Jun 27th, 11:05 AM - 11:25 AM

Concurrent Sessions D: Downstream Migrant Surface Collectors-What Works and What Doesn't Work - Evaluation of the Hydraulic Performance of a Free Surface Fish Bypass

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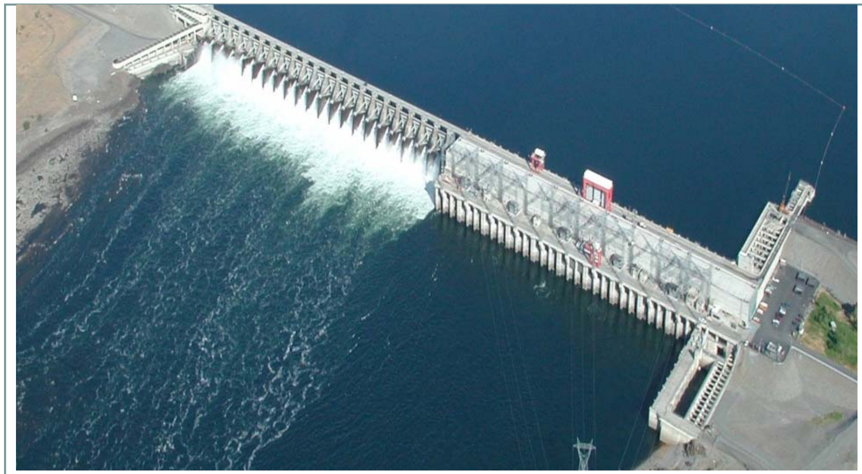

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Evaluation of the Hydraulic Performance of a Free Surface Fish Bypass

L. Weber, M. Politano, T. Lyons, and D. Hay

Fish Passage 2013, Corvallis, OR, June 25-27, 2013

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Background

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- Grant County Public Utility District No. 2 owns and operates Priest Rapids Dam.
- The concrete gravity dam was built between 1956-1961.
- The ten-unit powerhouse has a total generating capacity of 955.6 MW. The spillway has 22 tainter gates and can pass up to 1.4 million cfs.

The BiOp requires 93% juvenile salmon survival past the project.

The District is seeking to achieve at least 95% survival of juveniles past the dam through development of a non-turbine downstream fish bypass.

Current agreement requires 61% MOA spill in the spring, 39% in the summer.

Goal to keep within TDG standards set by the State of Washington.

Fish Bypass Design Challenges

THE PRIMARY DESIGN CHALLENGES/CONCERNS:

- Fish bypass location
- Fish bypass flow rate
- Optimizing the design for fish to enter the bypass
- Fish safety during passage
- Egress flow conditions

SECONDARY CHALLENGES/CONCERNS:

- Erosion potential in the tailrace
- Impact on project flow capacity for a permanent installation

Key Considerations

- Proximity of the non-turbine passage opening to where highest density of salmonids was expected to be;
- The degree to which there was competition between flow through the powerhouse and flow through the non-turbine passage route;
- The stability of the flow and acceleration field upstream of the non-turbine passage route;
- The source of bypass water and zone of influence of the bypass;
- The egress of the bypass water in the tailrace with respect to proximity to areas of potential high predation; and,
- The egress of the bypass water with respect to minimizing the uptake of gas in the tailrace.

Non-Turbine Alternatives

- The use of a single spillbay operated with a full-open gate to pass about 60,000 cfs;
- An overflow weir passing about 15,000 cfs from the left bank of the dam in the area of the earthen embankment;
- Screening all of the turbine intakes and providing a bypass through Spillbay 22 with a flow of about 5000 cfs;
- Collectors comprised of openings in a channel constructed in front of the powerhouse, or in front of a single spillbay, that would draw about 15,000 cfs from the surface of the forebay and deliver the flow through a spillbay to the tailrace;
- Numerous “top-spill” bypass configurations where surface flow was released through notches in existing spillway gates; and,
- Split spillbays where an existing spillbay was either split vertically with an additional pier or split horizontally by closing a portion of the spillbay above the spillway crest.

Physical Models

- 1:64 scale forebay model
- 1:64 scale tailrace model
- 1:20 scale fish bypass model

1:64 Scale Forebay Model

- General forebay flow conditions
- Concept development
  - Top spill bulkheads
  - Gate modifications
  - Spillway bay modifications
  - Behavioral guidance structure (BGS)
  - Powerhouse screen
  - Water jets
  - Surface collectors
- Final design testing
  - Approach flow conditions
  - Powerhouse operations and interaction with bypass

1:64 Scale Tailrace Model

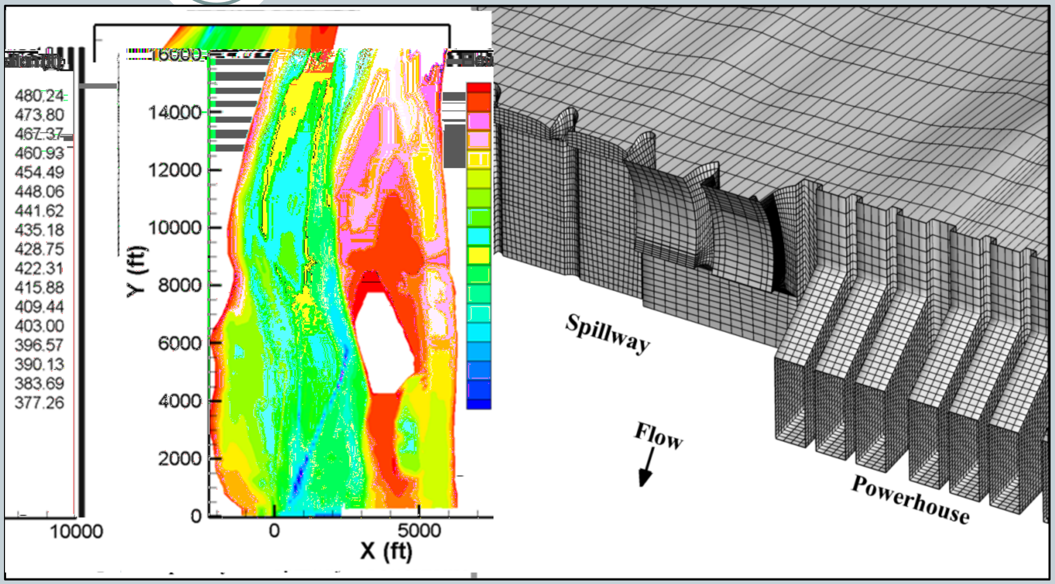
- General tailrace flow conditions
- Concept development
  - Top spill bulkheads
  - Gate modifications
  - Spillway bay modifications
- Final design testing
  - Water surface profiles
  - Apron elevation
  - Apron length
  - Pier extension height and length
  - Tailwater performance curve
  - Erosion potential
- Construction support
  - Contractor visit and demonstrations
  - Wave height and velocity data
  - Barge placement and anchoring

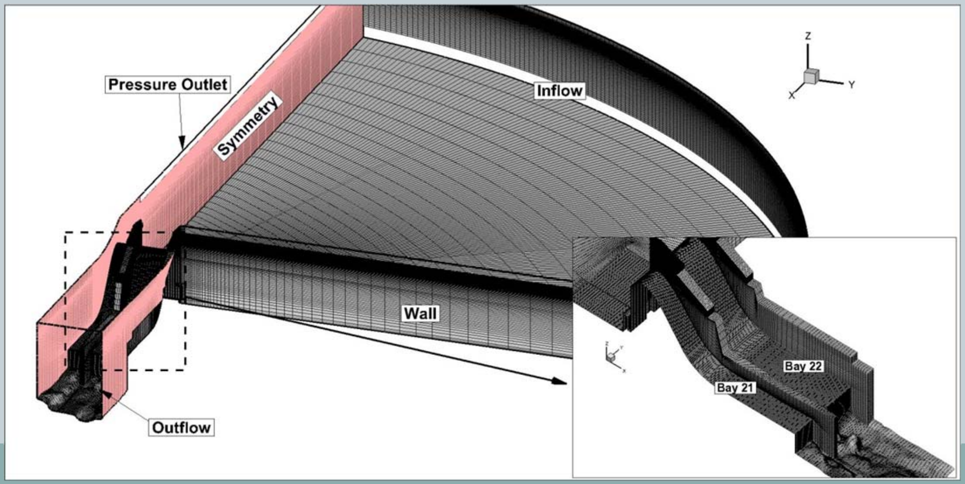
1:20 Scale Bypass Model

- Final concept testing
  - Near-field upstream flow patterns
  - Ogee shape
  - Ogee pressures
  - Water surface profiles
  - Velocities on apron
- Spillway gate modifications
  - Gate support arms
  - Ice/trash sluice

Numerical Models

- Forebay model
  - Approach flow hydraulics
  - Concept development
  - Zones of influence
  - Velocities and accelerations
- Top-spill model
  - Concept development
- Fish bypass model
  - Pressures
  - Forces on bypass walls
  - Cavitation indices
  - Free surface profiles
  - Jet characteristics
- Numerical fish surrogate model





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Top-Spill Development

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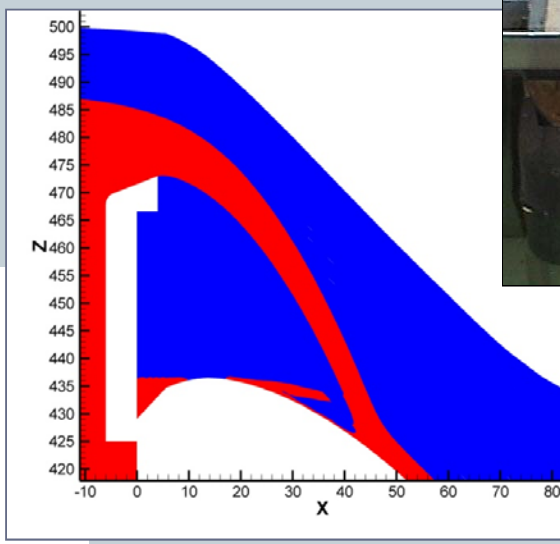
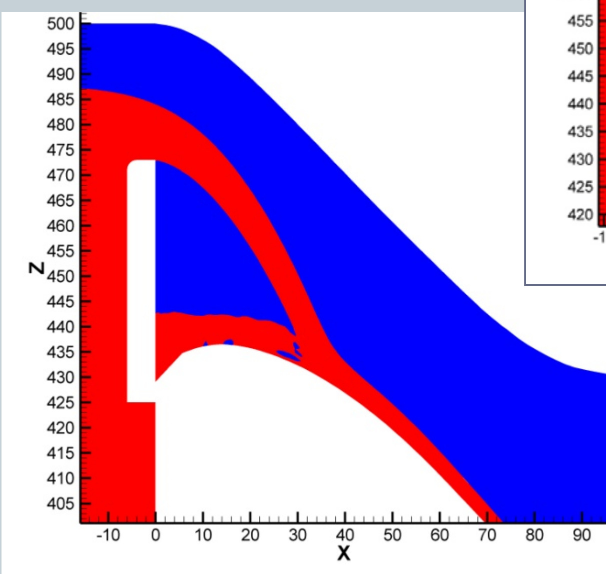
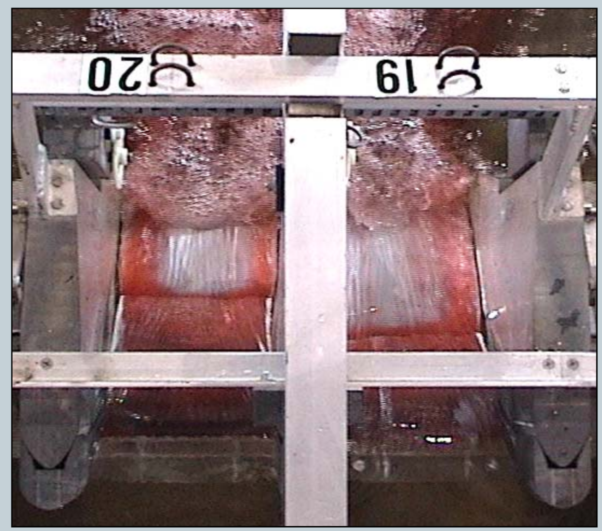
- Gate clearance
- Nappe profiles
- Jet impact location
- Stilling basin hydraulics
- Bypass rating

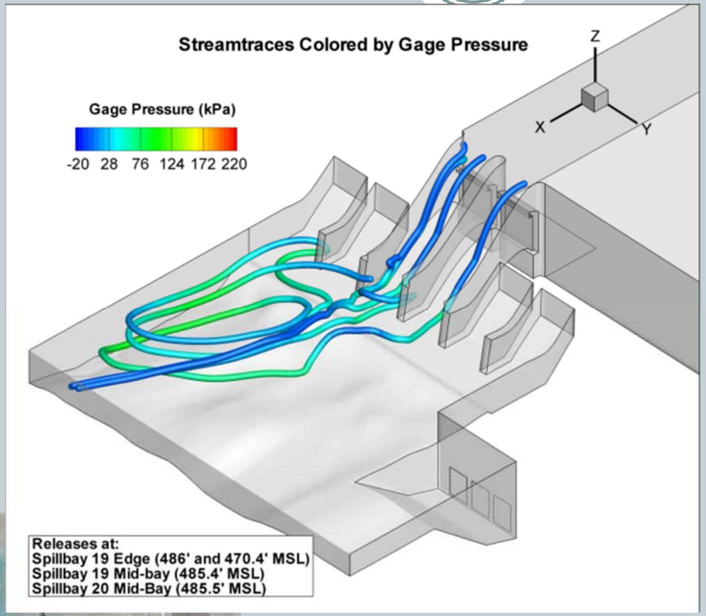


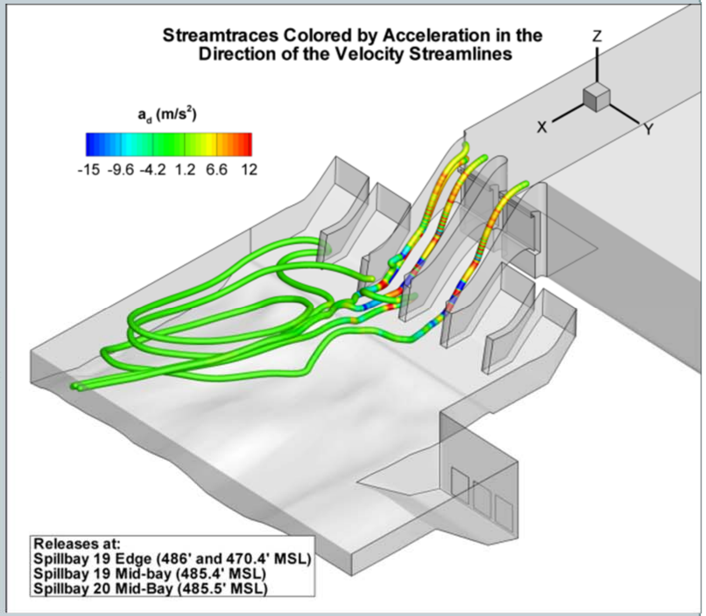


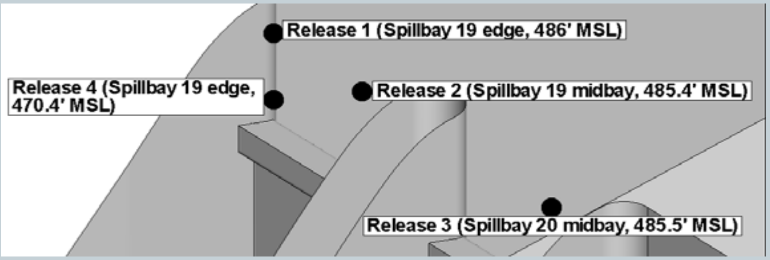


Top-Spill Development

- Pressure on particles (fish) through the top-spill
- Jet characteristics in near vicinity



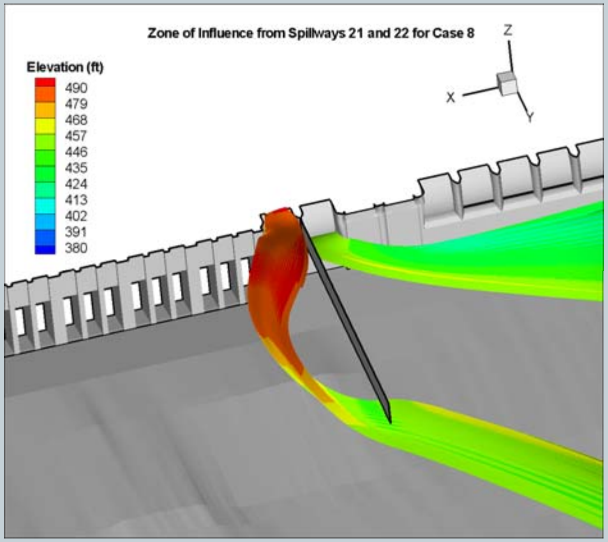


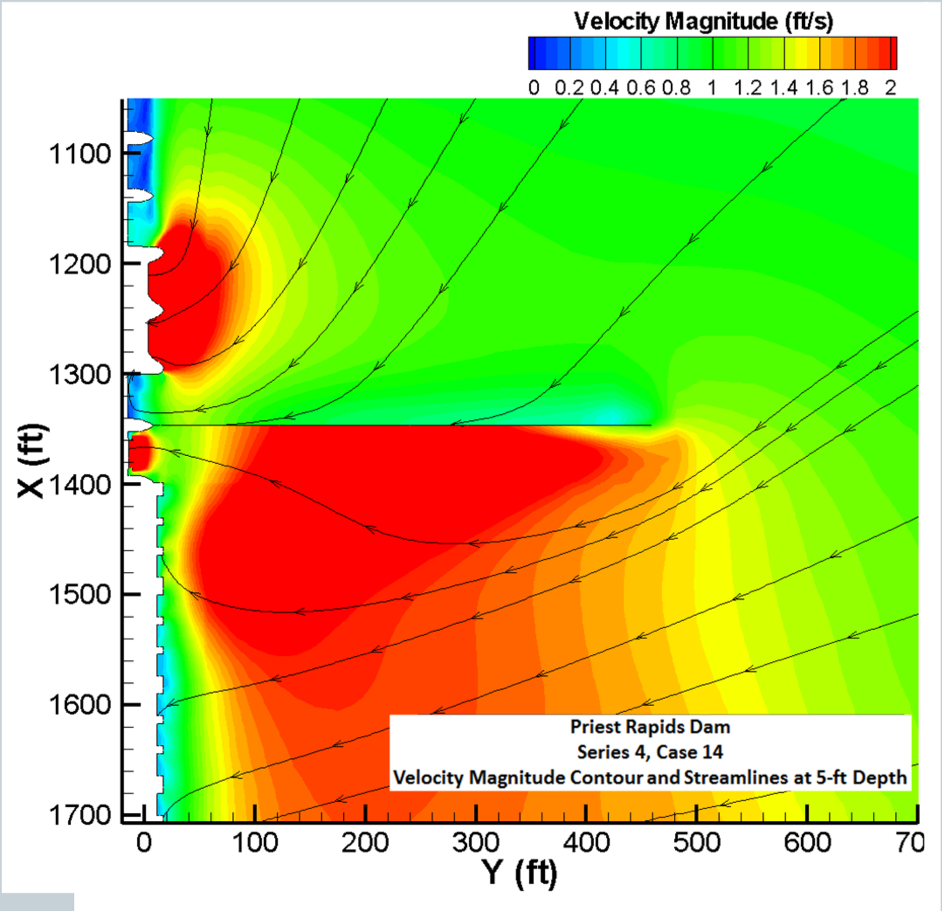


Particle release locations

Top-Spill Development

- Training wall evaluation
- Velocity contours
- Flow streamlines
- Forces on training walls
- Zone of influence





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Final Design Renderings

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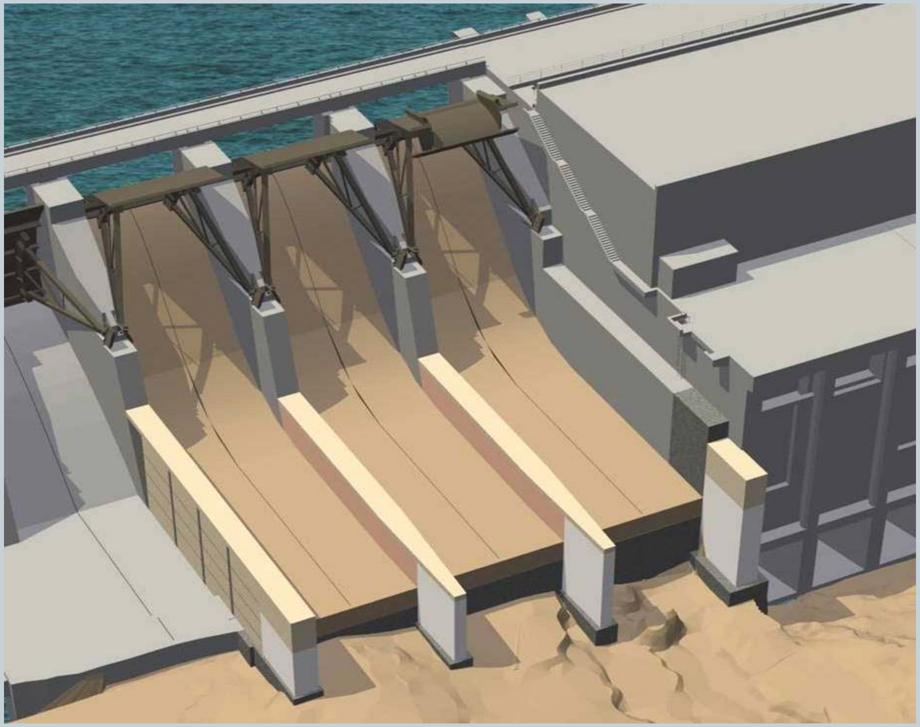

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Approach Flow

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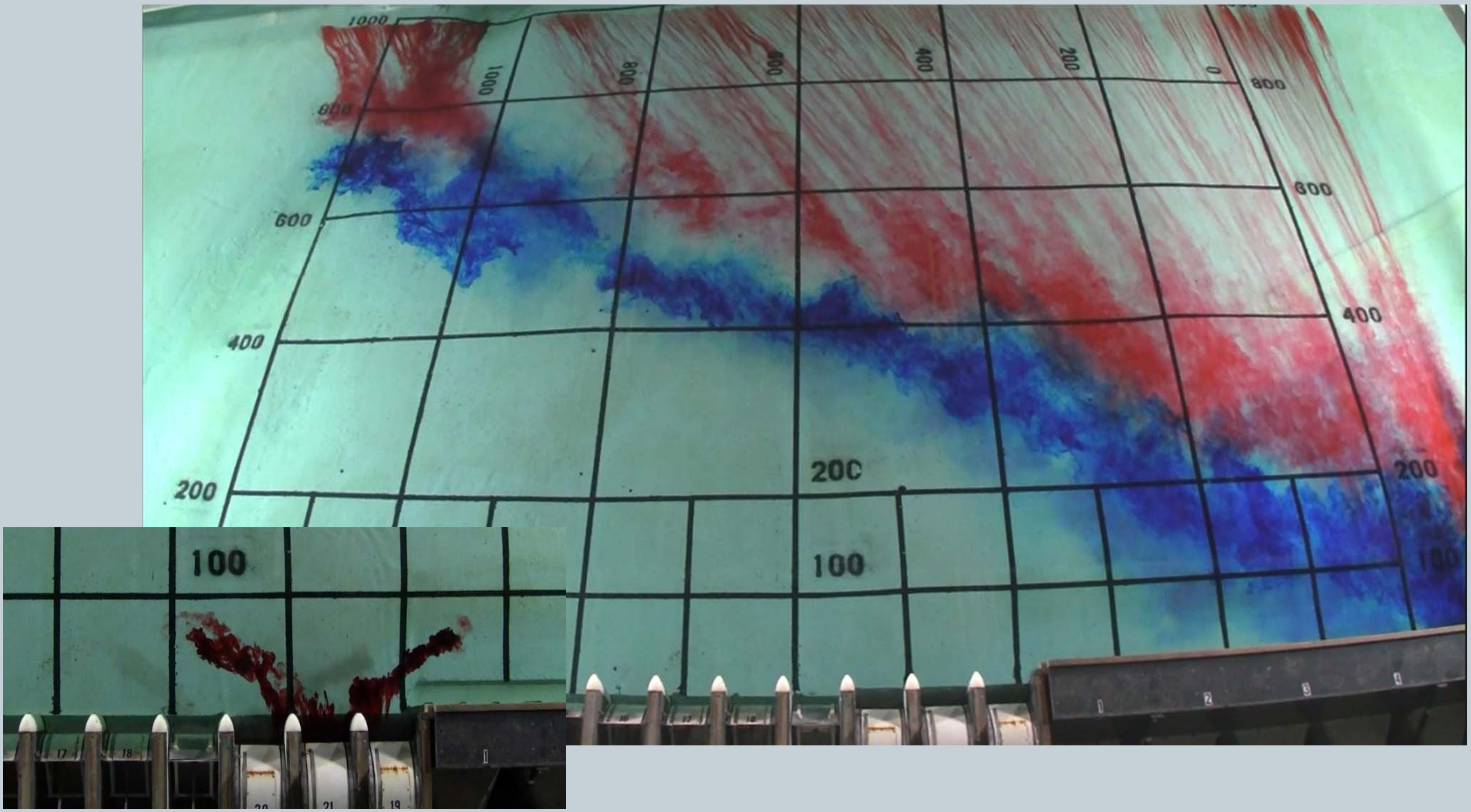
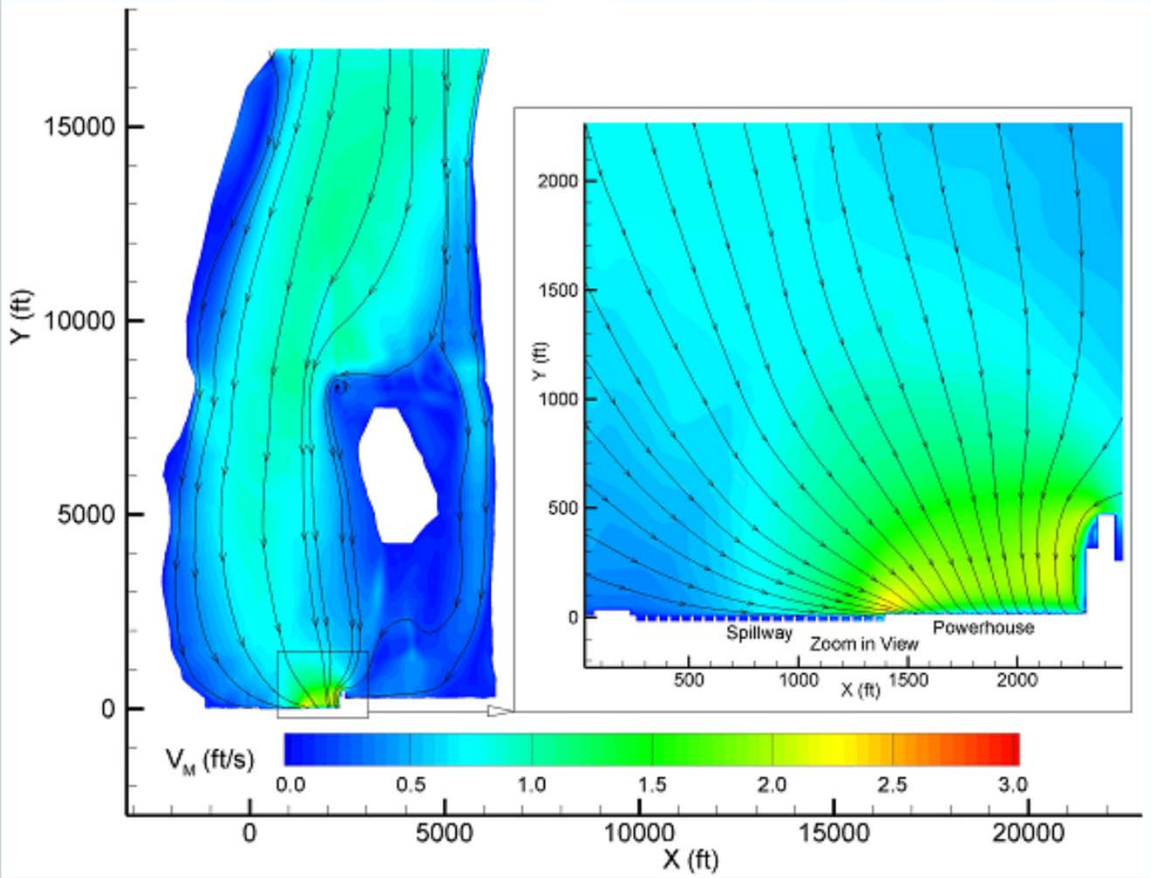
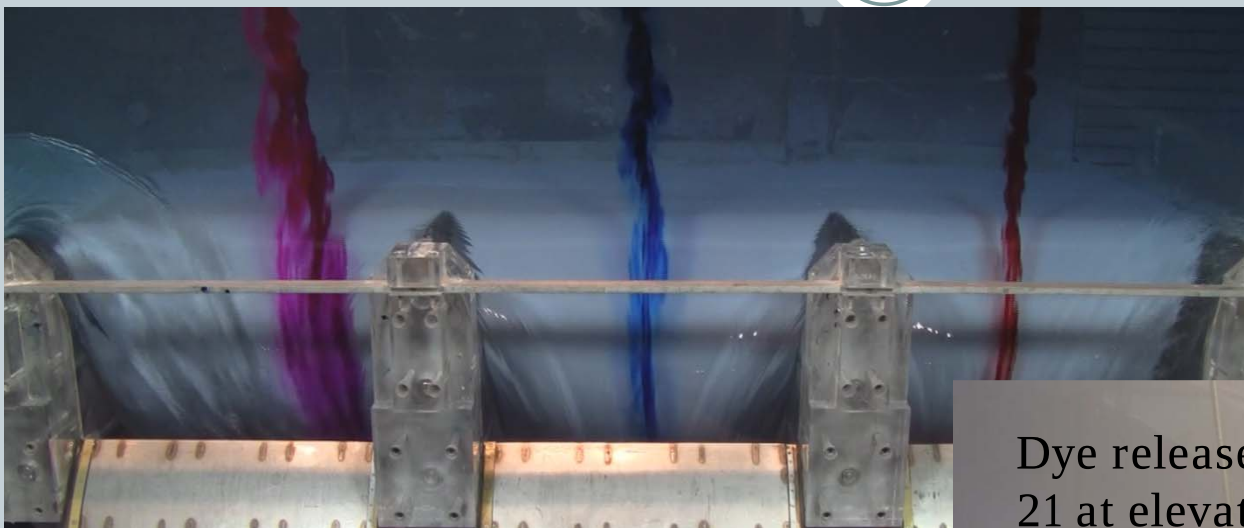


Approach Flow



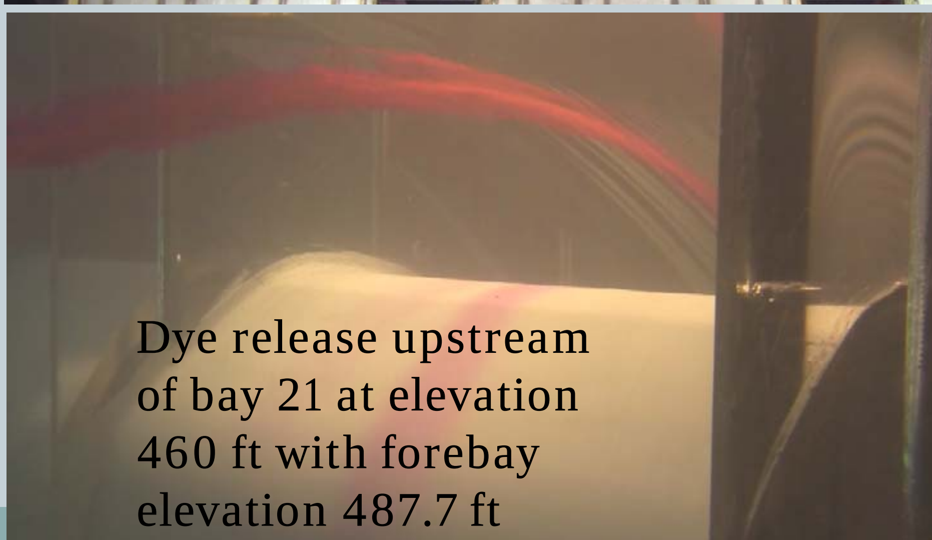
Velocity contours and 2D streamlines for a river flow of 160,000 cfs with no spillway operation

Detailed Approach Flow



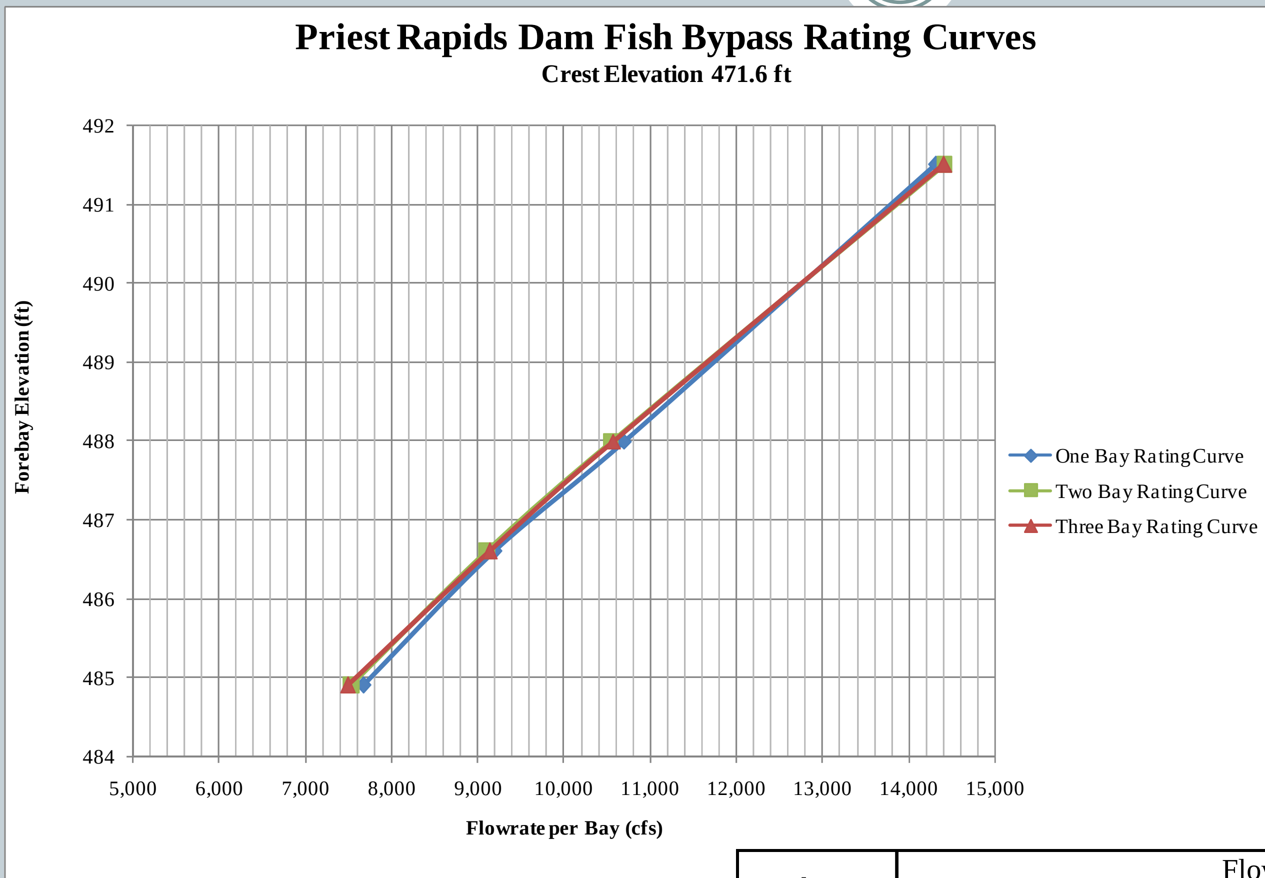
Three bypass bay dye release at elevation 451.6 ft in the center of each bay with headwater elevation of 487.7 ft

Dye released along face of bay 21 at elevation 460 ft with forebay elevation 486.6 ft



Dye release upstream of bay 21 at elevation 460 ft with forebay elevation 487.7 ft

Fish Bypass Rating

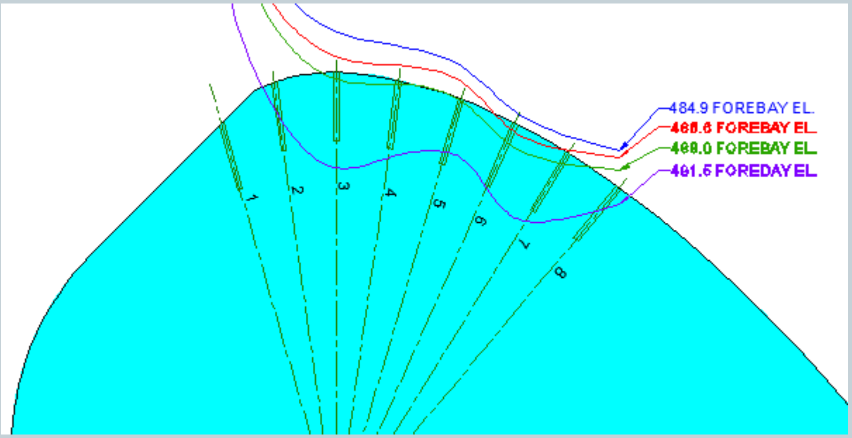


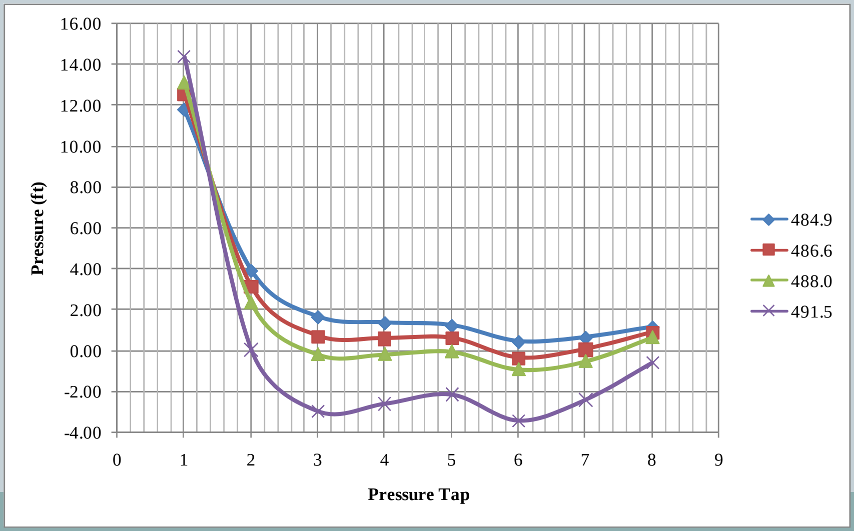
Forebay EL	Flowrate per Bay (cfs)		
	One Bay (21)	Two Bays (21 and 22)	Three Bays (20, 21, and 22)
484.9	7,640	7,541	7,498
486.6	9,259	9,117	9,142
488.0	10,709	10,551	10,565
491.5	14,401	14,422	14,407

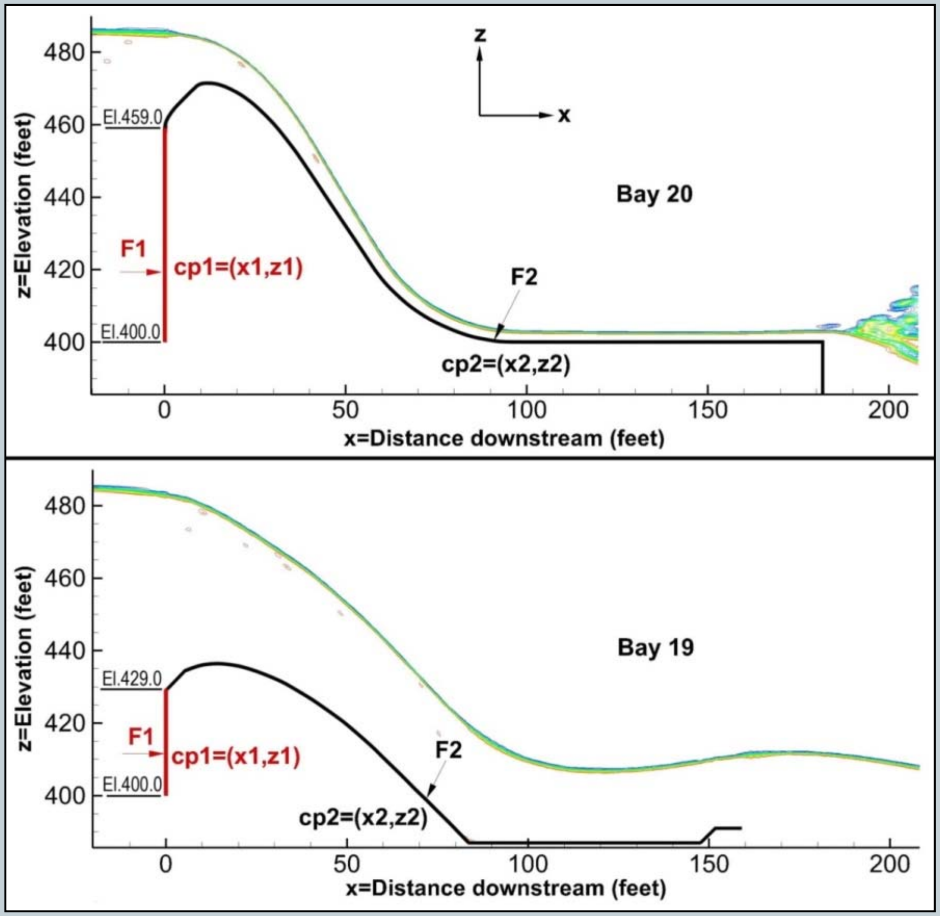
Fish Bypass Rating

	Forebay elevation (ft)	Tailwater elevation (ft)	Bay	Laboratory measured flow rate (kcfs)	Numerically predicted flow rate (kcfs)	Difference between predicted and measured flow rate (%)
Simulation I 90% Exceedance	484.9	405.2	21	7.50	7.67	2.3
Simulation II 50% Exceedance	486.6	411.0	21	9.00	9.28	3.1
Simulation III 10% Exceedance	487.7	415.0	21	10.10	10.40	3.0
Simulation IV PMF condition	491.5	459.7	21	14.40	14.80	2.8
Simulation V PMF condition	491.5	459.7	21	14.40	14.73	2.3
			22	14.40	14.65	1.7
Simulation VI 50% Exceedance	486.6	411.0	19	N/A	56.90	N/A
			20	9.00	9.33	3.7
Simulation VII PMF condition	491.5	459.7	19	64.00	64.40	0.6
			20	14.40	14.65	1.7
Simulation VIII 50% Exceedance	486.6	411.0	19	N/A	59.00	N/A
Simulation IX PMF condition	491.5	459.7	19	68.70	66.60	-3.0

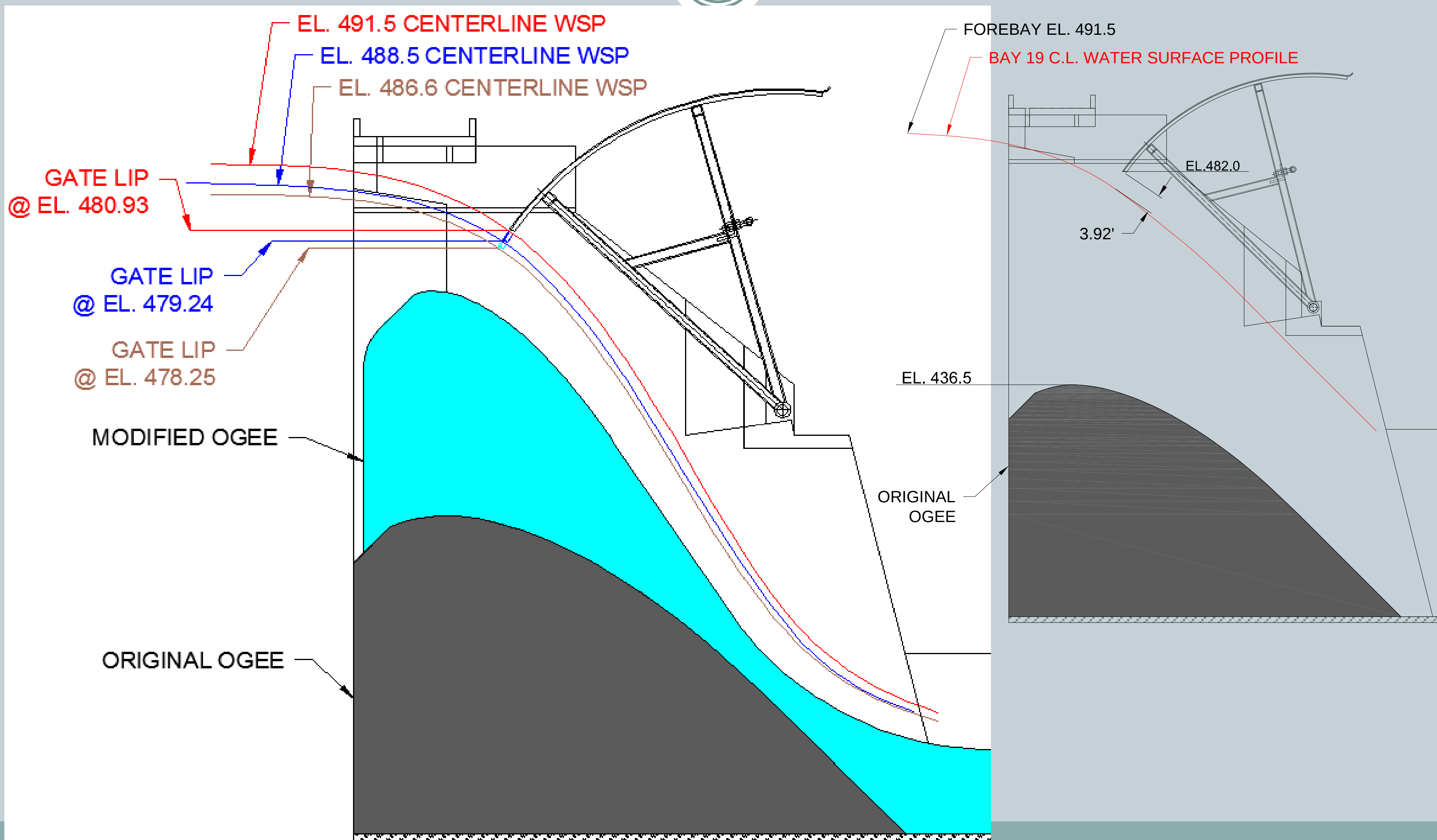
Pressures and Forces







Water Surface Profiles



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Pressure

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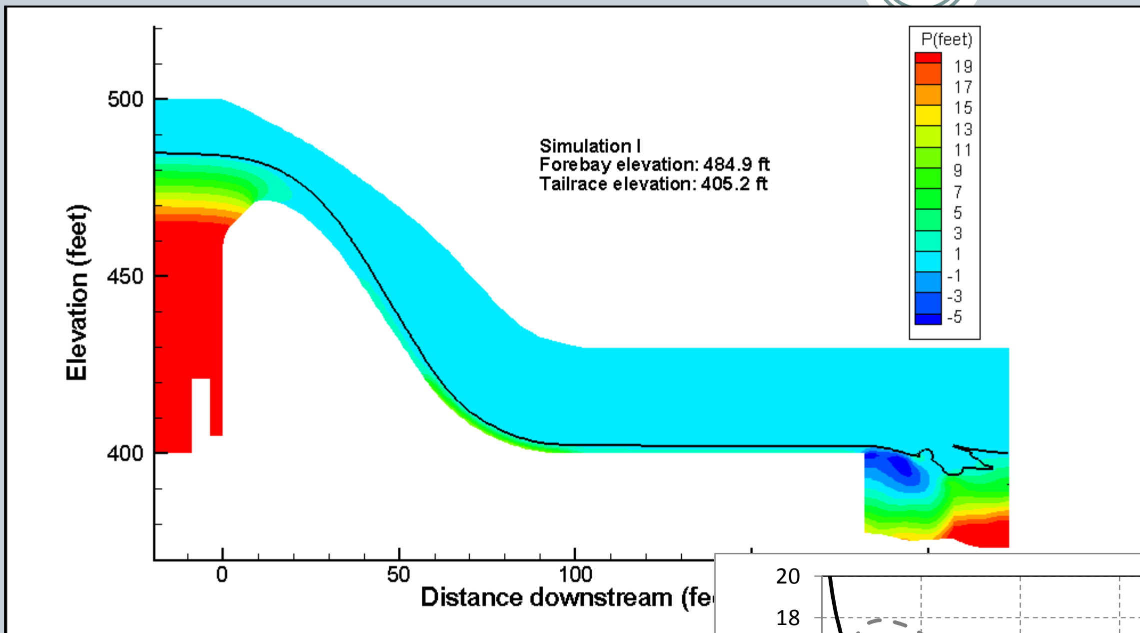
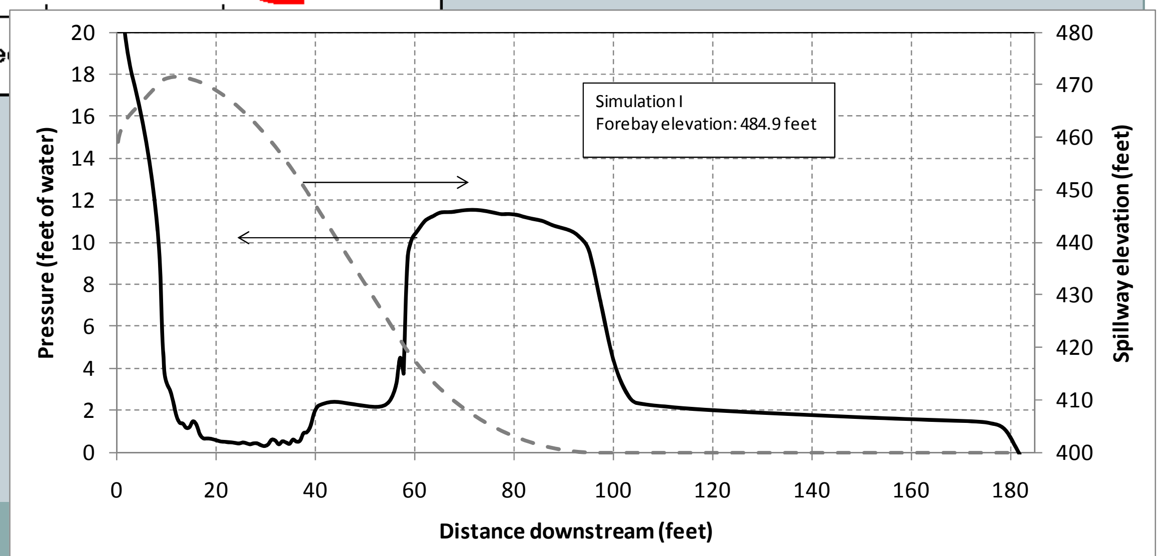
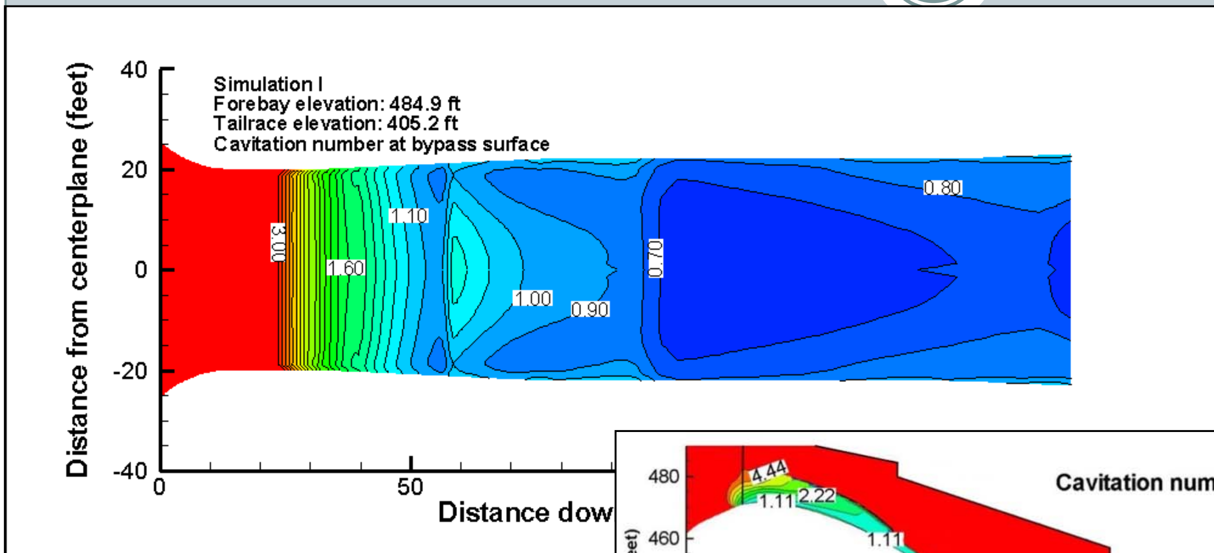


2D slice of pressure contours at centerline of bypass

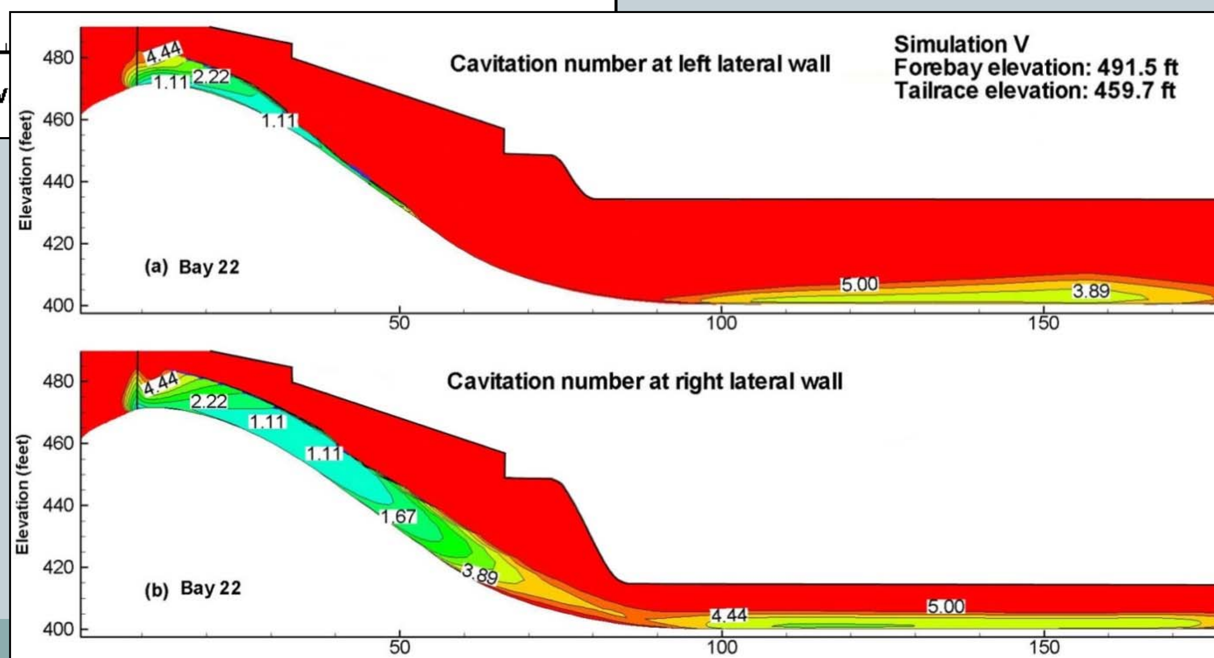


Gage pressure along the ogee centerline

Cavitation Indices

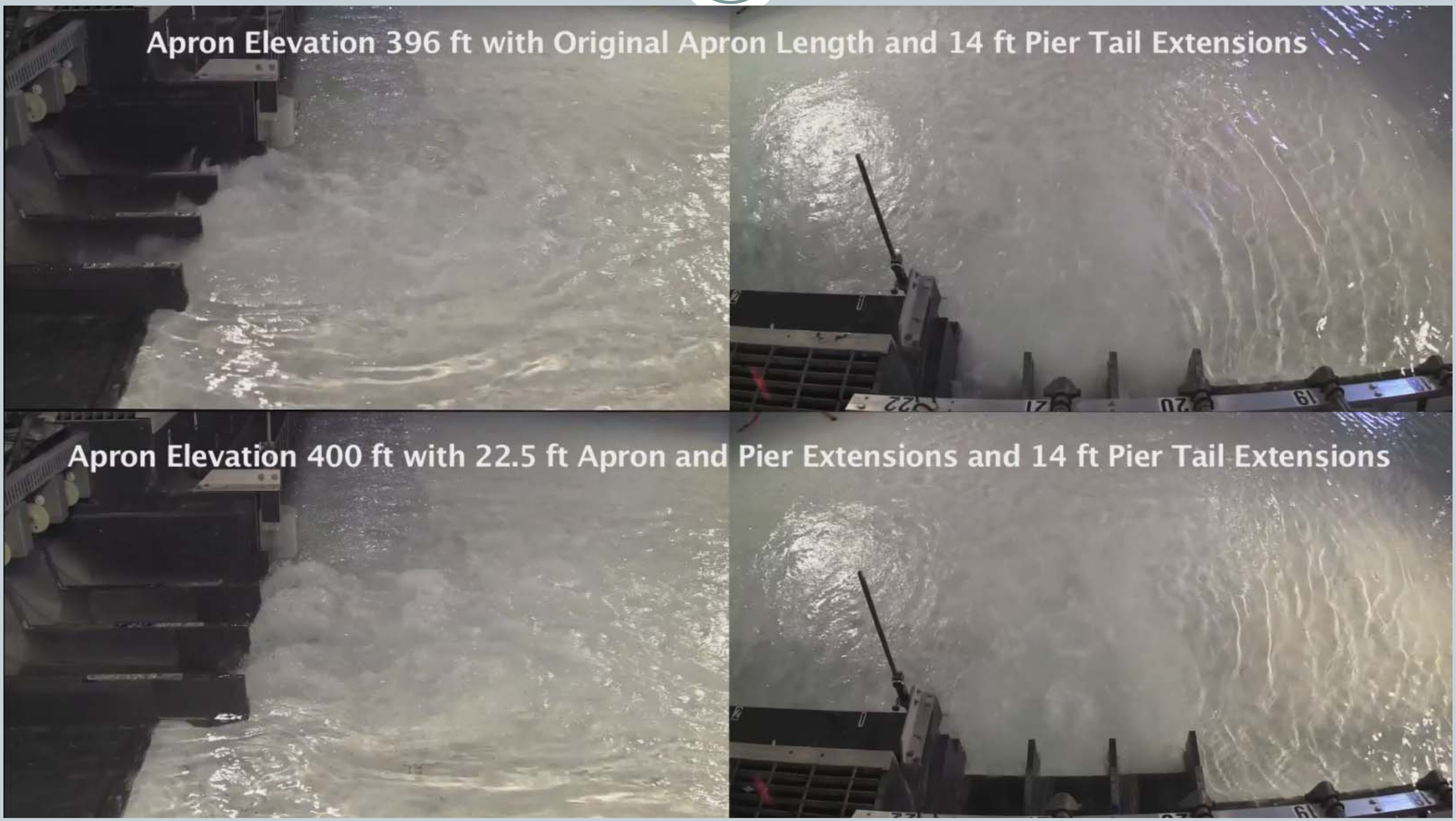


Contour of cavitation number at bypass surface for Simulation I

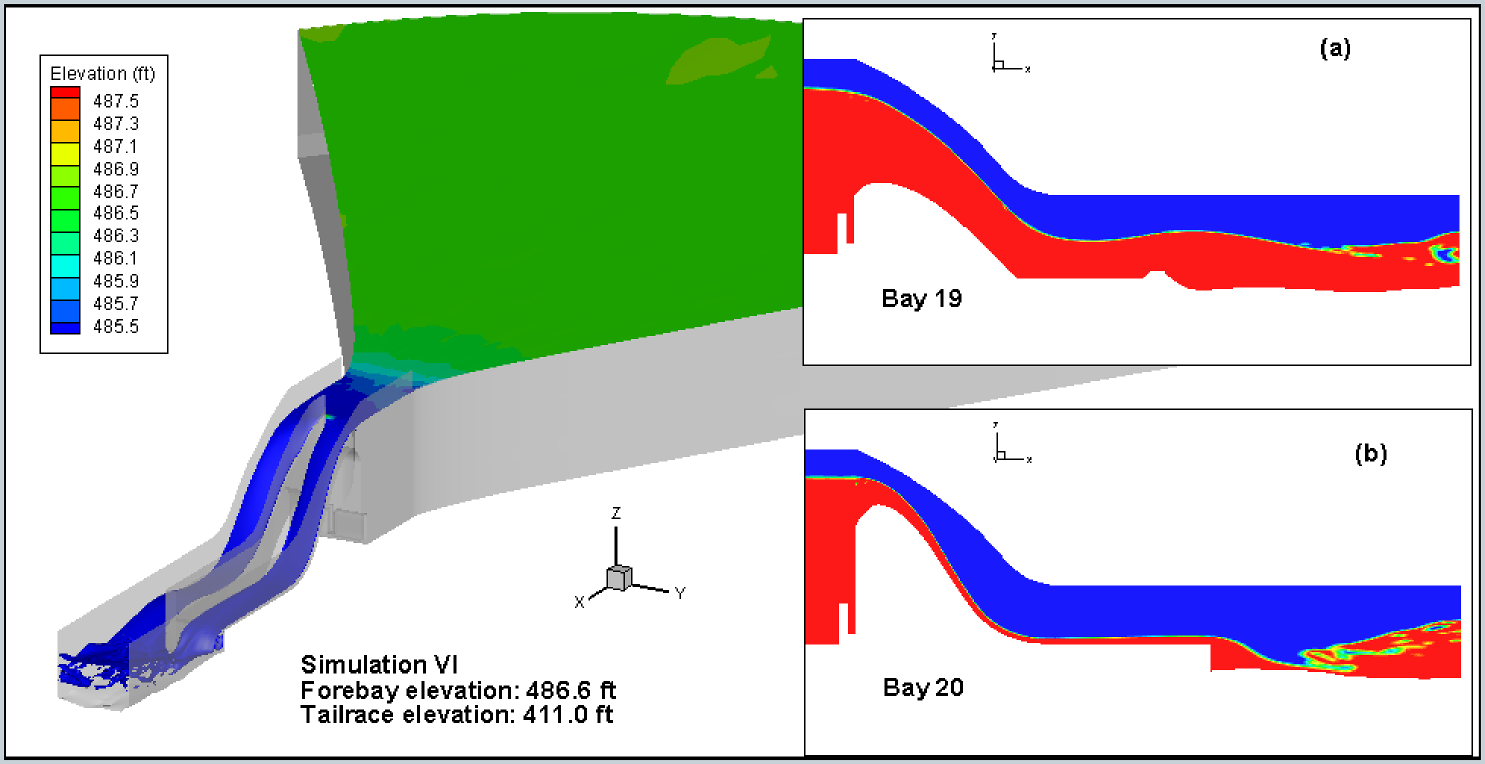


Contour of cavitation number at lateral walls in bay 21 (a and b) and bay 22

Apron Elevation

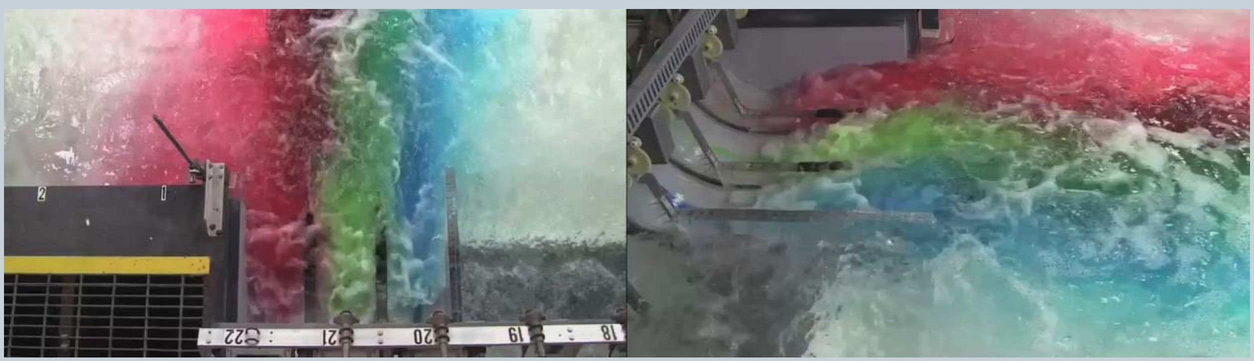


Jet Characteristics



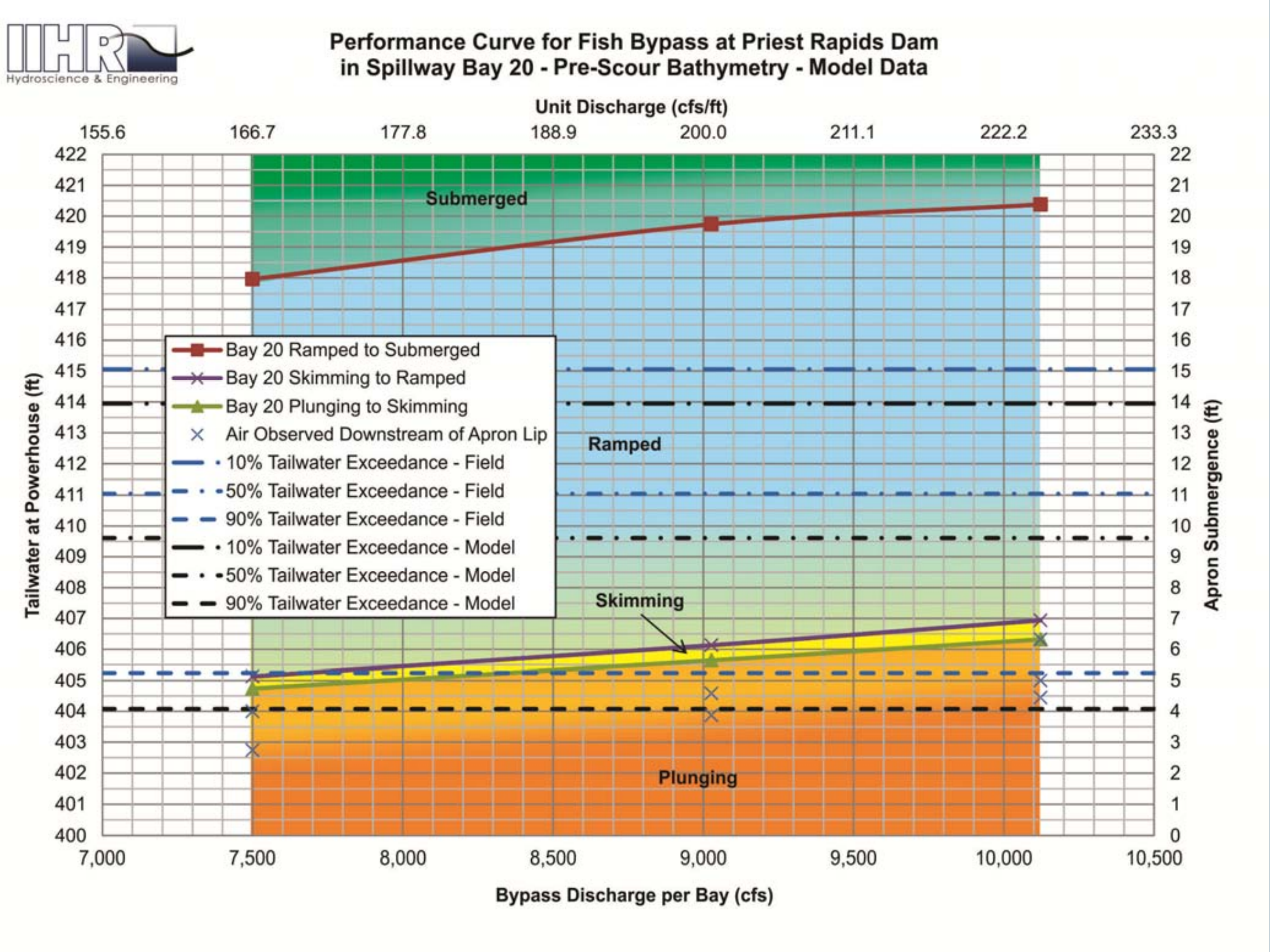
Jet Characteristics

Skimming jet in bay 20, ramped jet in bay 21, and skimming -to-ramped jet in bay 22



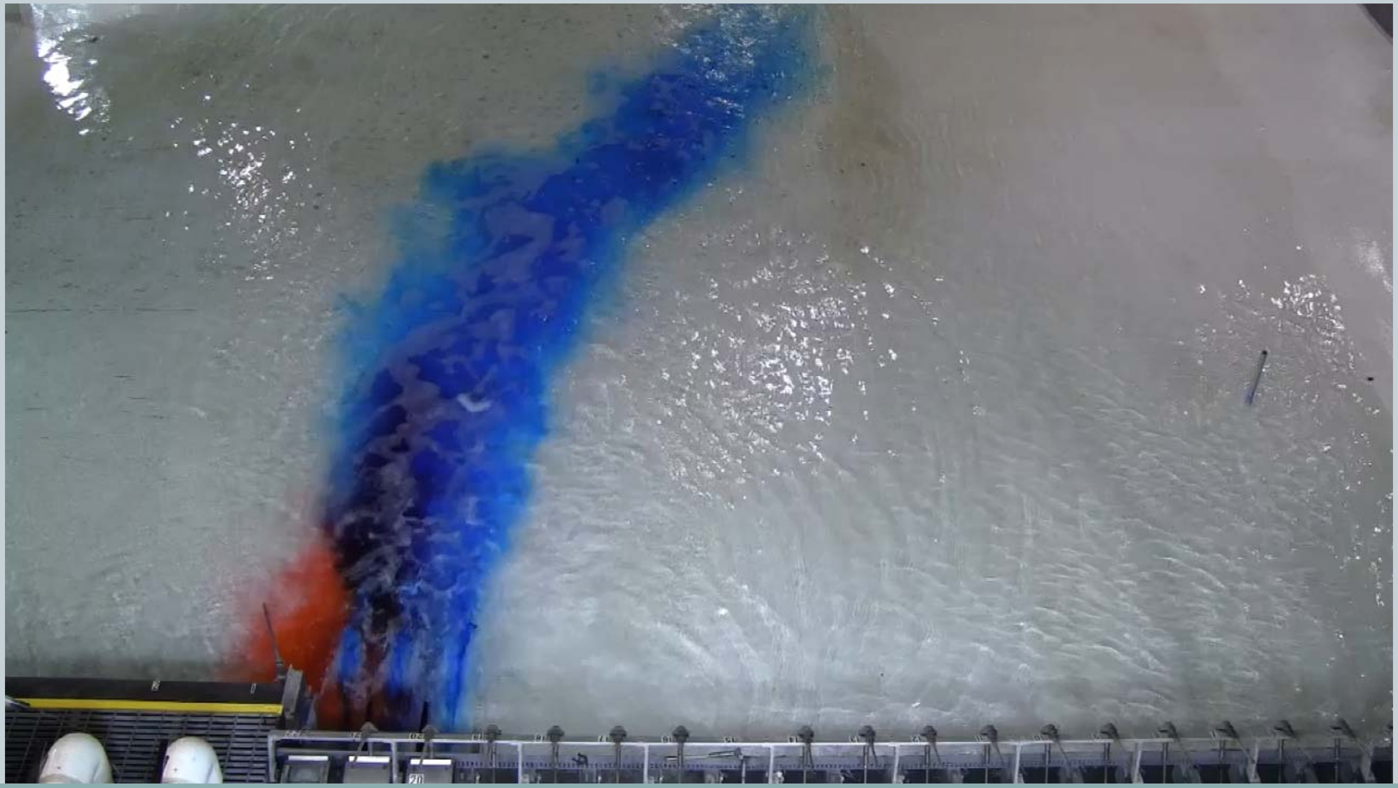
Hydraulic jump reaches face of spillway with forebay elevation of 488.0 ft and river flow of 414,900 cfs

Performance Curve



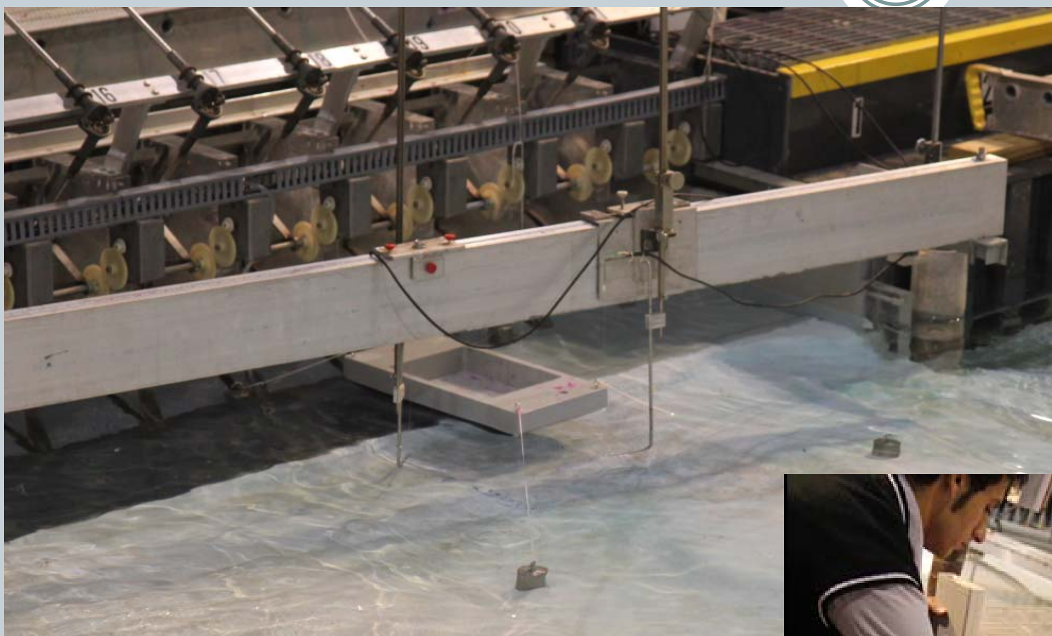
Tailrace Egress

- River flows of 64, 120, 180, and 220 Kcfs
- One, two, and three bypass bays operating
- Back eddies, merging powerhouse and bypass flows, and jet performance documented



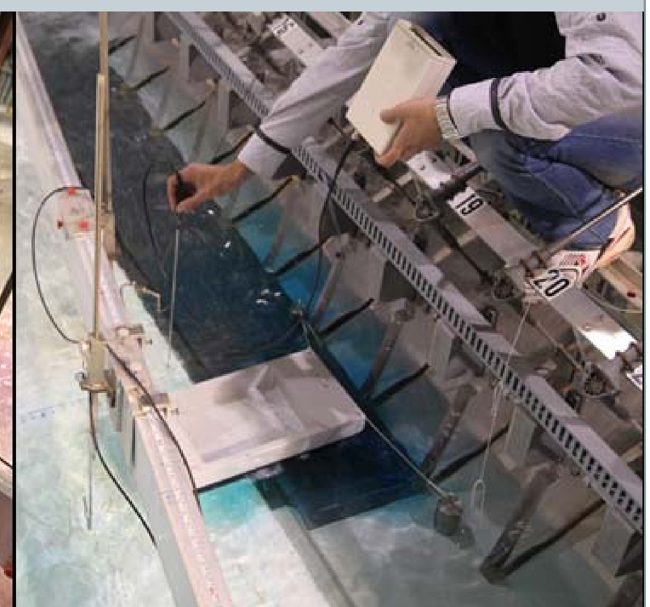
Tailrace conditions for a total river flow of 220kcfs with three fish bypass bays in operation

Construction Support

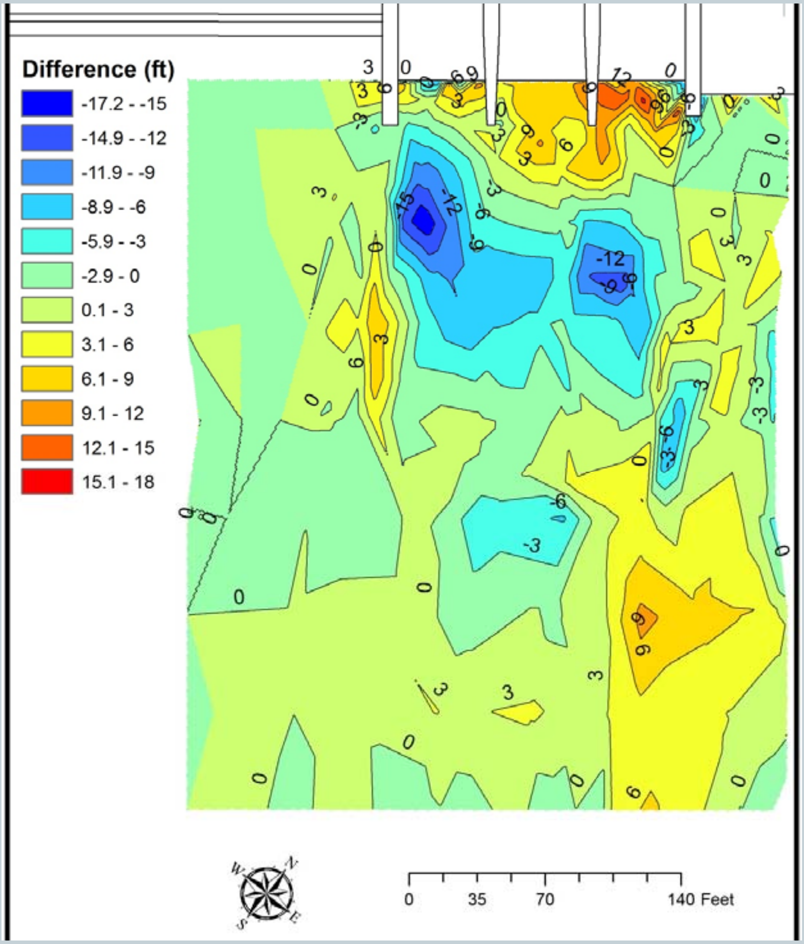


Wave height measurements for two barge positions. Barge size 50 x 100 ft and 7 ft draft.

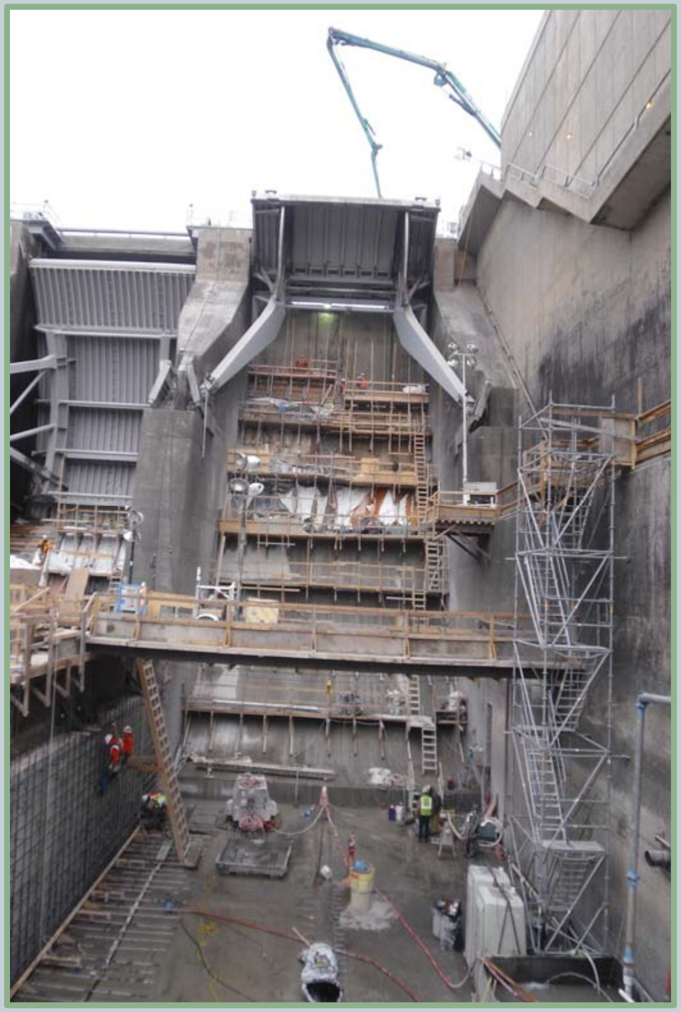
Velocity measurements and dye visualization near barge.

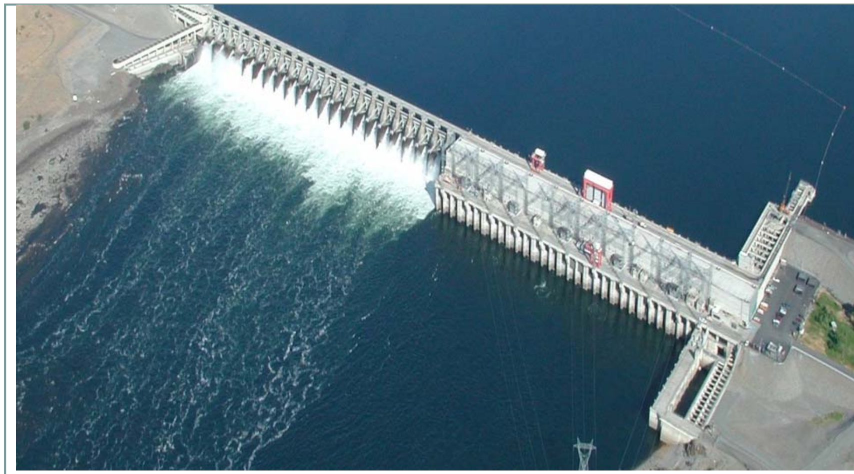


Erosion Potential



Construction Underway





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