

Packwood Lake Entrainment Intake Screen Velocity Screen Results

Prepared for Aquatics Work Group
January 6, 2009

Packwood Lake Entrainment Study

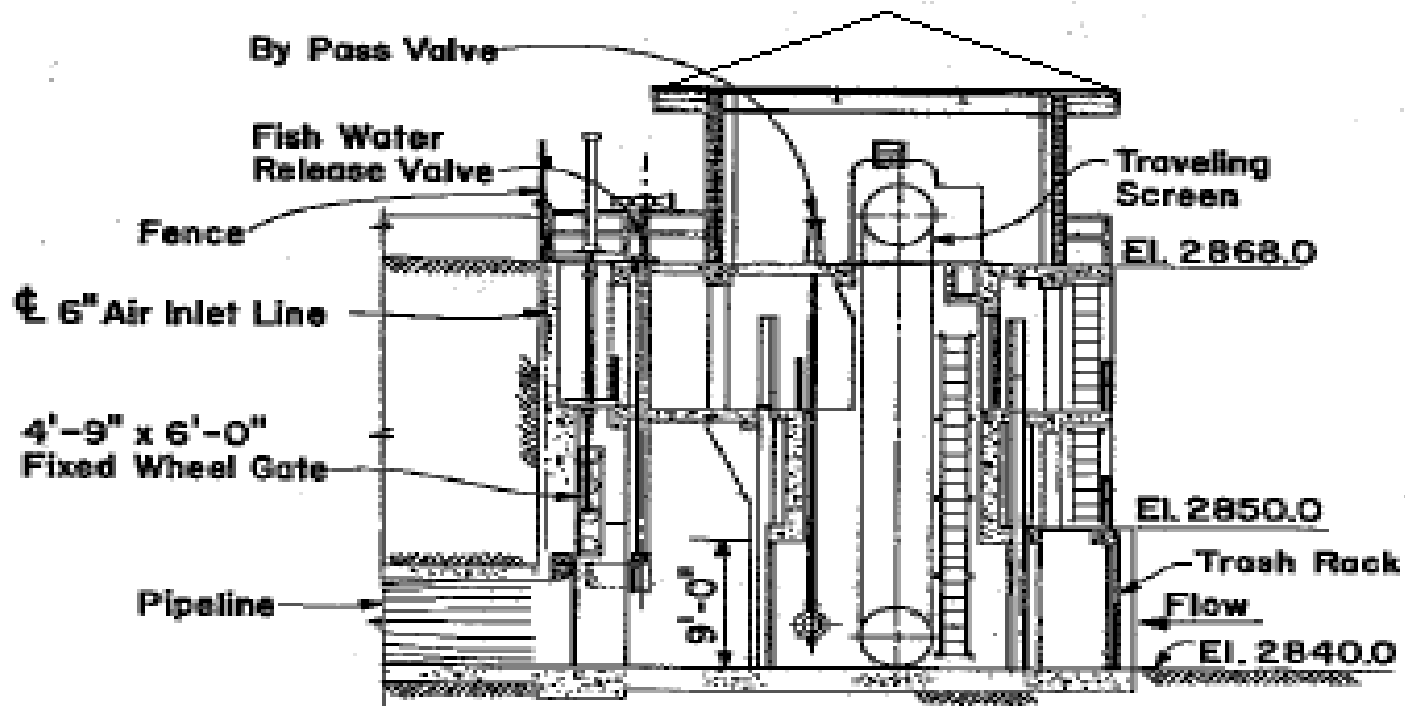
Goal and Objectives

- Goal:
 - To determine the effects of Project operation on potential entrainment of adult rainbow trout. Evaluate the effectiveness of the Project's screens in protecting fish.

- Objectives:
 - Determine the velocities present at the traveling screens at a range of lake elevations and Project flows
 - State criteria:
 - ≤ 0.80 ft/s for 95% of the screen
 - ≤ 0.88 ft/s for 99% of the screen
 - Examine the structural integrity of the traveling screen seals
 - Observe fish behavior within the intake wells
 - Develop a curve for lake elevations and water diversion rate
 - Summarize fish impingement data for 2008

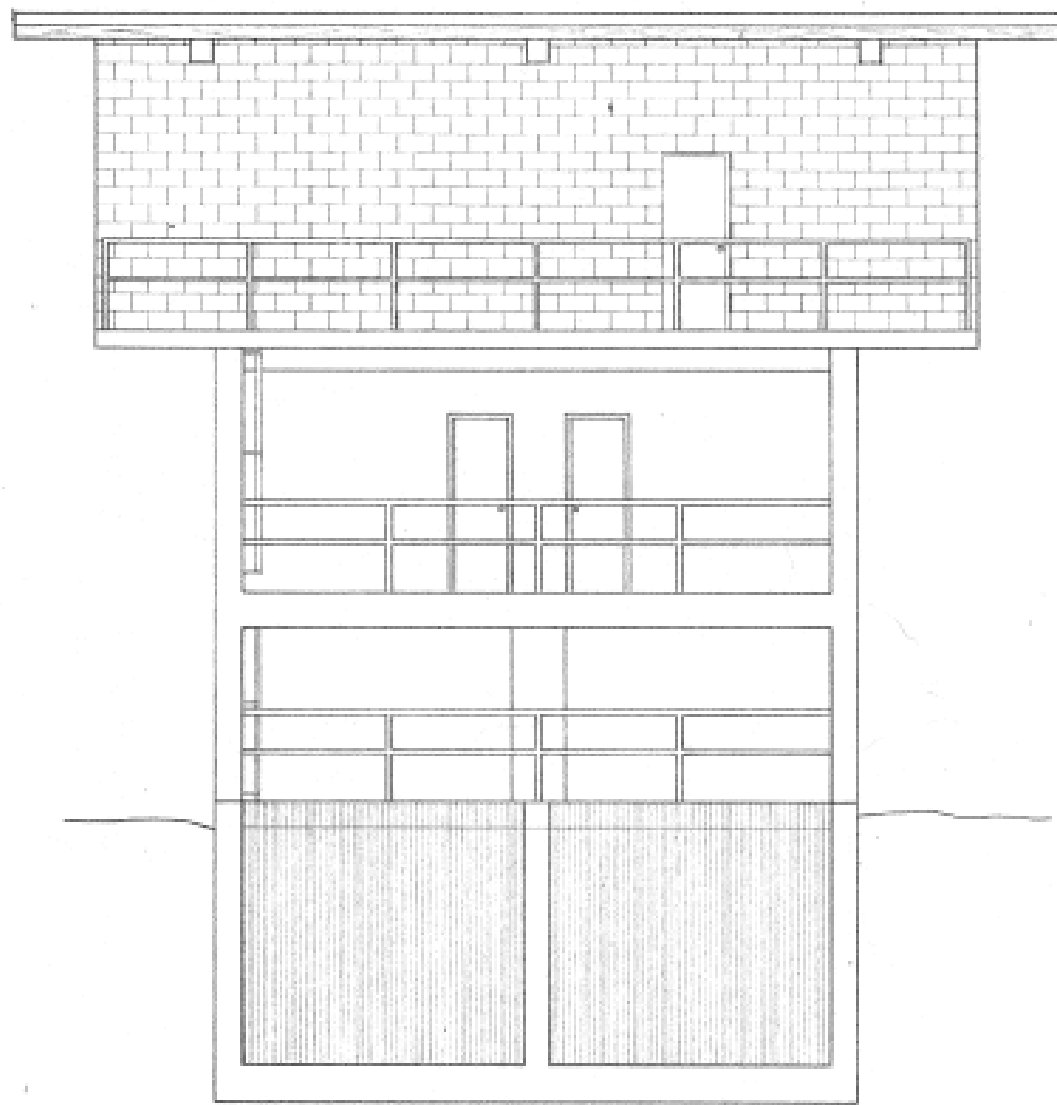
Screen Data

- Traveling Screen
 - (5/32 in) 3.968 mm X 3.968 mm
 - Set in “manual” position for checking
 - Size:
 - 2 screens
 - Each 9 ft wide
 - Base at 2840 ft; top at 2868 ft MSL
- Outer Debris Screens
 - Removed
- Outer Trash Racks
 - Debris cleaned by divers and rake



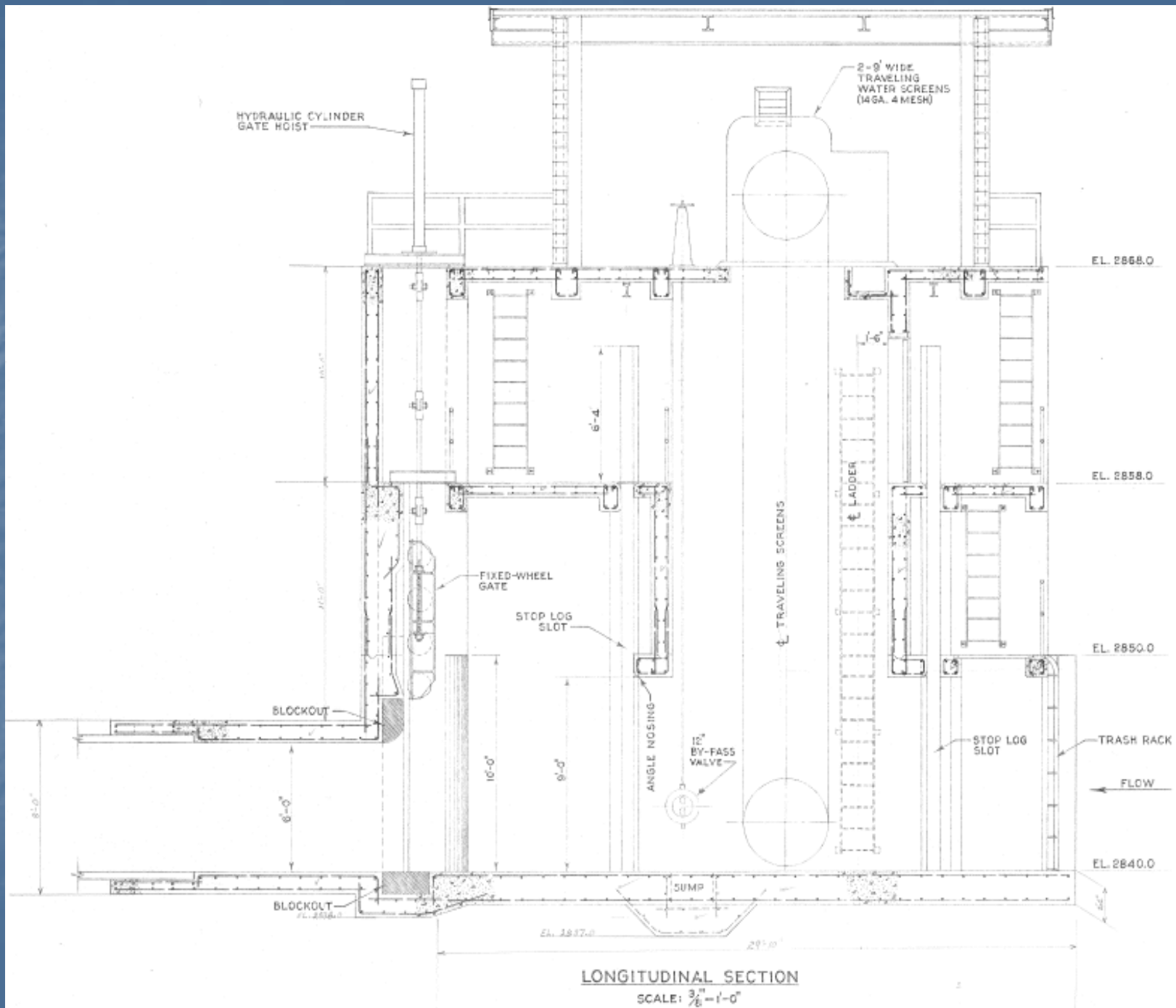
LONGITUDINAL SECTION

INTAKE STRUCTURE



SOUTHEAST ELEVATION

SCALE: $\frac{1}{4}'' = 1'-0''$



Proposed target lake elevations (+/- 0.5 ft) and Project flows for measuring intake screen velocities at the Packwood Lake Hydroelectric Project.

Day	Lake Elevation (ft)	Project Flows (cfs) ^{1/}				
1	2857.0	215	160	120	82	62
2	2856.0	215	160	120	82	62
3	2855.0	215	160	120	82	62
4	2854.0	215	160	120	82	62
5	2853.0	215	160	120	82	62
6	2852.0	215	160	120	82	62
7	2851.0	215	160	120	82	62

^{1/} Measurements were started at the high flow; when criteria were met, measurements at that lake elevation ceased and the lake elevation decreased to the next level for additional tests.

Velocity Measurements, cont'd

- Measurements were taken with a Swoffer meter from stationary platform in the intake wells.
- Measurements taken every foot vertically and horizontally

Examining the Integrity of the Screens

- Used Underwater Camera and Video to examine
 - Screen 1
 - Screen 2
 - Screens while rotating

Fish Presence and Behavior in the Intake Wells

- Traveling screens were checked at the beginning of each test for impingement
- Fish Behavior was monitored and videotaped at a range of flows and lake elevations
- Videos were converted to DVD format

RESULTS

Screen Velocities

Summary of lake levels and Project flows measured during 2008 velocity tests.

Date	Lake Elevation	Project Flow	Bypass Flow	Total Flow
9/16/2008	2857.10	214.95	3.87	218.82
9/16/2008	2857.00	158.20	3.97	162.17
9/16/2008	2856.92	114.85	3.75	118.60
9/18/2008	2855.99	121.40	3.46	124.86
9/18/2008	2855.95	82.45	3.70	86.15
9/19/2008	2855.07	121.20	3.43	124.63
9/19/2008	2855.04	83.80	3.38	87.18
9/21/2008	2854.01	119.65	4.81	124.46
9/21/2008	2854.00	82.65	4.91	87.56
9/22/2008	2853.09	82.55	4.45	87.00
9/23/2008	2852.16	83.15	4.64	87.79

Summary of velocities (ft/s) measured at Screen 1 during 2008 velocity tests.

Lake Elevation	Flow (cfs)	Minimum	Mean	Maximum	% ≤.8 ft/s	% ≤.88 ft/s	% >.88 ft/s
2857.10	218.82	0.04	0.62	2.09	54.4%	57.3%	42.7%
2857.00	162.17	0.00	0.39	1.33	79.9%	86.8%	13.2%
2856.92	118.60	0.01	0.19	0.59	100.0%	100.0%	0.0%
2855.99	124.86	0.00	0.38	1.18	75.0%	83.3%	16.7%
2855.95	86.15	0.00	0.25	0.80	100.0%	100.0%	0.0%
2855.07	124.63	0.00	0.29	0.83	99.3%	100.0%	0.0%
2855.04	87.18	0.01	0.30	0.82	99.3%	100.0%	0.0%
2854.01	124.46	0.01	0.43	1.17	73.8%	84.9%	15.1%
2854.00	87.56	0.00	0.32	0.83	97.6%	100.0%	0.0%
2853.09	87.00	0.00	0.33	0.85	99.1%	100.0%	0.0%
2852.16	87.79	0.01	0.33	0.86	97.2%	100.0%	0.0%

Summary of velocities (ft/s) measured at Screen 2 during 2008 velocity tests.

Lake Elevation	Flow (cfs)	Minimum	Mean	Maximum	% ≤.8 ft/s	% ≤.88 ft/s	% >.88 ft/s
2857.10	218.82	0.02	0.73	1.85	54.9%	56.9%	43.1%
2857.00	162.17	0.02	0.54	1.32	59.7%	65.3%	34.7%
2856.92	118.60	0.02	0.73	1.85	79.9%	93.1%	6.9%
2855.99	124.86	0.01	0.66	0.93	86.1%	96.5%	3.5%
2855.95	86.15	0.00	0.30	0.68	100.0%	100.0%	0.0%
2855.07	124.63	0.00	0.38	1.02	86.7%	94.8%	5.2%
2855.04	87.18	0.00	0.32	0.73	100.0%	100.0%	0.0%
2854.01	124.46	0.00	0.51	1.10	81.0%	88.1%	11.9%
2854.00	87.56	0.02	0.35	0.69	100.0%	100.0%	0.0%
2853.09	87.00	0.00	0.35	0.79	100.0%	100.0%	0.0%
2852.16	87.79	0.00	0.23	0.65	100.0%	100.0%	0.0%

Summary of velocities (ft/s) measured at both Screens 1 and Screen 2 during 2008 velocity tests.

Lake Elevation	Flow (cfs)	Mean	% ≤.8 ft/s	% ≤.88 ft/s	% >.88 ft/s
2857.10	218.82	0.68	54.6%	57.1%	42.9%
2857.00	162.17	0.46	69.8%	76.0%	24.0%
2856.92	118.60	0.46	89.9%	96.5%	3.5%
2855.99	124.86	0.58	80.6%	89.9%	10.1%
2855.95	86.15	0.28	100.0%	100.0%	0.0%
2855.07	124.63	0.52	93.0%	97.4%	2.6%
2855.04	87.18	0.31	99.6%	100.0%	0.0%
2854.01	124.46	0.65	77.4%	86.5%	13.5%
2854.00	87.56	0.33	98.8%	100.0%	0.0%
2853.09	87.00	0.34	99.6%	100.0%	0.0%
2852.16	87.79	0.28	98.6%	100.0%	0.0%

Regression Equations to Predict Lake Elevation and Project Flows (Based upon Velocity Test Data)

$$Z_1 = -11.3958 + 0.00445 X - 0.00364 Y \quad (r^2 = 0.93); \text{ (Equation 1) and}$$
$$Z_2 = -22.0354 + 0.00818 X - 0.003424 Y \quad (r^2 = 0.94) \text{ (Equation 2)}$$

where:

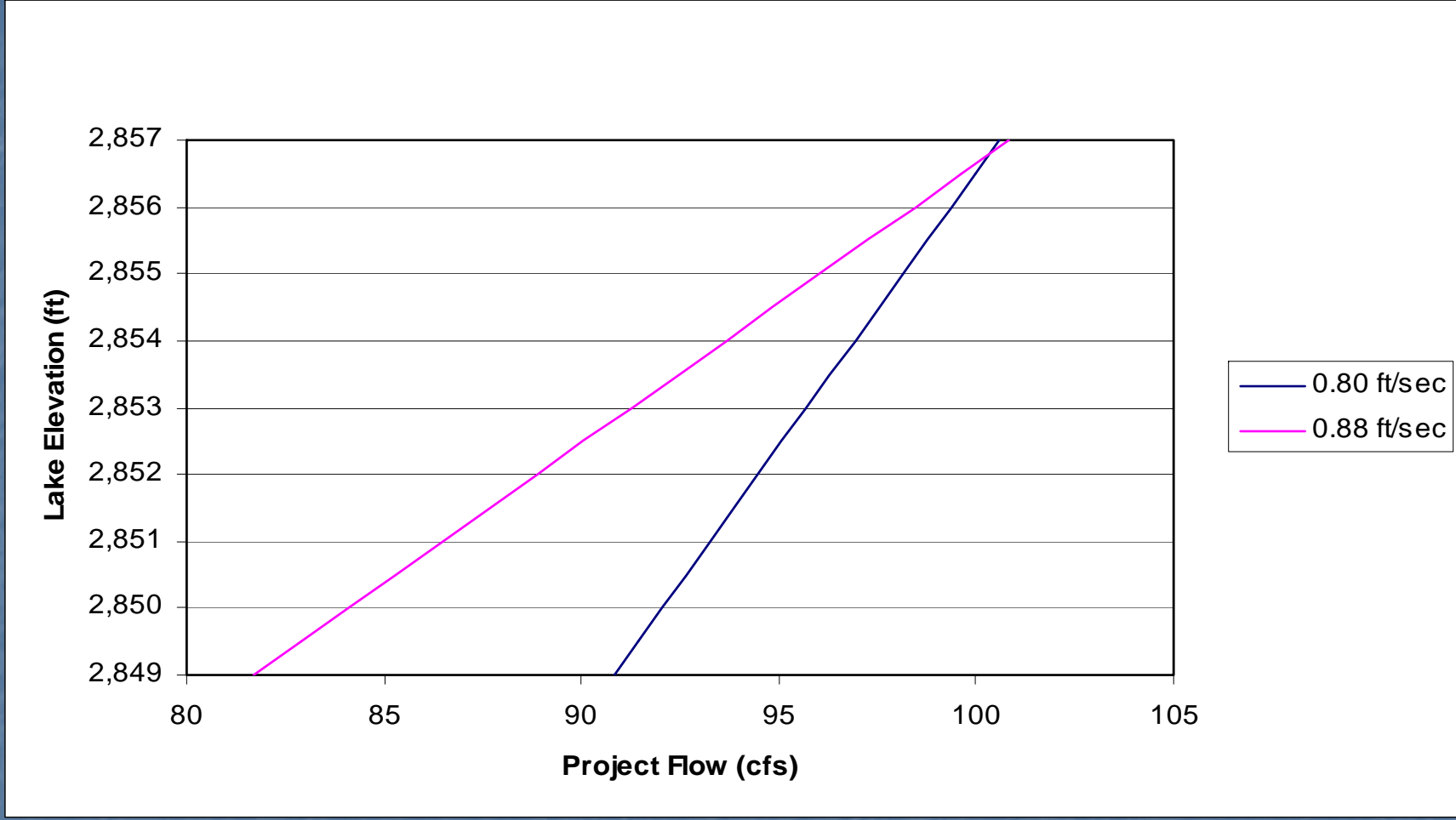
Z_1 = Percent of screen area with velocities ≤ 0.80 ft/s

Z_2 = Percent of screen area with velocities ≤ 0.88 ft/s

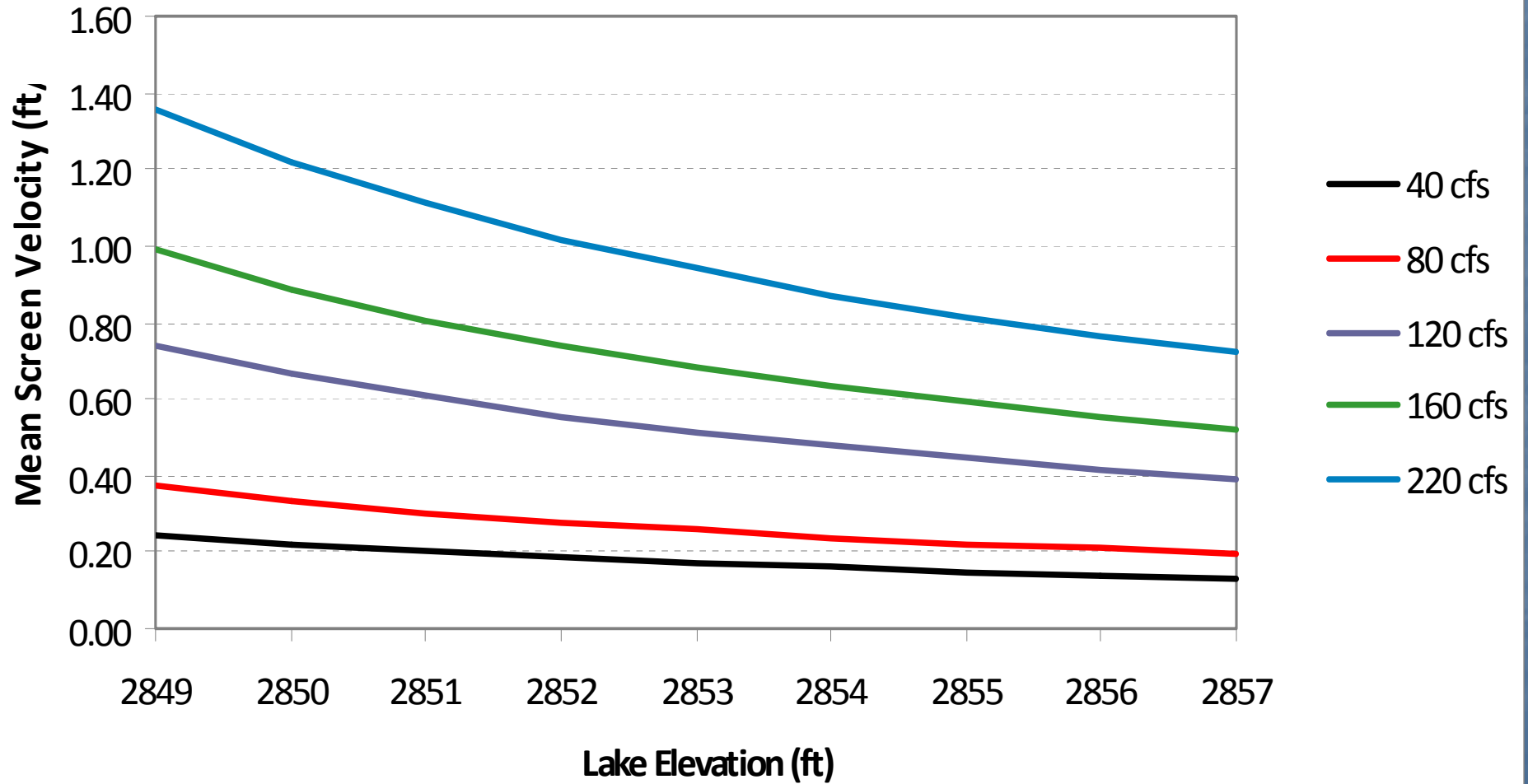
X = Lake Elevation (ft)

Y = Project Flow (cfs)

Relationship Between Lake Elevation and Project Flows (Based Upon Regression Equations While Meeting Criteria of 95% of the Screen Area Having Velocities ≤ 0.80 ft/sec and 99% of the Screen Area Having Velocities ≤ 0.88 ft/sec).



Mean Screen Velocities Based on 2008 Screen Tests



2857 ft

Screen 2

Elev	9	8	7	6	5	4	3	2	1
2855.95	0.17	0.22	0.24	0.28	0.29	0.17	0.15	0.14	0.18
2854.95	0.12	0.12	0.13	0.10	0.12	0.08	0.06	0.05	0.09
2853.95	0.10	0.12	0.11	0.09	0.08	0.10	0.07	0.09	0.15
2852.87	0.07	0.09	0.13	0.14	0.22	0.10	0.09	0.10	0.11
2851.87	0.06	0.11	0.11	0.10	0.08	0.05	0.05	0.03	0.08
2850.78	0.08	0.10	0.09	0.09	0.08	0.14	0.02	0.08	0.08
2849.78	0.09	0.10	0.07	0.15	0.08	0.07	0.13	0.08	0.08
2848.78	0.57	0.49	0.40	0.61	0.53	1.07	1.07	1.25	1.31
2847.72	1.53	1.59	1.50	1.61	1.76	1.72	1.68	1.85	1.81
2846.72	1.53	1.70	1.51	1.69	1.59	1.55	1.65	1.69	1.57
2845.66	1.35	1.44	1.47	1.43	1.50	1.47	1.51	1.59	1.62
2844.66	1.40	1.39	1.40	1.39	1.44	1.44	1.45	1.46	1.51
2843.66	1.26	1.33	1.28	1.30	1.29	1.32	1.40	1.43	1.42
2842.64	1.18	1.02	1.05	1.15	1.15	1.27	1.26	1.20	1.27
2841.64	0.77	0.81	0.73	0.99	1.12	0.90	0.91	0.81	0.86
2840.64	0.63	0.42	0.33	0.40	0.44	0.62	0.46	0.43	0.39

219 cfs

Screen 1

Elev	9	8	7	6	5	4	3	2	1
2855.90	0.08	0.15	0.13	0.15	0.20	0.14	0.11	0.15	0.09
2854.90	0.09	0.14	0.19	0.09	0.09	0.11	0.05	0.11	0.09
2853.84	0.16	0.29	0.20	0.12	0.08	0.09	0.05	0.06	0.06
2852.84	0.06	0.17	0.12	0.12	0.16	0.06	0.07	0.08	0.04
2851.84	0.08	0.17	0.13	0.06	0.06	0.10	0.08	0.11	0.10
2850.78	0.16	0.17	0.12	0.09	0.10	0.07	0.10	0.08	0.11
2849.78	0.18	0.18	0.11	0.12	0.14	0.11	0.24	0.43	0.38
2848.65	0.15	0.11	0.18	0.14	0.39	0.80	0.76	0.87	0.52
2847.65	0.44	1.25	0.73	1.15	0.95	1.33	1.32	1.10	1.05
2846.65	2.09	1.95	1.73	1.68	1.56	1.54	1.45	1.40	1.15
2845.59	1.68	1.63	1.56	1.48	1.55	1.52	1.49	1.28	1.07
2844.59	1.28	1.47	1.43	1.58	1.56	1.44	1.30	1.13	0.78
2843.57	1.05	1.26	1.36	1.26	1.29	1.44	1.23	0.90	0.65
2842.57	0.92	0.76	0.81	0.80	1.24	1.33	1.23	0.68	0.23
2841.57	0.84	0.61	0.34	0.66	0.46	0.82	1.26	0.66	0.34
2840.57	0.76	0.32	0.13	0.35	0.80	0.72	0.88	0.25	0.20

2857 ft

Screen 2

Elev	9	8	7	6	5	4	3	2	1
2855.95	0.14	0.11	0.14	0.19	0.18	0.15	0.17	0.09	0.15
2854.95	0.08	0.10	0.09	0.09	0.11	0.09	0.09	0.08	0.13
2853.95	0.08	0.06	0.11	0.08	0.09	0.13	0.09	0.06	0.09
2852.87	0.13	0.03	0.12	0.06	0.14	0.12	0.08	0.05	0.05
2851.87	0.06	0.04	0.09	0.06	0.11	0.09	0.10	0.06	0.06
2850.78	0.08	0.05	0.08	0.07	0.03	0.06	0.05	0.05	0.03
2849.78	0.07	0.09	0.06	0.05	0.09	0.07	0.05	0.03	0.02
2848.78	0.66	0.40	0.74	0.73	0.54	0.84	0.94	1.19	1.04
2847.72	1.11	1.23	1.13	1.12	1.26	1.19	1.19	1.27	1.32
2846.72	1.08	1.20	1.16	1.14	1.13	1.07	1.13	1.15	1.12
2845.66	1.05	1.06	1.05	1.08	1.08	1.07	1.09	1.06	1.14
2844.66	0.99	1.01	1.04	1.04	1.02	1.05	1.08	1.09	1.12
2843.66	0.94	0.91	0.95	0.94	0.80	0.98	0.99	0.97	1.02
2842.64	0.97	0.93	0.90	0.88	0.86	0.86	0.80	0.81	0.87
2841.64	0.81	0.82	0.55	0.64	0.79	0.65	0.57	0.49	0.52
2840.64	0.45	0.37	0.16	0.40	0.32	0.44	0.20	0.23	0.13

160 cfs

Screen 1

Elev	9	8	7	6	5	4	3	2	1
2855.90	0.05	0.11	0.11	0.10	0.09	0.07	0.06	0.11	0.17
2854.90	0.06	0.11	0.06	0.05	0.07	0.06	0.09	0.08	0.19
2853.84	0.16	0.15	0.17	0.15	0.10	0.07	0.07	0.08	0.12
2852.84	0.09	0.12	0.06	0.10	0.14	0.08	0.04	0.03	0.05
2851.84	0.10	0.21	0.11	0.09	0.09	0.11	0.10	0.01	0.07
2850.78	0.08	0.18	0.19	0.06	0.07	0.06	0.07	0.07	0.09
2849.78	0.11	0.14	0.11	0.11	0.07	0.09	0.06	0.07	0.07
2848.65	0.09	0.07	0.18	0.12	0.07	0.24	0.27	0.46	0.45
2847.65	0.97	0.93	0.97	0.80	0.77	0.77	0.79	0.59	0.54
2846.65	1.12	1.10	0.92	0.81	0.76	0.67	0.68	0.69	0.67
2845.59	1.33	1.02	0.92	0.70	0.72	0.81	0.80	0.61	0.64
2844.59	1.12	1.05	0.93	0.82	0.91	0.89	0.86	0.73	0.63
2843.57	1.01	0.84	0.97	0.88	0.89	0.90	0.87	0.66	0.53
2842.57	0.85	0.60	0.78	0.87	0.86	0.90	0.74	0.68	0.32
2841.57	0.46	0.17	0.18	0.39	0.37	0.56	0.20	0.14	0.19
2840.57	0.17	0.00	0.11	0.14	0.08	0.09	0.12	0.18	0.33

2857 ft

120 cfs

Screen 2

Screen 1

Elev	9	8	7	6	5	4	3	2	1	Elev	9	8	7	6	5	4	3	2	1
2855.95	0.13	0.07	0.10	0.04	0.15	0.09	0.12	0.03	0.18	2855.90	0.10	0.05	0.05	0.09	0.08	0.10	0.03	0.13	0.14
2854.95	0.06	0.09	0.15	0.12	0.05	0.04	0.07	0.05	0.06	2854.90	0.08	0.12	0.04	0.03	0.09	0.01	0.03	0.14	0.17
2853.95	0.02	0.03	0.04	0.07	0.08	0.07	0.05	0.03	0.02	2853.84	0.08	0.16	0.02	0.05	0.10	0.05	0.10	0.06	0.07
2852.87	0.08	0.04	0.07	0.03	0.12	0.09	0.03	0.02	0.03	2852.84	0.06	0.24	0.07	0.05	0.04	0.07	0.05	0.07	0.04
2851.87	0.03	0.05	0.20	0.11	0.10	0.10	0.03	0.02	0.08	2851.84	0.03	0.14	0.06	0.04	0.08	0.10	0.03	0.04	0.05
2850.78	0.01	0.09	0.06	0.06	0.08	0.05	0.03	0.02	0.06	2850.78	0.08	0.15	0.10	0.06	0.07	0.07	0.03	0.12	0.02
2849.78	0.07	0.06	0.03	0.04	0.06	0.05	0.04	0.01	0.01	2849.78	0.04	0.04	0.07	0.06	0.12	0.07	0.22	0.13	0.08
2848.78	0.68	0.20	0.37	0.65	0.48	0.63	0.70	0.79	0.76	2848.65	0.30	0.23	0.34	0.44	0.38	0.44	0.55	0.52	0.25
2847.72	0.87	0.85	0.92	0.89	0.88	0.90	0.92	0.95	0.71	2847.65	0.36	0.59	0.55	0.47	0.44	0.36	0.35	0.44	0.21
2846.72	0.82	0.87	0.83	0.85	0.78	0.83	0.86	0.88	0.88	2846.65	0.15	0.52	0.45	0.40	0.36	0.32	0.34	0.26	0.03
2845.66	0.81	0.85	0.85	0.89	0.91	0.89	0.87	0.89	0.89	2845.59	0.43	0.40	0.44	0.28	0.29	0.41	0.32	0.25	0.14
2844.66	0.76	0.79	0.80	0.82	0.81	0.82	0.80	0.80	0.81	2844.59	0.28	0.35	0.37	0.32	0.38	0.35	0.35	0.13	0.10
2843.66	0.76	0.77	0.78	0.76	0.76	0.76	0.77	0.74	0.72	2843.57	0.28	0.21	0.45	0.41	0.39	0.38	0.12	0.02	0.07
2842.64	0.42	0.63	0.74	0.77	0.76	0.70	0.79	0.65	0.67	2842.57	0.23	0.06	0.15	0.20	0.28	0.22	0.26	0.04	0.09
2841.64	0.32	0.08	0.38	0.69	0.74	0.59	0.32	0.32	0.47	2841.57	0.55	0.22	0.26	0.27	0.33	0.43	0.13	0.06	0.07
2840.64	0.04	0.09	0.11	0.24	0.31	0.49	0.12	0.05	0.08	2840.57	0.04	0.19	0.05	0.07	0.13	0.13	0.30	0.15	0.03

2856 ft

120 cfs

Screen 2

Screen 1

Elev	9	8	7	6	5	4	3	2	1	Elev	9	8	7	6	5	4	3	2	1
2855.95	0.07	0.22	0.41	0.50	0.11	0.46	0.33	0.47	0.37	2855.90	0.03	0.24	0.14	0.15	0.35	0.23	0.24	0.25	0.50
2854.95	0.21	0.05	0.19	0.09	0.29	0.06	0.17	0.15	0.05	2854.90	0.06	0.07	0.06	0.10	0.10	0.03	0.09	0.09	0.20
2853.95	0.09	0.10	0.03	0.09	0.04	0.09	0.02	0.06	0.10	2853.84	0.05	0.05	0.05	0.07	0.03	0.03	0.05	0.05	0.10
2852.87	0.07	0.12	0.03	0.11	0.09	0.01	0.08	0.08	0.03	2852.84	0.05	0.04	0.04	0.05	0.60	0.04	0.06	0.04	0.11
2851.87	0.03	0.08	0.04	0.09	0.10	0.05	0.02	0.02	0.04	2851.84	0.03	0.10	0.02	0.03	0.02	0.08	0.02	0.04	0.04
2850.78	0.09	0.08	0.02	0.07	0.12	0.05	0.09	0.08	0.07	2850.78	0.02	0.08	0.06	0.03	0.11	0.04	0.02	0.04	0.05
2849.78	0.05	0.03	0.05	0.06	0.05	0.08	0.05	0.03	0.04	2849.78	0.01	0.02	0.06	0.02	0.01	0.01	0.00	0.03	0.03
2848.78	0.19	0.13	0.31	0.39	0.37	0.56	0.67	0.91	0.65	2848.65	0.05	0.03	0.01	0.04	0.07	0.09	0.18	0.37	0.23
2847.72	0.72	0.72	0.84	0.91	0.87	0.93	0.89	0.88	0.82	2847.65	0.34	0.85	0.88	0.84	0.91	0.78	0.84	0.69	0.62
2846.72	0.84	0.87	0.93	0.87	0.86	0.76	0.88	0.87	0.86	2846.65	1.13	1.04	0.86	0.87	0.94	0.91	0.95	0.67	0.59
2845.66	0.75	0.77	0.80	0.79	0.80	0.83	0.83	0.83	0.84	2845.59	1.18	1.10	1.03	0.97	0.91	0.95	0.97	0.86	0.77
2844.66	0.75	0.77	0.74	0.77	0.75	0.75	0.76	0.75	0.72	2844.59	1.02	0.99	0.96	0.85	0.92	0.92	0.91	0.87	0.70
2843.66	0.54	0.64	0.59	0.63	0.64	0.72	0.68	0.67	0.70	2843.57	1.02	0.91	0.92	0.91	0.88	0.89	0.83	0.74	0.65
2842.64	0.58	0.59	0.61	0.47	0.55	0.60	0.59	0.46	0.55	2842.57	0.88	0.56	0.79	0.78	0.68	0.79	0.78	0.54	0.22
2841.64	0.45	0.34	0.39	0.48	0.48	0.31	0.29	0.28	0.39	2841.57	0.68	0.35	0.19	0.44	0.37	0.42	0.48	0.20	0.20
2840.64	0.25	0.26	0.20	0.09	0.28	0.14	0.10	0.14	0.24	2840.57	0.09	0.02	0.00	0.17	0.03	0.01	0.06	0.06	0.01

2856 ft

82 cfs

Screen 2

Screen 1

Elev	9	8	7	6	5	4	3	2	1	Elev	9	8	7	6	5	4	3	2	1
2855.95	0.07	0.02	0.23	0.35	0.35	0.21	0.03	0.03	0.18	2855.90	0.02	0.01	0.05	0.13	0.24	0.24	0.22	0.31	0.17
2854.95	0.11	0.11	0.07	0.03	0.05	0.05	0.10	0.07	0.06	2854.90	0.07	0.01	0.09	0.03	0.04	0.05	0.02	0.06	0.02
2853.95	0.11	0.05	0.10	0.09	0.03	0.05	0.05	0.09	0.03	2853.84	0.02	0.04	0.11	0.04	0.03	0.01	0.06	0.04	0.02
2852.87	0.03	0.06	0.23	0.09	0.05	0.06	0.06	0.05	0.02	2852.84	0.04	0.05	0.00	0.04	0.01	0.02	0.02	0.04	0.01
2851.87	0.01	0.09	0.12	0.17	0.04	0.02	0.10	0.02	0.07	2851.84	0.02	0.03	0.04	0.00	0.03	0.03	0.01	0.03	0.01
2850.78	0.13	0.07	0.13	0.16	0.15	0.11	0.02	0.00	0.02	2850.78	0.07	0.05	0.06	0.05	0.02	0.03	0.05	0.01	0.07
2849.78	0.03	0.04	0.02	0.06	0.07	0.05	0.02	0.01	0.01	2849.78	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.02
2848.78	0.15	0.08	0.10	0.29	0.25	0.48	0.47	0.61	0.60	2848.65	0.02	0.03	0.04	0.03	0.03	0.09	0.18	0.33	0.23
2847.72	0.63	0.58	0.60	0.64	0.62	0.62	0.62	0.63	0.58	2847.65	0.33	0.63	0.57	0.68	0.71	0.65	0.59	0.57	0.44
2846.72	0.61	0.68	0.63	0.63	0.59	0.60	0.62	0.59	0.57	2846.65	0.75	0.70	0.76	0.69	0.71	0.69	0.69	0.55	0.42
2845.66	0.59	0.63	0.60	0.61	0.59	0.59	0.60	0.59	0.59	2845.59	0.80	0.79	0.73	0.67	0.60	0.65	0.65	0.61	0.47
2844.66	0.56	0.58	0.58	0.57	0.56	0.55	0.52	0.56	0.53	2844.59	0.74	0.68	0.65	0.61	0.66	0.60	0.61	0.47	0.35
2843.66	0.46	0.51	0.53	0.51	0.48	0.50	0.49	0.51	0.48	2843.57	0.59	0.57	0.58	0.58	0.52	0.55	0.49	0.39	0.35
2842.64	0.47	0.43	0.48	0.50	0.49	0.47	0.37	0.43	0.47	2842.57	0.45	0.38	0.52	0.56	0.51	0.31	0.21	0.26	0.20
2841.64	0.46	0.40	0.47	0.42	0.45	0.40	0.18	0.16	0.32	2841.57	0.28	0.08	0.11	0.32	0.15	0.27	0.16	0.01	0.03
2840.64	0.36	0.17	0.10	0.03	0.40	0.16	0.02	0.08	0.15	2840.57	0.12	0.01	0.00	0.00	0.00	0.09	0.06	0.03	0.04

2855 ft

Screen 2

Elev	9	8	7	6	5	4	3	2	1
2855.95									
2854.95	0.08	0.42	0.49	0.40	0.42	0.17	0.03	0.32	0.33
2853.95	0.14	0.15	0.08	0.04	0.06	0.02	0.03	0.18	0.09
2852.87	0.10	0.50	0.08	0.05	0.01	0.07	0.05	0.06	0.04
2851.87	0.05	0.04	0.08	0.01	0.04	0.08	0.04	0.10	0.13
2850.78	0.02	0.15	0.08	0.11	0.02	0.05	0.03	0.02	0.03
2849.78	0.03	0.03	0.07	0.04	0.02	0.03	0.02	0.03	0.02
2848.78	0.12	0.27	0.51	0.62	0.68	0.78	0.50	0.93	0.83
2847.72	0.85	0.89	1.02	0.91	0.87	0.85	0.91	0.84	0.75
2846.72	0.85	0.89	0.86	0.84	0.84	0.84	0.80	0.93	0.88
2845.66	0.74	0.79	0.72	0.75	0.68	0.68	0.70	0.71	0.79
2844.66	0.66	0.62	0.58	0.64	0.59	0.65	0.74	0.73	0.73
2843.66	0.45	0.50	0.50	0.55	0.56	0.59	0.62	0.62	0.59
2842.64	0.49	0.45	0.46	0.49	0.53	0.59	0.49	0.48	0.53
2841.64	0.39	0.20	0.23	0.34	0.36	0.41	0.16	0.22	0.00
2840.64	0.20	0.07	0.09	0.07	0.03	0.06	0.06	0.07	0.06

120 cfs

Screen 1

Elev	9	8	7	6	5	4	3	2	1
2855.90									
2854.90	0.07	0.10	0.15	0.14	0.26	0.30	0.26	0.28	0.07
2853.84	0.06	0.05	0.06	0.05	0.08	0.12	0.11	0.09	0.11
2852.84	0.06	0.10	0.06	0.09	0.05	0.09	0.13	0.12	0.09
2851.84	0.05	0.08	0.04	0.08	0.02	0.05	0.05	0.08	0.20
2850.78	0.07	0.03	0.05	0.07	0.08	0.08	0.05	0.05	0.02
2849.78	0.14	0.04	0.09	0.03	0.10	0.07	0.05	0.04	0.07
2848.65	0.06	0.02	0.09	0.11	0.00	0.19	0.21	0.20	0.28
2847.65	0.41	0.62	0.59	0.48	0.55	0.55	0.47	0.44	0.41
2846.65	0.72	0.68	0.62	0.56	0.55	0.58	0.55	0.53	0.47
2845.59	0.83	0.76	0.66	0.64	0.57	0.72	0.80	0.64	0.57
2844.59	0.69	0.69	0.57	0.54	0.58	0.62	0.60	0.53	0.43
2843.57	0.64	0.71	0.65	0.62	0.57	0.65	0.60	0.41	0.32
2842.57	0.54	0.52	0.45	0.65	0.60	0.55	0.42	0.17	0.27
2841.57	0.34	0.08	0.27	0.20	0.04	0.04	0.03	0.00	0.20
2840.57	0.15	0.04	0.01	0.01	0.05	0.10	0.80	0.10	0.09

2855 ft

Screen 2

Elev	9	8	7	6	5	4	3	2	1
2855.95									
2854.95	0.31	0.42	0.32	0.32	0.19	0.01	0.17	0.36	0.36
2853.95	0.03	0.05	0.02	0.02	0.02	0.05	0.14	0.09	0.01
2852.87	0.02	0.07	0.01	0.01	0.00	0.02	0.02	0.07	0.03
2851.87	0.05	0.05	0.02	0.02	0.01	0.02	0.30	0.06	0.04
2850.78	0.20	0.03	0.00	0.00	0.00	0.04	0.02	0.01	0.00
2849.78	0.01	0.01	0.00	0.00	0.02	0.00	0.00	0.20	0.01
2848.78	0.10	0.20	0.52	0.52	0.53	0.53	0.59	0.62	0.65
2847.72	0.60	0.62	0.65	0.65	0.33	0.67	0.65	0.69	0.67
2846.72	0.73	0.69	0.71	0.71	0.65	0.63	0.65	0.65	0.66
2845.66	0.68	0.66	0.66	0.66	0.61	0.60	0.59	0.57	0.61
2844.66	0.57	0.56	0.57	0.57	0.52	0.55	0.58	0.57	0.55
2843.66	0.52	0.50	0.52	0.52	0.54	0.50	0.54	0.50	0.53
2842.64	0.44	0.47	0.38	0.38	0.43	0.51	0.45	0.42	0.38
2841.64	0.40	0.37	0.42	0.42	0.25	0.17	0.27	0.31	0.26
2840.64	0.22	0.17	0.09	0.09	0.05	0.22	0.05	0.08	0.00

82 cfs

Screen 1

Elev	9	8	7	6	5	4	3	2	1
2855.90									
2854.90	0.02	0.10	0.19	0.10	0.11	0.18	0.31	0.26	0.17
2853.84	0.03	0.07	0.04	0.05	0.06	0.07	0.04	0.12	0.07
2852.84	0.07	0.05	0.11	0.03	0.08	0.04	0.05	0.07	0.05
2851.84	0.11	0.04	0.12	0.05	0.12	0.04	0.06	0.01	0.02
2850.78	0.06	0.10	0.01	0.20	0.02	0.03	0.03	0.30	0.01
2849.78	0.05	0.05	0.30	0.01	0.03	0.03	0.01	0.01	0.02
2848.65	0.07	0.04	0.06	0.05	0.07	0.10	0.09	0.28	0.24
2847.65	0.50	0.72	0.63	0.65	0.72	0.74	0.60	0.56	0.40
2846.65	0.76	0.73	0.68	0.71	0.72	0.74	0.74	0.68	0.38
2845.59	0.82	0.71	0.72	0.69	0.66	0.64	0.77	0.70	0.49
2844.59	0.71	0.71	0.63	0.62	0.69	0.66	0.71	0.59	0.51
2843.57	0.69	0.63	0.71	0.66	0.62	0.59	0.55	0.53	0.30
2842.57	0.62	0.39	0.44	0.60	0.54	0.48	0.43	0.21	0.19
2841.57	0.48	0.23	0.11	0.28	0.27	0.28	0.14	0.09	0.07
2840.57	0.15	0.01	0.01	0.01	0.02	0.01	0.04	0.01	0.07

2854 ft

Screen 2

120 cfs

Screen 1

Elev	9	8	7	6	5	4	3	2	1	Elev	9	8	7	6	5	4	3	2	1
2855.95										2855.90									
2854.95										2854.90									
2853.95	0.07	0.61	0.58	0.51	0.57	0.00	0.06	0.21	0.21	2853.84	0.09	0.10	0.15	0.10	0.26	0.27	0.29	0.35	0.44
2852.87	0.40	0.16	0.05	0.10	0.13	0.09	0.16	0.07	0.11	2852.84	0.09	0.05	0.15	0.10	0.15	0.07	0.17	0.09	0.09
2851.87	0.04	0.10	0.04	0.07	0.50	0.03	0.17	0.38	0.02	2851.84	0.04	0.03	0.04	0.05	0.09	0.05	0.12	0.17	0.15
2850.78	0.03	0.06	0.08	0.23	0.80	0.15	0.13	0.07	0.70	2850.78	0.07	0.03	0.02	0.06	0.04	0.04	0.06	0.08	0.03
2849.78	0.09	0.18	0.05	0.10	0.11	0.14	0.02	0.03	0.03	2849.78	0.17	0.07	0.07	0.05	0.07	0.06	0.11	0.01	0.05
2848.78	0.53	0.26	0.65	0.77	0.83	0.78	0.74	0.85	0.91	2848.65	0.15	0.13	0.08	0.19	0.27	0.16	0.14	0.32	0.30
2847.72	0.80	0.94	0.97	1.05	1.02	0.96	0.89	0.93	0.91	2847.65	0.84	0.98	0.87	0.81	0.84	0.78	0.77	0.72	0.43
2846.72	0.78	1.10	0.91	0.92	0.91	0.84	0.88	0.91	0.88	2846.65	1.17	1.08	0.96	0.90	0.92	0.94	0.97	0.67	0.58
2845.66	0.91	0.86	0.81	0.88	0.78	0.72	0.75	0.74	0.77	2845.59	1.03	0.91	0.88	0.88	0.79	0.98	1.04	0.70	0.72
2844.66	0.82	0.77	0.71	0.72	0.73	0.75	0.74	0.79	0.80	2844.59	0.92	0.97	0.86	0.79	0.85	0.91	0.85	0.80	0.72
2843.66	0.74	0.73	0.69	0.78	0.65	0.73	0.72	0.74	0.73	2843.57	0.88	0.80	0.98	0.92	0.93	0.81	0.79	0.52	0.61
2842.64	0.66	0.71	0.71	0.74	0.71	0.64	0.53	0.60	0.59	2842.57	0.84	0.46	0.81	0.96	0.87	0.76	0.72	0.44	0.12
2841.64	0.45	0.58	0.50	0.27	0.63	0.70	0.34	0.30	0.28	2841.57	0.48	0.26	0.28	0.34	0.26	0.61	0.21	0.05	0.20
2840.64	0.49	0.26	0.21	0.14	0.38	0.14	0.19	0.13	0.00	2840.57	0.21	0.04	0.02	0.08	0.05	0.04	0.07	0.06	0.03

2854 ft

Screen 2

Elev	9	8	7	6	5	4	3	2	1
2855.95									
2854.95									
2853.95	0.30	0.05	0.49	0.48	0.08	0.27	0.04	0.16	0.09
2852.87	0.13	0.12	0.07	0.04	0.13	0.04	0.04	0.04	0.02
2851.87	0.09	0.04	0.07	0.04	0.02	0.09	0.08	0.11	0.03
2850.78	0.05	0.03	0.13	0.07	0.03	0.03	0.03	0.03	0.10
2849.78	0.08	0.50	0.05	0.02	0.06	0.03	0.02	0.02	0.05
2848.78	0.09	0.28	0.58	0.62	0.57	0.59	0.60	0.67	0.62
2847.72	0.58	0.61	0.58	0.66	0.65	0.67	0.66	0.69	0.69
2846.72	0.61	0.65	0.63	0.60	0.59	0.50	0.55	0.63	0.55
2845.66	0.60	0.66	0.55	0.59	0.53	0.50	0.50	0.50	0.55
2844.66	0.59	0.58	0.54	0.57	0.53	0.50	0.51	0.55	0.53
2843.66	0.57	0.55	0.52	0.53	0.53	0.54	0.51	0.55	0.52
2842.64	0.51	0.47	0.43	0.32	0.54	0.55	0.50	0.53	0.46
2841.64	0.57	0.34	0.39	0.42	0.42	0.45	0.25	0.13	0.16
2840.64	0.37	0.38	0.18	0.05	0.08	0.07	0.06	0.05	0.20

82 cfs

Screen 1

Elev	9	8	7	6	5	4	3	2	1
2855.90									
2854.90									
2853.84	0.13	0.12	0.10	0.13	0.18	0.11	0.09	0.18	0.12
2852.84	0.05	0.01	0.03	0.04	0.07	0.06	0.08	0.07	0.10
2851.84	0.03	0.06	0.06	0.04	0.02	0.09	0.09	0.06	0.05
2850.78	0.04	0.04	0.04	0.04	0.70	0.08	0.06	0.03	0.01
2849.78	0.06	0.11	0.04	0.05	0.01	0.04	0.02	0.04	0.05
2848.65	0.09	0.08	0.07	0.15	0.24	0.14	0.11	0.30	0.20
2847.65	0.58	0.73	0.64	0.56	0.64	0.58	0.64	0.48	0.43
2846.65	0.83	0.81	0.68	0.71	0.61	0.71	0.65	0.49	0.35
2845.59	0.72	0.65	0.62	0.65	0.61	0.65	0.82	0.71	0.59
2844.59	0.66	0.65	0.59	0.54	0.53	0.62	0.58	0.51	0.42
2843.57	0.62	0.61	0.72	0.66	0.61	0.58	0.63	0.49	0.48
2842.57	0.50	0.52	0.61	0.64	0.69	0.56	0.44	0.09	0.23
2841.57	0.34	0.06	0.19	0.23	0.36	0.42	0.24	0.03	0.05
2840.57	0.30	0.15	0.02	0.01	0.05	0.24	0.17	0.00	0.00

2853 ft

Screen 2

82 cfs

Screen 1

Elev	9	8	7	6	5	4	3	2	1	Elev	9	8	7	6	5	4	3	2	1
2855.95										2855.90									
2854.95										2854.90									
2853.95										2853.84									
2852.87	0.34	0.34	0.27	0.15	0.08	0.07	0.13	0.32	0.37	2852.84	0.05	0.13	0.05	0.09	0.12	0.22	0.22	0.22	0.21
2851.87	0.02	0.05	0.01	0.07	0.03	0.01	0.13	0.03	0.11	2851.84	0.04	0.11	0.15	0.02	0.06	0.11	0.07	0.05	0.09
2850.78	0.11	0.04	0.02	0.03	0.03	0.09	0.07	0.05	0.10	2850.78	0.01	0.07	0.02	0.06	0.00	0.06	0.05	0.05	0.05
2849.78	0.01	0.03	0.10	0.05	0.06	0.06	0.07	0.09	0.04	2849.78	0.06	0.02	0.10	0.06	0.06	0.10	0.05	0.06	0.04
2848.78	0.02	0.24	0.39	0.46	0.47	0.66	0.46	0.63	0.69	2848.65	0.05	0.02	0.08	0.10	0.03	0.08	0.08	0.14	0.26
2847.72	0.44	0.62	0.71	0.76	0.71	0.73	0.74	0.79	0.76	2847.65	0.46	0.76	0.71	0.55	0.61	0.56	0.57	0.47	0.38
2846.72	0.76	0.65	0.64	0.60	0.64	0.60	0.61	0.69	0.67	2846.65	0.75	0.80	0.78	0.68	0.69	0.79	0.77	0.55	0.56
2845.66	0.75	0.73	0.68	0.64	0.58	0.54	0.44	0.43	0.63	2845.59	0.64	0.62	0.65	0.67	0.63	0.78	0.85	0.74	0.64
2844.66	0.73	0.68	0.62	0.68	0.61	0.58	0.45	0.45	0.39	2844.59	0.72	0.65	0.59	0.62	0.66	0.78	0.78	0.67	0.50
2843.66	0.58	0.53	0.51	0.57	0.57	0.48	0.40	0.37	0.31	2843.57	0.68	0.59	0.65	0.58	0.66	0.69	0.69	0.38	0.34
2842.64	0.47	0.46	0.47	0.48	0.51	0.47	0.31	0.19	0.26	2842.57	0.54	0.35	0.71	0.58	0.55	0.45	0.45	0.11	0.09
2841.64	0.42	0.40	0.43	0.26	0.30	0.19	0.05	0.05	0.09	2841.57	0.31	0.18	0.21	0.31	0.29	0.29	0.29	0.07	0.05
2840.64	0.21	0.29	0.16	0.16	0.01	0.05	0.03	0.02	0.00	2840.57	0.19	0.01	0.05	0.03	0.02	0.02	0.04	0.06	0.01

2852 ft

Screen 2

Elev	9	8	7	6	5	4	3	2	1
2855.95									
2854.95									
2853.95									
2852.87									
2851.87	0.24	0.20	0.11	0.03	0.03	0.02	0.09	0.22	0.33
2850.78	0.03	0.01	0.03	0.01	0.06	0.14	0.01	0.06	0.01
2849.78	0.07	0.01	0.03	0.04	0.00	0.09	0.03	0.04	0.02
2848.78	0.08	0.03	0.37	0.52	0.49	0.57	0.34	0.59	0.54
2847.72	0.26	0.36	0.62	0.57	0.61	0.50	0.58	0.65	0.64
2846.72	0.42	0.43	0.54	0.54	0.51	0.44	0.40	0.48	0.50
2845.66	0.39	0.38	0.41	0.38	0.35	0.35	0.40	0.44	0.44
2844.66	0.34	0.34	0.32	0.26	0.27	0.30	0.28	0.26	0.27
2843.66	0.31	0.31	0.28	0.19	0.20	0.26	0.23	0.21	0.22
2842.64	0.15	0.23	0.20	0.05	0.10	0.18	0.13	0.11	0.12
2841.64	0.09	0.02	0.03	0.01	0.06	0.09	0.13	0.02	0.05
2840.64	0.08	0.07	0.08	0.06	0.08	0.07	0.01	0.02	0.00

82 cfs

Screen 1

Elev	9	8	7	6	5	4	3	2	1
2855.90									
2854.90									
2853.84									
2852.84									
2851.84	0.11	0.06	0.12	0.08	0.16	0.21	0.21	0.22	0.23
2850.78	0.10	0.02	0.06	0.05	0.05	0.09	0.05	0.08	0.05
2849.78	0.06	0.05	0.05	0.03	0.03	0.07	0.07	0.10	0.01
2848.65	0.08	0.06	0.06	0.07	0.07	0.06	0.06	0.12	0.21
2847.65	0.64	0.69	0.86	0.85	0.69	0.59	0.61	0.51	0.32
2846.65	0.73	0.75	0.75	0.79	0.73	0.85	0.78	0.57	0.36
2845.59	0.04	0.51	0.54	0.57	0.60	0.72	0.78	0.68	0.55
2844.59	0.68	0.56	0.49	0.53	0.64	0.65	0.78	0.70	0.56
2843.57	0.57	0.57	0.53	0.59	0.58	0.55	0.58	0.46	0.23
2842.57	0.09	0.42	0.52	0.41	0.52	0.41	0.36	0.17	0.09
2841.57	0.42	0.19	0.35	0.04	0.24	0.21	0.15	0.10	0.07
2840.57	0.26	0.14	0.08	0.01	0.03	0.06	0.20	0.03	0.08

Results

Screen Integrity

Screen Integrity Video

■ Screen Views

- Screen 1 (Clip #2 00:04:00 – 00:05:00)
- Screen 2 (Clip #5 00:10:00 – 00:10:40) &
- (Clip #6 00:11:15 – 00:12:00)

■ Rotating Screens

- (Clip #12 00:18:45 – 00:19:45)

RESULTS

Fish Entrainment

Fish Entrainment

- No fish were impinged on the screen during any of the velocity tests
- Fish were able to move about freely between the forebay and the intake wells with the debris screens removed
- Highest project flows (~219 cfs) did not negatively affect the fish.

Fish Behavior Video

- Flow/Fish View
 - Screen 1 (Clip #1 00:01:05 – 00:01:45)
 - Screen 2 (Clip #3 00:05:40 – 00:06:20)
- Transition From 82 cfs – 215 cfs
 - Screen 2 (Clip 12 00:25:15 – 00:26:15)

Results

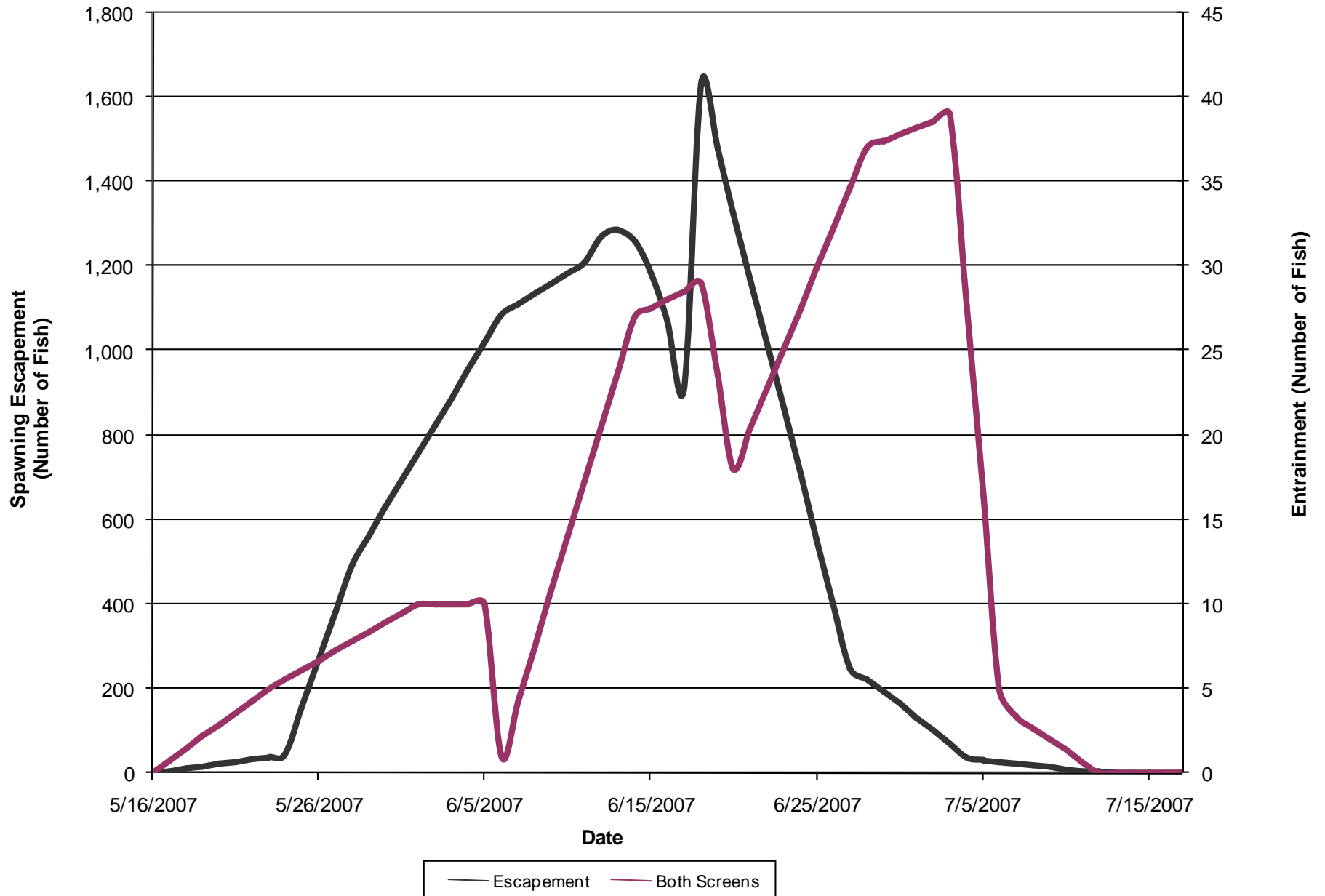
2008 Entrainment and Packwood
Lake Inflows

2008 Entrainment, cont'd

- Total of 60 fish were entrained on the screens in 2008
 - 26 on Screen 1
 - 29 on Screen 2
 - 5 – Screen number not recorded
 - Some of the fish impinged when the project was not operating
- 84% entrained between June 12 and July 23 (10 obs)
- Timing consistent with late and post-spawn periods of Packwood Lake rainbow trout
- Many of the fish were in advanced states of decay, suggesting poor condition when entering the intake wells.

2007

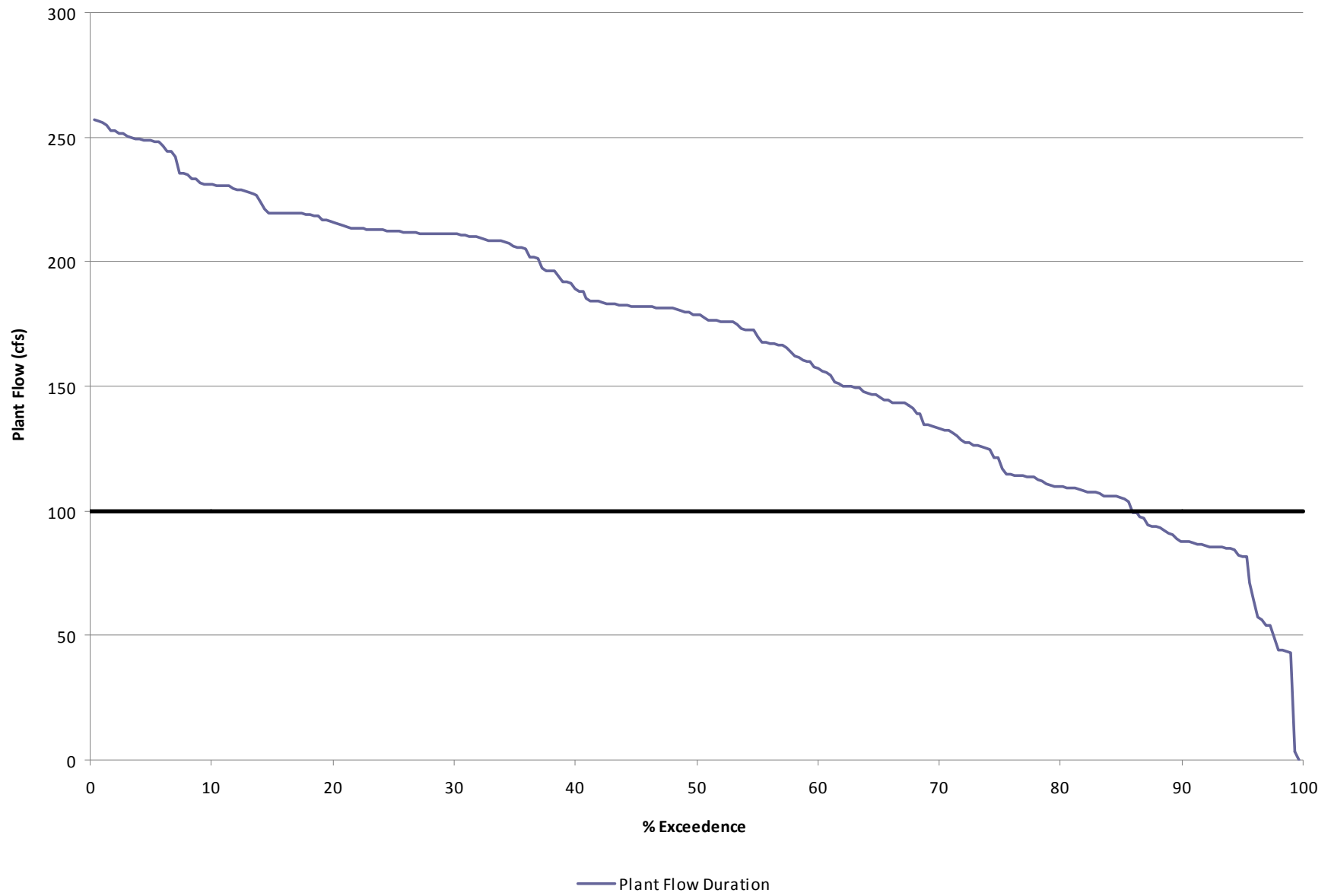
Packwood Lake Entrainment and Spawning Timing



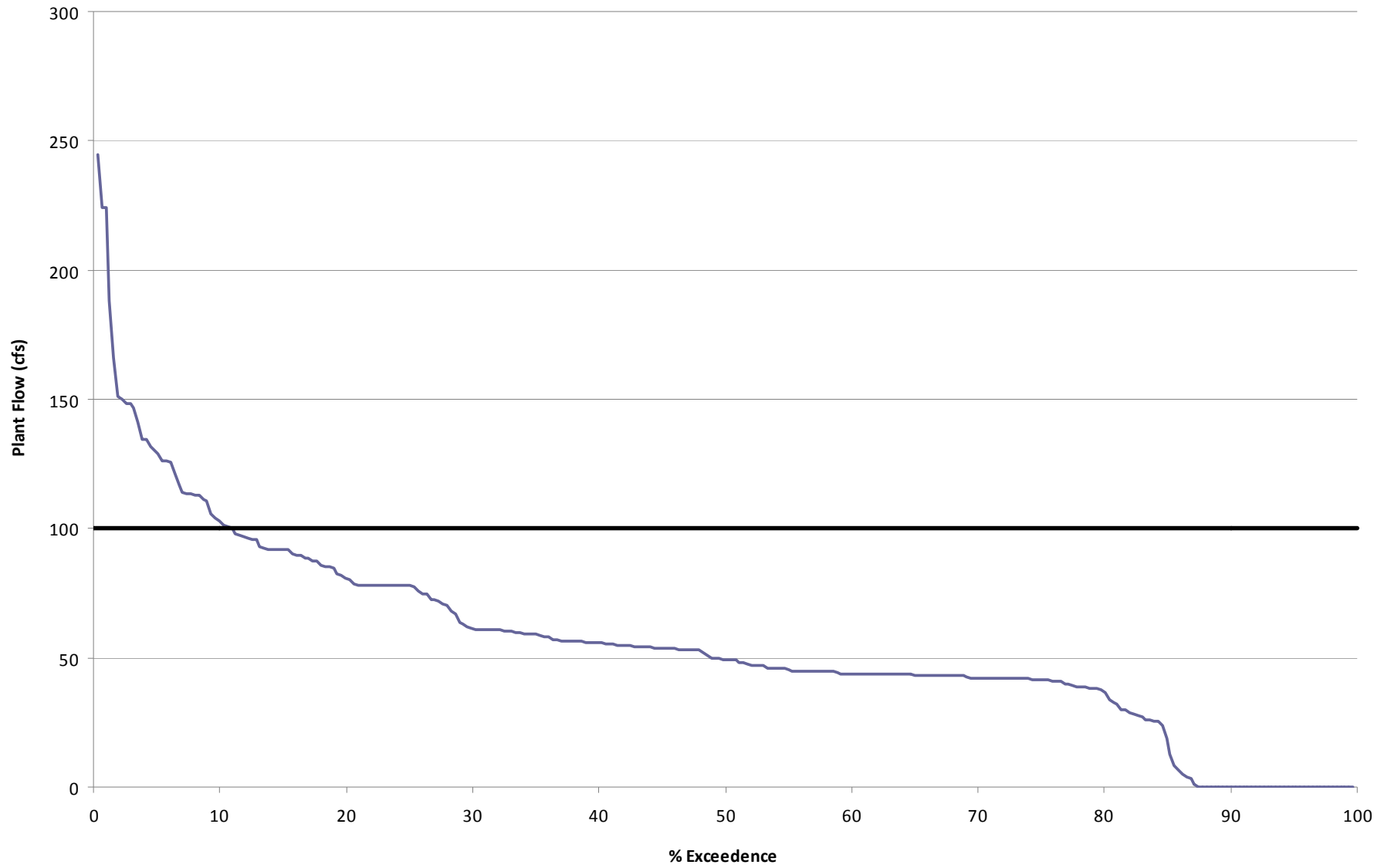
Percentage of Time that Packwood Lake
Operational Flows > 100 cfs

Month	% of Time > 100 cfs
January	28.6%
February	13.7%
March	12.2%
April	13.0%
May	59.5%
June	85.6%
July	55.3%
August	10.9%
September	29.2%
October	3.9%
November	24.4%
December	32.9%

June Plant Flow Duration (1999-2008)



August Plant Flow Duration (1999-2008)



— Plant Flow Duration

Conclusions

- On average, the flows at the Packwood Lake Intake structure only exceed 100 cfs 31% of the time on an annual basis
- Restricting plant flow would be onerous
 - Power Production
 - Preventing spill in Lake Creek

Conclusions, cont'd

- Observations during the velocity tests indicate that, although velocity criteria are exceeded, fish were observed to be able to avoid entrapment and impingement on the intake screens
- Energy Northwest proposes biological monitoring

Next Steps

- Energy Northwest proposes an “adaptive approach”
 - Clean out the debris in front of the Intake Building
 - Maintain the use of the debris screens, but leave 2 ft gap at the bottom to allow fish to move between the forebay and intake wells
 - This will allow fish access to/from the intake wells
 - Potential “Stop log” in front of the screens to prevent debris accumulation and a velocity shield

Next Steps, cont'd

- Monitor screens for impingement
- Use underwater camera to monitor fish behavior/numbers
 - During spawning
 - During spring
 - During fall prior to “drawdown” in 2009

Next Steps, cont'd

- If impingement on the screens exceeds threshold levels (to be established with the agencies), Energy Northwest will consult with the natural resource agencies and tribes to examine alternative means of protecting fish at the intake.