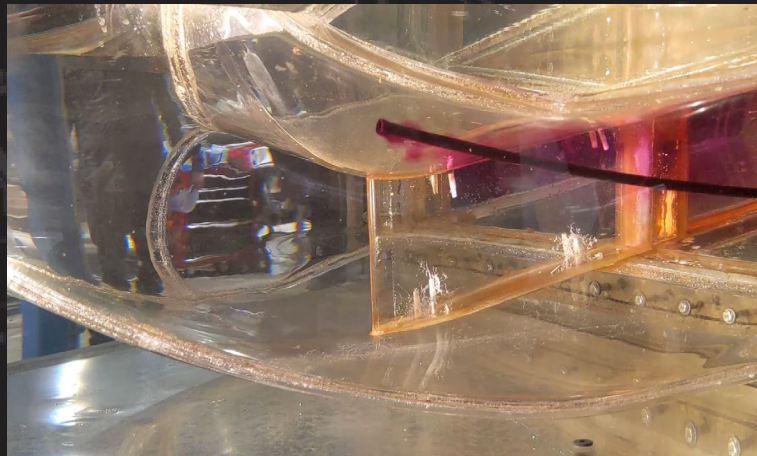
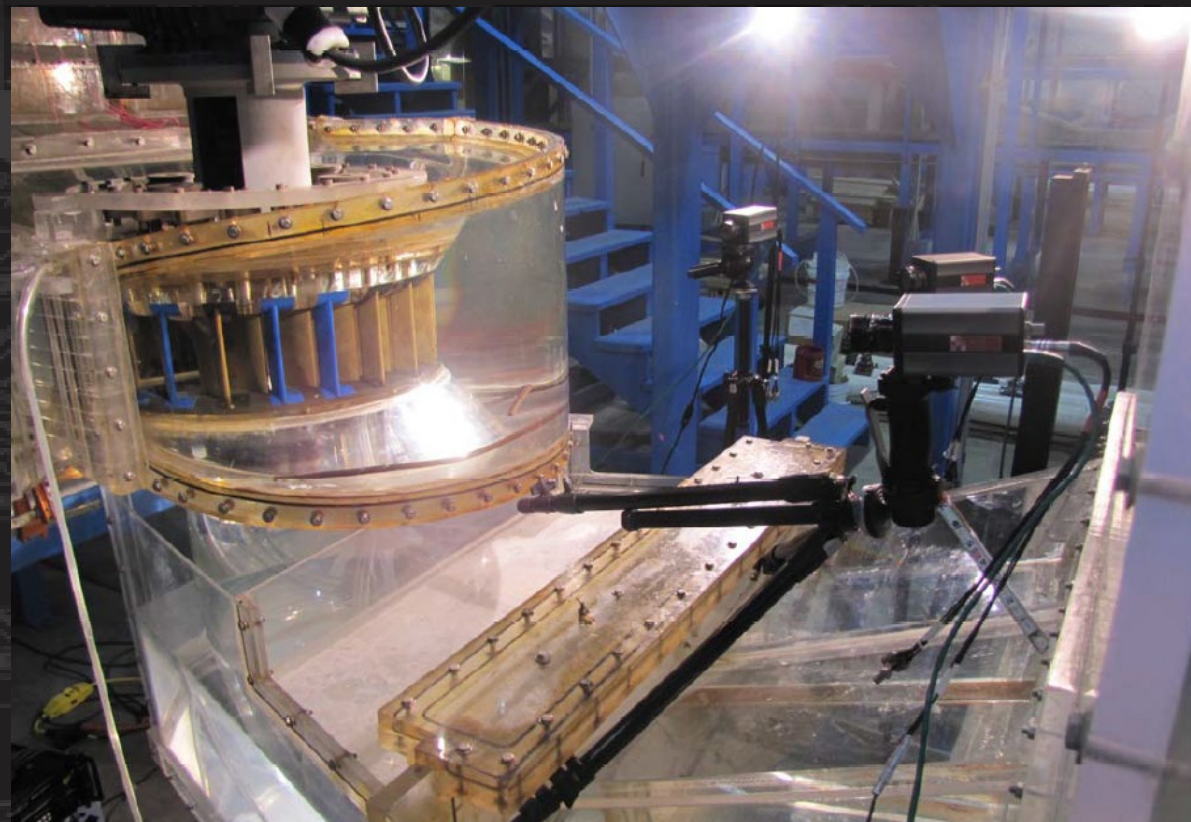


MCNARY TURBINE REPLACEMENT

JUNE 2025 FFDRWG
ADJUSTABLE RUNNER STATUS & FUTURE
OPERATING RANGE UPDATE

Jon Renholds
Senior Hydraulic Engineer
USACE Walla Walla District
June 5, 2025
Walla Walla, WA



U.S. ARMY



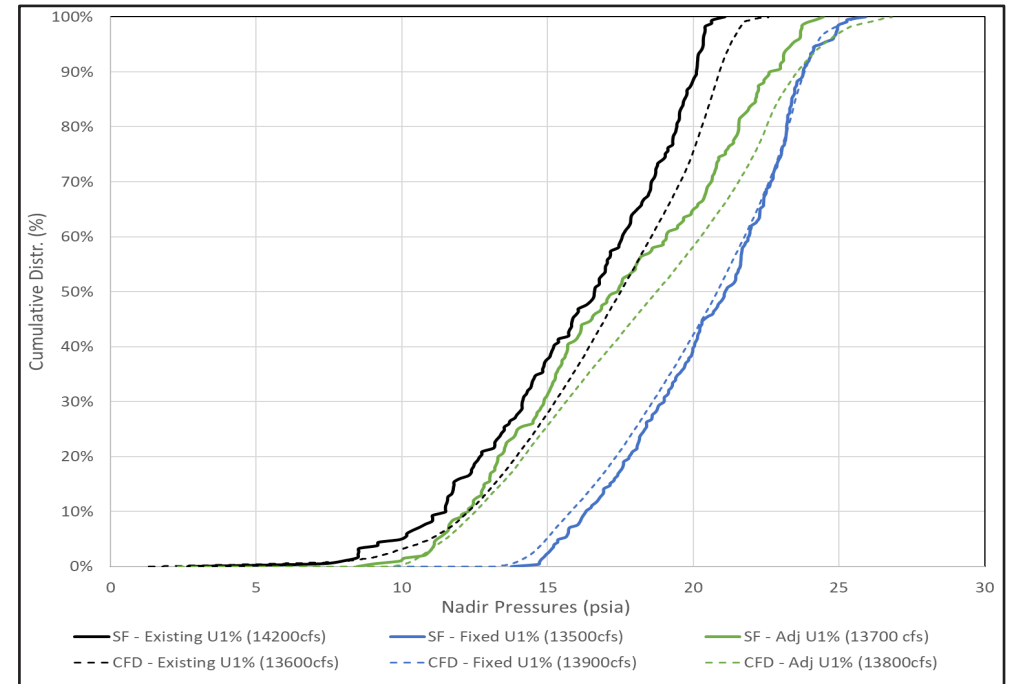
US Army Corps
of Engineers®



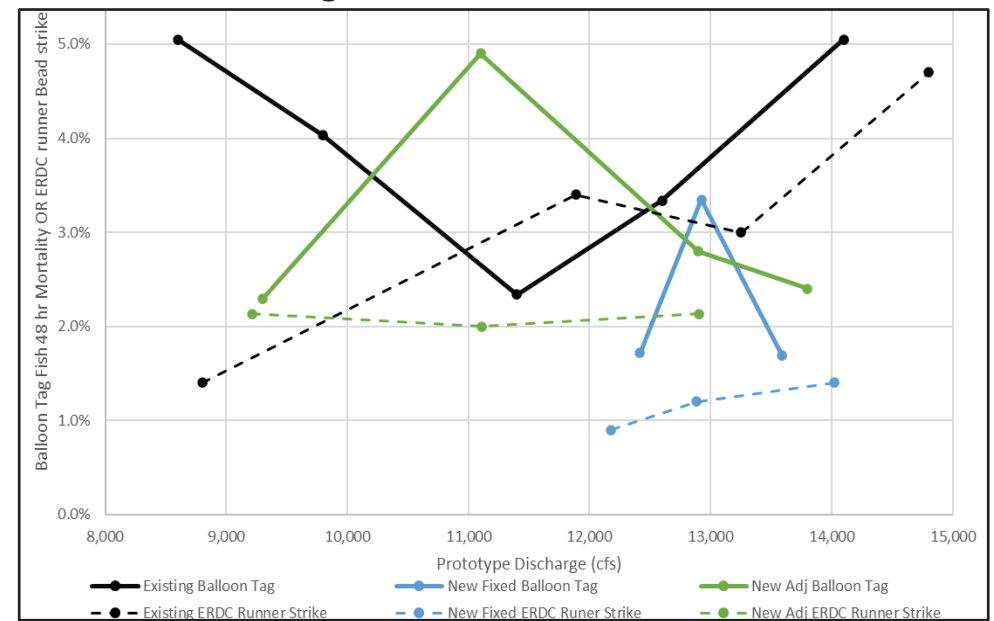
MCNARY TURBINE REPLACEMENT

- Status Adjustable Runner
 - Adjustable Turbine Components will start arriving in June and major runner components will be delivered prior to outage in September 2025
 - New 5-bladed adjustable runner, discharge ring, IHC extension, wicket gates and stay vanes extensions.
 - First Adjustable Installation ~ Sept 2025 thru Feb 2027
 - Will be installed in Unit 14 through 9 in that order.
- Future Adjustable Runner Operation
 - Significant design analysis was completed to select the final adjustable design. This should be used to establish the initial operating range.
 - CFD is the best analysis of pressure/barotrauma
 - ERDC bead analysis is the best source for assessment of direct strike and shear mortality
 - ERDC draft tube LDV & tailrace bead analysis is useful for egress and assessment of indirect mortality factors

Ice Harbor Sensor Fish to CFD Comparison



IH Balloon Tag to ERDC runner bead strike



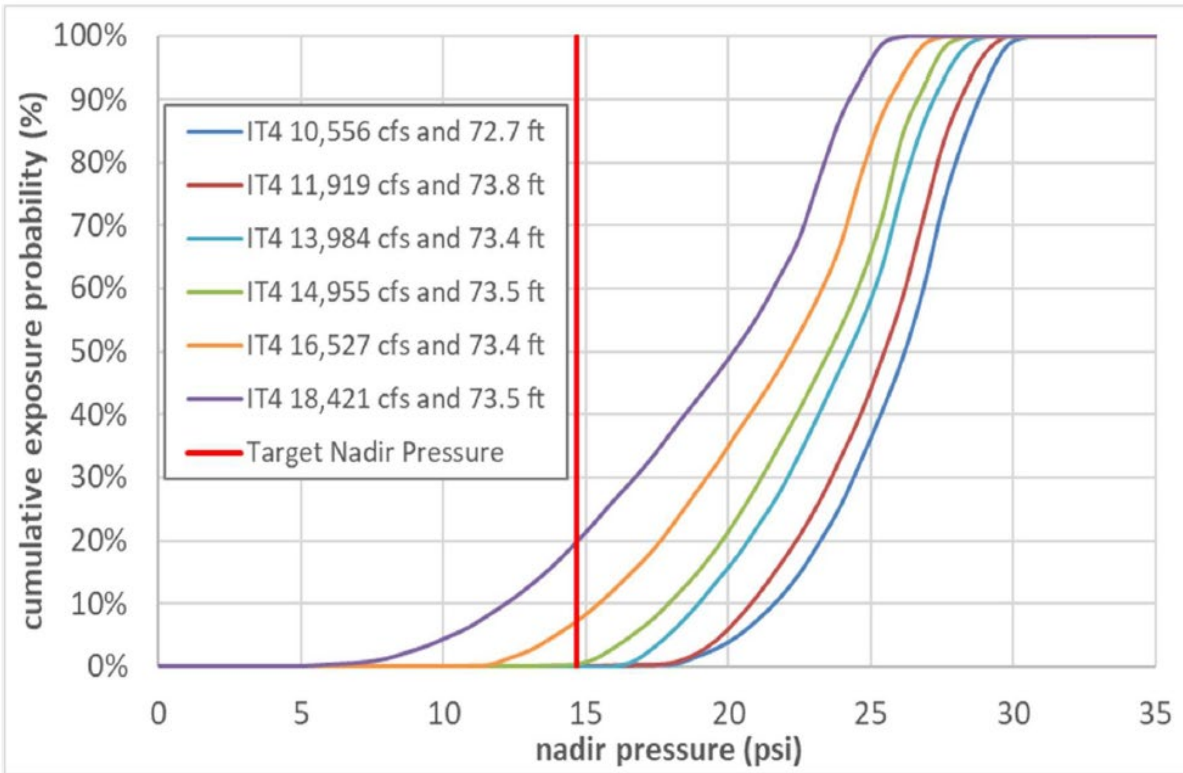


NEW ADJUSTABLE OPERATION – PRESSURES

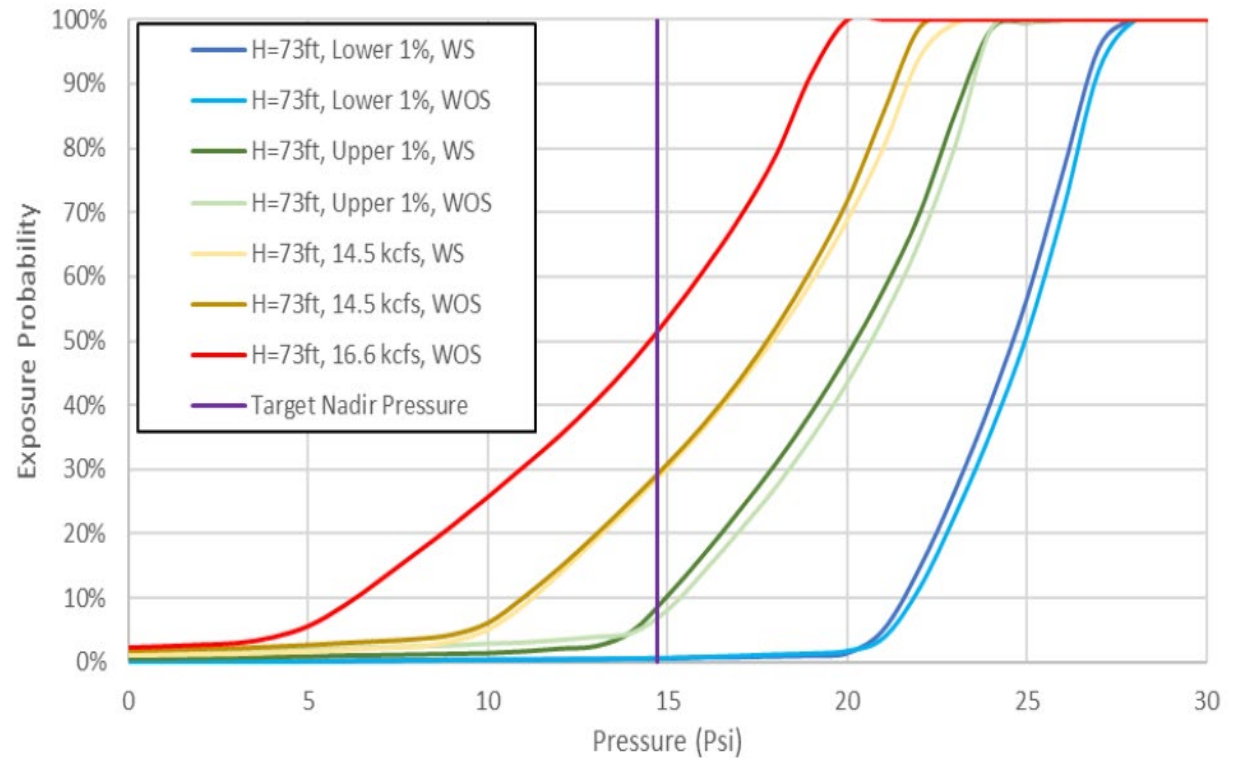
- Barotrauma estimated using CFD nadir pressure & estimated acclimation
 - Barotrauma based on nadir pressure & acclimation pressure
 - Nadir Pressures are significantly higher (i.e. lower risk) for new adjustable compared to existing
 - 15 kcfs met target of all pressures above 14.7 psia. The power limit of 16.2 kcfs has higher nadir pressures than the final Ice Harbor adjustable runner.

$$\text{Probability of mortal injury} = \frac{e^{-5.56+3.85 \cdot LRP}}{1 + e^{-5.56+3.85 \cdot LRP}}$$

$$LRP = LN \frac{P_A}{P_N}$$



McNary New Adjustable Nadir Pressures

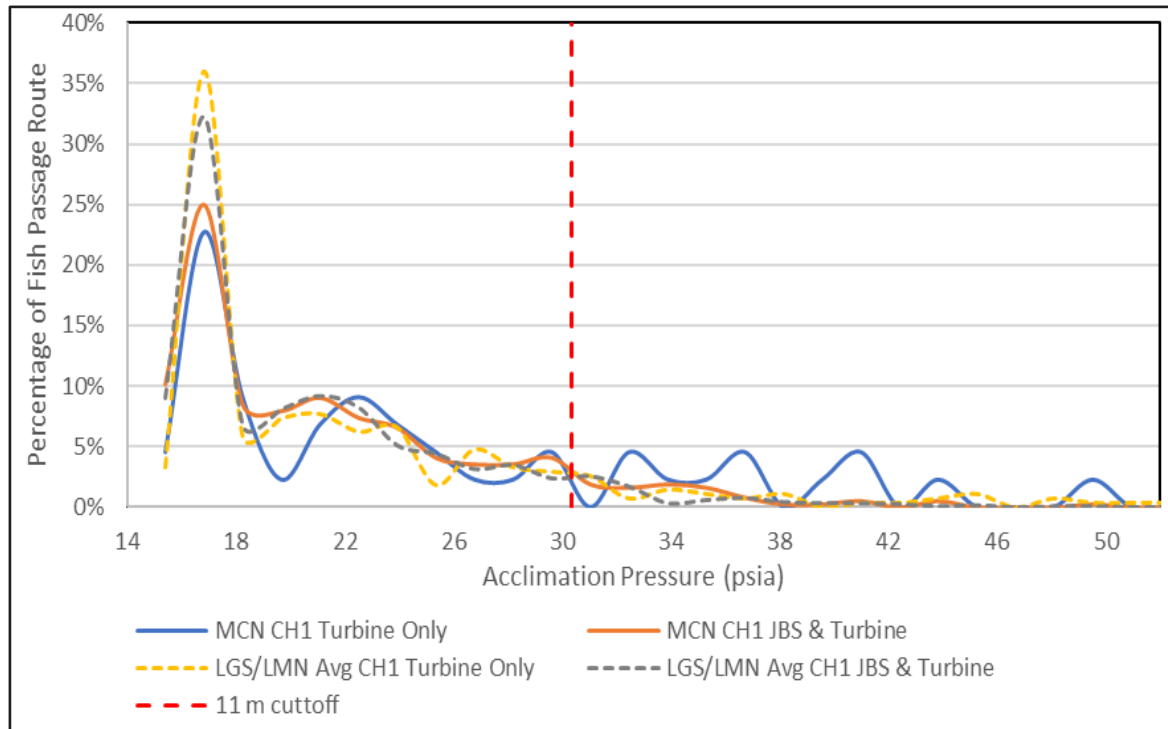


McNary Existing Adjustable Nadir Pressures

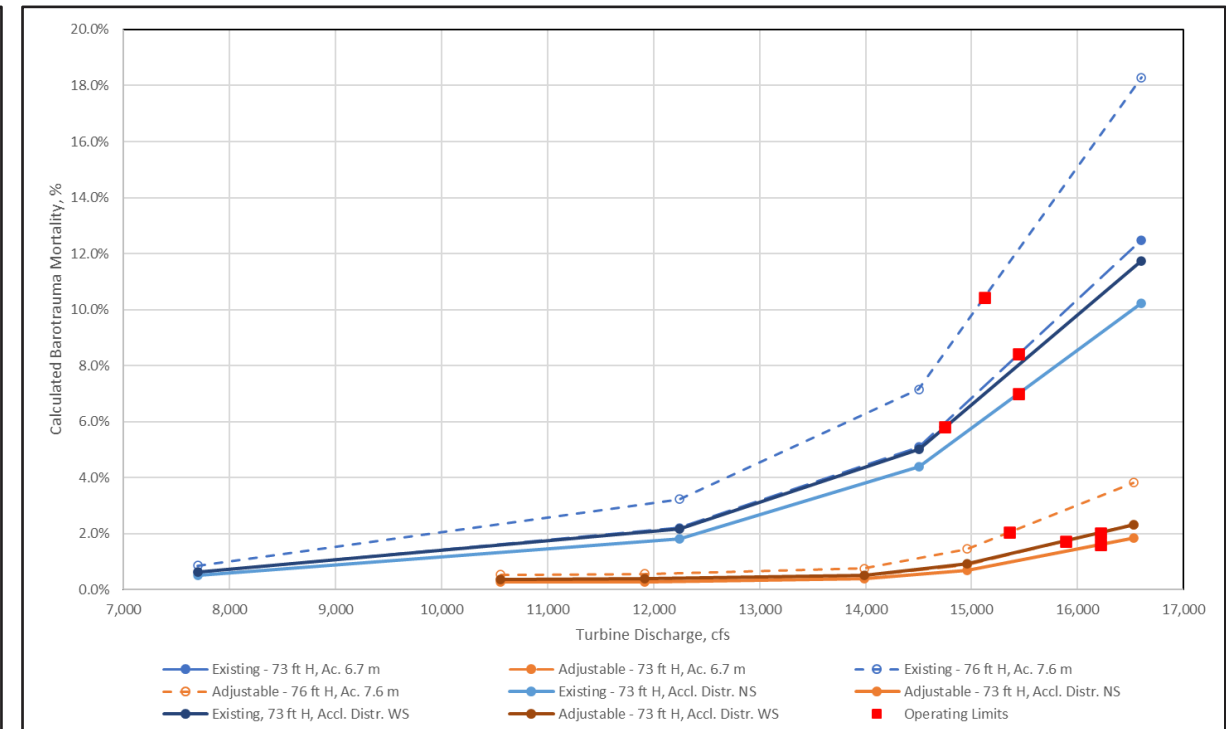


NEW ADJUSTABLE OPERATION – PRESSURES

- Acclimation pressures is difficult to obtain so conservative estimates are used
 - Acclimation pressures of 24.2 or 25.5 psia (6.7 or 7.6 m depth) used during design to compare risks
 - PNWD-4424 attempted to estimate acclimation based on fish approach depth to a dam and grouped results by where the fish passed
 - PNNL study indicate nearly all yearling chinook cannot acclimate deeper than 11 m
 - PNNL equations can conservatively estimate barotrauma – with large improvements for new adjustable



McNary & LGS/LMN Acclimation Pressures



McNary Conservative Barotrauma Rates

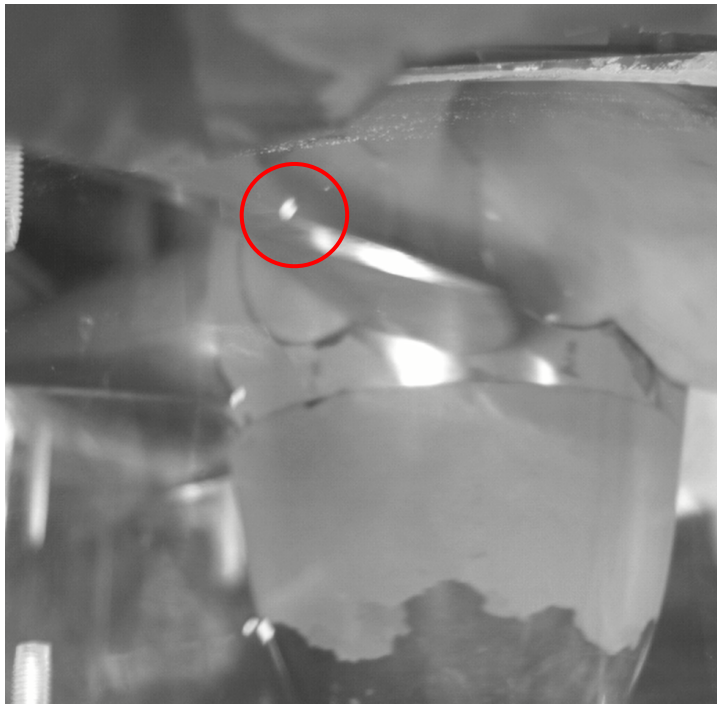


NEW ADJUSTABLE OPERATION – STRIKE/SHEAR

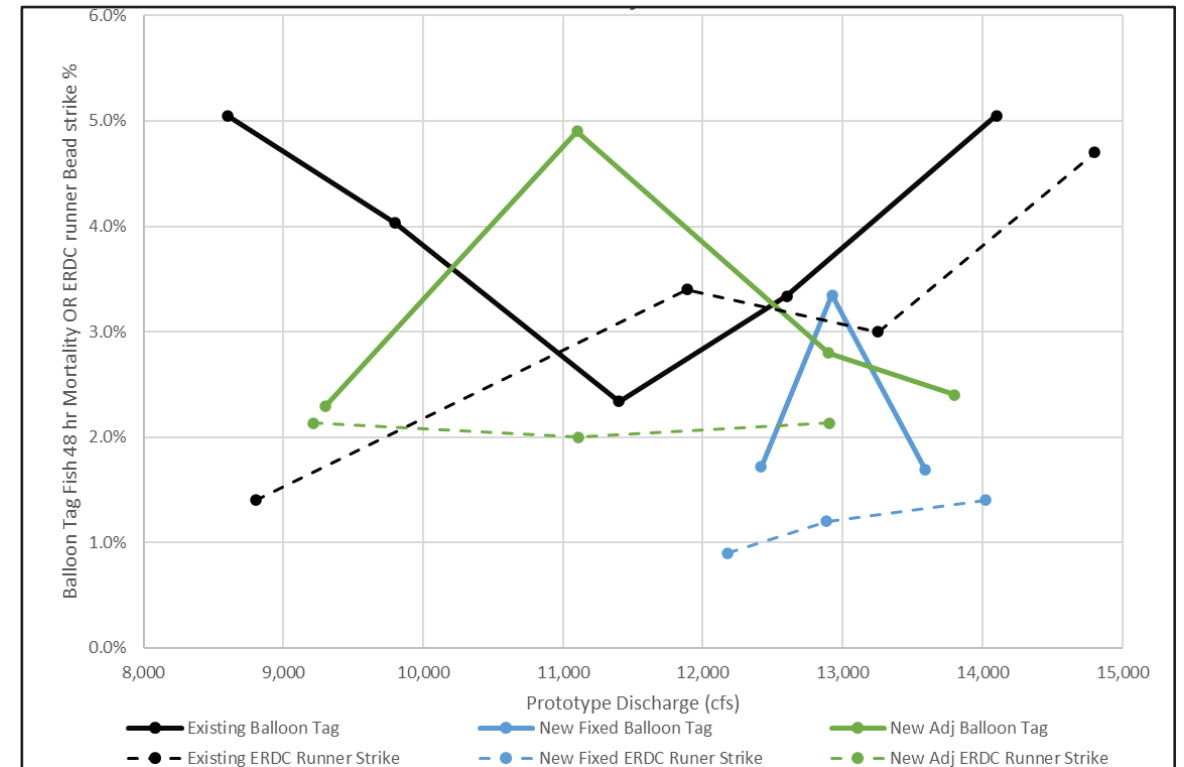
- ERDC physical model good tool to assess strike and shear
 - Strike and shear during CFD design phase can be assessed with particle tracking
 - Physical model at ERDC uses neutrally buoyant beads to assess strike and direction change at the end of each iteration
 - ERDC runner bead strike appears to explain most of the balloon tag mortality Ice Harbor turbine studies



ERDC beads



McNary existing runner bead strike

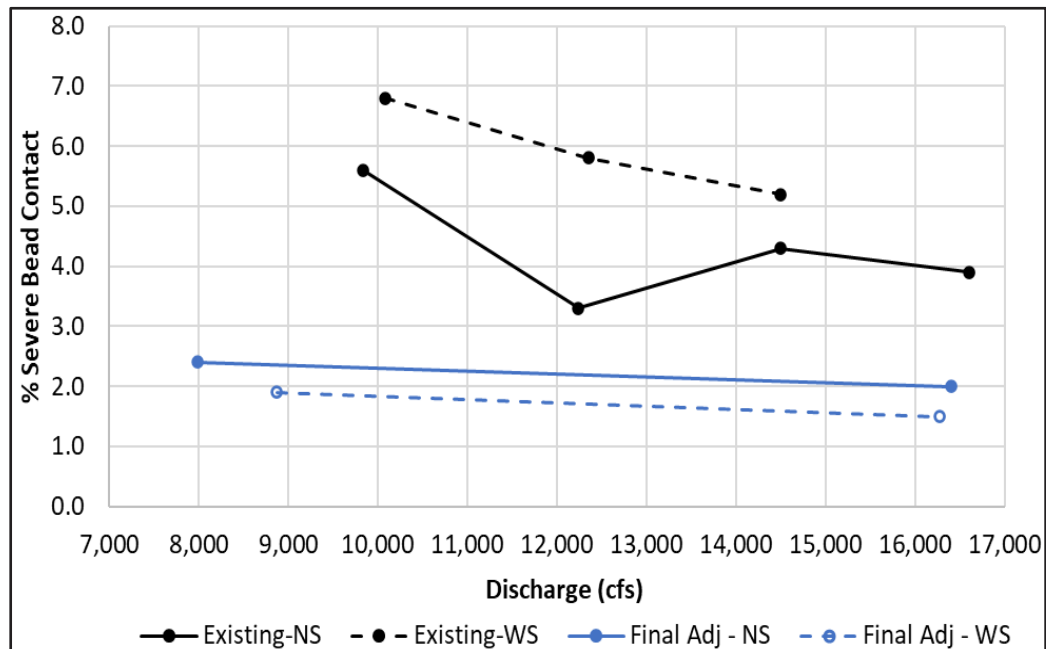


Ice Harbor 48-hr BT mortality and ERDC severe runner bead strike

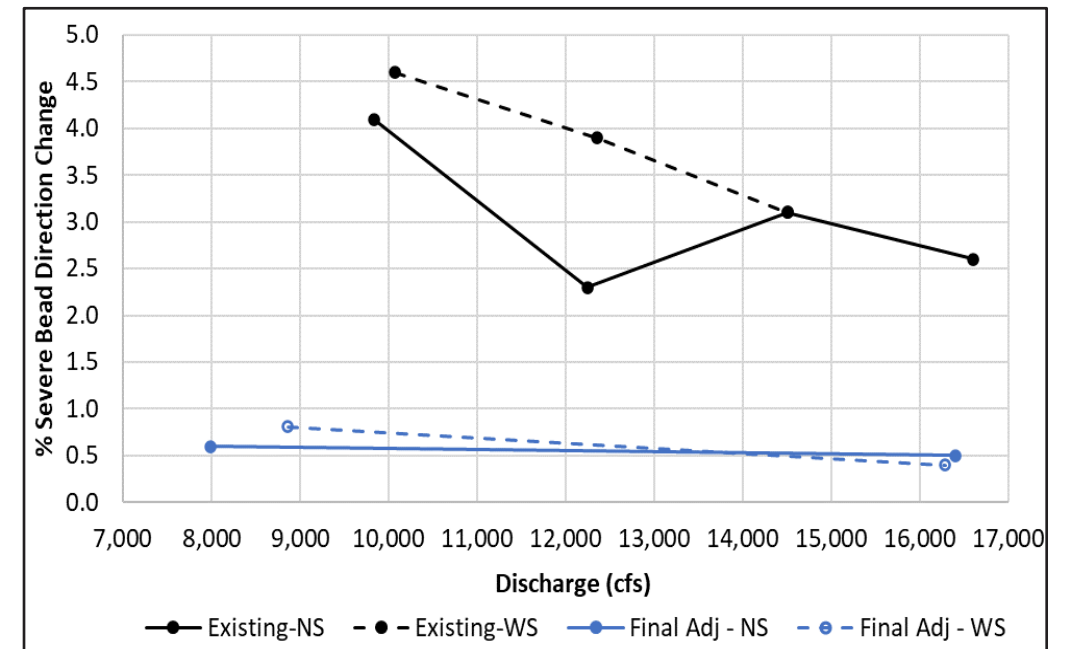


NEW ADJUSTABLE OPERATION – STRIKE/SHEAR

- Stay vane and wicket gate showed reduced strike and shear
 - Encapsulated stay vane better aligned and covered leading edge of new wicket gates
 - Beads are released in intake to assess stay vane and wicket gate bead strike and direction change for every sector of the distributor cascade
 - Significant improvement with new SV/WG strike and direction change w/ slightly better at higher Q
 - Not all severe strike is a fish mortality with slower velocities and larger contract areas of SV/WG passage
 - Eliminated gap passage between stay vane and wicket gate for new adjustable (from ~2.5% to 0%)



McNary SV/WG severe bead strike

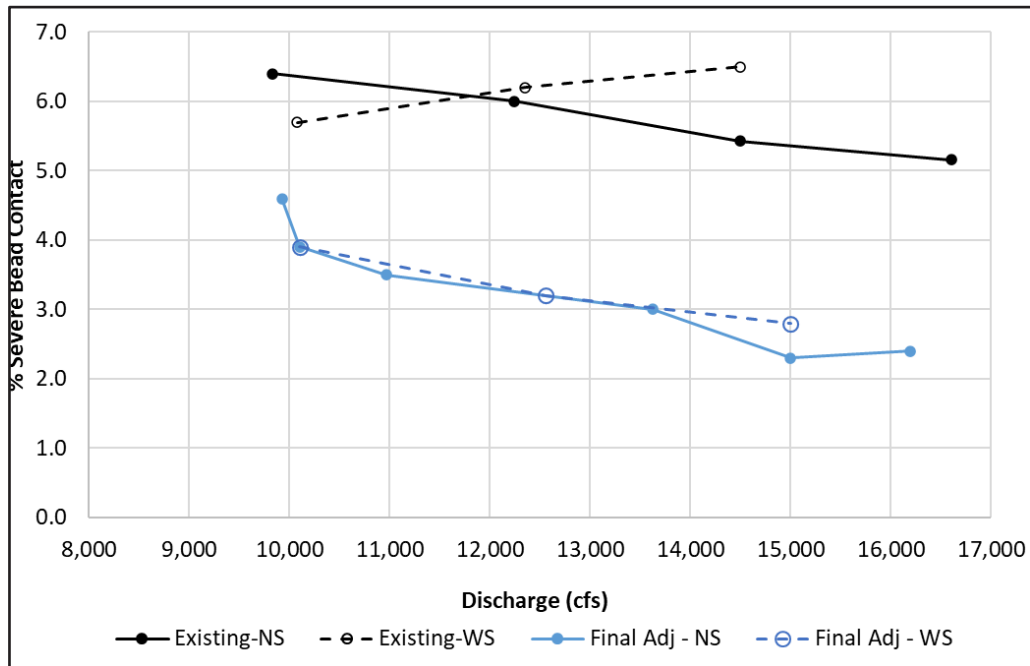


McNary SV/WG severe bead direction change

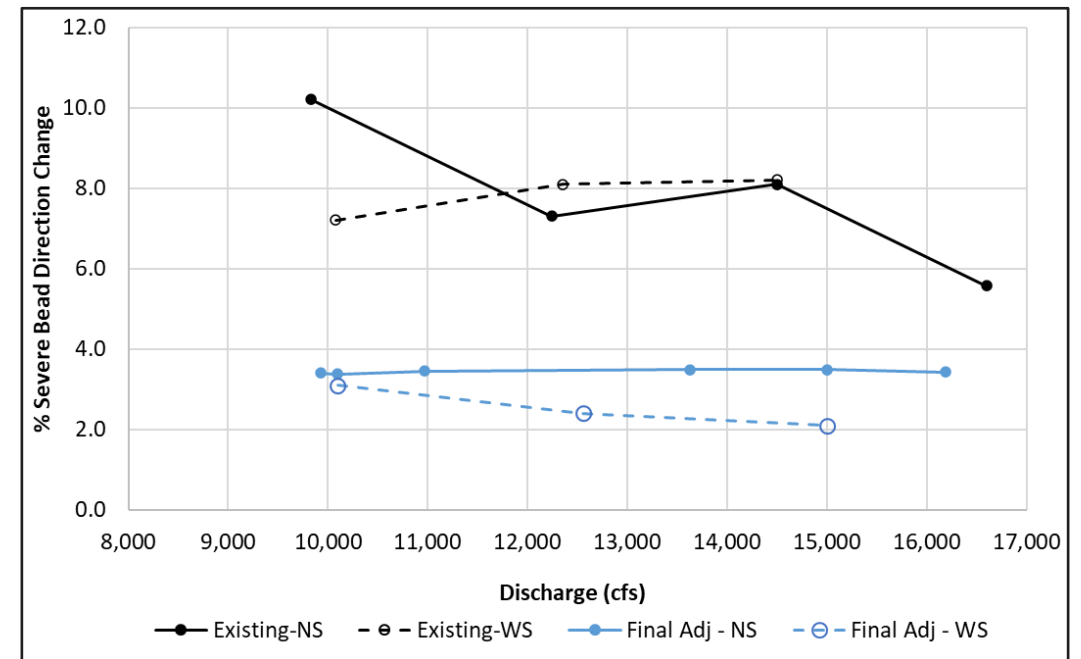


NEW ADJUSTABLE OPERATION – STRIKE/SHEAR

- Runner shows reduced strike and shear decreasing across operating range
 - New 5-blade adjustable runner much lower strike and direction change than existing 6-blade runner
 - Direction change flat across operating range (w/o screens) or decreasing (w/ screens)
 - Strike decreasing across operating range (steeper blade angle)
 - Sharp increase in strike at lower 1% efficiency since off CAM at minimum blade angle



McNary runner severe bead strike

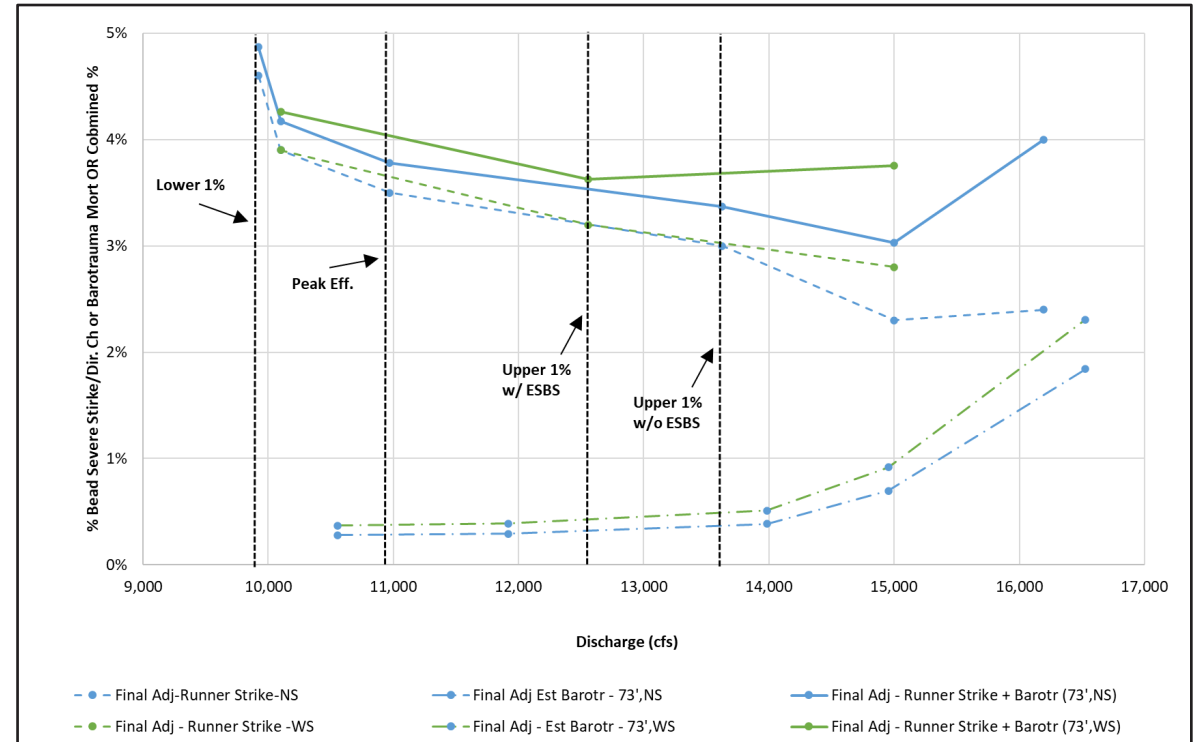
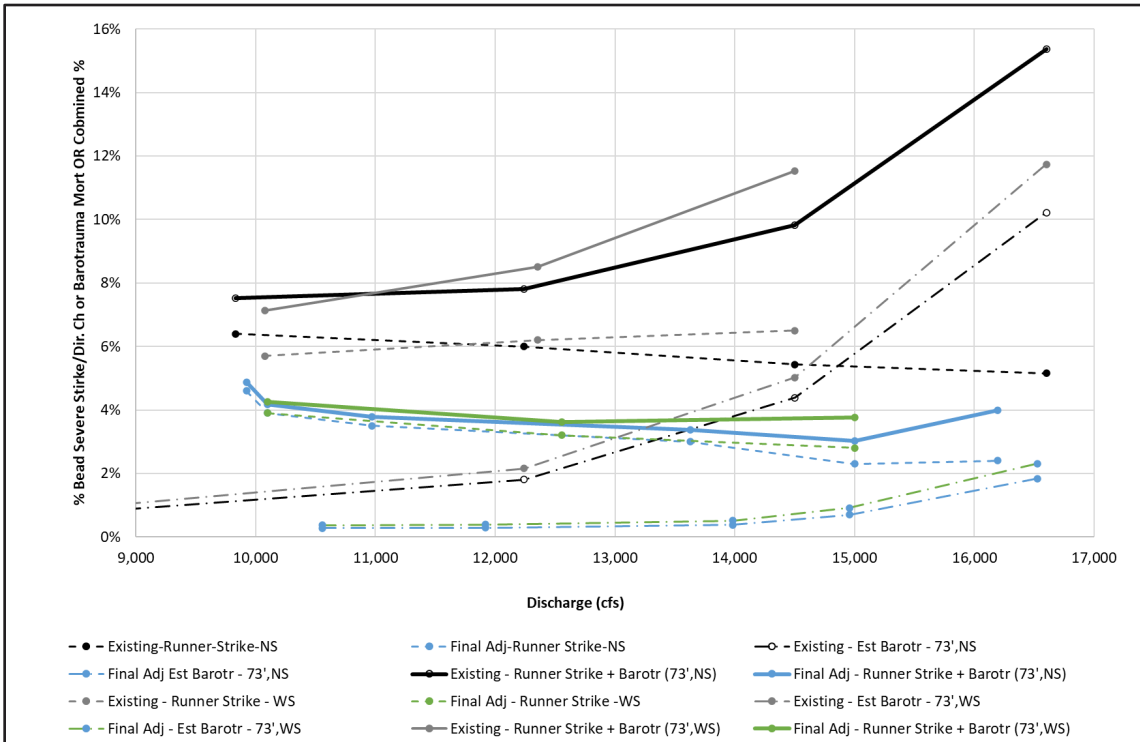


McNary runner severe bead direction change



NEW ADJUSTABLE OPERATION – DIRECT MORTALITY

- Runner strike and barotrauma estimates major components of direct mortality
 - These metrics probably overlap some but added together in figures to see combined effect
 - Distributor strike and direction change is constant across new adjustable operating range
 - Decrease in strike across operating range more than offsets small increase in conservative barotrauma for new adjustable runner – i.e. operation above upper 1% up to 16.2 kcfs power limit should be acceptable
 - Does not make sense to operate below 10.1 kcfs, peak efficiency of minimum blade angle

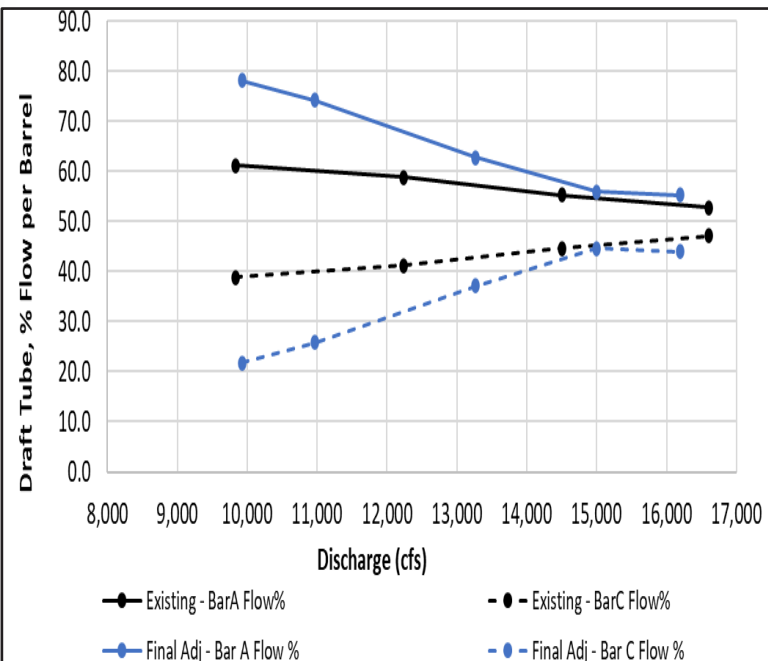


McNary combined direct mortality factors with existing runner and without existing runner

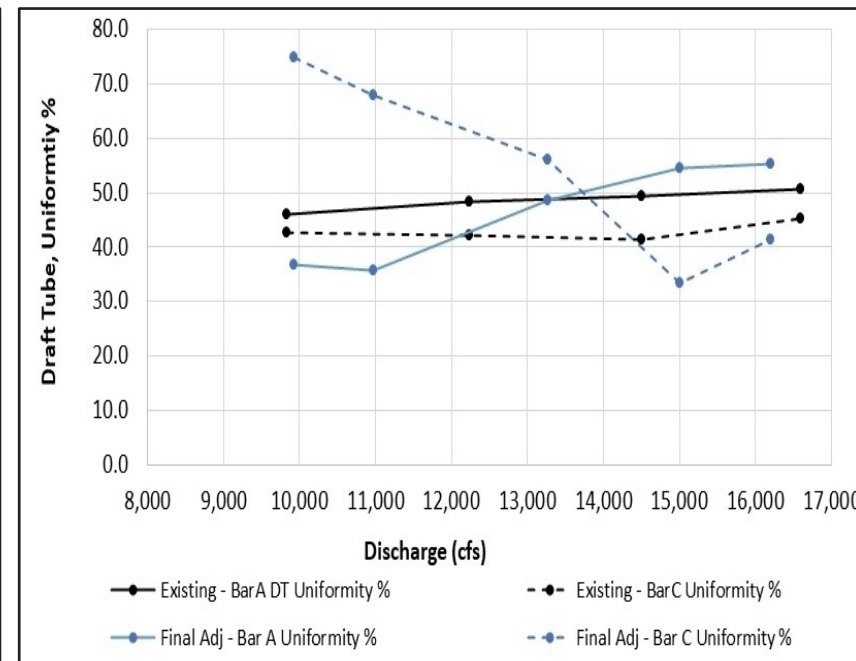


NEW ADJUSTABLE OPERATION – INDIRECT FACTORS

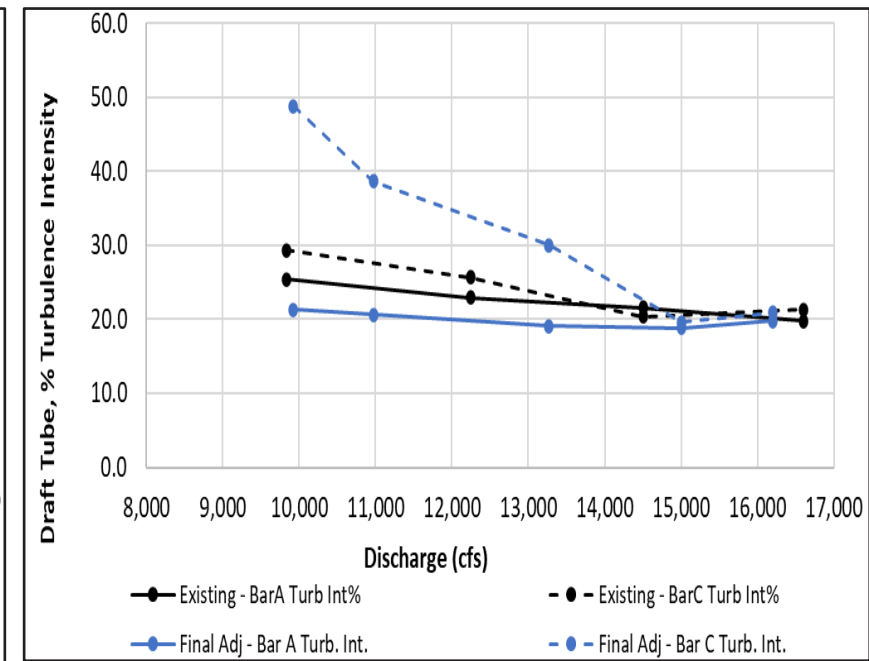
- Draft Tube passage and egress likely affect indirect mortality
 - Draft tube passage assessed with velocity measurements in the ERDC model
 - Figures below show conditions without ESBS screens but with ESBS screens is very similar
 - Draft tube flow split more unbalanced than existing runner especially at lower discharges
 - Draft tube barrel A similar to or slightly better than existing for uniformity and turbulence
 - Draft tube barrel C worse than existing at lower discharges and similar to existing at higher discharges



DT Flow Split



DT Barrel Uniformity



DT Barrel Turbulence



NEW ADJUSTABLE OPERATION – COMBINED

- Combining all available information provides an initial operating range
 - 1% efficiency range does not correlate with best fish passage per all available information
 - Best fish passage range approximately from 12,000 cfs to 15,700 cfs considering both direct and indirect
 - The recommended fish passage range extends from 10,100 cfs (peak eff. of minimum blade angle) to 16,200 cfs (power limit)
 - Biological testing (both direct and indirect) should be done to verify and adjust fish passage operation

