



Willamette Valley High Head Bypass Downstream Passage Prototype Evaluation: Sensor Fish Evaluation of Bypass Pipes at Green Peter Dam, 2015

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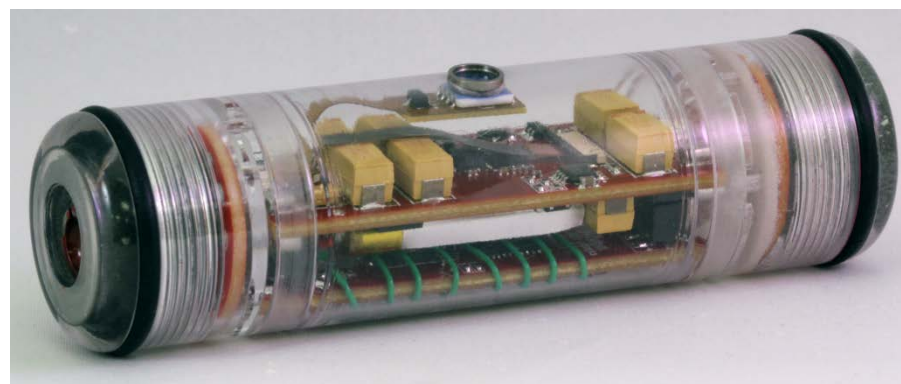
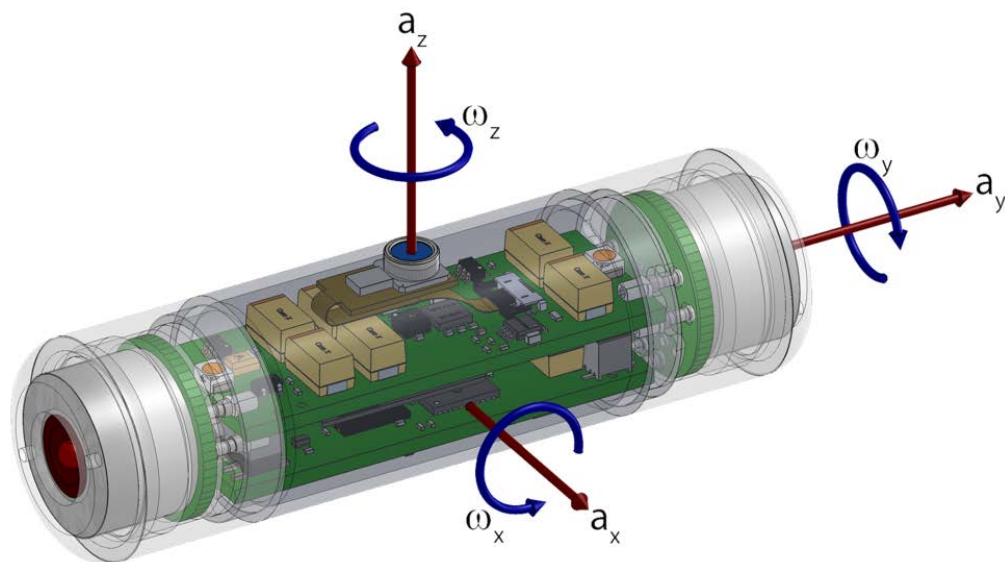
The objectives of the study were to describe and compare hydraulic conditions for passage through the downstream migrant bypass pipes operated at:

- ▶ Full flow at four bypass pipe elevations*;
- ▶ Three partial flow levels, each at four bypass elevations.*

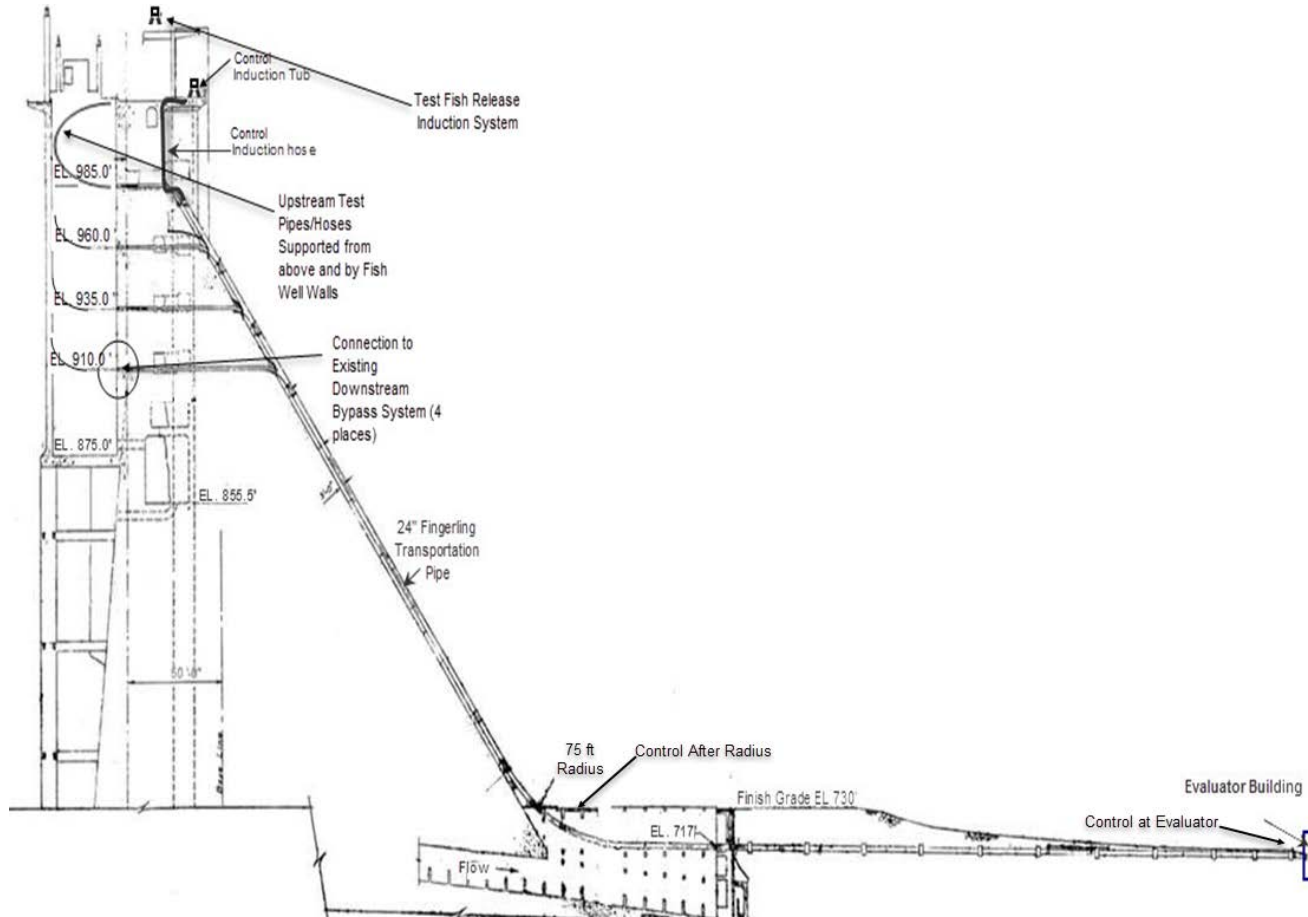
*Due to forebay conditions, only the lower two elevations were evaluated in 2015; Testing of all elevations may be conducted at a later date

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

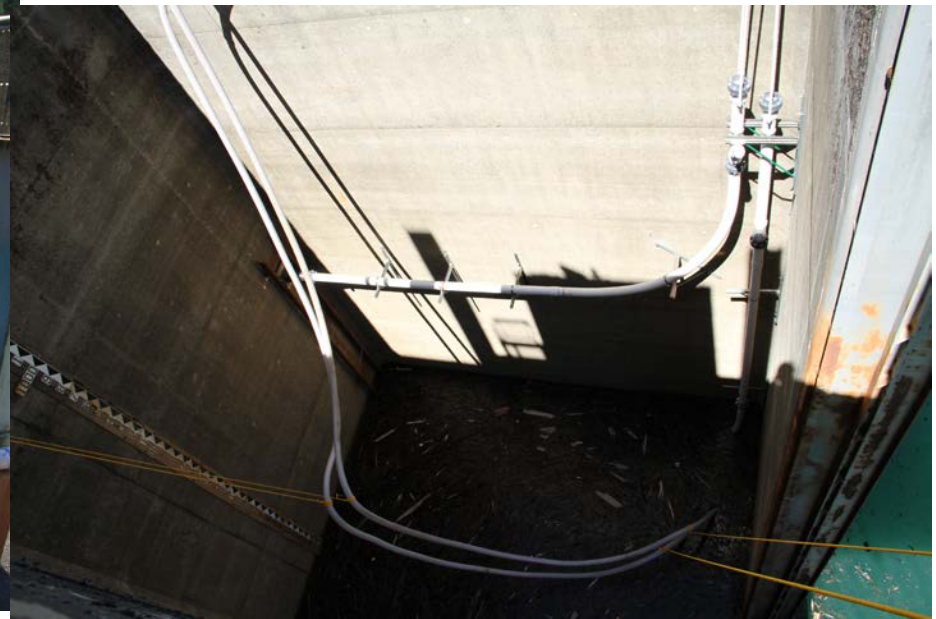


Passage through the Green Peter Dam Downstream Migrant Bypass Pipes to the Fish Evaluator

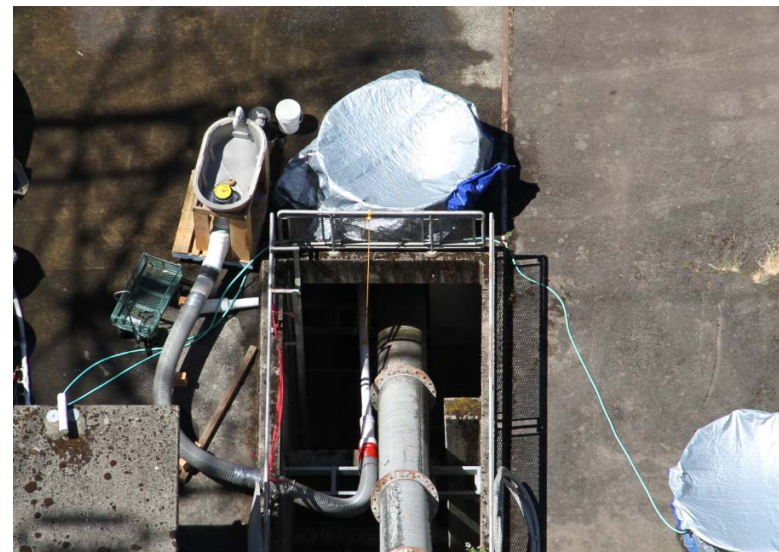


Methods and Deployment

- ▶ 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-Upper: Evaluator building, Injection Control System Exit (not shown)
- ▶ Right-Lower: Mid-Pipe Control Injection

Methods and Deployment: Treatments

Elevation/Location	Gate Valve Position	Valid Releases
910	Full Open	38
935	Full Open	40
910	25% Closed	28
935	25% Closed	24
910	50% Closed	26
935	50% Closed	22
910	75% Closed	36
935	75% Closed	32
Control—Top of 24-in.Pipe	N/A	32
Control—Adjacent to Powerhouse Immediately Downstream of 75-ft Radius	N/A	4
Control—Evaluator	N/A	2
	Total	284

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



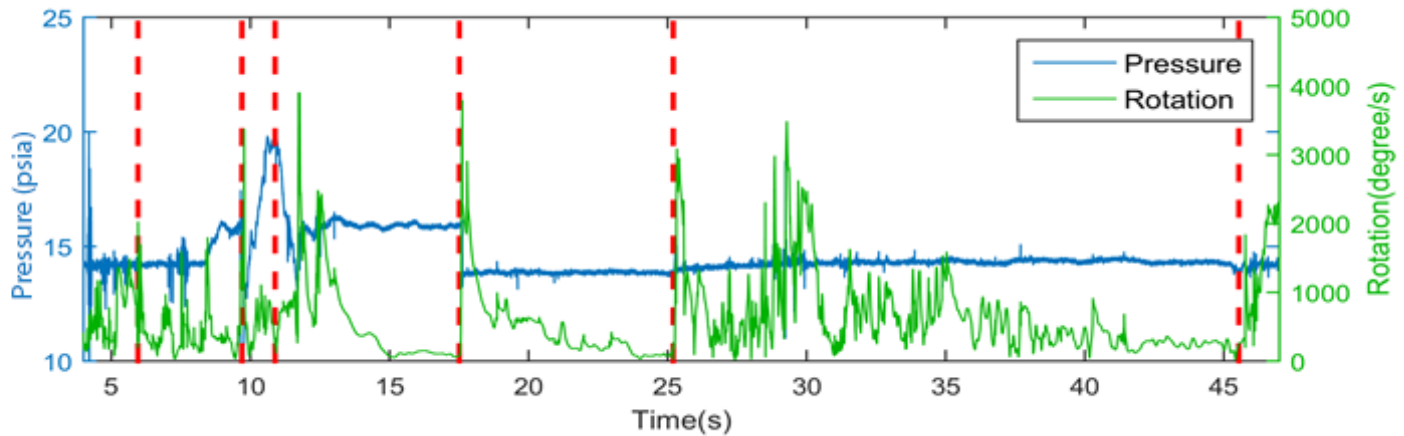
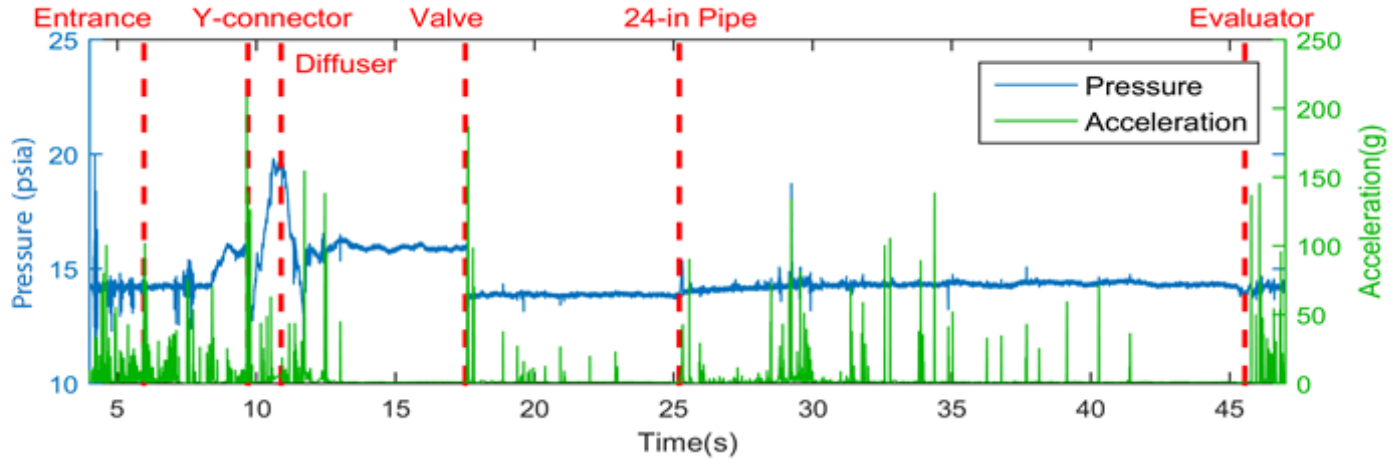
Timing Marks

- ▶ Gate Valve: A knife-valve controlled the flow for the treatments. At the 50% and 25% 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



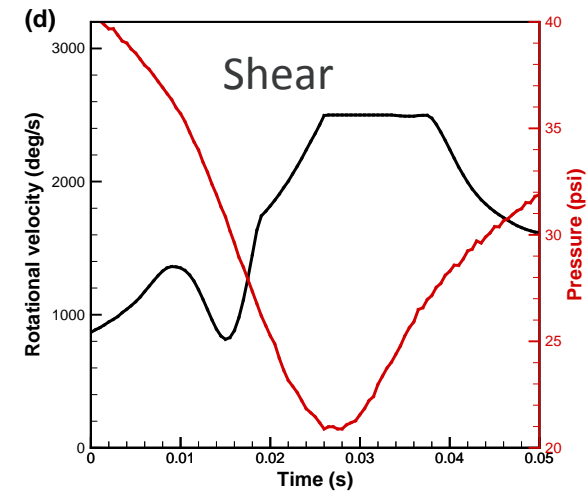
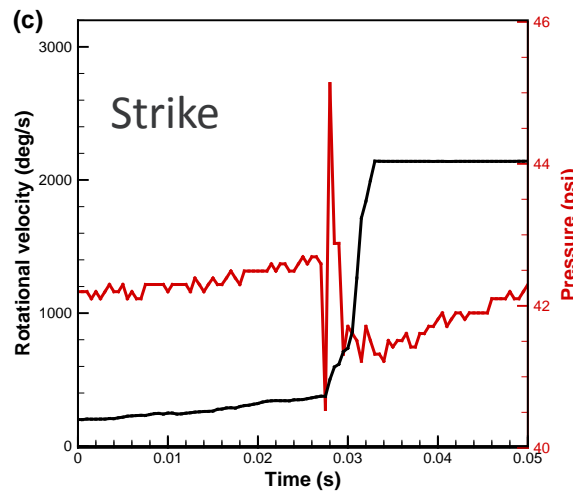
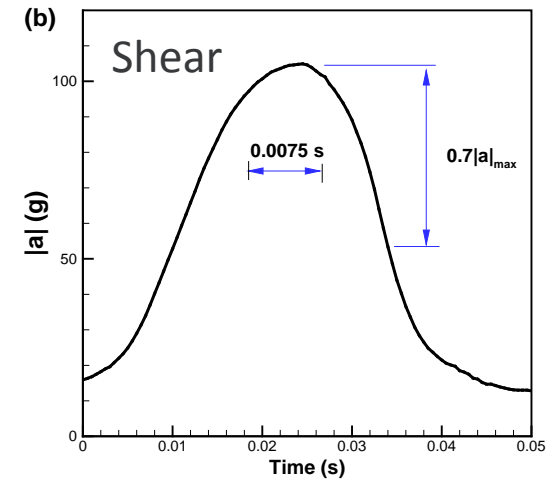
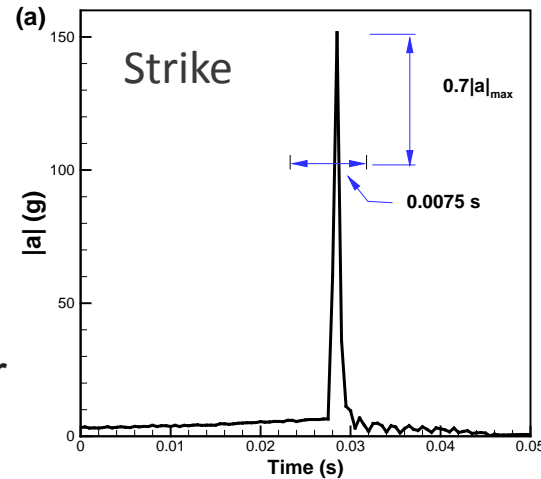
Passage Example:

910 ft Elevation and 25% Gate Valve Opening

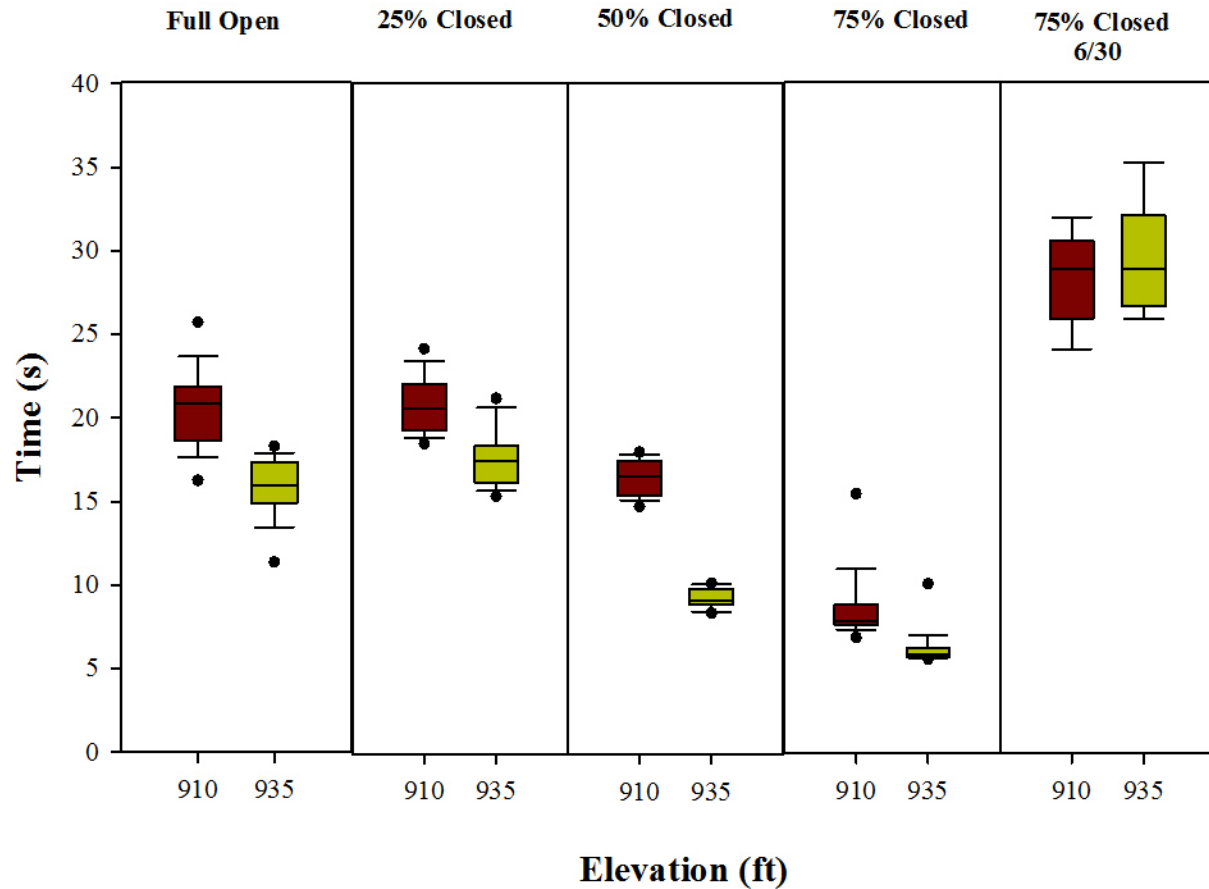


Shear and Strike: Definitions

- ▶ **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)



Passage time from the gate valve to the 24-in. pipe increased with gate valve opening, apart from the June 30 releases



Average Passage Times and Velocities from the Entrance to the Evaluator

Gate Valve Setting	Elevation (ft)	Travel Time (s)	Velocity (fps)
Full Open	910	55.6	13.4
	935	51.5	14.5
25% Closed	910	55.3	13.5
	935	52.8	14.1
50% Closed	910	50.0	14.9
	935	41.8	17.8
75% Closed	910	41.9	17.9
	935	39.3	19.0

Sensor Fish significant 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
Full Open	910	38	92	61	71	5	100
	935	40	88	68	55	0	100
25%	910	28	86	64	64	0	100
Closed	935	24	79	79	58	0	100
50%	910	26	81	69	65	4	100
	935	22	95	86	73	18	100
75%	910	26	85	69	81	46	100
Closed	935	22	91	73	59	64	100
75% Closed 06/30	910	10	60	20	60	100	90
	935	10	80	30	20	90	100
Control – Top Deck		32					97
Control – Lower Pipe		4					75

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

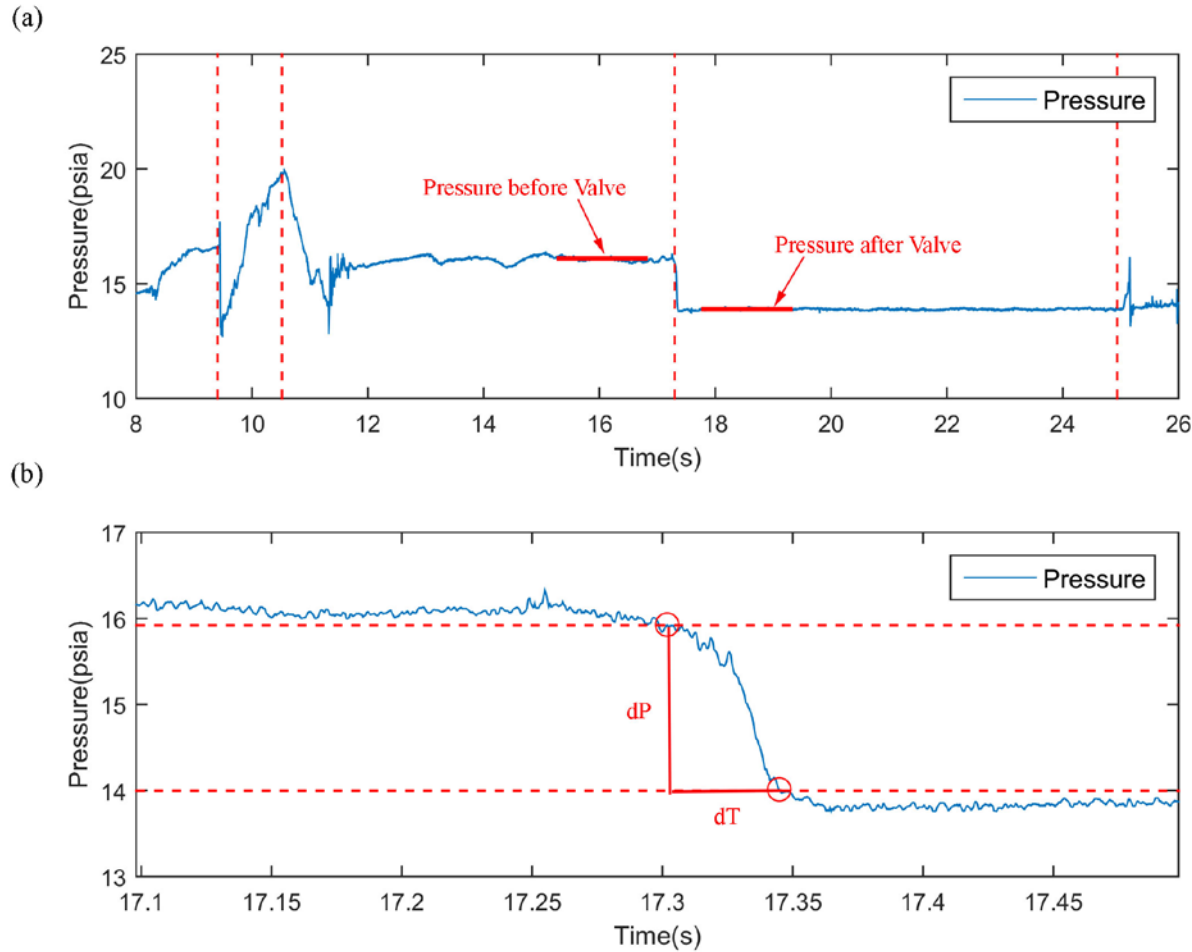
910 ft

	Full Open	25% Closed	50% Closed	75% Closed
Full Open		0.504	1	<0.001
25% Closed	0.504		0.482	<0.001
50% Closed	1	0.482		<0.001
75% Closed	<0.001	<0.001	<0.001	

935 ft

	Full Open	25% Closed	50% Closed	75% Closed
Full Open	-	1	0.013	<0.001
25% Closed	1	-	0.045	<0.001
50% Closed	0.013	0.045	-	0.005
75% Closed	<0.001	<0.001	0.005	-

The greatest pressure drops were observed during the gate valve region of passage when the valve was set at 75% closed, but not close to barotrauma threshold



- ▶ Sensor Fish passage times varied with gate valve setting, increasing with gate valve opening.
- ▶ Passage time was longer and average velocities were less for the 910 ft elevation treatments when compared with the 935 ft treatments.
- ▶ Gate valve position had little effect on pressures observed upstream of the gate valve for the full open and 25% closed setting, and transit times and velocities were similar between these two treatments. Gate valve closures greater than 25% resulted in higher pressures behind the valve, increasing with valve closure.
- ▶ Gate valve opening can affect the hydraulic conditions in the passage region between the valve and the 24-in pipe
 - The highest percentage of Sensor Fish experiencing significant events occurred at the 75% closed setting.
 - No significant difference was observed between the 25% closed and the full open gate valve settings, indicating the best hydraulic condition in the passage region would be achieved when the gate valve is opened 75% or more.

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