



# Level Set Simulation of Free Surface Flow in Spillway for Fishway Design

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## Objective of Study

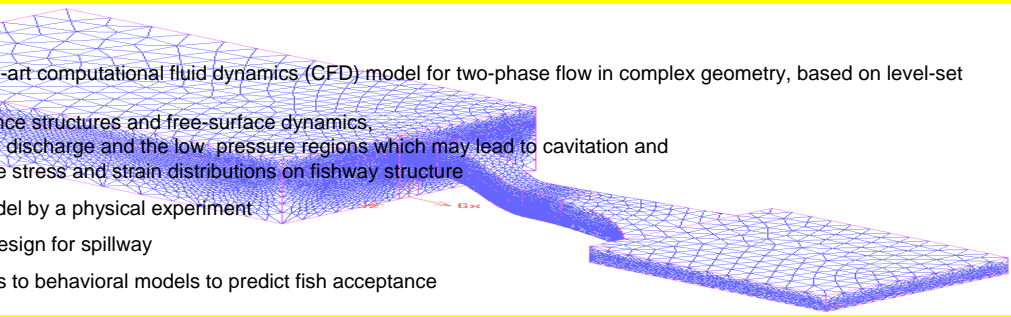
Develop a state-of-the-art computational fluid dynamics (CFD) model for two-phase flow in complex geometry, based on level-set method.

- (a) to study turbulence structures and free-surface dynamics,
- (b) to determine the discharge and the low pressure regions which may lead to cavitation and
- (c) to investigate the stress and strain distributions on fishway structure

Validate the CFD model by a physical experiment

Suggest an optimal design for spillway

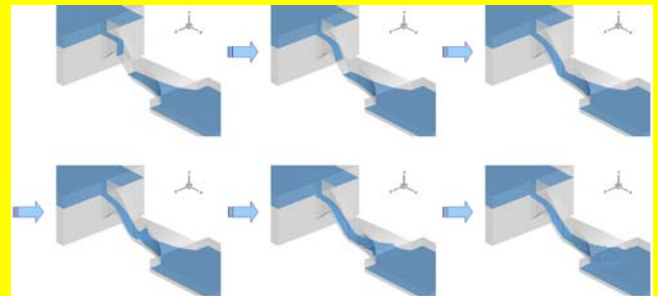
Link simulation results to behavioral models to predict fish acceptance



## Main features of numerical model

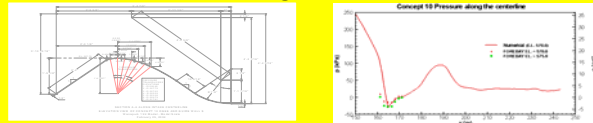
- Taylor-Galerkin Finite Element Method
- Fractional four-step method
- Incompressible Navier-Stokes equations
- Level-set technique for simulation of free surface
- LES-Smagorinsky's model

## Free surface evolution to quasi-steady state

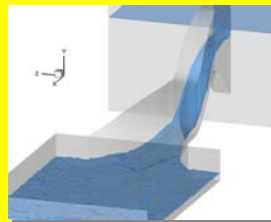


## Validation of CFD model

### Pressure distribution along the bottom center line



## Hydraulic jump



## Analysis of two design concepts

## Physical experiment

- Juvenile fish passage facility at the Wanapum Dam
- Design Concept-10 (Courtesy of Troy Lyons)
- Discharge of 20,000 cfs
- Laboratory model scale 1:24



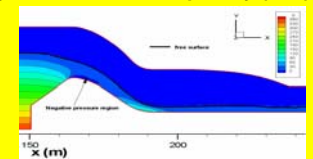
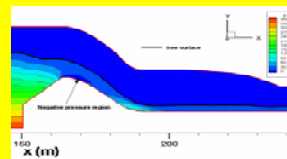
## Concept-10



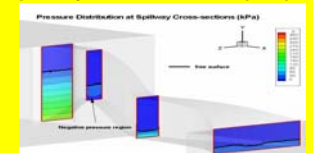
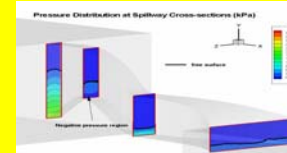
## Concept-11



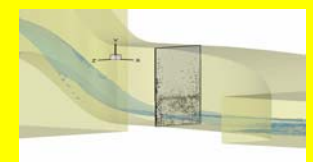
## Pressure distribution along the center of the spillway (kPa)



## Pressure distribution at the spillway cross-sections (kPa)



## Vortical structure at tailrace



## Conclusions and future study

- The developed numerical code can simulate several flow characteristics observed in the physical experiment.
- More refined experimental techniques are needed to confirm the detailed flow structures found in this study.