2D Hydraulic Modelling in the Consulting Environment

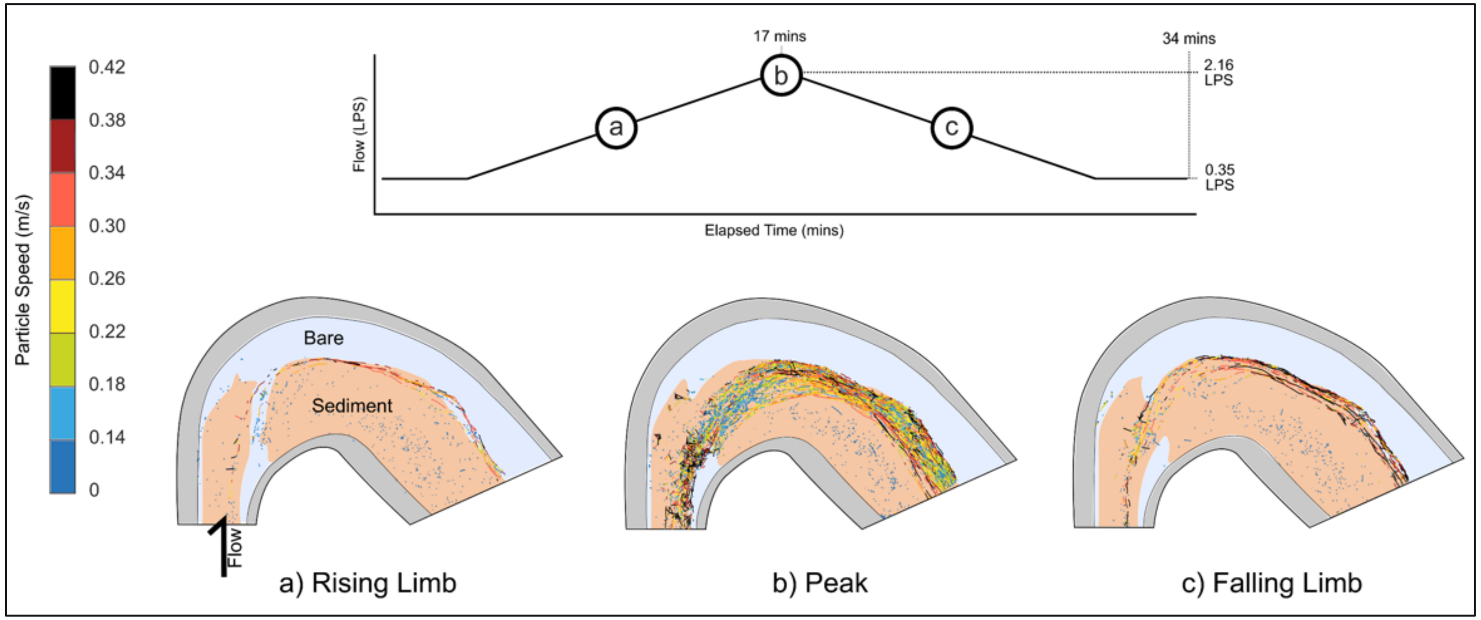
By Lukas Mueller

My Background

- 3 years as an engineer at GEI
  - Restoration design
  - Erosion hazard delineation
  - Erosion analyses

- M.A.Sc. at the University of Waterloo
  - Focus on hydraulics
  - Sediment transport in a flume
  - Field tracer studies

- Background in:
  - 1D modelling
  - GIS and CAD



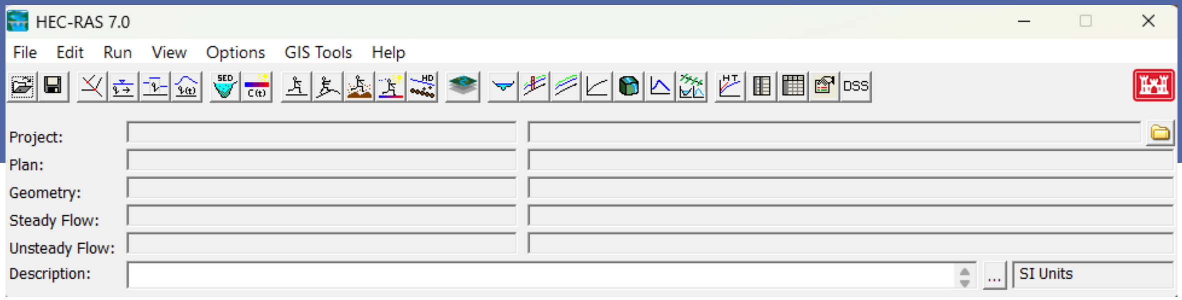
Key Objective

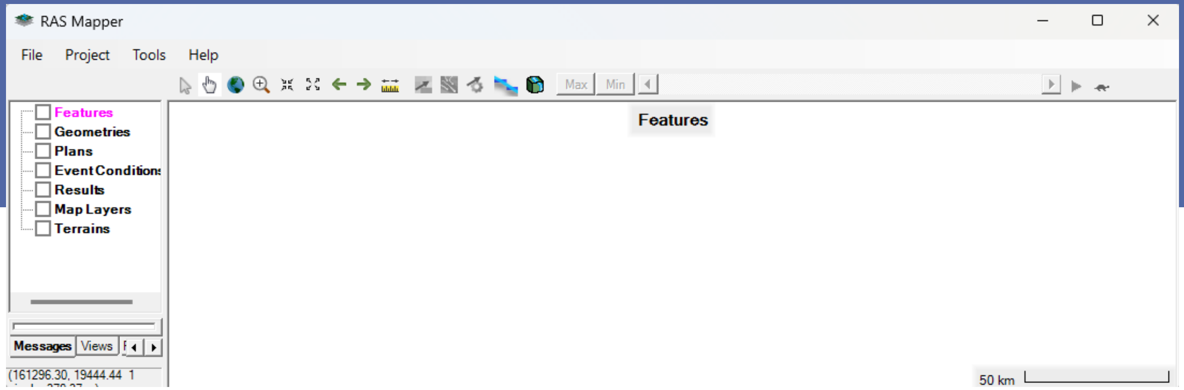
- To validate proposed designs by creating simple 2D models

Considerations

- Does the model accurately represent the proposed design?
- Are modeling goals reasonable and simple?
- Is it fast? Are there potential ‘hang-ups’?
- Is it worth the effort / is it useful?

HEC-RAS and RAS Mapper





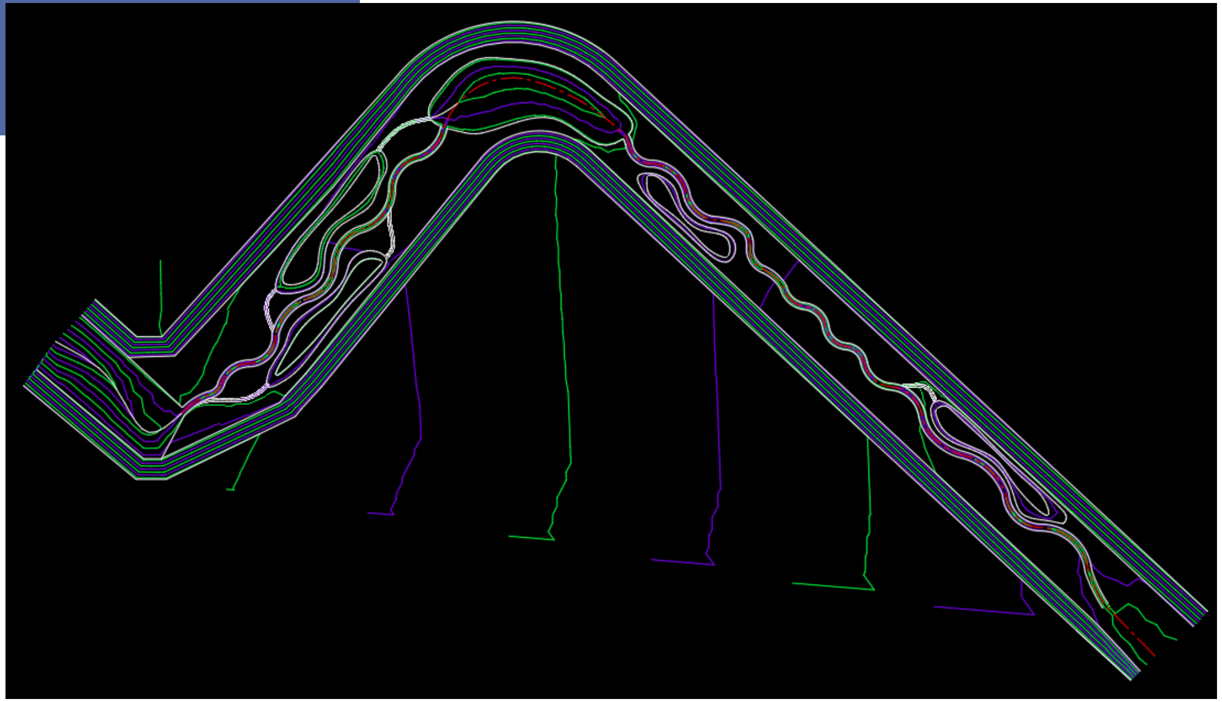
HEC-RAS: Hydraulic computation engine

- First released in 1995 by the USACE
- Solves river and floodplain hydraulics
  - Can analyze sediment transport, water quality, and other parameters
- Widely adopted standard in academia and industry

RAS Mapper: Spatial modelling environment

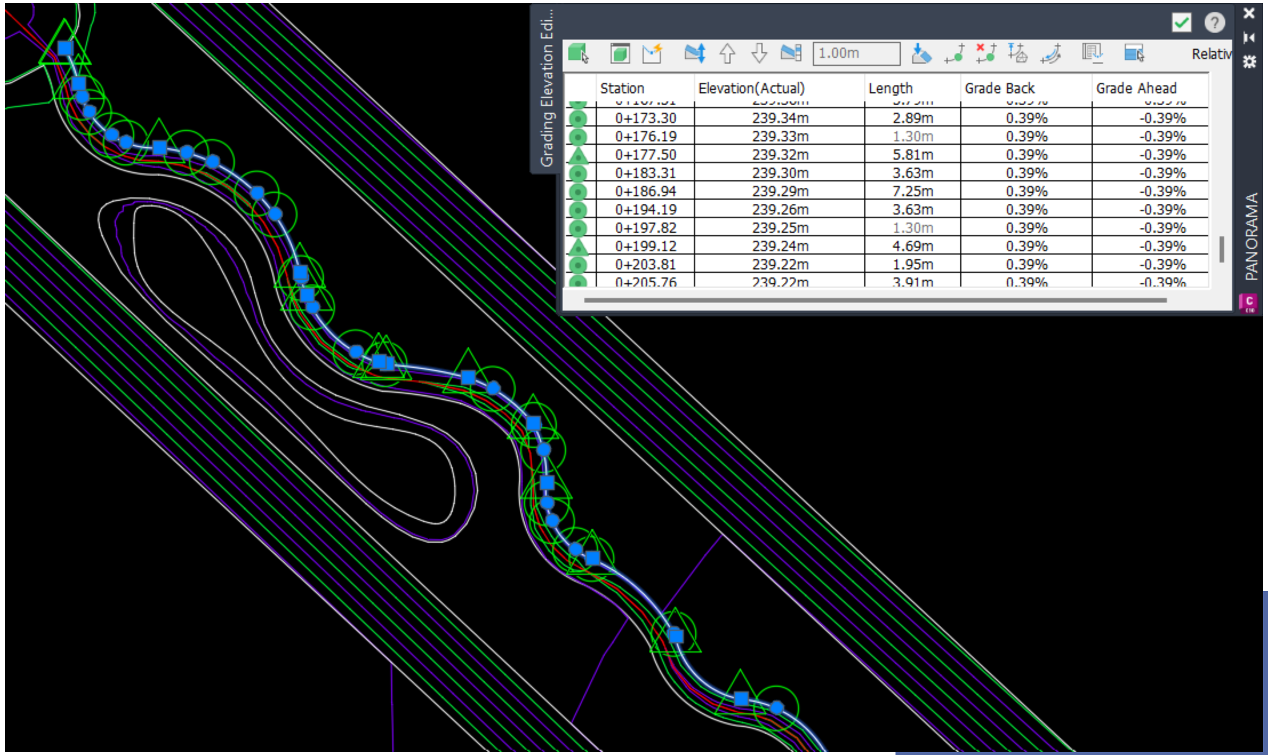
- Integrated geospatial interface within HEC-RAS
  - You can build the model and view results, all in one
- Replaces GIS workflows for many tasks
- Intuitive and user-friendly

Building the Terrain



Surface consists solely of feature lines

Create complex feature lines with text files, simple lines with built in grading tools



Workflow

Define Objectives

Create Terrain

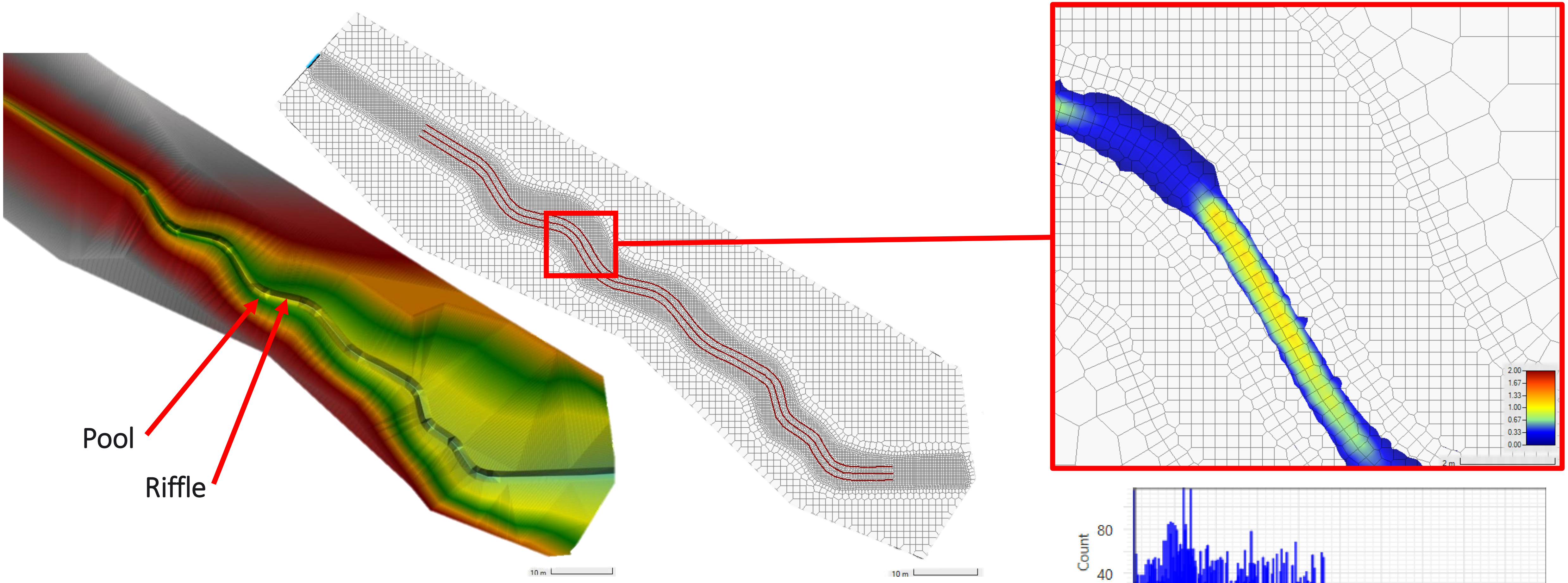
- Corridor often provided by Project Engineer
- Feature lines already generated as part of the design package
- Resolution is very important in the long run!

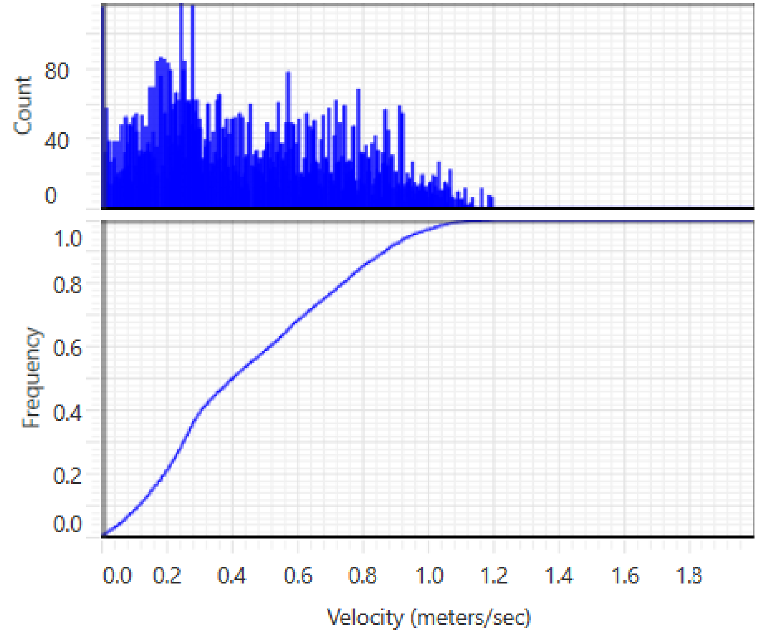
Create Model

- Import terrain
- Create mesh from 2D flow area
- Define boundary conditions
- Create or import breaklines
- Create land cover layer for roughness

Generate Results

- Run various plans
- Test model sensitivity
- Troubleshoot
- Attempt to better understand model shortcomings





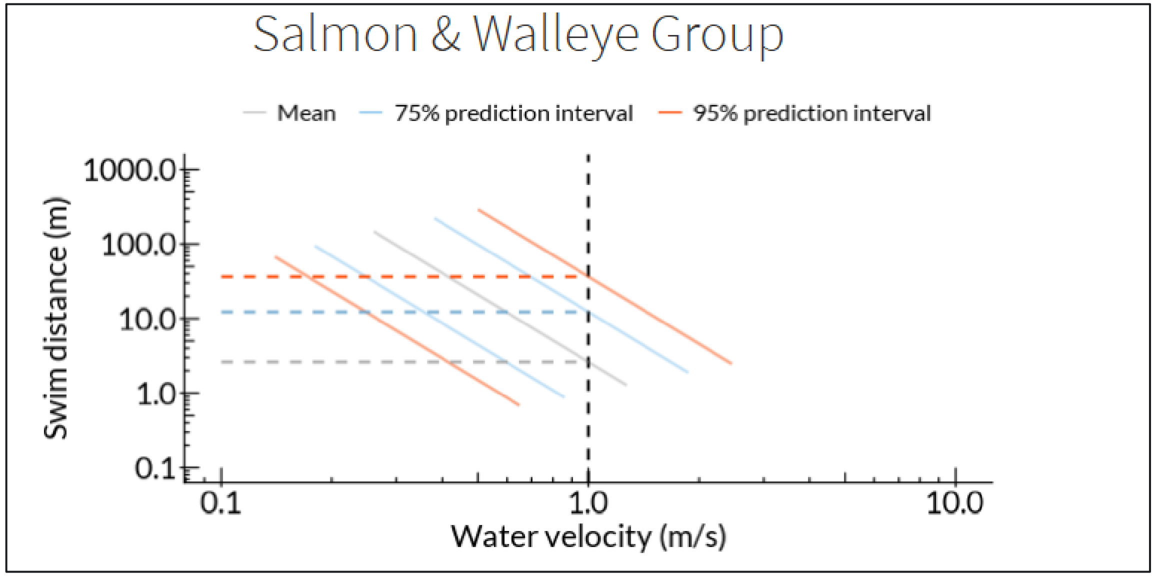
Fish Passage Analysis

- Stream restoration under a wide, Con-Span bridge
- Riffle gradient = ~4%
- Under typical low flow, riffle velocities range between 0.8 – 1.2 m/s

Passage of Target Species

Photo from DFO

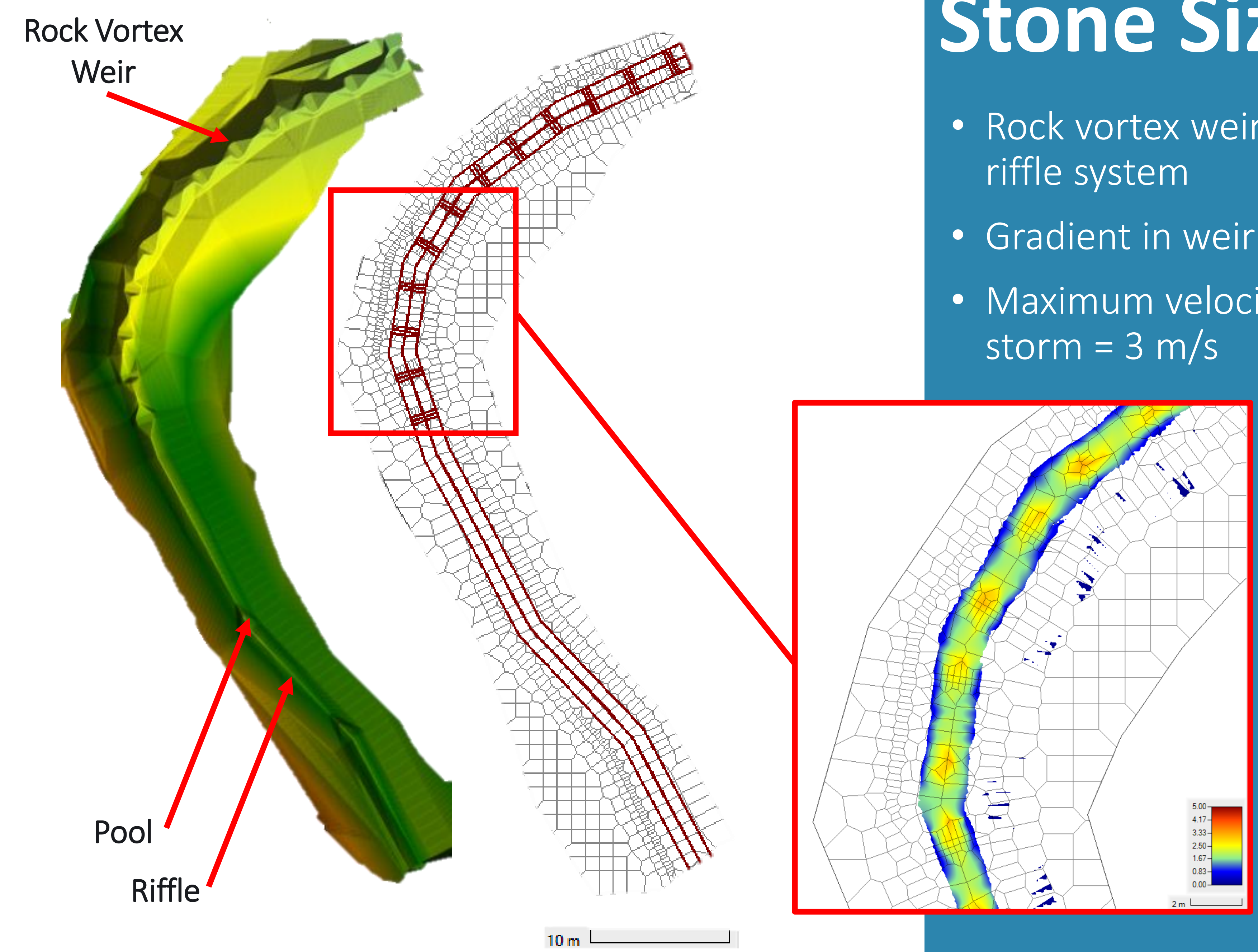
- Stream in question is critical habitat for Redside Dace
- Run check using the Swim Performance Online Tool (SPOT; DFO, 2025)

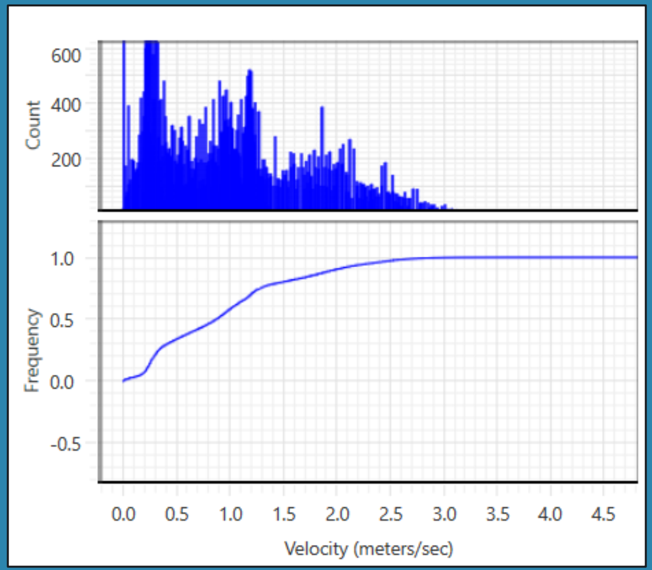


- Redside Dace fall under the ‘Salmon & Walleye Group’ as they are subcarangiform swimmers
- 50% of 100 mm fish can swim 2.6 m in 1 m/s flow, 12.5% of 100 mm fish in 1 m/s current can swim 12 m

Stone Sizing Analysis

- Rock vortex weirs downstream of a pool-riffle system
- Gradient in weir section =~ 6%
- Maximum velocity (at weirs) during 100-year storm = 3 m/s





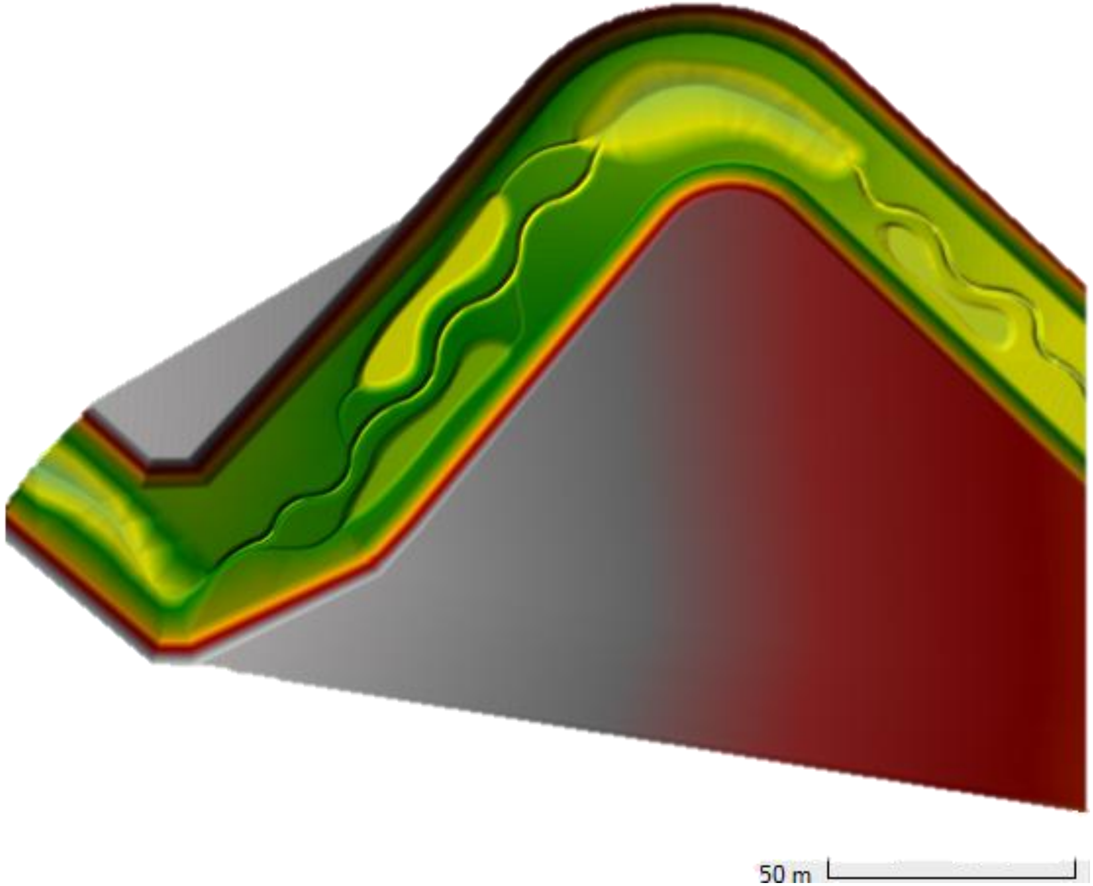
Stone Sizing Analysis

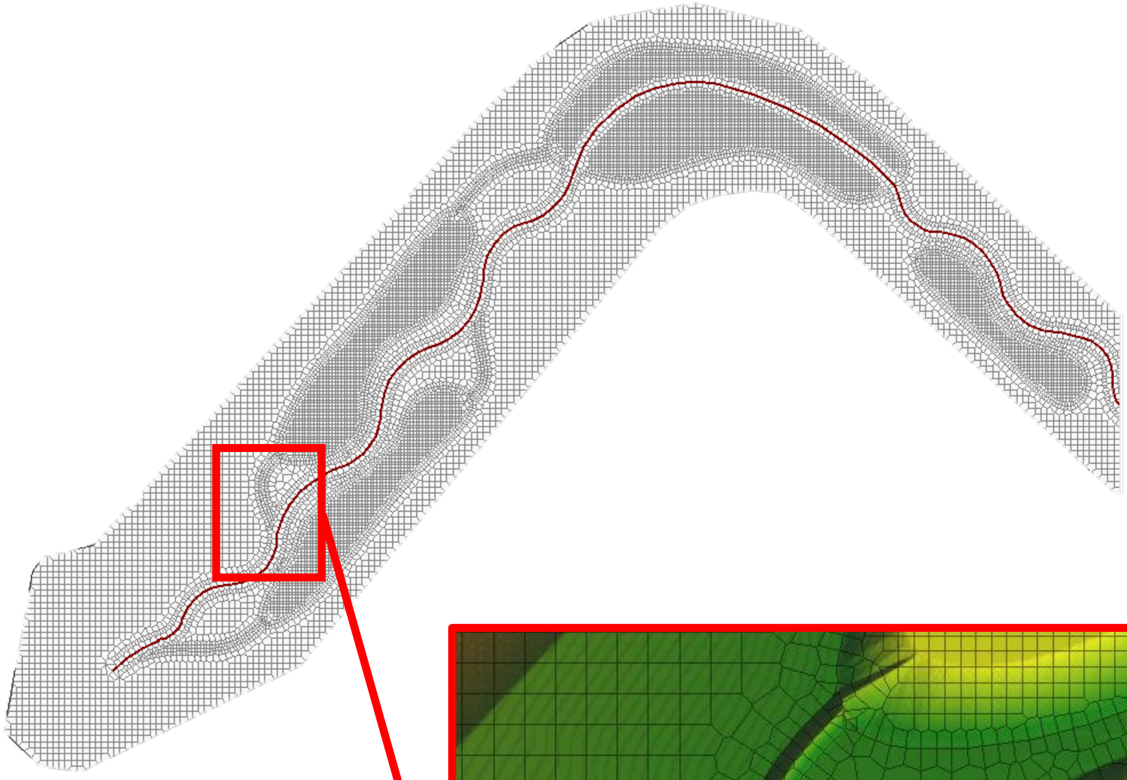
Photo from US Bureau of Reclamations

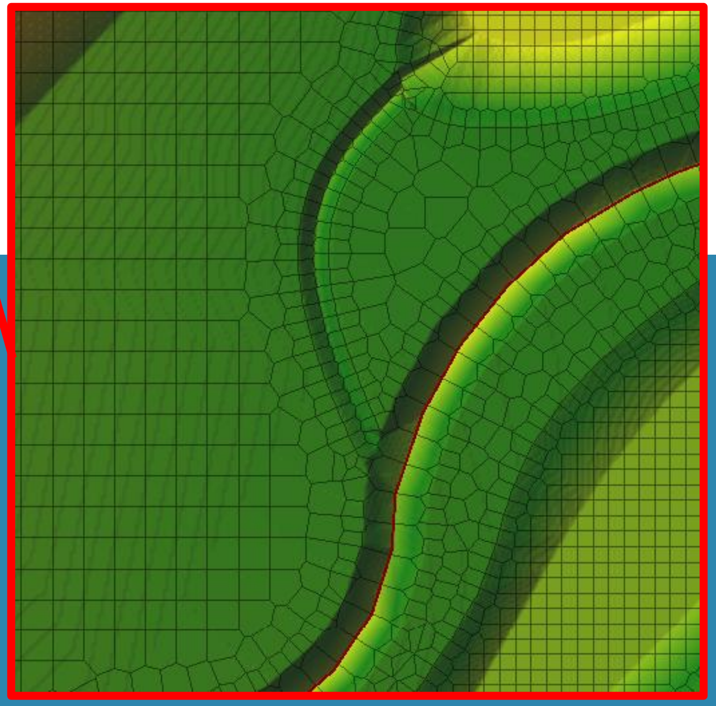
- Velocity in channel initially determined using simple approximations
  - FlowMaster

- Confirmed that the proposed stone sizes were adequate, slightly large

- Aids in strategic placement of heavier material
  - More robust
  - Looks more natural



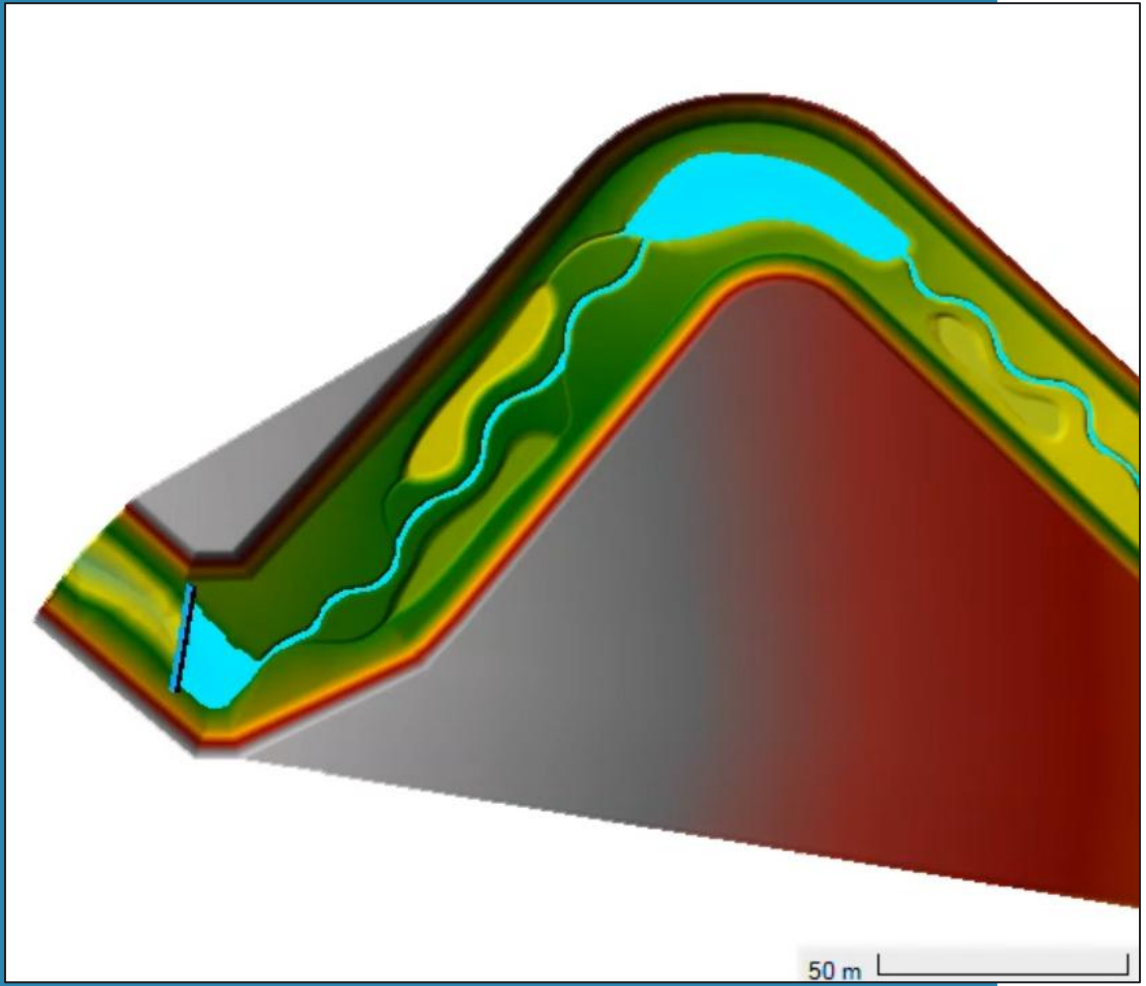




Riparian Wetland Analysis

- Large corridor provided for realigned channel and riparian wetlands
- Ingress channels to convey flow into wetlands during high flow
- ‘Control’ wetland without ingress / egress channel

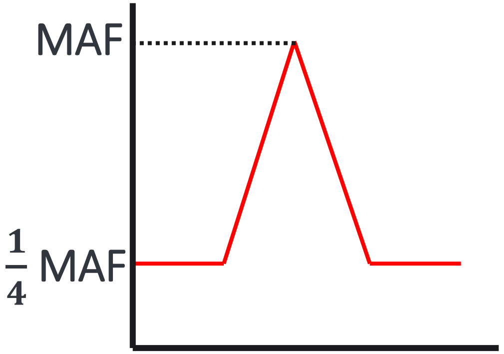
Riparian Wetland Analysis



- Simple triangular hydrograph was created
  - Baseflow = 0.25 x Mean Annual Flood (MAF)
  - Peak = Mean Annual Flood

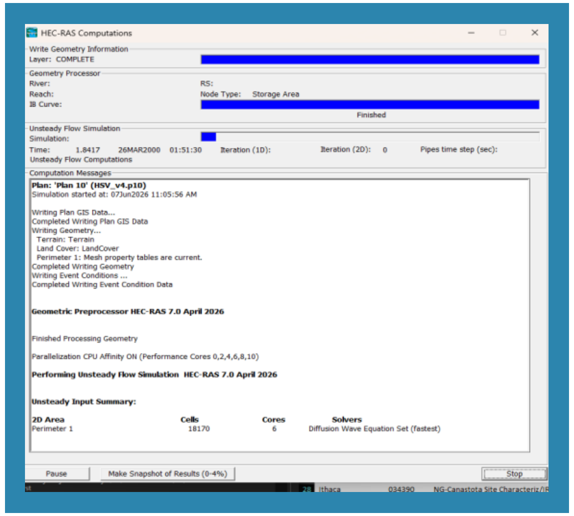
- Ingress channels are not active during baseflow

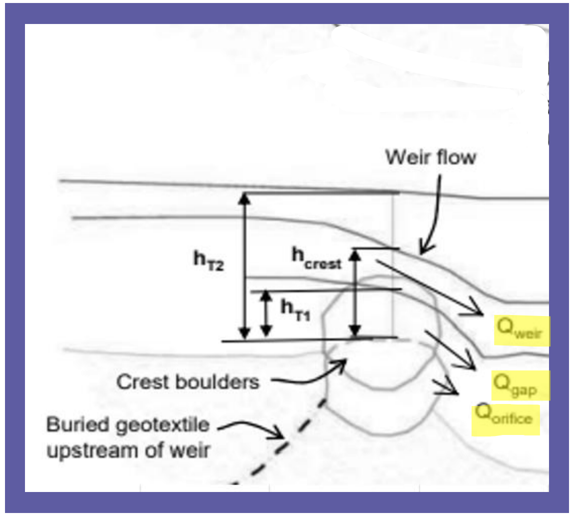
- During the rising limb and the peak of the storm, they become active

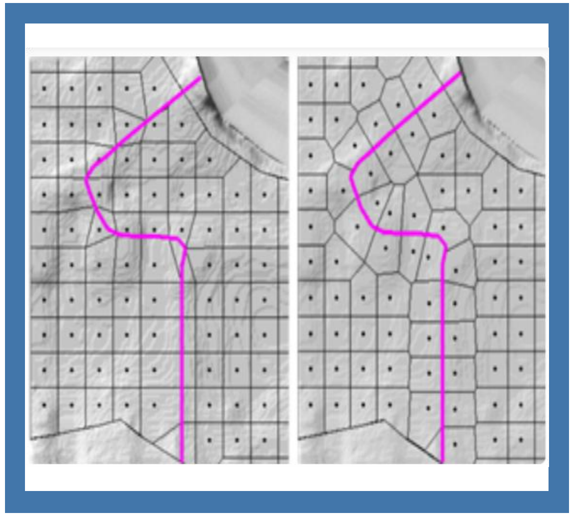


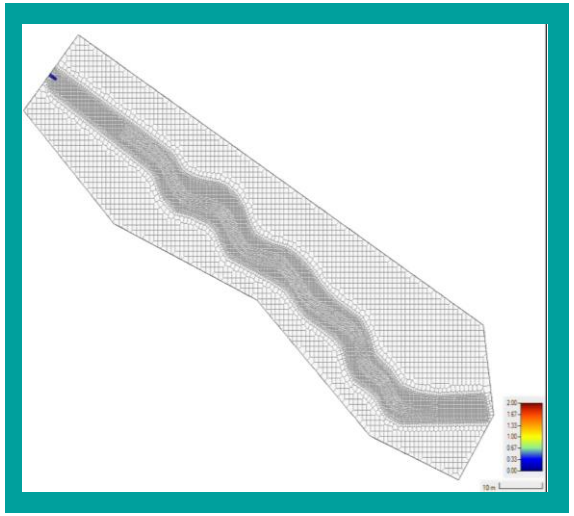
- Wetlands periodically fill, crest of ingress channels can be modified

Lessons Learned / Lessons to be Learned









Resolution Matters

- Terrain resolution limits spatial resolution
- 2D analysis timestep limits temporal resolution
- Without conceding somewhere, runs will take too long

Understand Limitations

- Some things cannot be modelled in 2D
- Flow partitioning in a rock vortex weir relies on vertical (3D) separation
- Look for alternatives, i.e. 3D modelling or manual calculation

Hydraulic Control Matters

- 2D models do not “know” where flow should go
- Terrain and mesh alone often let water spread unrealistically
- Breaklines guide the model to behave correctly

The Mysterious Surge

- All models show initial surge of flow
- Despite adjustments to BC slopes or flow ramp up
- Without conceding somewhere, runs will take too long


Questions?