Jun 22nd, 4:00 PM - 4:15 PM

Session B3: Replacement Turbine Design for Improved Fish Passage at Ice Harbor

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VOITH

Replacement Turbine Design for Improved Fish Passage at Ice Harbor

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M. Ahmann and R. Davidson, USACE

Fish Passage 2015, June 22nd – 24th, Groningen, Netherlands

Contents

- Background (Provided by Martin Ahmann)
- **Development and Evaluation**
- Summary and Conclusions

Ice Harbor Development

- Iterative Design Process

Fixed blade:

CFD design → York testing (Power, efficiency, cavitation, etc.) → Vicksburg testing (Bead observation, draft tube flow visualization, etc.) → Repeat

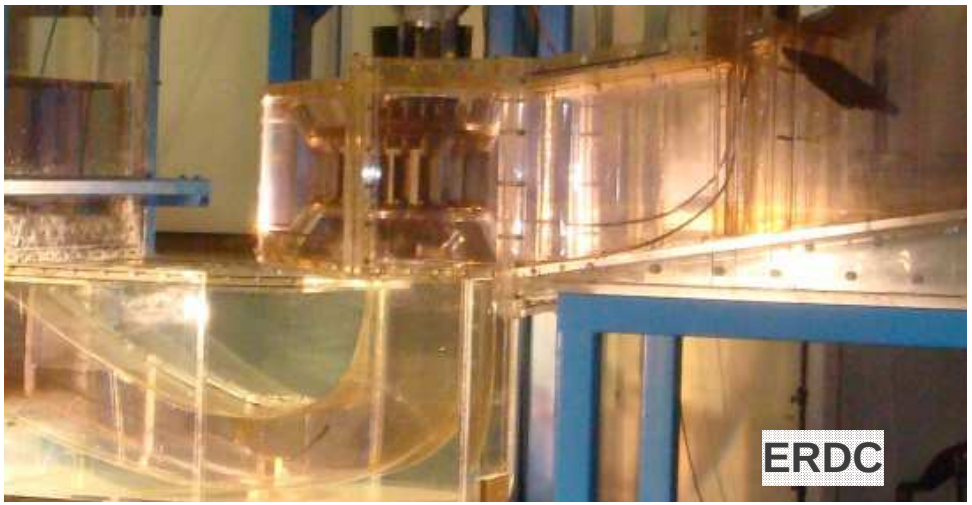
Completed Summer 2013

Adjustable Blade:

CFD design → York testing → Vicksburg testing → Repeat

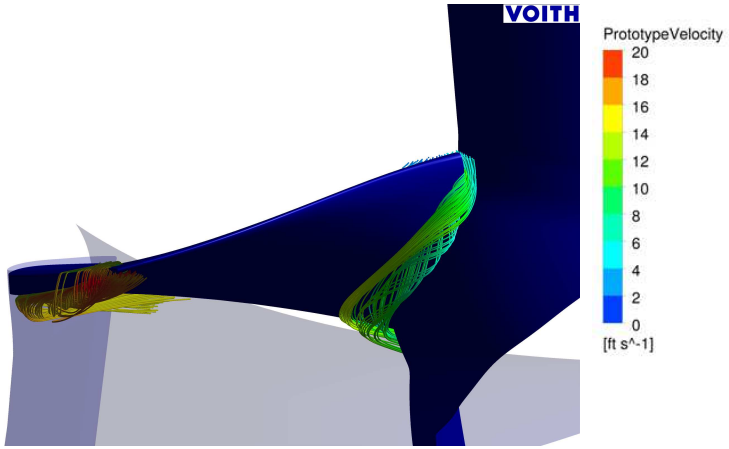
Completed Summer 2014

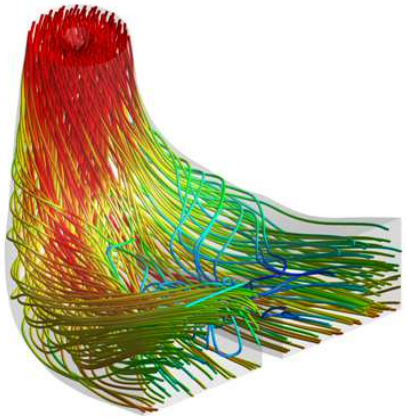
Performance model 1:25 to match ERDC model. Includes trash racks, VBS & STS.

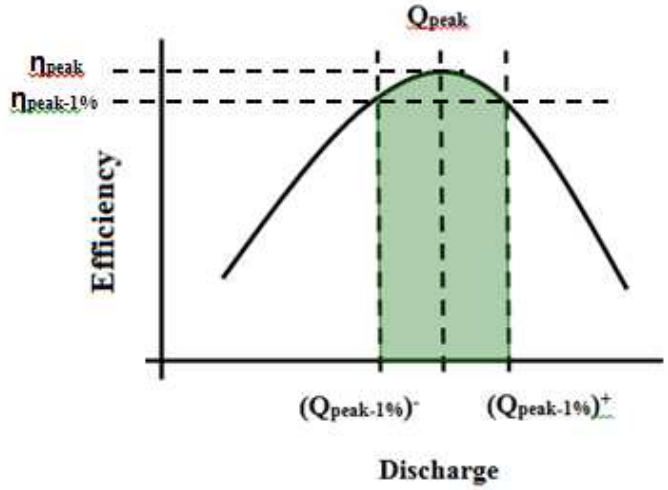


Ice Harbor Development

- Fish Passage Design Criteria
  - Minimum pressures (69 to 83 kPa, 10 to 12 psia)
  - Optimize flow quality in runner & DT
  - Minimize blade strike by considering blade number and length
  - “1%” discharge range target

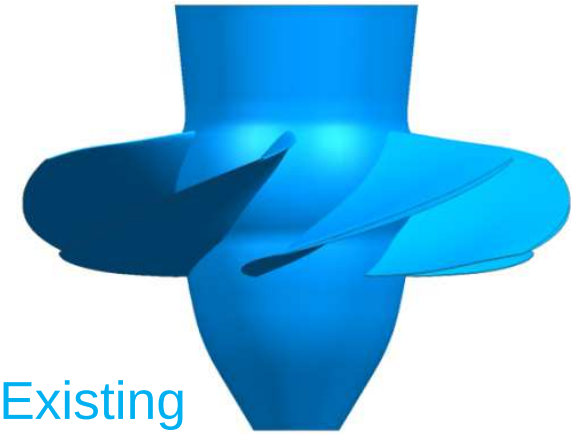




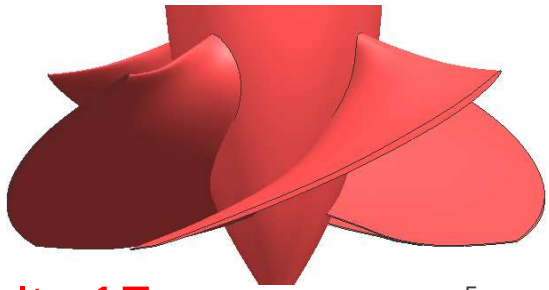


Ice Harbor Development

- Initial fixed blade development focused on meeting pressures with the fewest blades:
  - 4 blades (existing has 6 blades).
  - Blades lengthened to meet pressures.
  - Hub diameter kept small to reduce velocities between blades.



Existing



Itr. 1F

Ice Harbor Development

- Initial Propeller Design (103.4 kPa pressure iso-contour,15 psia)

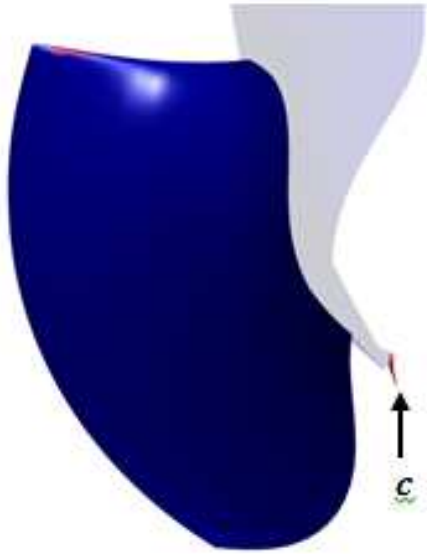
  Calculations run at model size, but at correct Froude speed.

Q = 11,200 cfs

Lower 1% Discharge (Planned)

Q = 11,508 cfs

Peak Discharge (Planned)

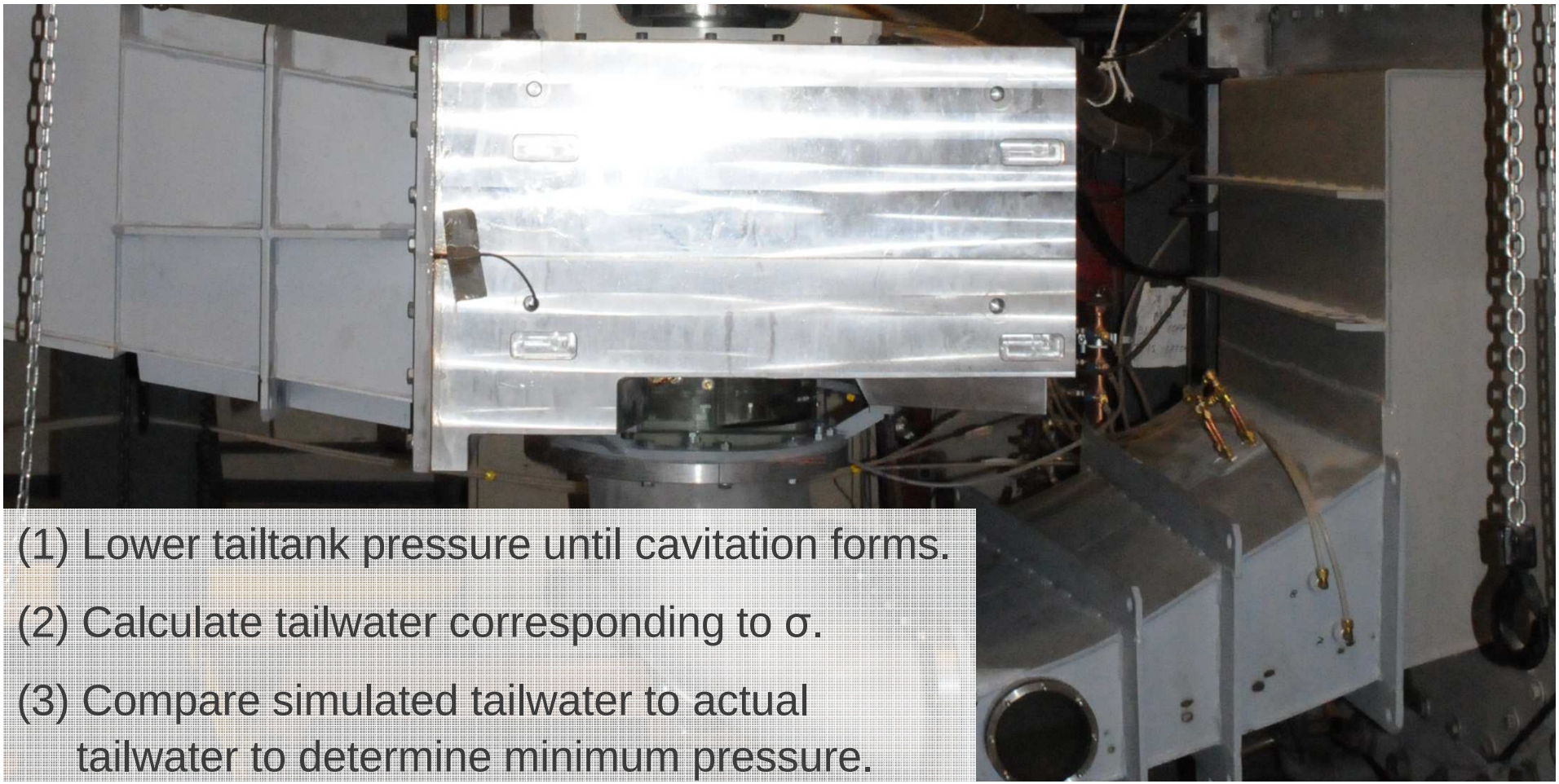


Q = 12,406 cfs

Upper 1% Discharge (Planned)

Ice Harbor Development

- Minimum pressure evaluation on performance model



(1) Lower tailtank pressure until cavitation forms.

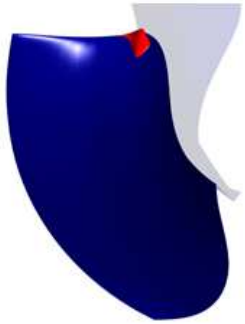
(2) Calculate tailwater corresponding to σ.

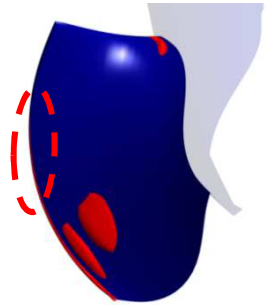
(3) Compare simulated tailwater to actual tailwater to determine minimum pressure.

Ice Harbor Development

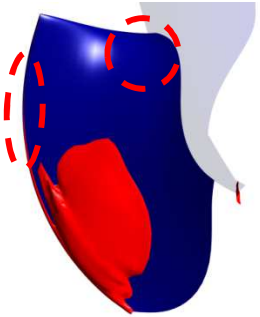
- Minimum pressure evaluation on performance model
  - sigma corresponding to 103.4 kPa, 15 psia minimum pressure
  - not able to match Froude speed on performance model

Lower 1% Discharge (Planned)





Upper 1% Discharge (Planned)



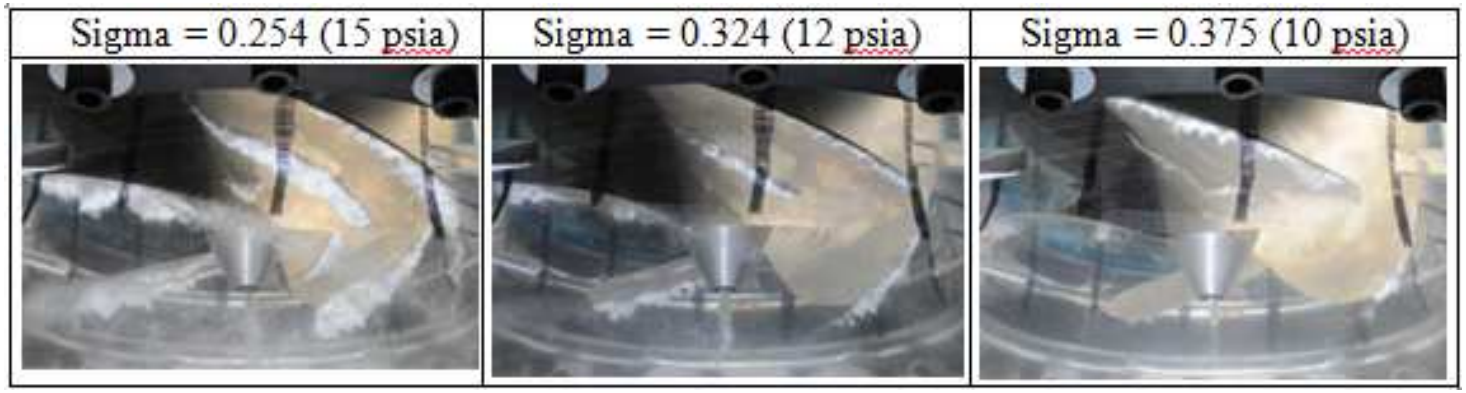
Froude Speed

Model Speed

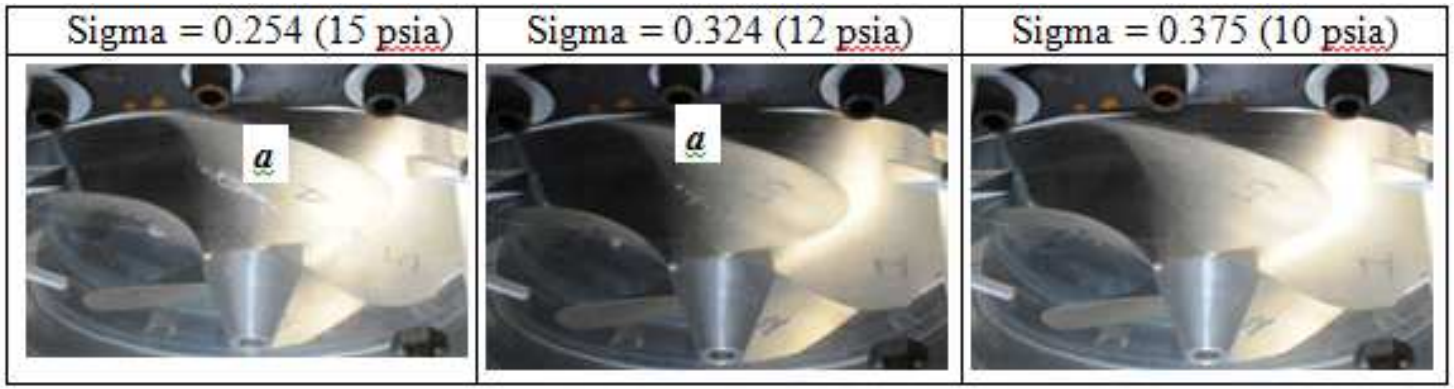
Model Speed

Ice Harbor Development

- Lower 1% discharge:



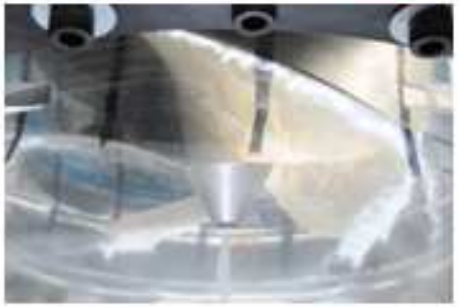
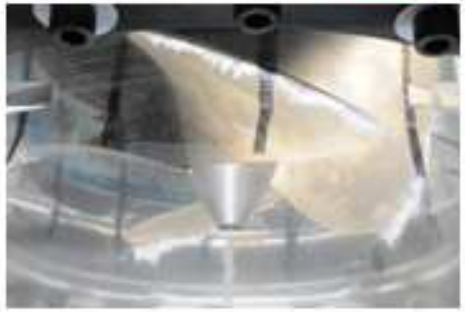
Initial Design



Intermediate Design

Ice Harbor Development

- Upper 1% discharge:

Sigma = 0.254 (15 psia)	Sigma = 0.324 (12 psia)	Sigma = 0.375 (10 psia)
		

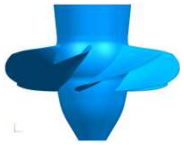
Initial Design

Sigma = 0.254 (15 psia)	Sigma = 0.324 (12 psia)	Sigma = 0.375 (10 psia)
		

Intermediate Design

Ice Harbor Development

- General Bead Summary (relative to Existing Kaplan)
  - up to 650 beads released per location

		1st Iteration	2nd Iteration	3rd Iteration	4th Iteration
Hub Contact	Baseline	Comparable (some discharges worse)	Improved	Further Improved	Same as 3rd
Tip Contact	Baseline	Worse	Comparable	Large Improvement	Same as 3rd
Hub Direction Change	Baseline	Worse	Improved	Further Improved	Same as 3rd
Tip Direction Change	Baseline	Worse	Comparable	Improved	Further Improved

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Conclusions

- Ice Harbor was a collaborative design effort between engineers and biologists.
- During the fixed blade development, model test results showed a strong correlation between local minimum pressures and flow quality.
- As minimum pressure levels improved, observed fish passage characteristics also improved.
- Goal of design process was to balance tradeoffs (pressure, contact, flow quality, etc.) to provide best overall design for fish passage.
  - After 4th fixed blade iteration, improving one aspect of fish passage expected to negatively impact others.
- Next step – Prototype testing after installation.


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