Hydrodynamic Optimization of Deep-Water Surf Machines Using DualSPHysics

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ADG History

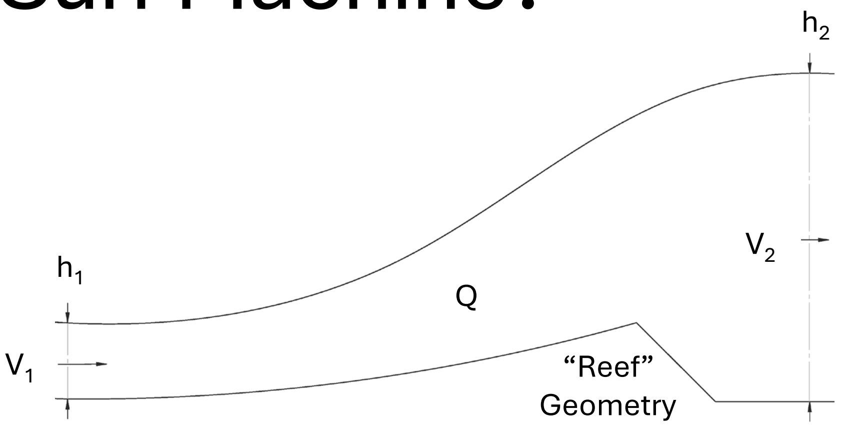
Began in 1950's as a commercial pool contracting business.

Today we are a manufacturing and design/build company with unique expertise in water waves.

Portfolio includes water parks, resorts, surf parks, aquatic centers, zoos, film studios and more.

What is a Deep-Water Surf Machine?

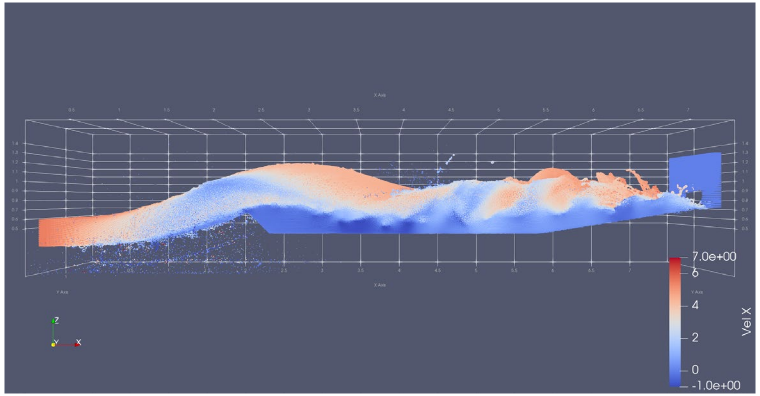
- Formed hydraulic jump
- Smooth wave that does not break
- Mimics aspects of a standing river wave
- 27 machines world-wide since 2018



Surfers enjoying the Eisbachwelle, Munich, Germany

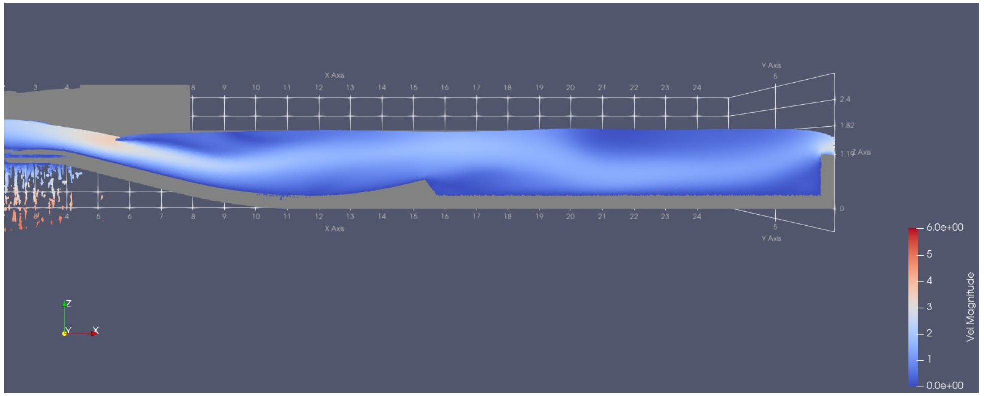
Why DualSPHysics?

- Large Deformation of Free Surface
- Jump is sensitive to flow conditions
- Understanding of physics is crucial for success
- Many unknown variables



Simulation of smooth surf machine jump
DualSPHysics_v5.4_BETA

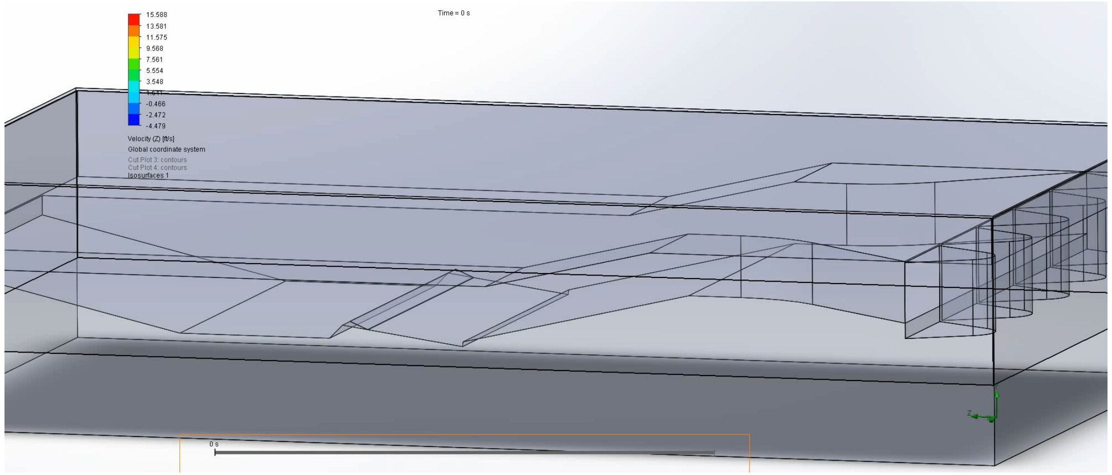
Breaking/collapsed Eisbachwelle surf wave, Nov. 2025
Michaela Stache/AFP via Getty Images



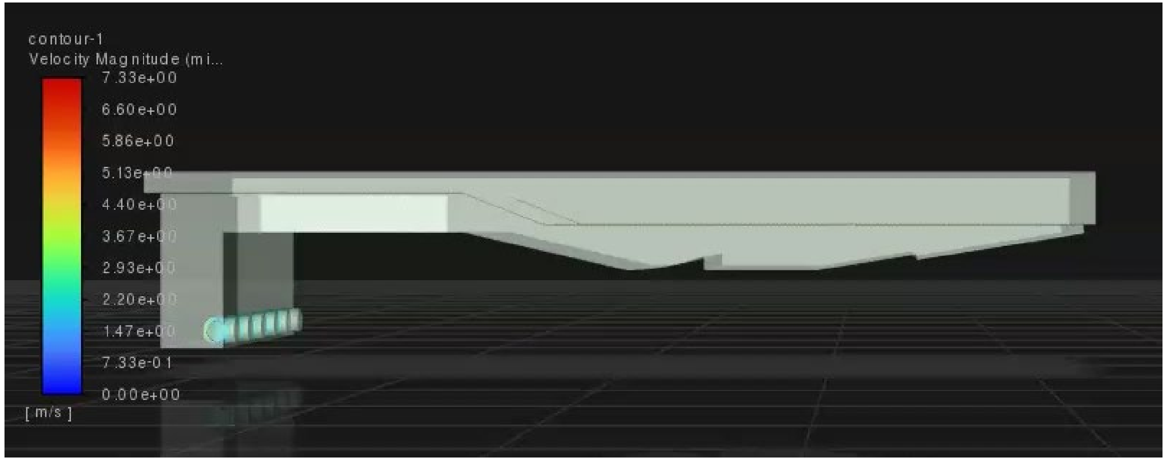
Simulation of breaking/collapsed surf machine jump
DualSPHysics_v5.4.2
85 Million Particles, 120s Physical Time
5 Week Computational Time

Before DualSPHysics

- No GPU support
- Not enough free surface detail
- No option for custom physics



Solidworks Simulation

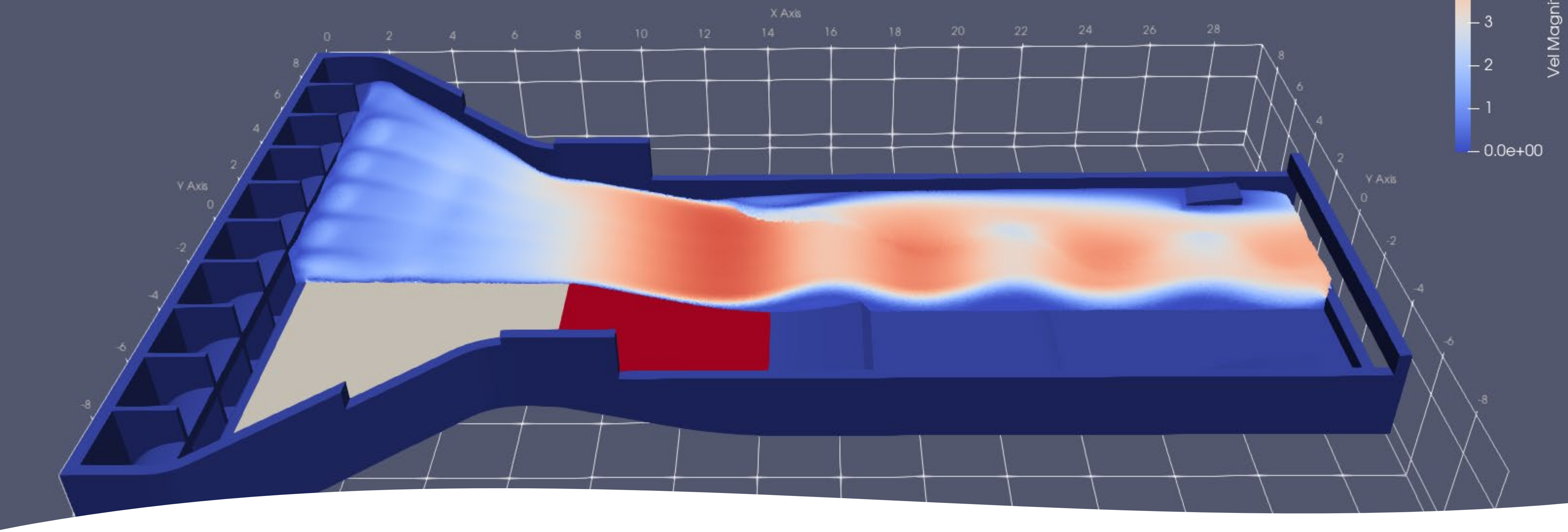


Ansys Fluent

- Hardware locks/digital keys
- Do I own my data?
- Cost vs return

What we hope to gain:

- Relevant velocities, pressures and free surface elevations
- Understanding dynamic loading conditions
- Geometric optimizations – Smooth, variable-height jump
- Helpful insights for fabrication, installation, operation and maintenance
- Accurate visual representation for sales and marketing

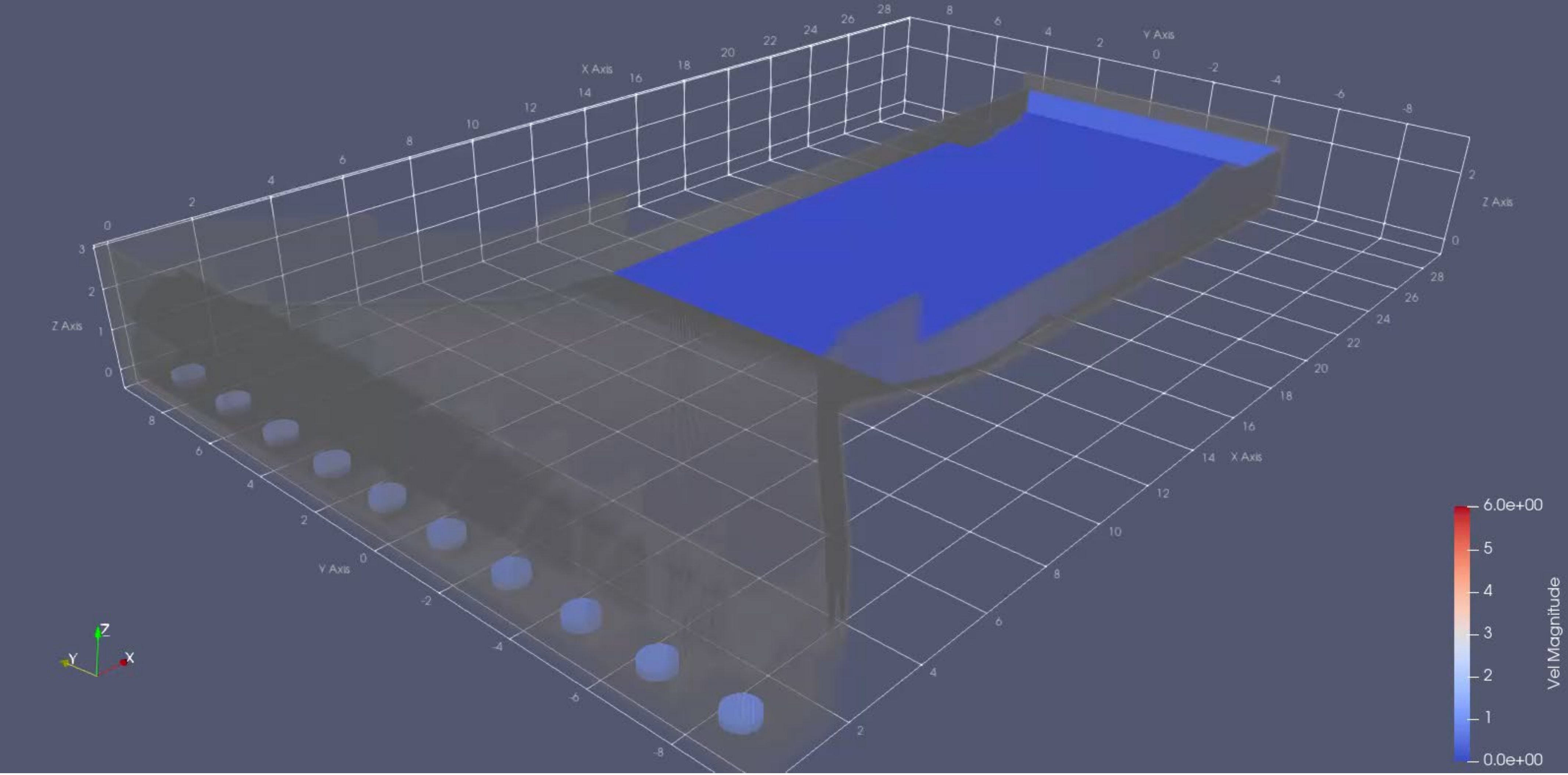


Challenges

- Open Boundary Conditions
  10 Inlets, 1 outlet
  Variable imposed velocity
- Large Domain in Space & Time
  29.8m x 19.5m x 3.4m
  120s
- MKfluid Limit of 10
- Complex Imported Geometry
  <drawfilestl>
  depthmin ="DP*0.001"
  depthmax = "DP*5"
- Data Management
  PartVTK vs IsoSurface
- Validation

Assessment and Validation of Surf Machine,
Z. Racine, November 2024

Assessment and Validation of Wave Pool, Z. Racine, July 2023



Surf Machine Simulation – DualSPHysics v5.4.2

Elements of code used:

- Modified Dynamic Boundary Conditions [mDBC]

  Drawfilestl: depthmin="DP*.001"
  depthmax="#DP*5"
- SlipMode: No-slip
- NoPenetration
- DensityDT: Fourtakas Full
- ViscoTreatment: Laminar+SPS
- Shifting: Ignore Bound
- Damping
- Inout: Impose Variable Velocity
- hdp value="1.3"
- speedsystem value="6"

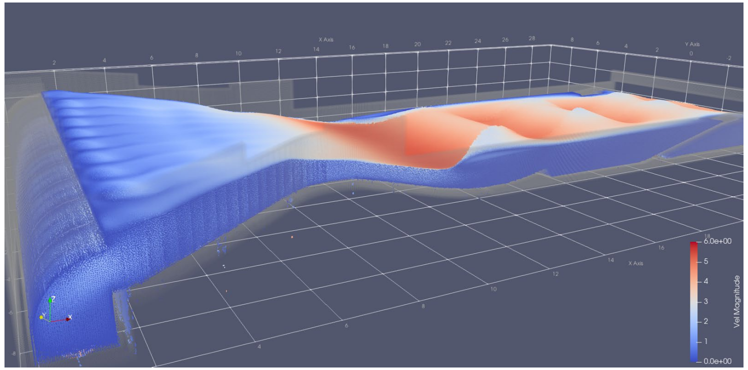
Hardware:

- Nvidia RTX 6000 [Ada Lovelace]
- Nvidia RTX A5000 [Ampere]
- Nvidia Geforce 4090 Mobile [Ada Lovelace]

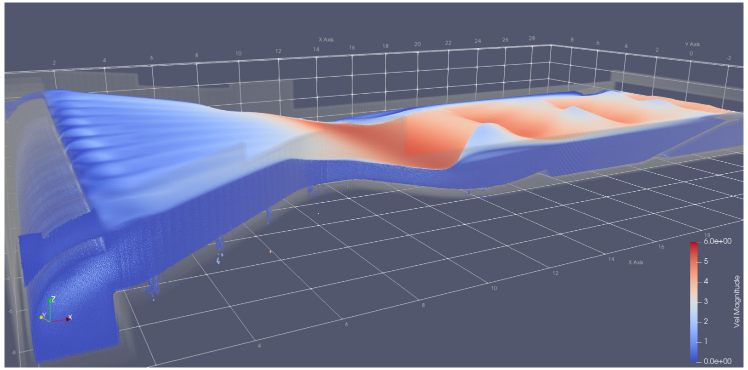
Visual Validation:

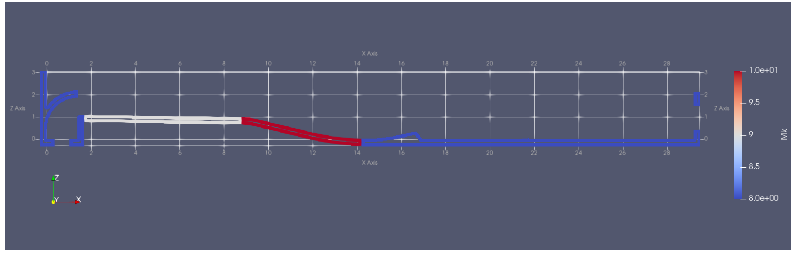
Computeforces [MK9]

DP=0.0375m [~11 Million Particles]

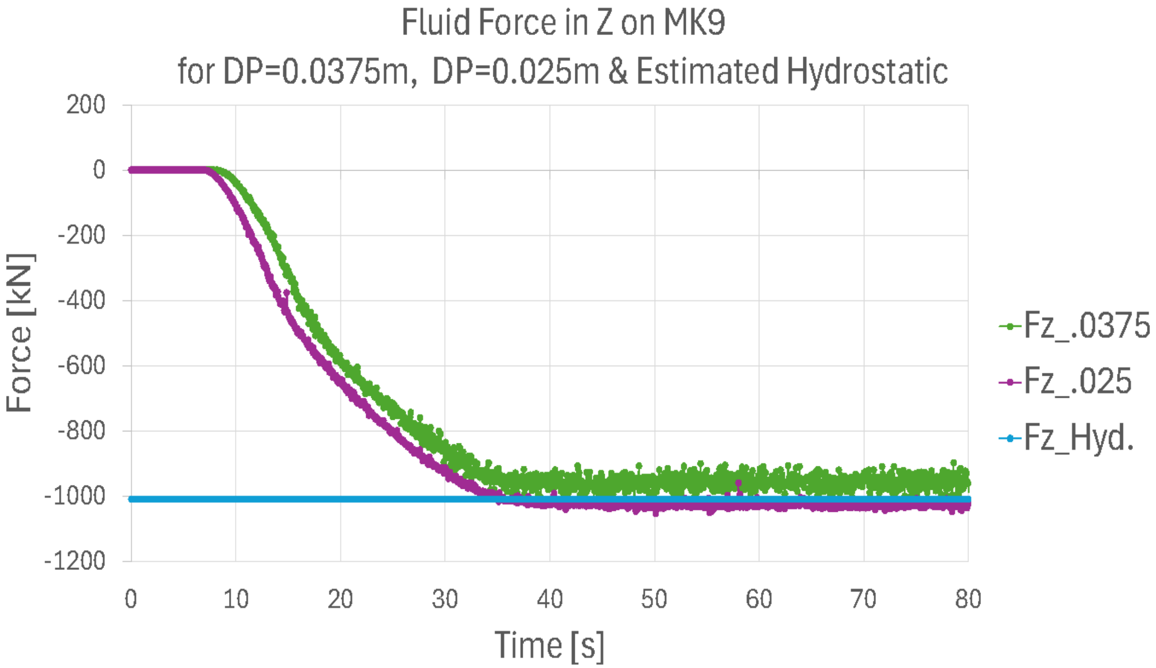


DP=0.025m [~32 Million Particles]

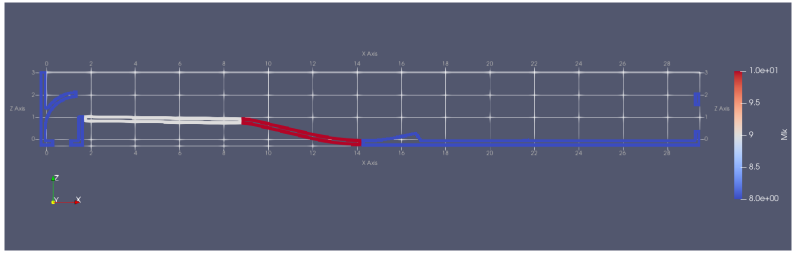




MK9 Shown in White

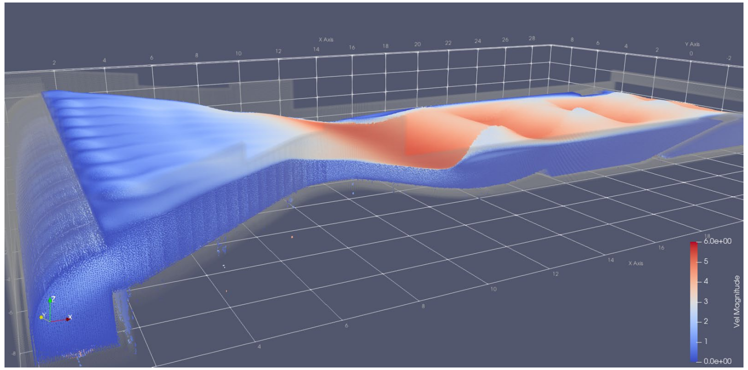


Computeforces [MK10]

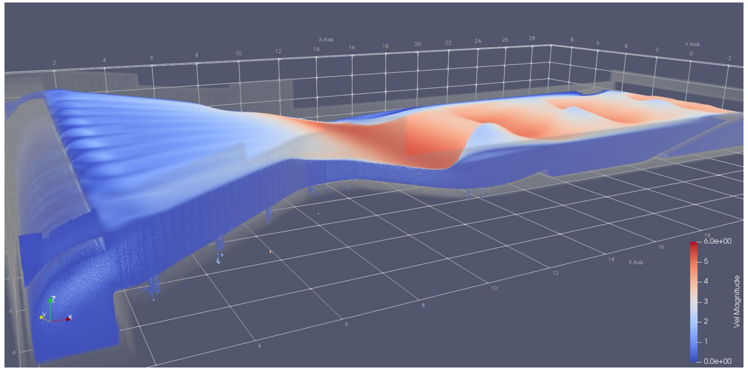


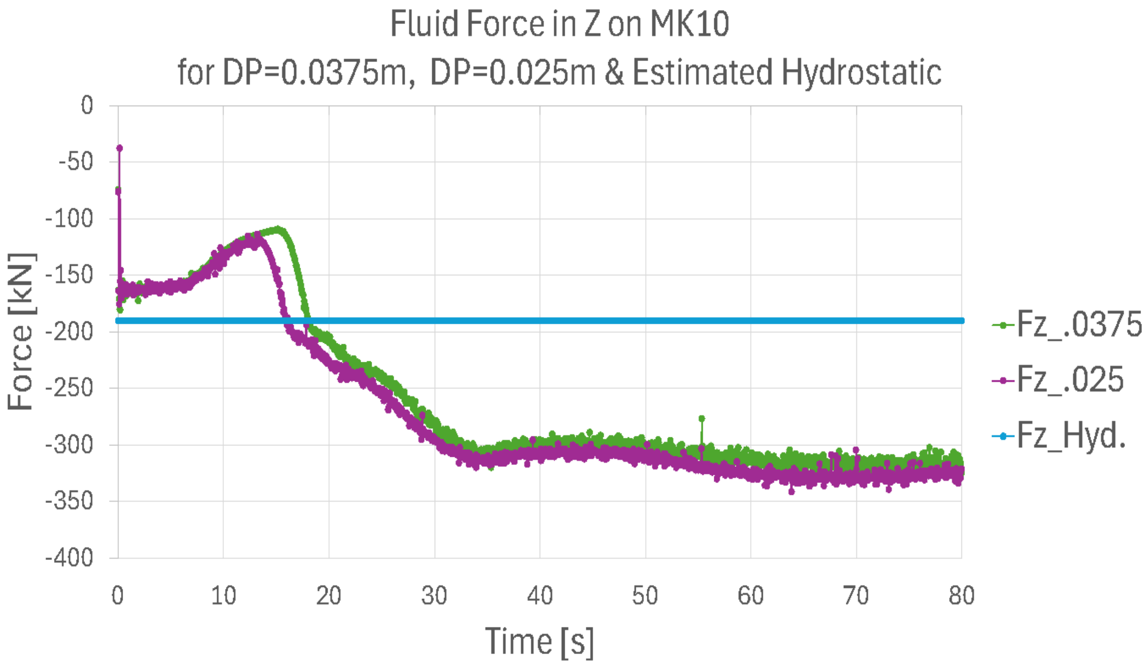
MK10 Shown in Red

DP=0.0375m [~11 Million Particles]



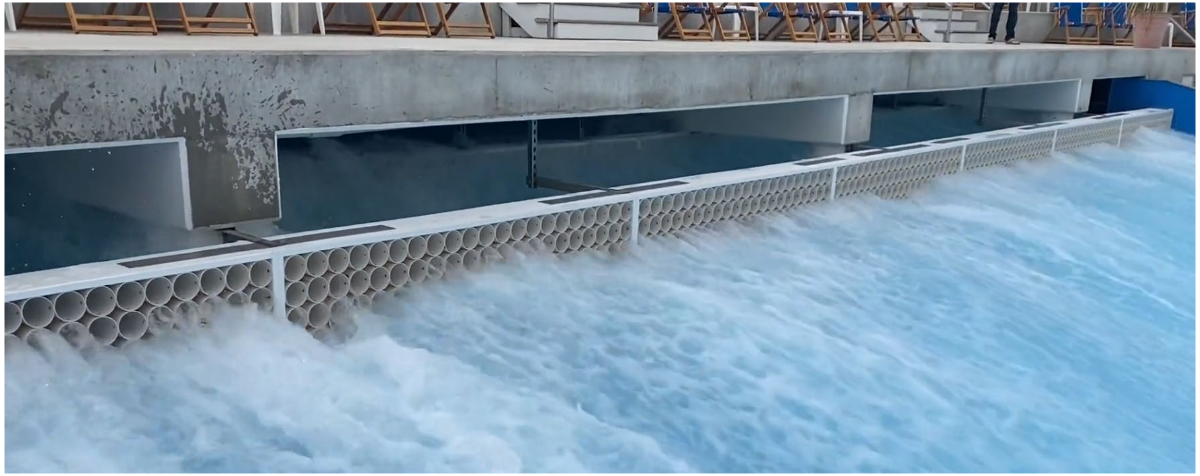
DP=0.025m [~32 Million Particles]



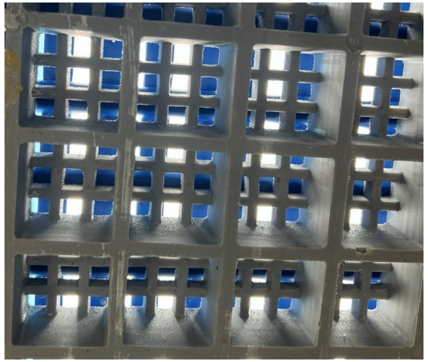


Future Surf Machine Simulations

- Prescribe movement of “reef” section
- Model substructure
- Model flow conditioning components using variable resolution tools
- Approximate turbulence from pumps
- Adjust outlet to reflect actual geometry (Series of grates and plates?)



View of Flow Conditioning Components

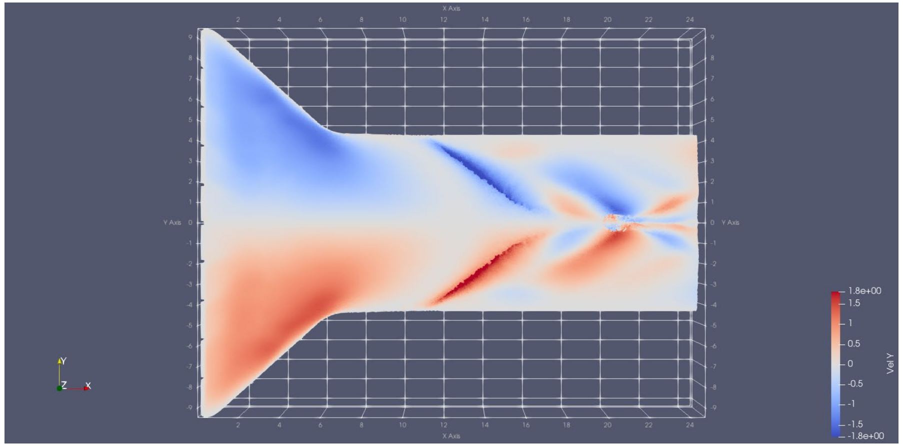


View Through Outlet Grating

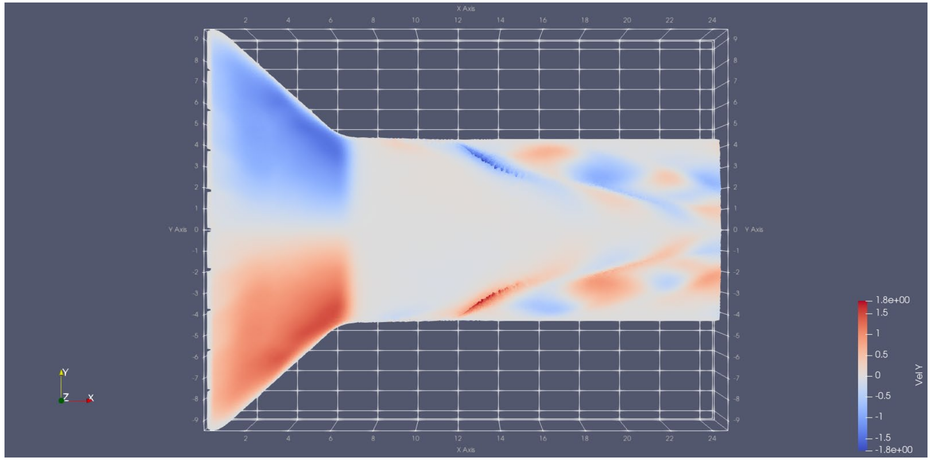
View From Inside Tank

Damping V_y to Approximate Effect of Flow Conditioning System

- Simplified geometry
- ~ 7 Million Particles
- 120s Physical Time
- 3 Days Computational Time



No Damping

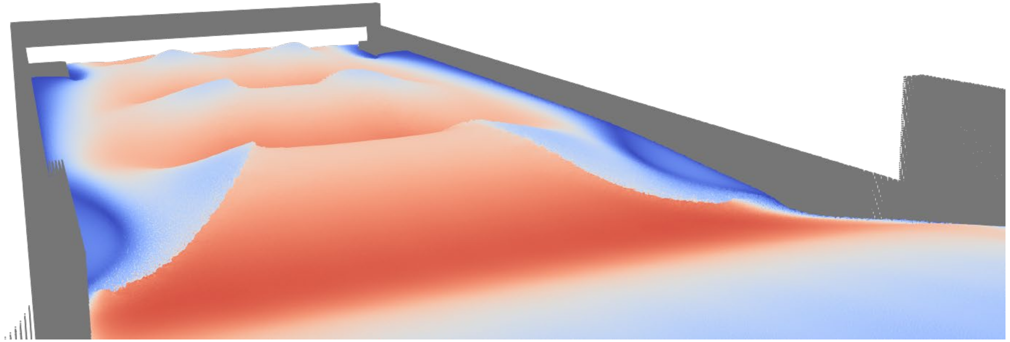


Damping V_y from X = 6m to X = 7m

Conclusions

- Tailwater depth and “reef” geometry are the most significant variables for generating a smooth surfable hydraulic jump.
- SPH has provided our most accurate estimate of dynamic loading conditions for structural engineering.
- We continue to explore the impact of various flow conditioning techniques.
- Forces from SPH were used to size replacement mechanical components that were experiencing failure.

Gracias!



List to Santa 2026

- Easier open boundary controls
- Resume for simulations with open boundaries
- Multi-GPU
- VisualSPHysics?