Jun 27th, 2:35 PM - 2:55 PM

Session A2- Simple drag force and energy calculations for fish passage through a model a steeppass

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Simple Drag Force and Energy Calculations for Fish Passage Through a Model A Steeppass

Photo Credit: USFWS

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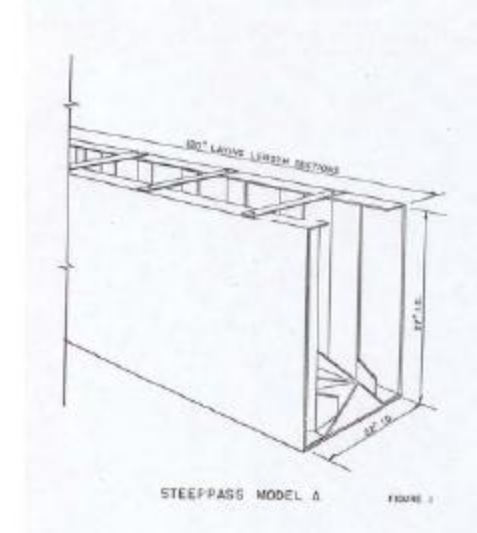
Model “A” Steeppass Design

Photo Credit: USFWS

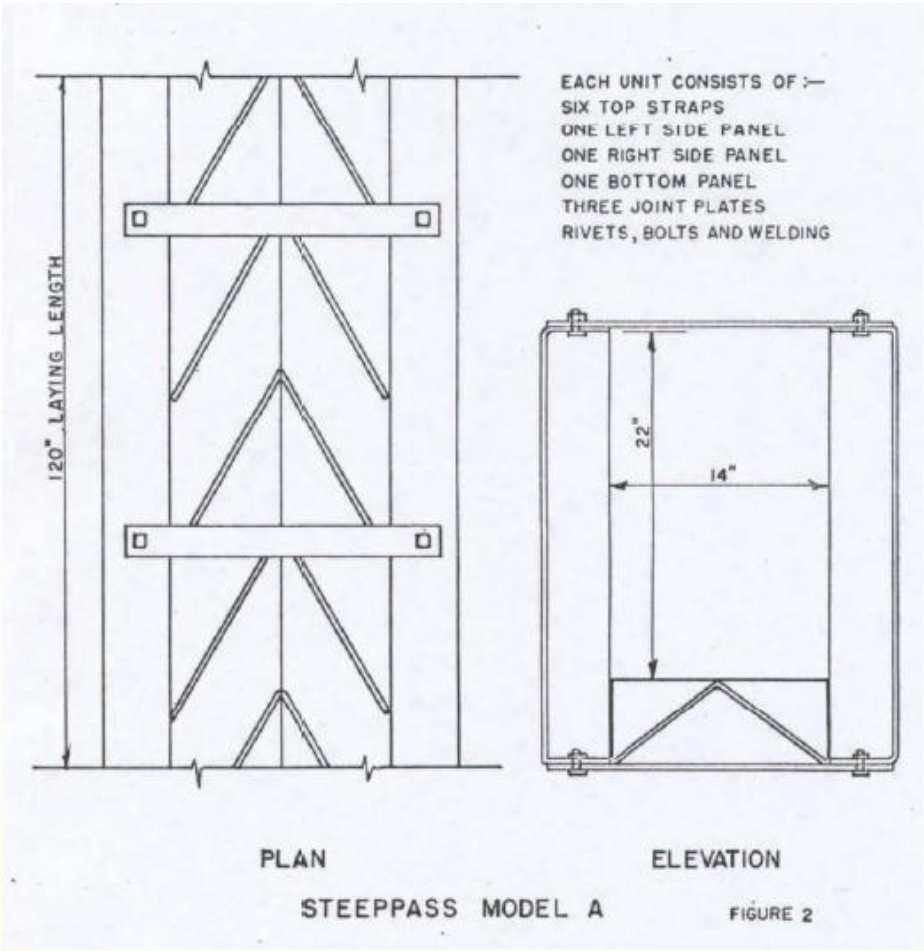
- designed by Ziemer in 1962 to pass salmonids
- baffle (Denil) type fishway
- prefabricated 27-inch high, 18-inch wide, 10 foot long sections
- highly portable and inexpensive
- suited to small streams and low head dams

Model “A” Steeppass Design



G. L. Ziemer, P.E.

Alaska Department of Fish and Game
Division of Engineering and Services
April 27, 1962



Recommended Operating Range

Photo Credit: USFWS

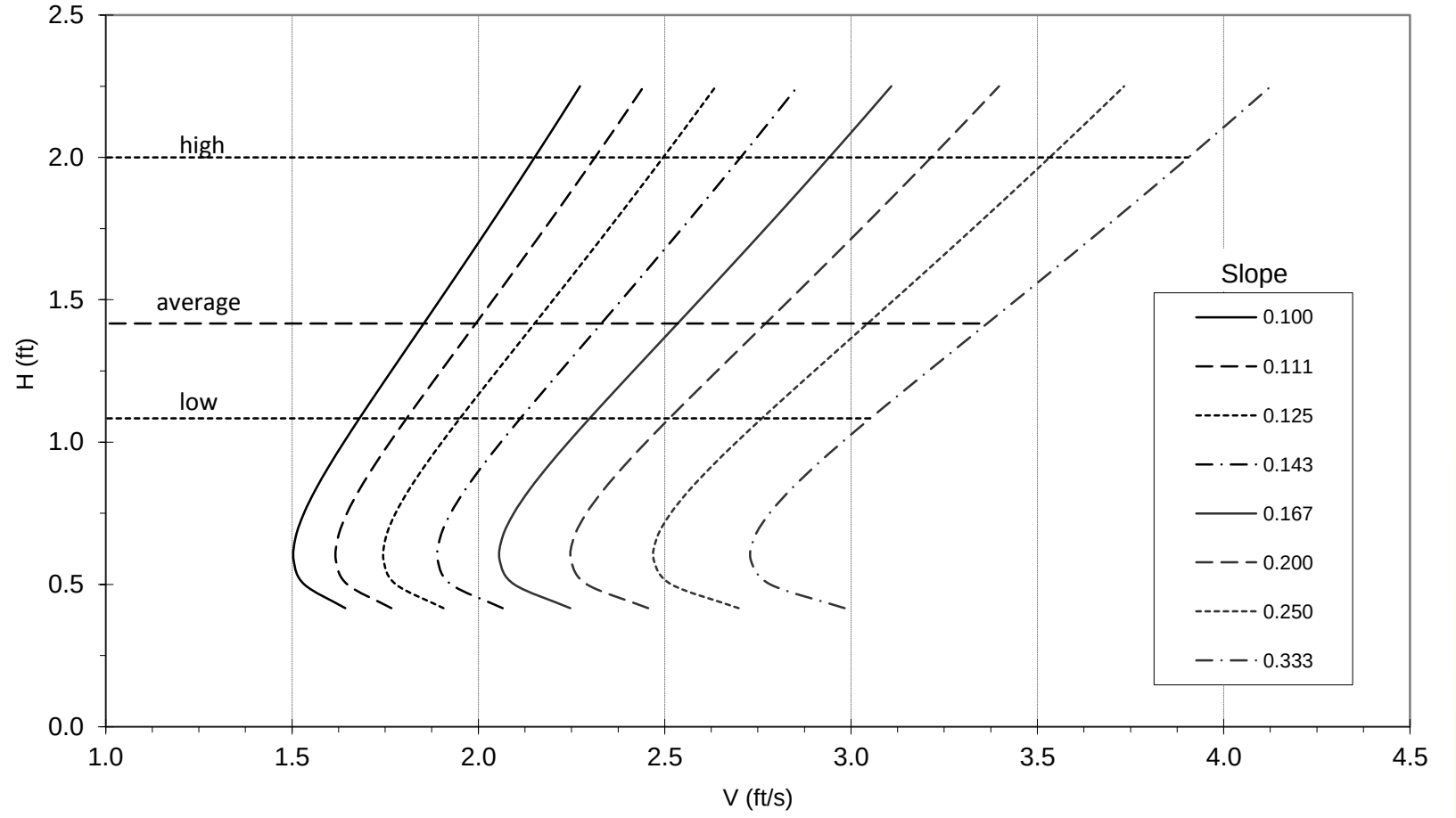
- Head – 13” to 24”
- Slope – 1:10 to 1:3

Results in….

- Bulk Velocity ~1.5 to 4 ft/s
- Discharge ~1.5 to 8 cfs

- Capacity~750 migrants per hour

Steeppass Model A Velocity vs. Head for Standard Slopes*



*Data complied from Ziemer (1962) and Odeh (1993).

Steeppass Research

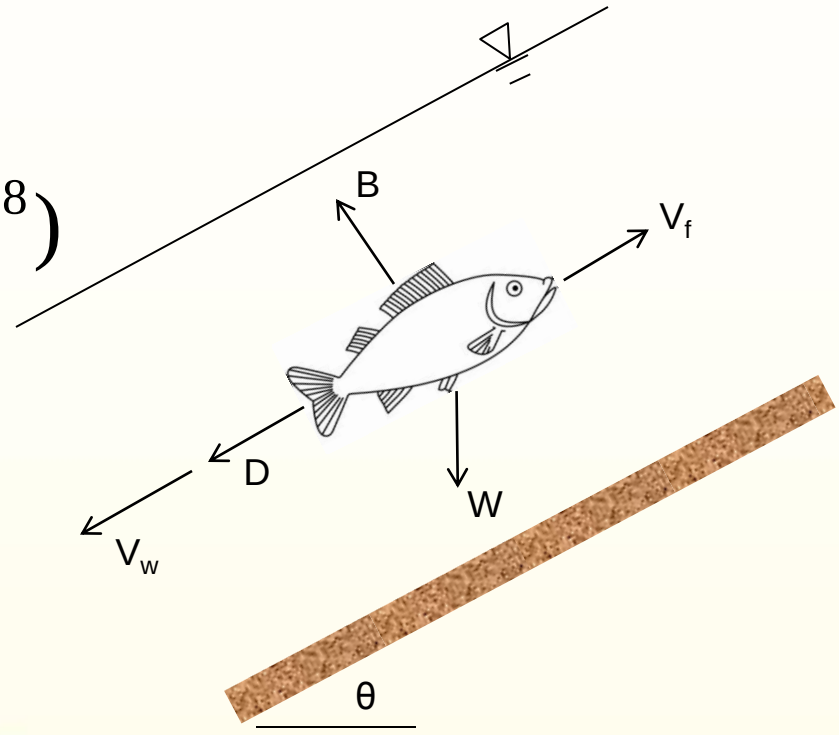
- 1D hydraulic characteristics
  - head and velocity relationships
  - centerline velocity profiles
- Passage rates
  - good for salmonids
  - not good (or unknown) for other species, i.e. American Shad, Blueback Herring

Simple Drag Force Calculation

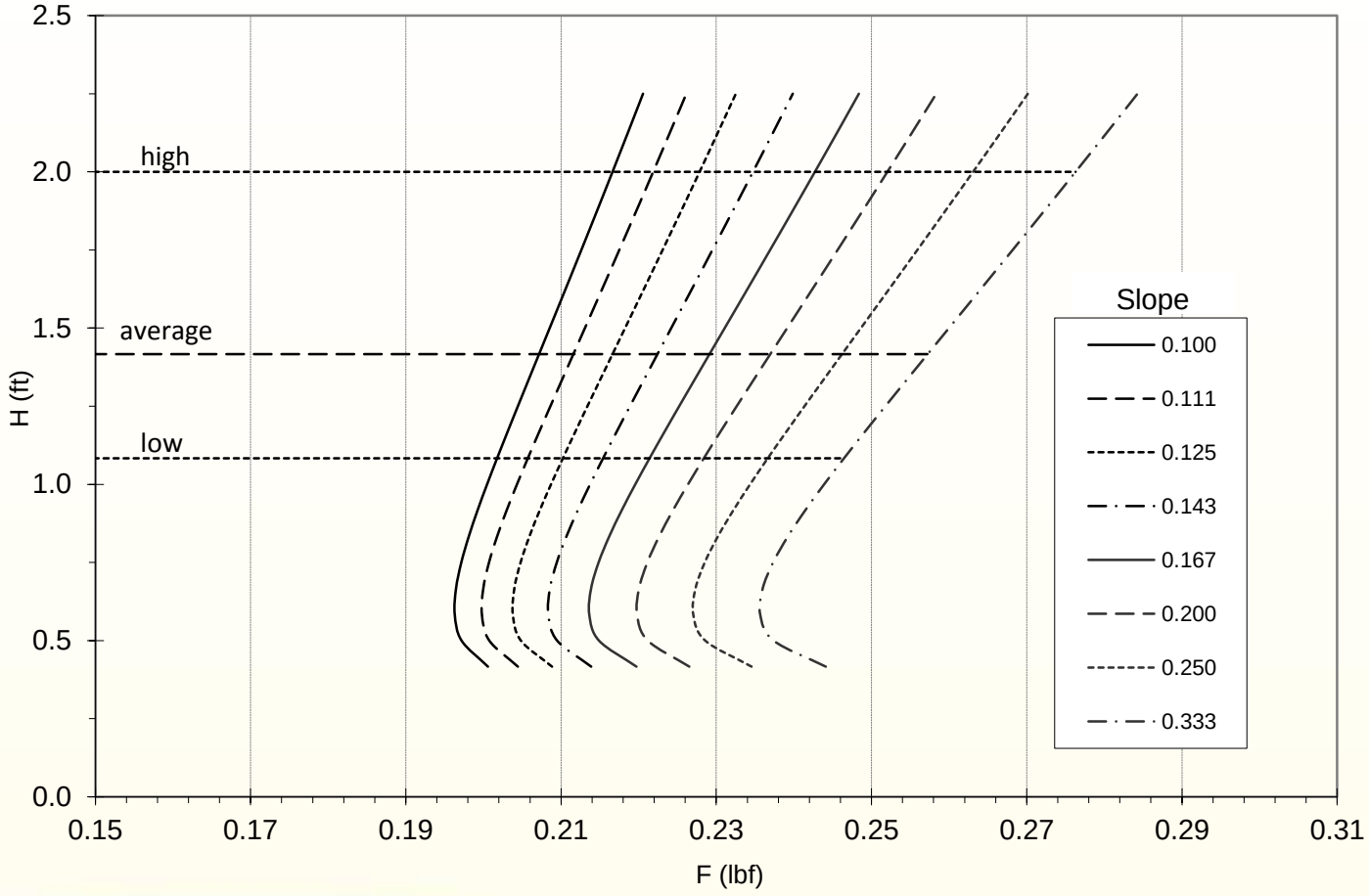
$$R_{Lfish} = \frac{V_{fw} * L}{\nu}$$

$$C_D = 1.2 * (0.455 / (\log R_L)^{2.58})$$

$$D = C_D * \rho * S * \frac{V_{fw}^2}{2}$$



Drag Force on Blueback Herring vs. Head for Standard Slopes

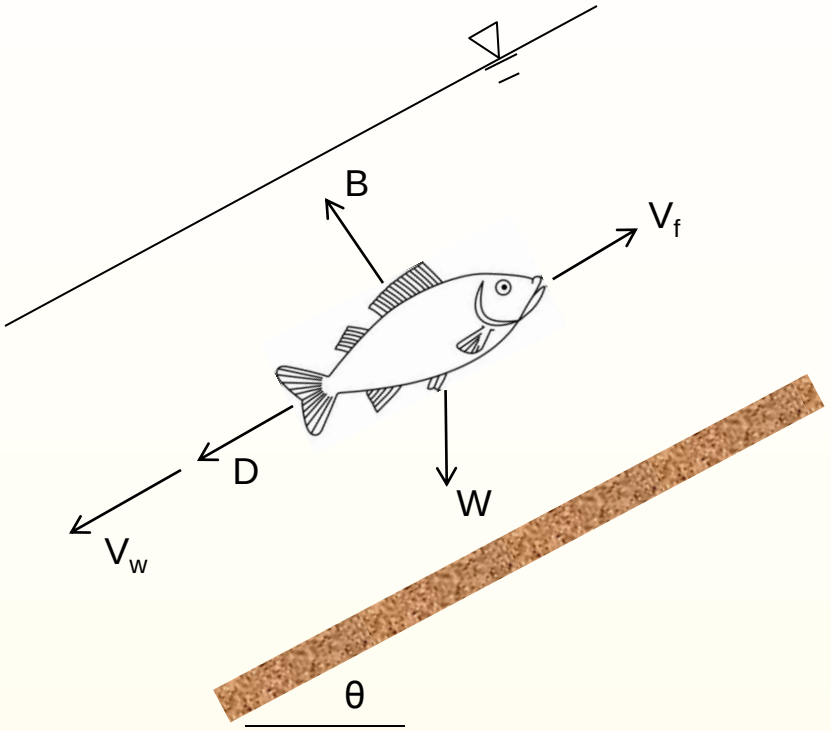


Energy (Work) Calculation

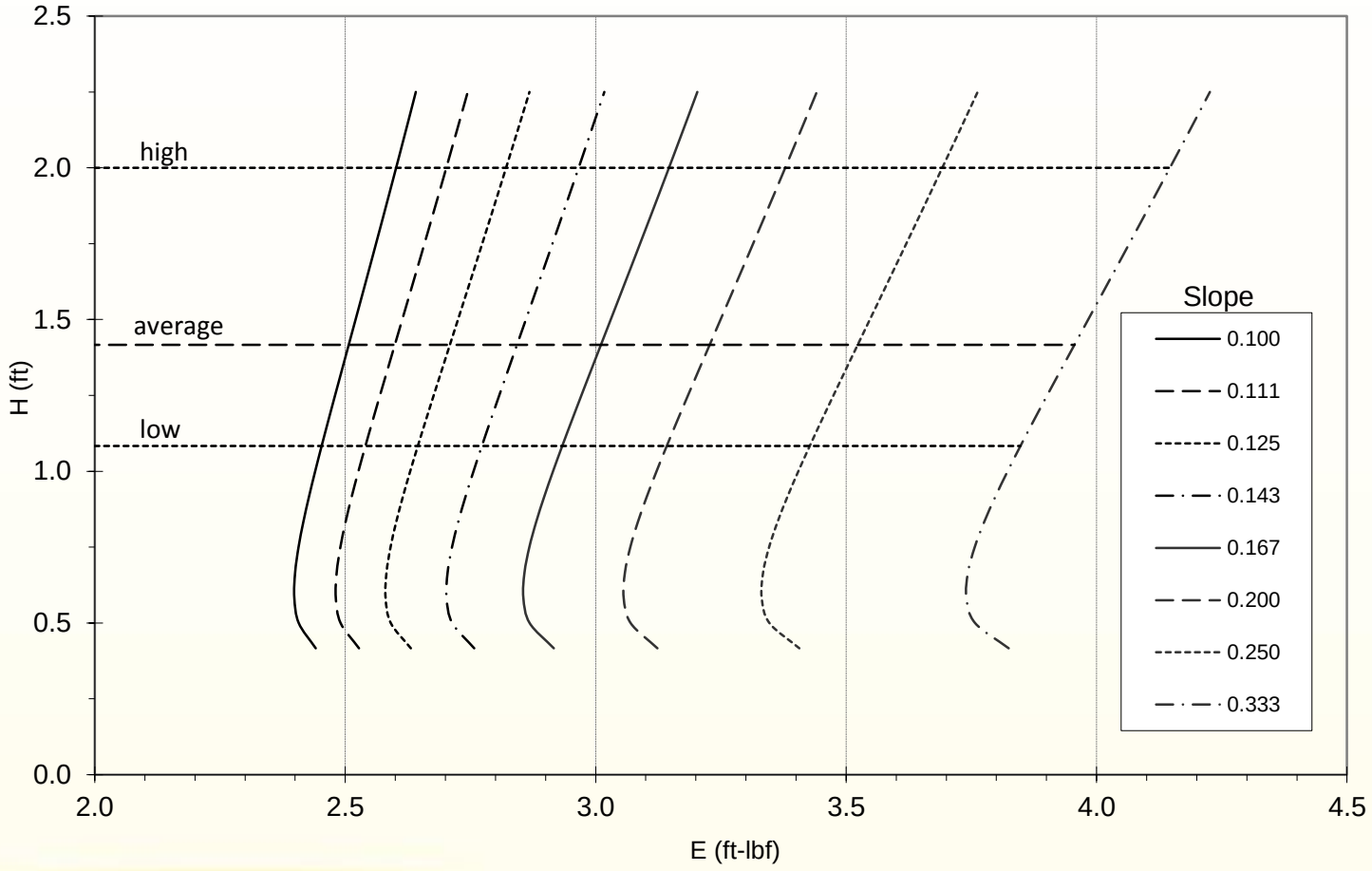
$$F = D + W * \sin\theta$$

$$Pwr = F * V_{fw}$$

$$E = F * L$$



Energetic Costs for Blueback herring Ascending 10-foot Model A Section at Standard Slopes



Energy Example

- 1:8 Slope
- 5.0 cfs
- 2.5 f/s
- 2.82 ft-lbf

Photo Credit: http://www.chesapeakebay.net

- 1:4 Slope
- 1.5 cfs
- 2.5 f/s
- 3.35 ft-lbf

Nearly a 20% increase in energy required for the same bulk velocity.

Major Assumptions

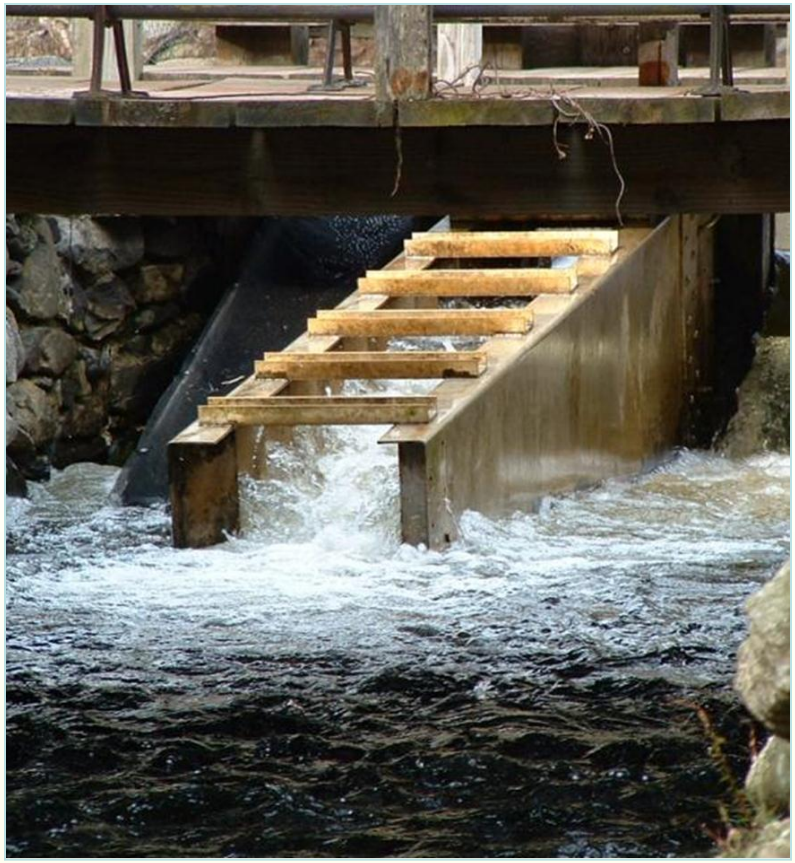


Photo Credit: USFWS

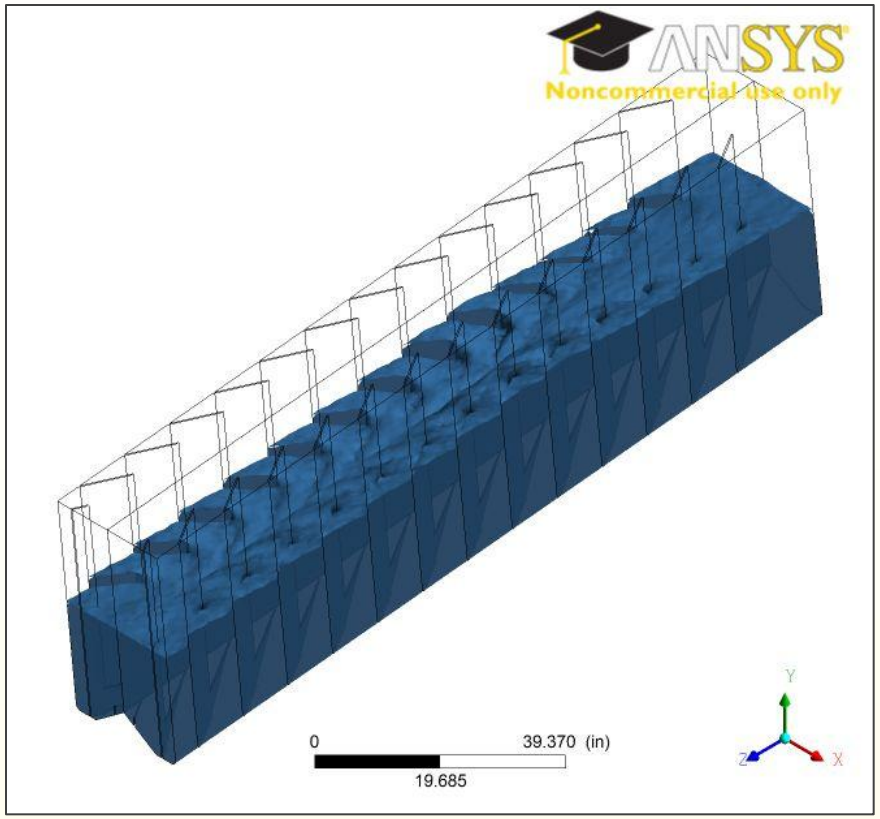
- Due to 1D approximation passage pathway is not accounted for
- Constant swimming speed is assumed due to lack of data for fish swimming in Steeppass
- Model neglects effects of turbulence and air entrainment

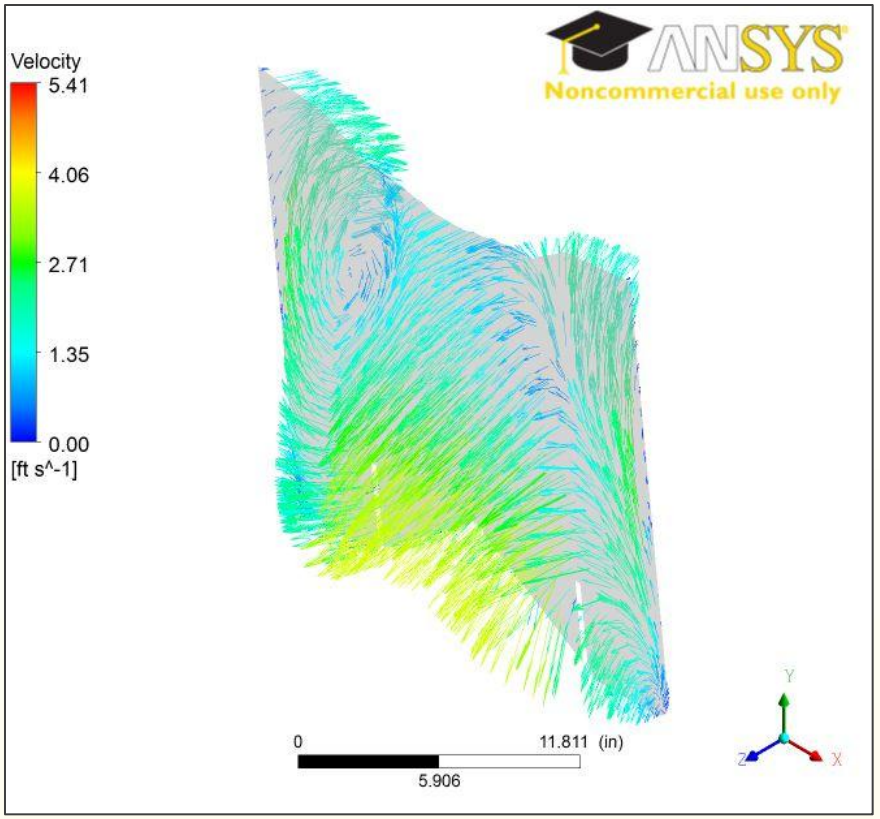
Future Work

- Computational Fluid Dynamics (CFD) model of Steeppass fishway
- Steeppass swimming study required to define swimming pathways for target specie
- Fish swimming cost in turbulence for target specie

CFD Model

(preliminary results)





Research Challenges

- Cost of swimming in turbulence unknown for most species
- High air entrainment makes observations of fish swimming and measurement of velocities difficult

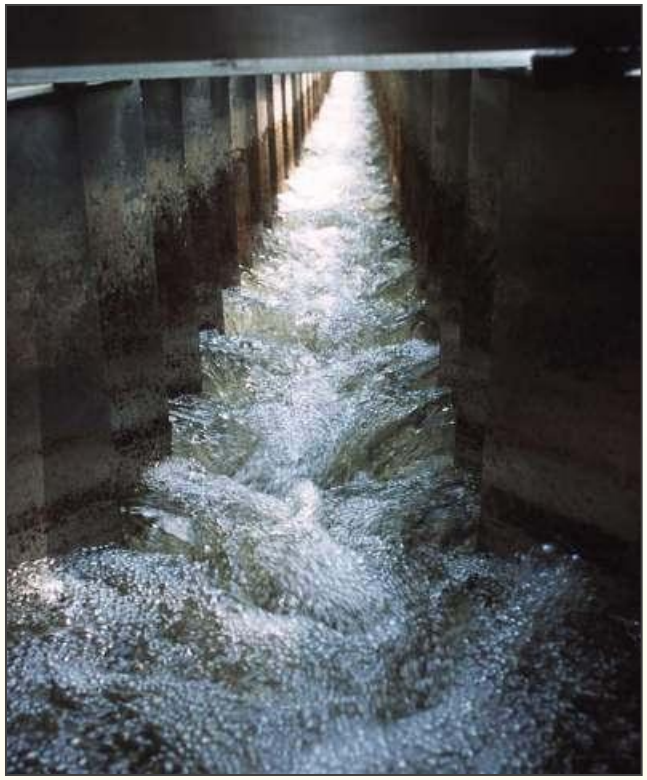


Photo Credit: http://luirig.altervista.org

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