RECLAMATION

Managing Water in the West

Cle Elum Dam Fish Passage Modeling & Design

Yakima Basin Science & Management Conference

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Joel Hubble, Yakima Field Office
Leslie Hanna, Hydraulic Investigations & Research Laboratory
Jason Wagner, Water Conveyance Group
Yakima Storage Dams Fish Passage Core Team

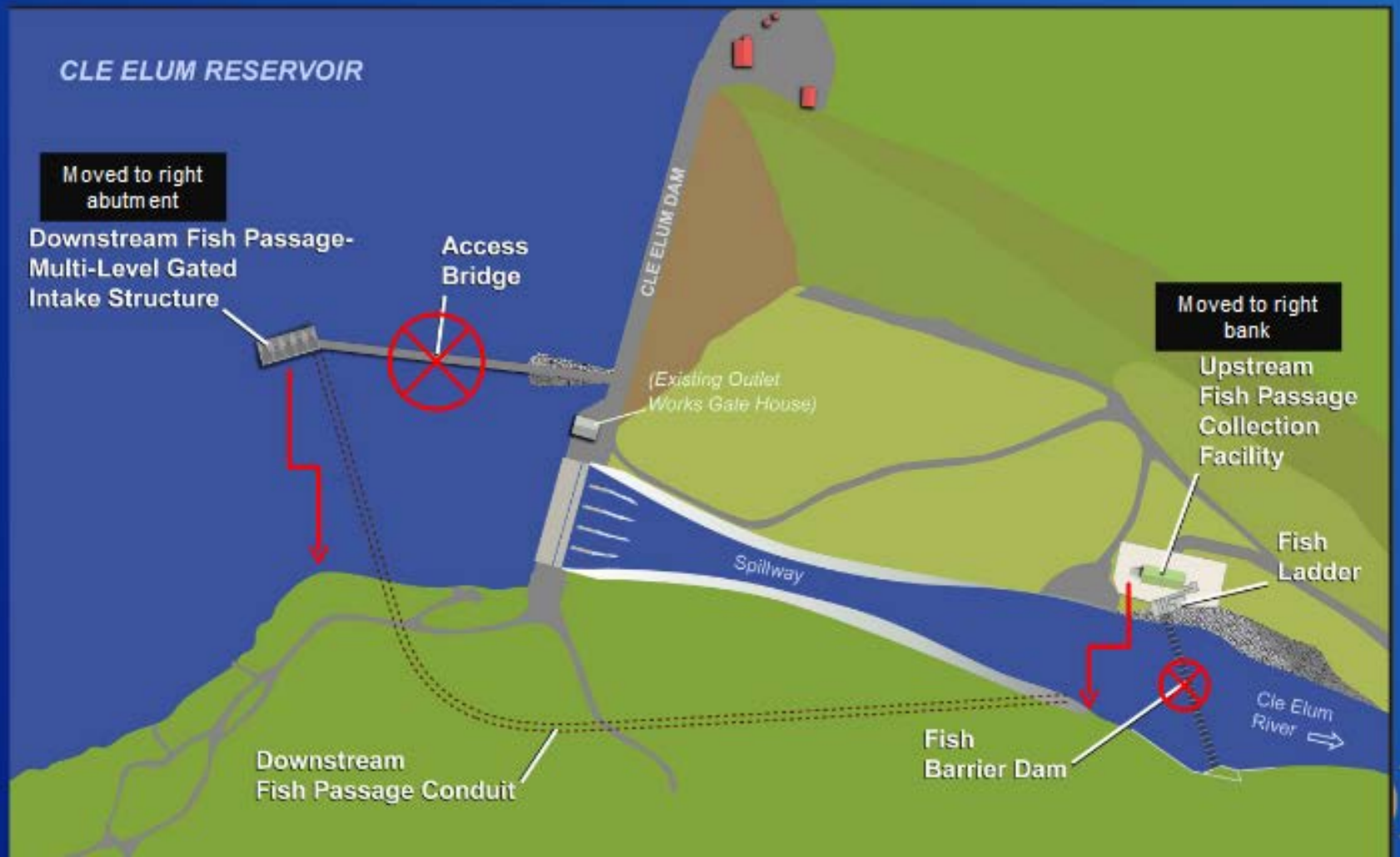
U.S. Department of the Interior
Bureau of Reclamation

Large Storage Reservoir Challenges

- Large water surface fluctuations due to seasonal releases.
- Dam Height
- Minimize Operational & Maintenance Costs

Fish Passage Concept- original design

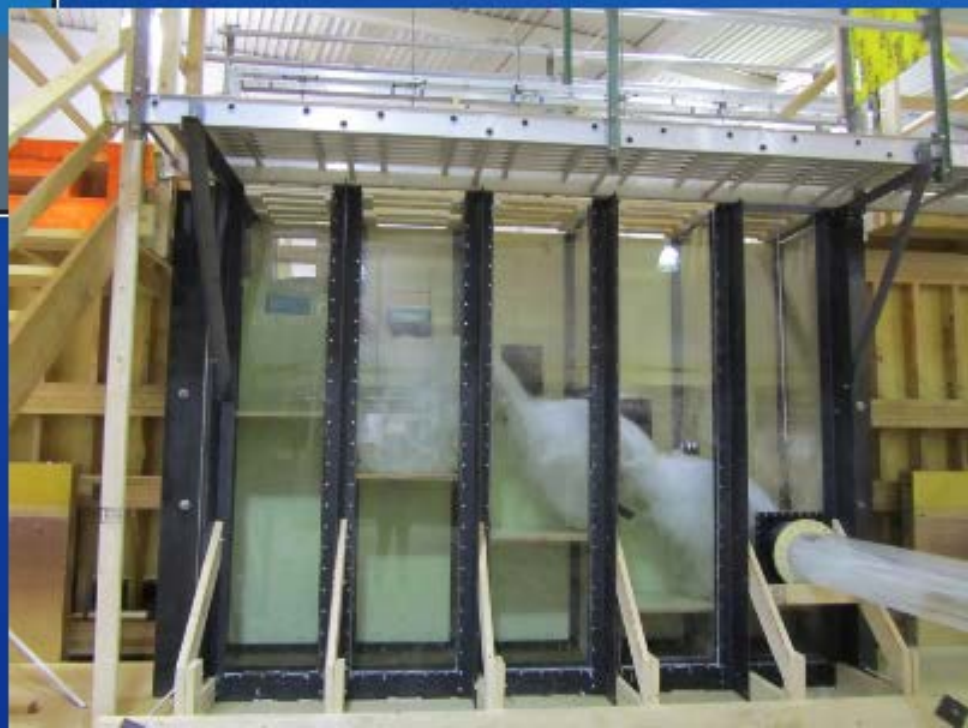
- **Downstream juvenile passage**
  - **Multi-level gated intake structure; conduit to below dam**



Original Design

Eliminated Because: The potential for excessive turbulence in the down well plunge pools inside the multilevel intake structure.

Multilevel Intake Structure



Original Design

Eliminated Because: The potential for excessive turbulence in the down well plunge pools inside the multilevel intake structure.

Current Fish Passage Design

Adult Collection Facility

Cle Elum River

Downstream Passage Conduit

Spillway

Flow

Cle Elum Dam

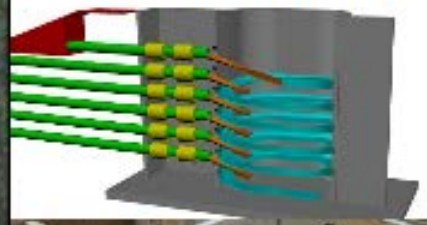
Cle Elum Reservoir Forebay

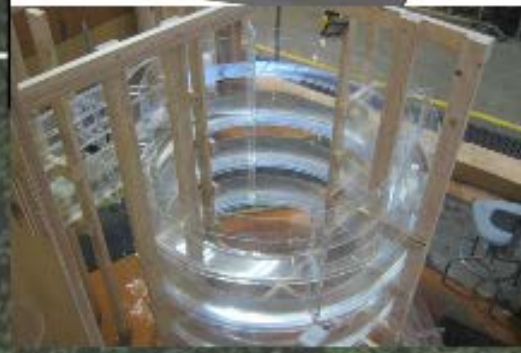
Splitter Wall to reduce recirculation in the tailrace

Flow

Ramped Weir Crest Design

Helix Conduit Structure





Inlet Structure

1st Downstream Passage

- Most Challenging
- Positive Feedback on the Current Design
  - Yakima Storage Dams Fish Passage Core Team
  - From the Consultant Review Board
  - International Conference on Engineering & Ecohydrology for Fish Passage

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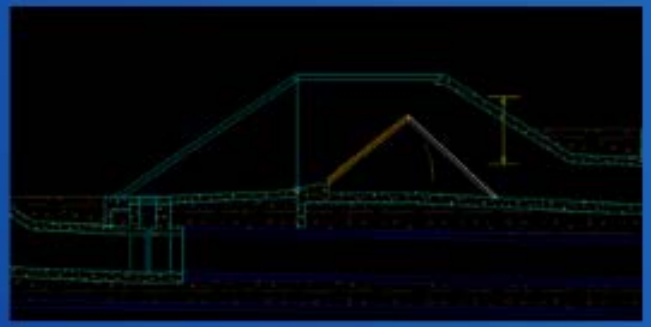
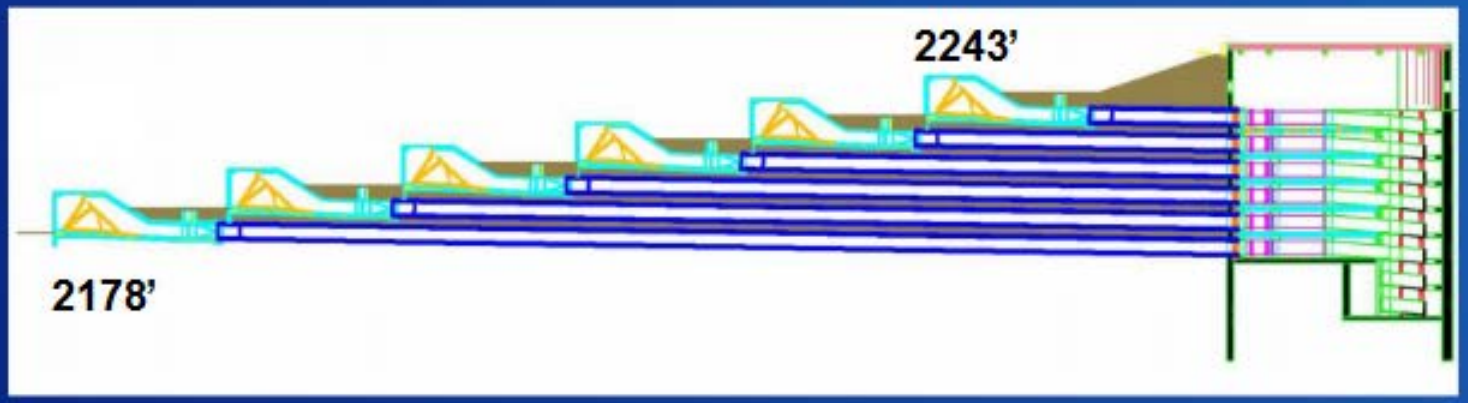
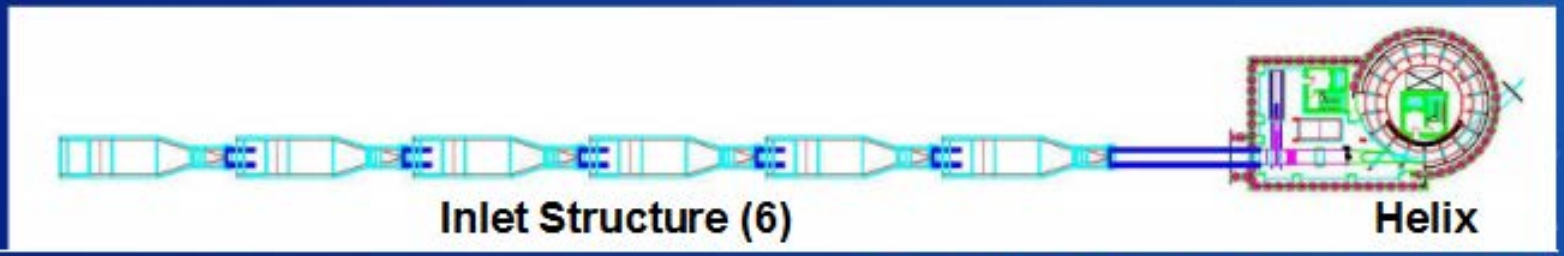
Intake Structure Design (final?)

- Follows Reservoir bank-line
- Overlapping intake zones







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Initial Inlet structure Design

Initial Inlet Structure

Operating at 400 ft3/s with Depth Over Sill = 3.5 ft

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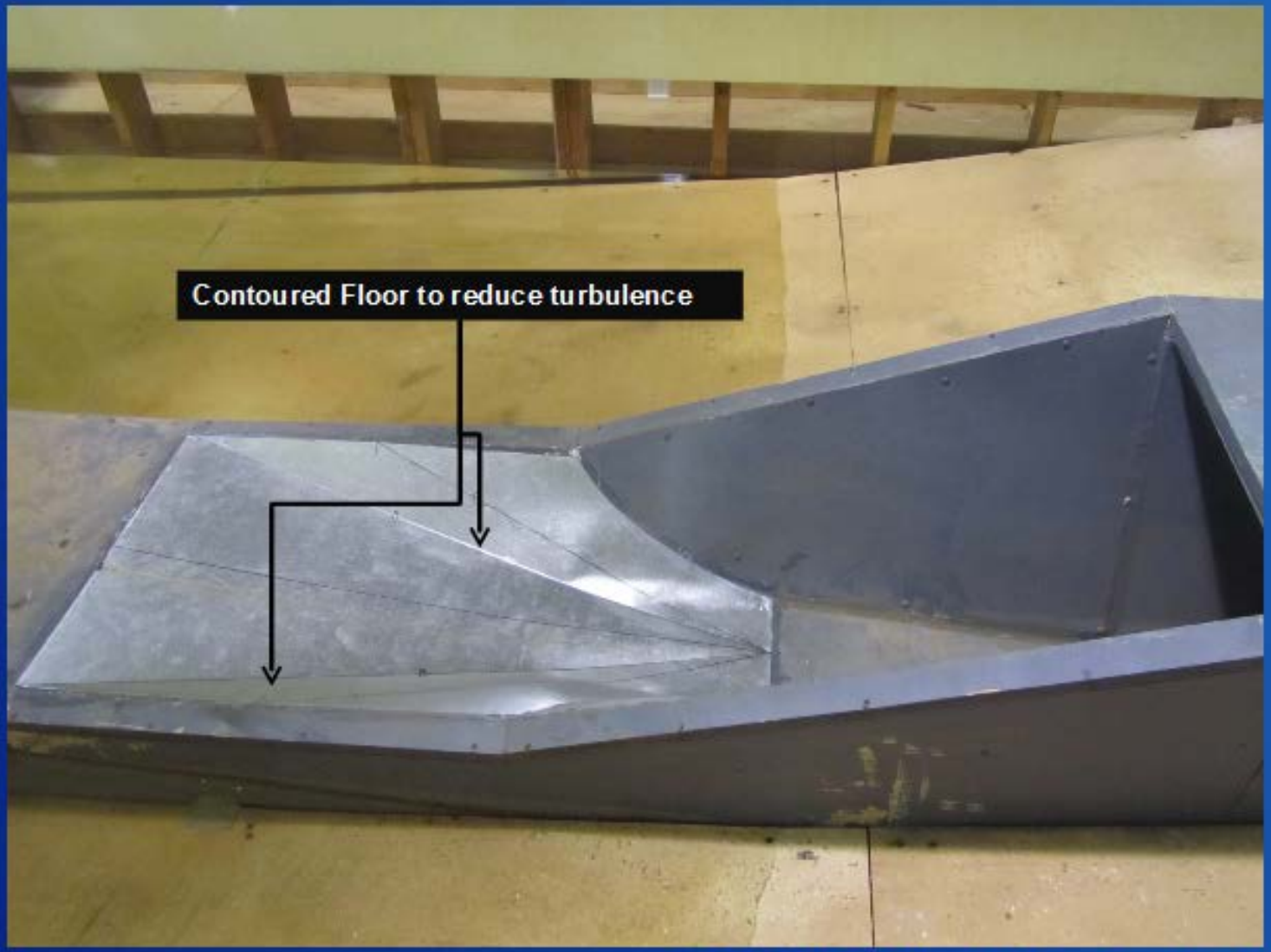
2nd Inlet Structure Design



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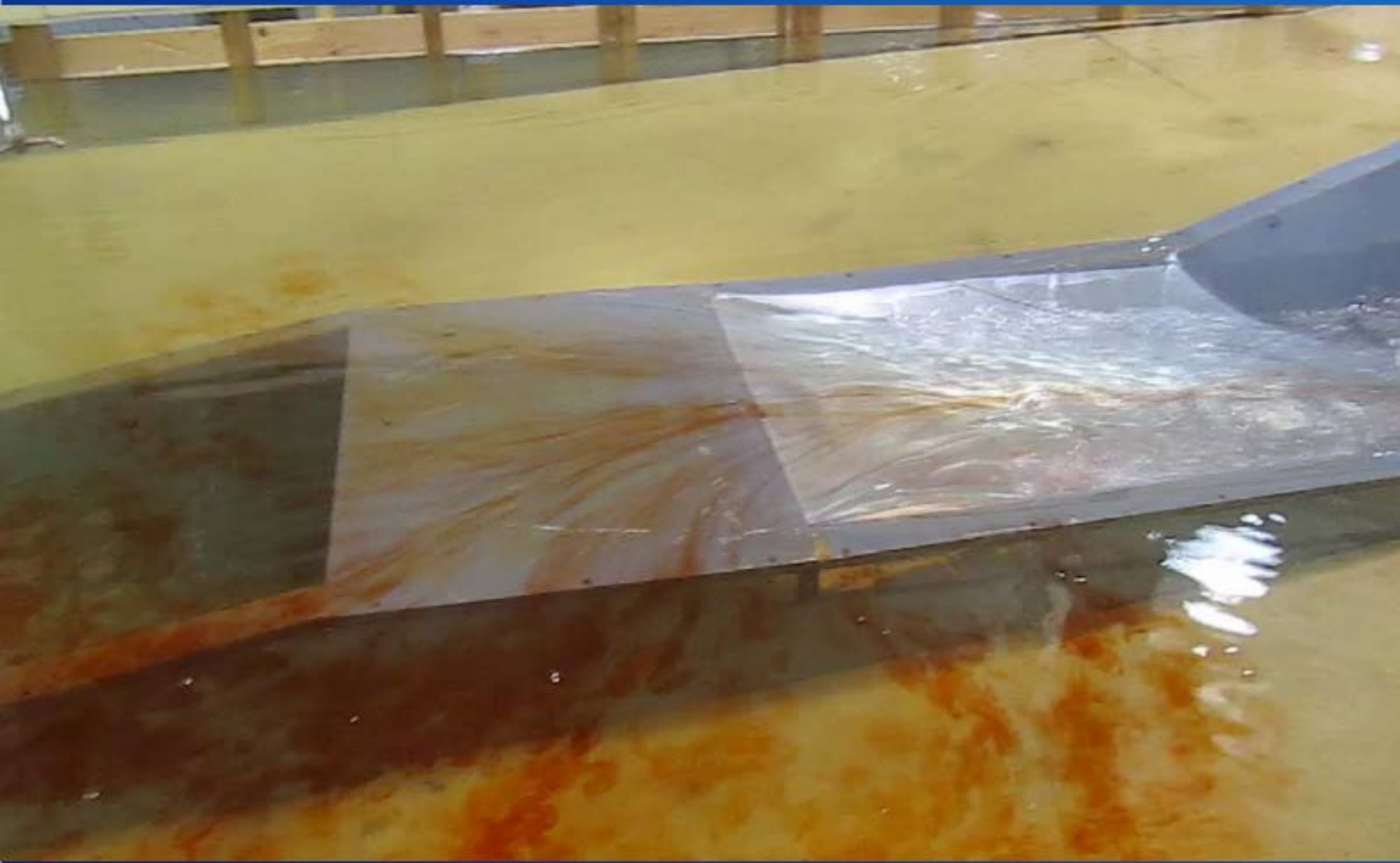
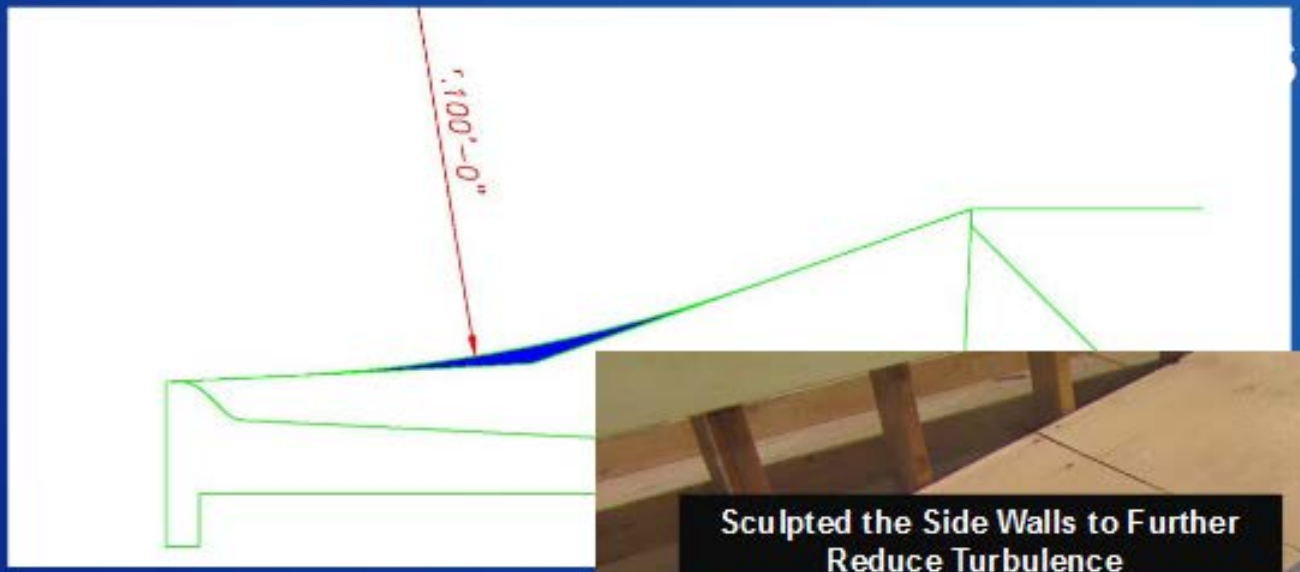
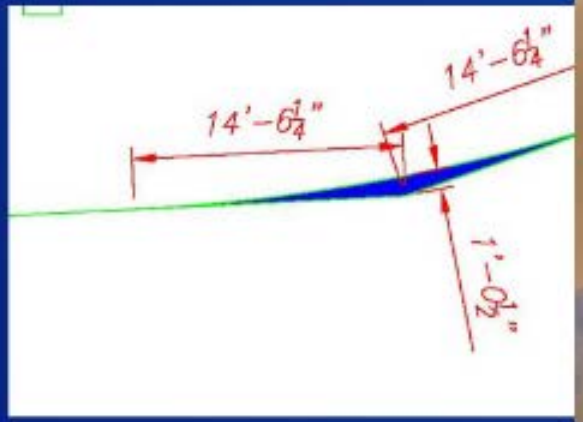
2nd Inlet Structure Design



3rd Inlet Structure Design





3rd Inlet Structure Design

Operating at 400 ft3/s

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4th Inlet Structure Design

Weir Crest Design

Similar to the Interim Flume Design

That Works!

Weir Crest Design

Now Modified to a Ramped Design

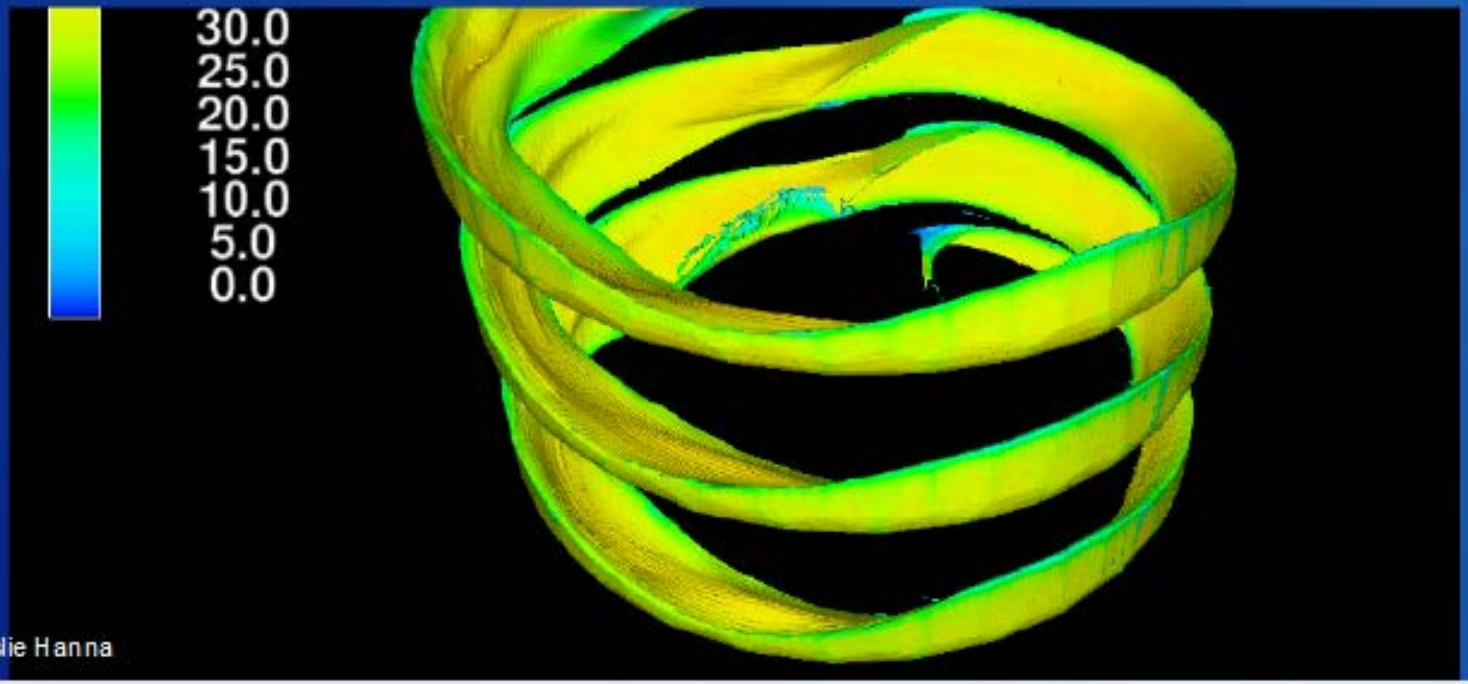
Development of the Helix

Helix CFD studies

(Jim Higgs)

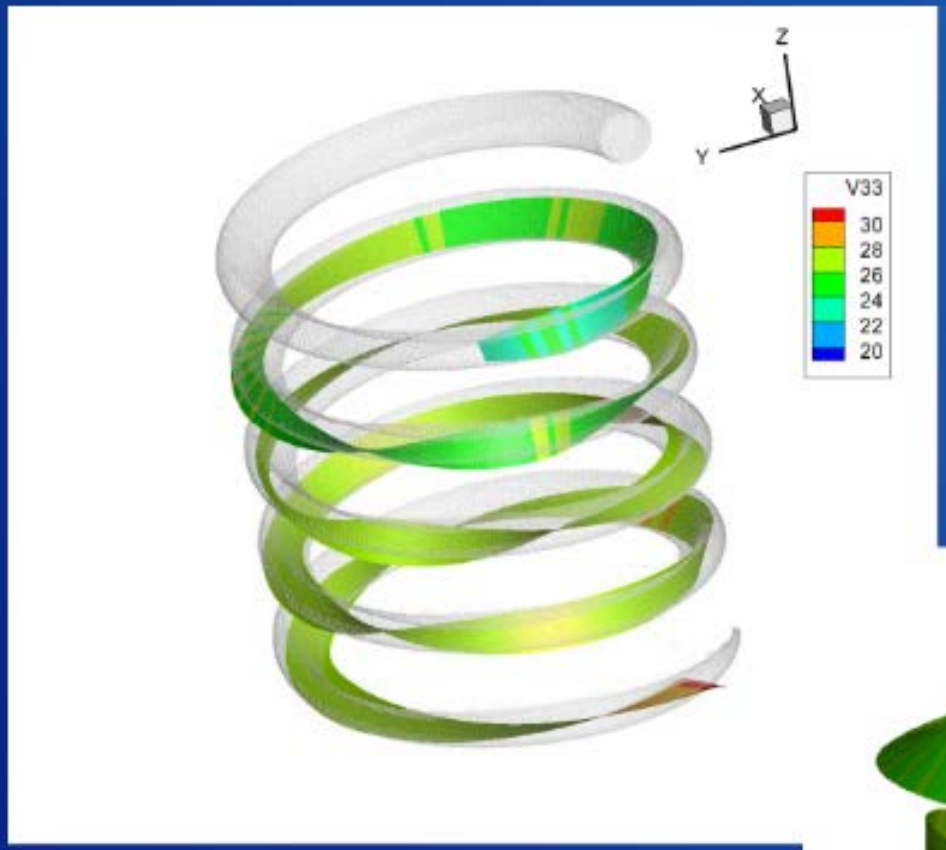
- **Initial Helix geometry**
  - 6 ft diameter pipe
  - 52 ft Helix diameter
  - 11.75 ft drop between loops

CDF = Computational Fluid Dynamics

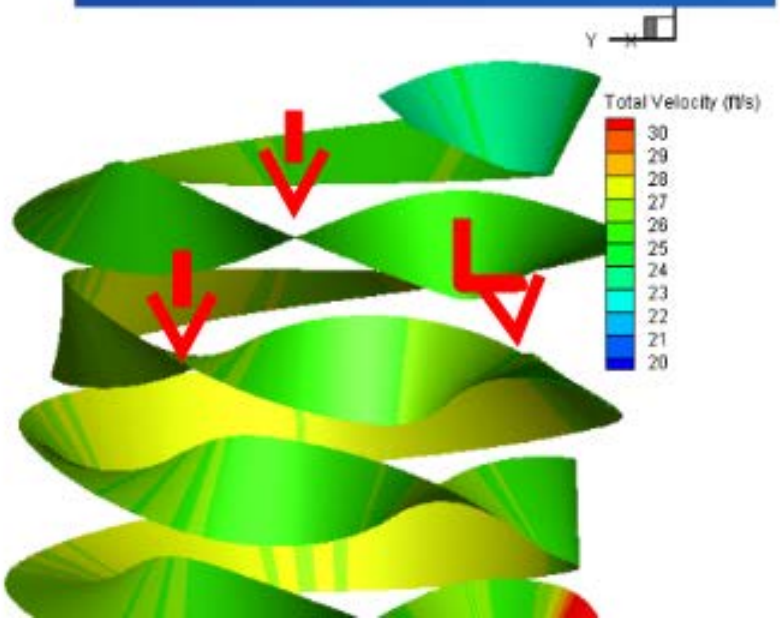


Courtesy of Leslie Hanna

Observed Severe "Corkscrew" Water Movement Down the Helix



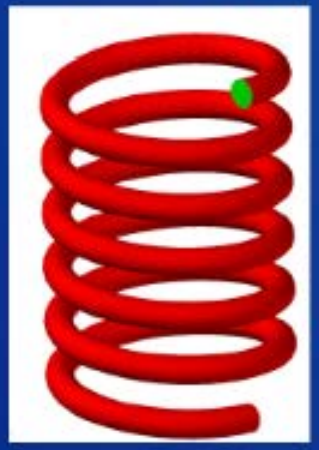
Corkscrew Flow Pattern = Unhappy Fish

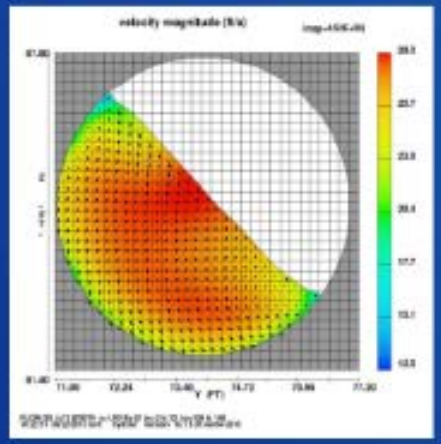


Courtesy of Leslie Hanna

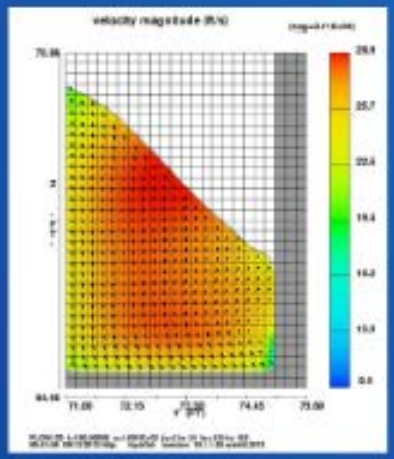
Sensitivity Analysis - shapes

6-ft diameter pipe with 3 helix diameters



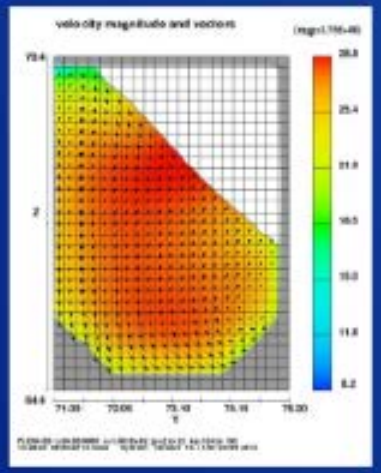


4-ft and 5-ft rectangular box

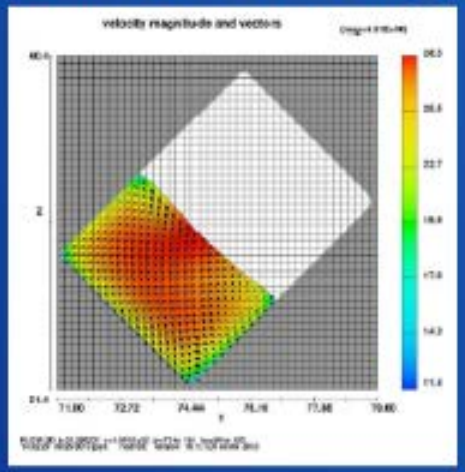


A "Fishing" Expedition!

4-ft chamfered rectangular box



4-ft and 5-ft rotated rectangular boxes



Courtesy of Leslie Hanna

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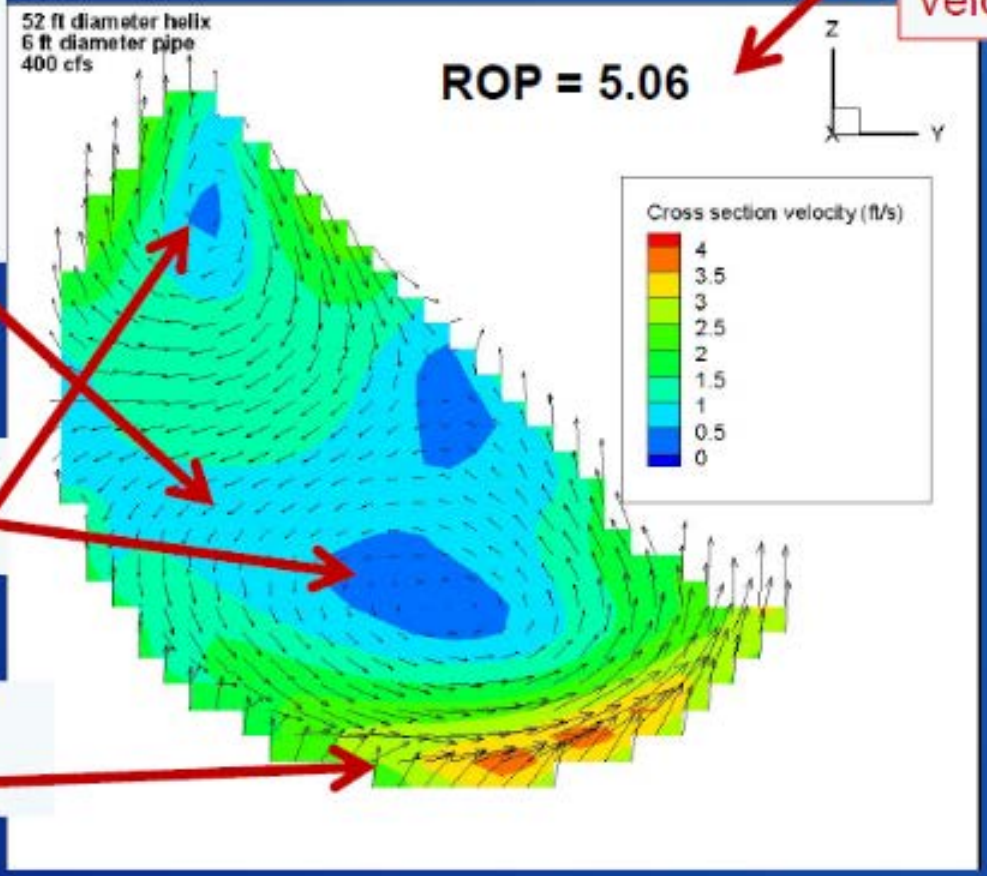
Sensitivity Analysis (from fish's perspective)

Rollover Parameter (ROP)
Difference in Max and Min vertical velocity

Total area with velocity less than 1 ft/s cross-velocity (blue shades indicate a more favorable condition).

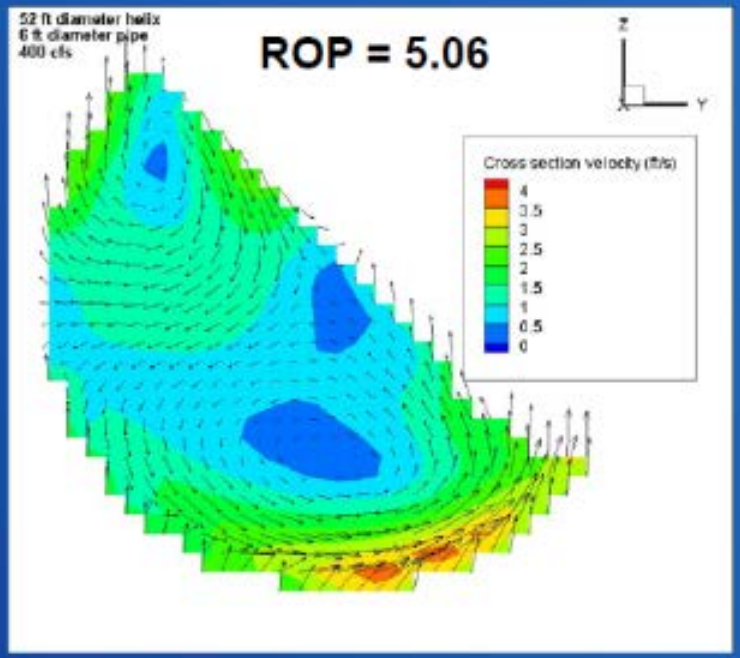
Tightness of rotational flows.

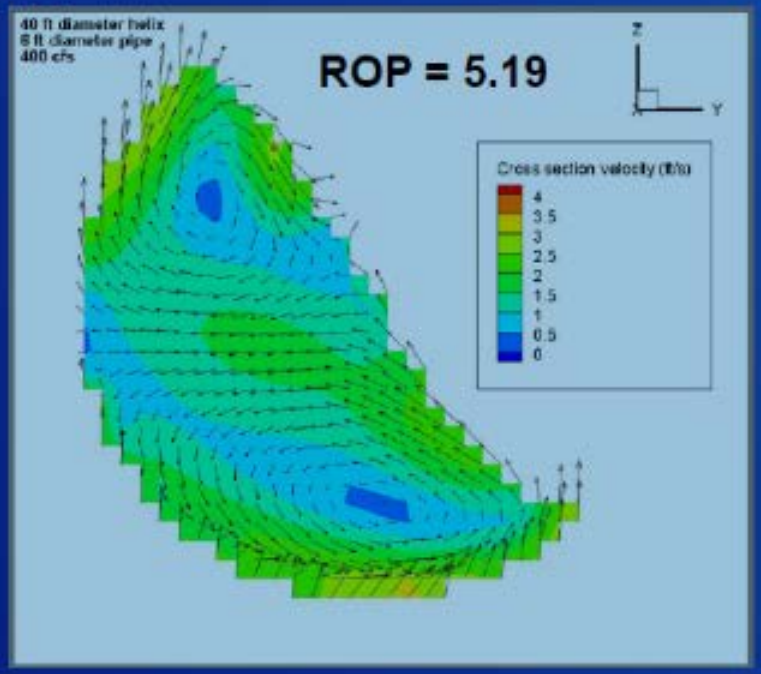
Maximum sweeping velocity.

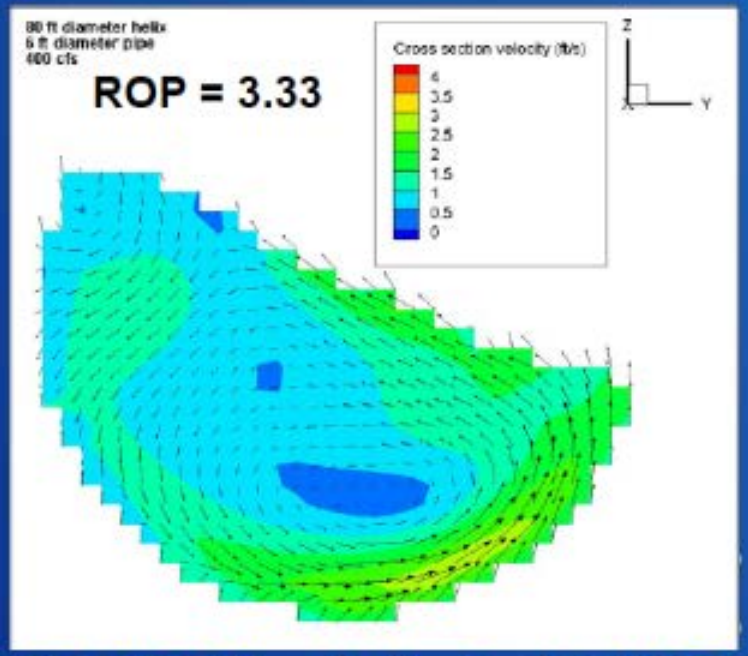


Courtesy of Leslie Hanna

6-ft diameter pipe with 3 helix diameters







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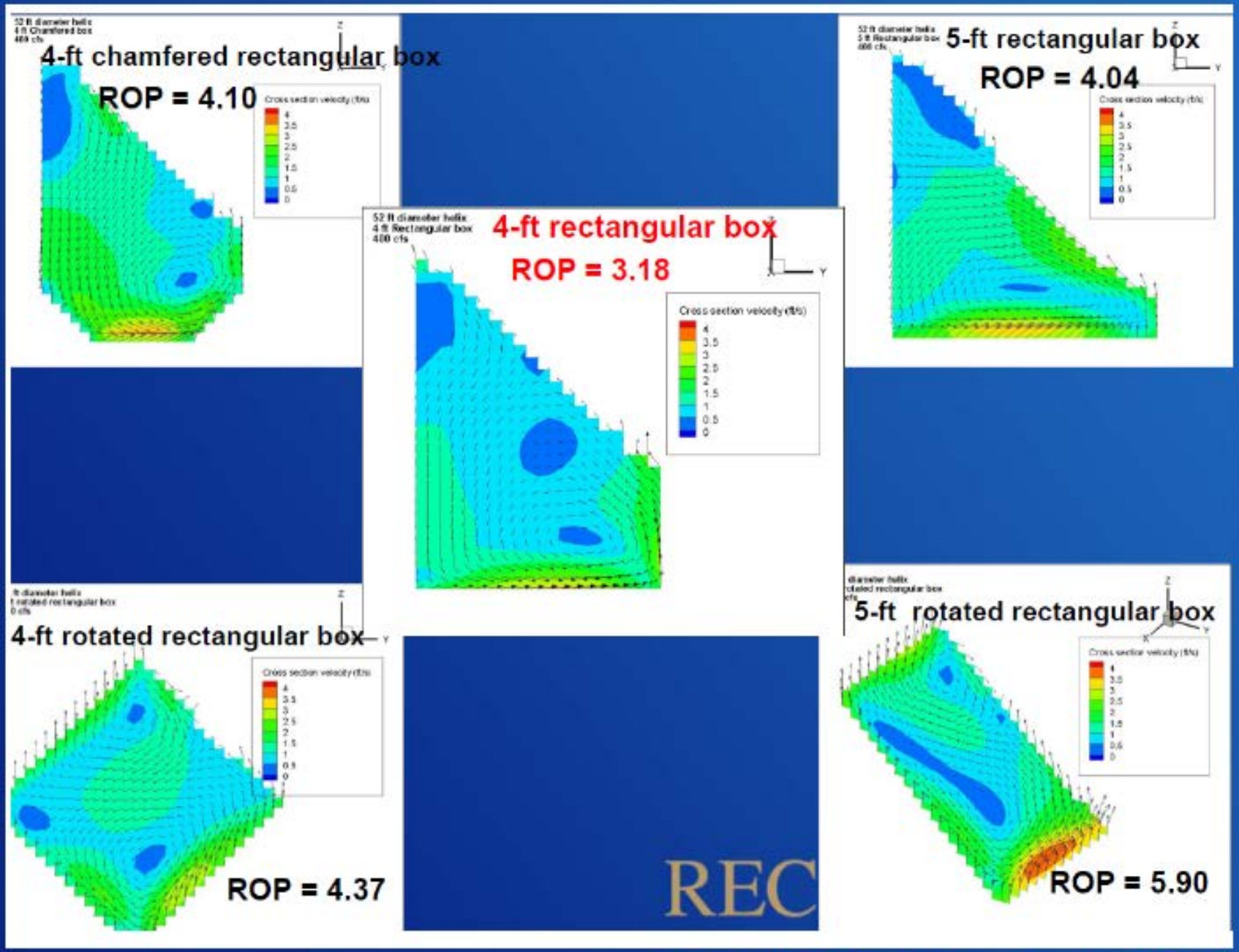

Courtesy of Leslie Hanna

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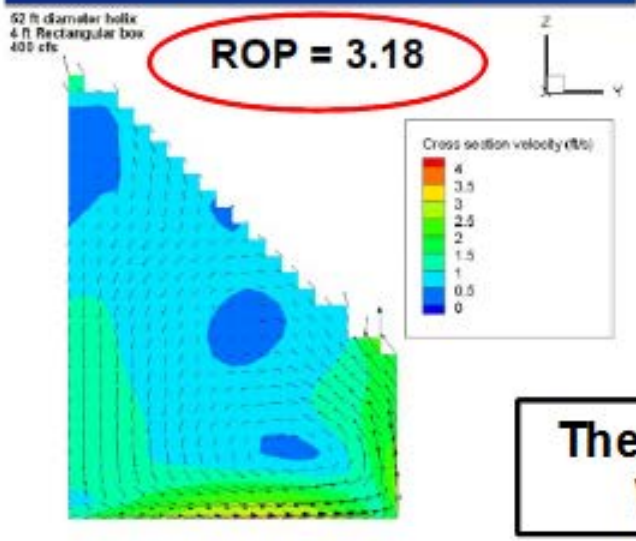
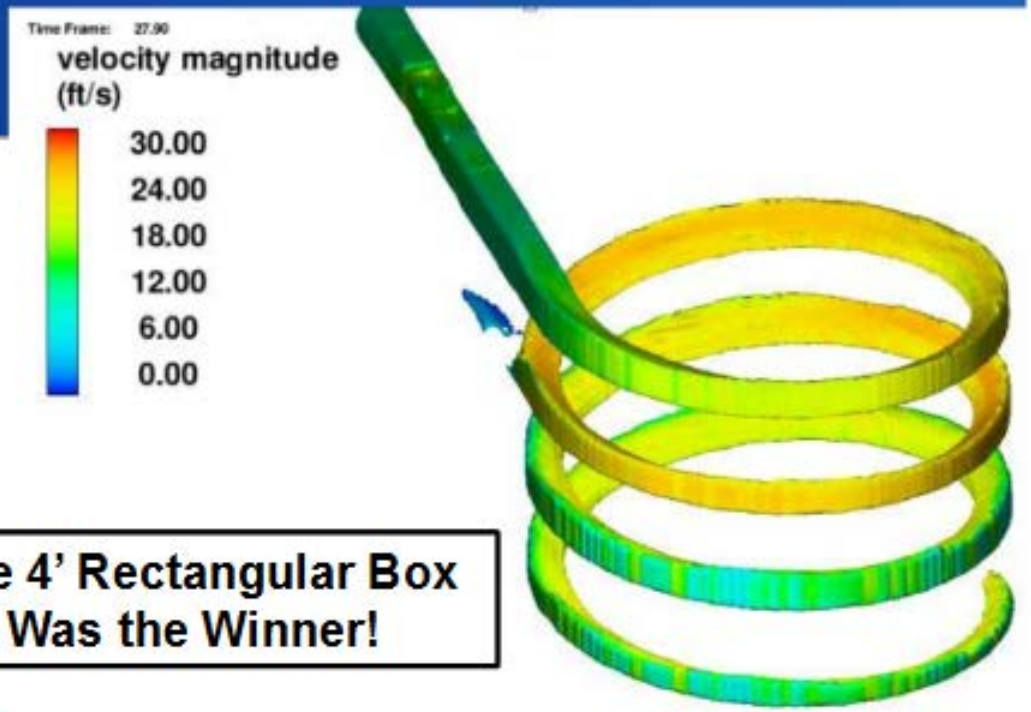
Helix Numerical analysis

- **Most stable flume geometry**
  - Large sweet spot – low secondary rotational velocities
  - Appears to have no excessive sloshing or rollover





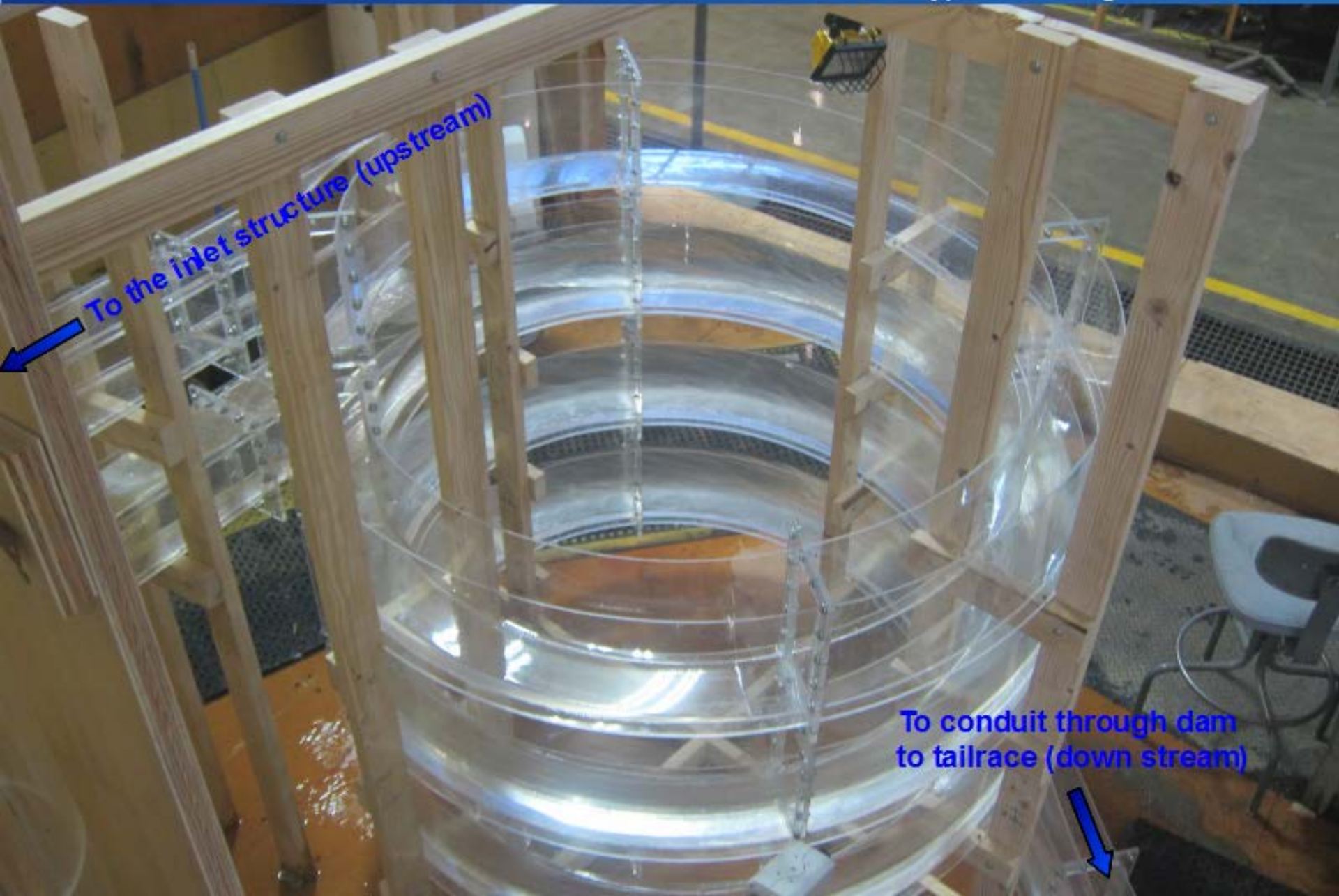
The 4' Rectangular Box Was the Winner!

: 8.50 in

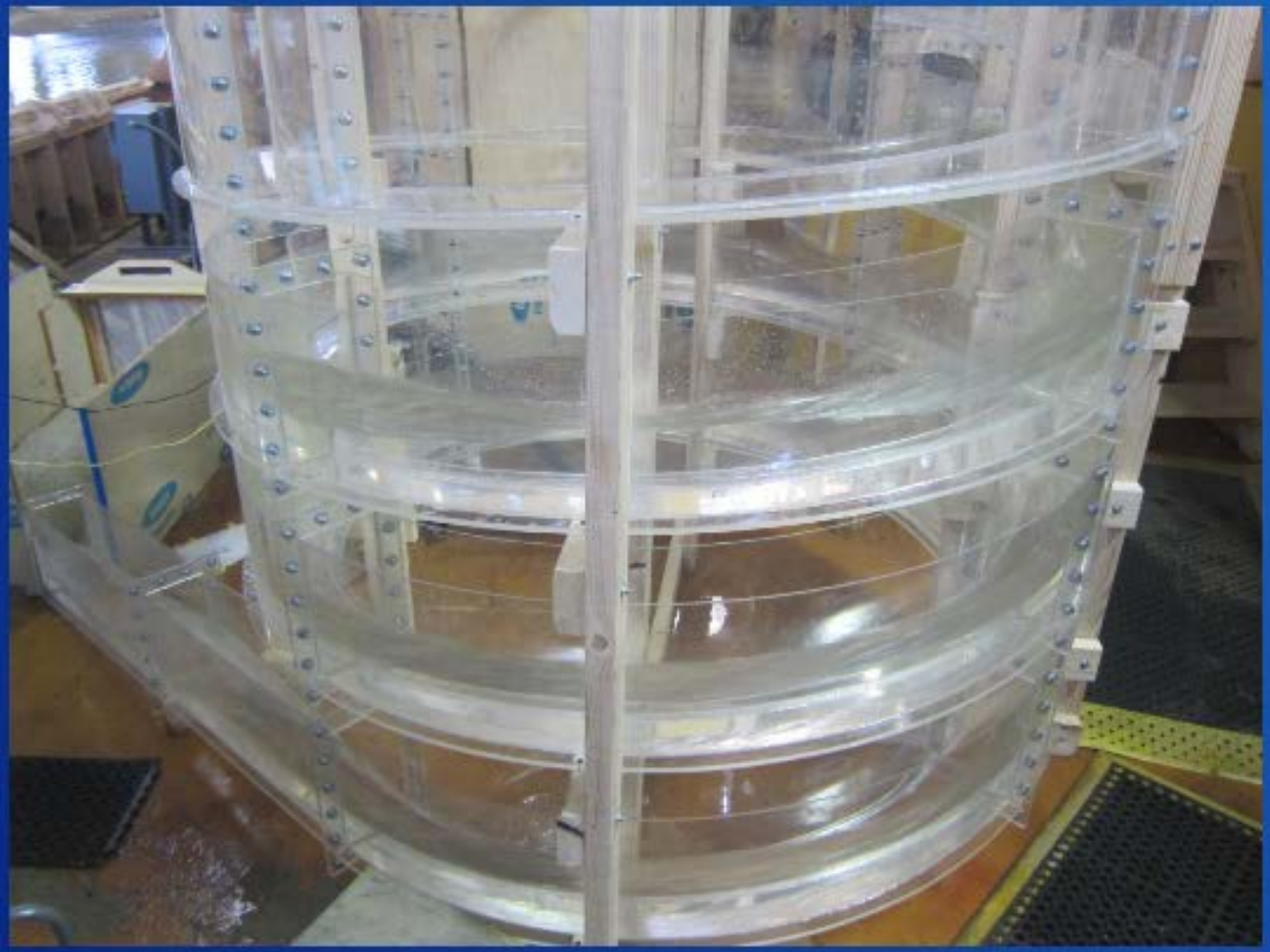
Courtesy of Leslie Hanna

Helix Tower

Function- moves fish from the inlet structure into conduit bypass through the dam



Go To Helix Video Power Point



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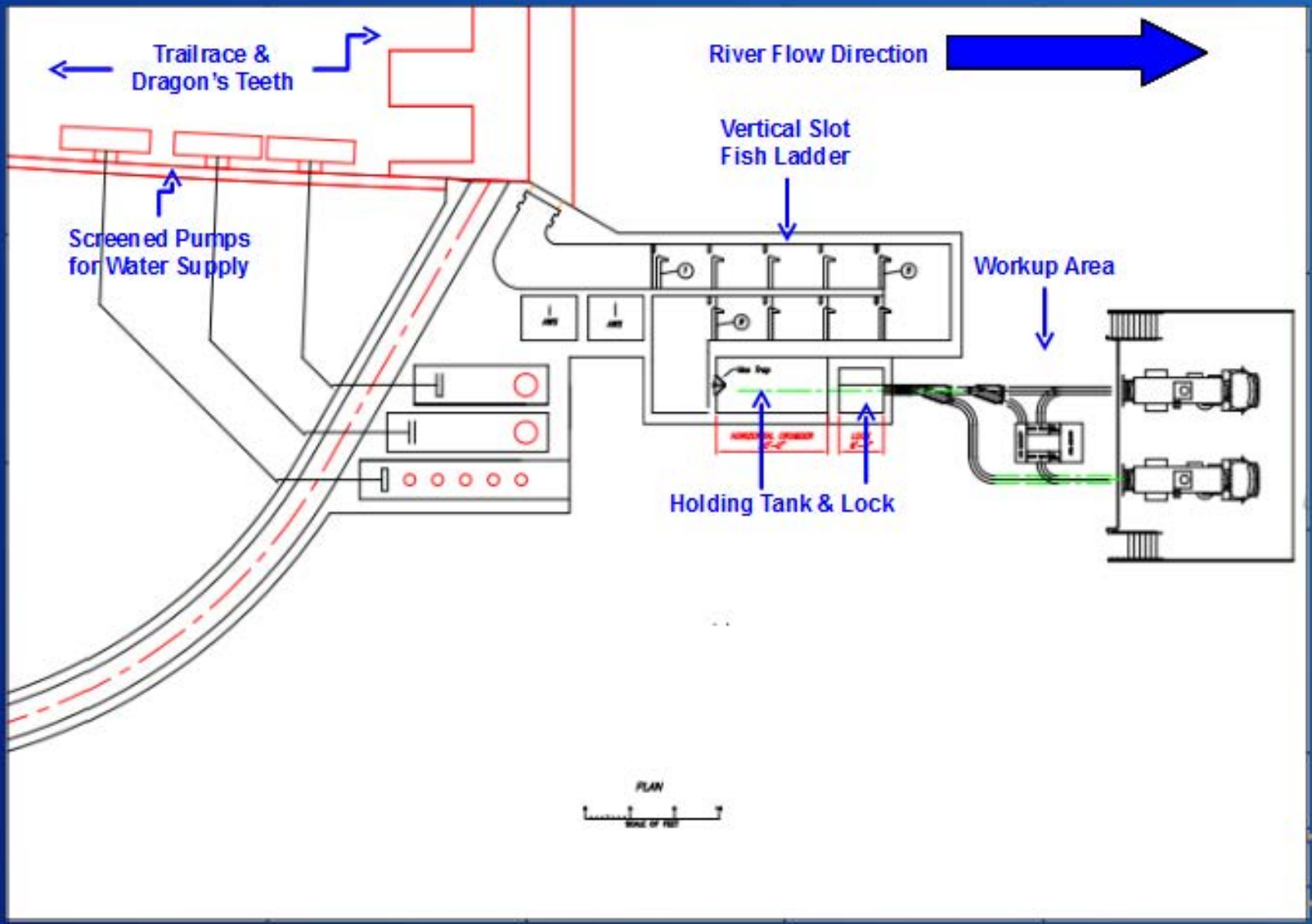
Adult Fish Passage Facility Layout

A Conventional Trap & Haul Approach



2nd Upstream Passage

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Adult Fish Passage Modeling

I’m Outta Here