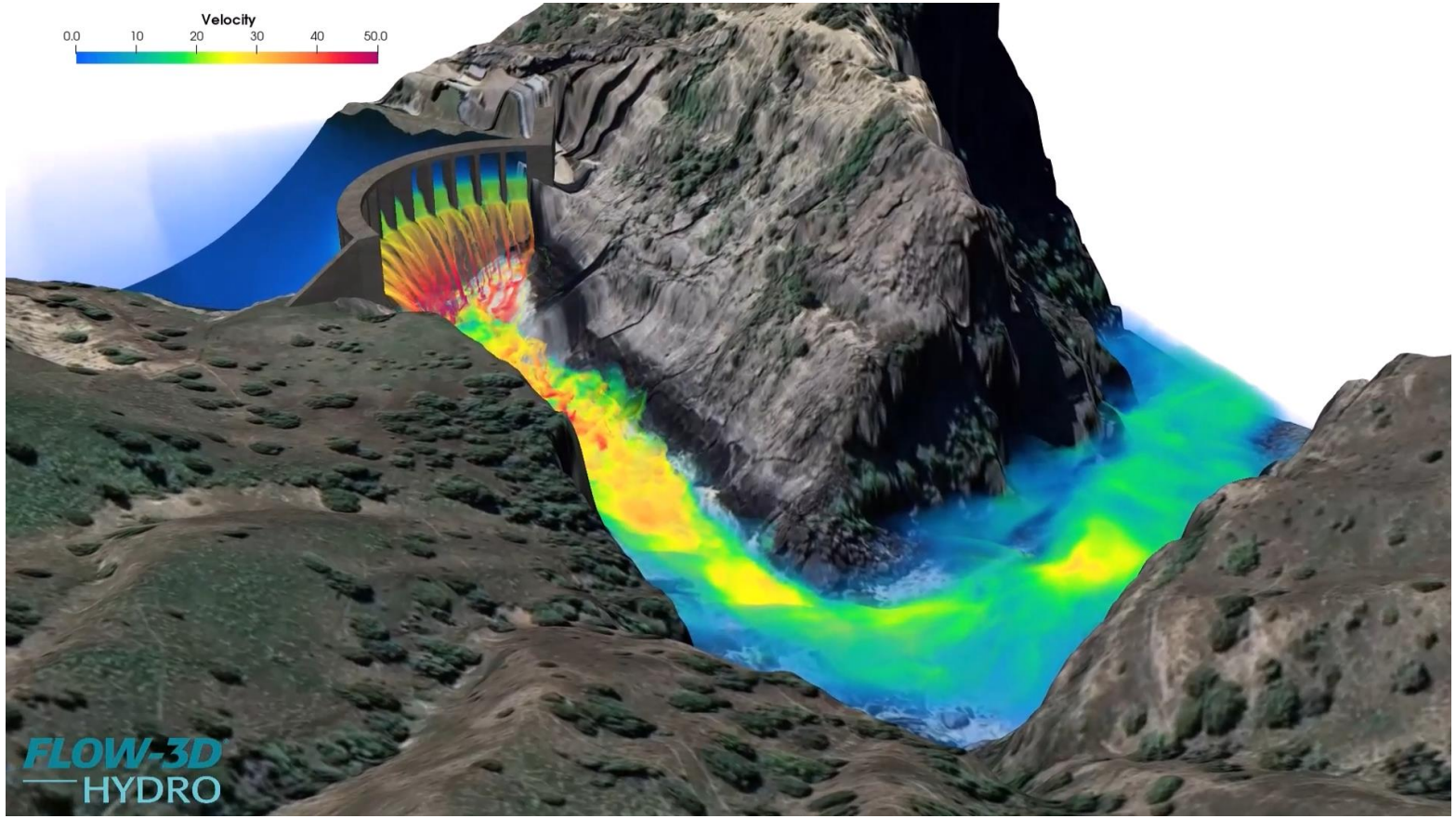
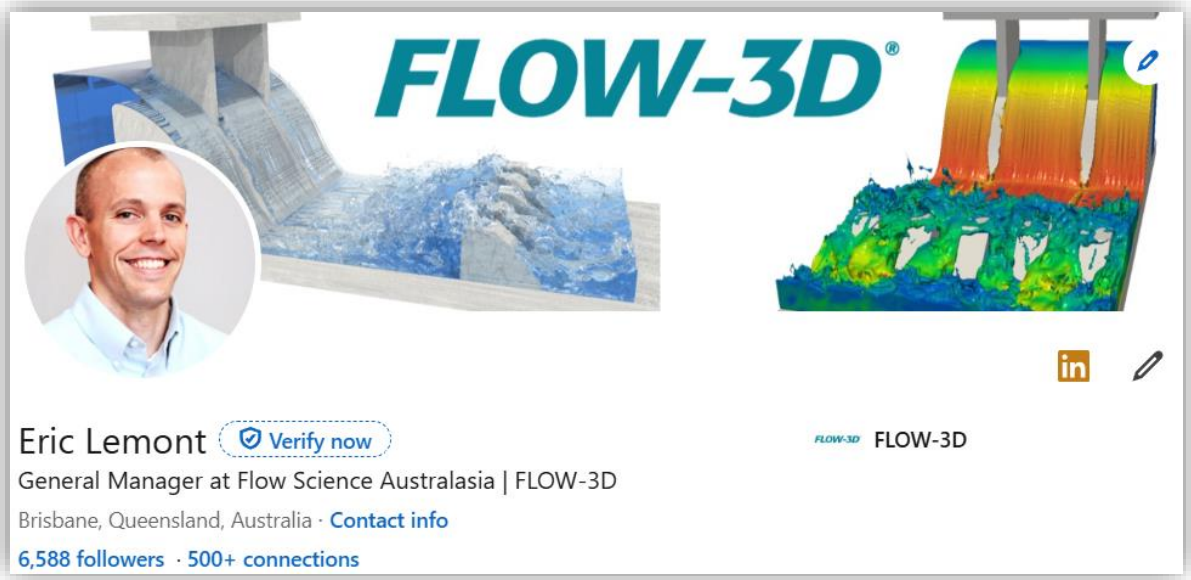


Build confidence in CFD modelling with *FLOW-3D* HYDRO

Eric Lemont

Flow Science Australasia Pty Ltd

Welcome!



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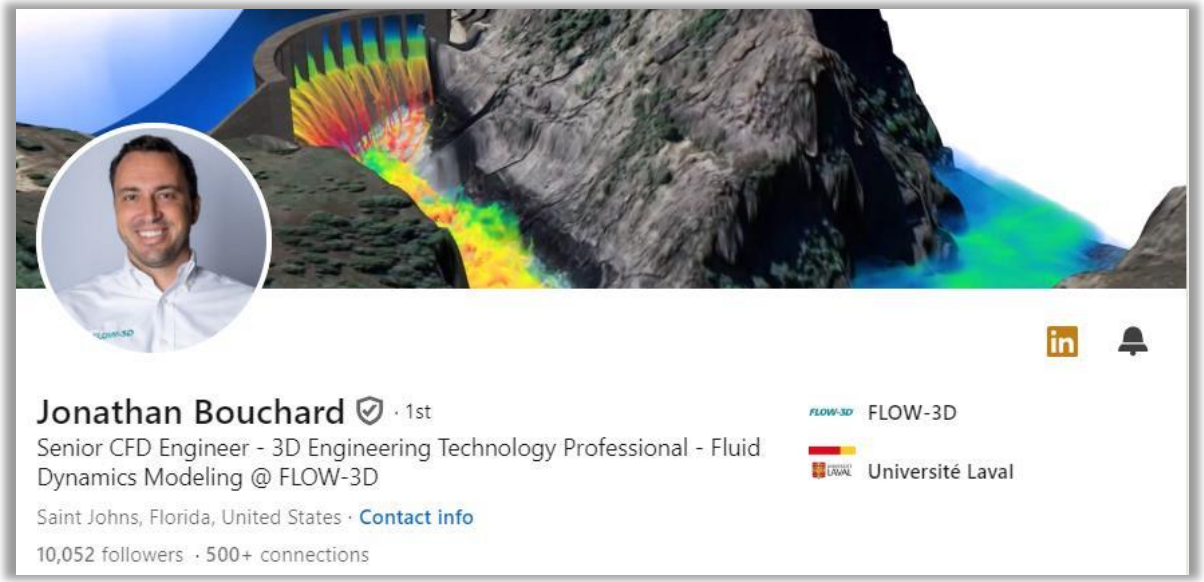
eric.lemont@flow3d.com.au

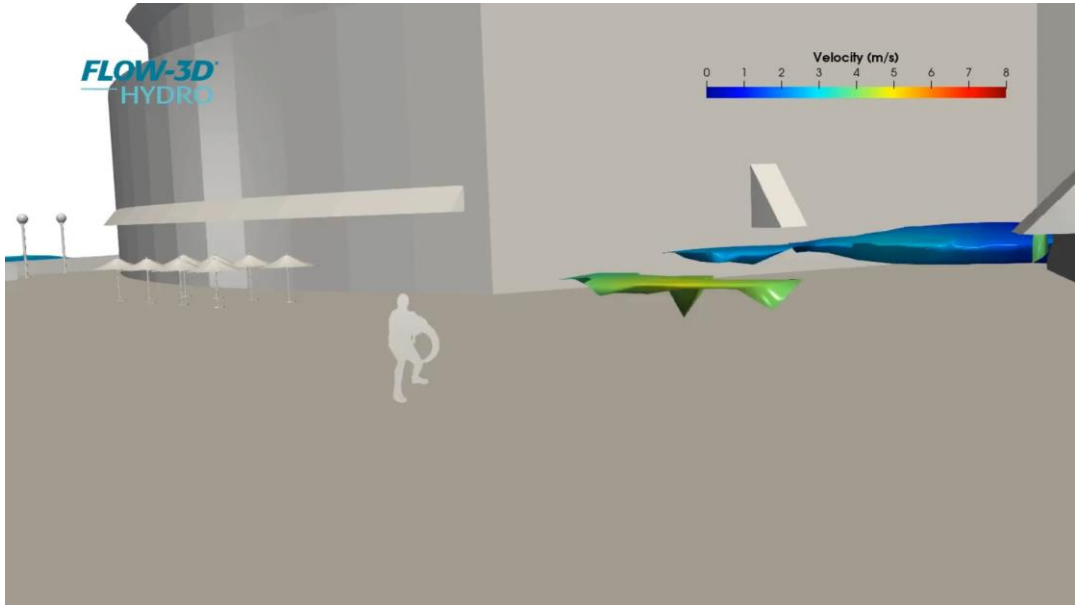


www.linkedin.com/in/jonbouchard/

Jon.Bouchard@flow3d.com

FLOW Science® AUSTRALASIA

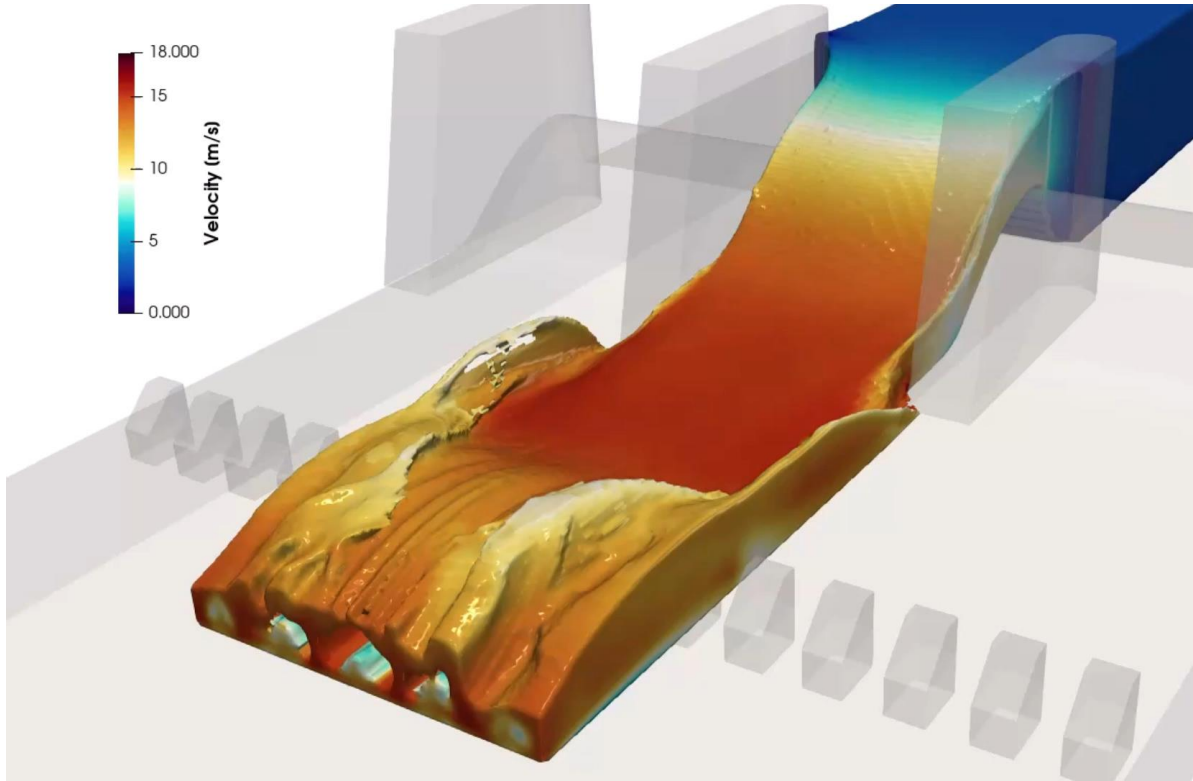
- ***FLOW-3D*** distributor for Australia & New Zealand
- Former ***FLOW-3D*** user in civil engineering industry
- Based in Brisbane



Website: www.flow3d.com.au
LinkedIn: www.linkedin.com/company/flow-science-australasia/
Phone: +61 499 077 607
Email: info@flow3d.com.au

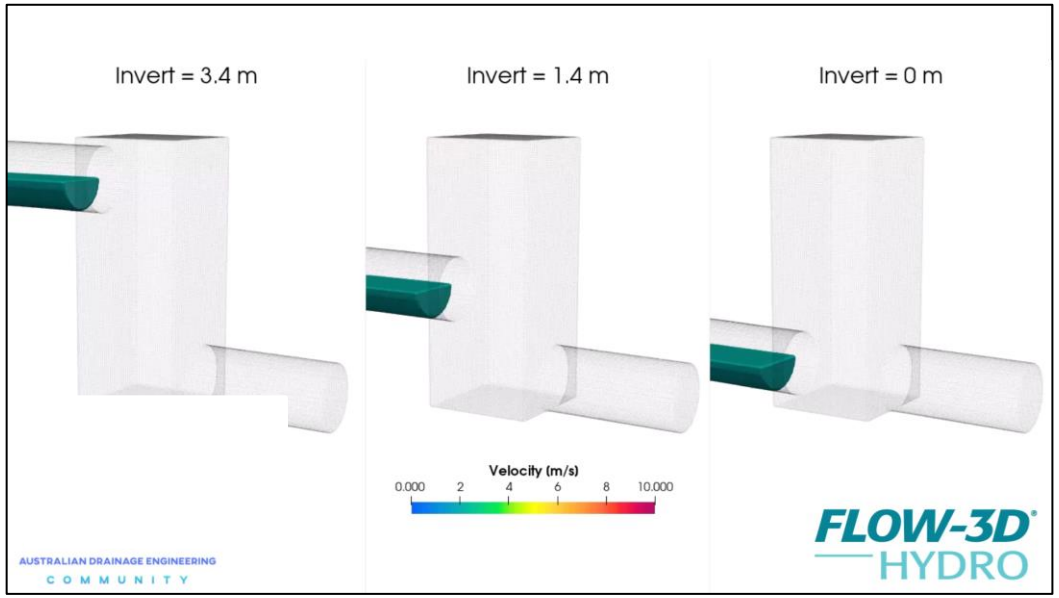
Today's Agenda

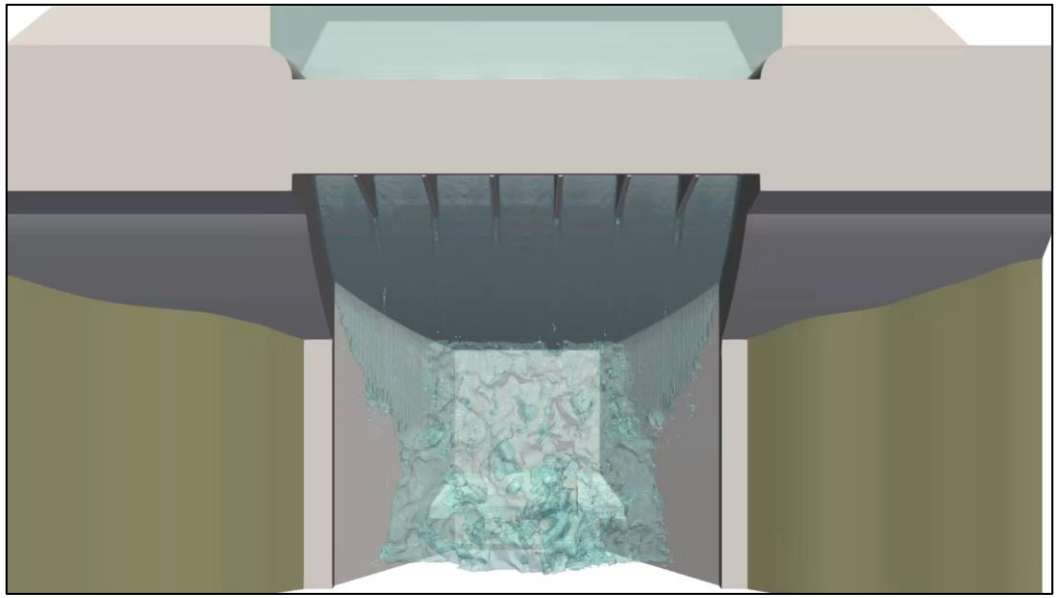
1. Introduction to 3D CFD and an overview of ***FLOW-3D*** **HYDRO**
2. User case studies
3. Launch the ***FLOW-3D*** **HYDRO** on-demand training course hosted by the Australian Water School
4. Live 5-minute ***FLOW-3D*** **HYDRO** demo



Today's Theme: Building Confidence in CFD

- How do our users build confidence into their CFD projects?
- How can you build confidence in your own CFD modelling skills?
- How does the ***FLOW-3D* HYDRO** interface and workflow help you build confidence in CFD modelling?



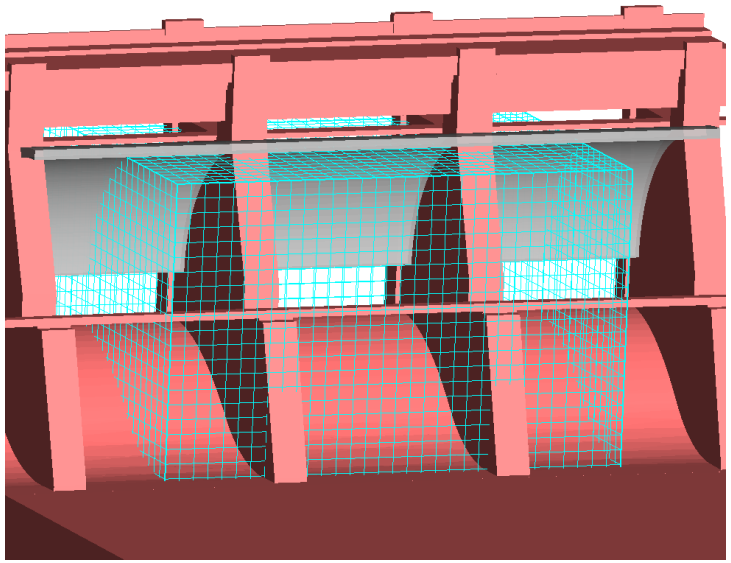


What is CFD?

A simulation tool that provides a highly **accurate**, **detailed**, and **dynamic** representation of how the flow interacts with its environment

What is CFD?

- Numerical solution for conservation of mass, momentum and energy

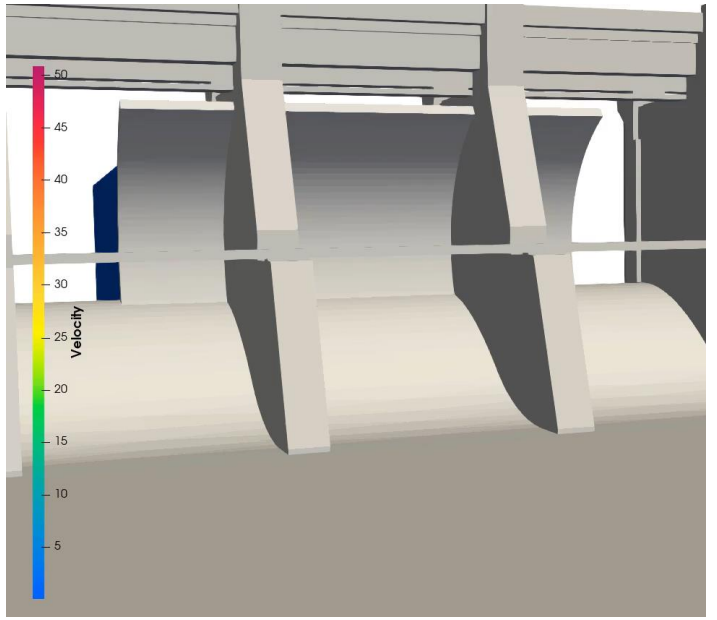


Continuity: $\nabla \cdot \boldsymbol{u} = 0$

X-Momentum: $\frac{\partial u}{\partial t} + \nabla \cdot (u\boldsymbol{u}) = -\frac{1}{\rho}\frac{\partial p}{\partial x} + \nu\nabla^2 u$

Y-Momentum: $\frac{\partial v}{\partial t} + \nabla \cdot (v\boldsymbol{u}) = -\frac{1}{\rho}\frac{\partial p}{\partial y} + \nu\nabla^2 v$

Z-Momentum: $\frac{\partial w}{\partial t} + \nabla \cdot (w\boldsymbol{u}) = -\frac{1}{\rho}\frac{\partial p}{\partial z} + \nu\nabla^2 w$



What is CFD?

Continuity: $\nabla \cdot \boldsymbol{u} = 0$

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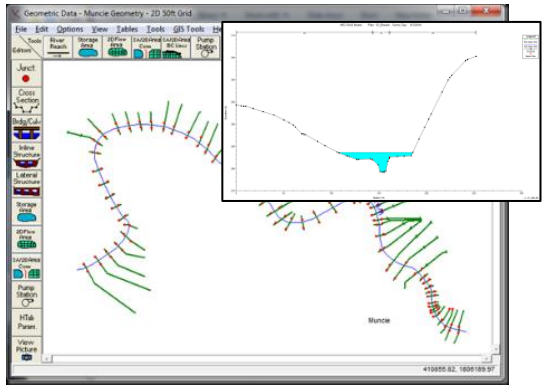
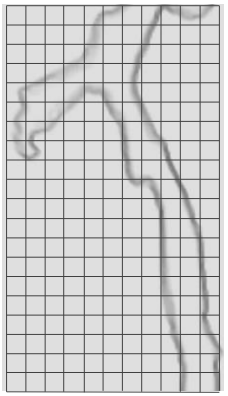
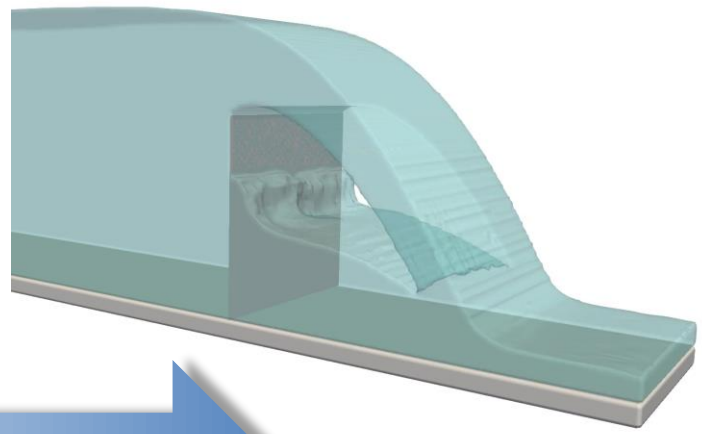
1 Dimensional



2 Dimensional



3 Dimensional

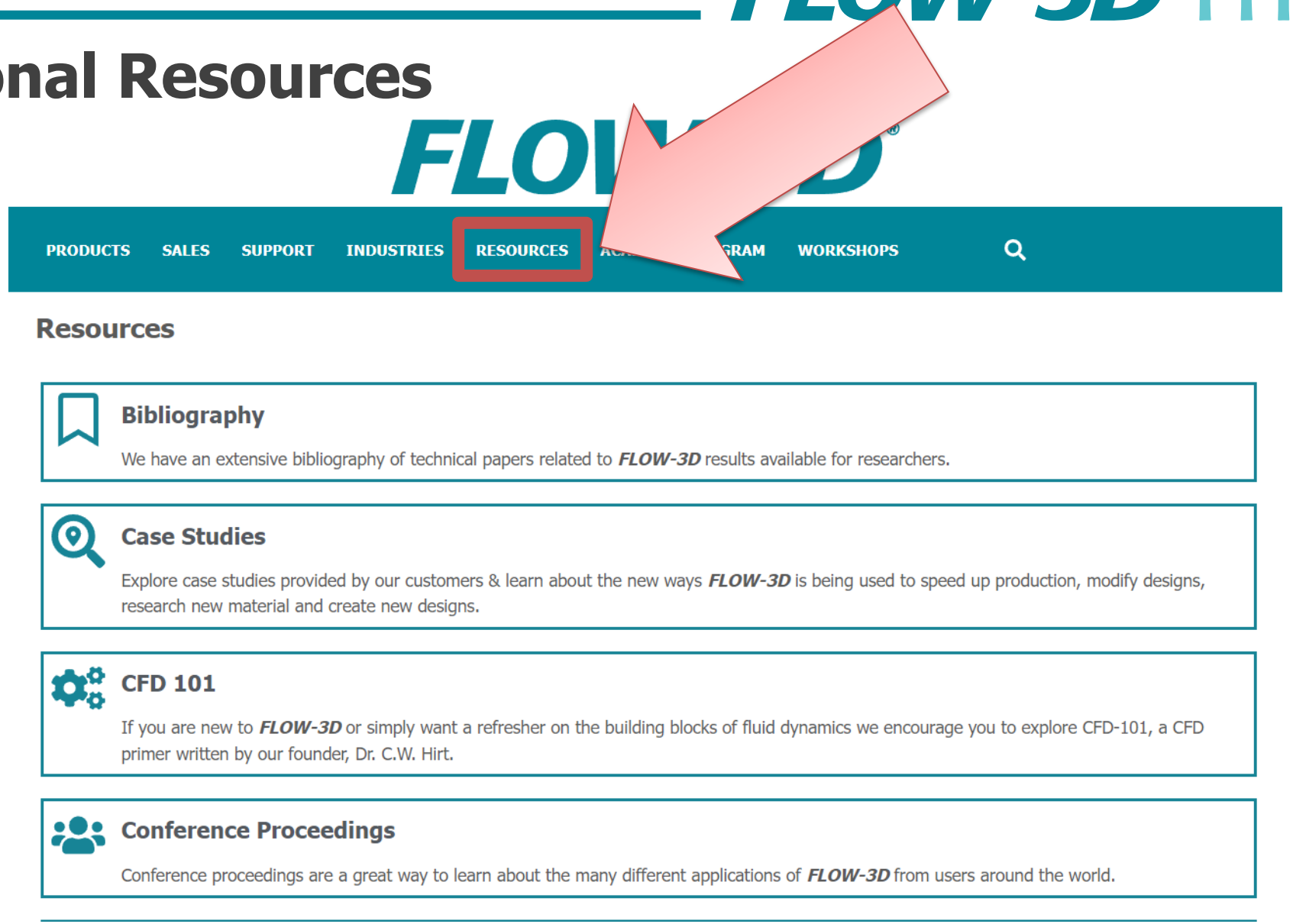


Increasing Complexity

When to Use 3D CFD?

- Higher accuracy alternative
- Reduction of design uncertainty
- Flexibility and versatility
- Analysis of complex / interacting multi-physics
- Supplement to physical and 1D/2D numerical models
- Effective communication
- And more…

Additional Resources



https://www.flow3d.com/resources/

About Flow Science…

FLOW-3D®

FLOW-3D® HYDRO

FLOW-3D® AM

FLOW-3D® WELD

FLOW-3D® (x)

FLOW-3D® CAST

LANL, T-3 GROUP

EARLY 1960's - 1979

FLOW

Marker-and-Cell

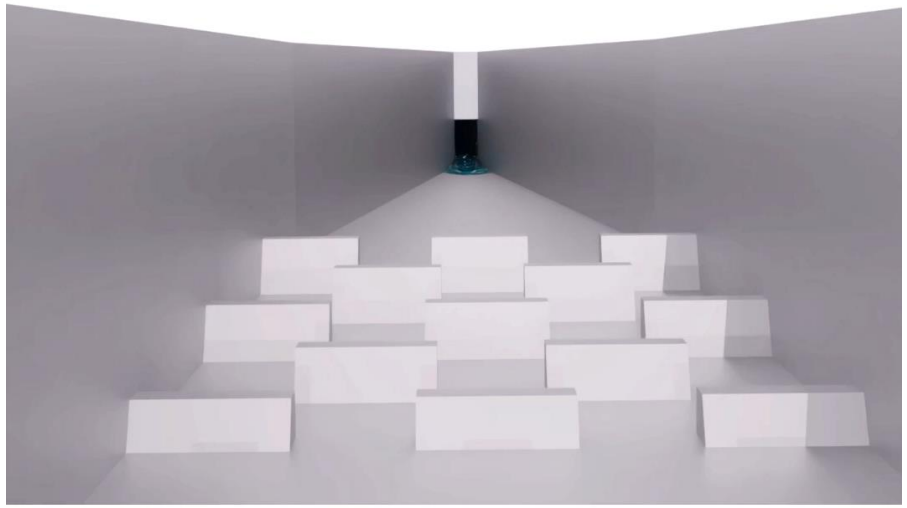
Flow Science Distributors

DISCOVER FLOW-3D

interface tracking

About *FLOW-3D* HYDRO

Complete CFD modelling solution for water applications in civil, coastal and environmental engineering industry

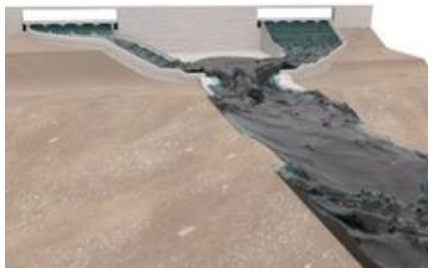


- ***45+ years*** of development
- Key features:
  - State-of-the-art 3D free surface capabilities
  - Advanced multiphysics
  - Advanced post-processing
  - Technical support
  - Versatility

About *FLOW-3D* HYDRO

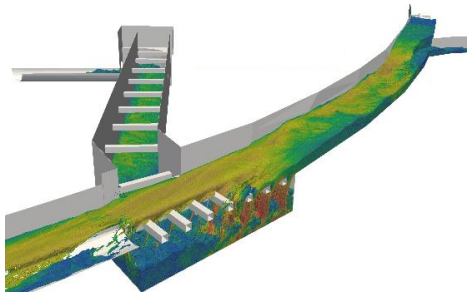
Dams & Spillways

- Hydraulics
- Rating curves
- Cavitation
- Air entrainment
- Sediment transport
- Rip-rap / embankment protection
- Moving gates
- Floating barriers
- Debris
- Free surface vortices at gates
- Uplift and forces
- Siphons
- Fish passage



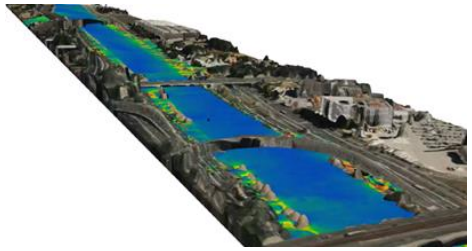
Conveyance Infrastructure

- Mixed free surface and pressurized flows
- Air supply
- Air entrainment
- Sedimentation
- Moving gates
- Debris
- Pump stations
- Free surface pump Intake vortices
- Valves
- Flow splitting



Rivers & Environmental

- River hydraulics
- 2D/3D hybrid models
- GIS/CAD integration
- Contaminants and plumes
- Bridge hydraulics and scour
- Sediment transport
- Fish passage
- Debris
- Tailings and non-Newtonian fluids
- Erosion protection



Water Treatment

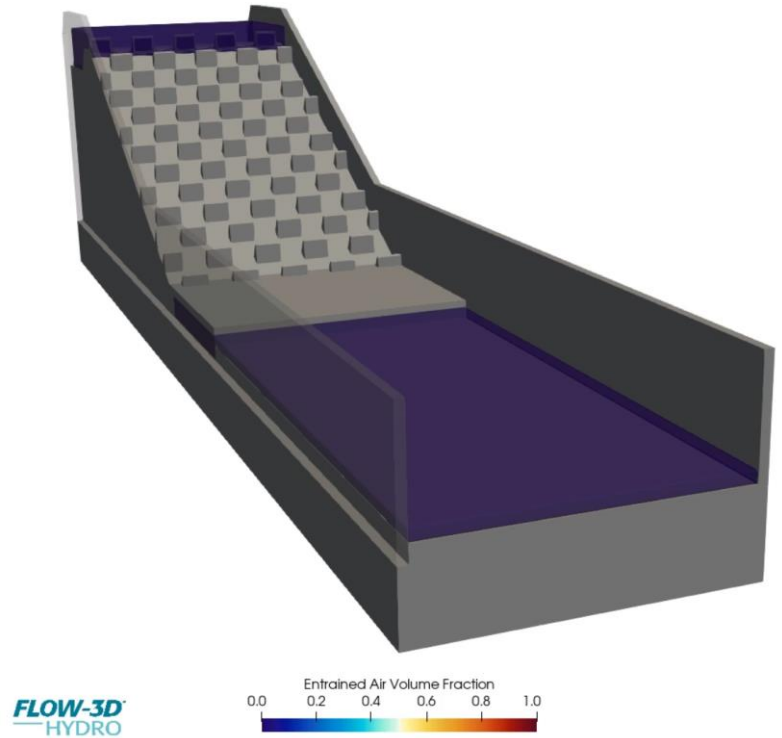
- WWTP hydraulics
- Disinfection
- Sedimentation
- Hindered settling
- Dispersed multiphase
- Gas dissolution
- Non-Newtonian fluids
- Density flows
- Reaction kinetics
- Mixing
- Screens
- Lagoon aeration and dissolved oxygen

Ports & Coastal

- Wave/structure interactions
- Breakwaters
- Moving objects
- Density flows
- Wave energy devices
- Mooring, catenaries
- Coastal outfalls
- Ship launches
- Locks

Not all CFD software is the same…

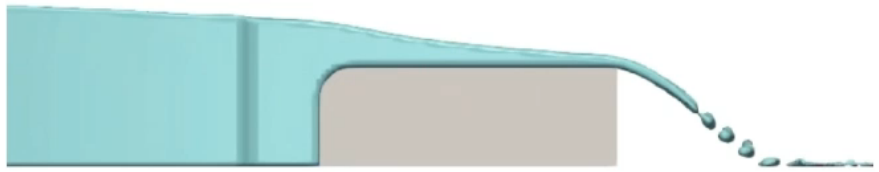
- What makes ***FLOW-3D* HYDRO** different?
  - Easy to use user interface
  - Simple meshing and geometry handling
  - Robust free-surface modelling with a 1-fluid volume of fluid approach
    - Faster simulations → less hardware required
  - Supported and developed by people with experience in the water industry

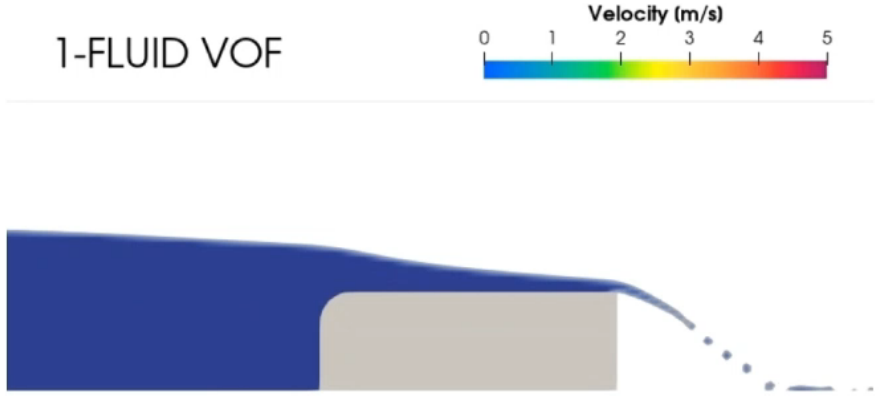


1-fluid VOF vs. 2-fluid VOF: a simple comparison

1-fluid VOF

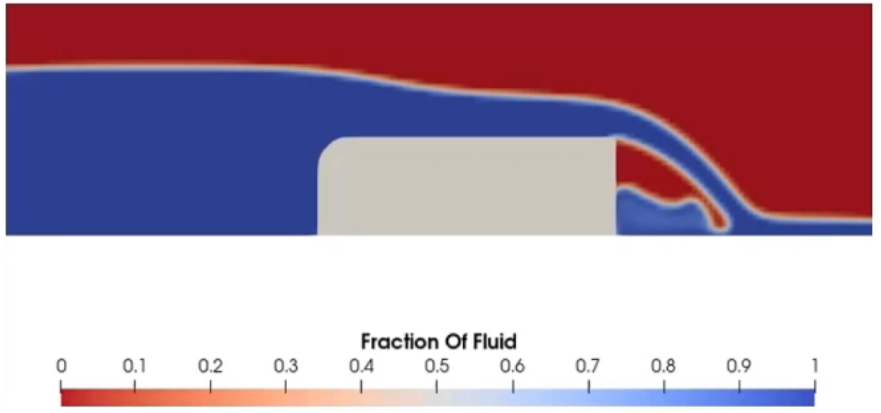
Air flow is not modelled





2-fluid VOF

Air flow is modelled



Kerb break capture efficiency

Location: Queensland, Australia

Contact: Steven Voss
ARUP
Steven.Voss@arup.com

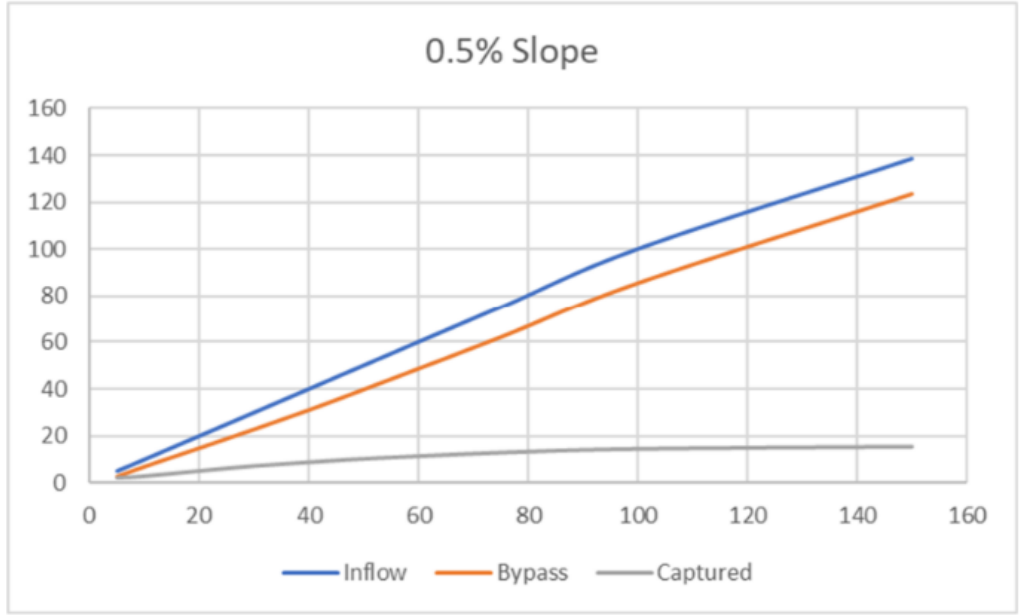
ARUP

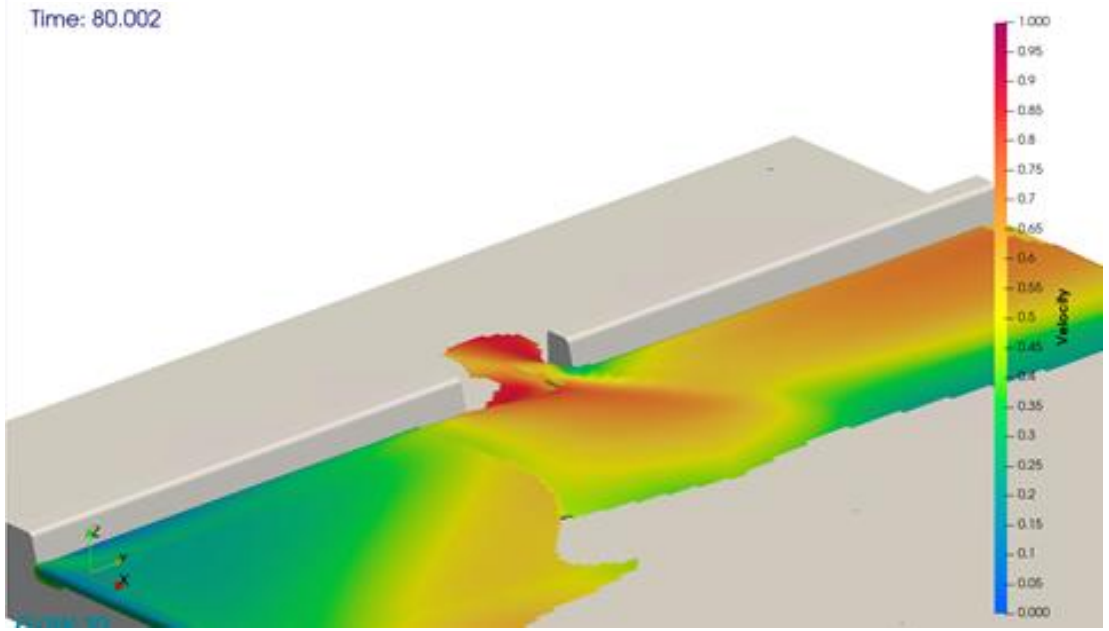
Cycle track drainage

- Problem:
  - Capture efficiency of kerb breaks is uncertain
    - How many do we need?
- Approach:
  - Create a 3D virtual lab in ***FLOW-3D* HYDRO**
  - Simulate a range of flow rates and longitudinal slopes
  - Develop capture curves

Capture efficiency

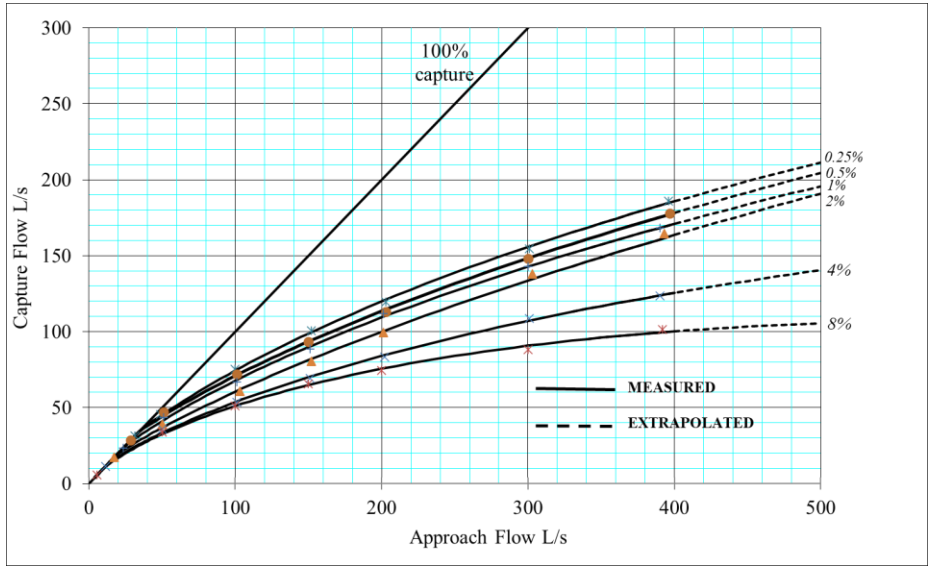
- Generated capture curves for range of longitudinal gradients and flow rates
- Gained insights into the design approach for kerb break spacing
  - Spacing dependent on road width
  - Wider gaps may reduce spacing
  - Possible sediment issues due to low velocities

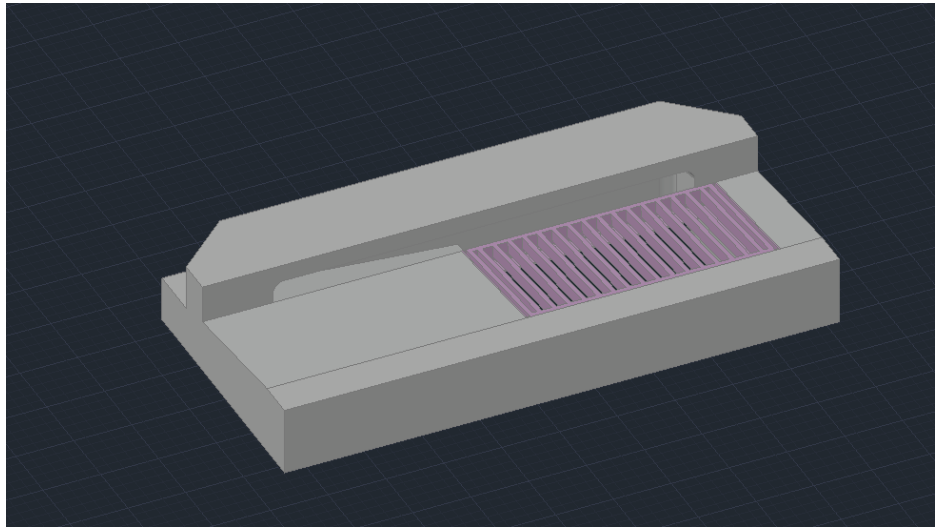




Ongoing drainage applications

- Combination pit design
- Lab testing at UniSA Laboratory
  - CFD validated to physical data
  - CFD used to test additional variations





Primary settling tank (non-Newtonian sludge)

Location: Victoria, Australia

Contact: Greg Chalmers
CMP Consulting Group
gchalmers@cmpgroup.com.au

CMP CONSULTING GROUP

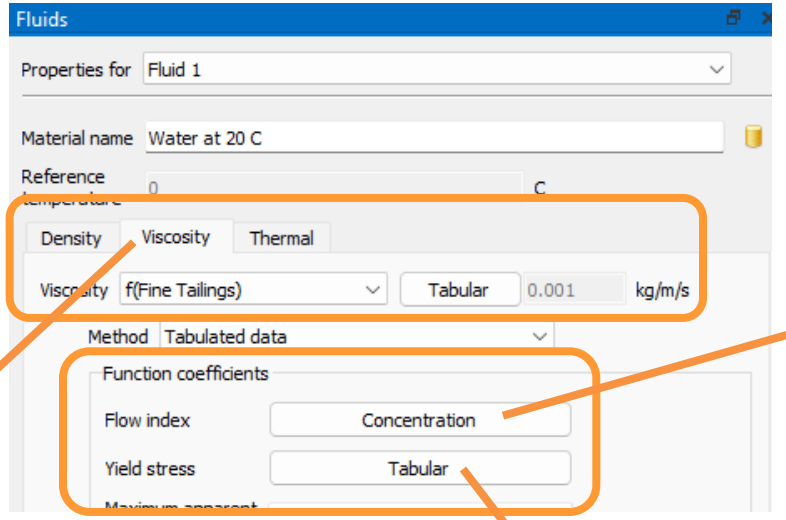
Primary settling tank sludge pumping issue…

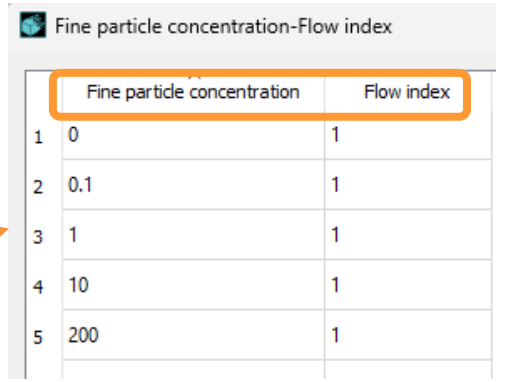
- Primary settling tank for wastewater treatment
  - When sludge pumps are in operation for 10-15 minutes, a "rathole" develops in sludge layer
    - This results in the upper water layer being pumped out instead of the sludge layer
    - Currently, they run the pumps for shorter durations (1-2 minutes) to get around the ratholing issue

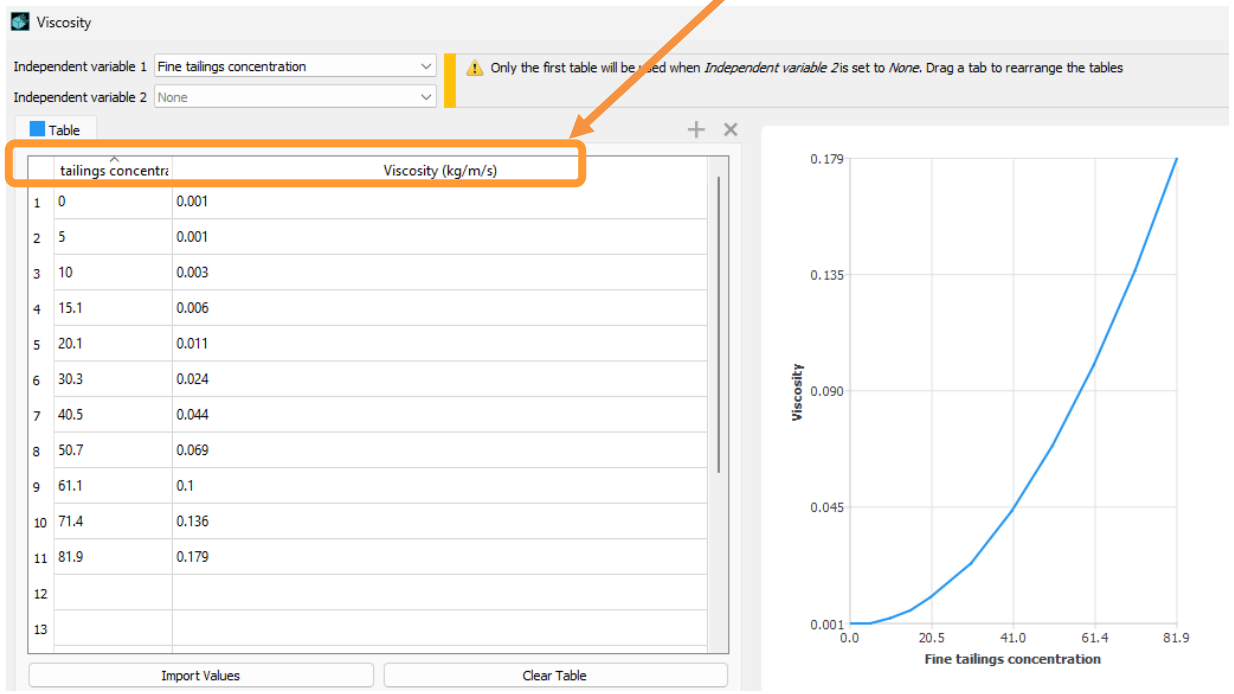
- Can CFD modelling assist with the solution?
  - Initial perception from the client:
    - *"Standard CFD software will not accurately model Herschel-Bulkley fluids despite vendor claims."*

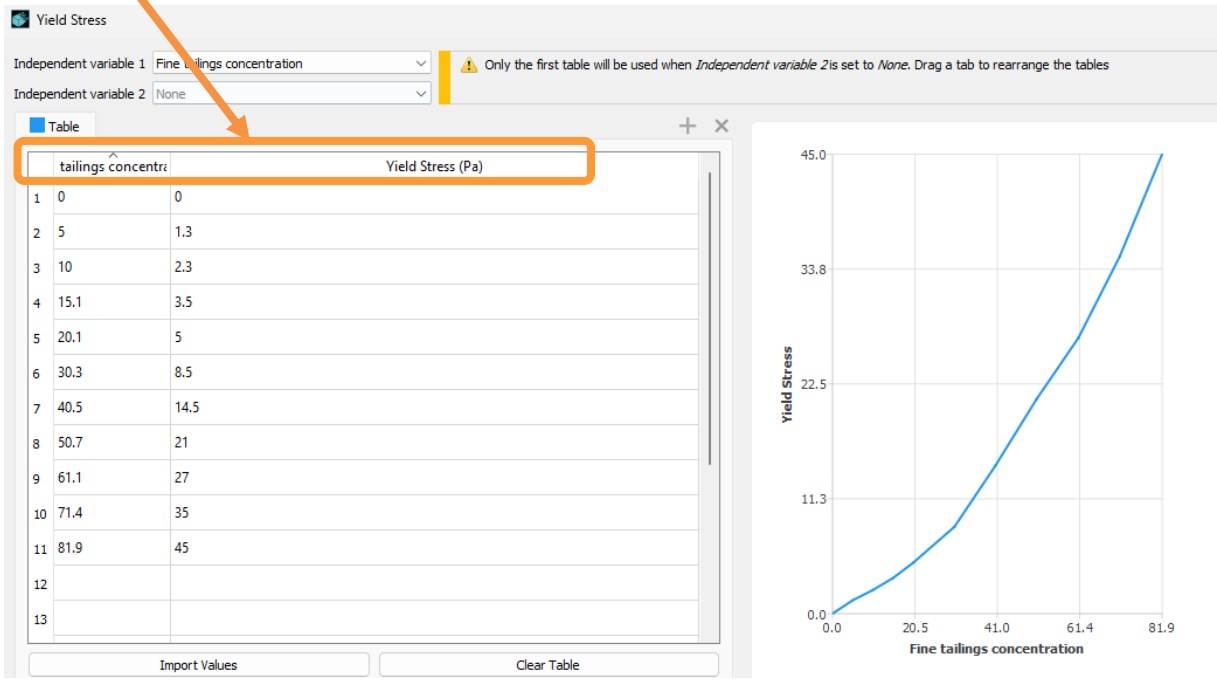
Sludge properties

- Tabular properties
- Based on site data

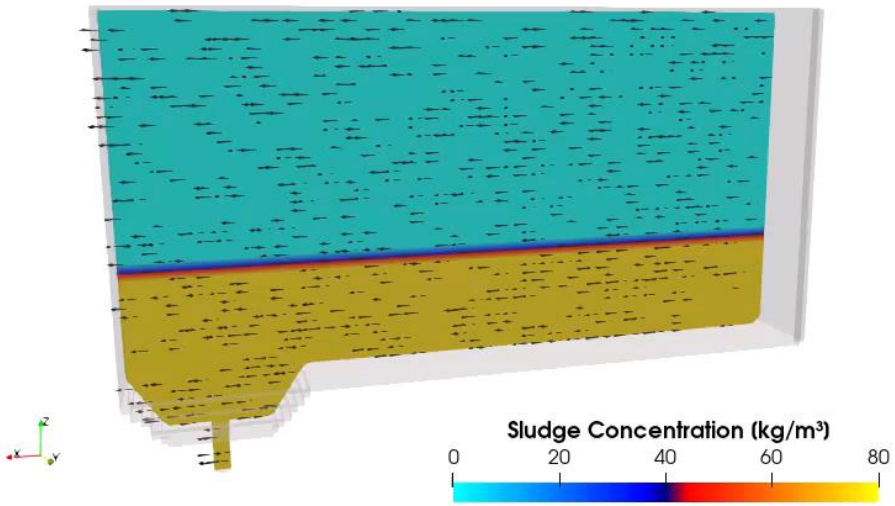


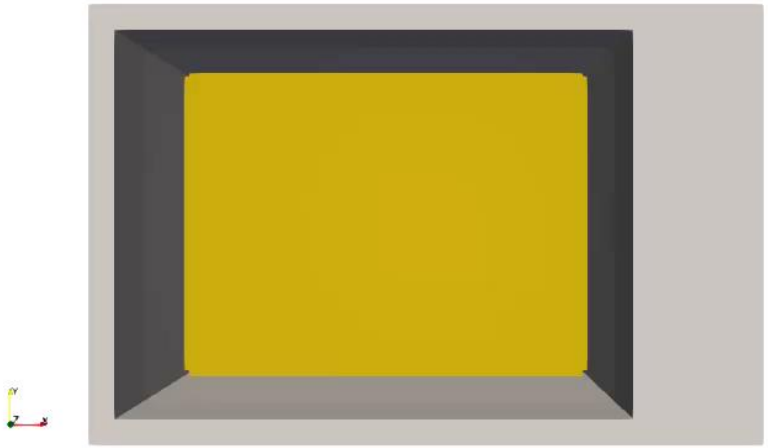


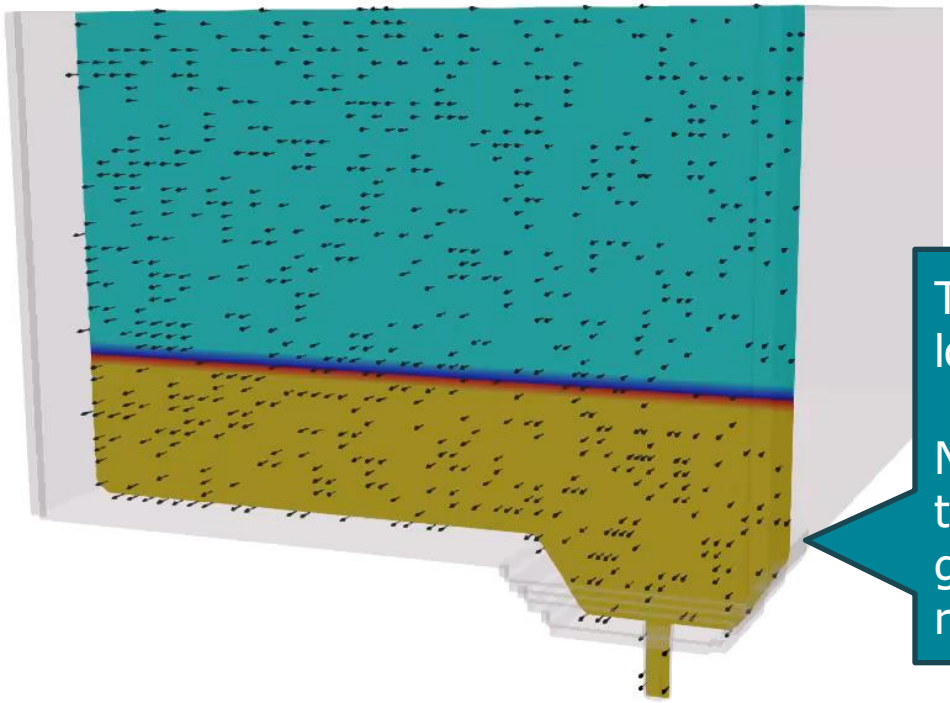




Can we mix water and non-Newtonian sludge?







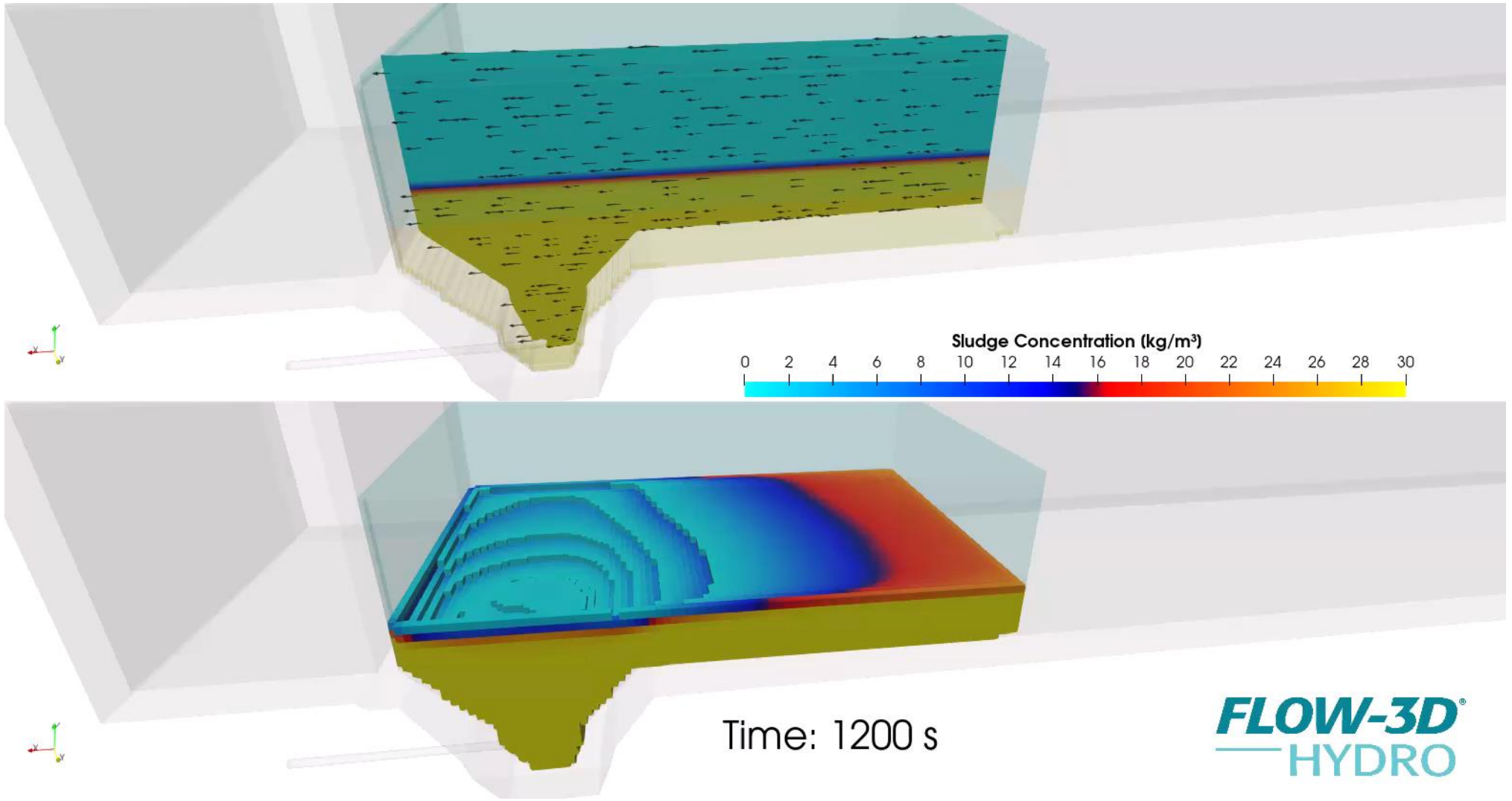
The rathole formation looks promising.

Now let's try it with the actual tank geometry and flow rates.

Time: 0.000 s

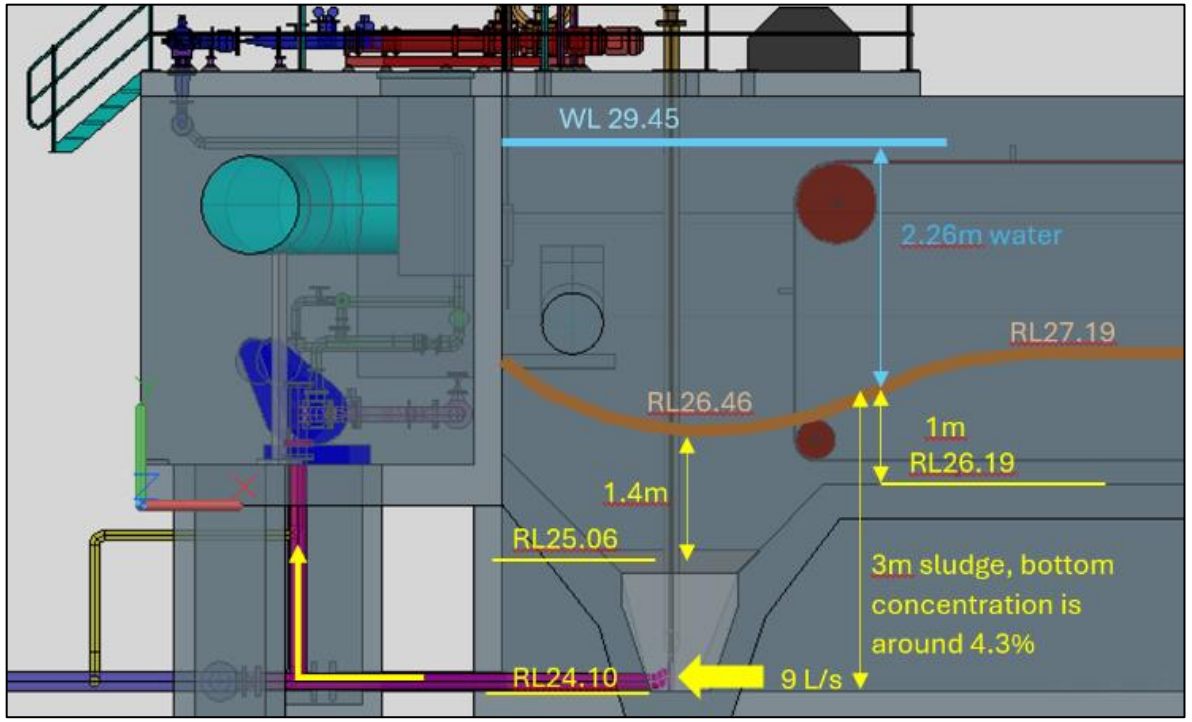
FLOW-3D® HYDRO

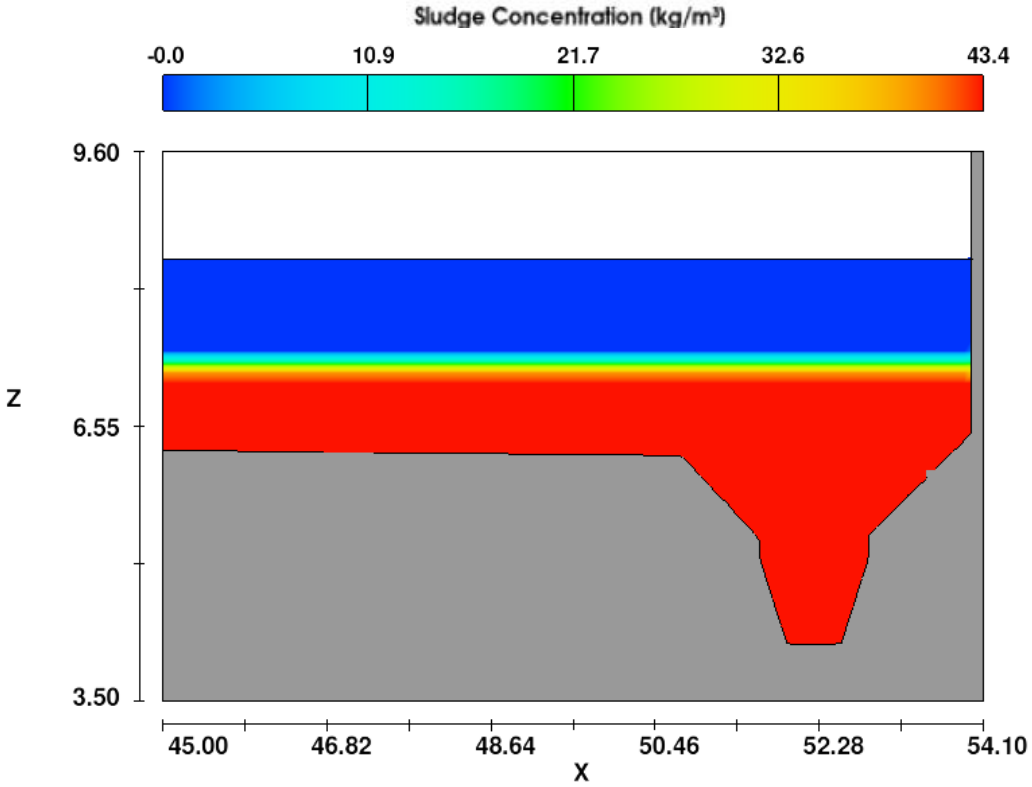
Existing condition (actual geometry): 12 L/s



Site testing and proposed design/improvements

- Initial site testing was consistent with CFD model tests
- Final CFD runs ongoing to support proposed design and operational improvements





Innovative nursery slot fishway

Location: Central Queensland, Australia

Contacts: Kyle Thomson
Forward Hydro
kthomson@forwardhydro.com.au

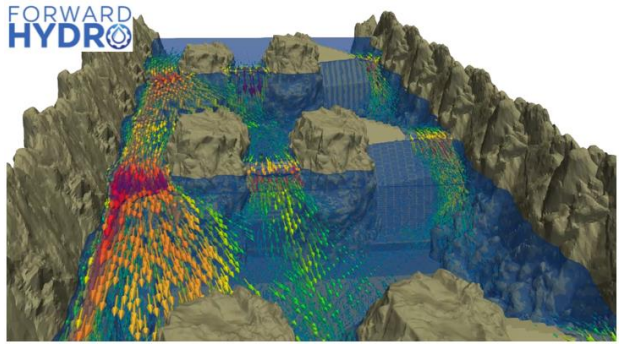
Matt Moore
Catchment Solutions
Mmoore@catchmentsolutions.com.au

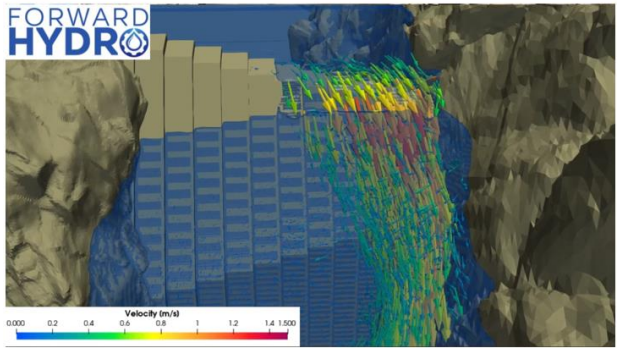
Nursery slot fishway

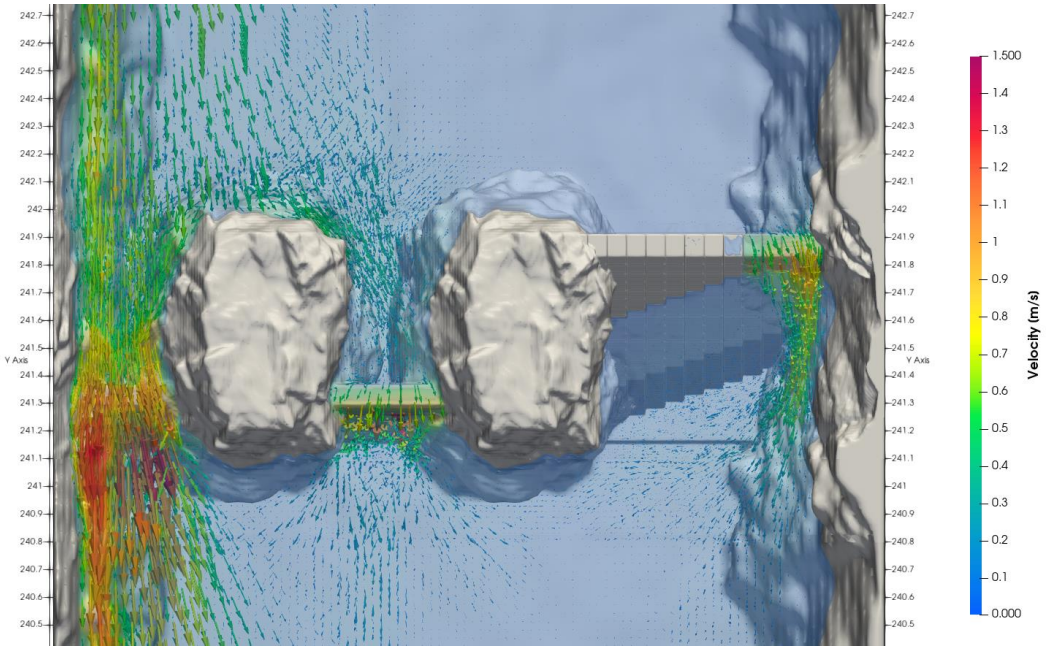
- Coastal ponded pasture
  - Weak swimming fish (postlarvae and juveniles)
  - Migration between saltwater and freshwater habitats
- Innovative slot design added to a rock fishway concept; works for a variety of water levels

Nursery slot fishway

- CFD modelling in two phases:
  - Larger-scale fishway model for overall flow patterns
  - Finer-scale model of nursery slot ramp for detailed insights

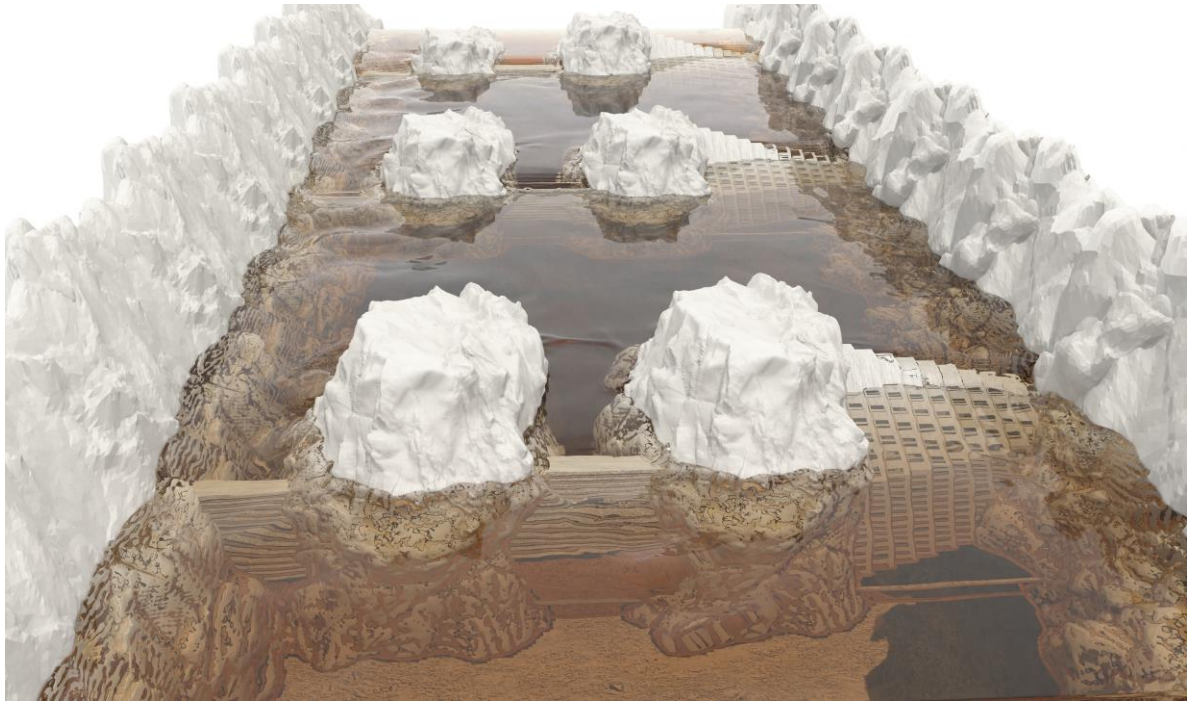


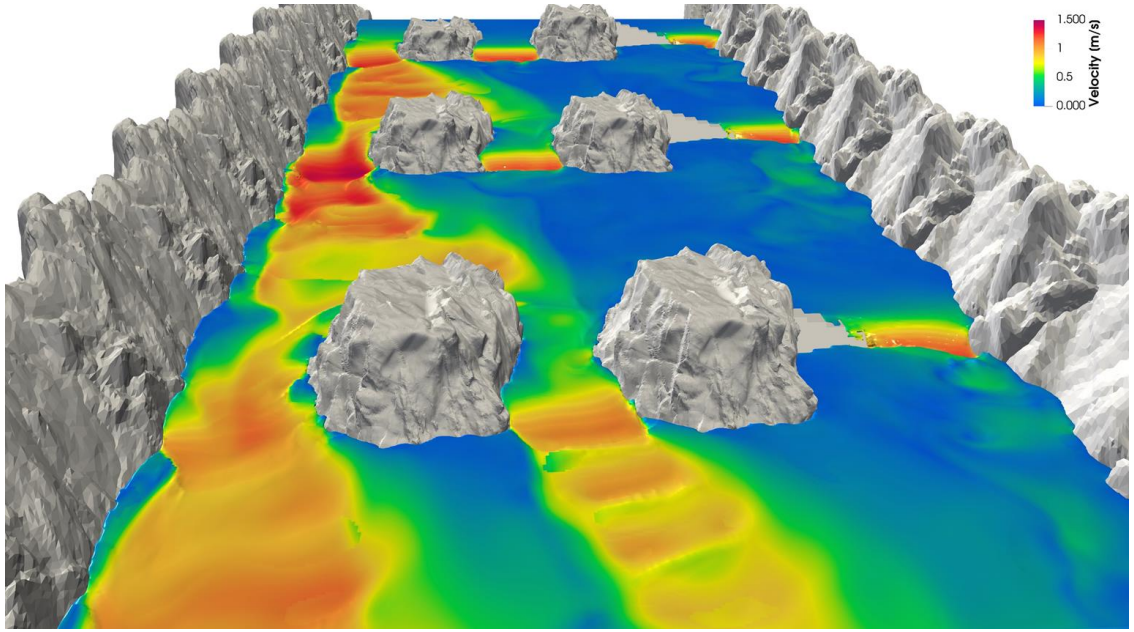




"***FLOW-3D* HYDRO**'s ease of use enabled us to efficiently investigate a variety of design and hydraulic conditions... Working with the fisheries ecologists, we were able to assess the hydraulic performance of an innovative fishway design and provide advice on ways to **optimize performance** relating to the native fish species' swimming habits."

Kyle Thomson, Technical Director, Forward Hydro





Monitoring results

- During a three-day monitoring period, over 2,700 fish representing 13 different species ascended the fishway, including postlarvae and juvenile fish.

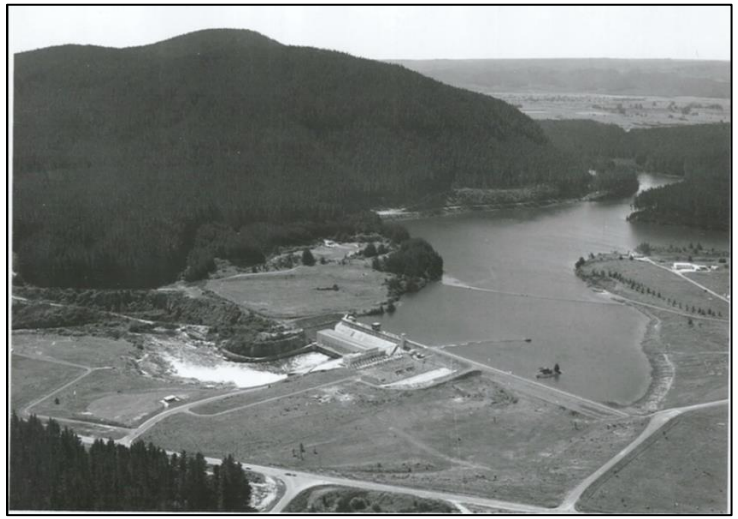
Hydro intake gate: hoist load investigation

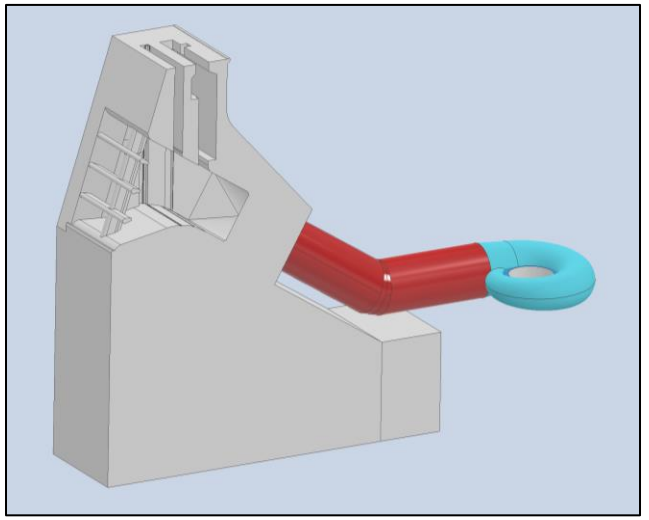
Location: Waikato River, New Zealand

Contact: Darryl Andrews
Civil Hydraulics Consulting Ltd
darryl@civilhydraulics.co.nz

Hydro intake gate: hoist load investigation

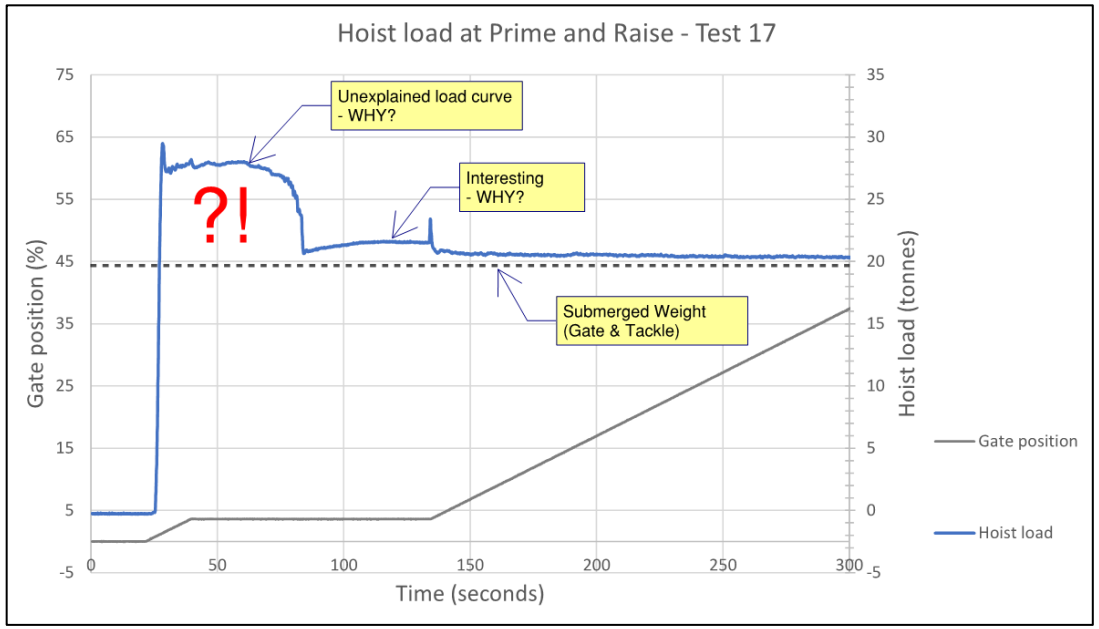
- Atiamuri Power Station on the Waikato River
  - Four 21MW Francis turbines
  - 27.4m of operating head
- Full presentation on the ***FLOW-3D*** Conference Proceedings page:
  - https://www.flow3d.com/resources/conference-proceedings/

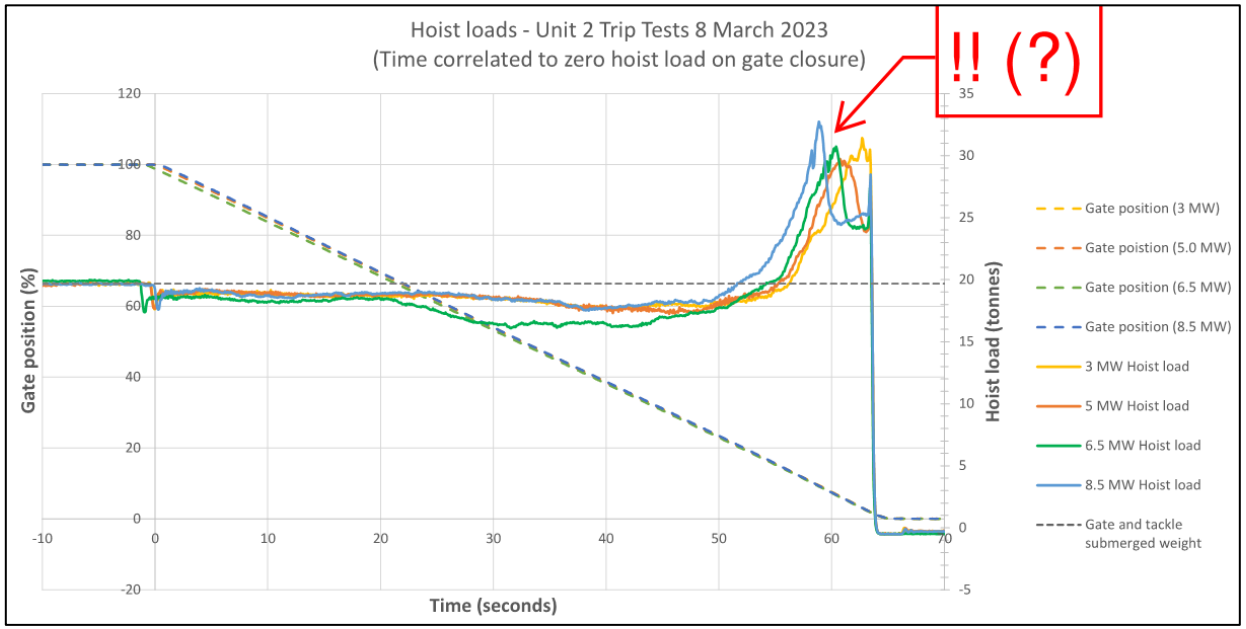




Site testing

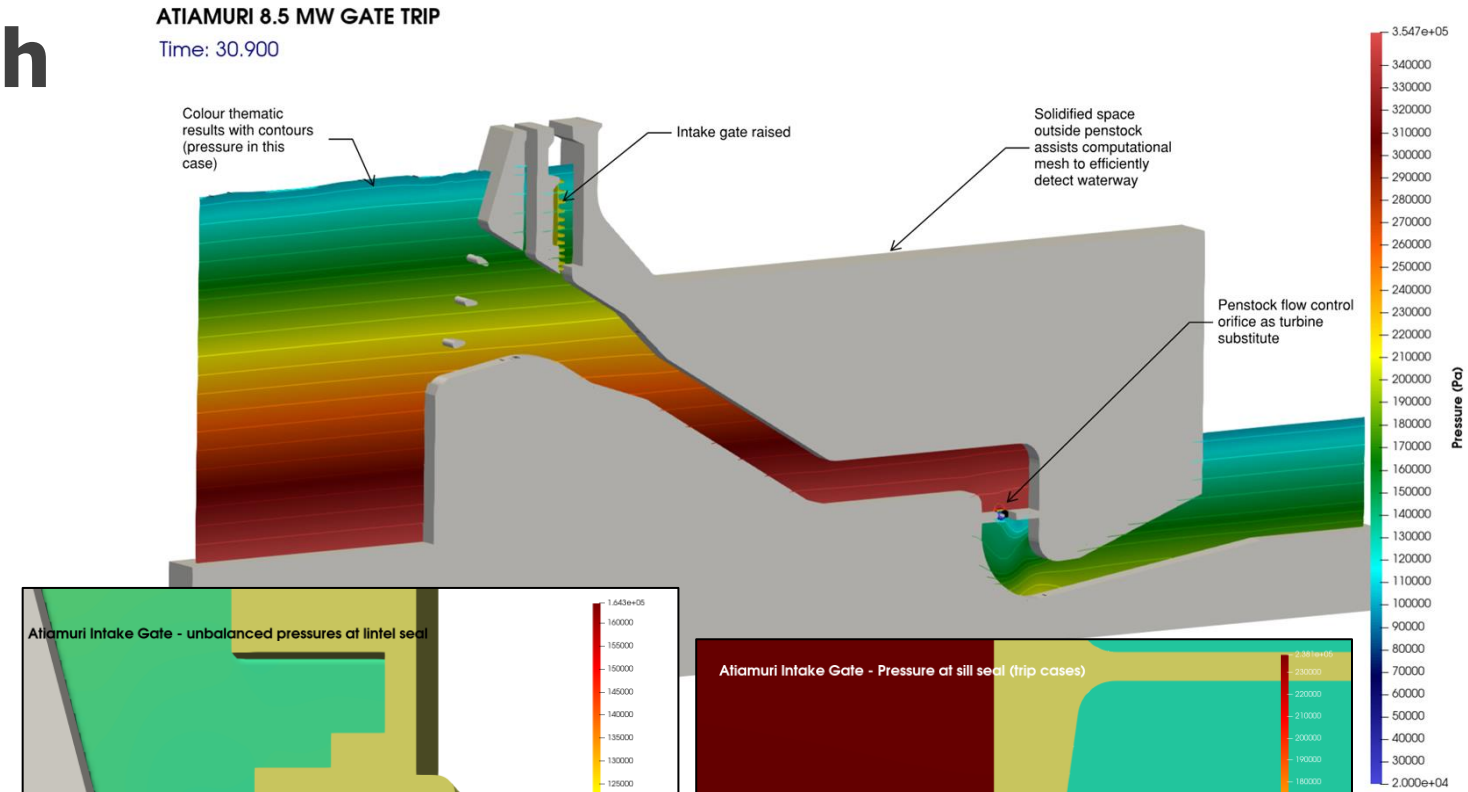
- Difficult to access gates for monitoring
- Key observations from site data:
  - Priming load irregularities
  - Excessive trip loads

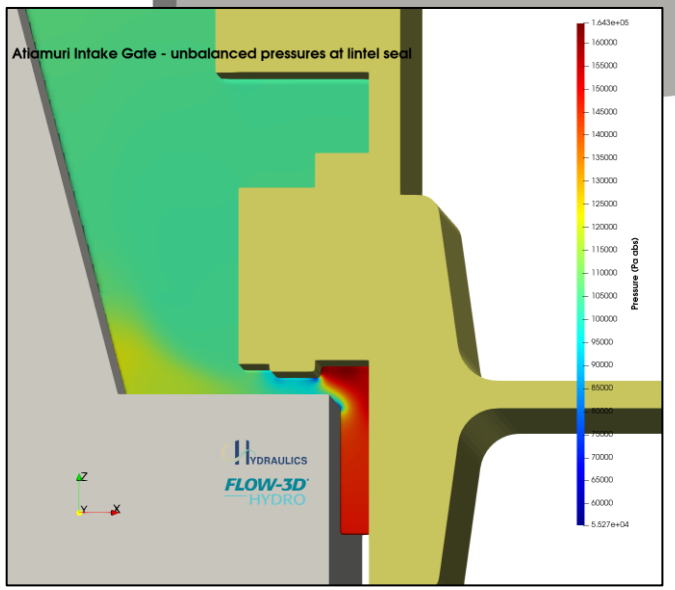


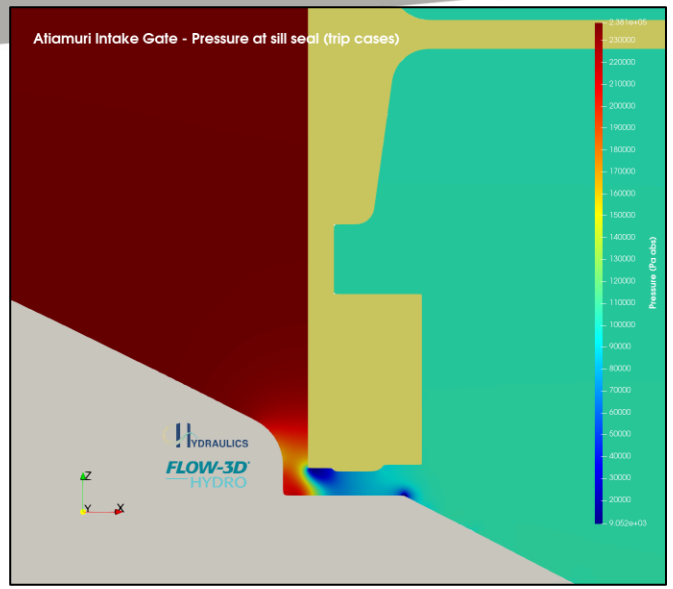


CFD modelling approach

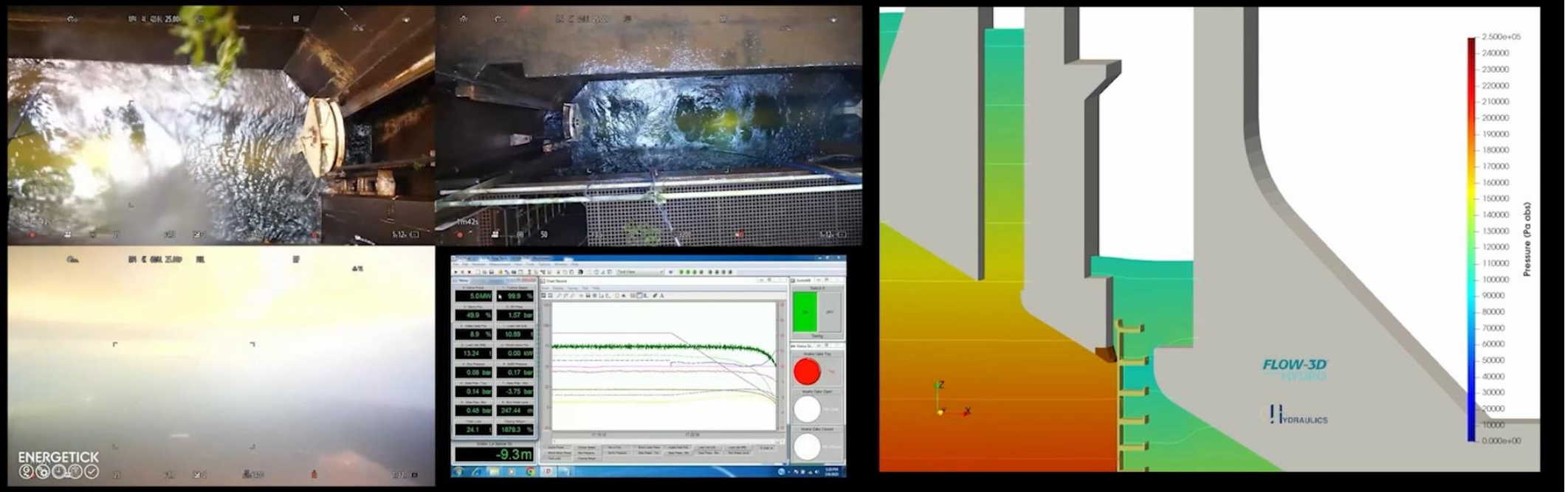
- Used a "2D slice" approach to capture more detail
  - Larger model for priming and trip investigations
  - Other detailed models for localized cases
- Data and video comparisons to site data



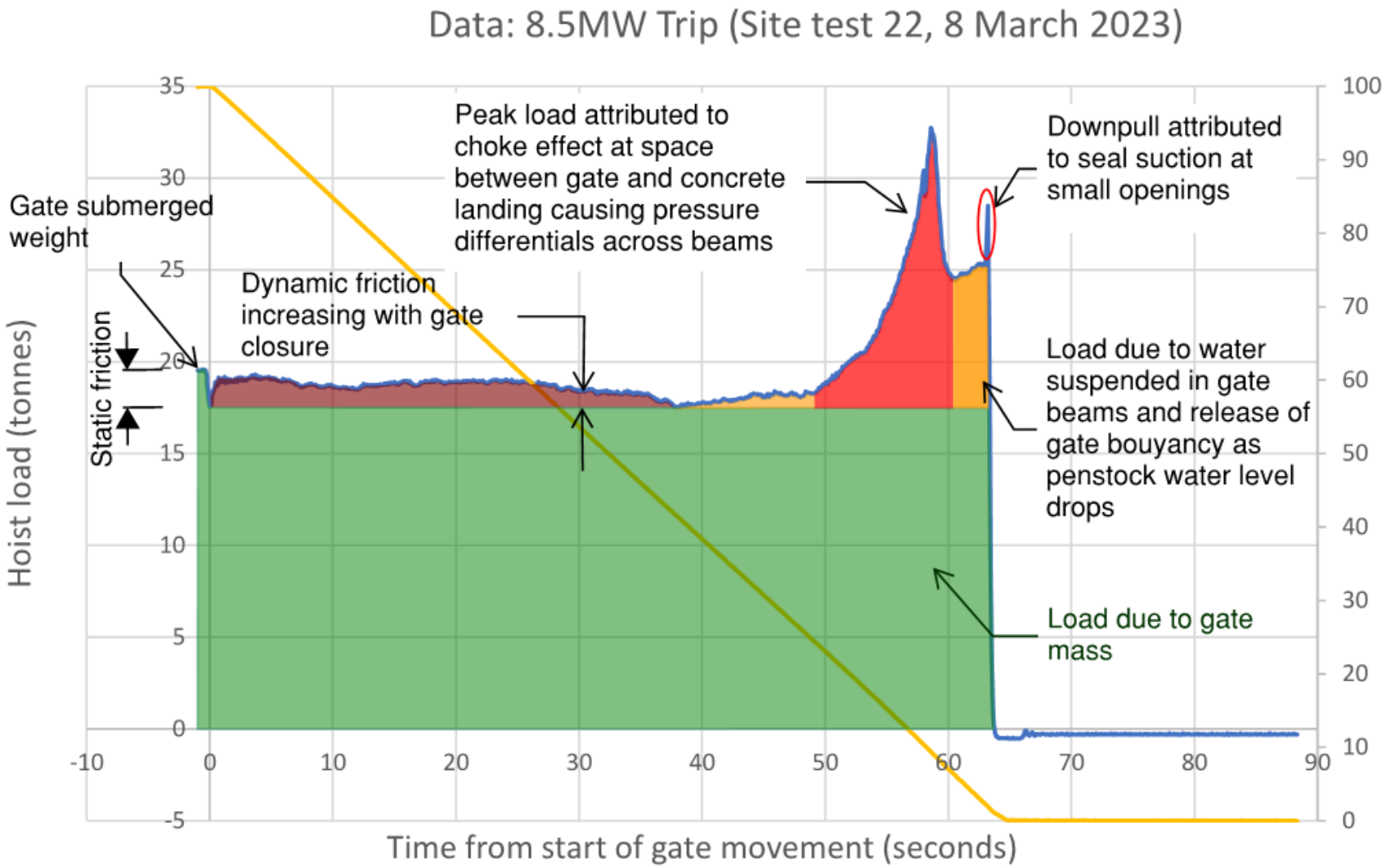


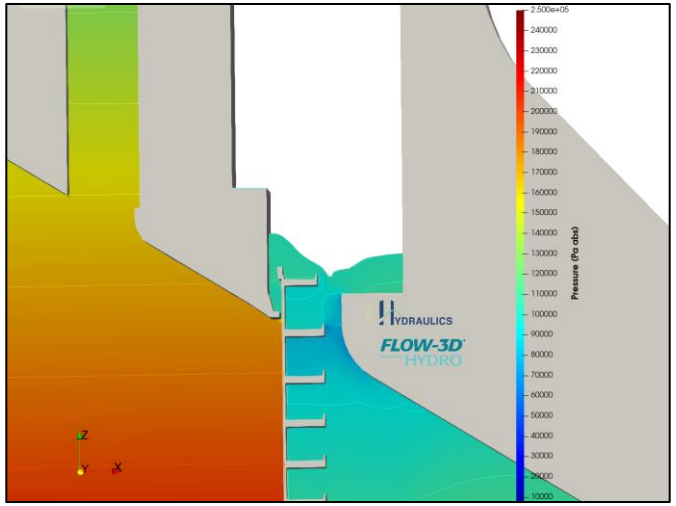


Atiamuri Intake Gate G2 8.5MW Trip (Test 21)
8 March 2023
Gate Shaft Camera Views, Data Capture and CFD Pressure Simulation



Trip loads delineated



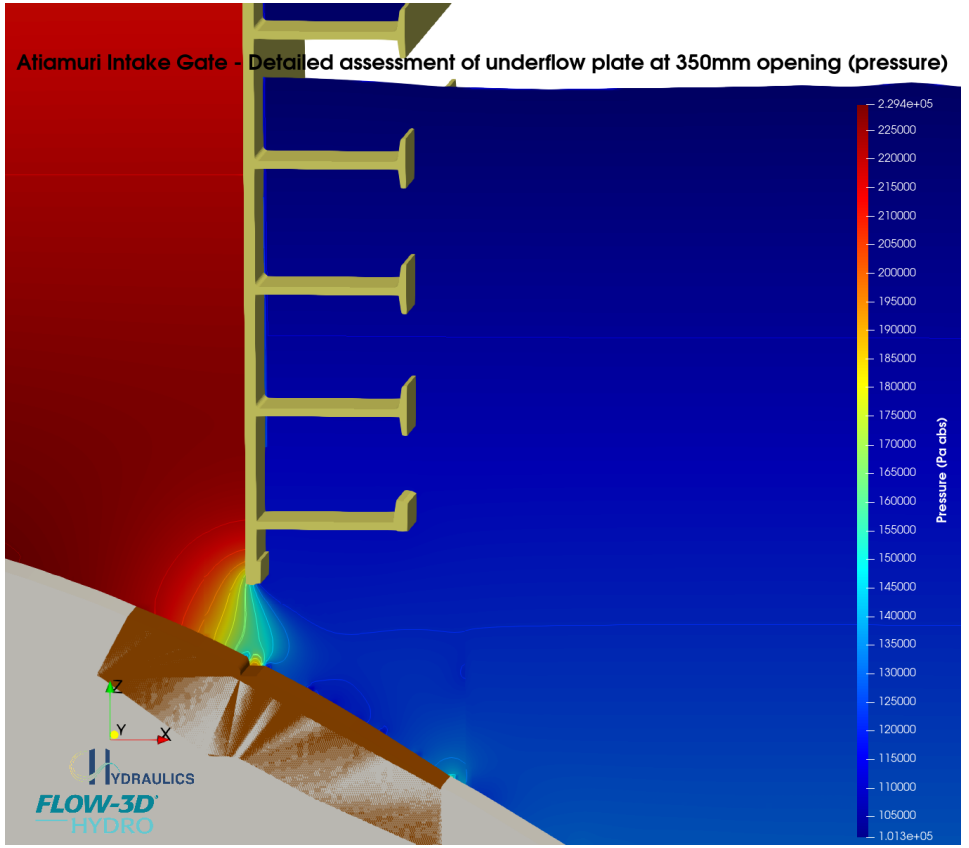


Hoist load

Gate position

Main takeaways…

- CFD provided insight for what could not otherwise be observed below the surface
- Load origins were not quite as originally expected
- Provided clarity for the Client on the ‘why’
- Truncated domain, high-resolution CFD models can be extremely helpful



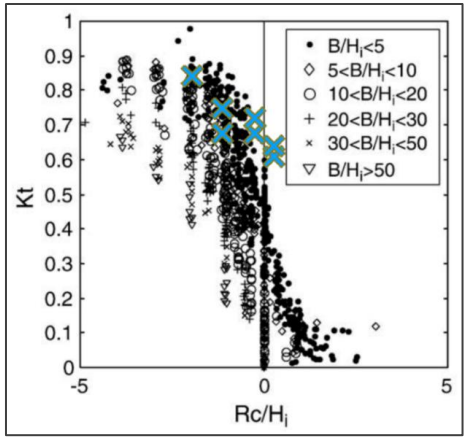
Living shoreline coastal structures

Location: Louisiana, USA

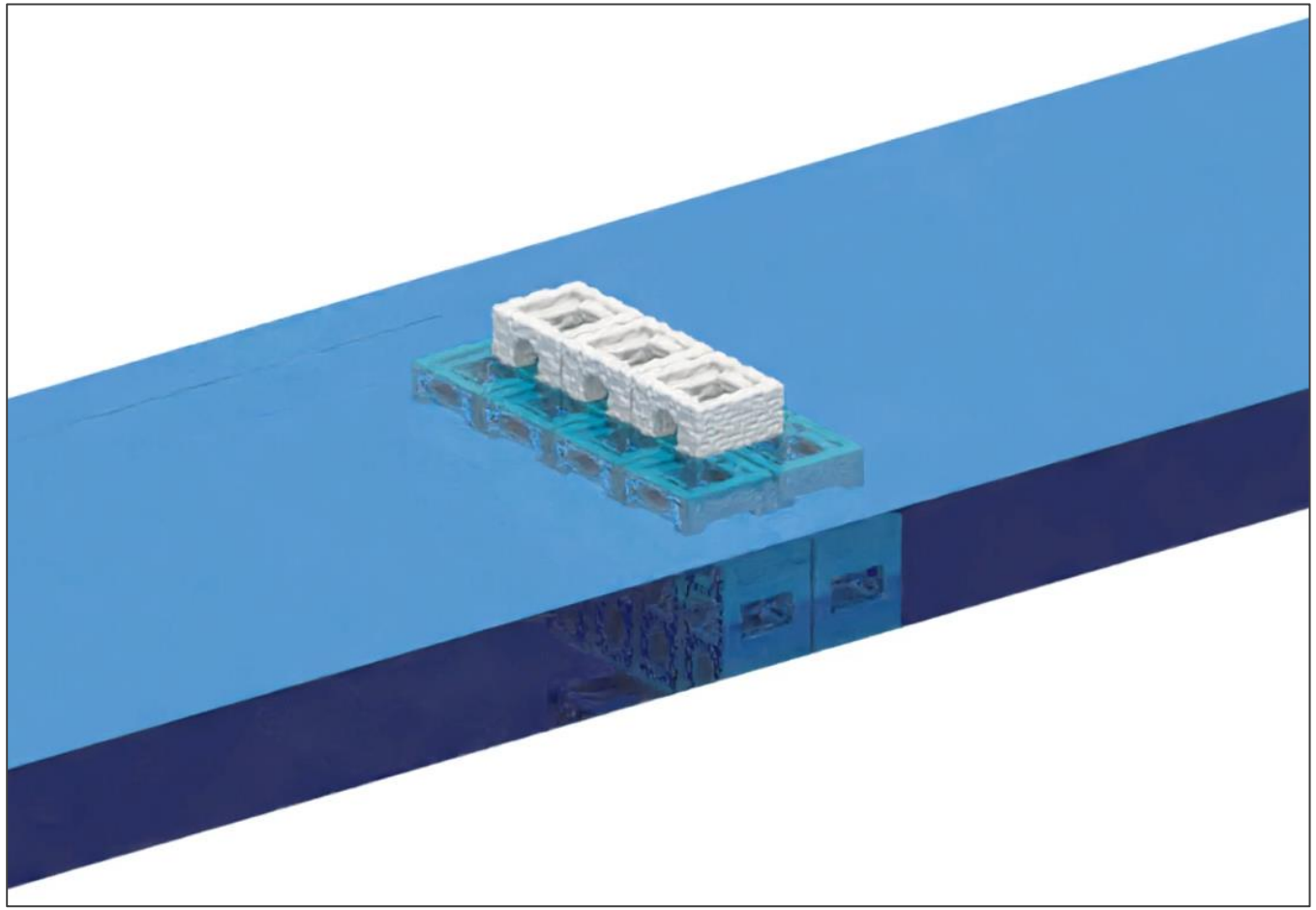
Carter, J., Fenical, S., Harter, C., & Todd, J. (2017). CFD modeling for the analysis of living shoreline structure performance. In Coastal Structures and Solutions to Coastal Disasters 2015: Resilient Coastal Communities (pp. 442-450). Reston, VA: American Society of Civil Engineers.

Living Shorelines

- Nature-based solutions for coastal resilience
- Wave height and shoreline retreat reduction
- Promotes bio-diversity



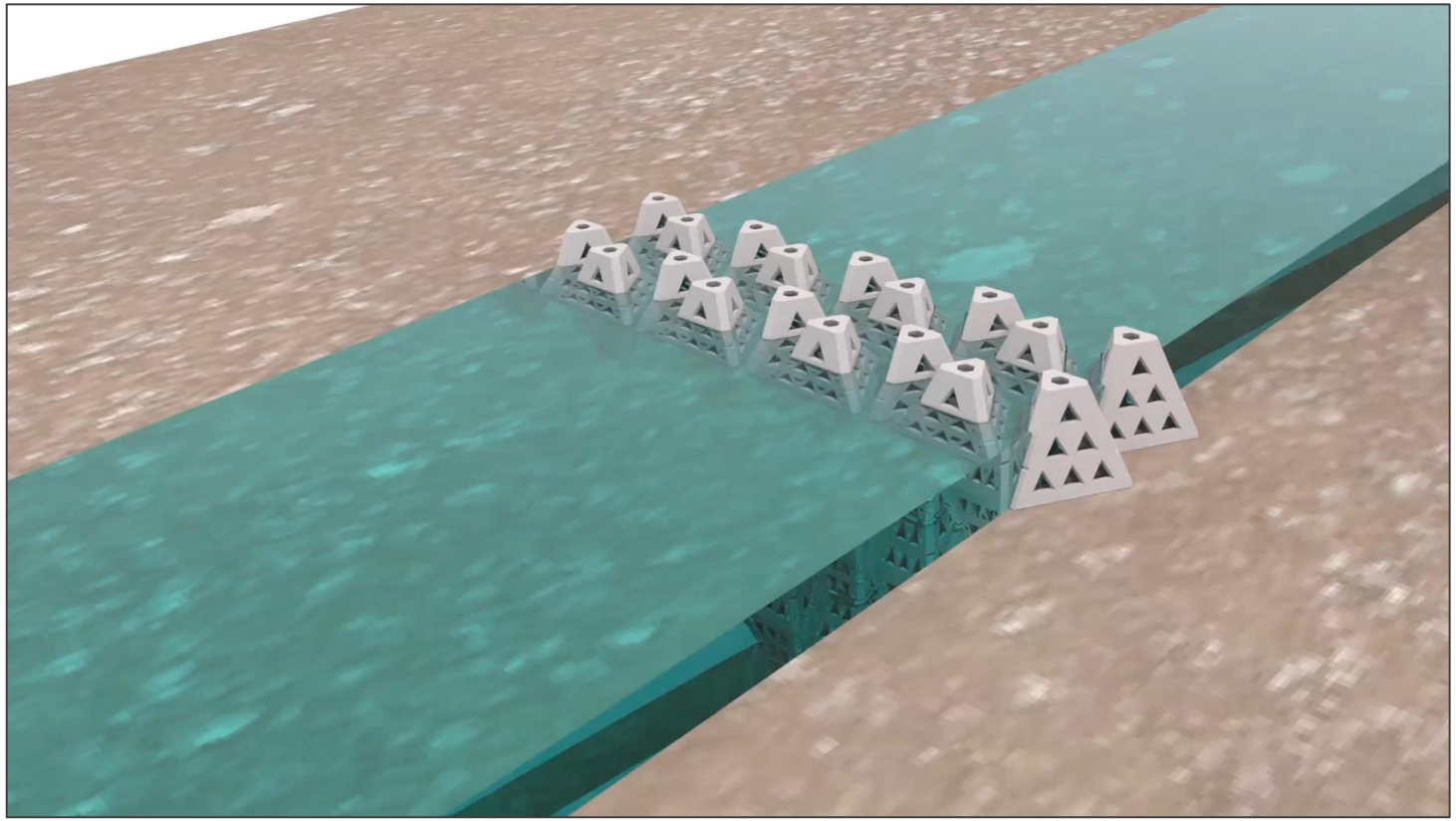
Transmission coefficient (K_t) from CFD (blue) vs. normalized crest height, compared against Van Der Meer plot for short crested breakwaters



Natrx ADAPTIVE INFRASTRUCTURE

Living Shorelines

- Nature-based solutions for coastal resilience
- Wave height and shoreline retreat reduction
- Promotes bio-diversity



Florida Dept. of Transportation – Skyway WADs Project

LIVING SHORELINE SOLUTIONS

Case Study - Living Shoreline

- Problem:
  - Site in coastal Louisiana experience **10-40 ft erosion/year**
- Goal:
  - Protect 13 miles of shoreline using artificial oyster reef
  - Reduce wave transmission
  - Stimulate oyster growth for ecological benefits
- Challenges
  - 9 potential products for consideration
  - Limited information on wave reduction performance and stability
  - High cost for physical modelling

COAST & HARBOR ENGINEERING

Carter, J., Fenical, S., Harter, C., & Todd, J. (2017). CFD modeling for the analysis of living shoreline structure performance. In Coastal Structures and Solutions to Coastal Disasters 2015: Resilient Coastal Communities (pp. 442-450). Reston, VA: American Society of Civil Engineers.

Case Study - Living Shoreline

- ***FLOW-3D* HYDRO** used a used as "virtual laboratory"
  - Evaluate wave transmission performance for 9 products
  - Incorporate site specific wave and water level conditions
  - Cost-effectiveness analysis performed for each option

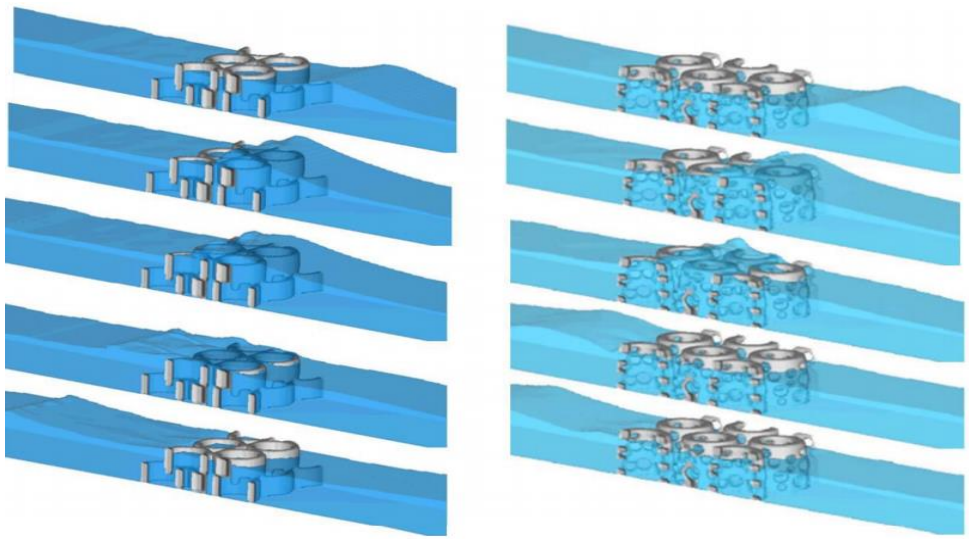
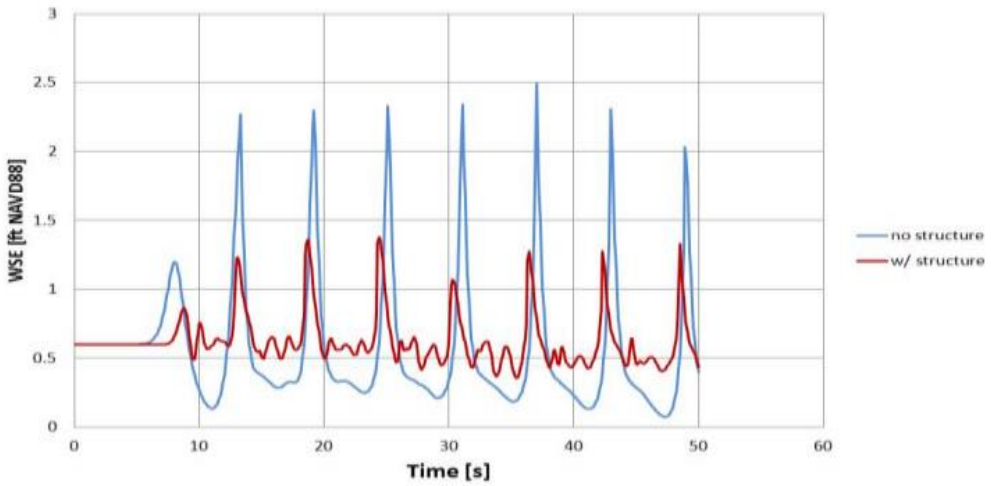


Image showing waves interacting with Oysterbreak (left) and Reef Ball (right) from ***FLOW-3D***. Source: Carter et al. 2015



Case Study - Living Shoreline

- Results (state monitored):
  - Wave height reduced by half
  - 48-52% shoreline retreat reduction
  - Modeled predictions were within 2% of monitored results (!)

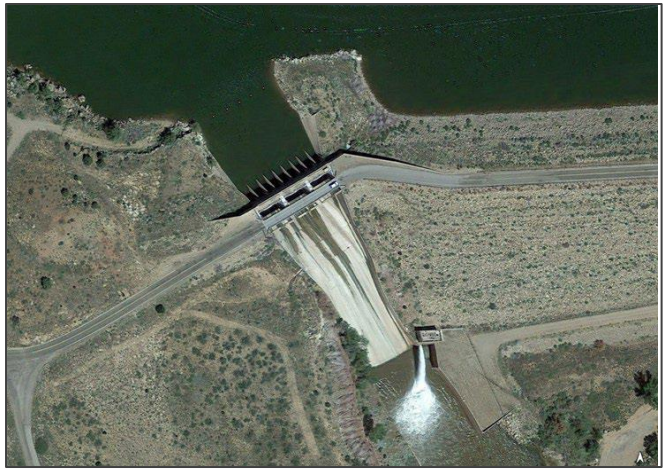
Stage-discharge rating curve development

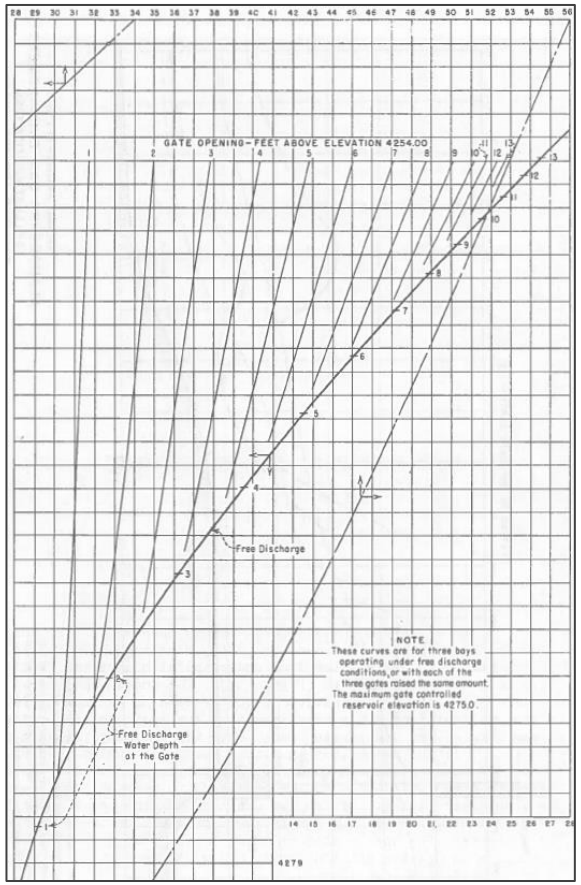
Location: New Mexico, USA

Heiner, B., Fox, B., Smithgall, K. Generating a Service Spillway Rating Using Both Physical and 3D CFD Modeling. Dam Safety, 2024, Denver, Colorado

Case Study: Stage-Discharge Rating Development

- Proposed modifications to an existing service spillway
- Required update to the existing spillway rating curve



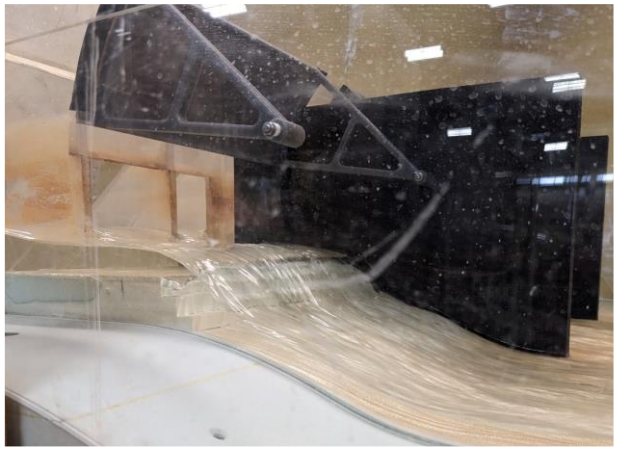


Heiner, B., Fox, B., Smithgall, K. *Generating a Service Spillway Rating Using Both Physical and 3D CFD Modeling.* Dam Safety, 2024, Denver, Colorado

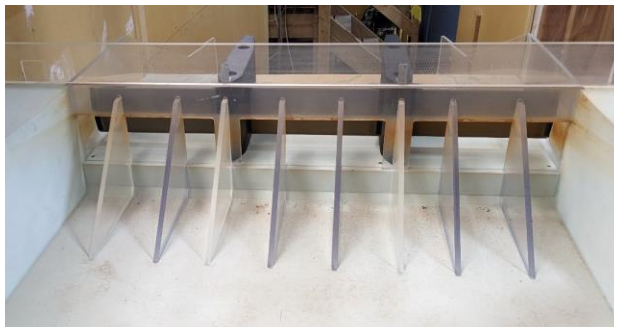
Case Study: Stage-Discharge Rating Development

- Proposed modifications to an existing service spillway
- Required update to the existing spillway rating curve
  - ➢ Originally completed using a physical model

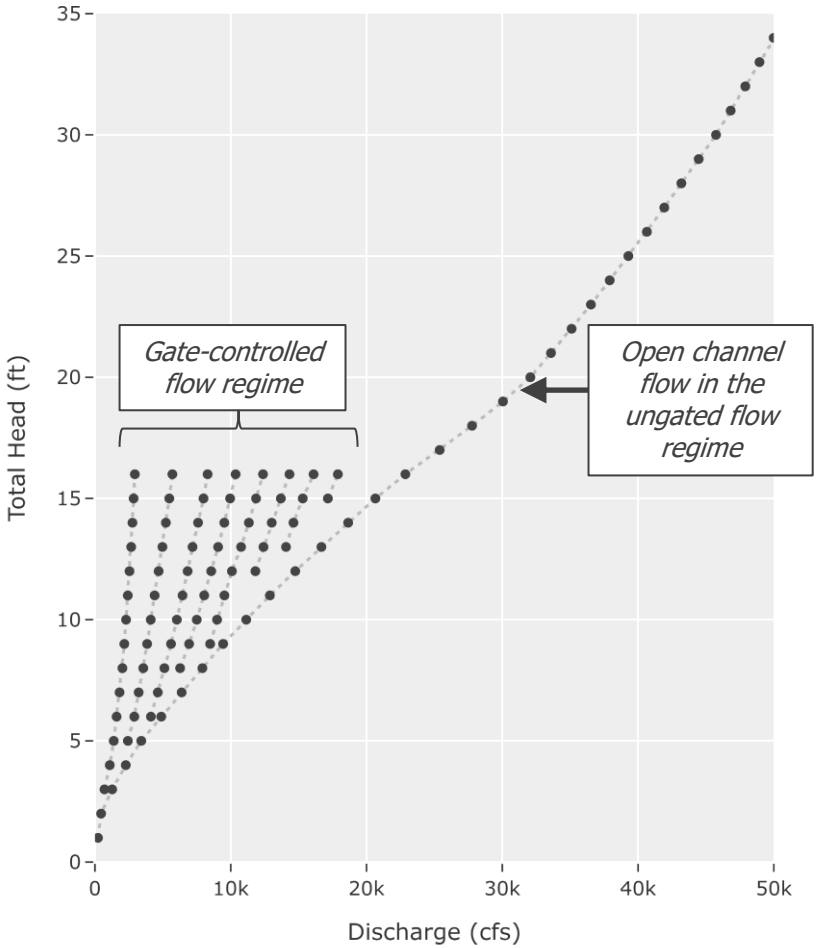
Question:
How quickly and accurately can this be completed using 3D CFD?



Open channel flow in the ungated flow regime



View looking at upstream side of model

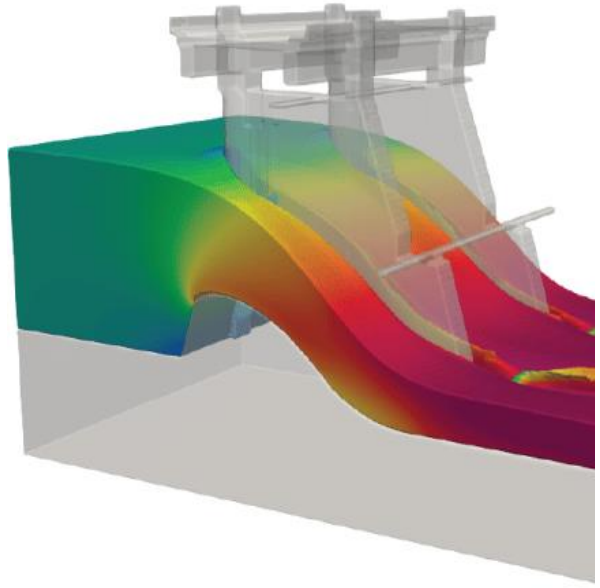


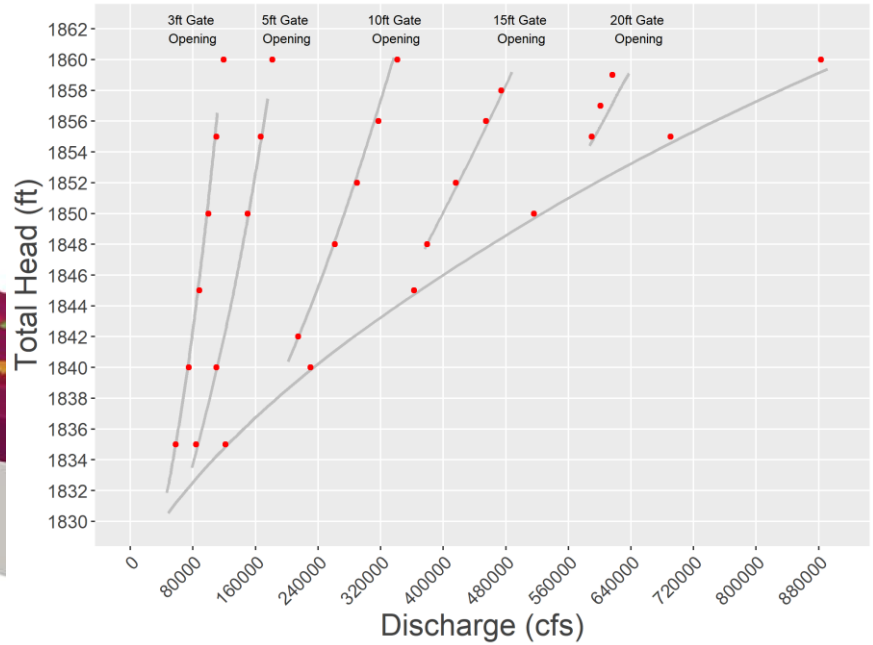
Updated spillway rating curve from physical modelling study

CFD Study

- Extensive validation for similar studies
- Provides for well-defined model setup best practices
- ➢ Basic free surface modelling
  - – Key model setup steps
    1. Geometry
    2. Mesh resolution
    3. Boundary conditions

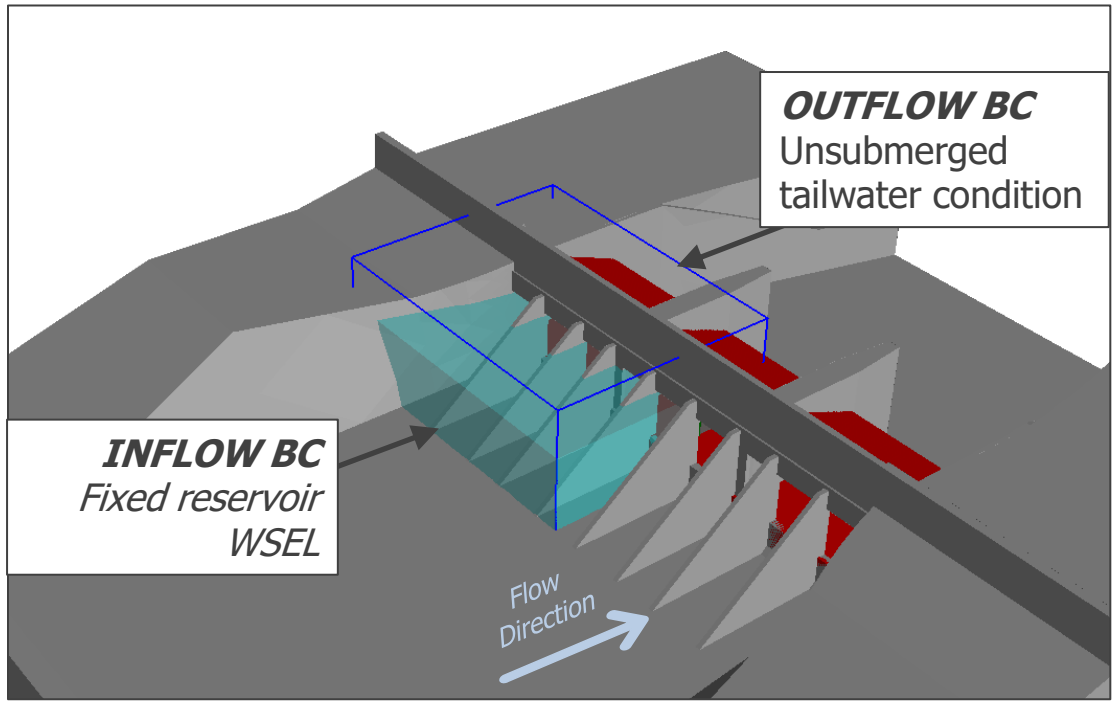
Example of Existing Validation Study for Gated Spillway

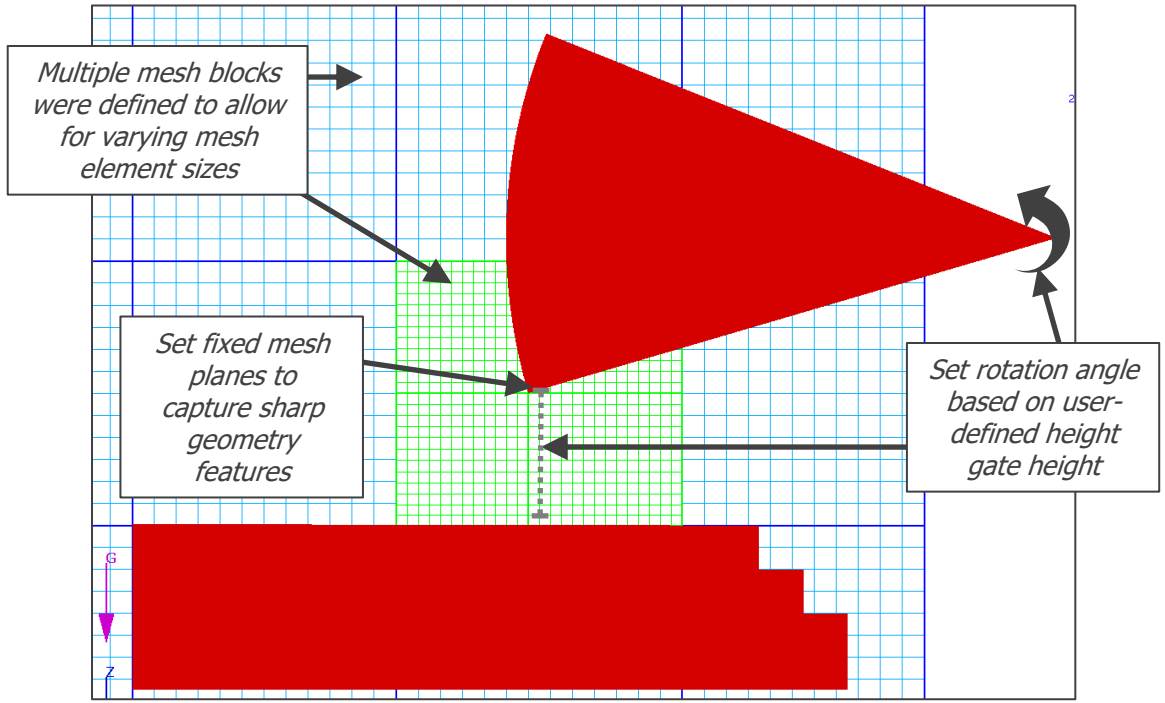




Fox, B., Wendelbo, J., (2023, May 23). *CFD modeling strategies for the analysis of the Garrison Dam spillway and flood control tunnel structures*. ASDSO Northeast Regional Conference, Portland, Maine.

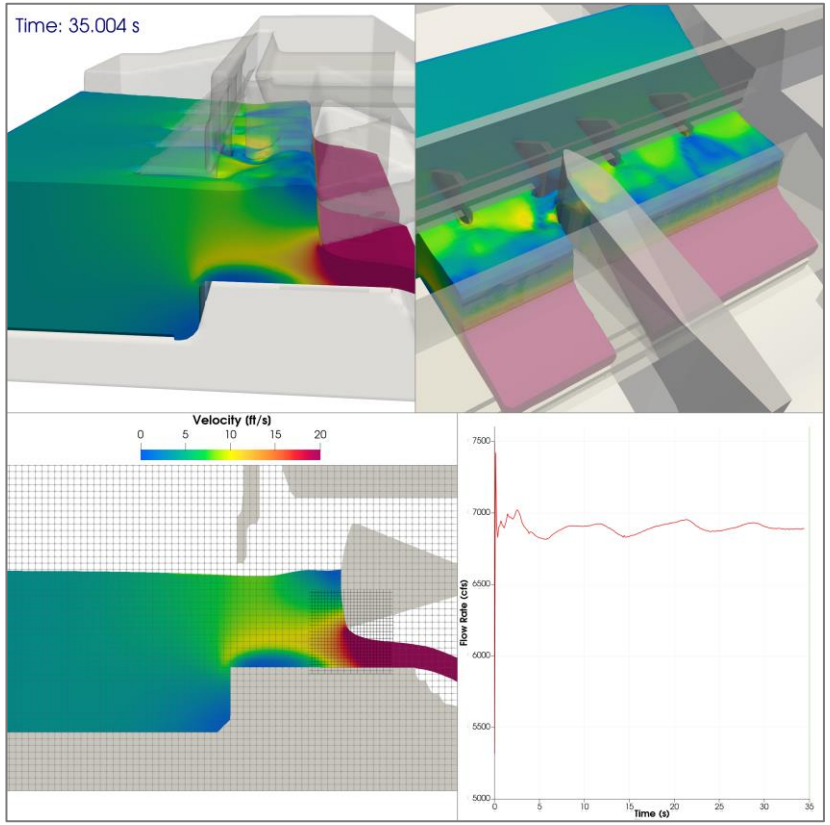
Model Setup: Basic Workflow

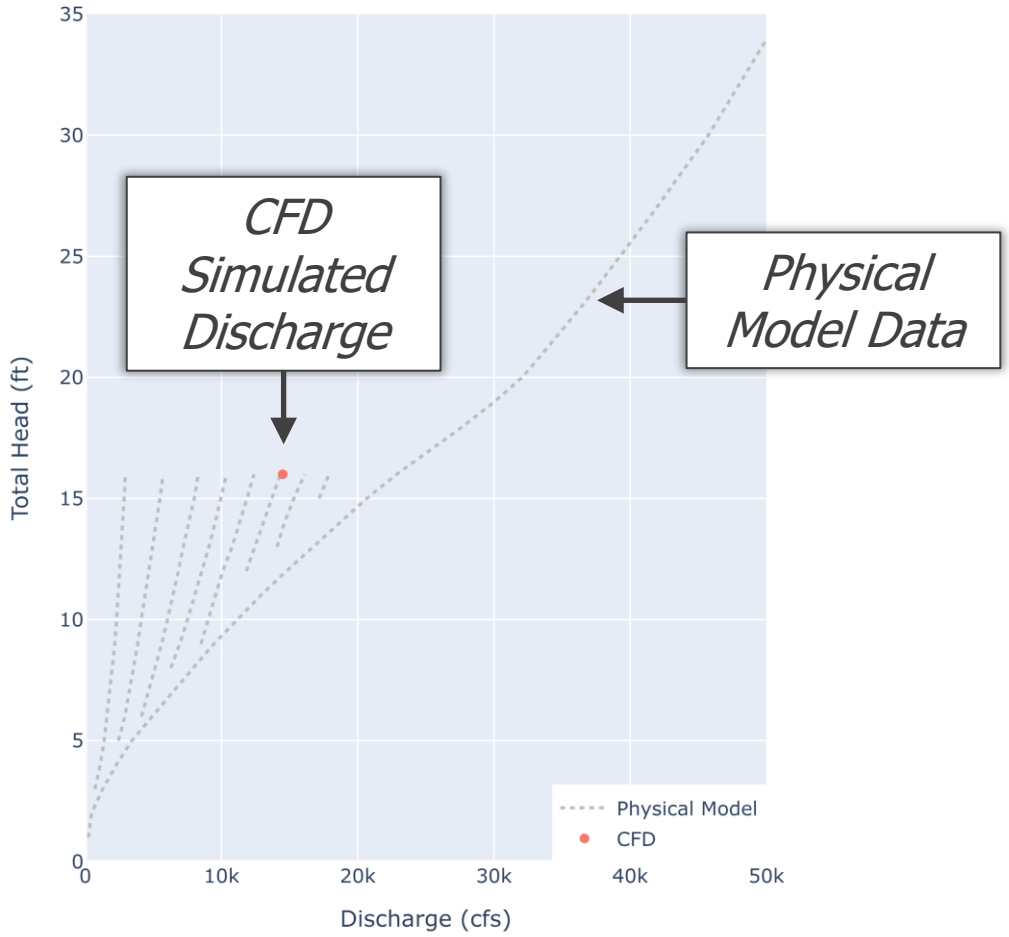




Create Simulation › Geometry › Meshing › Initial and Boundary Conditions › Run Simulation › Post-processing

Model Setup: Basic Workflow

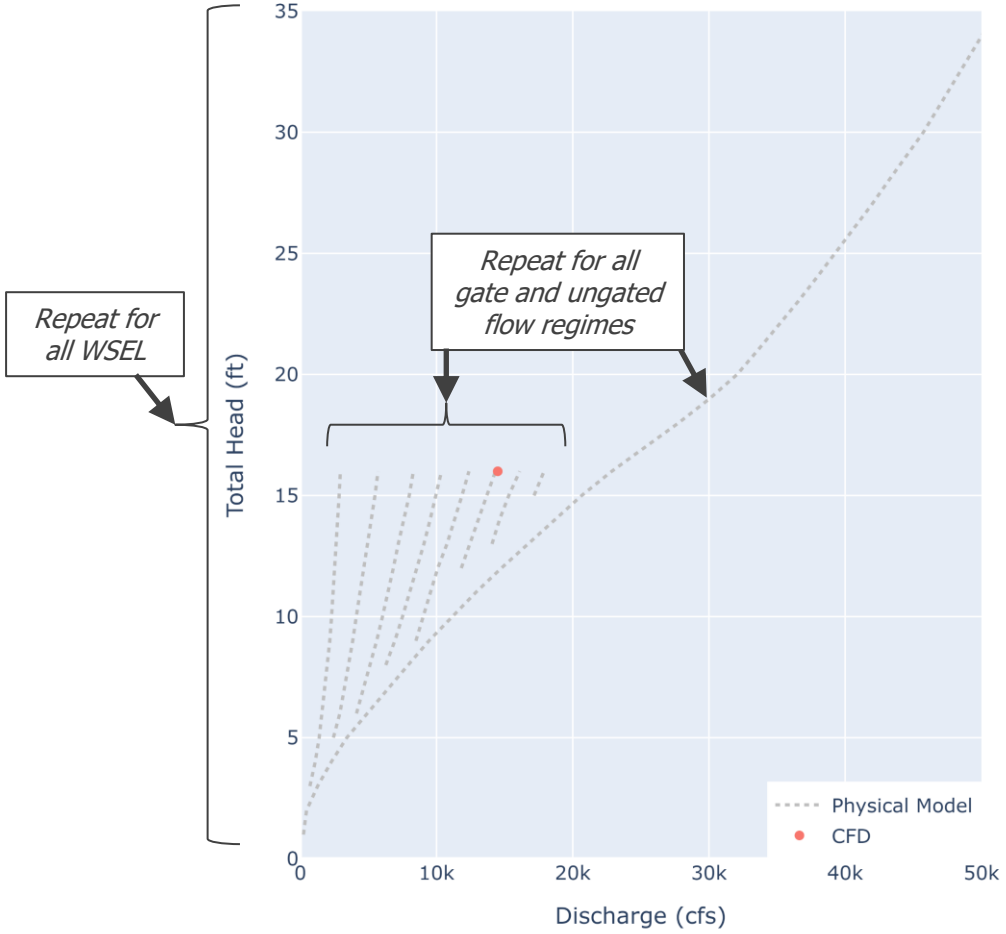




Create Simulation › Geometry › Meshing › Initial and Boundary Conditions › Run Simulation › Post-processing

Rating Curve Generation

- Next steps:
  - Repeat:
    - Ungated and gated conditions
    - Expected range of WSEL
  - 87 total CFD simulations!
  - ~100+ hours!
- Primary project challenge:
  - Set up, run, and post-process 87 individual simulations
  - Compute time



Rating Curve Generation

- Next steps:
  - Repeat:
    - Ungated and gated conditions
    - Expected range of WSEL
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  - ~100+ hours!
- Primary project challenge:
  - Set up, run, and post-process 87 individual simulations
  - Compute time

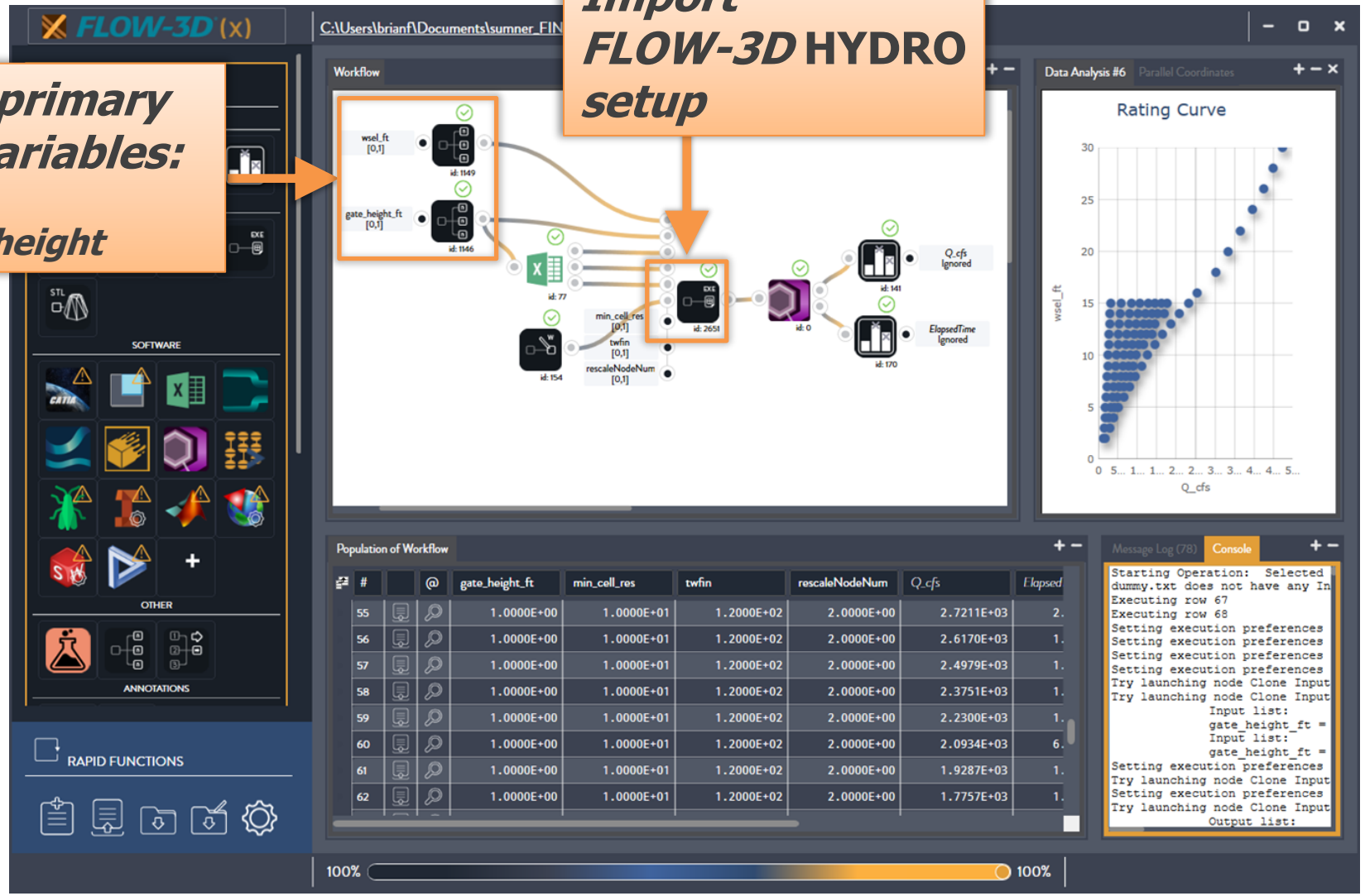
Workflow Automation with FLOW-3D (x)!

Workflow Automation with *FLOW-3D* (x)

Define primary input variables:

- ***WSEL***
- ***Gate height***

Import FLOW-3D* HYDRO *setup

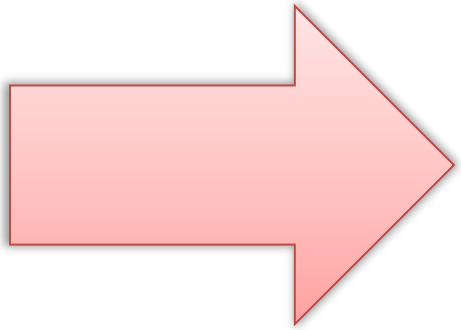


#	gate_height_ft	min_cell_res	twfin	rescaleNodeNum	Q.cfs	Elapsed
55	1.0000E+00	1.0000E+01	1.2000E+02	2.0000E+00	2.7211E+03	2.
56	1.0000E+00	1.0000E+01	1.2000E+02	2.0000E+00	2.6170E+03	1.
57	1.0000E+00	1.0000E+01	1.2000E+02	2.0000E+00	2.4979E+03	1.
58	1.0000E+00	1.0000E+01	1.2000E+02	2.0000E+00	2.3751E+03	1.
59	1.0000E+00	1.0000E+01	1.2000E+02	2.0000E+00	2.2300E+03	1.
60	1.0000E+00	1.0000E+01	1.2000E+02	2.0000E+00	2.0934E+03	6.
61	1.0000E+00	1.0000E+01	1.2000E+02	2.0000E+00	1.9287E+03	1.
62	1.0000E+00	1.0000E+01	1.2000E+02	2.0000E+00	1.7757E+03	1.

Compute Time

Desktop PC

18-core Intel i9-10980XE CPU @ 3.00GHz



rescale FLOW-3D CLOUD

44-core and 88-core Intel Xeon Platinum 8168 @ 2.7 GHz

Reduce single simulation run time

- Avg simulation runtime: **4.7 hours → 1.3 hours**

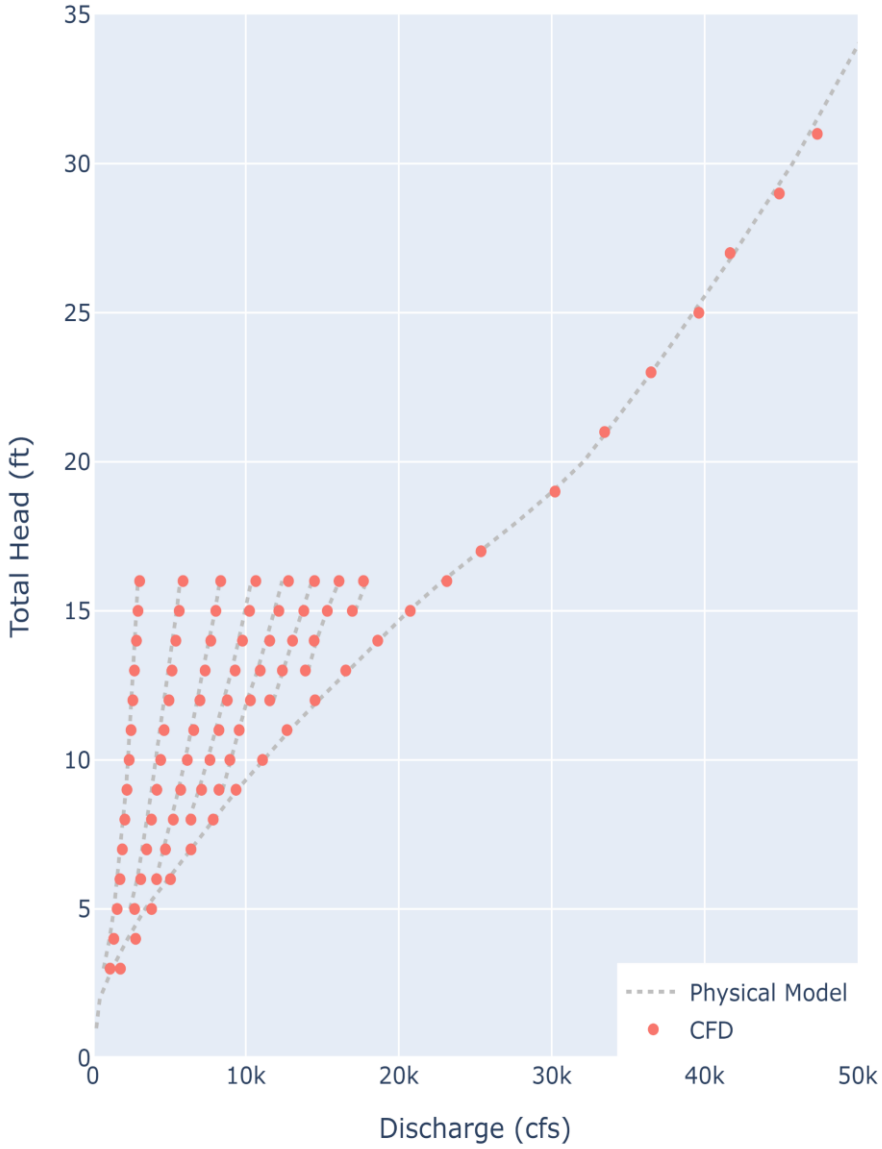
Run all 87 simulations in parallel!

- Total project runtime: **17 days → 7 hours**

Directly launch on computing resources through FLOW-3D (x)

Summary

- Agreement between CFD and physical model
  - less than 3% difference!
- ***FLOW-3D* (x)**
  - Saves time, reduces mistakes, builds confidence
  - 85% labor time/cost reduction
    - 31 days → 4 days
- Cloud/HPC computing:
  - Average simulation speed up
    - 4.7 hours → 1.3 hours
  - Project speed up
    - 17 days → 7 hours
  - Affordable cloud computing costs → $730 USD
- Exciting opportunities for automation / optimization



Heiner, B., Fox, B., Smithgall, K. *Generating a Service Spillway Rating Using Both Physical and 3D CFD Modeling.* Dam Safety, 2024, Denver, Colorado

Getting Started with

FLOW-3D® HYDRO

aws 10 YEARS

Australian Water School On-Demand Training

Self-reflection…

How did I go from:

A graduate with no hydraulic modelling experience

A somewhat proficient 1D/2D/3D hydraulic modeller

How did I learn 1D/2D/3D hydraulic modelling tools?

- Review tutorials, examples, existing models
- Read the software manuals
- Technical support from software providers
- Training workshops
- Access to great mentors
- Review technical papers, conference proceedings and academic research
  - "Has someone done this before?"
- Try pushing buttons and adjusting dials…
  - "What does this do?"
  - "Do I really need that input?"

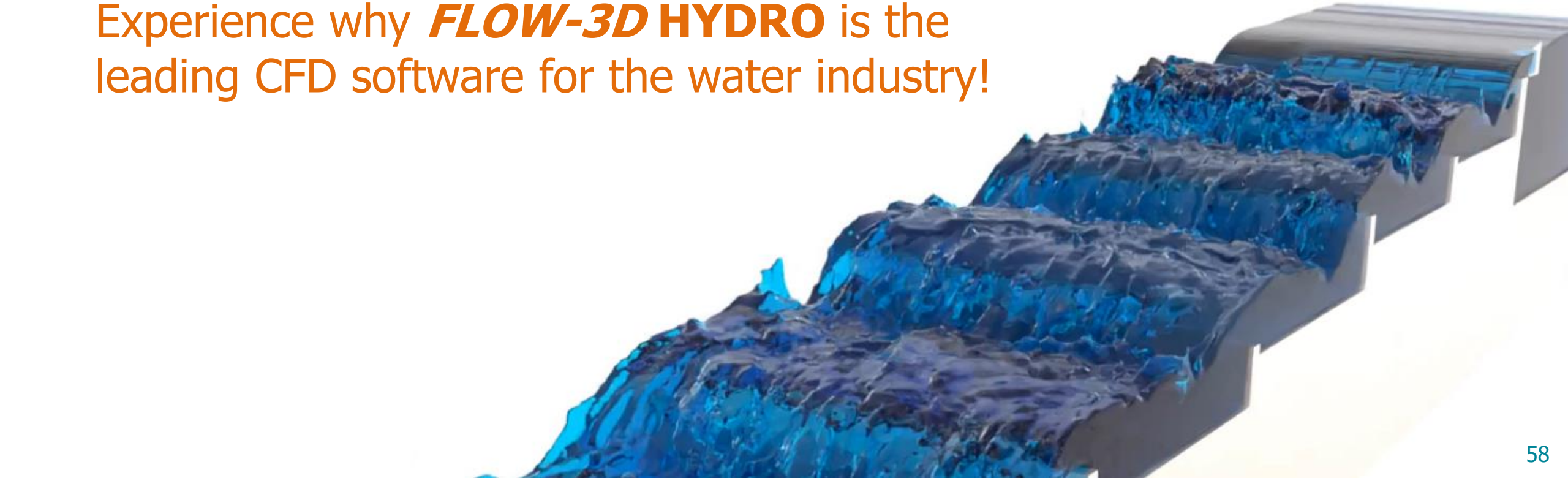
The AWS on-demand training incorporates these approaches

The most valuable learning came from trying to solve a real problem on a real project.

Learn CFD through flexible, hands-on training

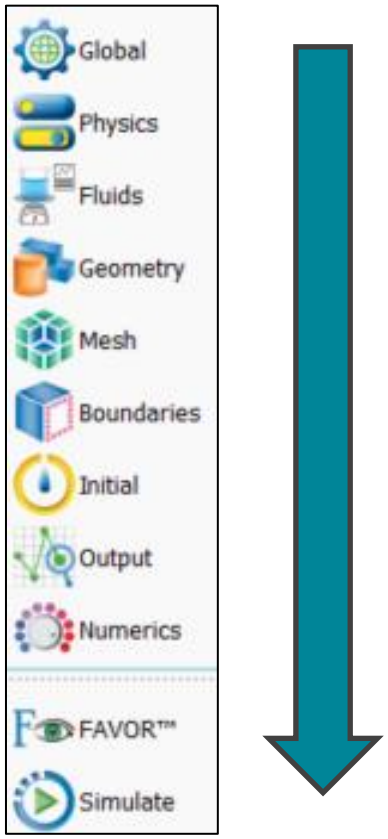
- Gain confidence by repeating the ***FLOW-3D* HYDRO** workflow
- Choose the exercises that interest you

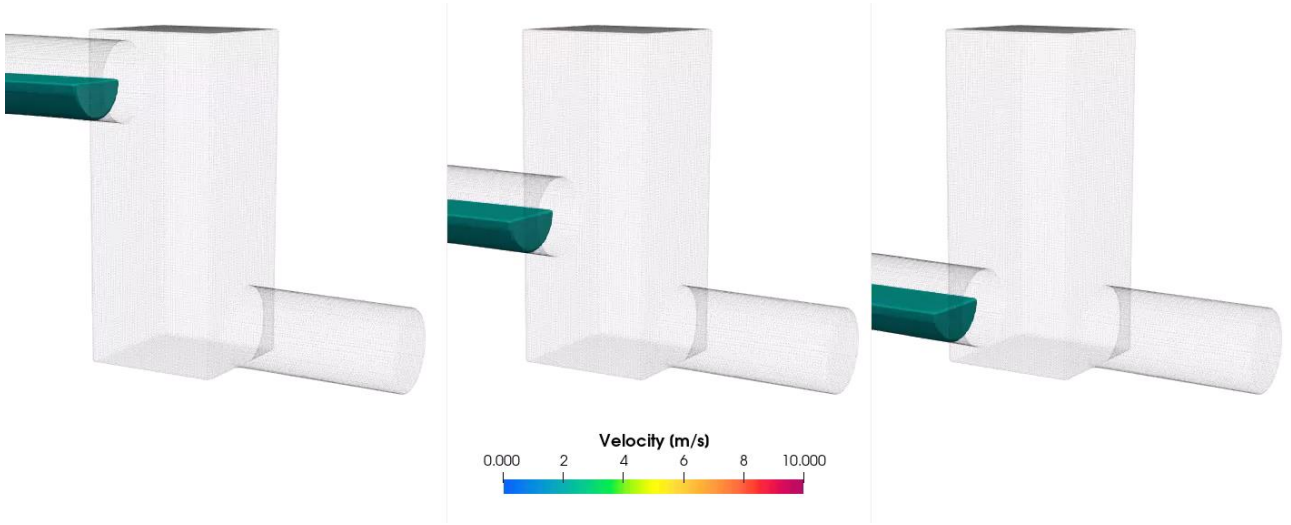
Experience why ***FLOW-3D* HYDRO** is the leading CFD software for the water industry!

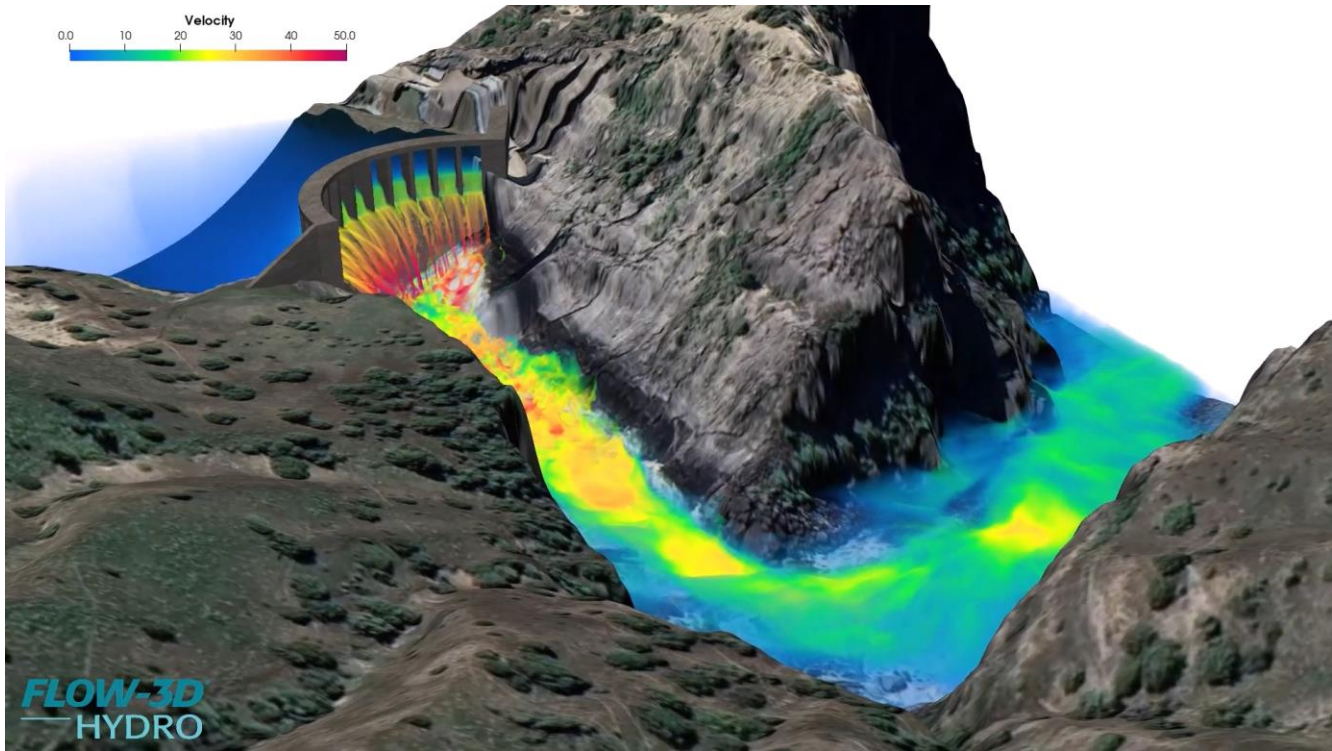


FLOW-3D® HYDRO

Intuitive user interface



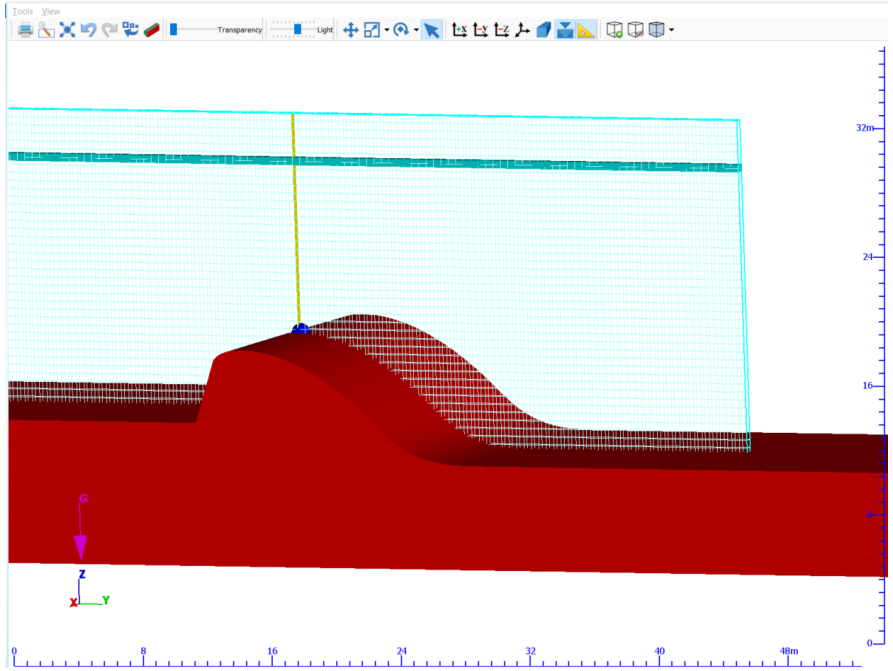


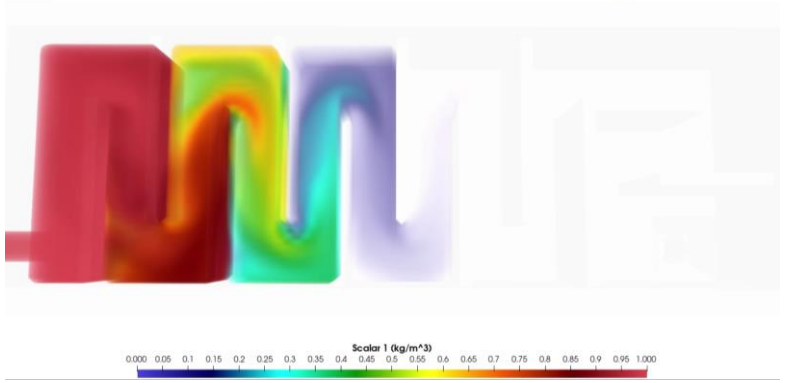


Two-part course structure

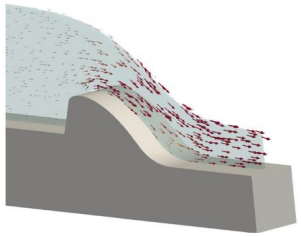
- Part 1: Basic Workflow Introduction
  - Start with a simple 2D slice of an ogee weir
  - Expand the ogee weir model to a 3D domain

- Part 2: Application-specific Exercises
  - A total of 7 exercises are available
    - As of November 2024; plans to add more throughout the upcoming year
  - Only need to complete a portion of these exercises to receive a completion certificate





FLOW-3D® HYDRO



Exercise Guide 1A: Ogee Weir (2D Slice)

Created in *FLOW-3D* HYDRO 2024R1, Updated: 28 October 2024

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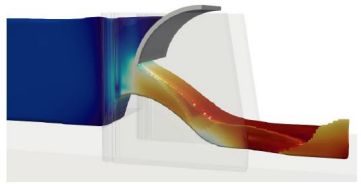
FLOW-3D® HYDRO



Exercise Guide 1B: Ogee Weir (3D)

Created in *FLOW-3D* HYDRO 2024R1, Updated: 28 October 2024

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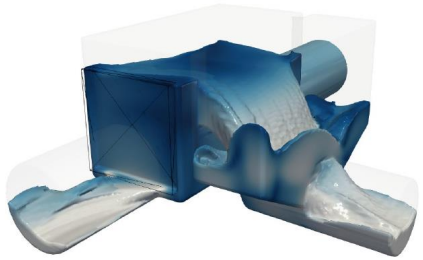
FLOW-3D® HYDRO



Exercise Guide 2A: Diversion Structure

Created in *FLOW-3D* HYDRO 2024R1, Updated: 04 October 2024

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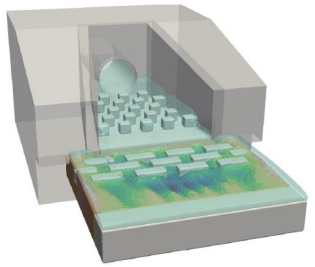
FLOW-3D® HYDRO



Exercise Guide 2B: Culvert Erosion

Created in *FLOW-3D* HYDRO 2024R1, Updated: 28 October 2024

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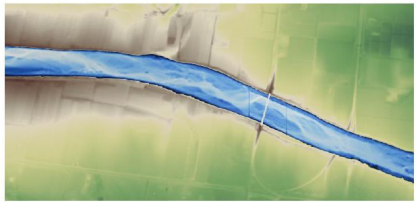
FLOW-3D® HYDRO



Exercise Guide 2C: Bridge Hydraulics (2D/3D)

Created in *FLOW-3D* HYDRO 2024R1, Updated: 15 October 2024

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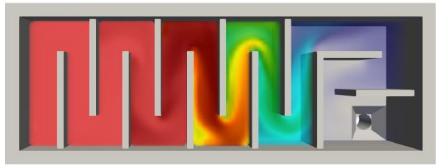
FLOW-3D® HYDRO

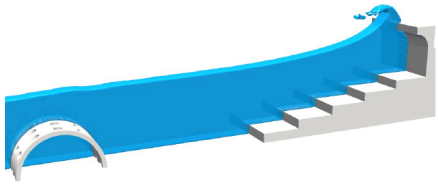


Exercise Guide 2D: Contact Tank

Created in *FLOW-3D* HYDRO 2024R1, Updated: 28 October 2024

aws 10 Australian Water School On-Demand Training

FLOW-3D® HYDRO



Exercise Guide 2E: Wave Overtopping

Created in *FLOW-3D* HYDRO 2024R1, Updated: 28 October 2024

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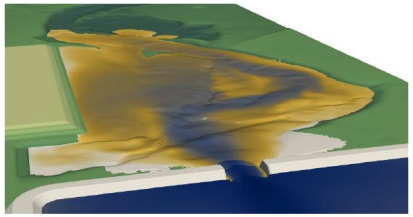

Exercise Guide 2F: Tailings Dam Breach

Created in *FLOW-3D* HYDRO 2024R1, Updated: 16 October 2024

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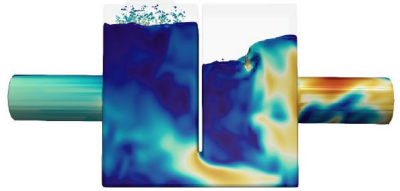

Exercise Guide 2G: Stormwater Pit

Created in *FLOW-3D* HYDRO 2024R1, Updated: 23 October 2024

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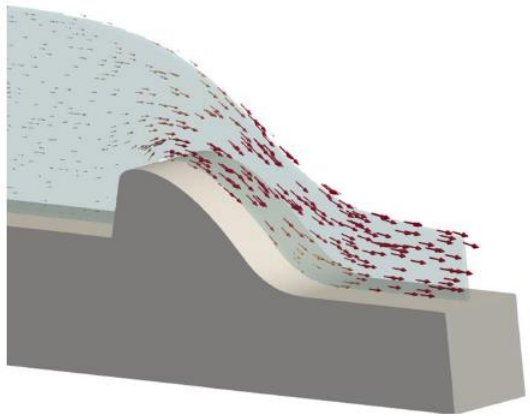


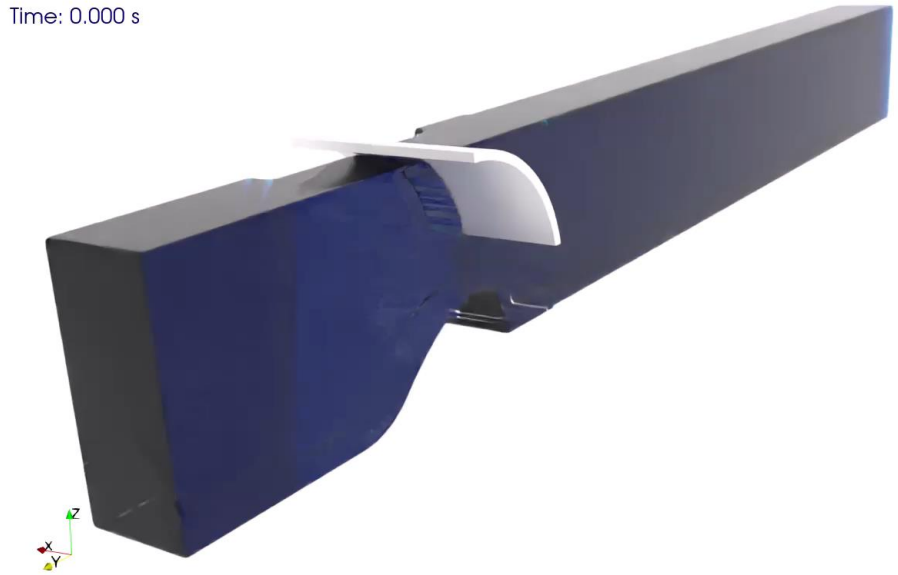
Exercise Guide 1A:
Ogee Weir (2D Slice)

Created in *FLOW-3D* **HYDRO** 2024R1, Updated: 28 October 2024

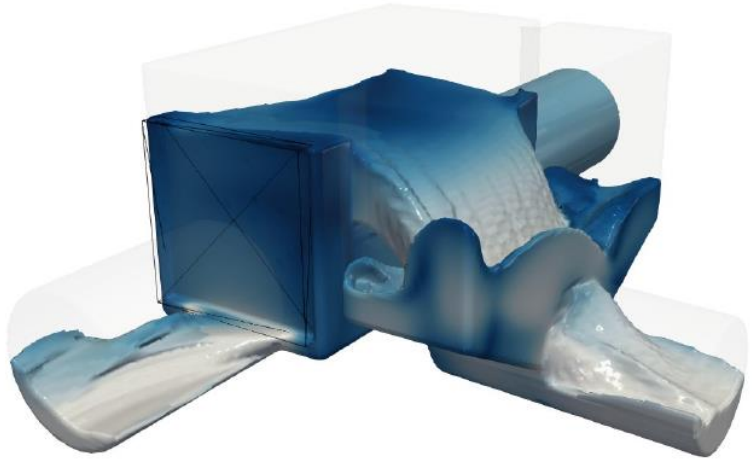
aws 10 YEARS

Australian Water School
On-Demand Training

- Ogee Weir (2D slice, then 3D)
  - Basic introduction to workflow



FLOW-3D® HYDRO



Exercise Guide 2A:
Diversion Structure

Created in *FLOW-3D* HYDRO 2024R1, Updated: 04 October 2024

aws 10 YEARS

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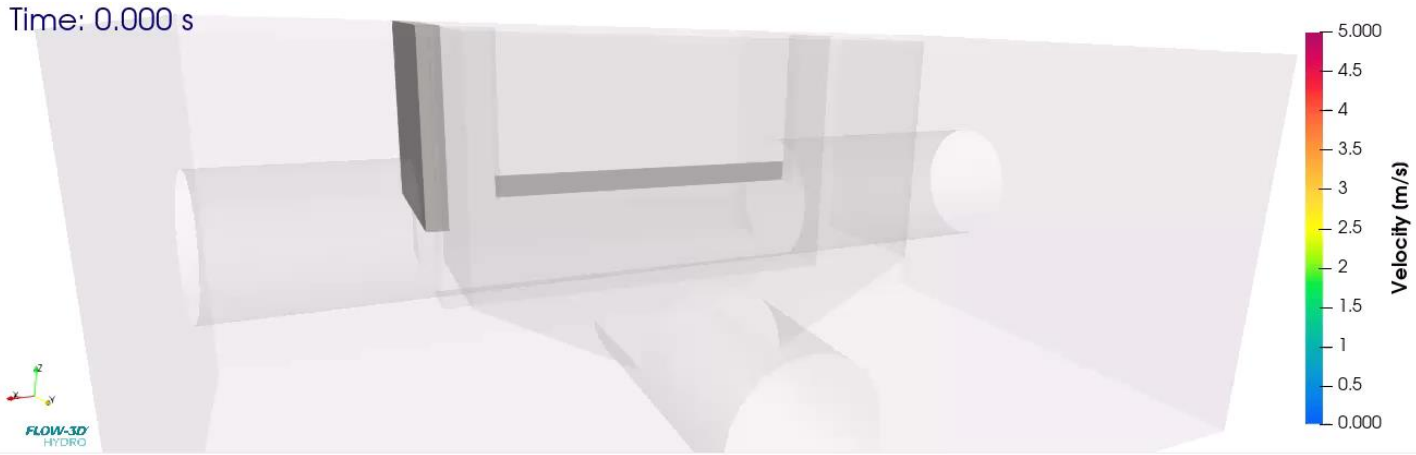
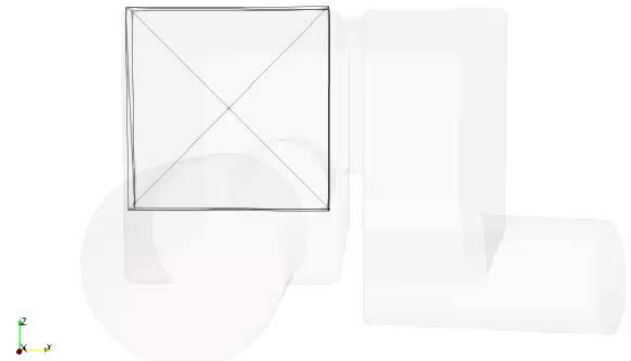
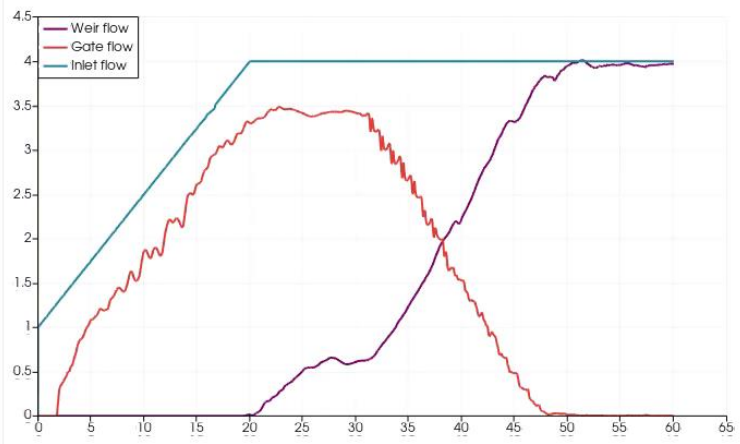
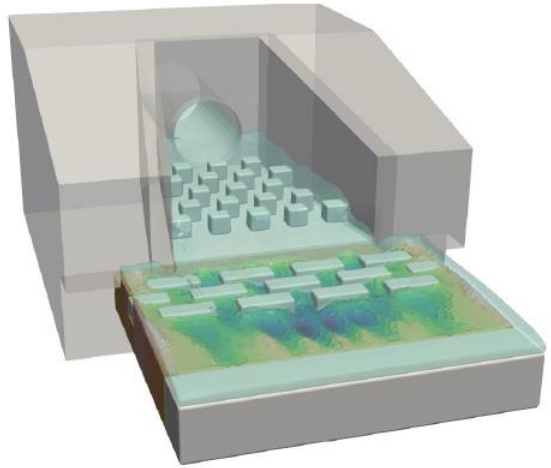
- Diversion Structure
  - Moving gate, flux surfaces







FLOW-3D® HYDRO



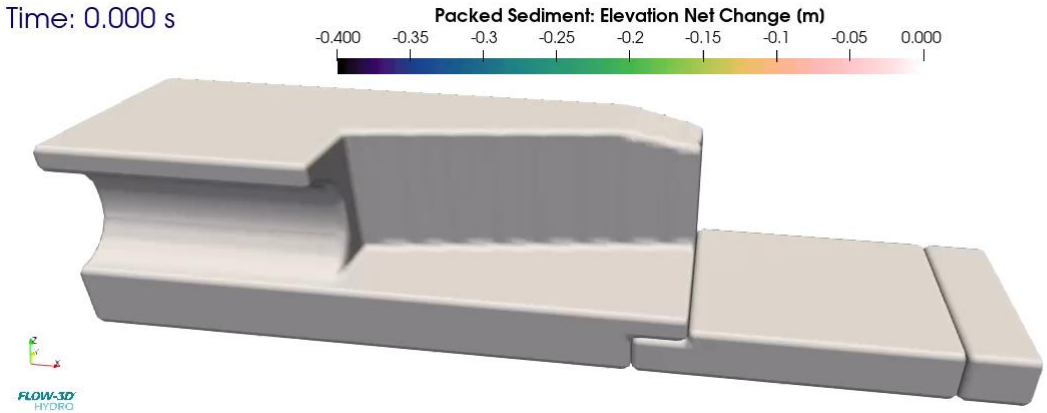
Exercise Guide 2B:
Culvert Erosion

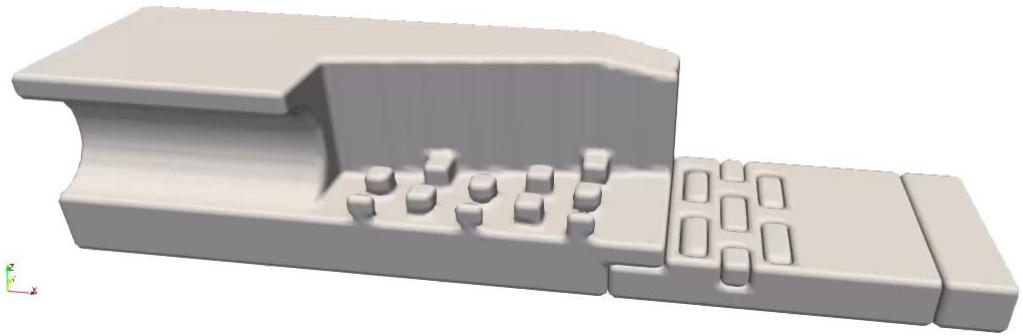
Created in *FLOW-3D* **HYDRO** 2024R1, Updated: 28 October 2024

aws 10 YEARS

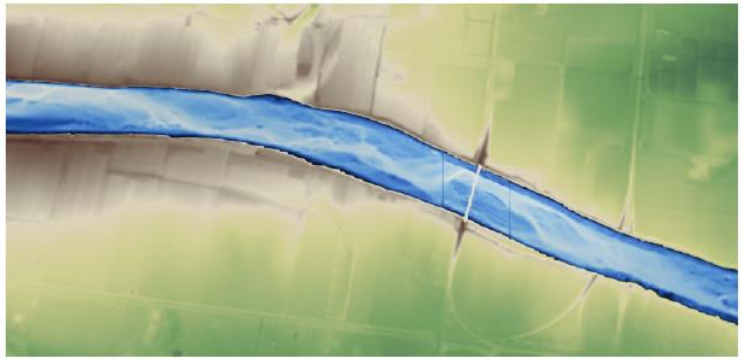
Australian Water School
On-Demand Training

- Culvert Erosion
  - Sediment transport, geometry edits





FLOW-3D® HYDRO



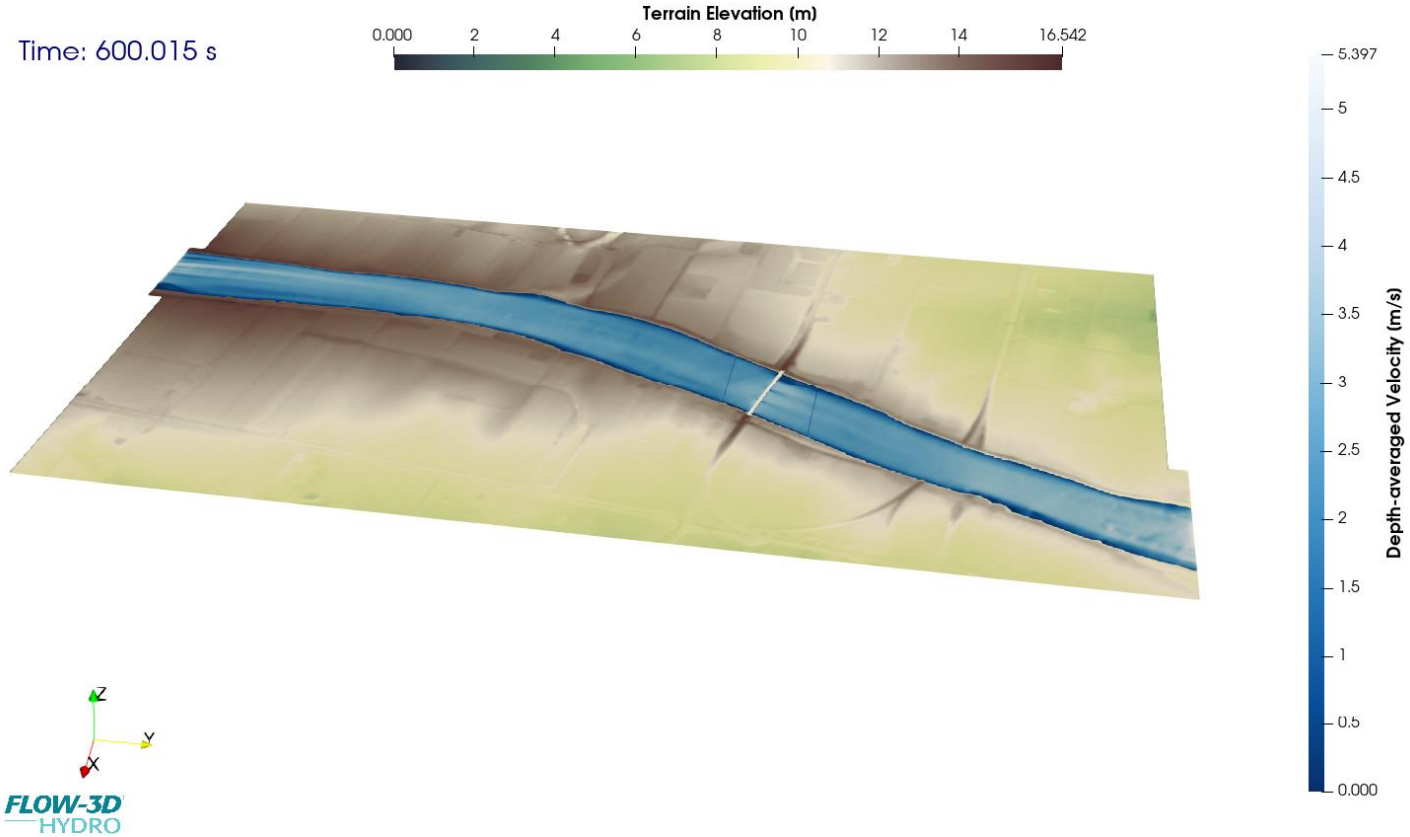
Exercise Guide 2C:
Bridge Hydraulics (2D/3D)

Created in *FLOW-3D* **HYDRO** 2024R1, Updated: 15 October 2024

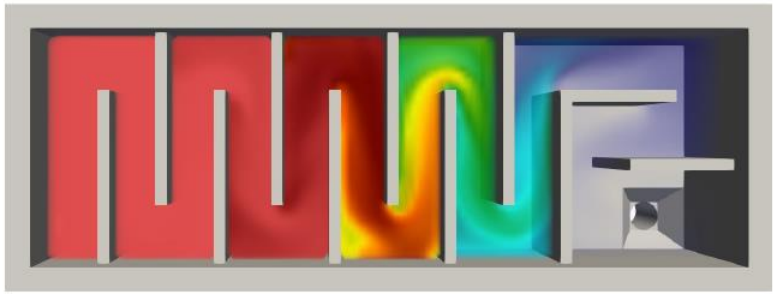
aws 10 YEARS

Australian Water School
On-Demand Training

- Bridge Hydraulics
  - 2D/3D mesh, conforming mesh



FLOW-3D® HYDRO



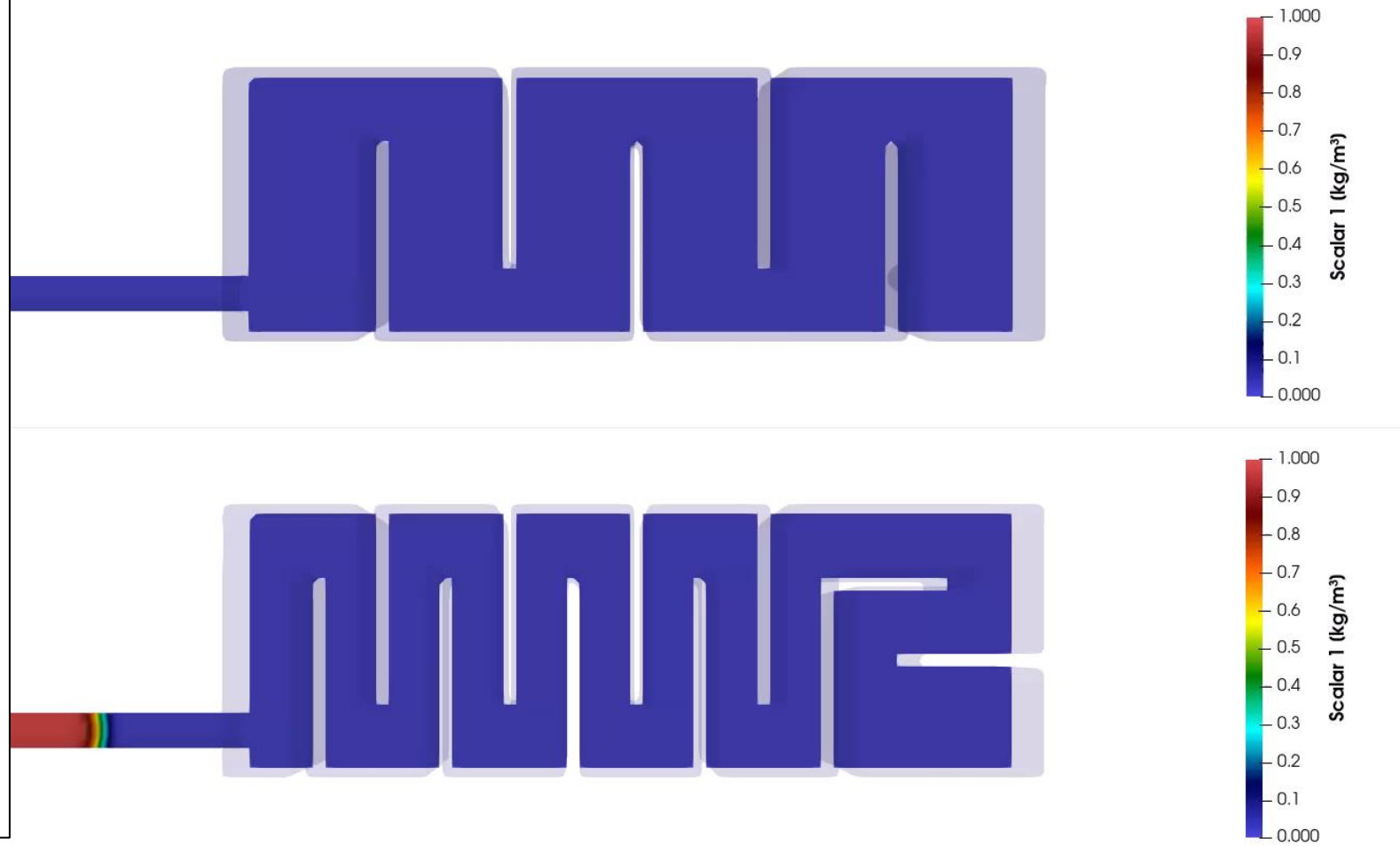
Exercise Guide 2D:
Contact Tank

Created in *FLOW-3D* **HYDRO** 2024R1, Updated: 28 October 2024

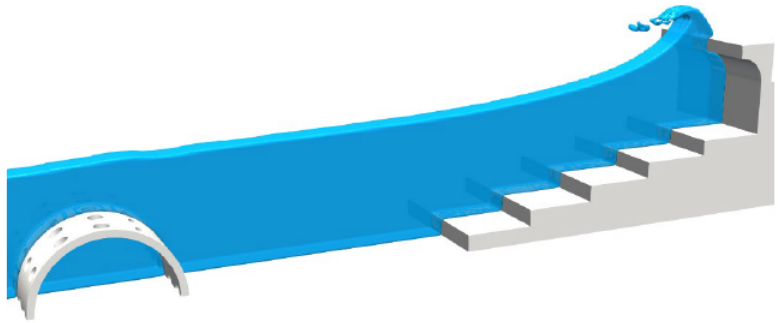
aws 10 YEARS

Australian Water School
On-Demand Training

- Contact Tank
  - Scalars, export data, plot multiple results



FLOW-3D® HYDRO



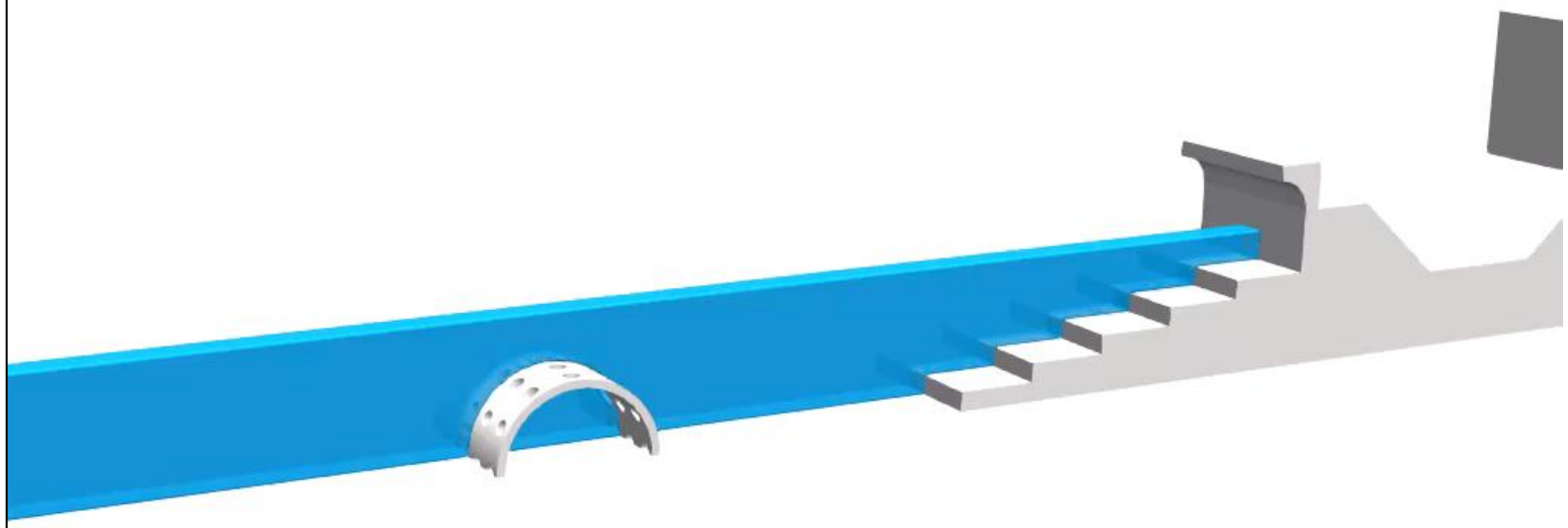
Exercise Guide 2E:
Wave Overtopping

Created in *FLOW-3D* **HYDRO** 2024R1, Updated: 28 October 2024

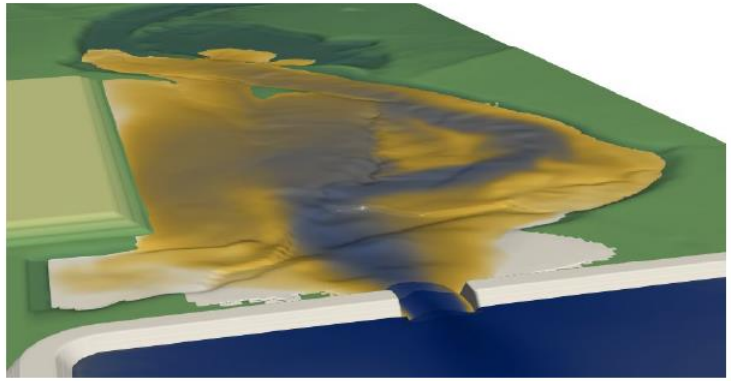
aws 10 YEARS

Australian Water School
On-Demand Training

- Wave Overtopping
  - Wave boundary, sample volume



FLOW-3D® HYDRO



Exercise Guide 2F:
Tailings Dam Breach

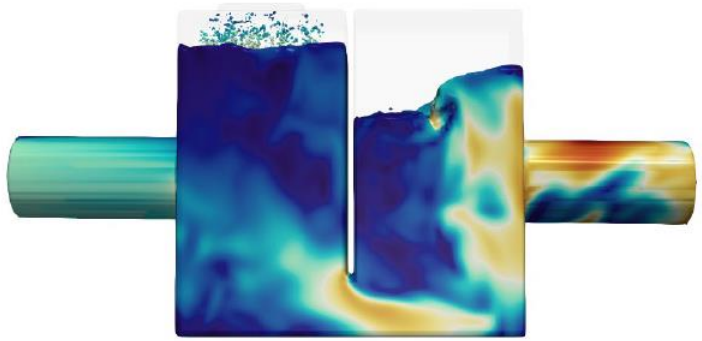
Created in *FLOW-3D* **HYDRO** 2024R1, Updated: 16 October 2024

aws 10 YEARS

Australian Water School
On-Demand Training

- Tailings Dam Breach
  - Multi-layer non-Newtonian fluid (with water) on a 2D/3D mesh

FLOW-3D® HYDRO



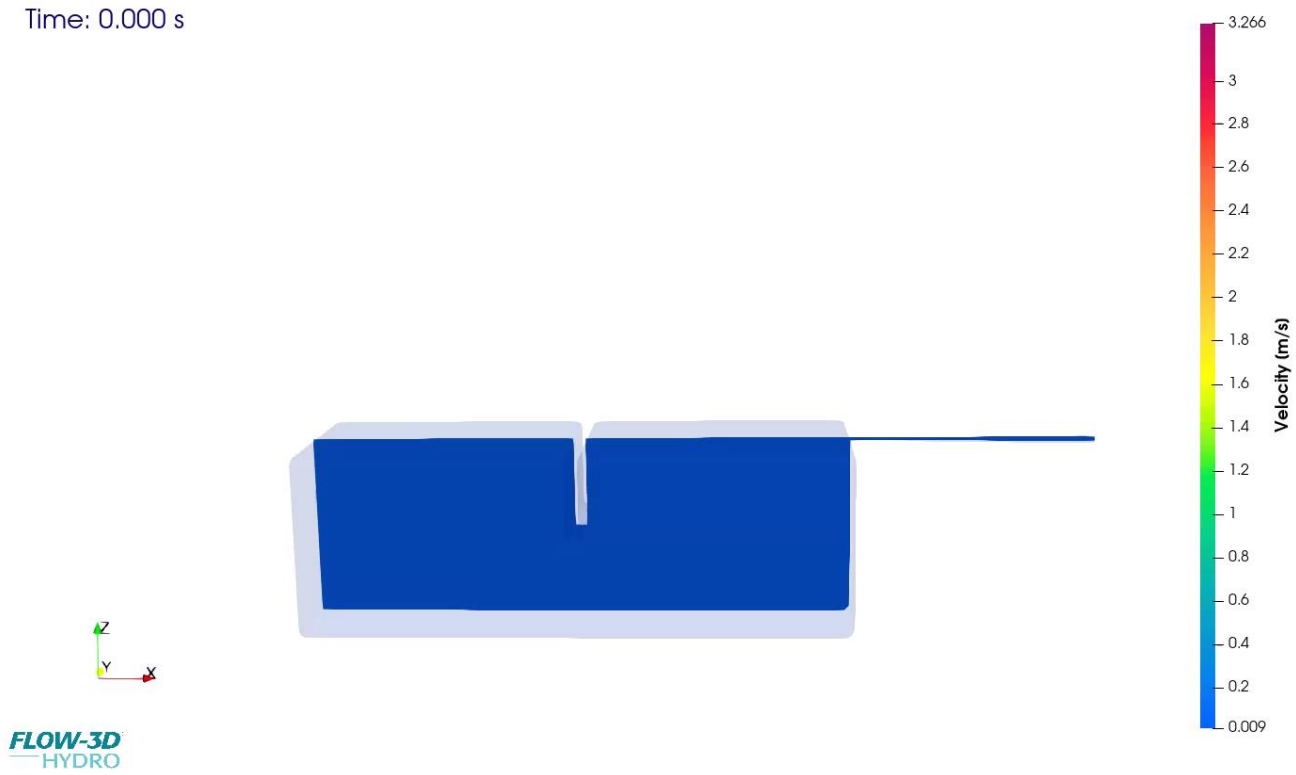
Exercise Guide 2G:
Stormwater Pit

Created in *FLOW-3D* **HYDRO** 2024R1, Updated: 23 October 2024

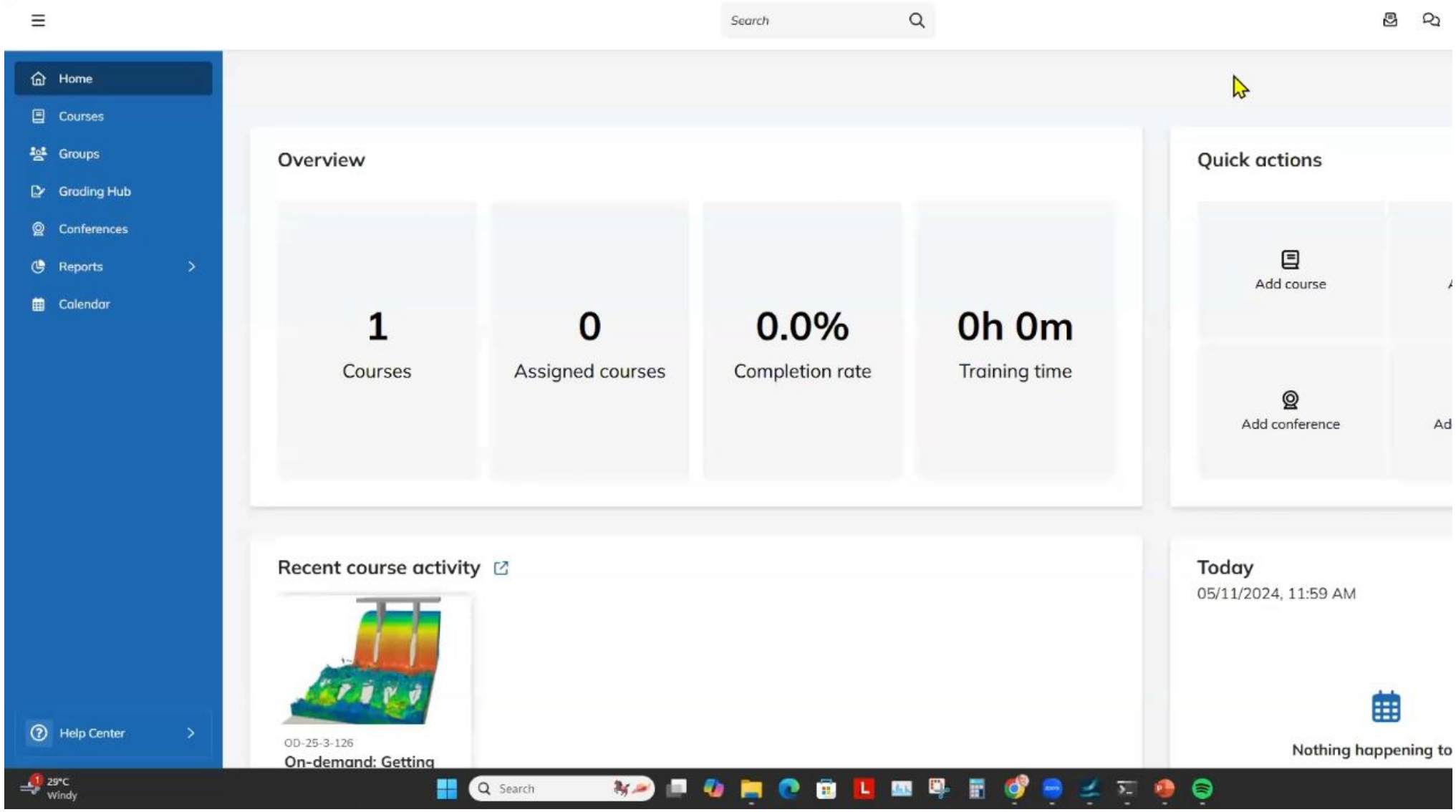
aws 10 YEARS

Australian Water School
On-Demand Training

- Stormwater Pit
  - Mass momentum source, droplet to particle conversion



How do you navigate the course?



What is included?

- ***FLOW-3D* HYDRO** license (30 days, 8 CPU cores)
  - ***FLOW-3D* POST** included for post-processing
  - Exercises can be run on a standard laptop or workstation (Windows OS)
  - Access to the user documentation (theory, model reference, etc.)
  - Login credentials to the ***FLOW-3D* Getting Started** website
- Step-by-step modelling guides in video and PDF format
- Technical support provided by Flow Science Australasia
  - While the course is intended to be fully on-demand, you can arrange one-on-one online meetings if you require further assistance

Who is the target audience?

- Anyone with an interest in CFD modelling for the water industry
  - Academics and professionals of all experience levels
- No previous CFD or ***FLOW-3D*** modelling experience is required
  - Prior experience with 1D/2D modelling tools is beneficial, but is not necessary

- Note: This course is intended for people based in **Australia and New Zealand** as it is coordinated by Flow Science Australasia.
  - If you are in another location, please submit the Expression of Interest (EOI) form and your request will be passed along to your local ***FLOW-3D*** distributor.

What will you learn?

- Learn the basics of the ***FLOW-3D* HYDRO** workflow
  - Experience the ease-of-use of the user interface
    - Create new simulations, simulation copies, and restarts
    - Gain exposure to common physics used in water applications
    - Work with various 3D geometry types
    - Learn a variety of simple meshing techniques
    - Define several types of boundary conditions and initial conditions
    - Perform post-processing in ***FLOW-3D* HYDRO** and ***FLOW-3D* POST**

What I like about the on-demand training format…

- You can approach the training in the manner that suits you
  - If you want more personal interaction, you have our support
- We plan on adding more exercises in the future
- Training exercises are more representative of "real" projects
  - In-person training → simpler models, faster simulations
  - On-demand training → more representative models, longer simulations

- Existing users: allows you to train additional staff without tying up your time and existing ***FLOW-3D* HYDRO** license

What this course is not…

- You will not be a CFD "expert" after taking one on-demand course
  - Hopefully, the course inspires you to explore CFD modelling further
  - This is one step on your journey to being a proficient CFD user

- Not an in-depth review of CFD theory
  - However, you have access to the documentation if that interests you

Learn CFD through flexible, hands-on training

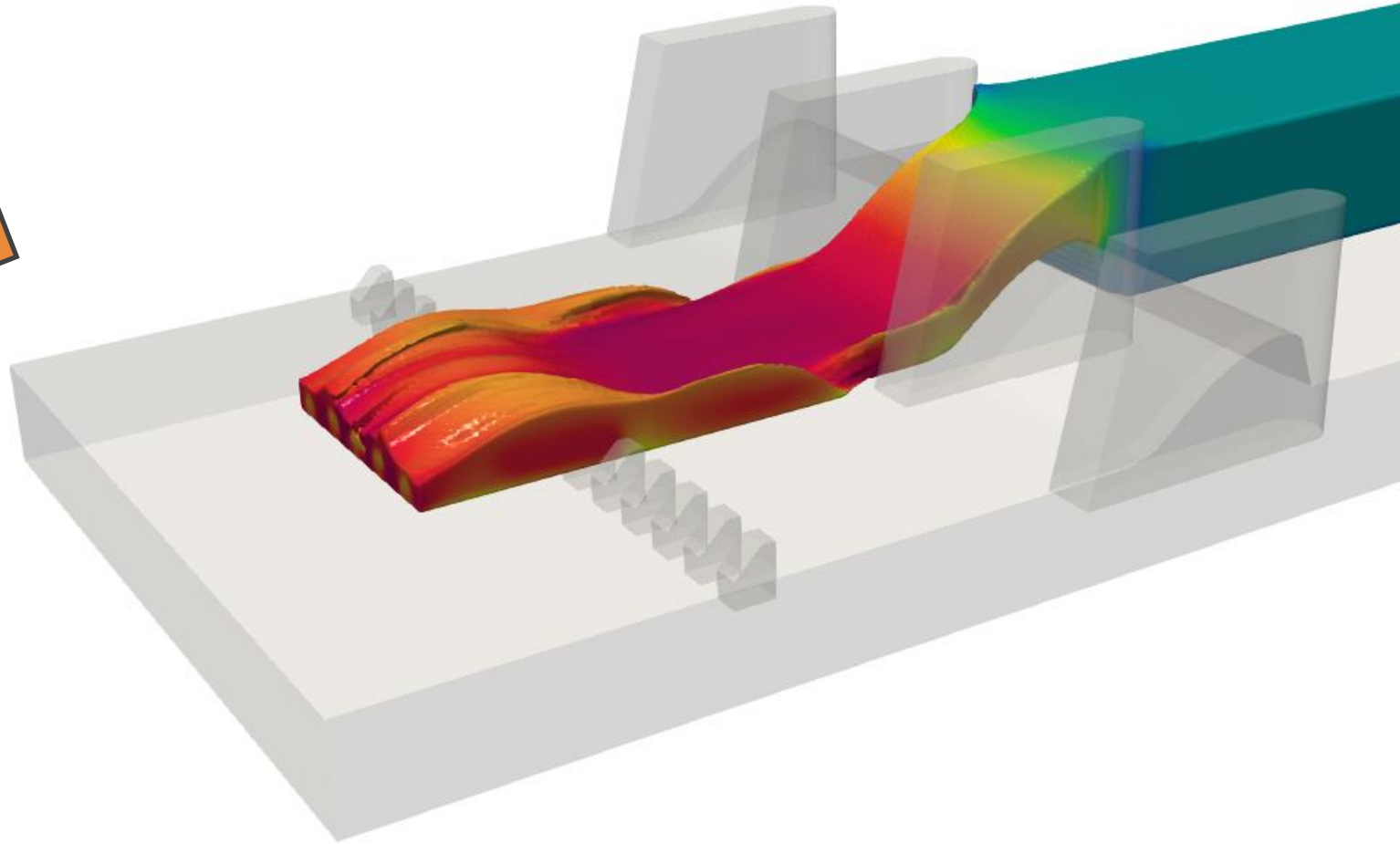
- Gain confidence by repeating the ***FLOW-3D* HYDRO** workflow
- Choose the exercises that interest you
- Access to a **30-day** license to explore your own projects!

Experience why ***FLOW-3D* HYDRO** is the leading CFD software for the water industry!

Sign up today on the Australian Water School training portal:
https://awschool.com.au/training/

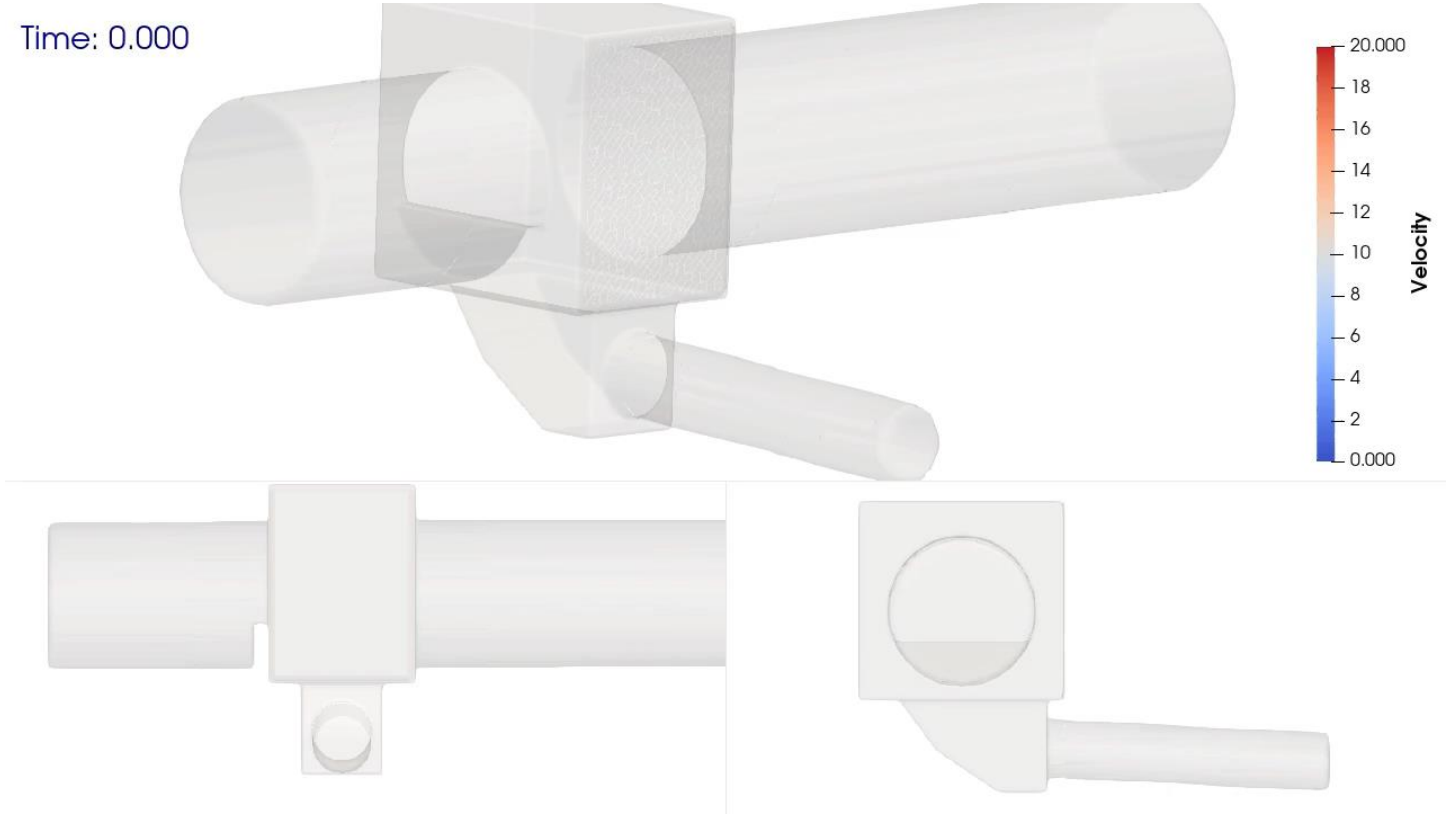
Model workflow and live demo

- Review of the general modelling workflow in ***FLOW-3D* HYDRO**
- Live demo



Model setup: Basic free surface simulation

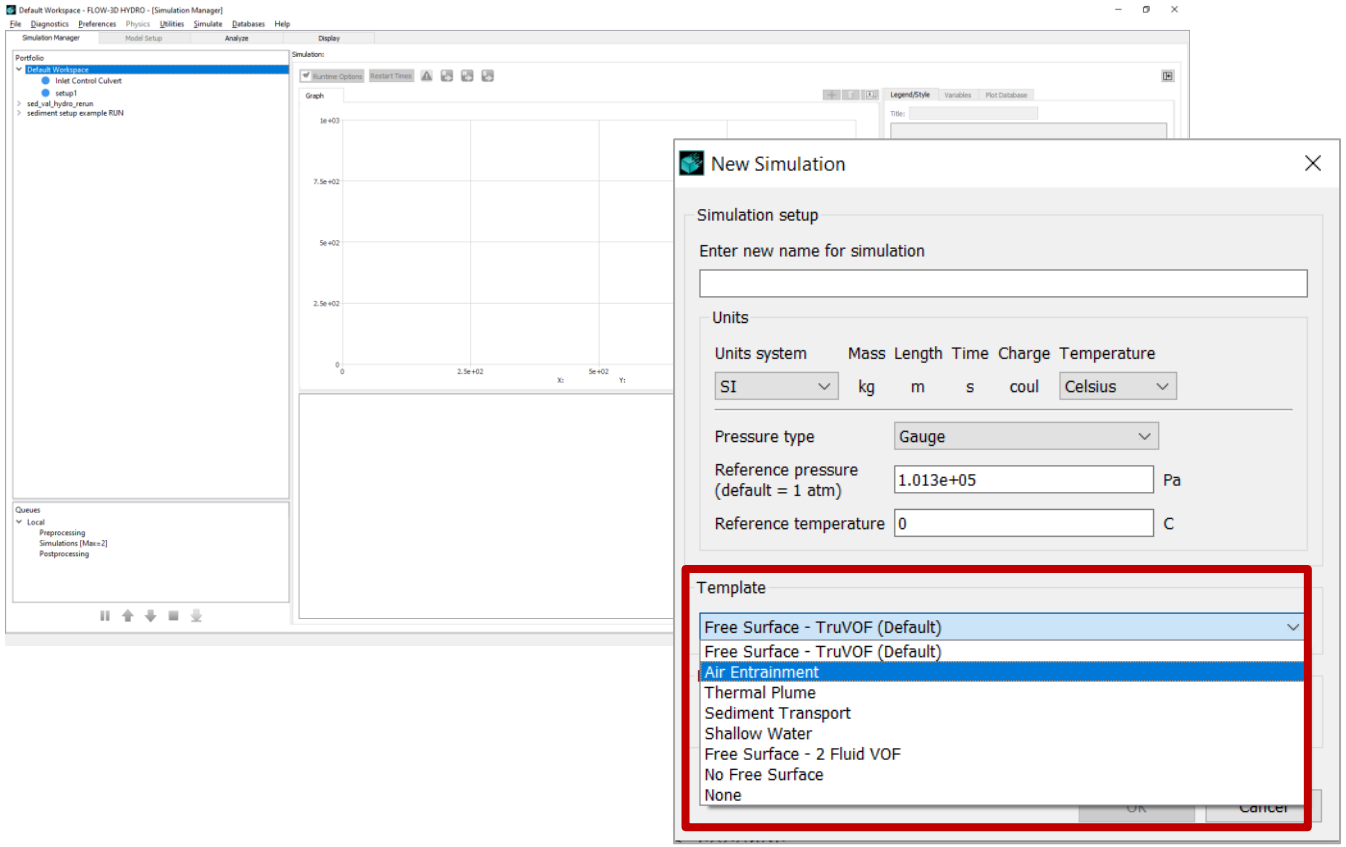
- Setup requirements
  - Water flowing over solid geometry
  - Free surface physics
    - 1 fluid VOF, gravity, turbulence



- Setup workflow

Create Simulation › Geometry › Meshing › Initial and Boundary Conditions › Run Simulation › Post-processing

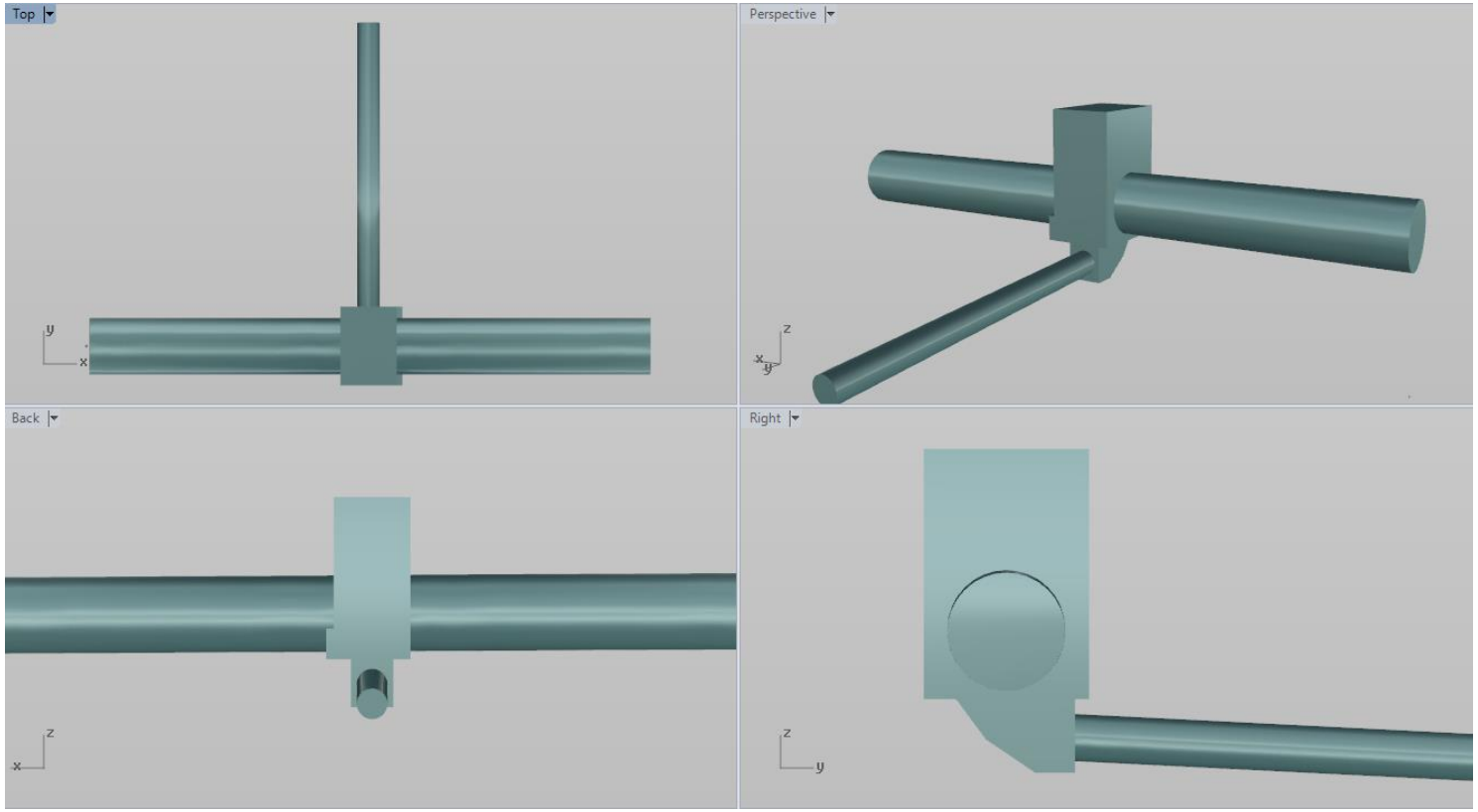
Model setup: Basic free surface simulation



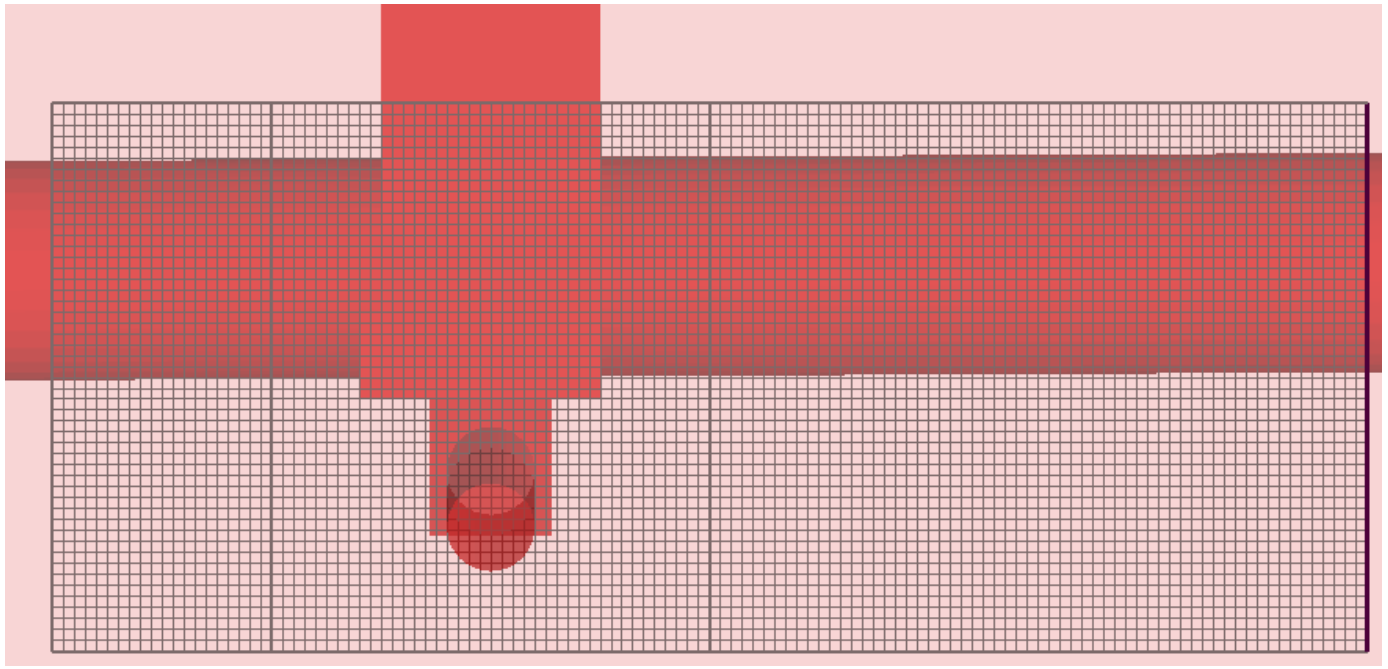
- Activates physics models
- Specified input parameters
- Loads fluid properties
- Sets recommended numerical options
- Selects output variables

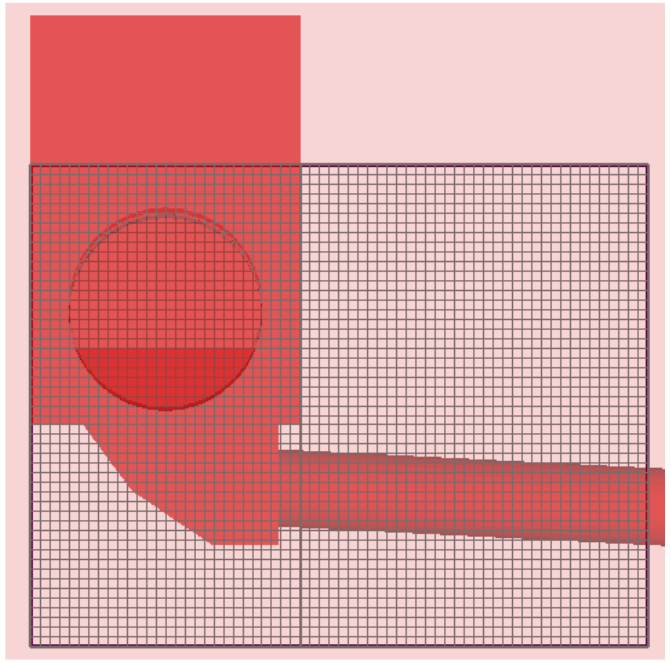
Create Simulation › Geometry › Meshing › Initial and Boundary Conditions › Run Simulation › Post-processing

Model setup: Basic free surface simulation

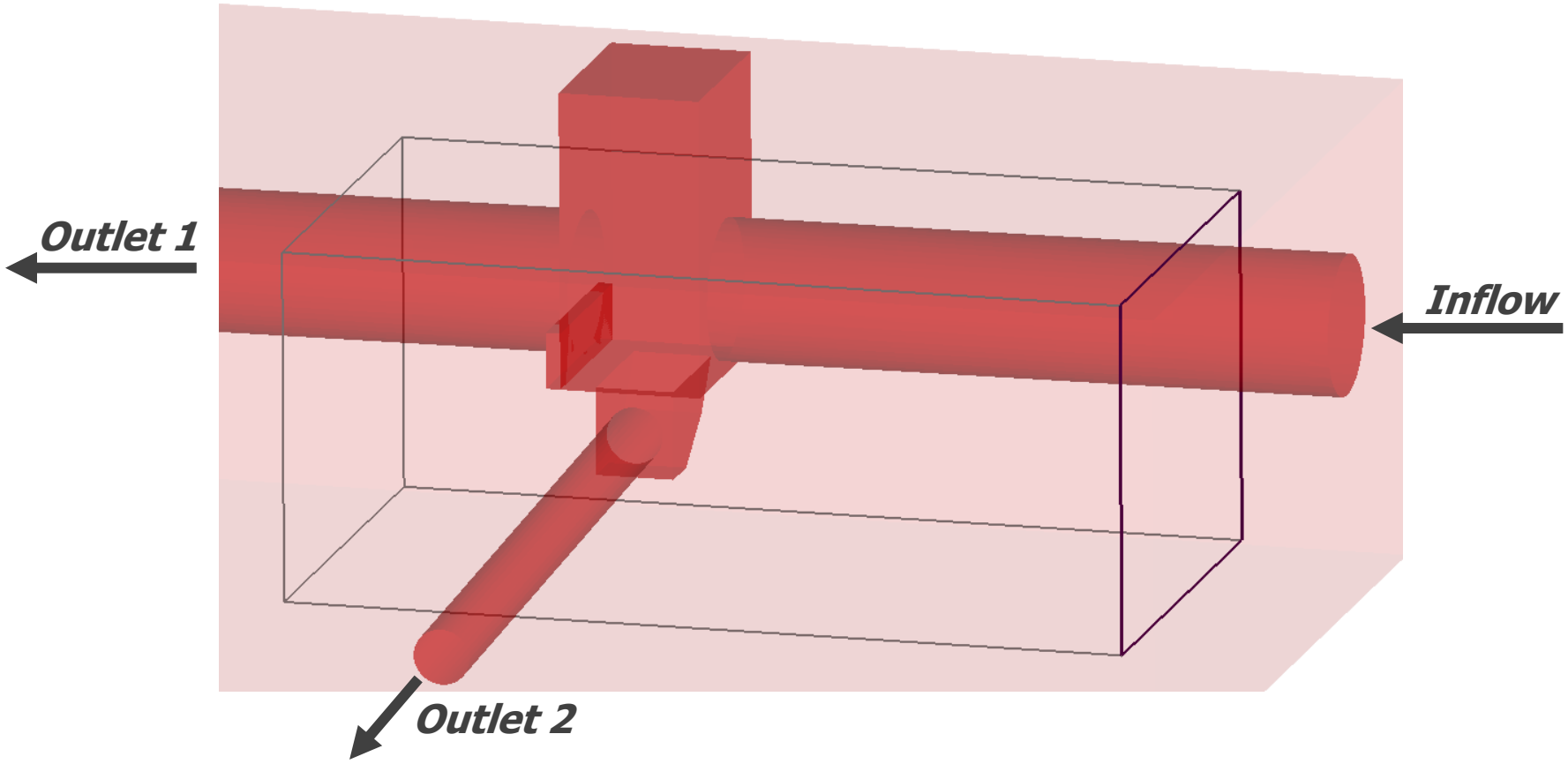


Model setup: Basic free surface simulation



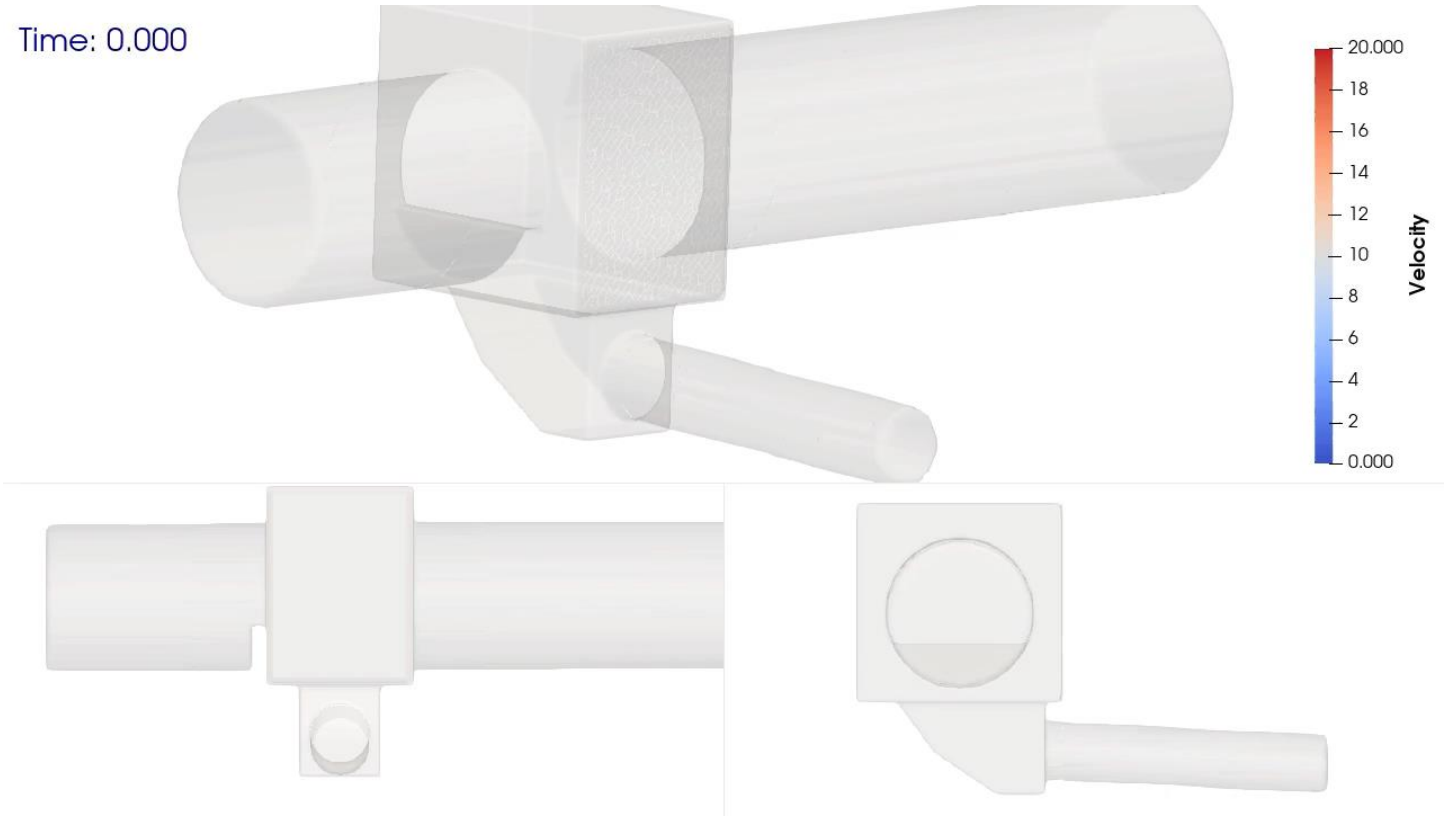


Model setup: Basic free surface simulation



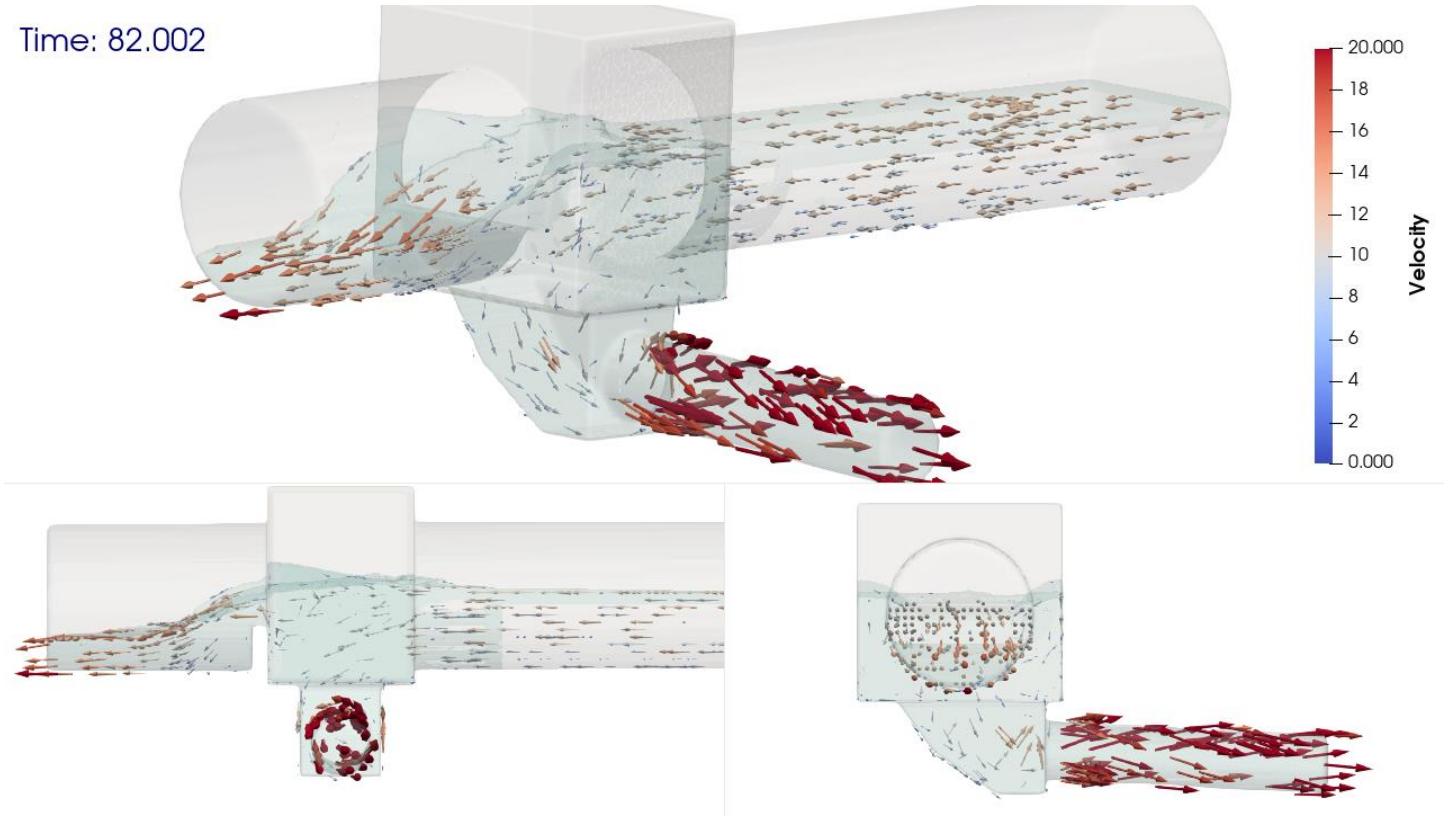
Model setup: Basic free surface simulation

- Setup time
  - 15 min - 2 hours
- Run time
  - 1 hour
    - 260,000 active cells
    - 10 cores workstation



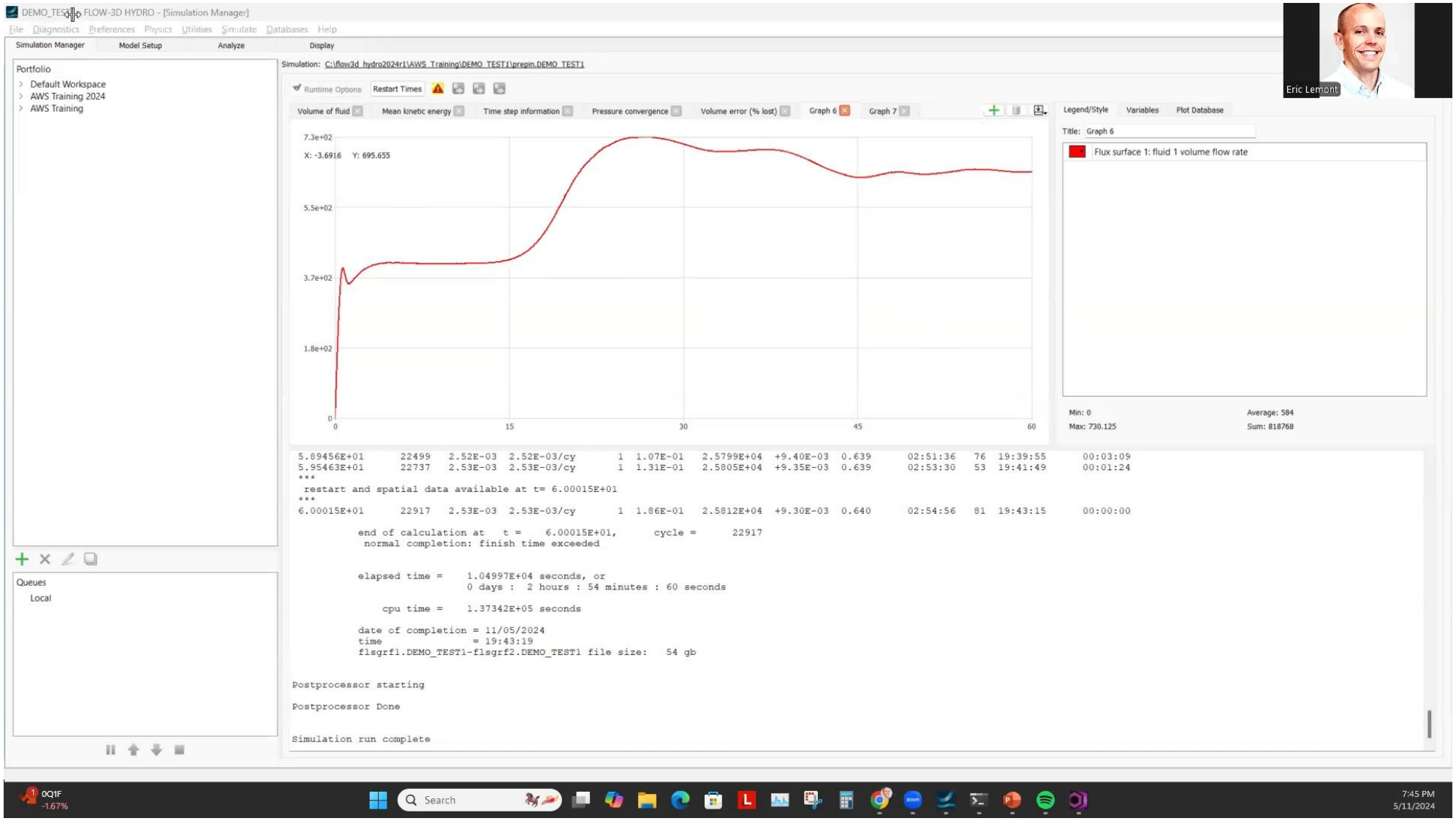
Create Simulation › Geometry › Meshing › Initial and Boundary Conditions › **Run Simulation** › Post-processing

Model setup: Basic free surface simulation

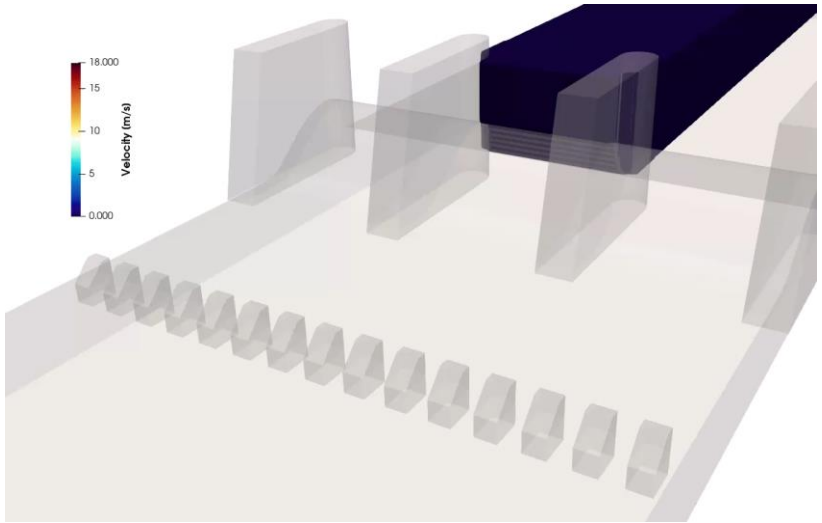


Create Simulation › Geometry › Meshing › Initial and Boundary Conditions › Run Simulation › **Post-processing**

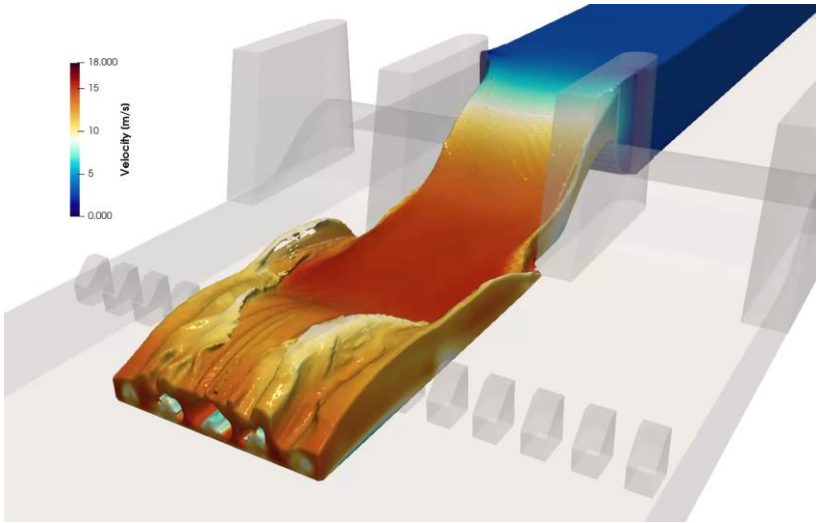
Live demo – ogee weir



Post-processing and sensitivity testing



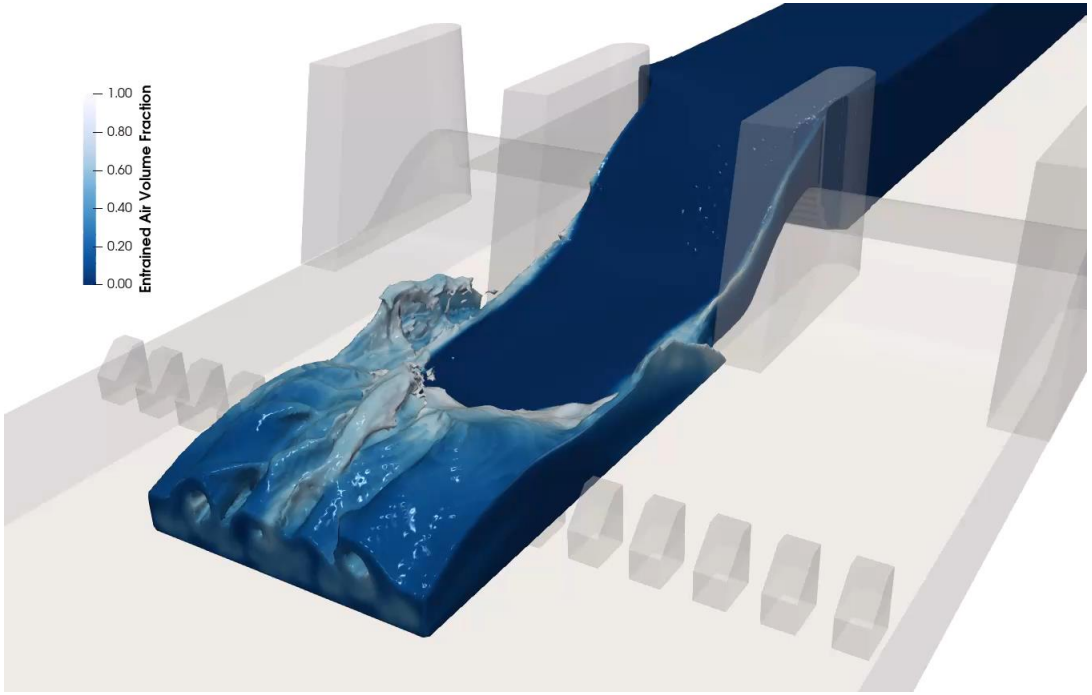
Demo model (RNG, 1st order)



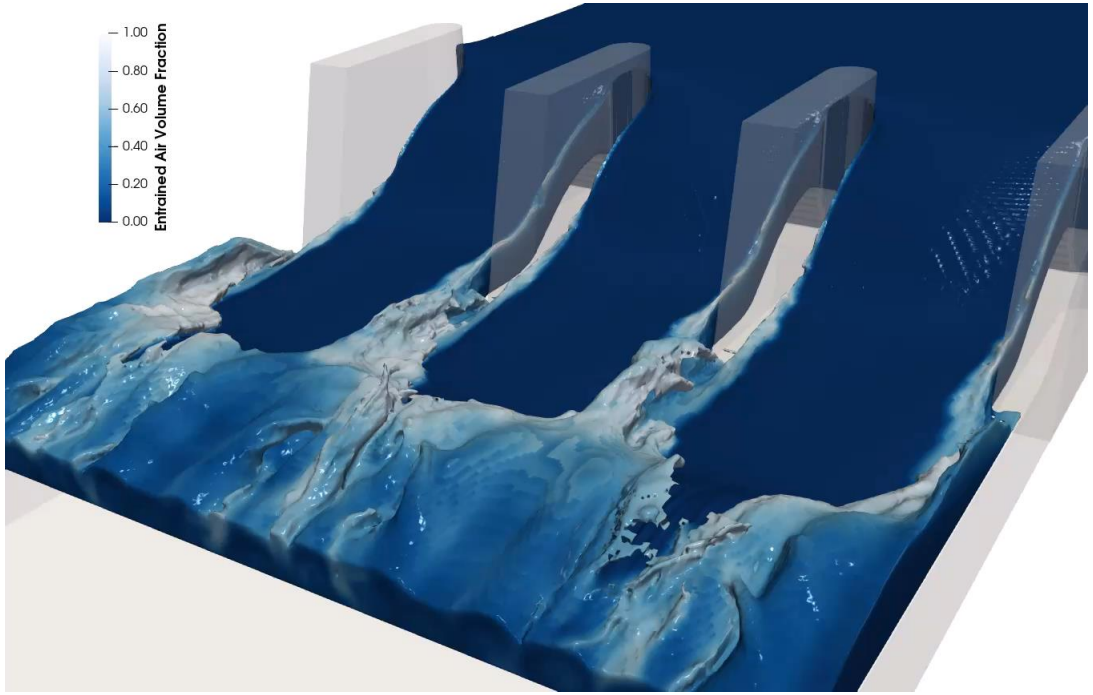
Restart model (LES, 2nd order)

Ray tracing (LES, 2nd order)

Post-processing and sensitivity testing



Air entrainment (RNG, 2nd order)



Full width model
(air entrainment, RNG, 2nd order)

Take Home Message

- Benefits of 3D CFD
  - Accuracy
  - Flexibility and versatility
  - Risk and uncertainty reduction
  - Supplement to other modelling approaches
  - Effective communication

- ***FLOW-3D* HYDRO**
  - Industry-leading 3D CFD modelling for civil hydraulics applications
  - Streamlined, intuitive application-based workflows
  - Training content library
  - Technical support services
  - A continued commitment to developing advanced solver capabilities for the civil engineering industry

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https://awschool.com.au/training/

Upcoming Events this November

- ANCOLD Conference
  - 11-14 November in Adelaide
    - Booth #32
- Hydrology & Water Resources Symposium
  - 18-21 November in Melbourne
    - Lanyard sponsor

Thank you!

Questions or Comments?