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High Head Bypass Study – Sensor Fish – Green Peter Dam, Oregon, 2017

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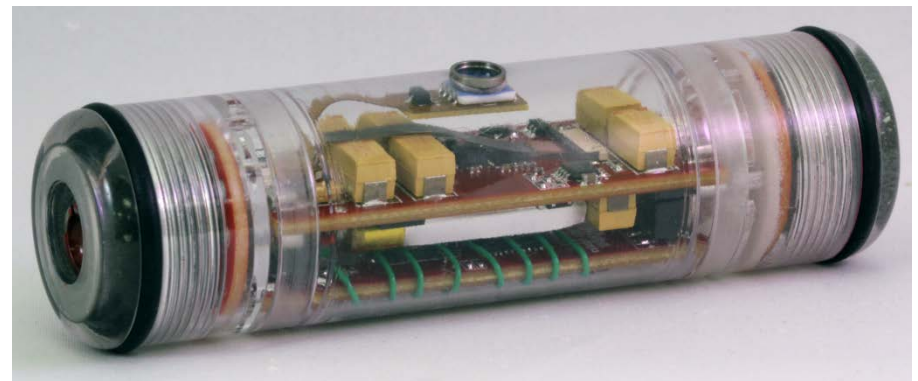
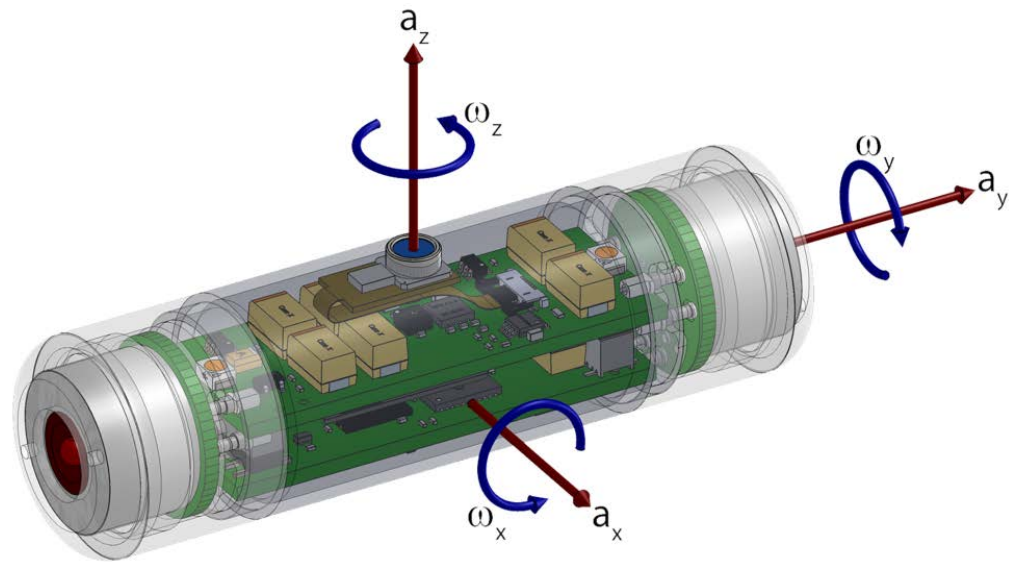
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The objectives of the study were to measure the hydraulic conditions at high forebay levels for the following test treatments:

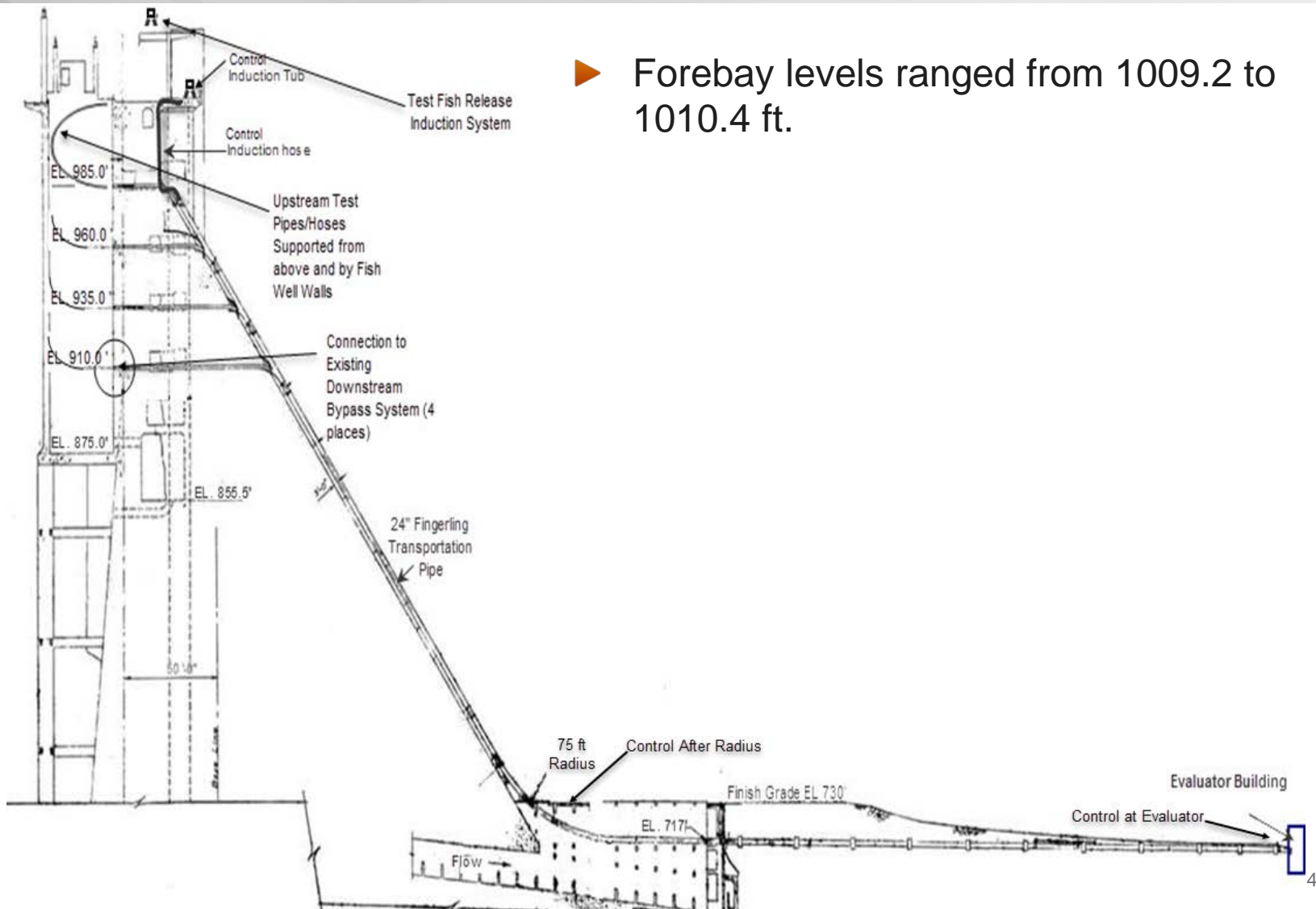
- ▶ One **full flow** level (valve 100% open) for releases at two bypass pipe elevations (935 and 910 ft);
- ▶ Two **partial flow** levels (75% and 50%) each with releases at the two bypass pipe elevations.

Gen 2 Sensor Fish Device

- ▶ Autonomous sensor package
- ▶ Developed to understand physical conditions fish experience
- ▶ Sensor Fish Characteristics
 - Dimensions: 89.9 x 24.5 mm
 - Density: 1.01 mg/mm³
 - Excess mass (wet weight): 0.5 g
 - Sampling rate: 2048 Hz
 - Maximum sampling time: 4 min
 - 3D acceleration: 0 - 200 g
 - 3D rotational velocity: 0 - 2000 °/s
 - Pressure: 0 - 203 psia
 - Temperature sensor: -40 - 125 °C
 - 3D orientation
 - Automatic floatation system
 - Built-in RF-transmitter
 - Significantly reduced cost



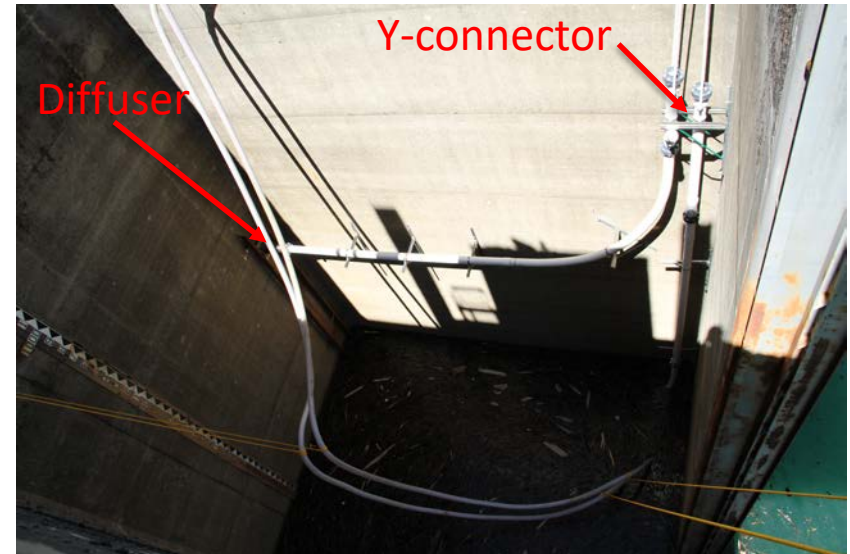
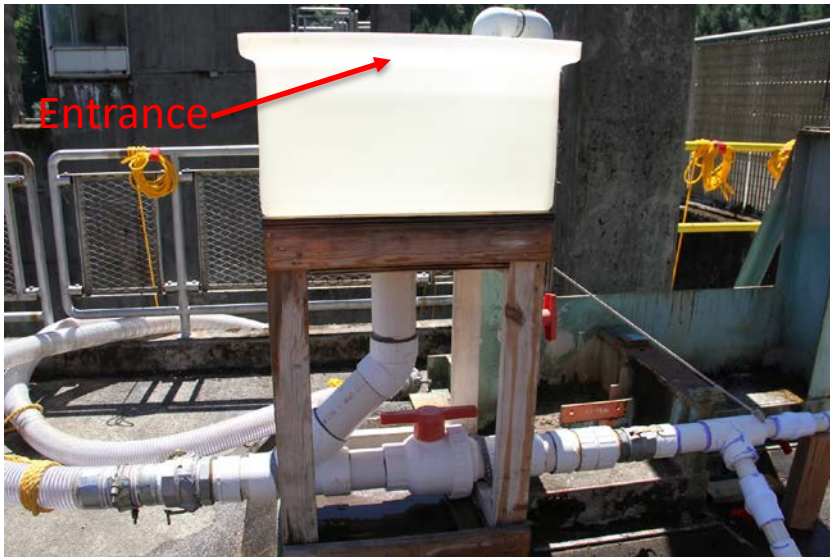
Passage through the Green Peter Dam Downstream Migrant Bypass Pipes to the Fish Evaluator.



- Forebay levels ranged from 1009.2 to 1010.4 ft.

Methods and Deployment

- ▶ Sensor Fish were introduced through the same release pipes used by Normandeau for releasing juvenile Chinook salmon and steelhead.
- ▶ Sensor Fish releases were interspersed among live fish releases.
- ▶ Following deployment, Sensor Fish were recovered from the evaluator facility.



Control Releases

- ▶ Evaluator building (right), Injection Control System (below).



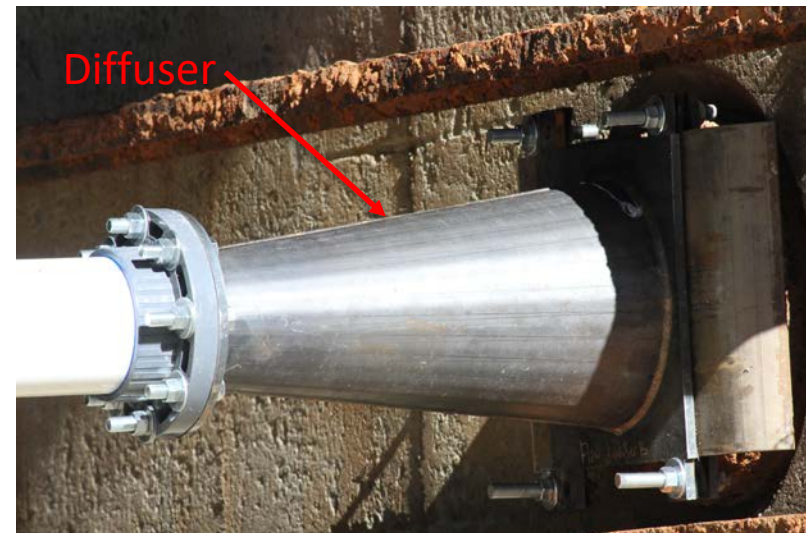
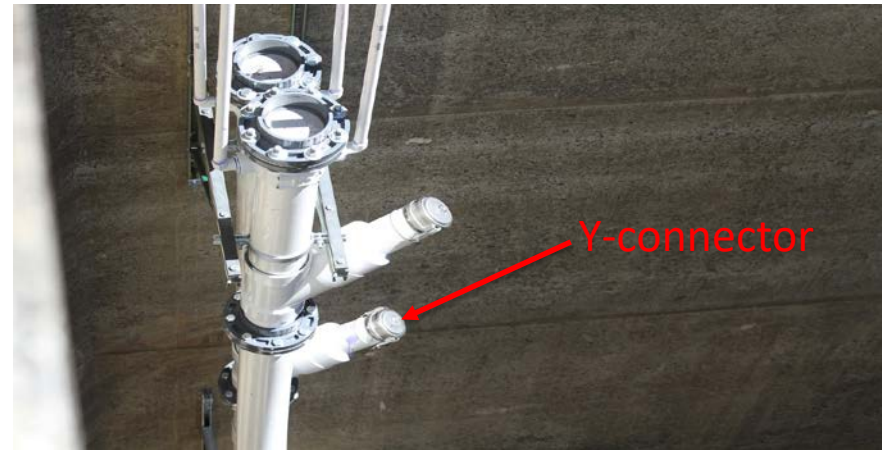
Methods and Deployment: Treatments

Elevation/Location	Gate Valve Position	Valid Releases
910	100% Open	69
935	100% Open	56
910	75% Open	53
935	75% Open	53
910	50% Open	56
935	50% Open	56
Control—Evaluator	N/A	38
	Total	381

Results: Timing Marks

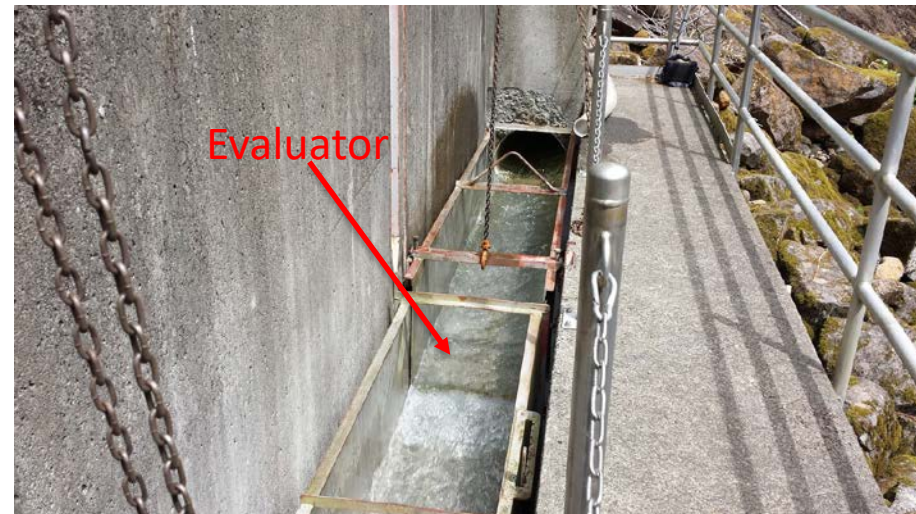
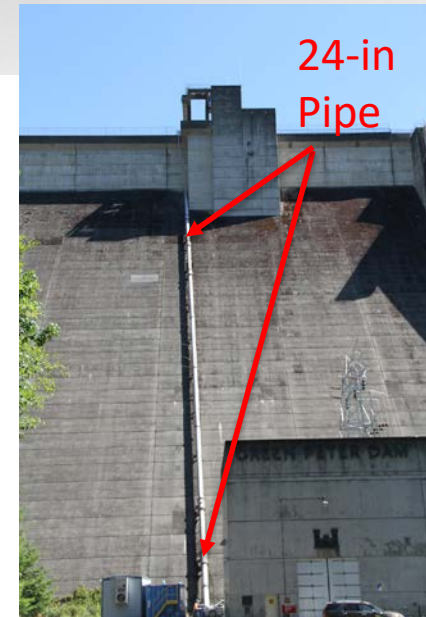
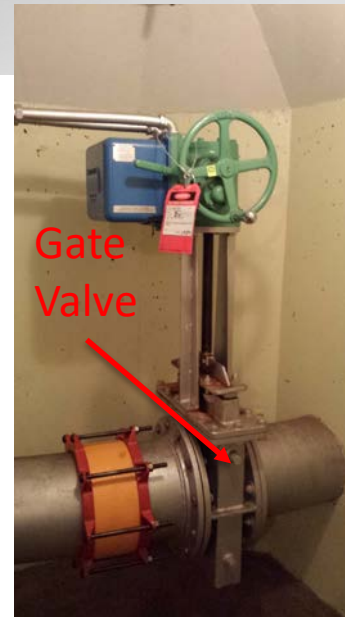
Timing marks were added to each data file, separating the passage route into six regions:

- ▶ Entrance: Sensor Fish entry to the injection system.
- ▶ Y-connector: The system was designed to convey flow to supplement the injection system by allowing flow at depth to enter via a 4-in. pipe.
- ▶ Diffuser: The diffuser connected the 4-in. pipe to a 12-in. pipe, increasing the cross-sectional area of the flow.

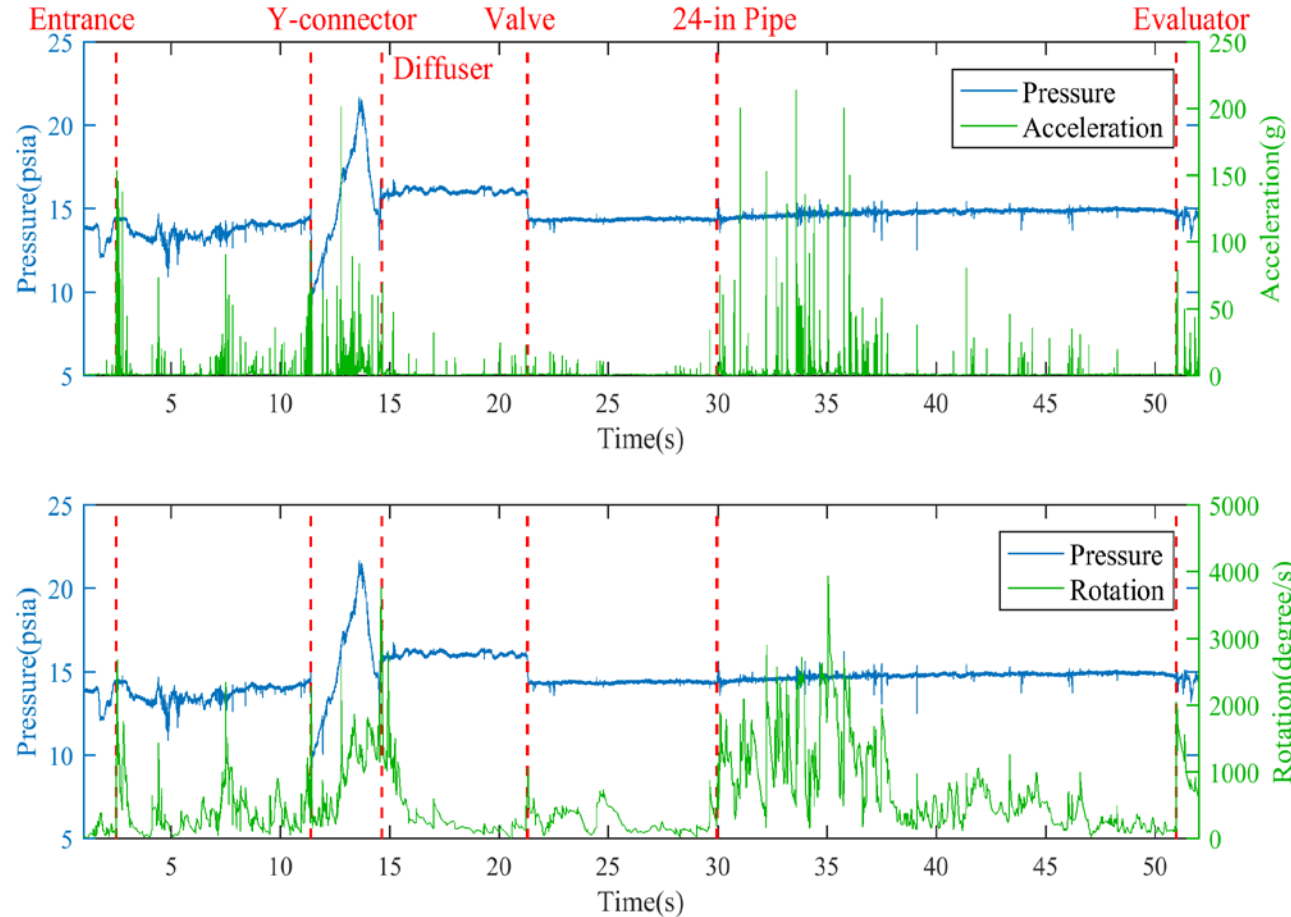


Results Timing Marks

- ▶ Gate Valve: A knife-valve controlled the flow for the treatments. At the 50% open position, a sudden decrease in pressure and a sharp increase in rotation was visible. At the 100% and 75% open valve position, little difference was seen in pressure or rotation before or after the valve and the timing mark was estimated by assessing the sensor data and time.
- ▶ 24-in. Pipe: Entrance to this region was marked as having a small increase/tremor in pressure with concurrent increases in acceleration and rotation.
- ▶ Evaluator: Rotation, acceleration, and a fluctuation in pressure are typical of entrance into this evaluator as the Sensor Fish collides with the metal screens.

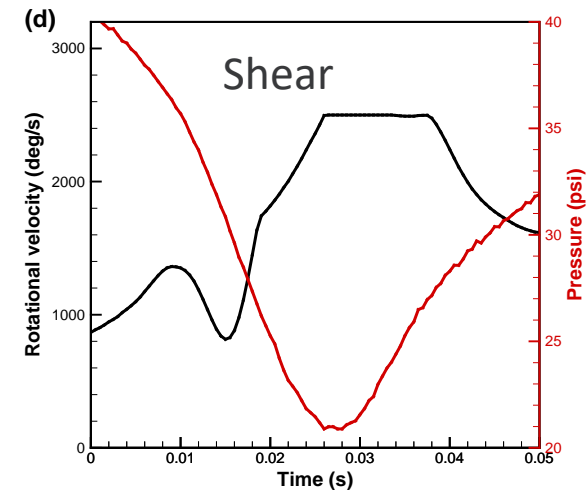
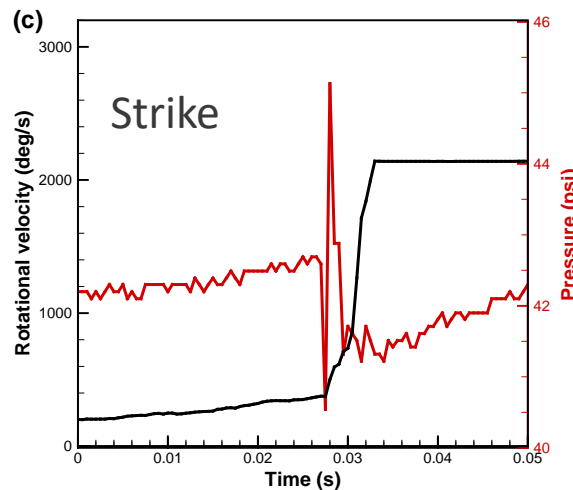
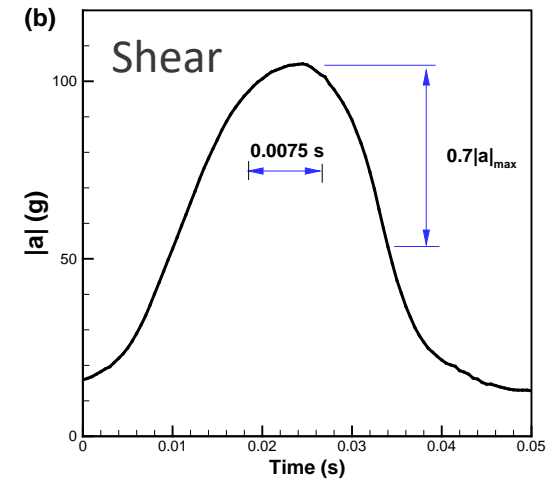
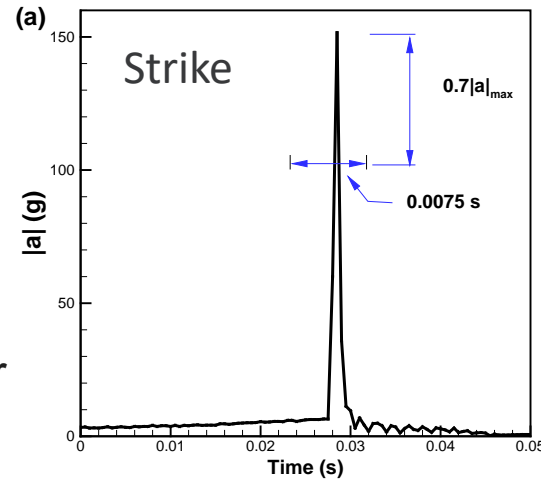


Passage Example: 910 ft Elevation, 50% Gate Valve Opening



Shear and Strike: Definitions

- ▶ **Strike:** Duration of acceleration within 70% of the peak value is less than 0.0075s.
 - Increases in pressure and rotation are more evident for strike than for shear.
- ▶ **Shear:** Duration of acceleration within 70% of the peak value is greater than 0.0075s.
- ▶ Severe event is defined as an acceleration exceeding 95g (932 m/s²).

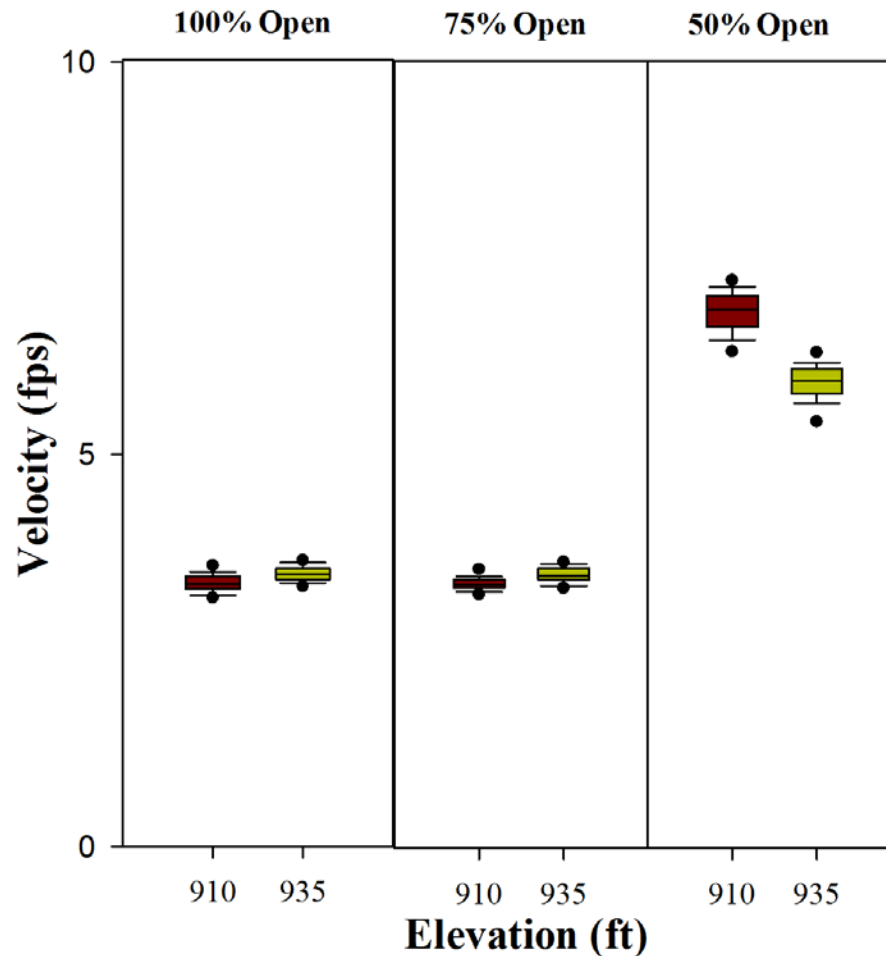


Average Passage Times and Velocities from the Entrance to the Evaluator

Gate Valve Setting	Elevation (ft)	Travel Time (s)	Velocity (ft/s)
100% Open	910	62.2	12.0
	935	56.9	13.1
75% Open	910	66.5	11.2
	935	58.4	12.8
50% Open	910	48.0	15.6
	935	47.4	15.7

Passage Velocity

- ▶ Velocities for most of the regions were similar, with the exception of the time from the diffuser to the 24-in. pipe, which was significantly higher for the 50% open valve condition.



Sensor Fish Severe Events by Treatment and Passage Region

Gate-Valve Setting	Elevation (ft)	Valid Releases	Entrance to Y-Connector	Y-connector to Diffuser	Diffuser to Gate Valve	Gate Valve to 24-in. Pipe	24-in. Pipe
100% Open	910	69	100%	96%	22%	7%	100%
75% Open	935	56	100%	91%	16%	0%	100%
50% Open	910	53	100%	94%	36%	2%	100%
	935	53	100%	92%	19%	0%	100%
	910	56	100%	91%	21%	16%	100%
	935	56	100%	95%	20%	9%	100%

P-values comparing Gate Valve Settings

910 ft

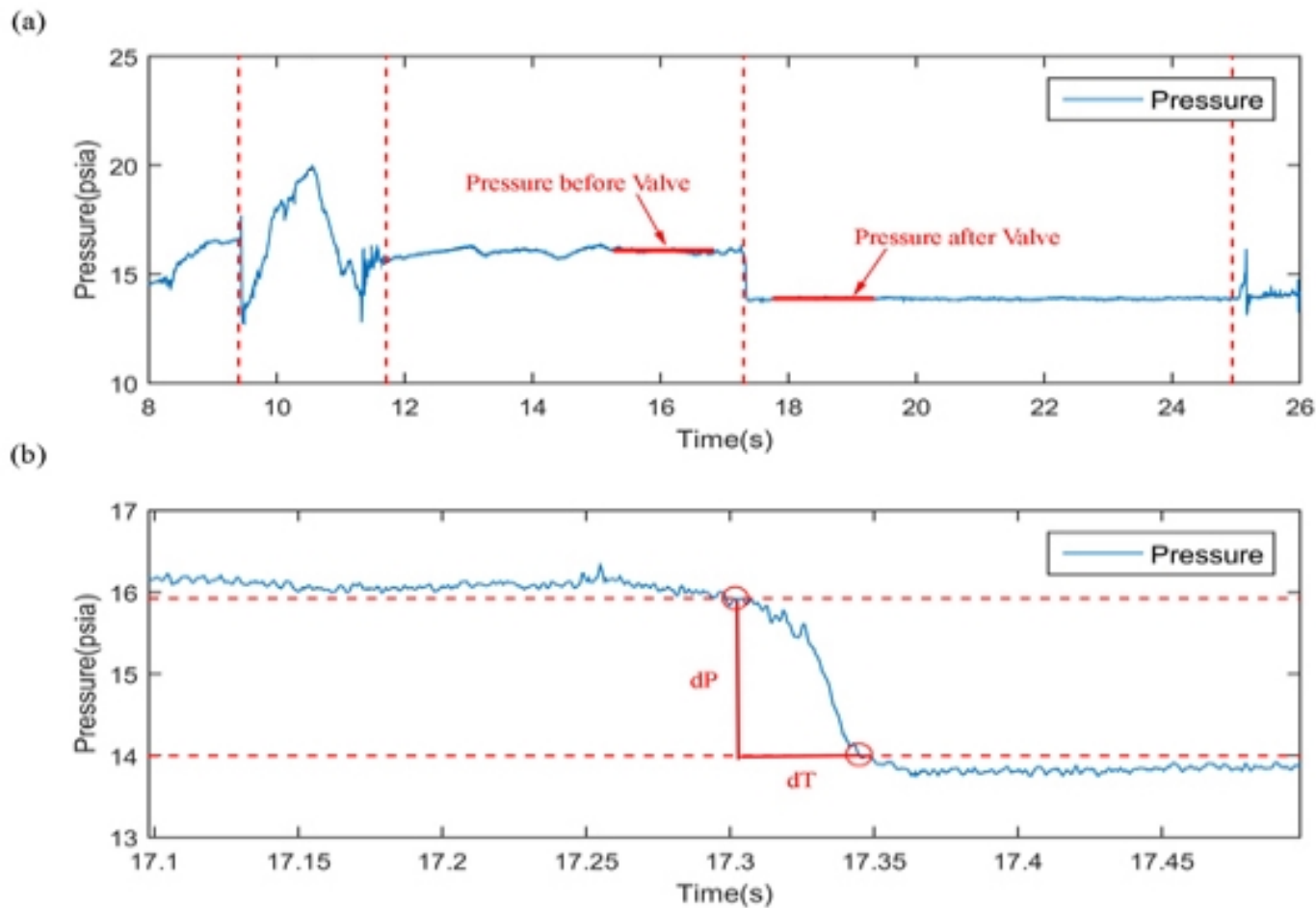
	100% Open	75% Open	50% Open
100% Open	-	0.232	0.156
75% Open	0.232	-	0.017
50% Open	0.156	0.017	-

935 ft

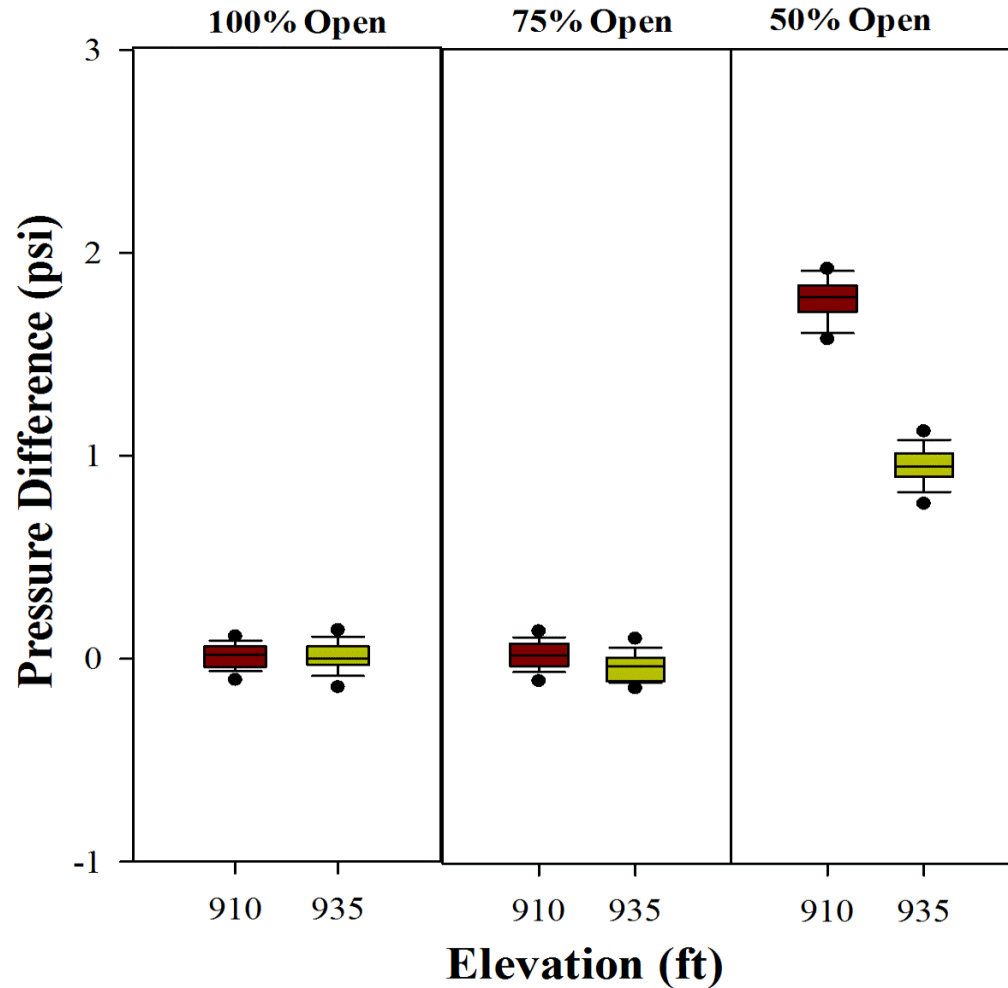
	100% Open	75% Open	50% Open
100% Open	-	1	0.057
75% Open	1	-	0.057
50% Open	0.057	0.057	-

Pressure drop at the gate valve

- ▶ Greatest pressure drops were observed during the gate valve region of passage when the valve was set at 50% open, but not near the barotrauma threshold



Median Pressure Differential during Gate Valve Passage



Sensor Fish Measurements and Live fish Injury Comparison

- ▶ Normandeau calculated survival and malady-free estimates adjusted using losses experienced from the control data for Juvenile Chinook Salmon and for YOY Steelhead.
- ▶ No significant correlations between Sensor Fish attributes and juvenile Chinook Salmon or YOY steelhead results (p-value > 0.05).
- ▶ Sensor Fish data showed that 935 ft elevation is better than 910 ft in the Diffuser to Gate Valve and Gate Valve to 24-in. Pipe regions, consistent with Juvenile Chinook Salmon results.

- ▶ Passage time was generally longer and average velocities were less for the 910 ft elevation treatments when compared with the 935 ft treatments.
- ▶ Gate valve opening can affect the hydraulic conditions in the passage region between the valve and the 24-in pipe:
 - At the 910 ft elevation there were more severe events at the 50% opening, with the difference being significant between 50% and 75%.
 - At the 935 ft elevation there were more severe events at the 50% opening but none of the differences were significant.
 - No significant difference was observed between the 75% and 100% openings.
- ▶ There was no significant correlation between Sensor Fish attributes and juvenile Chinook salmon or YOY steelhead results.

Acknowledgements

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