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High Head Bypass Study – Sensor Fish – Green Peter Dam, Oregon, 2016

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Objectives

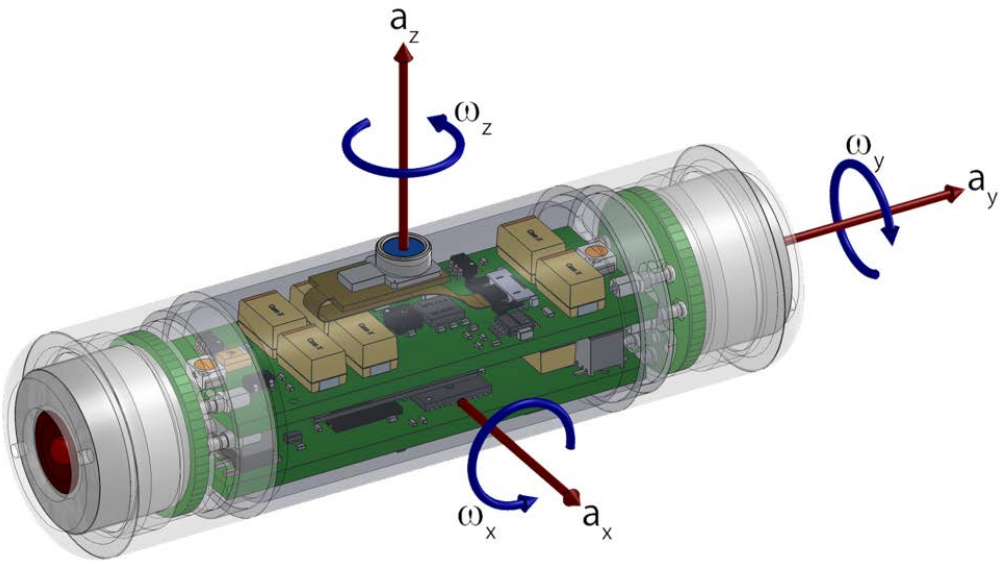
The objectives of the study were to measure the hydraulic conditions (pressures, accelerations, rotational velocities) for the following test treatments:

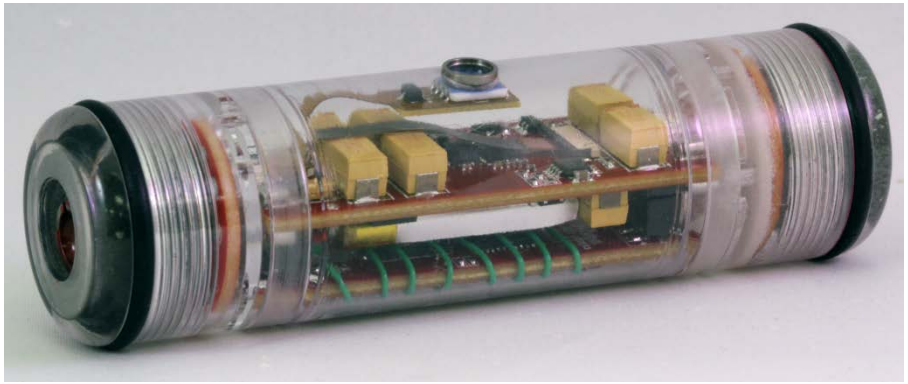
- One **full flow** level (valve 100% open) for releases at four bypass pipe elevations (985*, 960*, 935, and 910 ft);
- Three **partial flow** levels (75%, 50%, and 40%) each with releases at the four bypass pipe elevations.

*Due to the low forebay level (~990 ft), only the two lower elevations (911 ft and 935 ft) were evaluated in 2016.

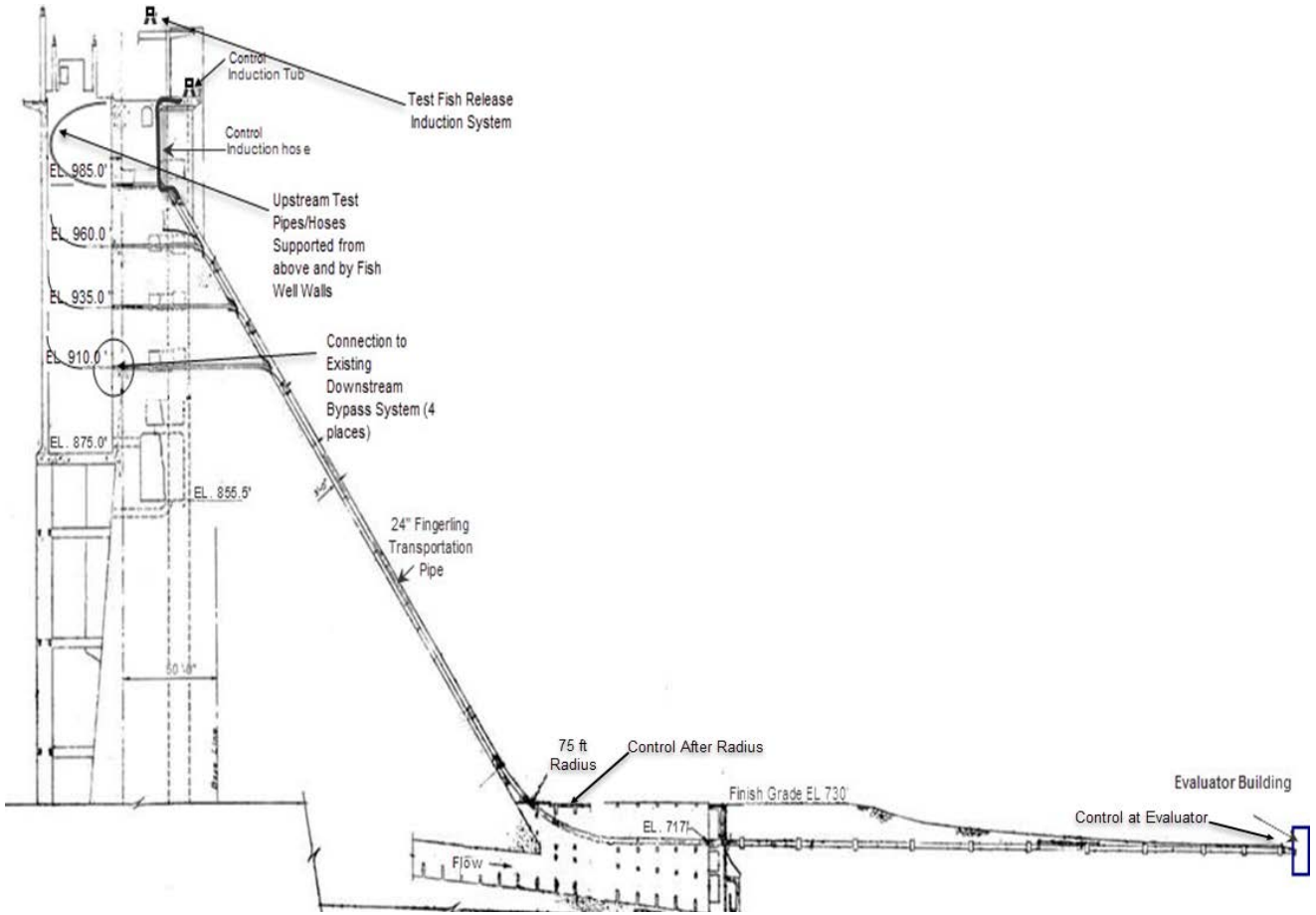
Gen 2 Sensor Fish Device

- 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



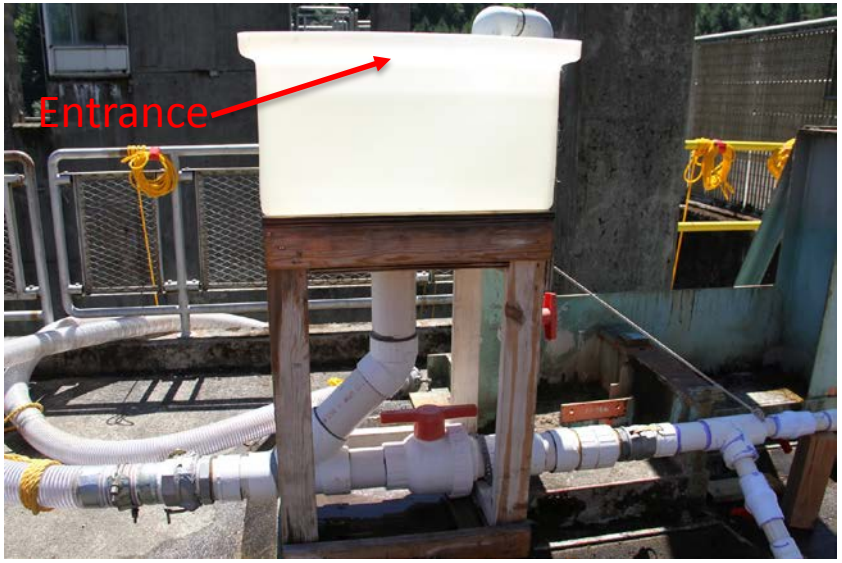


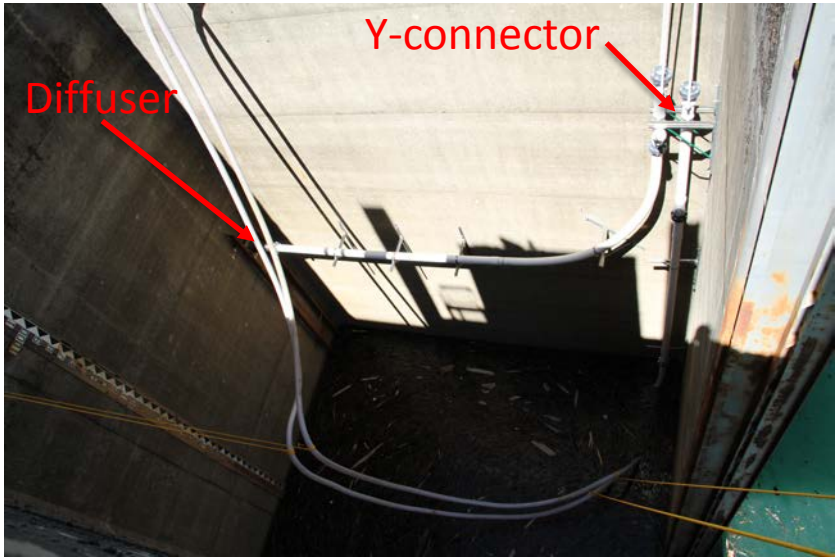
Passage through the Green Peter Dam Downstream Migrant Bypass Pipes to the Fish Evaluator



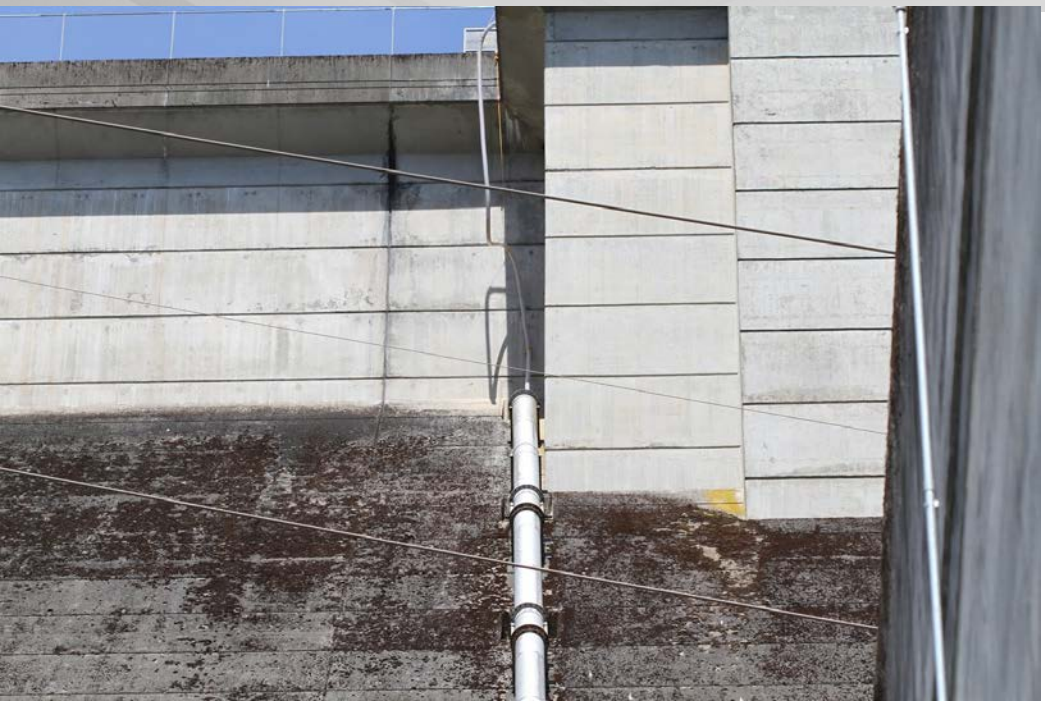
Methods and Deployment

- 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



- Above: Control injection at top of 24-in. Pipe.
- Right: Evaluator building, Injection Control System Exit (not shown).

Methods and Deployment: Treatments

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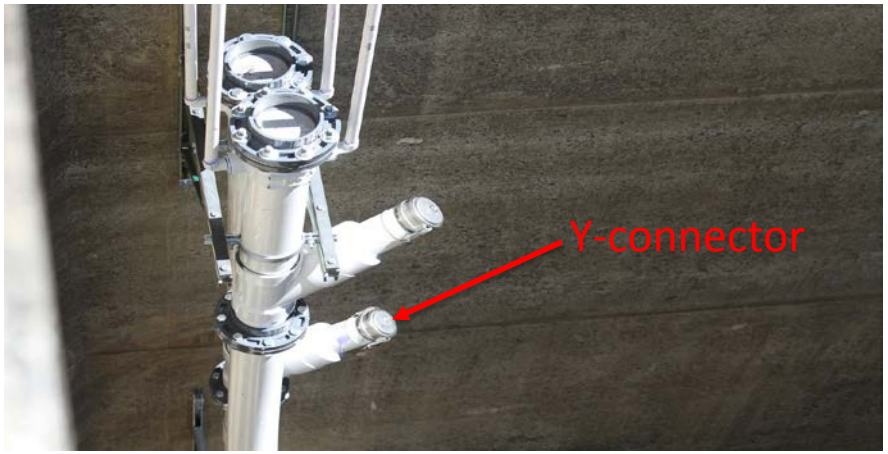
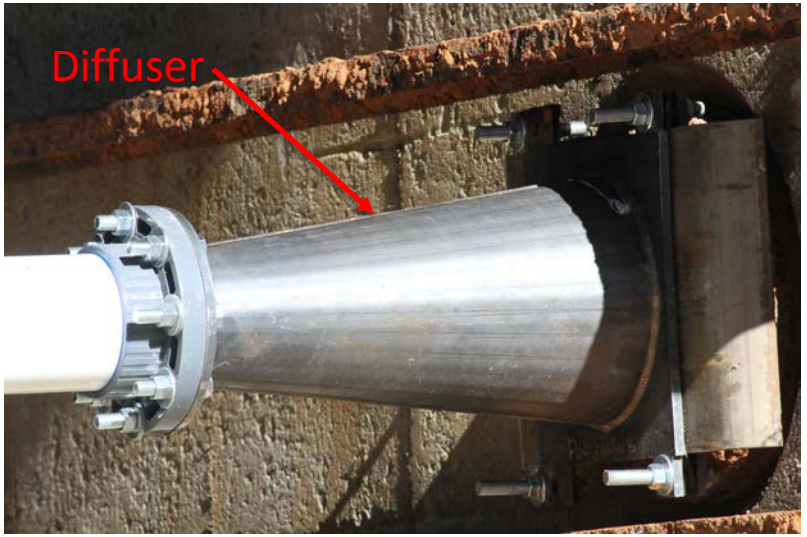
Elevation/Location	Gate Valve Position	Valid Releases
910	100% Open	49
935	100% Open	49
910	75% Open	40
935	75% Open	39
910	50% Open	51
935	50% Open	53
910	40% Open	44
935	40% Open	47
Control—Top of 24-in. Pipe	N/A	20
Control—Evaluator	N/A	2
	Total	394

Results: Timing Marks

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

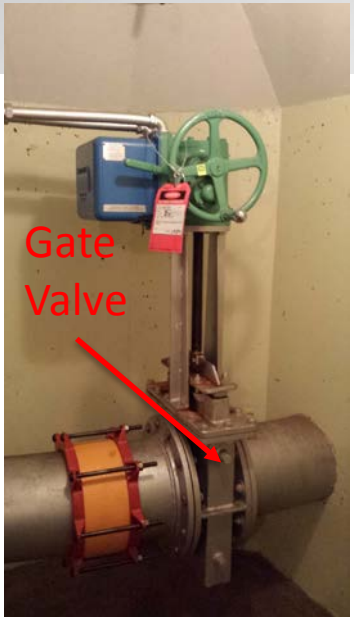
- Entrance: Sensor Fish entry to the injection system.
- Y-connector: The system was designed to convey flow to supplement the injection system by allowing flow at depth to enter via a 4-in. pipe.
- Diffuser: The diffuser connected the 4-in. pipe to a 12-in. pipe, increasing the cross-sectional area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

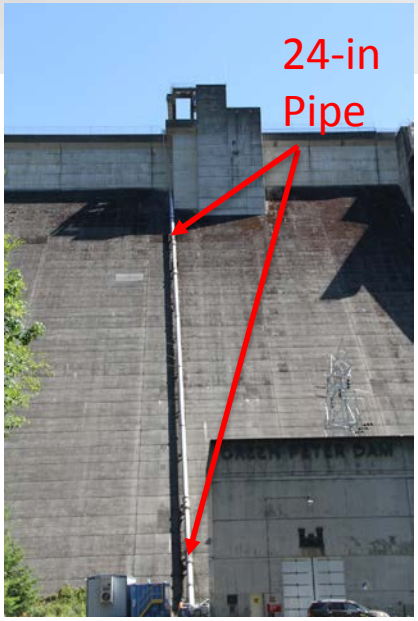




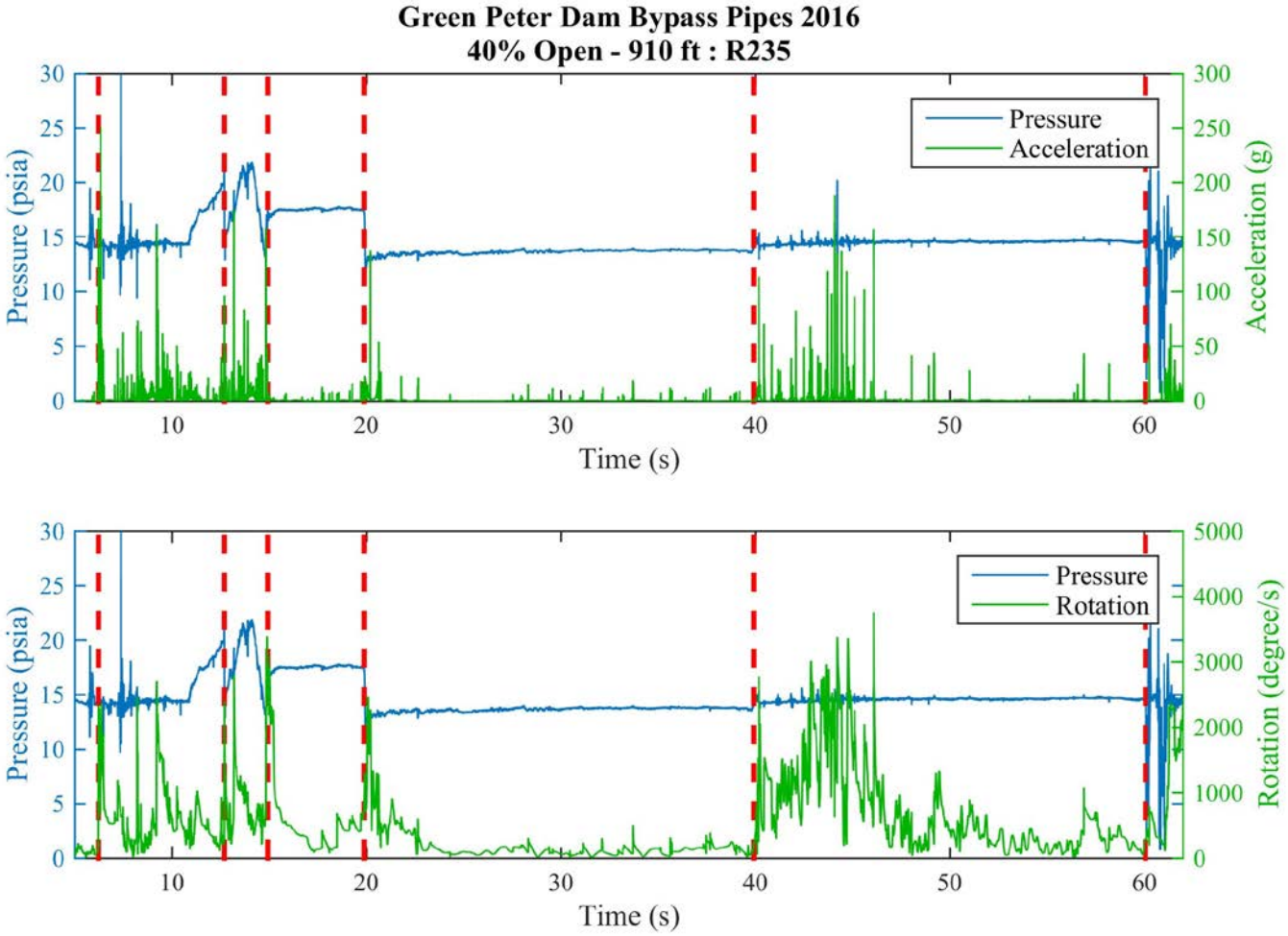
Results Timing Marks

- Gate Valve: A knife-valve controlled the flow for the treatments. At the 50% and 40% open positions, a sudden decrease in pressure and 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.



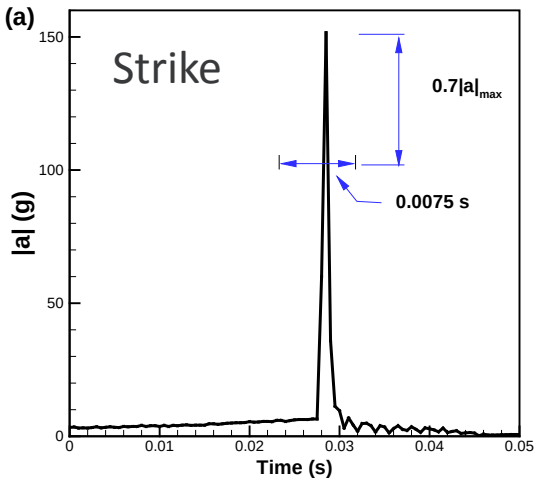


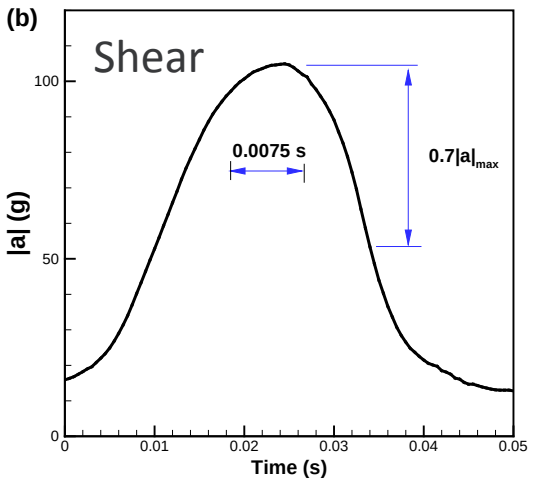
Passage Example:
910 ft Elevation and 40% Gate Valve Opening

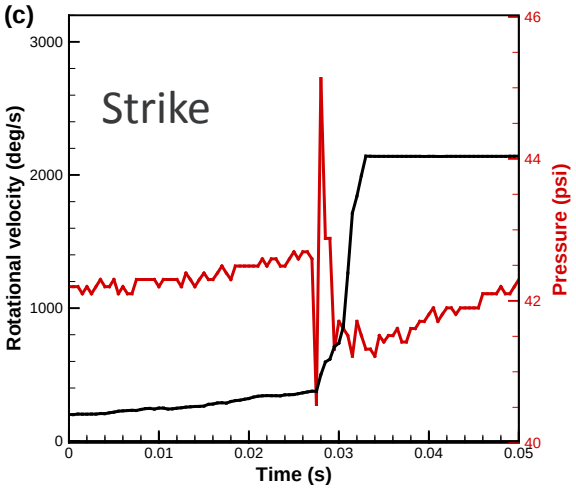


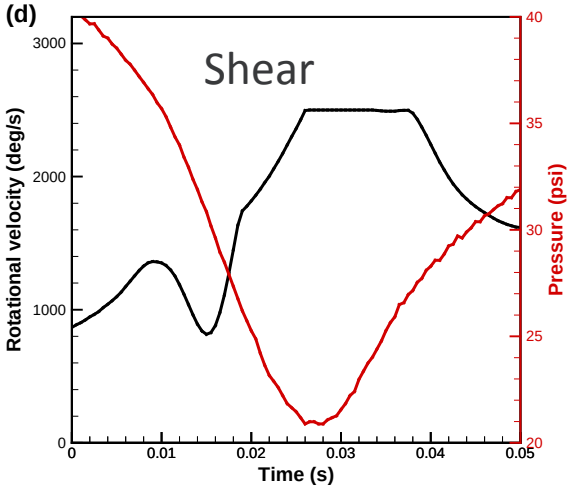
Shear and Strike: Definitions

- 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/s^2).







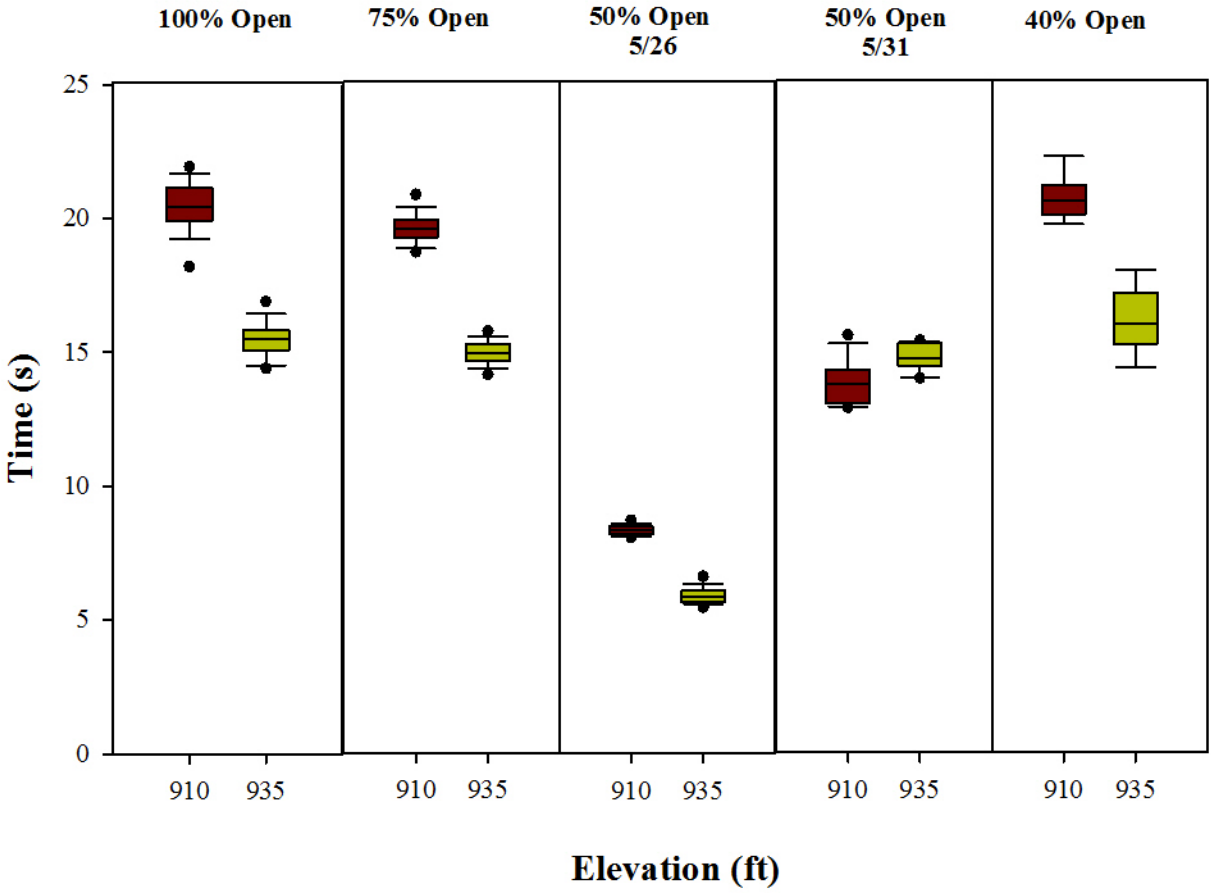


Average Passage Times and Velocities from the Entrance to the Evaluator

Gate Valve Setting	Elevation (ft)	Travel Time (s)	Velocity (ft/s)
100% Open	910	55.7	13.4
	935	51.1	14.6
75% Open	910	55.0	13.6
	935	51.3	14.5
50% Open 5/26	910	44.6	16.8
	935	42.8	17.4
50% Open 5/31	910	49.3	15.2
	935	50.9	14.7
40% Open	910	55.7	13.4
	935	53.6	13.9

Passage times in each region

- Passage times for most of the regions were similar, with the exception of the time from the valve to the 24-in. pipe, which was significantly less 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	49	100	92	18	**2**	100
	935	49	100	86	22	**0**	100
75% Open	910	40	100	95	20	**5**	100
	935	39	100	79	8	**0**	100
50% Open	910	39	100	85	8	21	100
	935	41	98	80	12	2	100
50% Open 5/31	910	12	100	75	17	8	100
	935	12	100	92	33	0	100
40% Open	910	44	98	91	32	**66**	100
	935	47	98	72	15	**83**	98
Control – Top Deck							100

P-values for comparing data for releases with severe events between every two treatments in the passage region between the valve and the 24-in pipe

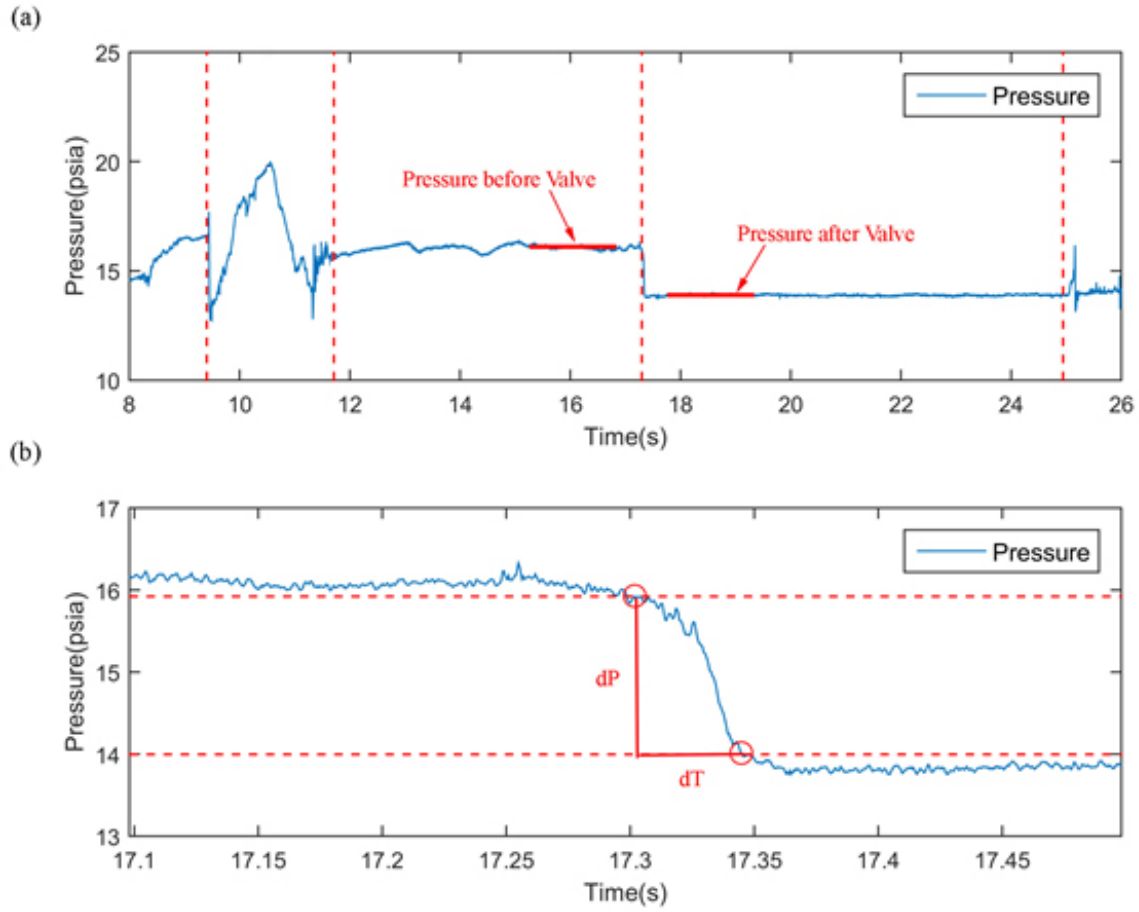
910 ft

	100% Open	75% Open	50% Open 5/26	50% Open 5/31	40% Open
100% Open	-	0.586	0.009	0.357	<0.001
75% Open	0.586	-	0.048	0.553	<0.001
50% Open 5/26	0.009	0.048	-	0.666	<0.001
50% Open 5/31	0.357	0.553	0.666	-	<0.001
40% Open	<0.001	<0.001	<0.001	<0.001	-

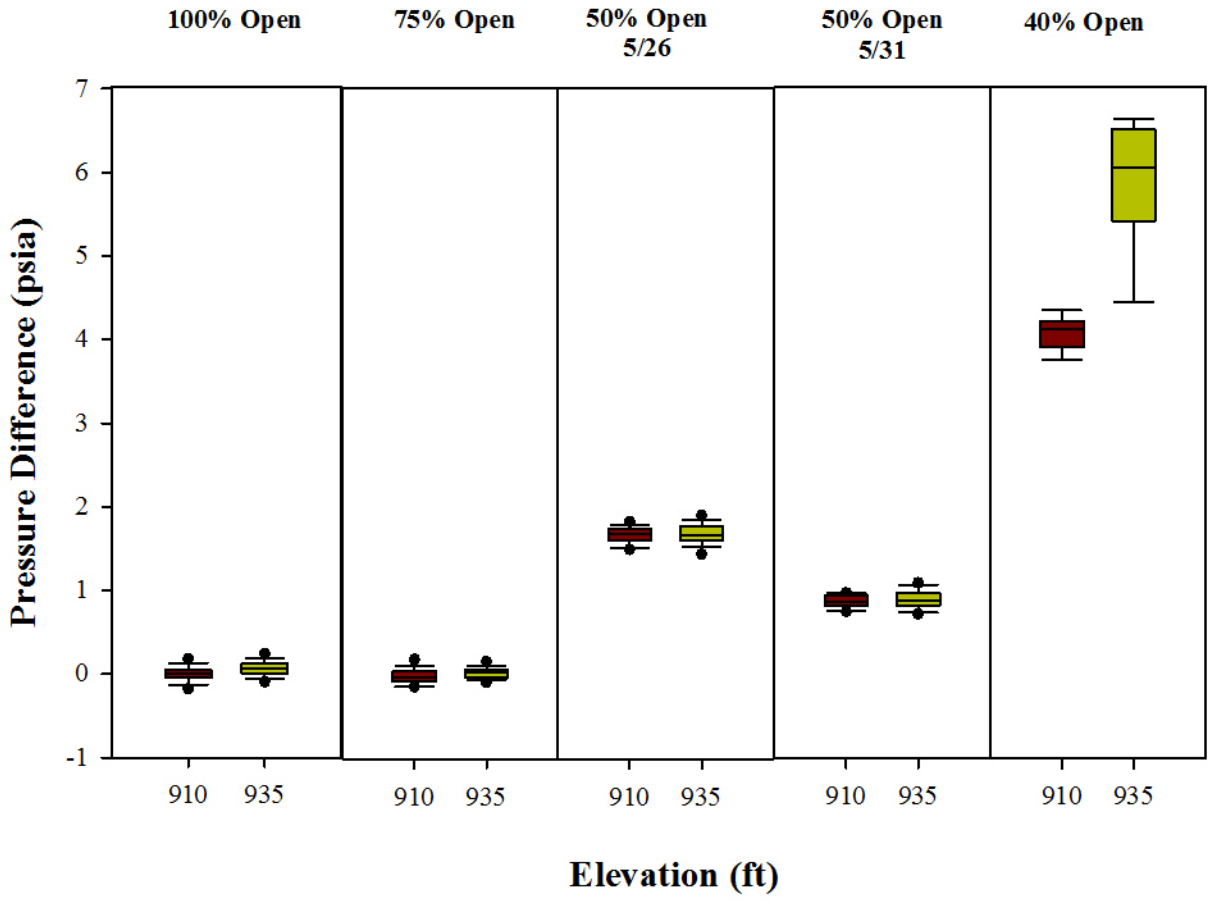
935 ft

	100% Open	75% Open	50% Open 5/26	50% Open 5/31	40% Open
100% Open	-	1	0.456	1	<0.001
75% Open	1	-	1	1	<0.001
50% Open 5/26	0.456	1	-	1	<0.001
50% Open 5/31	1	1	1	-	<0.001
40% Open	<0.001	<0.001	<0.001	<0.001	-

The greatest pressure drops were observed during the gate valve region of passage when the valve was set at 40% open, but not close to barotrauma threshold

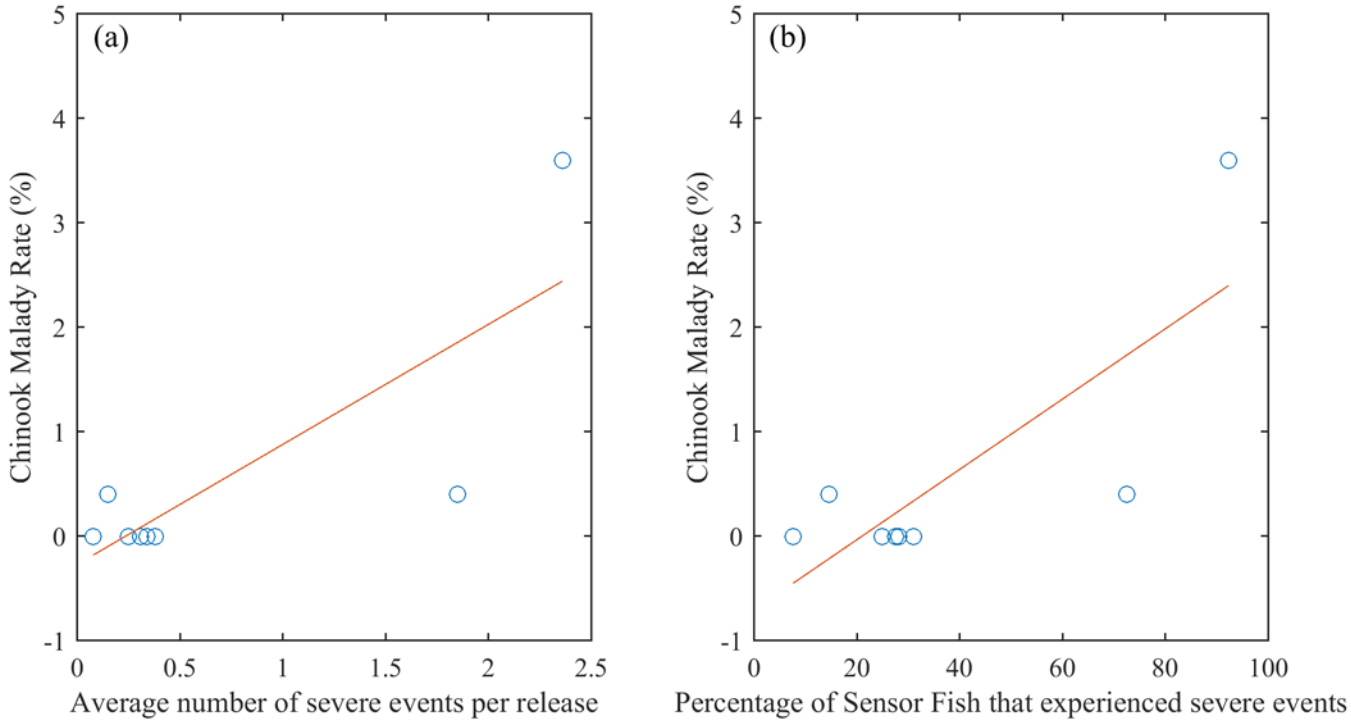


Median Pressure Differential during Gate Valve Passage



Sensor Fish Measurements and Live fish injury comparison

- No significant correlations with juvenile or YOY steelhead results (p-value > 0.05).
- Significant linear correlation (r = 0.81; p-value = 0.016) between the average number of severe events experienced by the Sensor Fish in the 12-in. pipe and the Chinook salmon malady rate, as well as between the percentage of Sensor Fish that experienced severe events in the 12-in. pipe and the Chinook salmon malady rate (r = 0.79 and p-value = 0.019).



Summary

- 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:
  - 40% opening has significantly more severe events than other openings (50%, 75%, 100%).
  - No significant difference was observed between the 75% and 100%, indicating the best hydraulic condition in the passage region would be achieved when the gate valve is opened 75% or more.
- There is a significant linear correlation between Sensor Fish severe events in the 12-in. pipe and the Chinook salmon malady rate but no significant correlations with between Sensor Fish and Steelhead results.

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