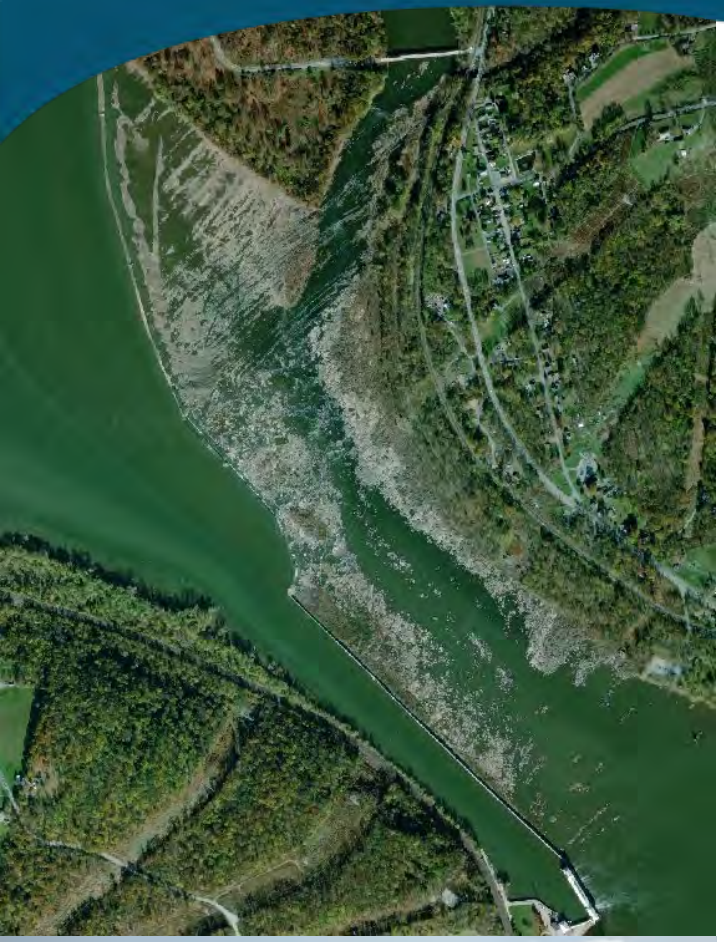


2D Hydraulic Modeling of a Nature-Like Fishway using HEC-RAS

Chris Goodell, P.E. D.WRE

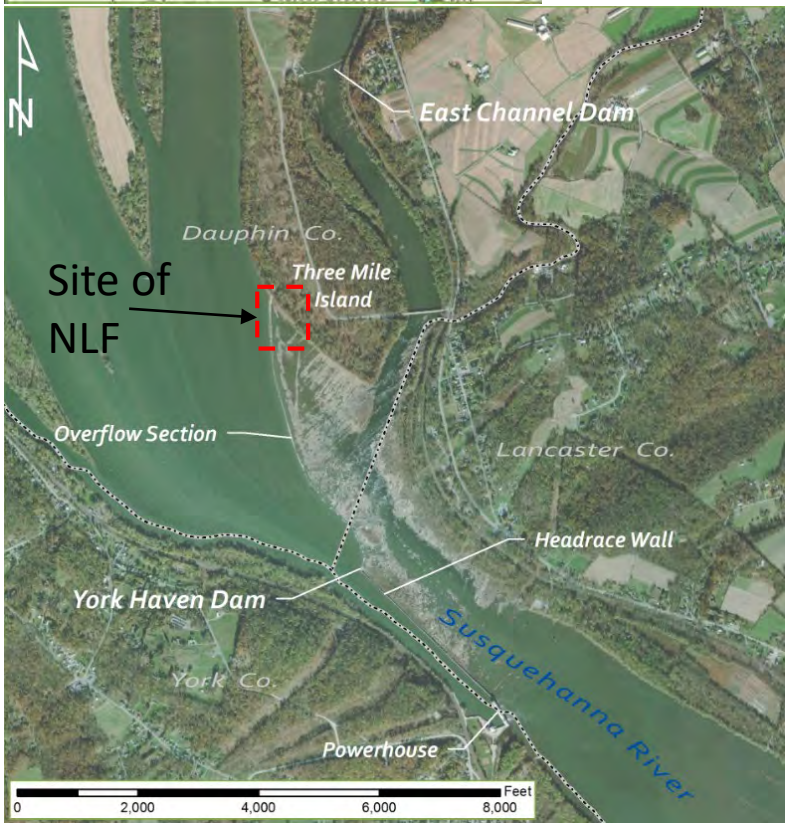
Kleinschmidt Associates

October 2018

Project Background and Objectives

- Project owned by Cube Hydro Partners LLC (Cube)
- Located on Susquehanna River in southeast Pennsylvania
- Cube's Goal: provide fish passage upstream of York Haven Dam using a Nature-Like Fishway (NLF)
- Original NLF design developed in 2016 by previous consultant
- Kleinschmidt Associates evaluating alternative designs

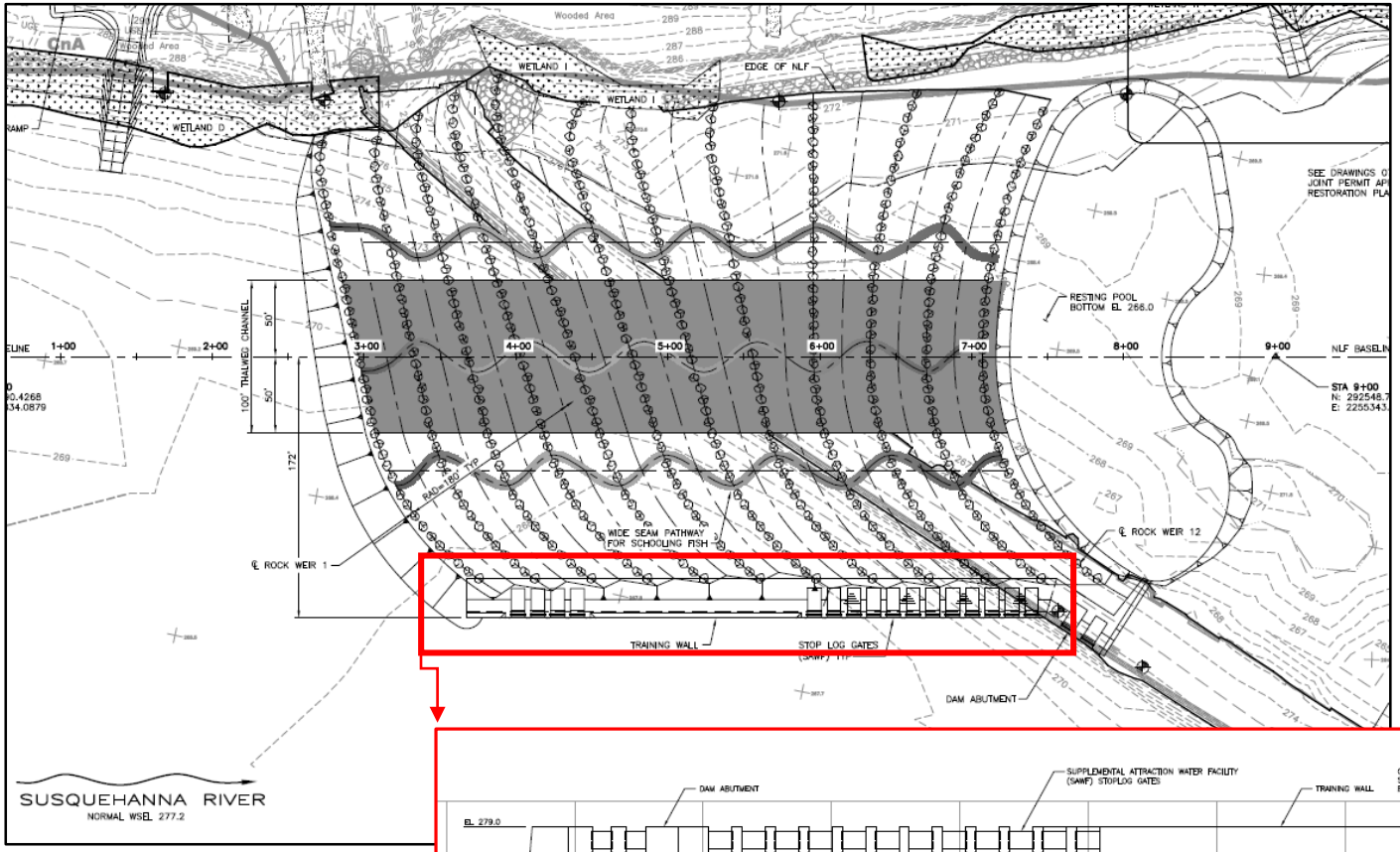
Primary Objective – Develop a detailed 2D model using powerful software tool to evaluate hydraulics and optimize fish passage design



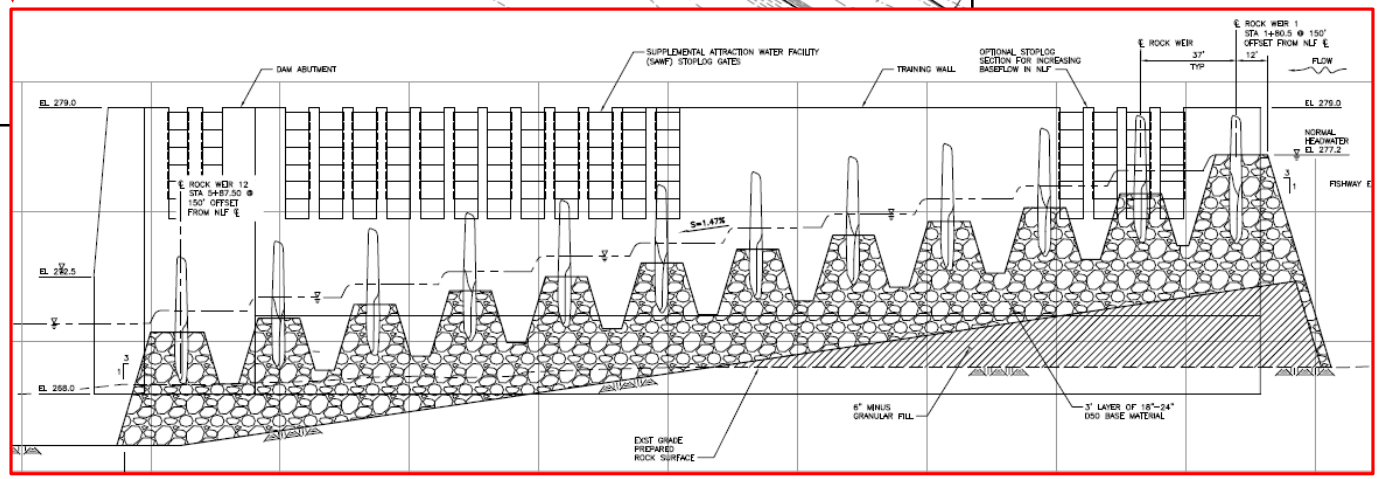
Fish Passage Criteria

- Target species
  - American shad
  - American eel
  - Alewife
  - Blueback herring
  - Various resident species
- Fish Passage Season: 15 April – 15 June
- Flow Capacity – 5% of total river flow (5,000 to 150,000 cfs river flow)
  - NLF entrance + Supplemental Attraction Water Structure
- Depth – Minimum 1 foot through weir notches
- Velocity – < 6 feet/second

Original 2016 NLF Design



NLF



Supplemental Attraction Water Structure

Our Modeling Approach

- Step 1 -Develop 2D model of section of Susquehanna River Existing Conditions – "coarse" Scale model (cells up to 220 feet); informs "fine" scale boundary conditions (cells down to 0.75 foot)
- Step 2 – Calibrate to available data (flow distribution; stage-discharge)
- Step 3 – Develop Proposed Conditions model with 2016 Design at "coarse" scale from Existing Conditions Model—informs boundary conditions
- Step 4 – Develop "fine" scale model of NLF

Coarse Scale Model Development and Calibration

1 – Flow Distribution West+Middle vs East Channel

2 – Tri-County Marina

3 – East Channel Dam Headpond

4 – Dam Headpond at Three Mile Island

5 – Three Mile Island South Bridge

6 – York Haven Dam Powerhouse headpond

7 – York Haven Dam Powerhouse tailwater

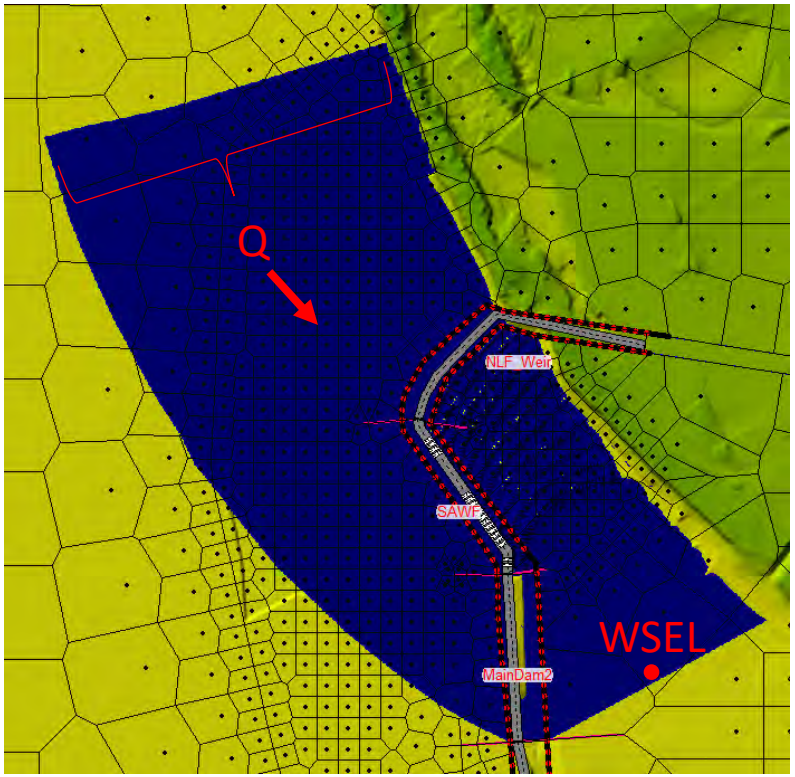
Fine Scale Model Boundary Conditions

Upstream Boundary

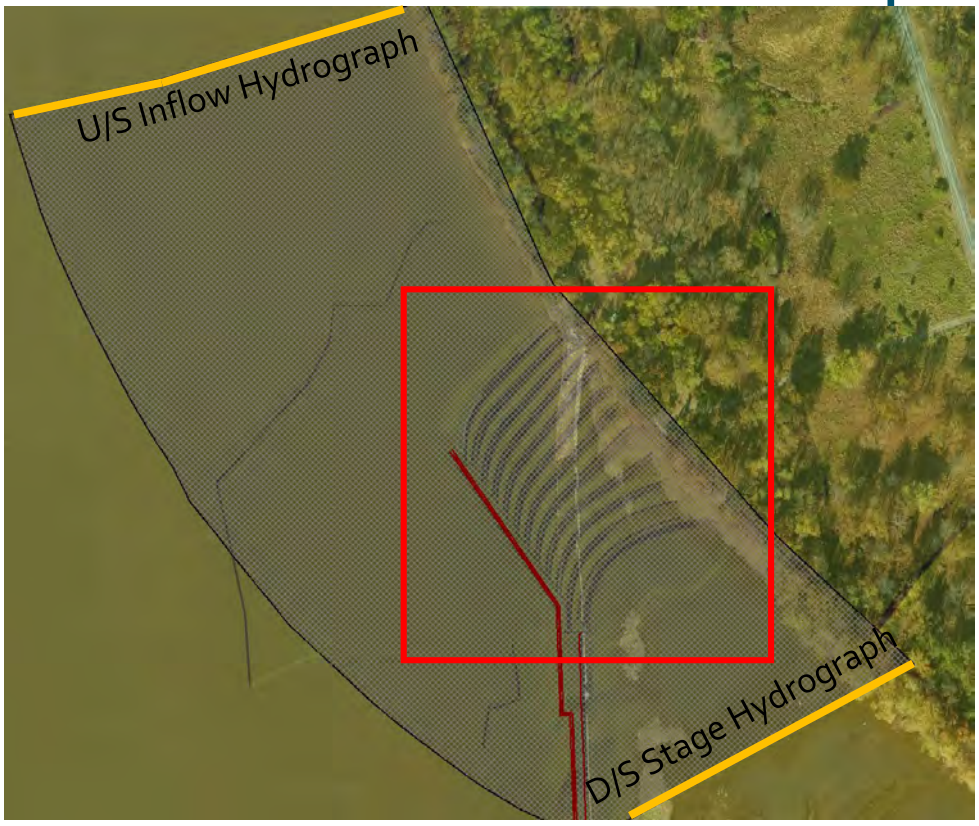
- Inflow Hydrograph
- Amount of flow determined by measuring inflow to Fine Scale domain at the Coarse Scale
  - Flow passing over 1D structure elements (NLF upstream weir + Supplemental Attraction Flow Structure+ section of York Haven Dam spillway)

Downstream Boundary

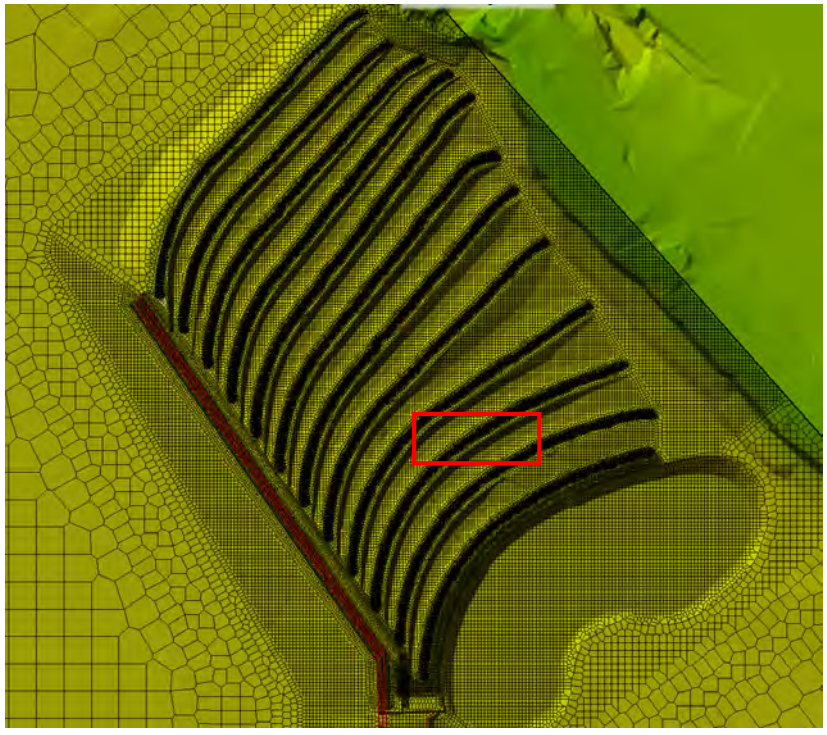
- Stage Hydrograph
- Water surface elevation (WSEL) measured at model domain terminus on downstream side



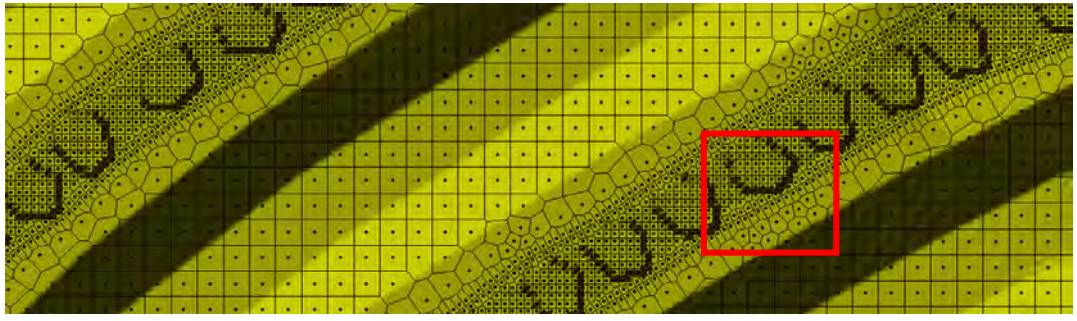
Fine Scale Model Development

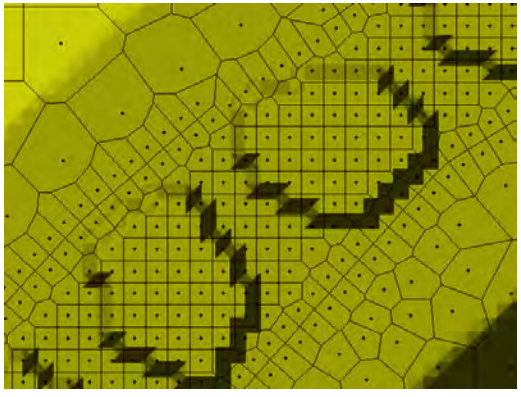


3 feet (generally) cells up to 96 feet



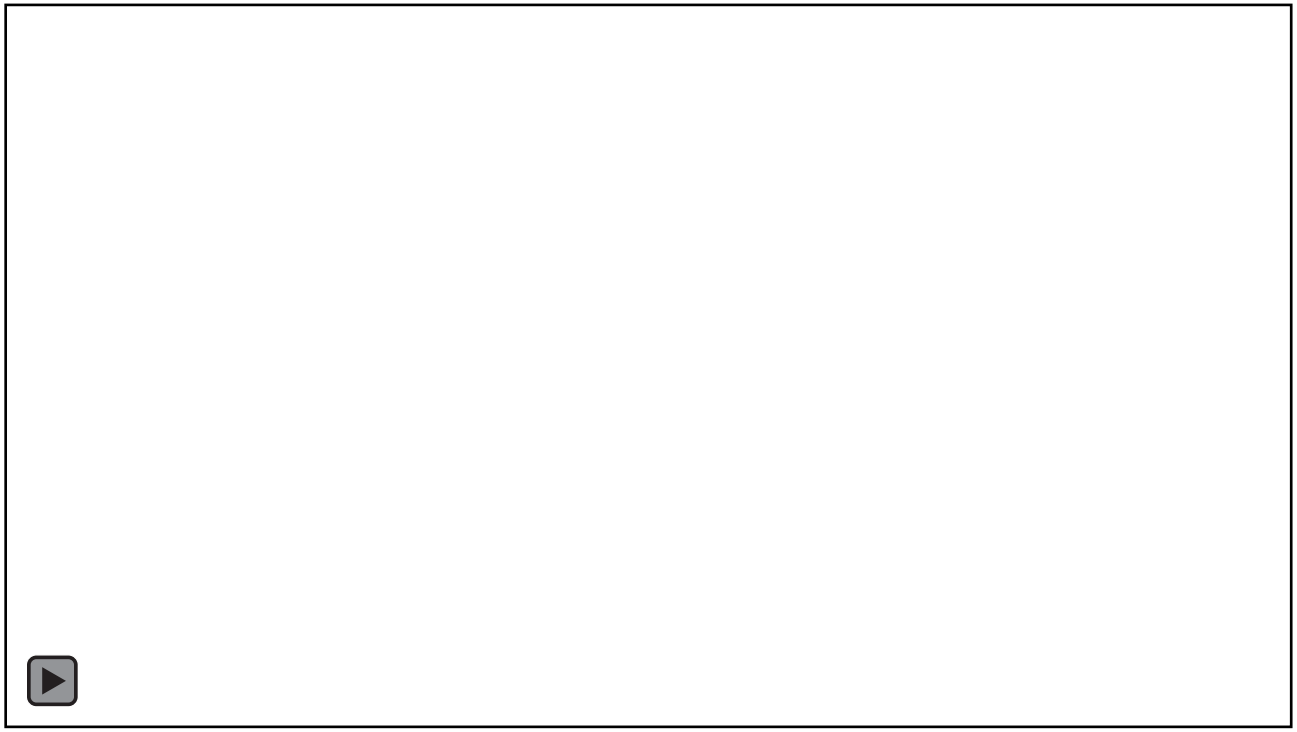
0.75 foot spacing between boulders

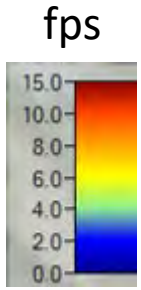




Fine Scale Model Results – Low Flow

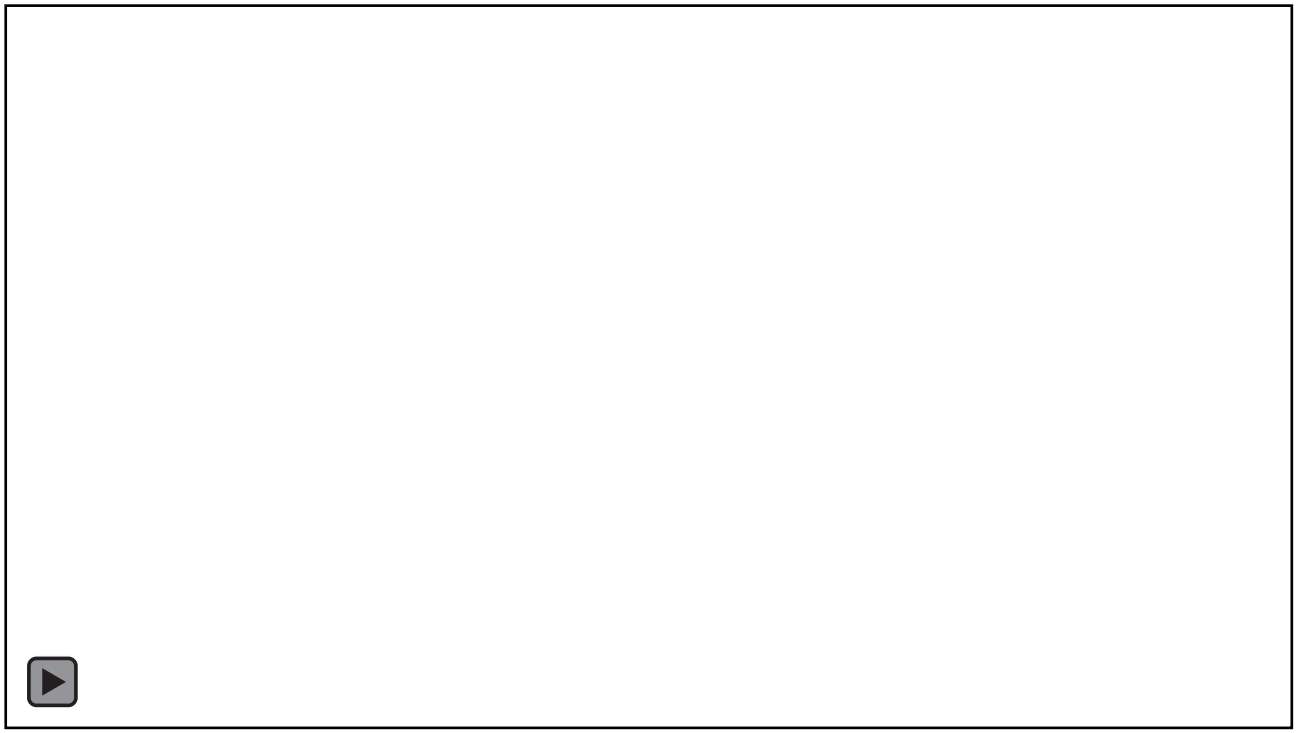
95 % Fish Passage Season Exceedance Flow (12,400 cfs River Flow)

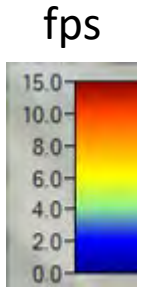




Fine Scale Model Results – High Flow

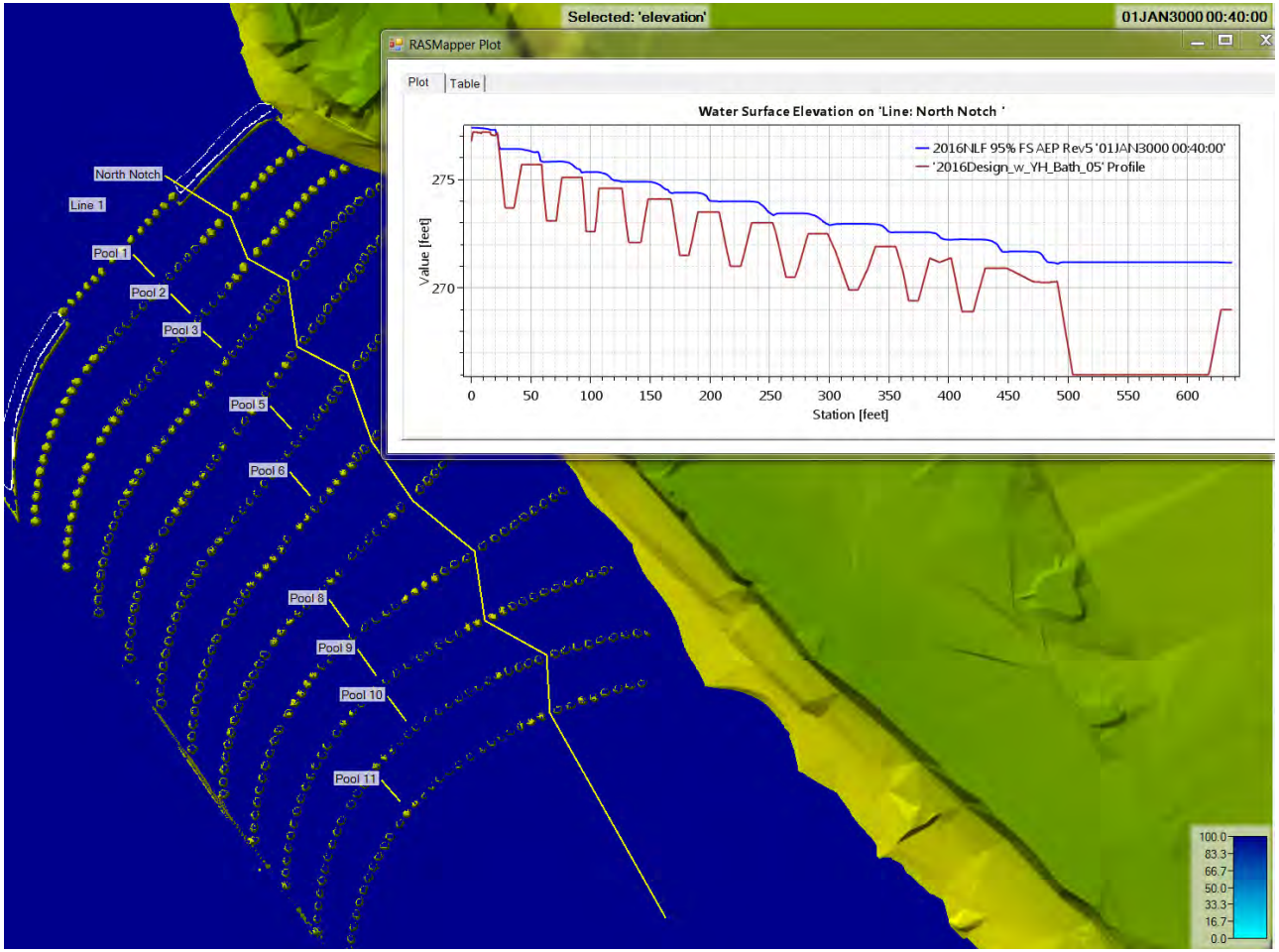
5 % Fish Passage Season Exceedance Flow (119,800 cfs River Flow)



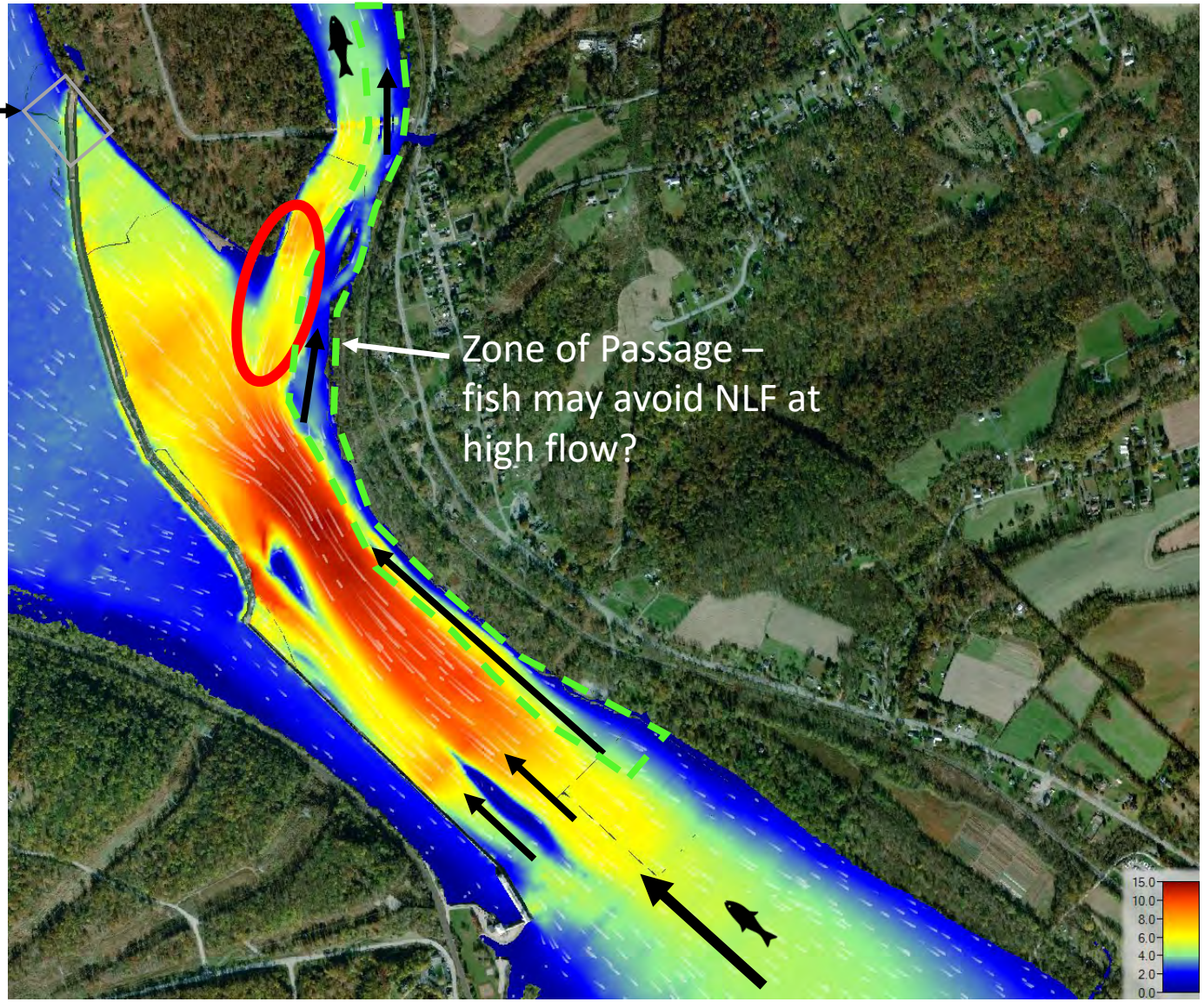


HEC-RAS Mapper Data Viewing

- Ability to draw profile lines, retrieve hydraulic data (depth, velocity, flow, etc.) along a profile and over time.
- Provides detailed data to customer to inform stakeholders
  - Low flow notch depth/velocity
  - Flow through NLF vs rest of river



Potential Hydraulic Issue Identified



5 % Fish Passage Season Exceedance Flow (119,800 cfs River Flow)

HEC-RAS Modeling Moving Forward

- Continue model validation
  - Compare results with physical data collected at site
  - Model validation/verification with aid of Penn State University 3D (OpenFOAM) and Physical Model
- Leverage model to optimize NLF design
- Use model to assess/compare Alternative Designs

Conclusions

- HEC-RAS a powerful tool for assessing NLF hydraulics at small scales
- HEC-RAS Mapper allows retrieval/assessment of detailed hydraulic data (velocity, depth, etc.)
- Detailed resolution provides insight into complicated hydraulic conditions
- Model results show possibility for fish passage optimization