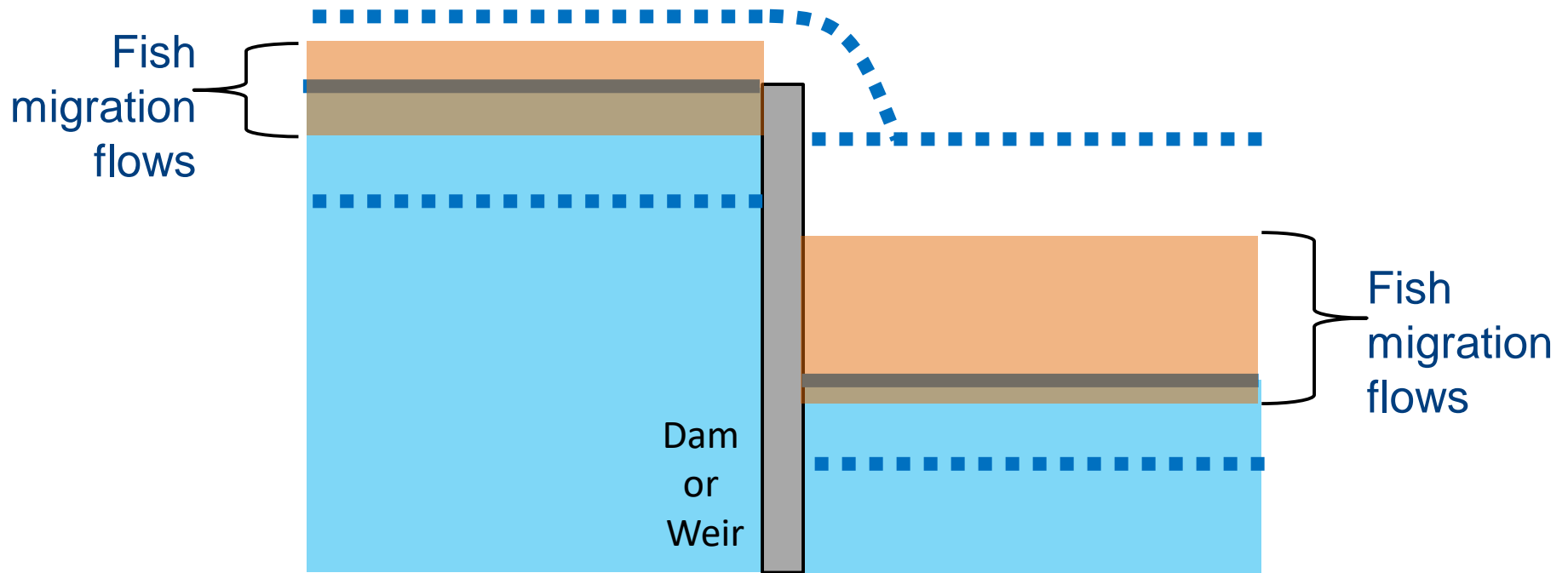
Biology, hydrology and hydraulics

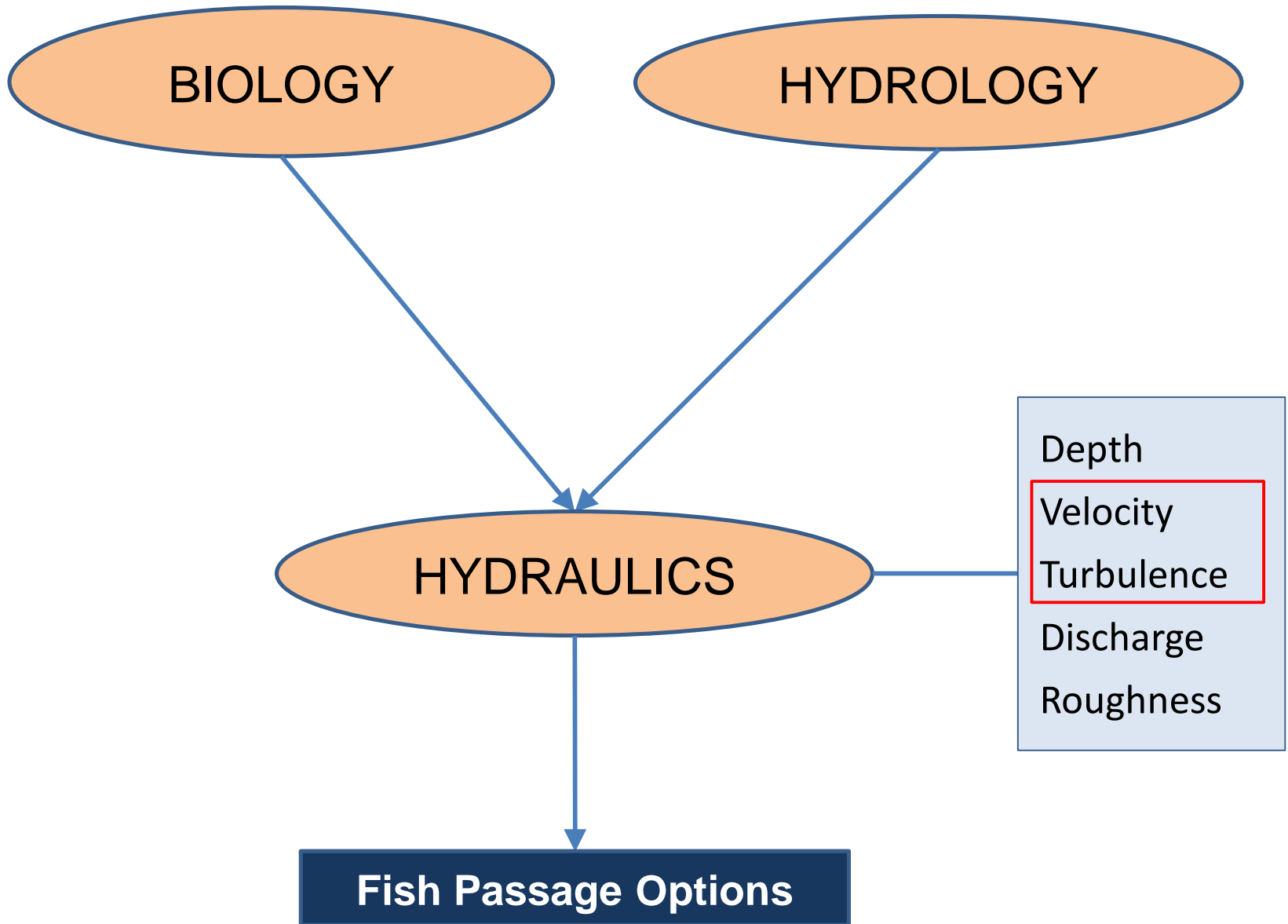


- If levels unknown, be conservative (erosion, climate change)
- Make fishway a bit longer and deeper; adjustable hydraulics

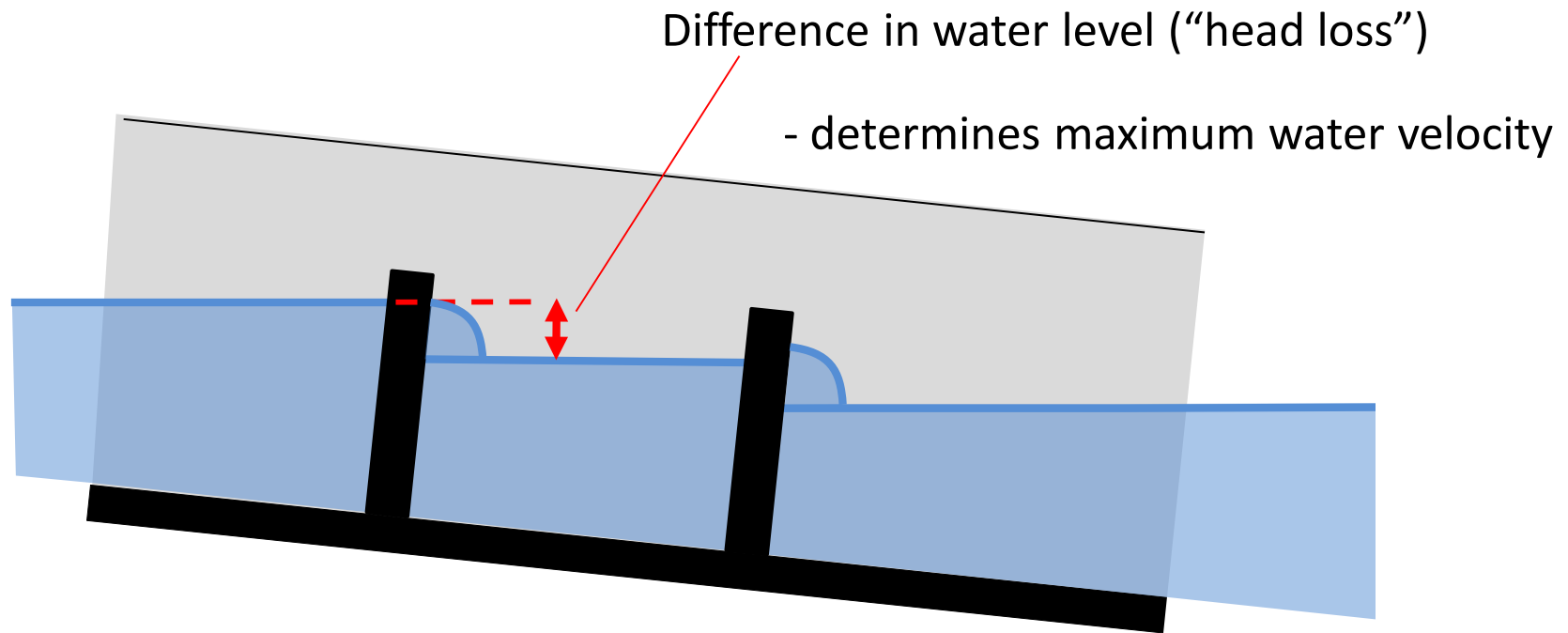
Fishway flow: >10% of river flow

Biology, hydrology and hydraulics

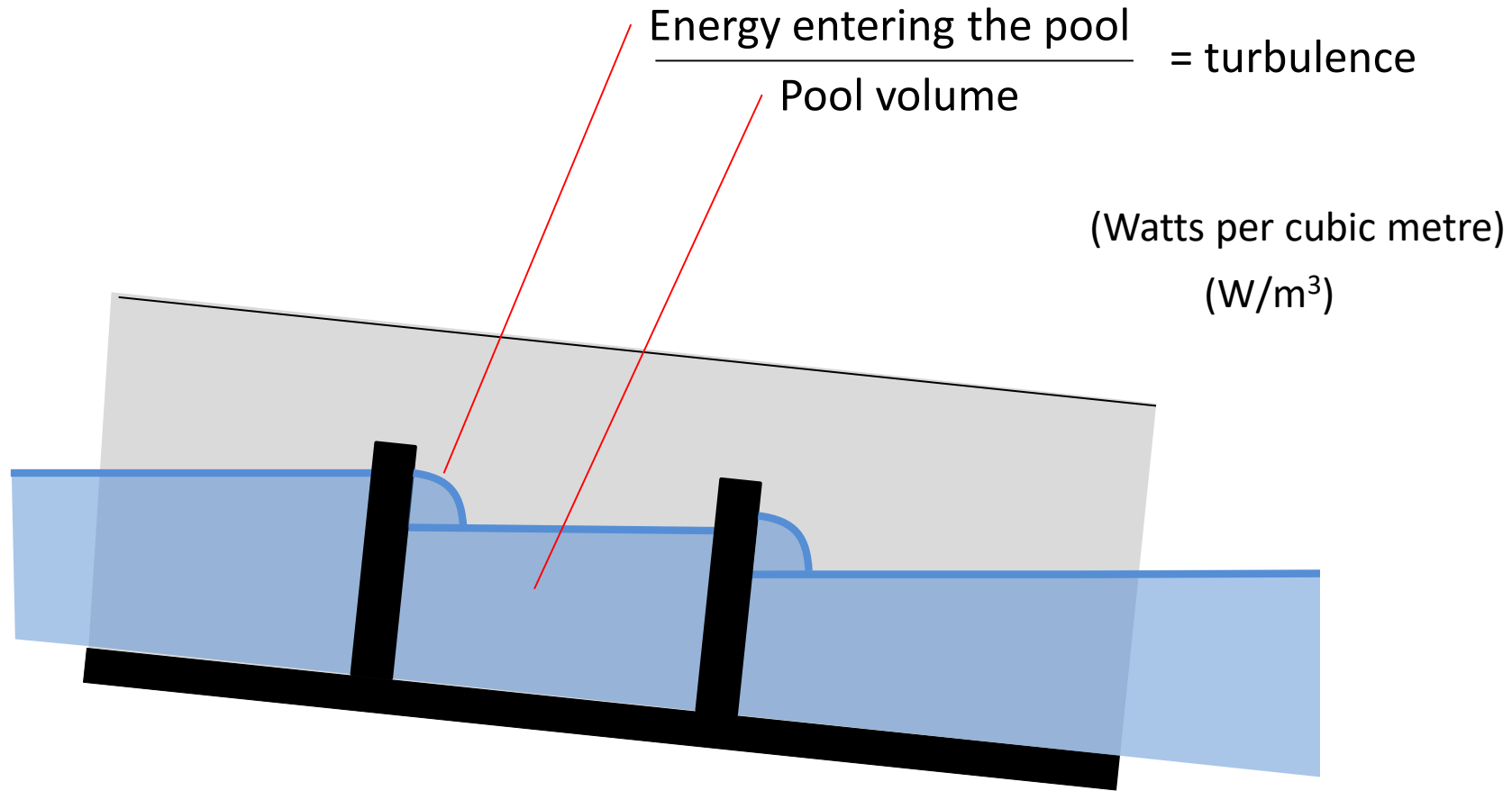




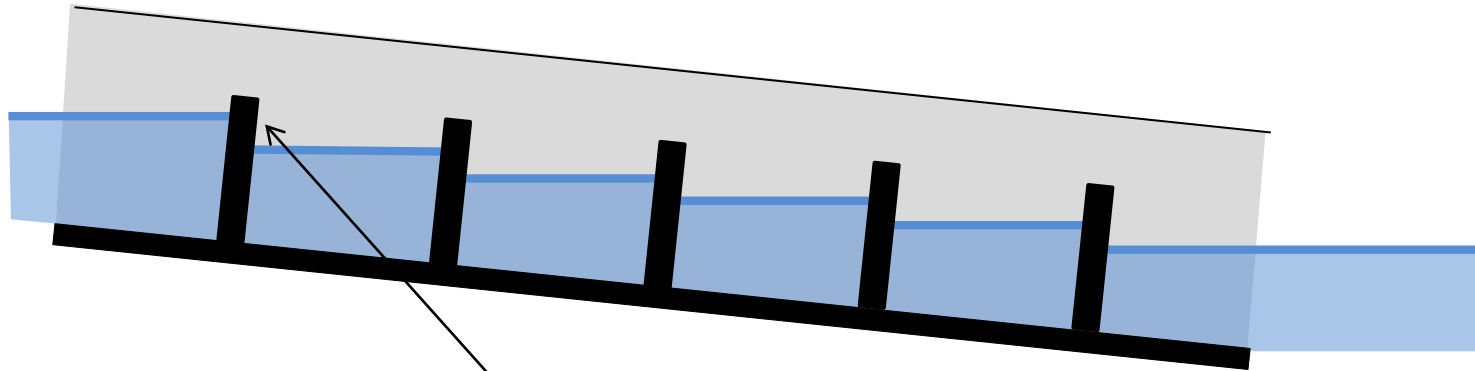
Hydraulics - velocity



Hydraulics - turbulence

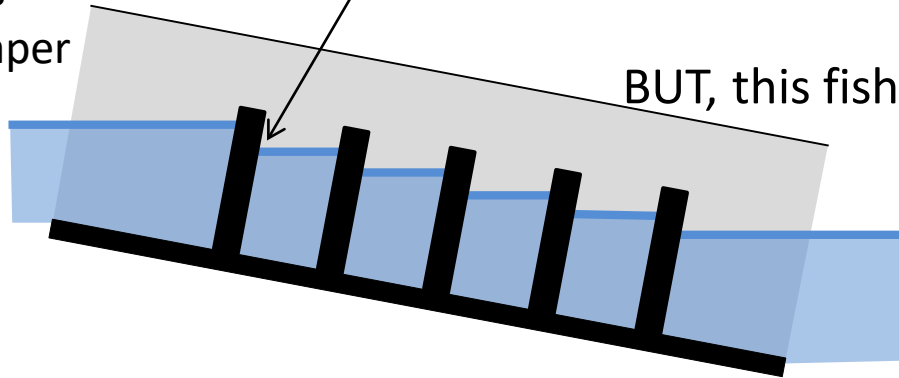


Turbulence and velocity in fishways



Same difference in water level = same max. water velocity

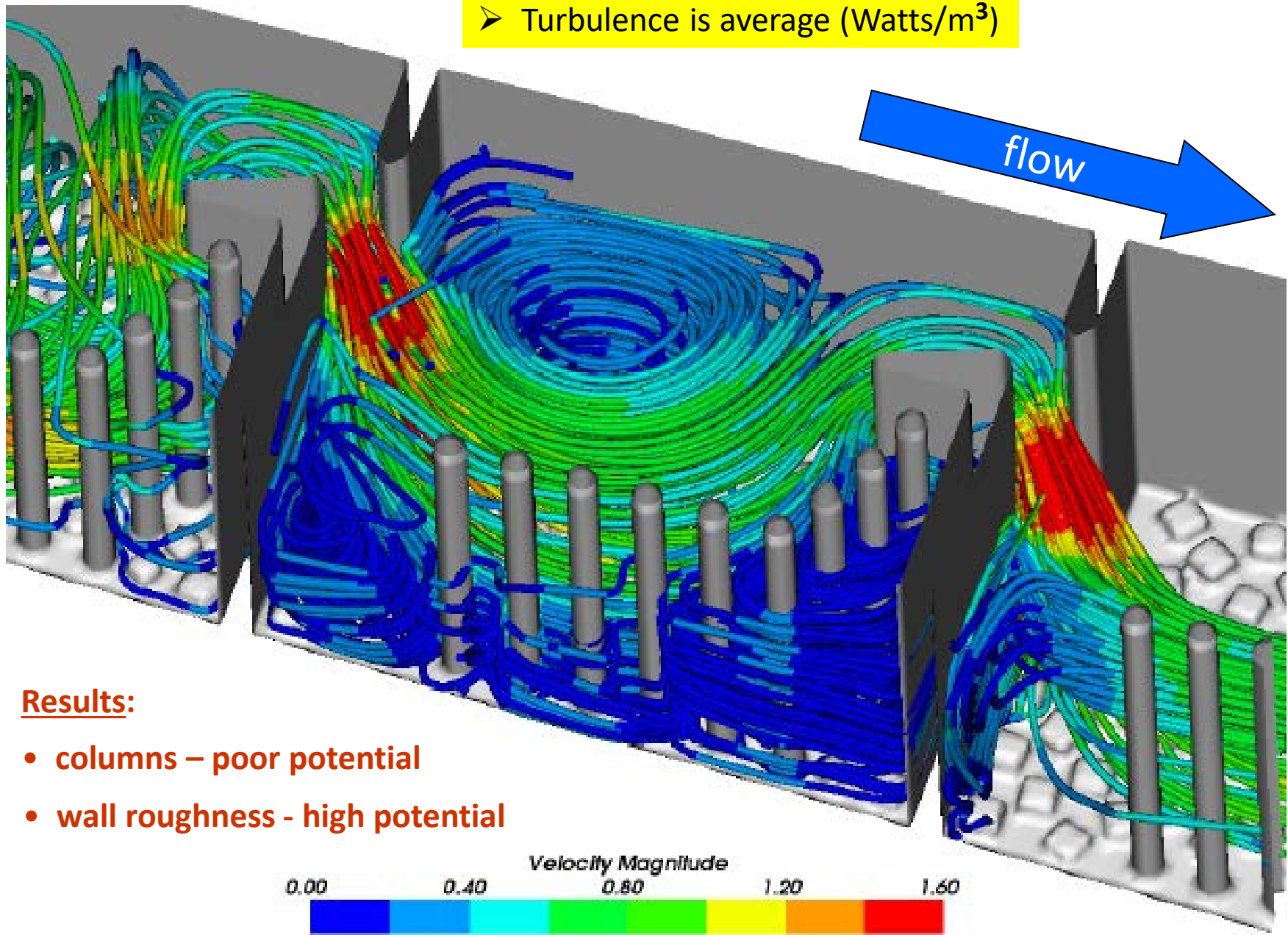
This fishway is shorter and cheaper



BUT, this fishway has double the turbulence

Turbulence and velocity in fishways

➤ Turbulence is average (Watts/m³)

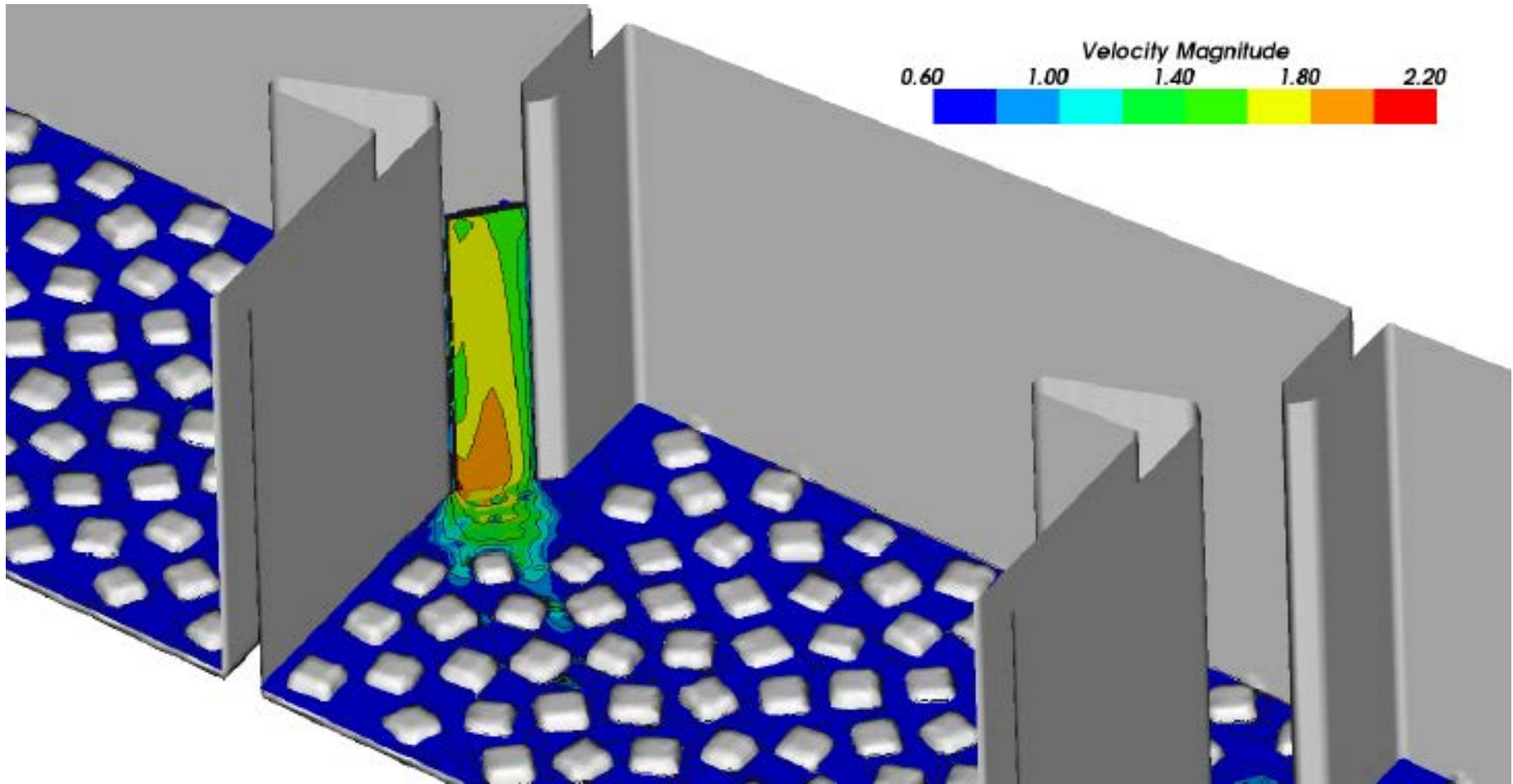


Results:

- columns – poor potential
- wall roughness - high potential

Turbulence and velocity in fishways

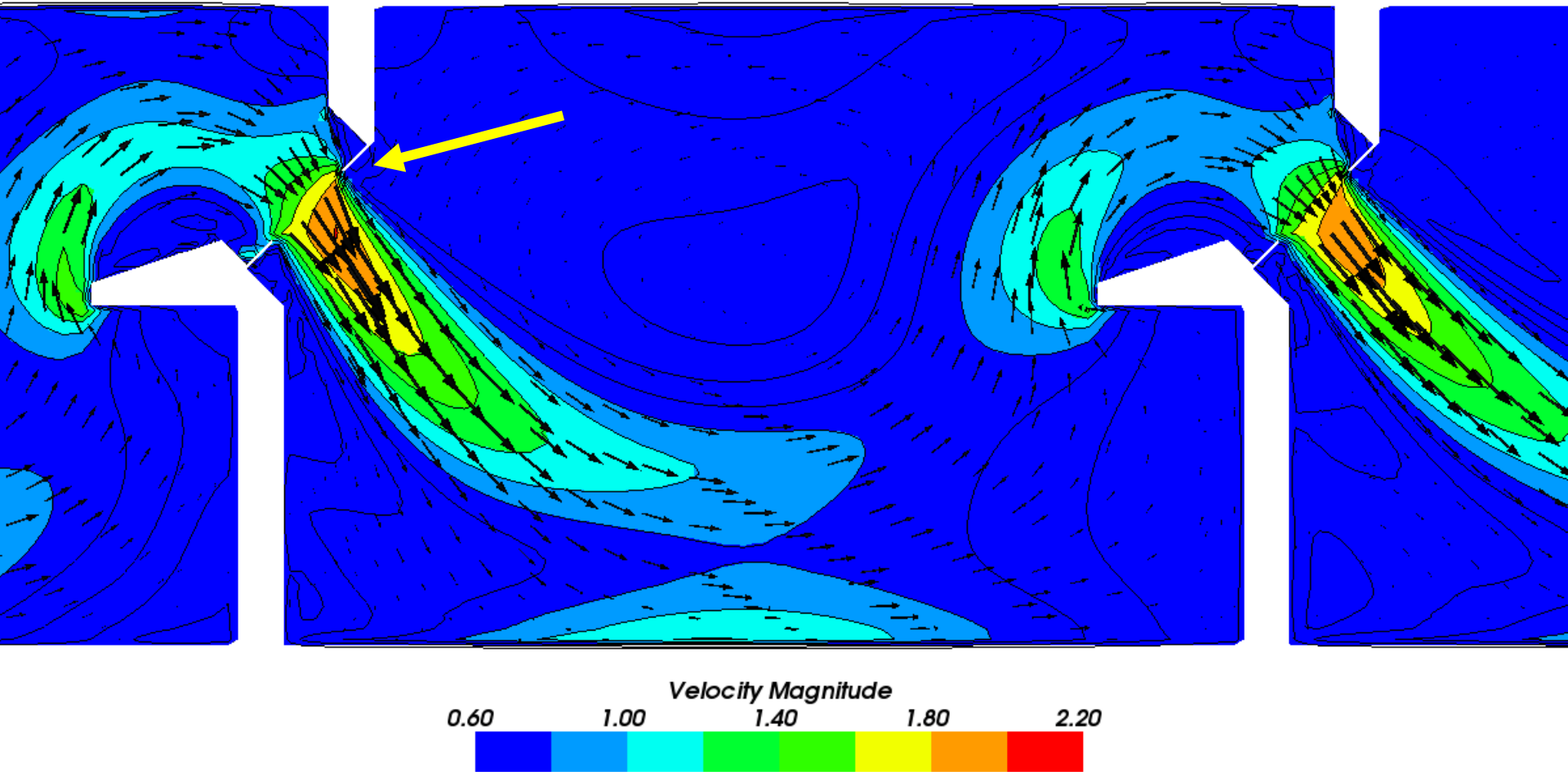
➤ Velocity is a maximum (from head loss)



Result:

- floor rocks need to be a higher density near the slot
 - being applied now

Velocity distribution of sharp-edged slot



Result:

- sharp-edged slot has a favourable velocity distribution
- being applied now

Principles of Fish Passage Design

Biology, hydrology and hydraulics

Design

1 Fishway entrance (Attraction)

No Fish In = No Fish Out

2 Passage

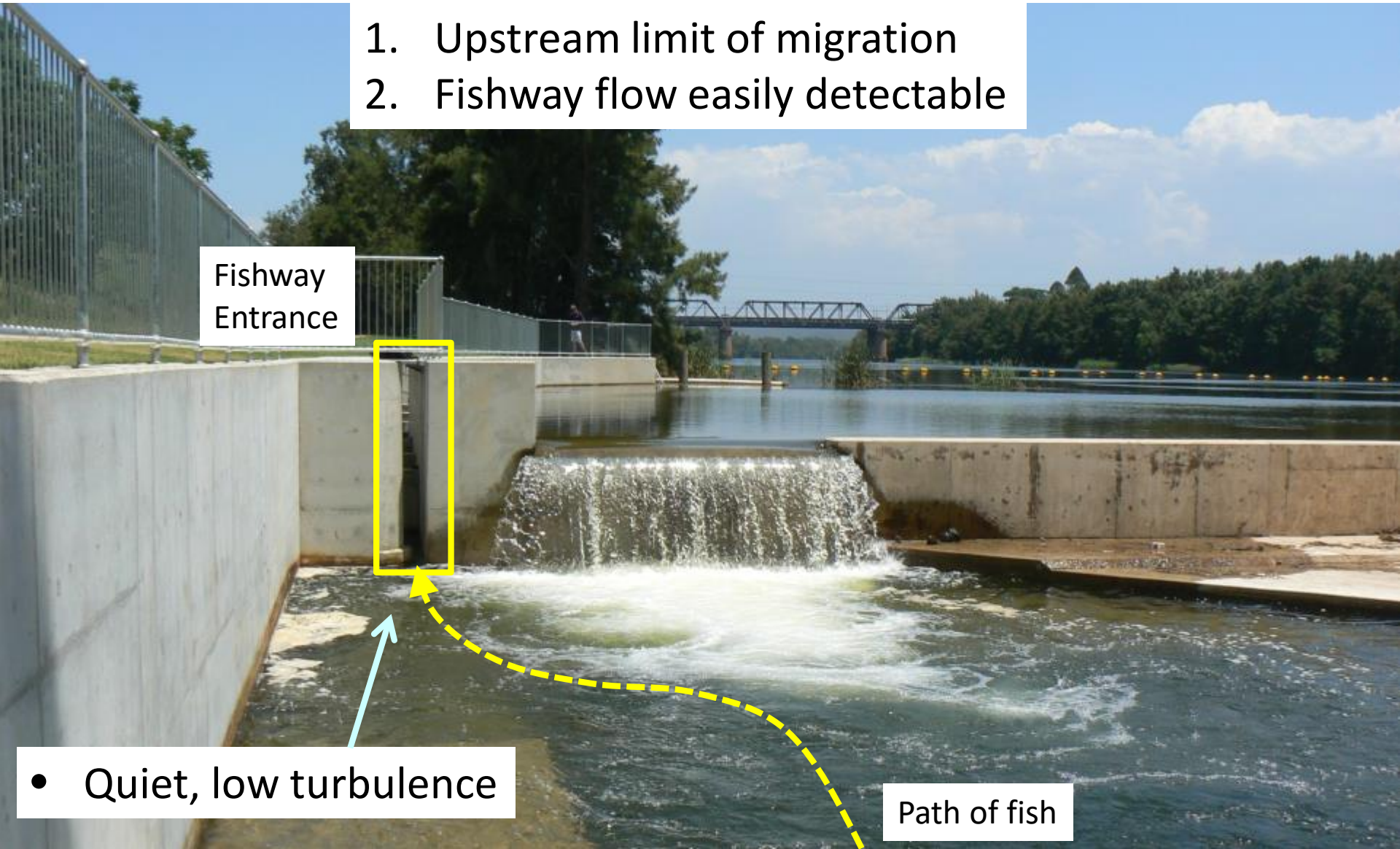
Fishway Entrance

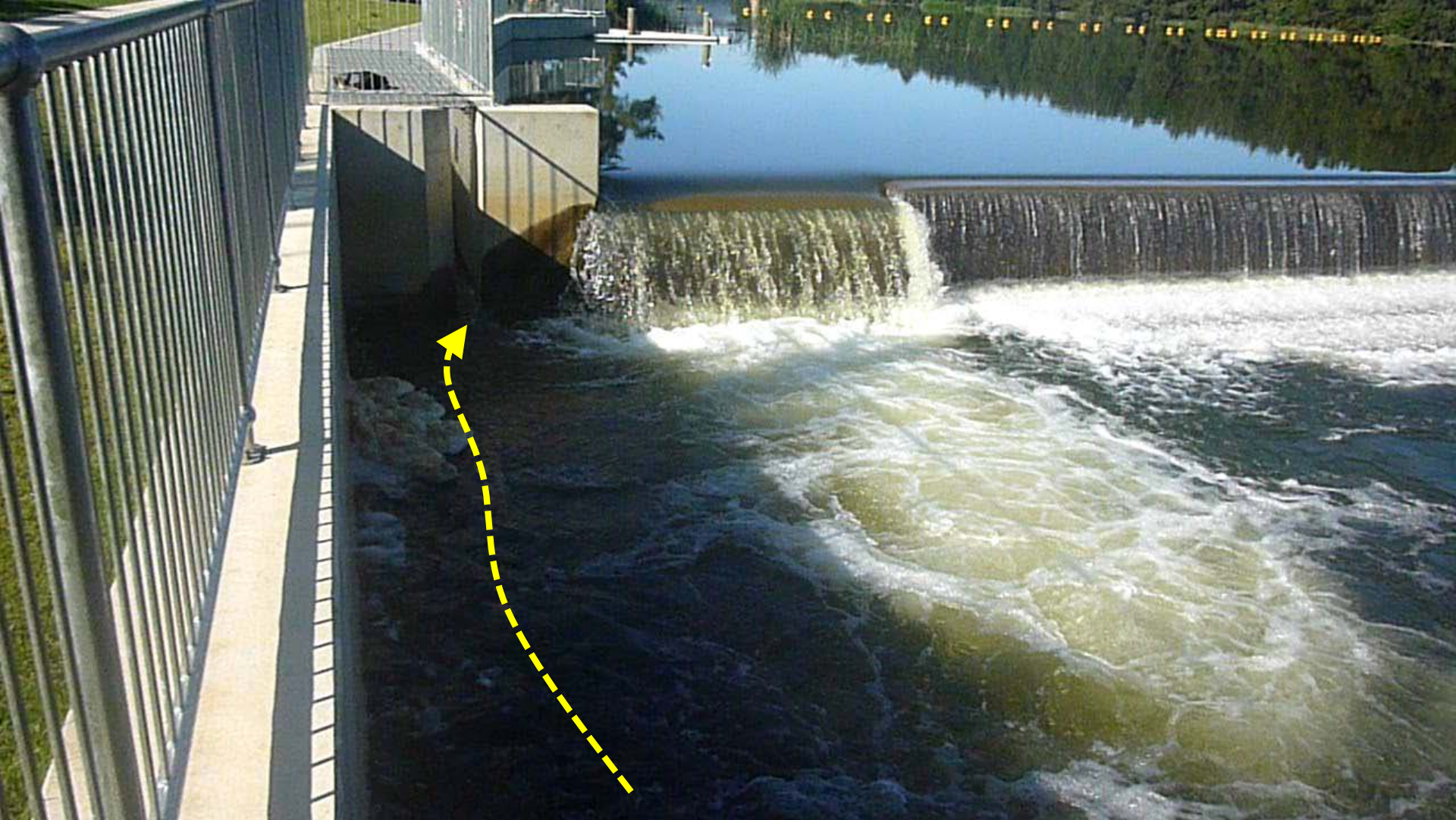
1. Upstream limit of migration
2. Fishway flow easily detectable

Fishway
Entrance

- Quiet, low turbulence

Path of fish

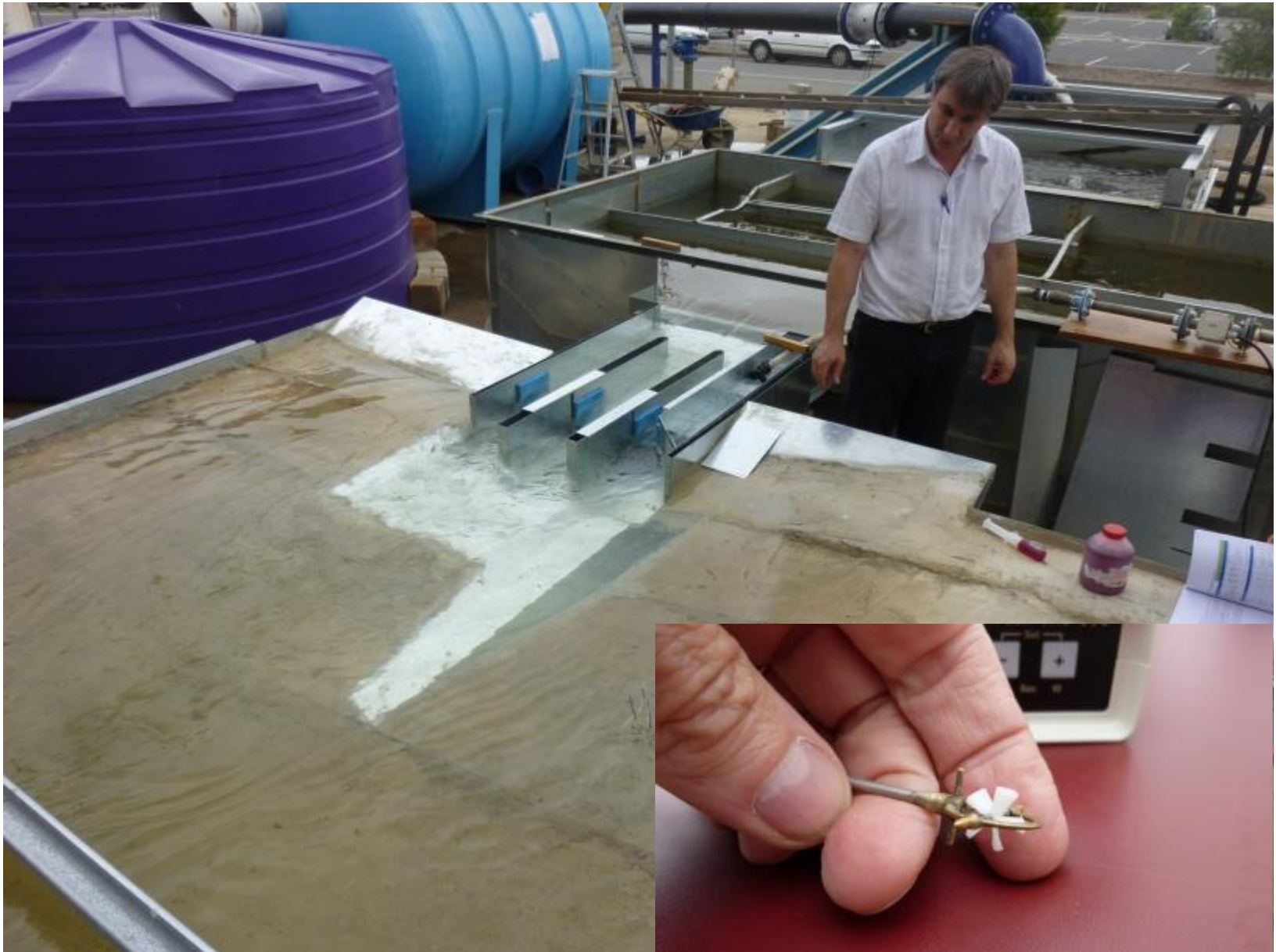








Fishway Entrance – Physical modelling

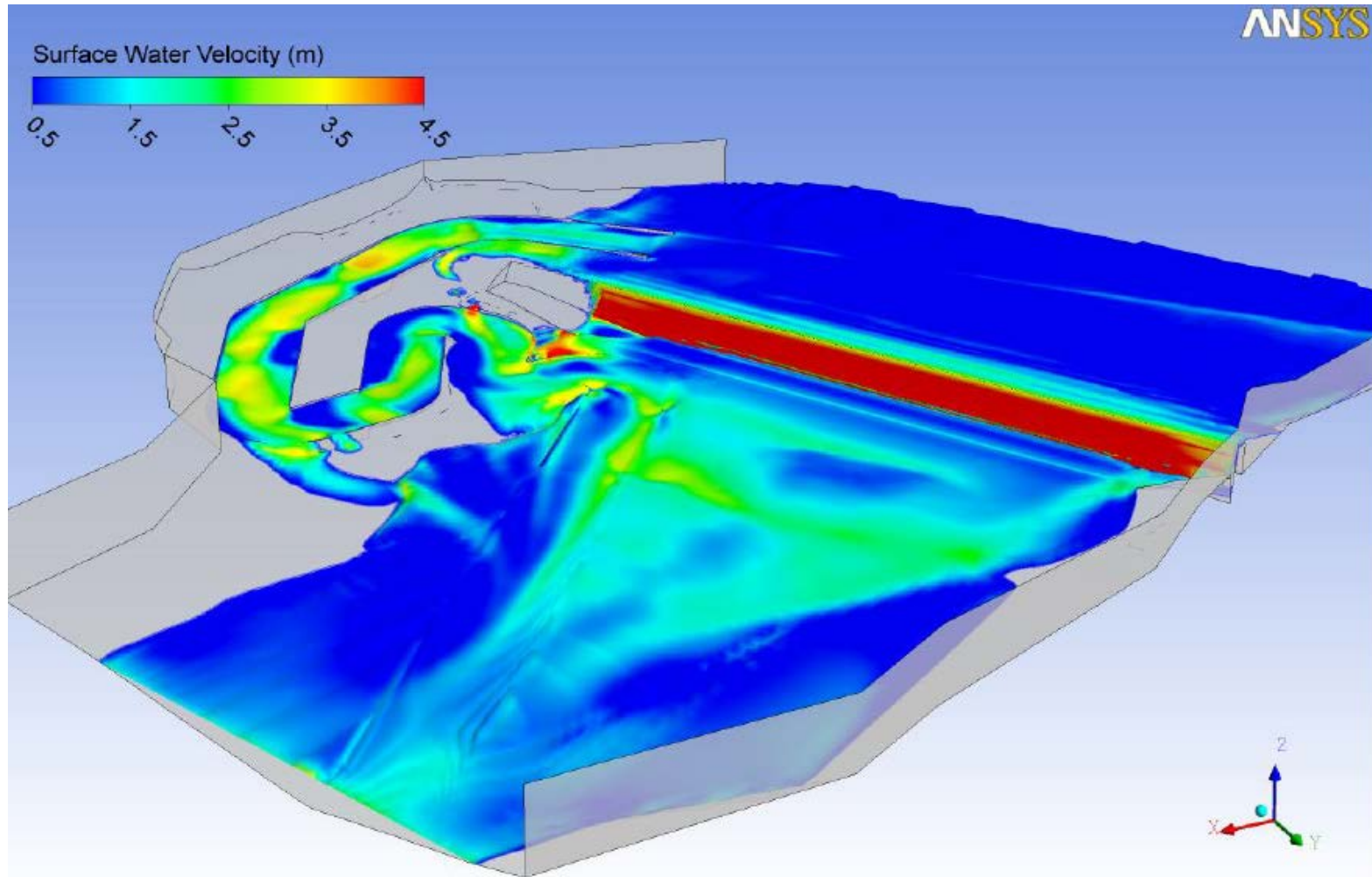


Fishway Entrance – Physical modelling



Fishway Entrance – Computer Modelling

Computational Fluid Dynamics (CFD)



GHD – Burrum Weir Fishway Project

Fishway Entrance – scope in design



Fishway Entrance – scope in design



Outlet works

Dam axis

Gates

Abutment

Bank protection

Spillway

Dissipating basin

Fishway Entrance – scope in design



Gate Operation

Gate design

Dissipating basin

Abutment design

Bank protection

- Fish passage is an integrated part of dam/weir design.
- Biologist, engineer, operator on-site and a team from the start



Think like a fish!

Conclusion

Fishway Types

- Vary in water level range, discharge & fish size; and O&M

Design process

- Biology, hydrology, hydraulics
- Design
 1. Attraction (entrance) Design
 2. Passage Design

It's a team approach!

- Tender, site inspection, background data, workshop concepts; review, discuss, question,
- Consider assumptions, risks
- Never a cookbook, each solution is unique

