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Helix Design for Downstream Fish Passage

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University of Wisconsin - Madison

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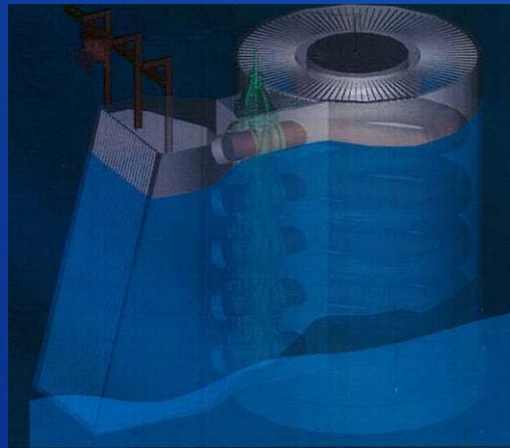
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Managing Water in the West

Cle Elum Helix Design for Downstream Fish Passage



Leslie Hanna, Jim Higgs,
Brent Mefford, Jason
Wagner



U.S. Department of the Interior
Bureau of Reclamation

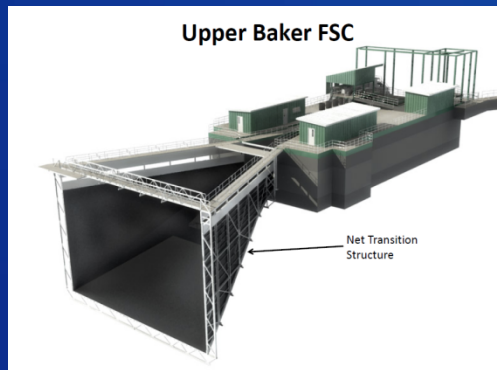
Hydraulic Investigations &
Research Laboratory

Large Storage Reservoir

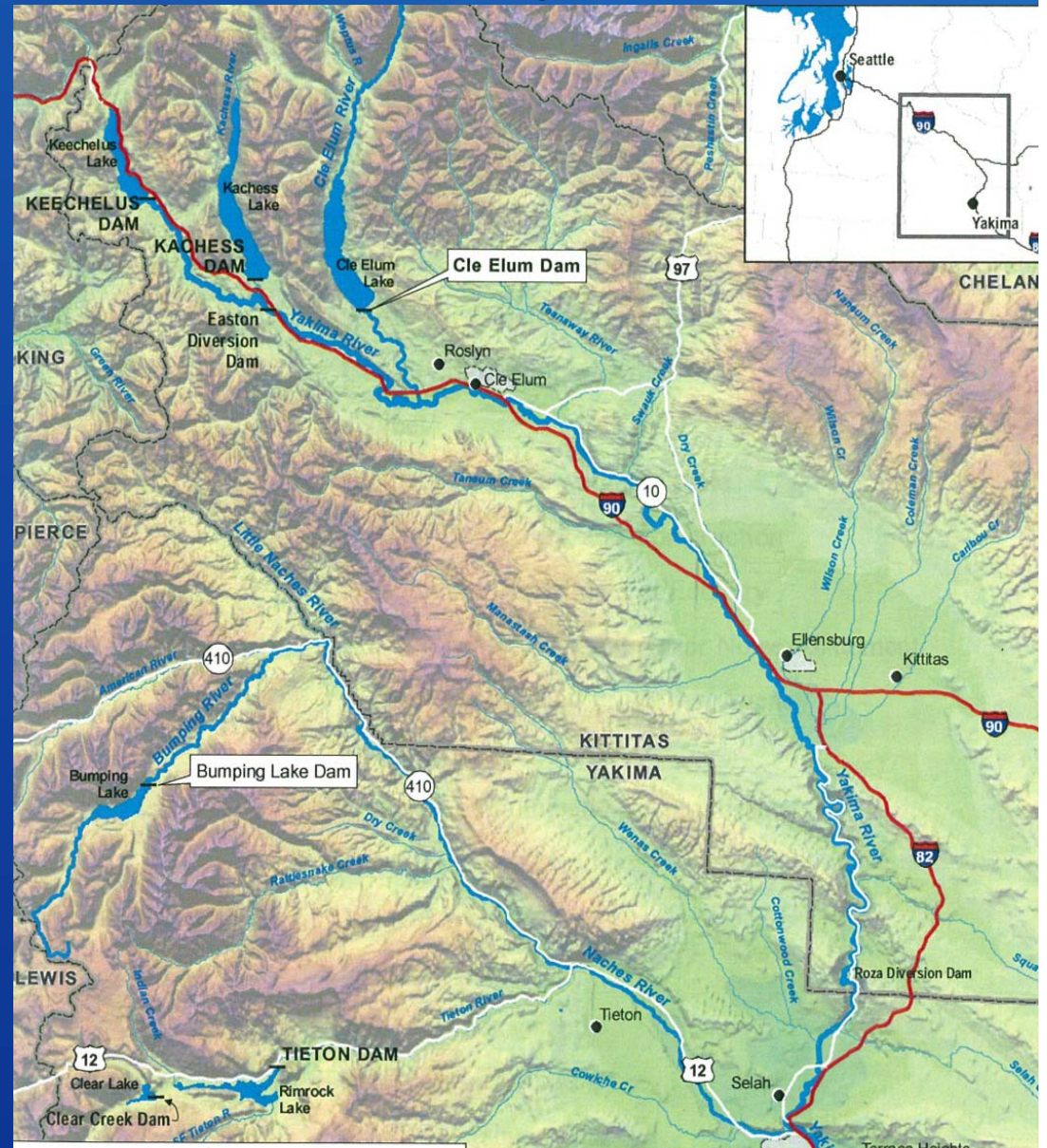
Yakima Projects Dams

Challenges

- Reduce Operation and Maintenance costs



- Dam Height
- Large water surface fluctuations due to seasonal releases.

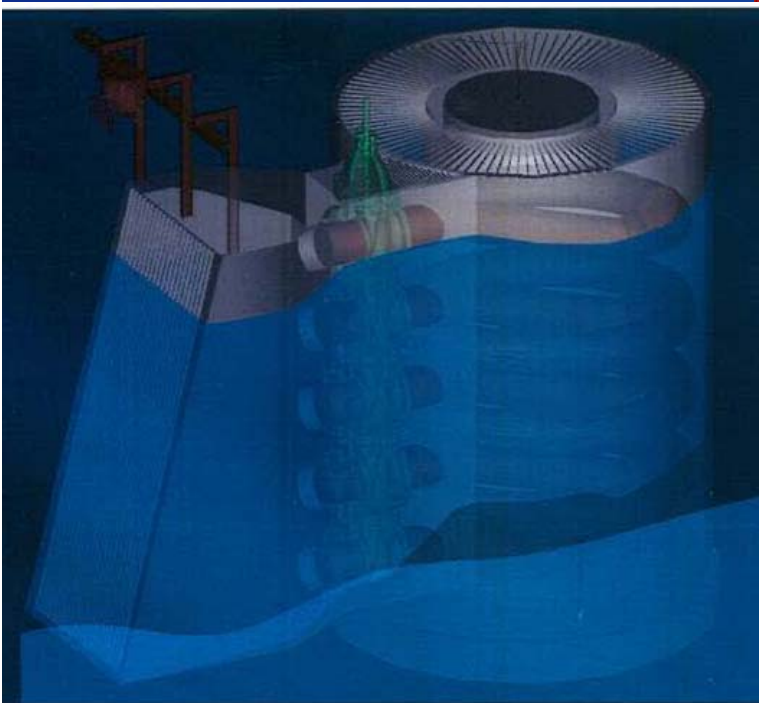


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Helix Concept

Advantages

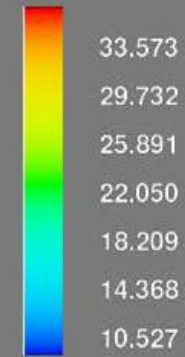
- Long, relatively mild slope
- Small footprint
- Smooth transitions



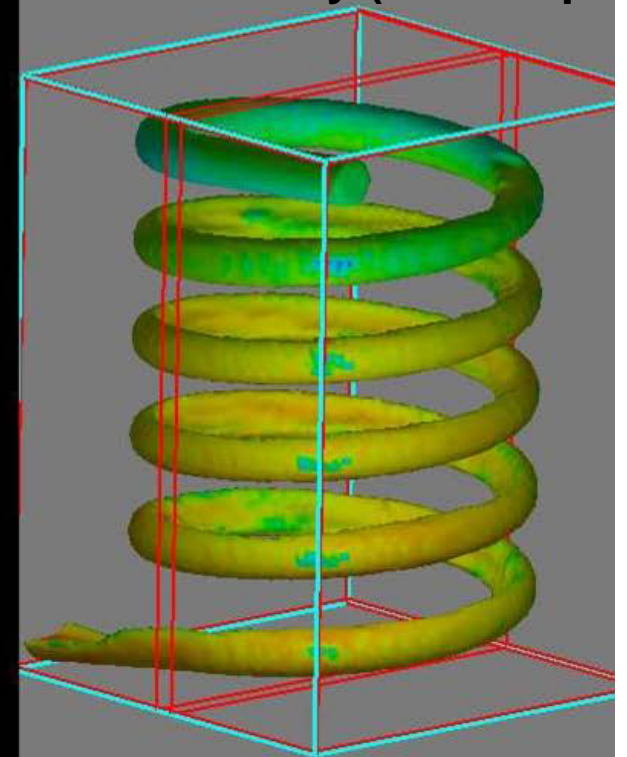
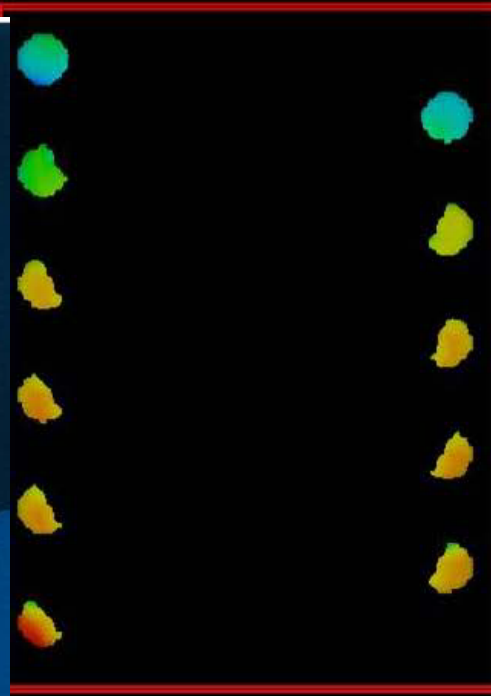
velocity magnitude



velocity magnitude

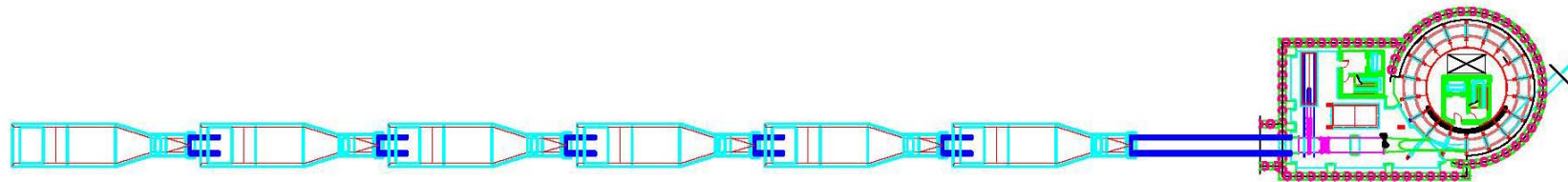
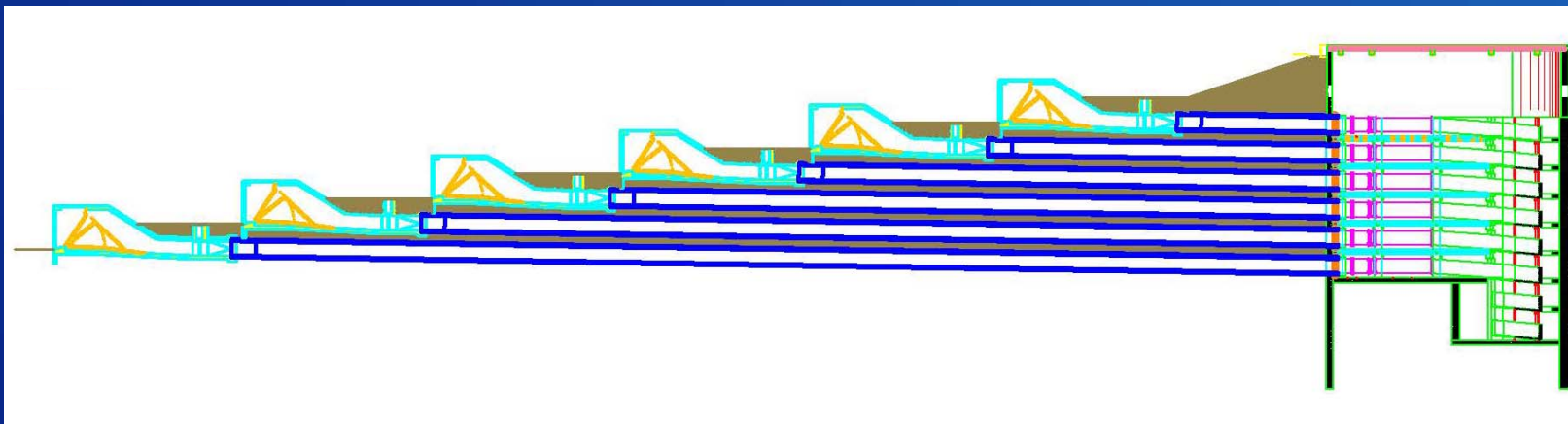
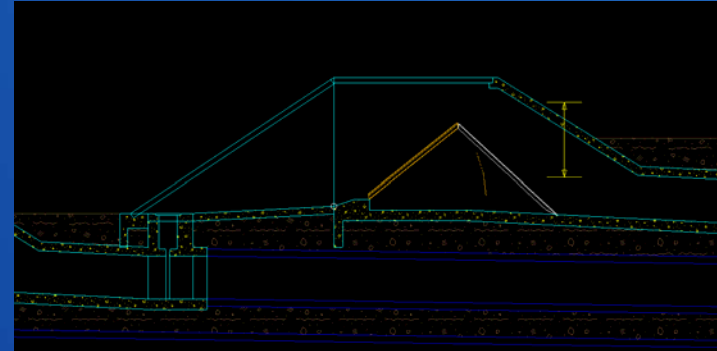


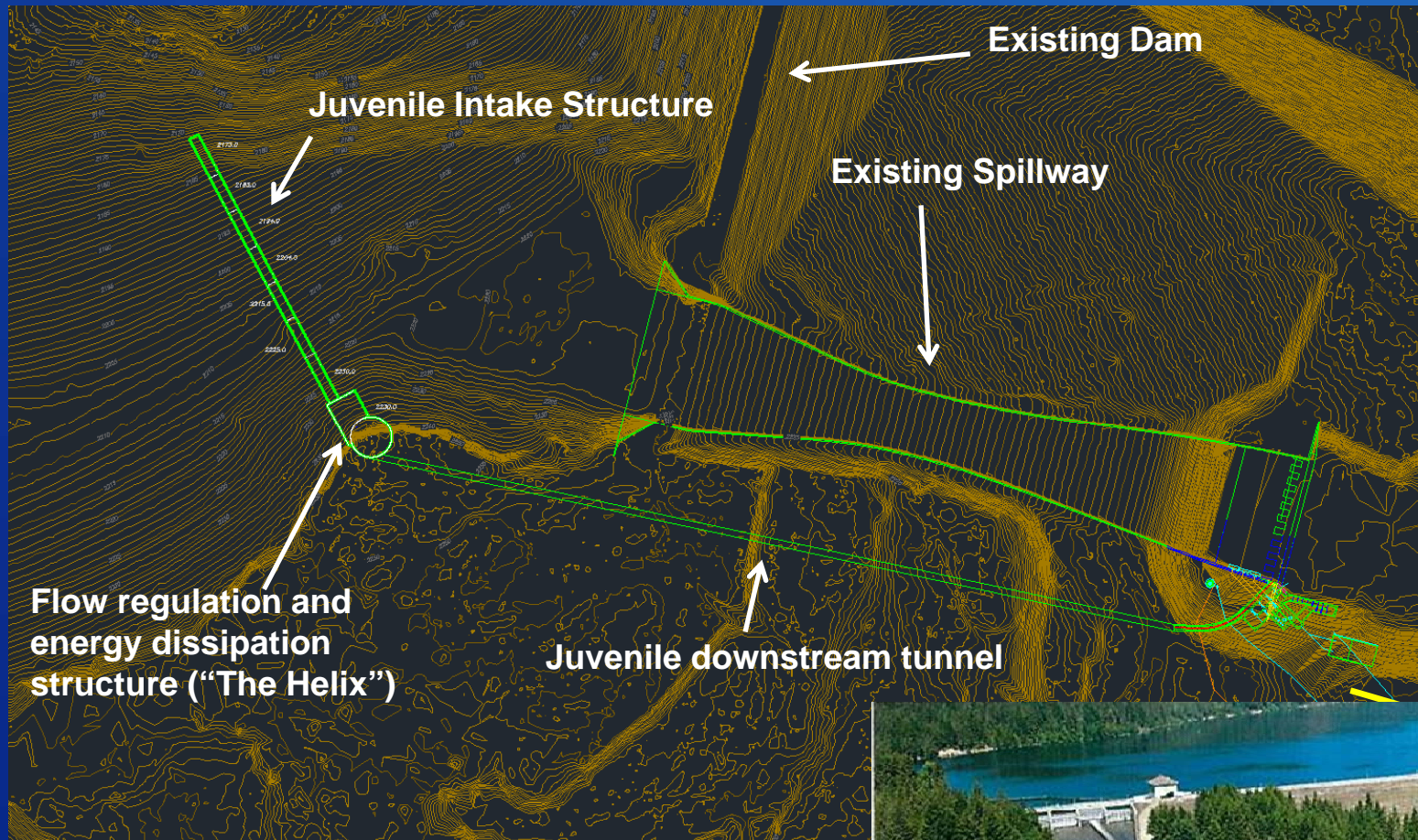
Preliminary (10% slope)



Intake Structure

- Follows Reservoir bank-line
- Overlapping intake zones

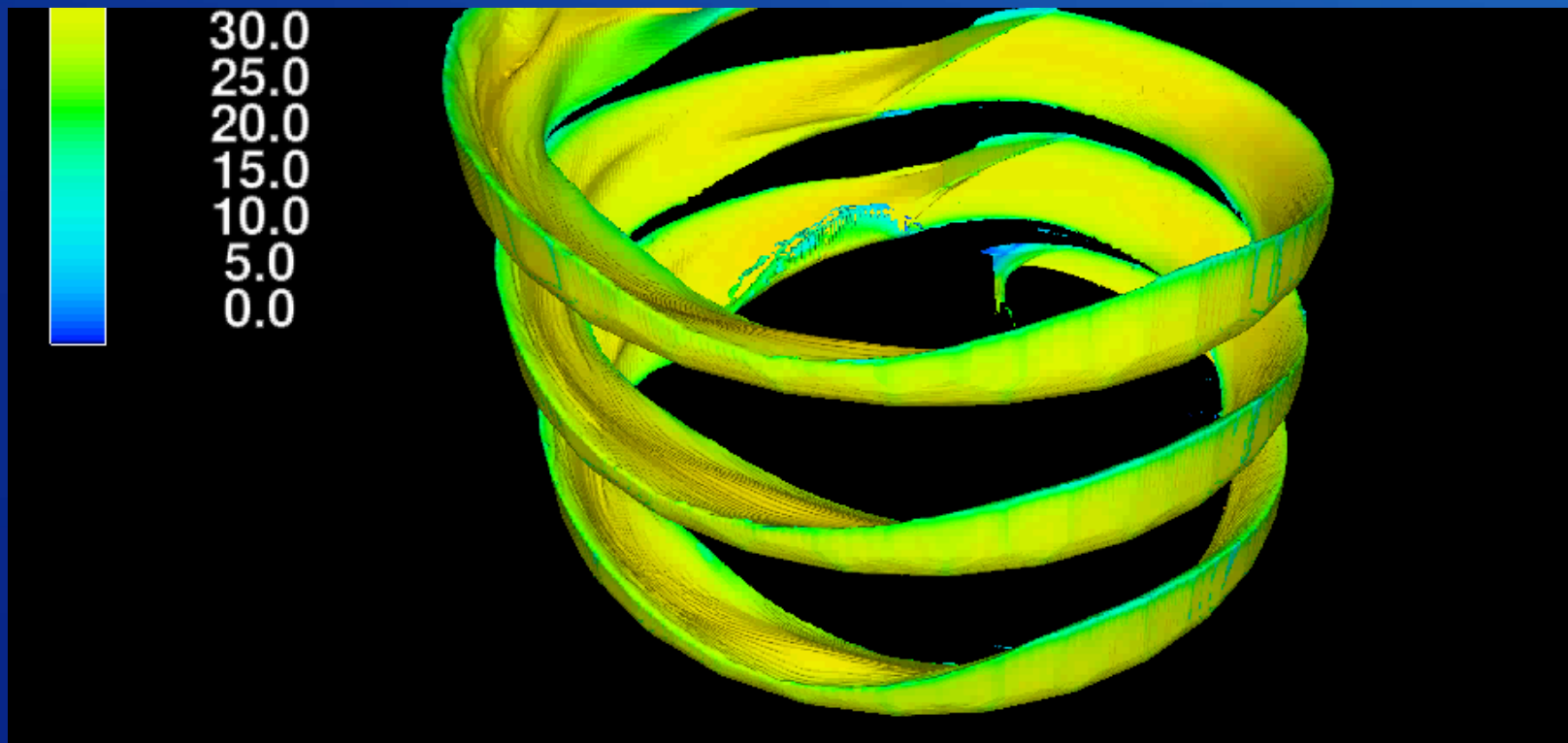




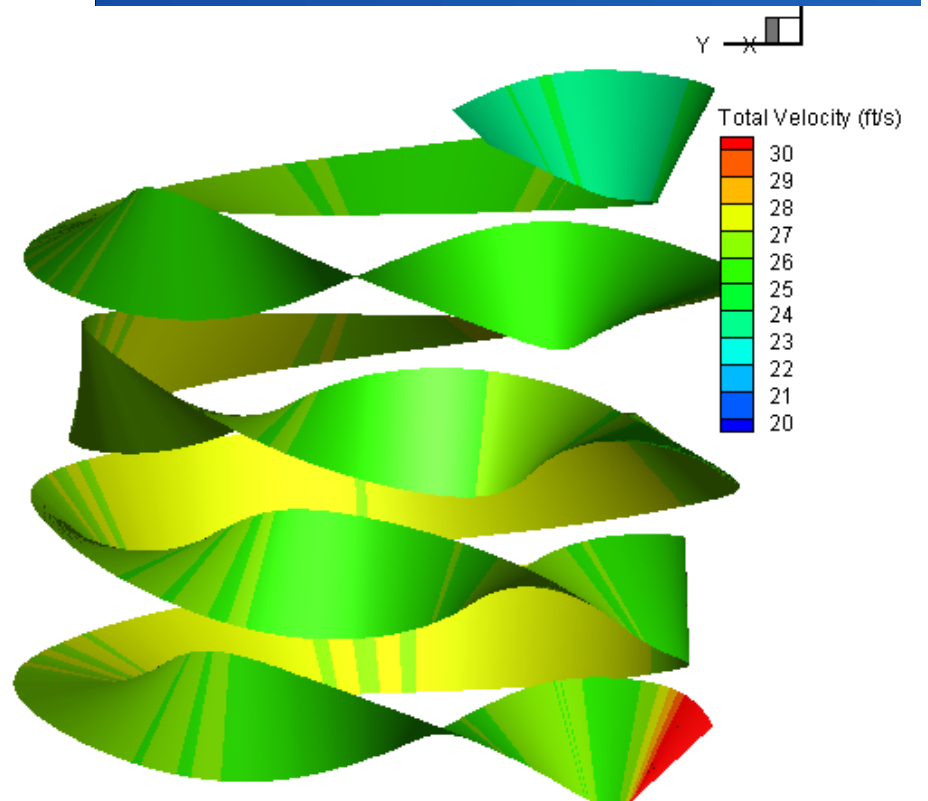
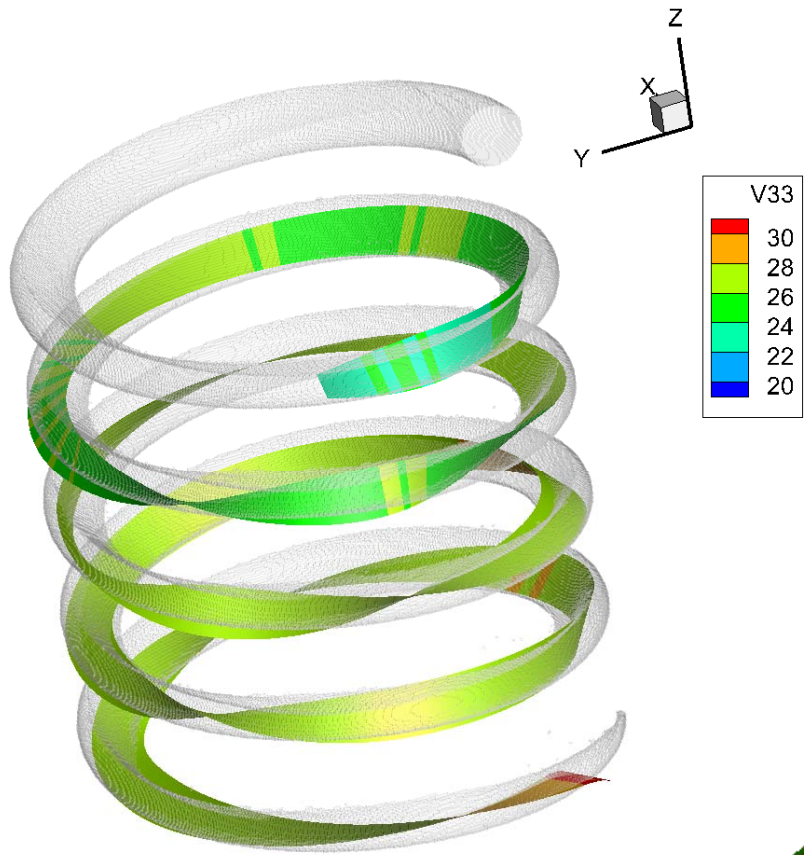
Helix CFD studies

(Jim Higgs)

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

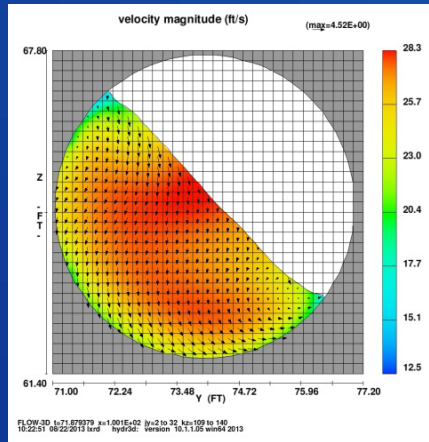
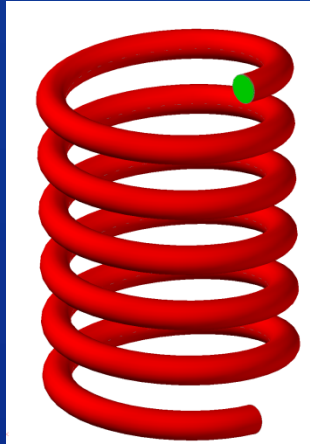


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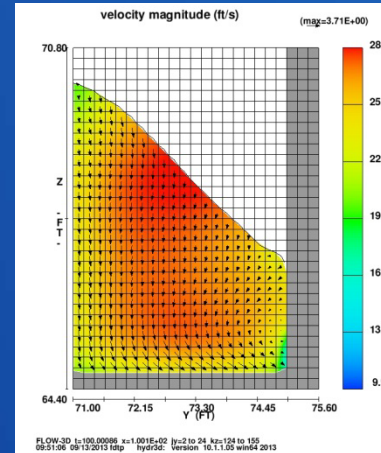


Sensitivity Analysis - shapes

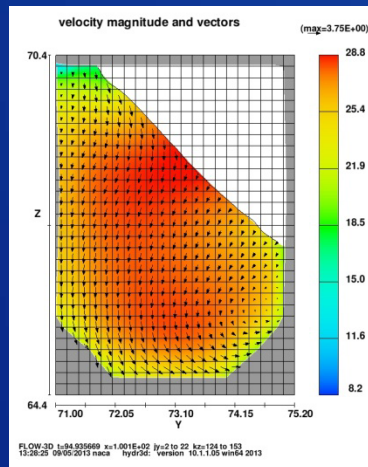
6-ft diameter pipe with 3 helix diameters



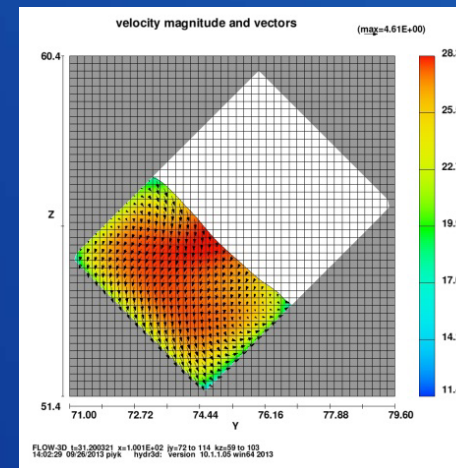
4-ft and 5-ft rectangular box



4-ft chamfered rectangular box



4-ft and 5-ft rotated rectangular boxes



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Sensitivity Analysis (from fish's perspective)

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

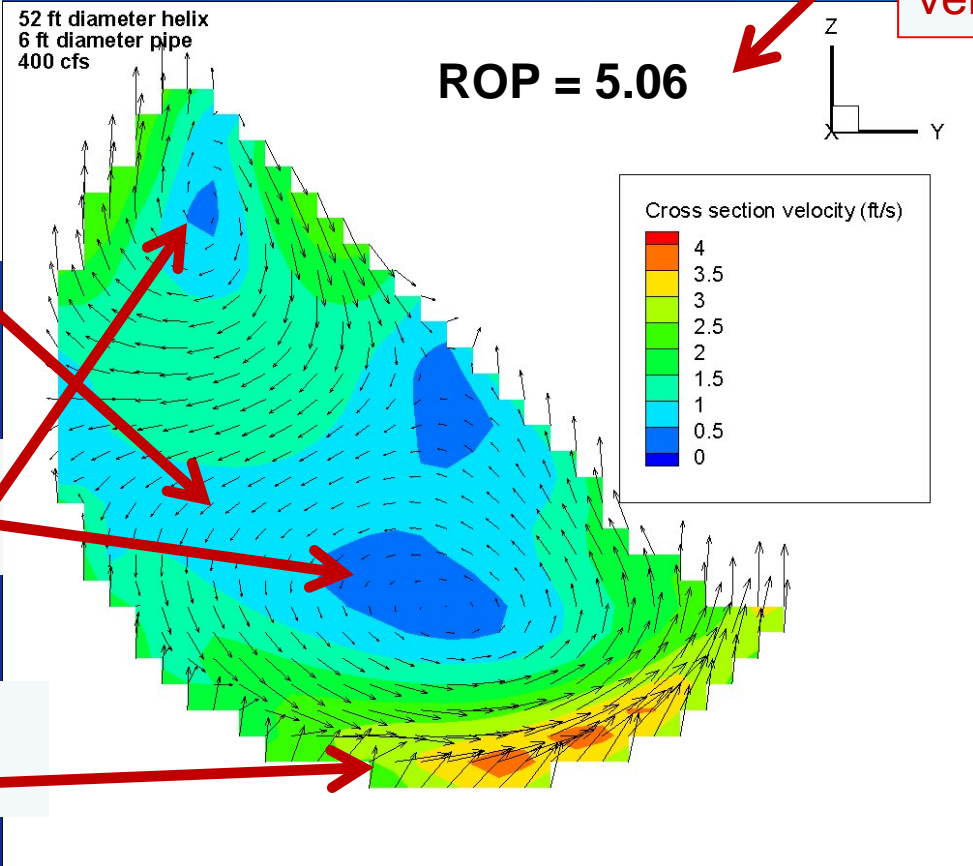
Total area with velocity less than 1 ft/s cross-velocity (blue shades indicate a more favorable condition).



Tightness of rotational flows.

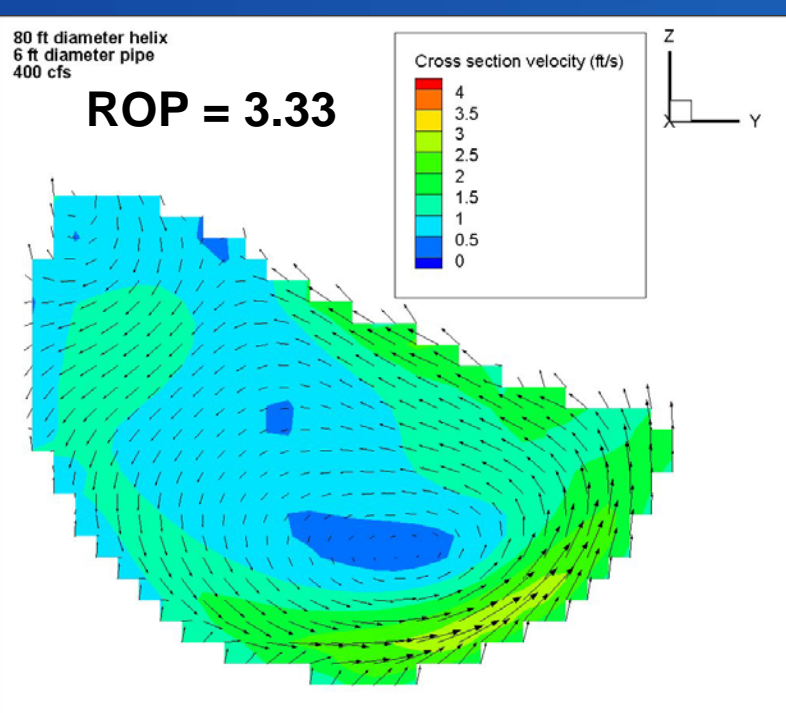
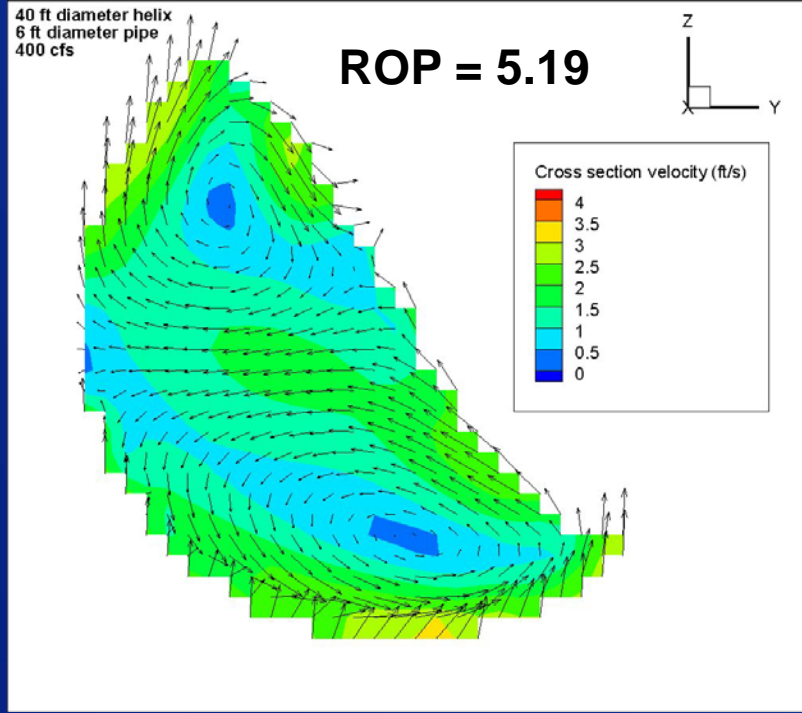
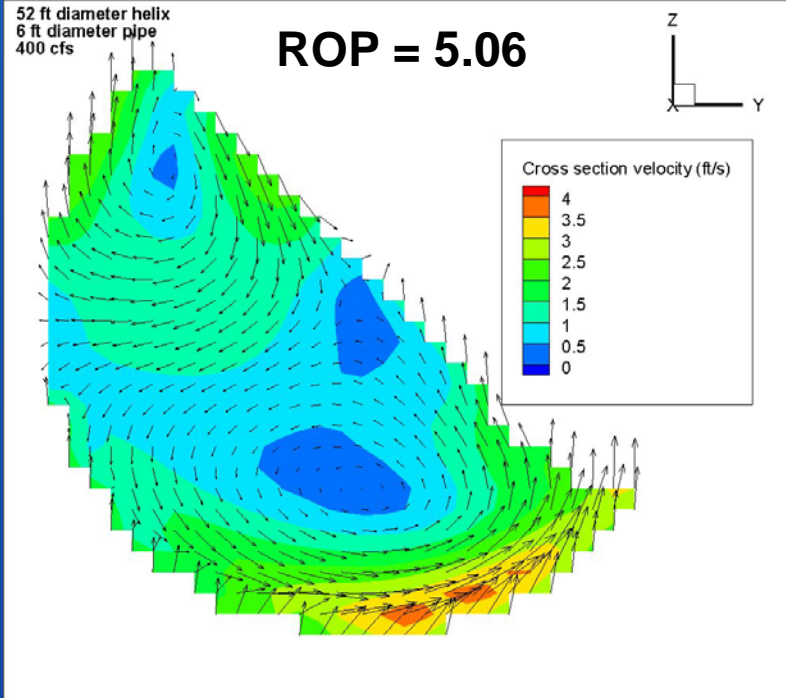


Maximum sweeping velocity.



Surface roughness = 0.0042 feet

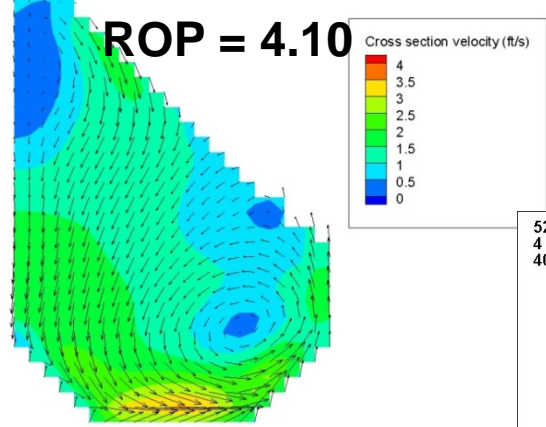
6-ft diameter pipe with 3 helix diameters



52 ft diameter helix
4 ft Chamfered box
400 cfs

4-ft chamfered rectangular box

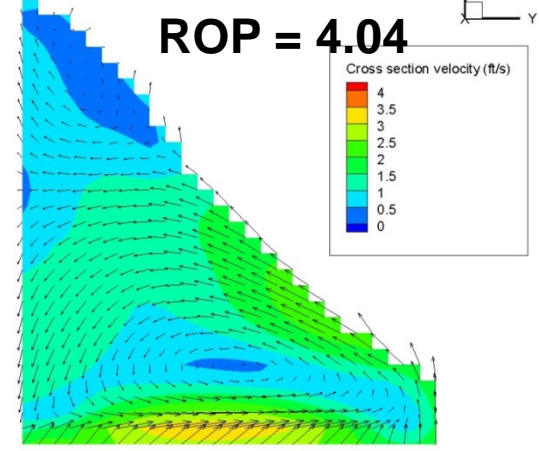
ROP = 4.10



52 ft diameter helix
5 ft Rectangular box
400 cfs

5-ft rectangular box

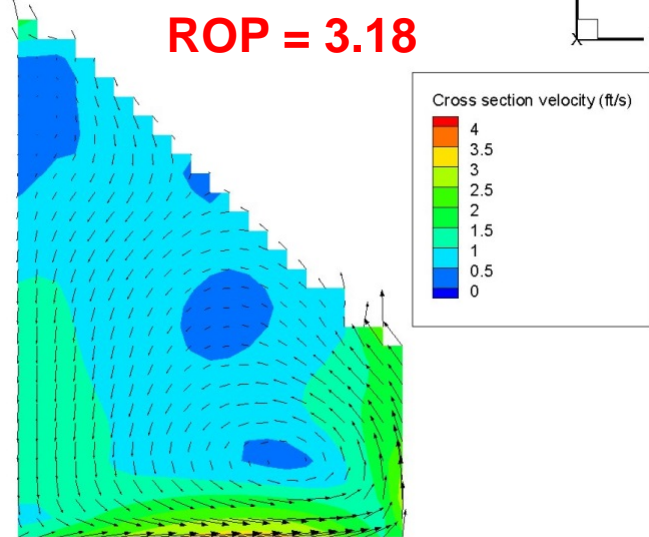
ROP = 4.04



52 ft diameter helix
4 ft Rectangular box
400 cfs

4-ft rectangular box

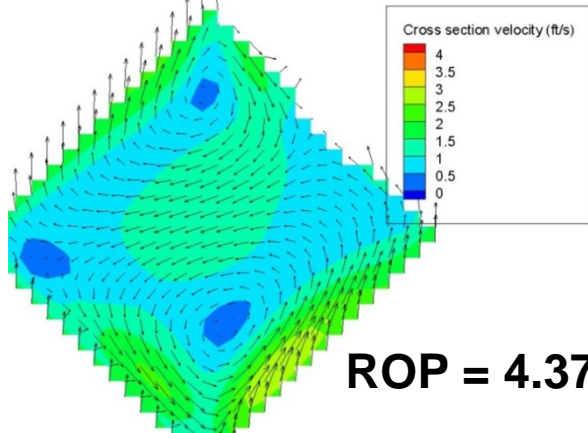
ROP = 3.18



52 ft diameter helix
4 ft rotated rectangular box
400 cfs

4-ft rotated rectangular box

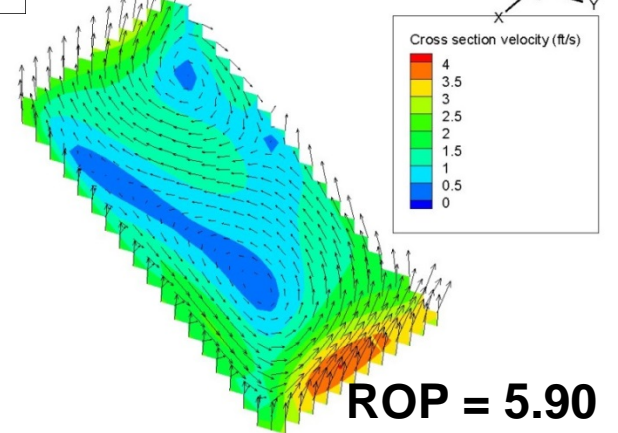
ROP = 4.37



52 ft diameter helix
5 ft rotated rectangular box
400 cfs

5-ft rotated rectangular box

ROP = 5.90



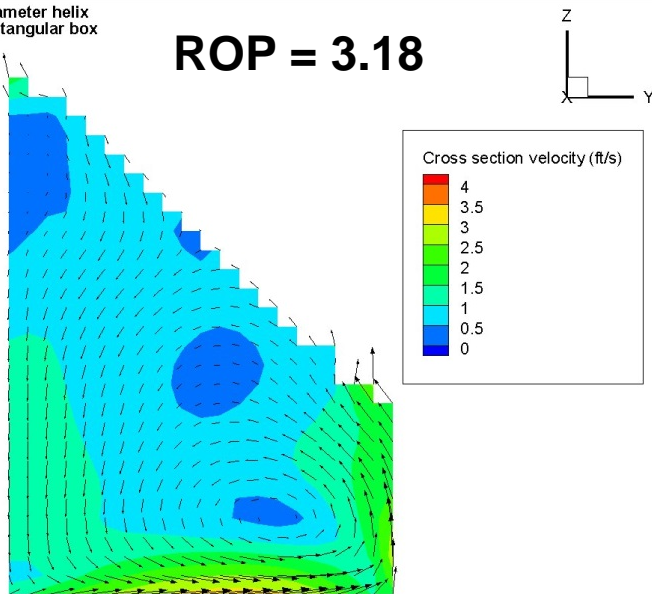
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Helix Numerical analysis

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

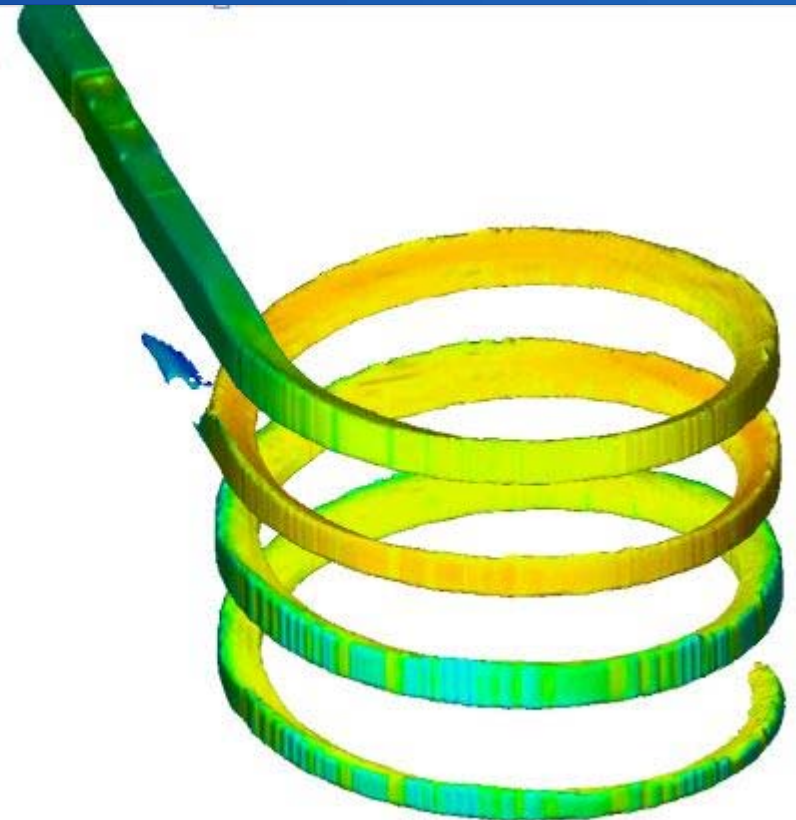
52 ft diameter helix
4 ft Rectangular box
400 cfs

ROP = 3.18



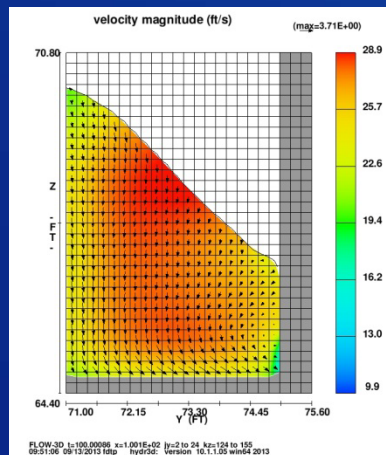
Time Frame: 27.90

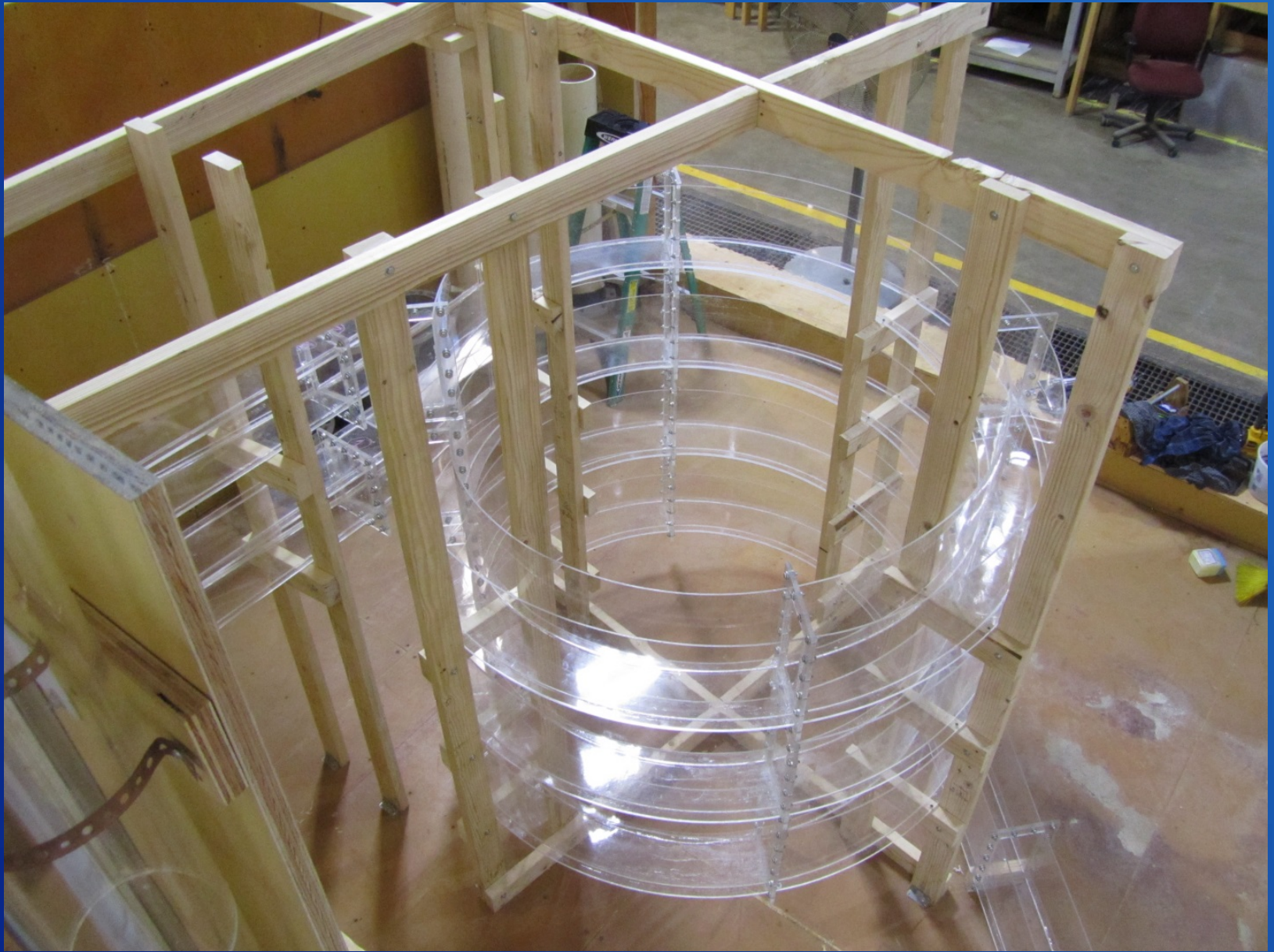
velocity magnitude
(ft/s)



Helix Model Construction (1:9.5 scale)

- At every cross section -- horizontal floor, slope varies across width of flume
 - 8.5% Inside wall
 - 7.8% centerline
 - 7.14% Outside wall





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Helix Physical Model Study Objectives

- **Verify CFD and Refine into the final design for Cle Elum downstream passage**
 - Evaluate flow conditions in helix flume to ensure no excessive sloshing or roll-over
 - Determine flow depths and velocities in the flume
 - Evaluate transitions
 - From inlet structure into helix structure
 - From helix to downstream conduit

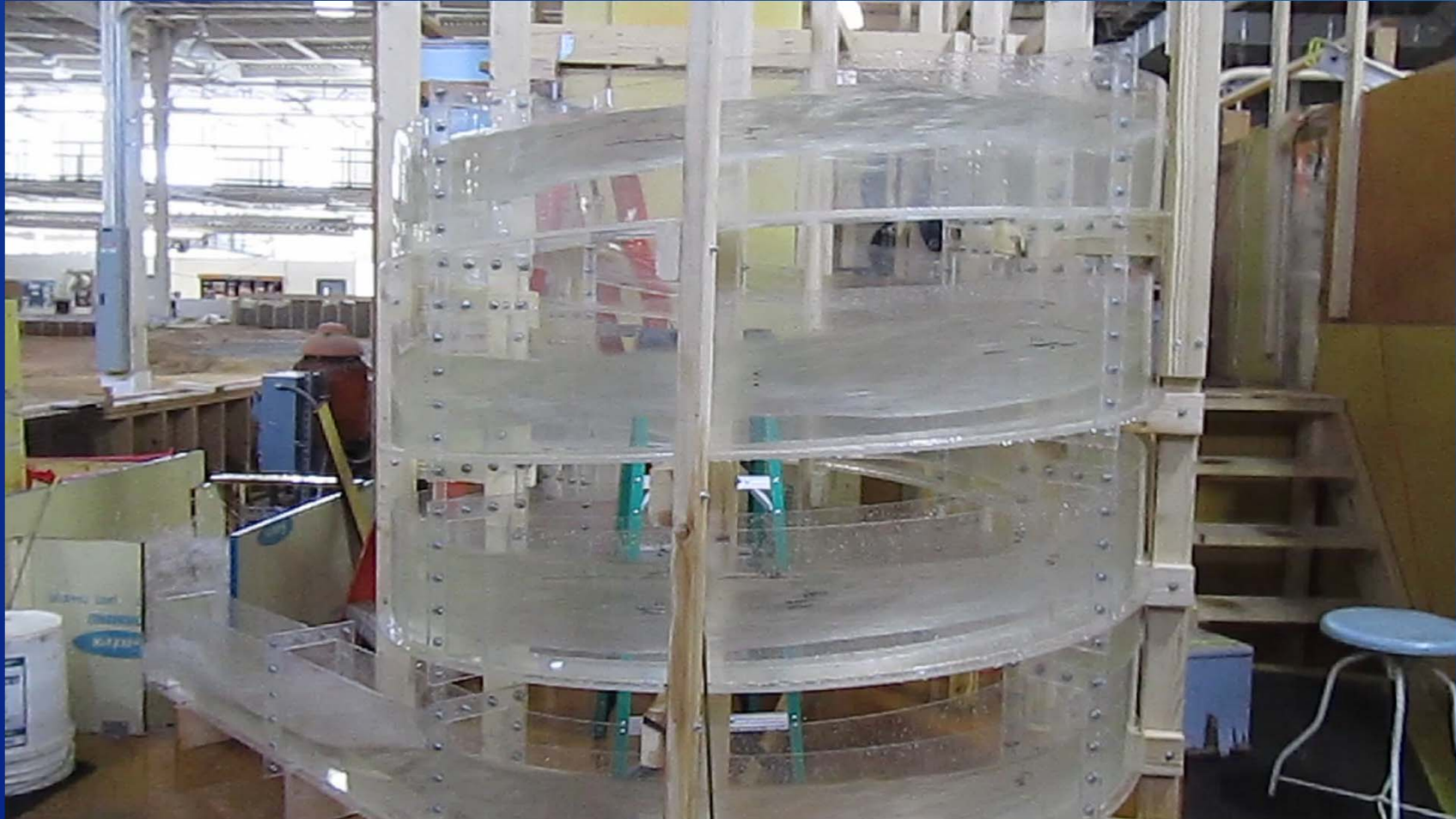


Helix operating at 300 ft³/s



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Helix operating at 400 ft³/s



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Beads at 300ft³/s

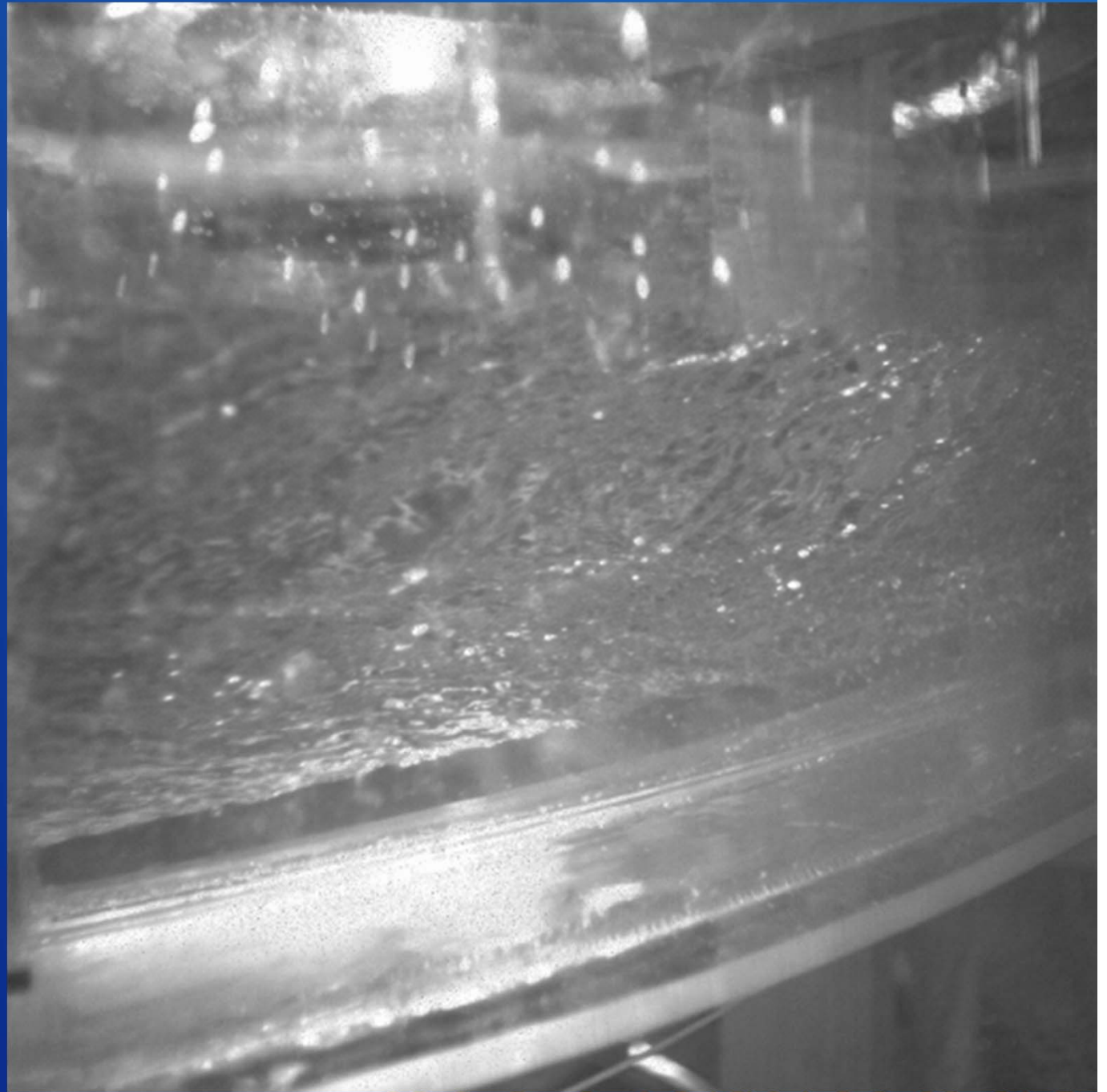


String Loop 2 at 400 ft³/s



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**2 inch trout at
300 ft³/s - 2**



RECEIVATION

2 inch trout at 300 ft³/s - 3



RECLAMATION

2 inch trout at 400 ft³/s - 4

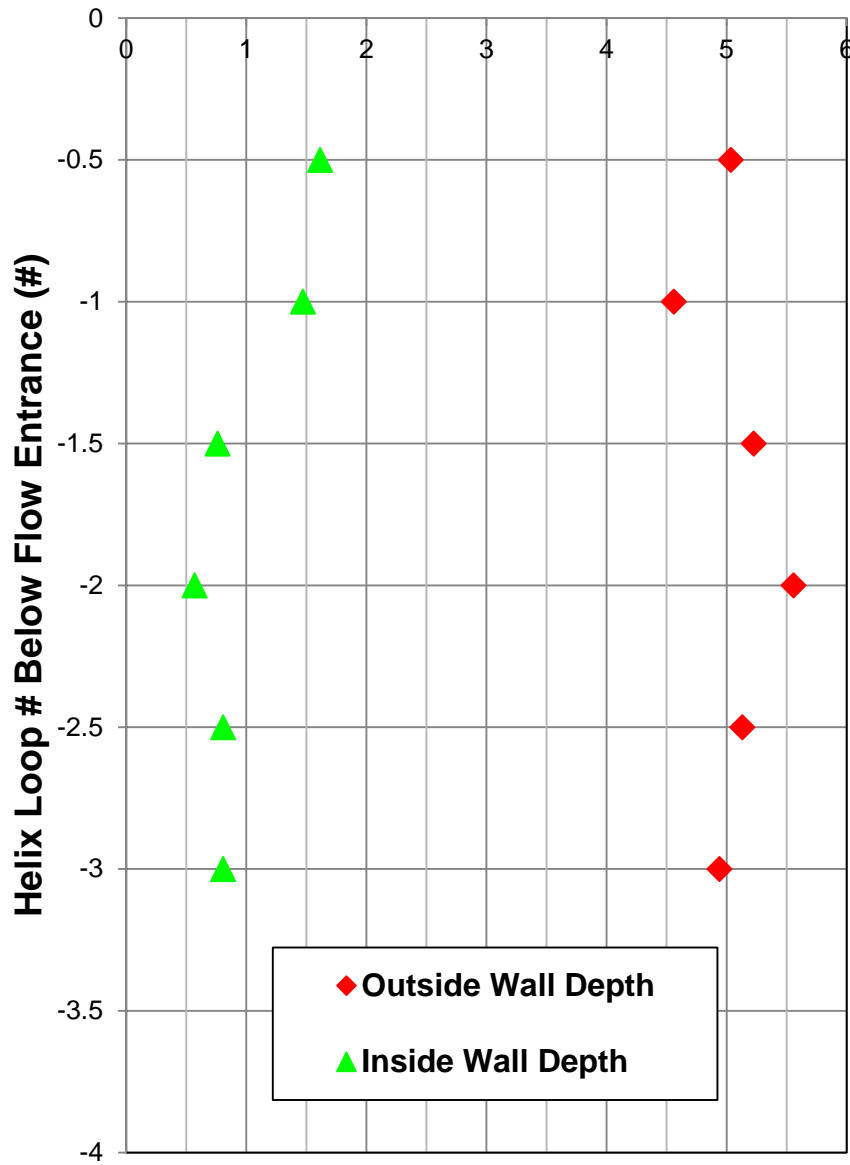


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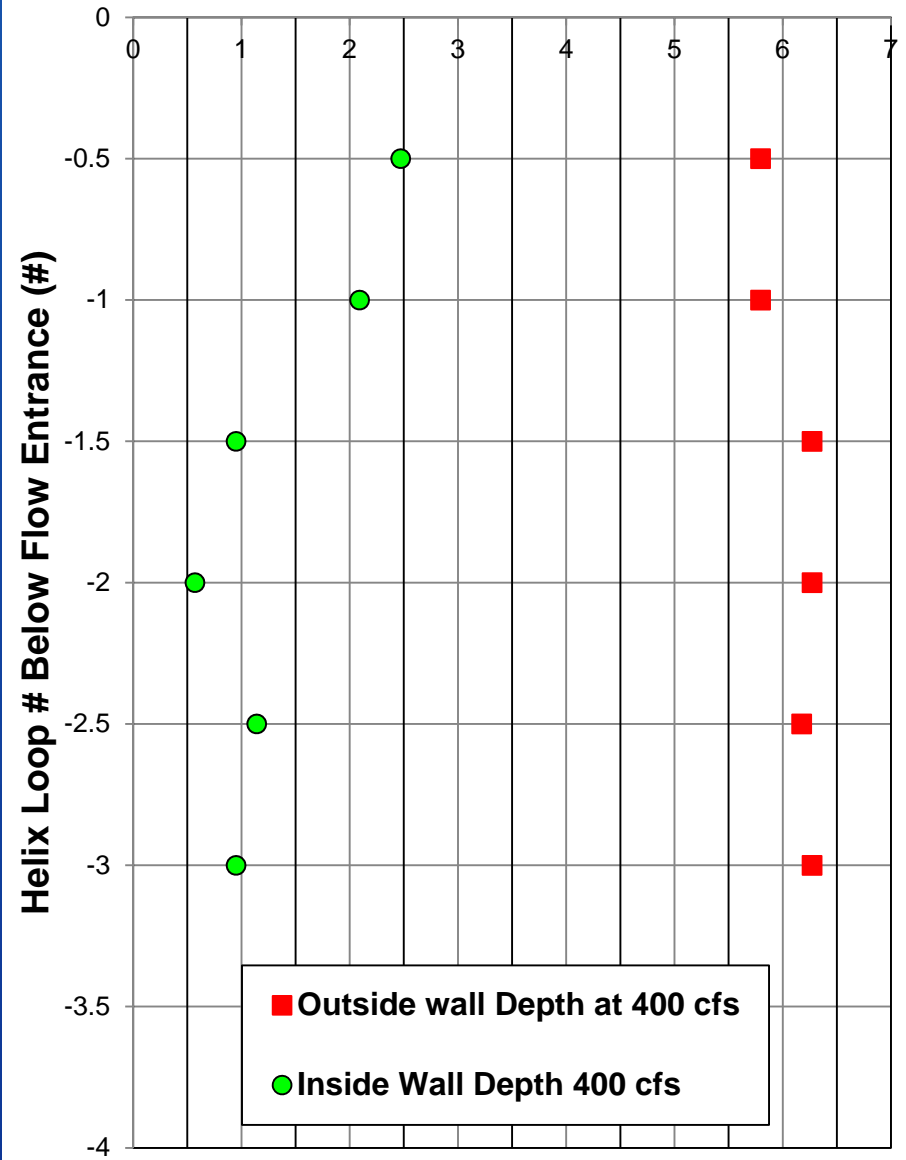
2 inch trout at 400 ft³/s - 5



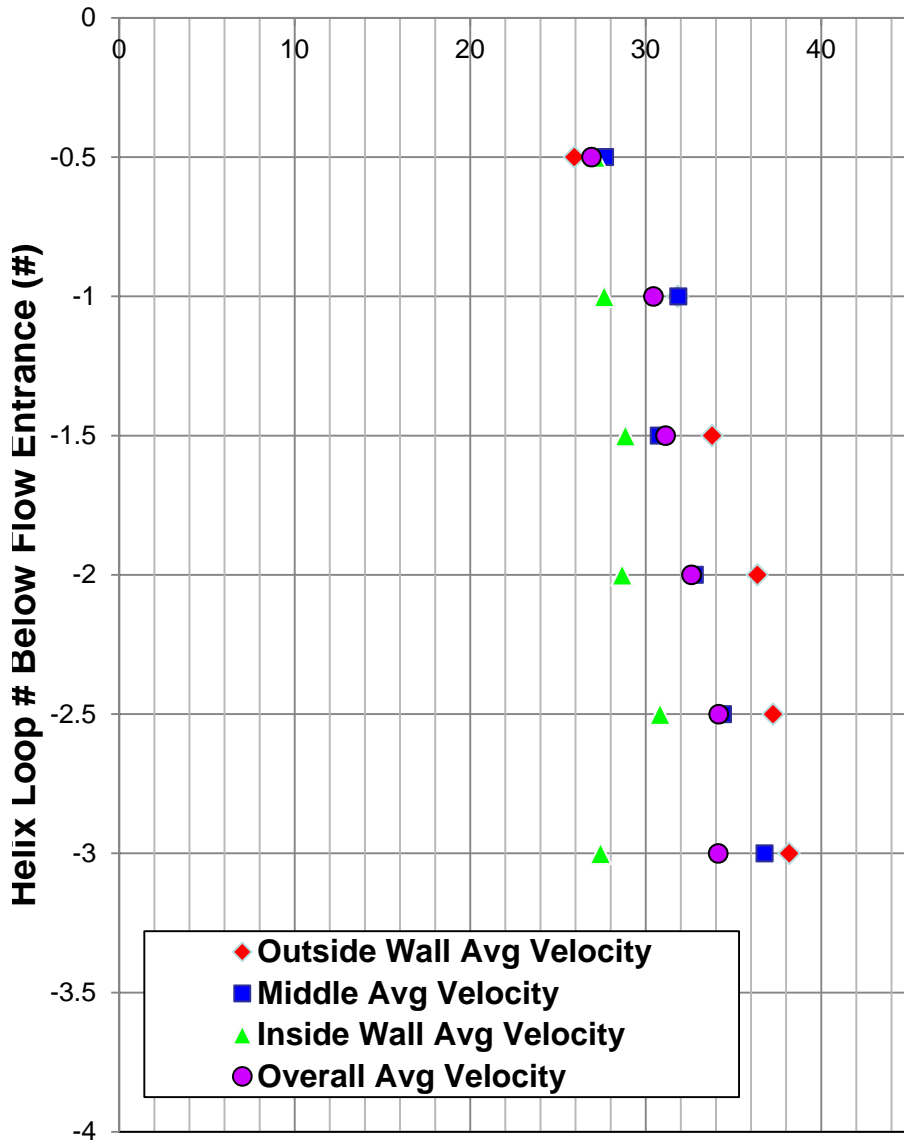
Flow Depth at 300 ft³/s (ft)



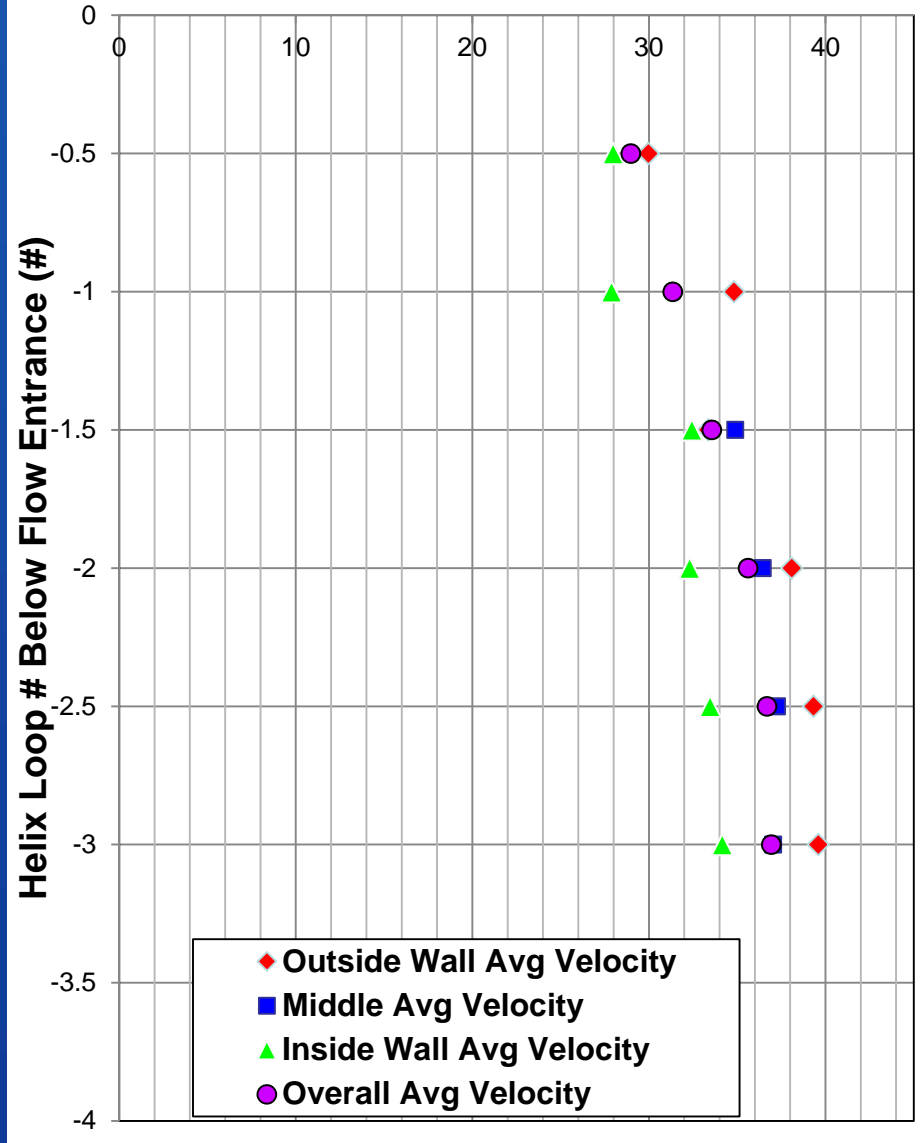
Flow Depth at 400 ft³/s (ft)



Average Velocity at 300 ft³/s (ft/s)



Average Velocity at 400 ft³/s (ft/s)



Wall of Death Daredevil Motorcycle Stunt Riders



© Rod Kirkpatrick/F Stop Press

(It feels like “down” is towards the wall)

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Next Steps

- Refine inlet structure design
- Refine Helix transitions
- Final Design completion 6/30/2015
- Construction begins Nov 2015?



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Acknowledgments



Special Thanks to:

- Yakama Nation: Mark Johnston, Brian Saluskin, Dave Fast
- NMFS: Bryan Nordlund, Sean Gross, Jeff Brown
- Yakima Basin Joint Board: David Child (the YBJB represents the major irrigation districts)
- WA State Department of Fish & Wildlife (WDFW): Bruce Heiner, John Easterbrooks
- WA State Department of Ecology: Derek Sandison
- Bureau of Reclamation: Joel Hubble, Wendy Christensen, Brent Mefford, Jason Wagner, Steve Montague, Walter Larrick,

Questions?

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End

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