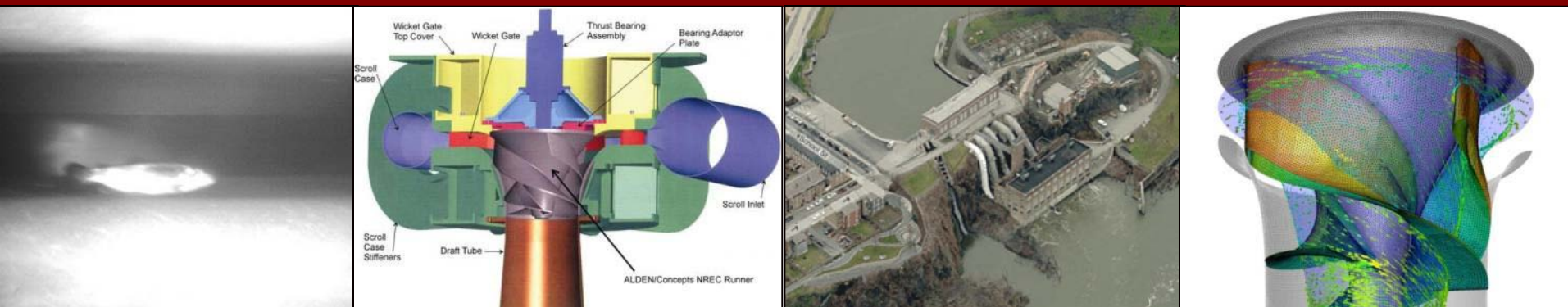


FUTURE APPLICATION OF THE ALDEN FISH-FRIENDLY HYDRO TURBINE



Steve Amaral, Norman Perkins, Greg Allen, and George Hecker

ALDEN

Solving flow problems since 1894

Doug Dixon

EPRI | ELECTRIC POWER
RESEARCH INSTITUTE

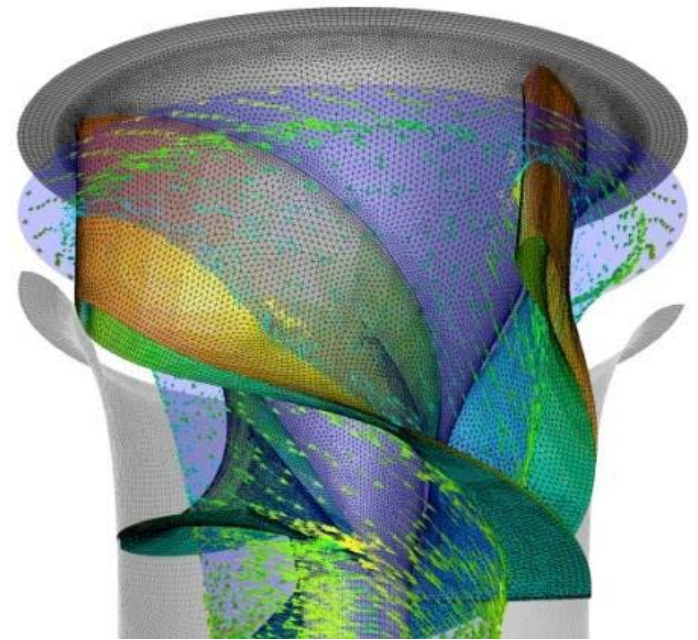
Jason Foust

VOITH HYDRO
POWER GENERATION

ALDEN TURBINE DEVELOPMENT

Conceptual Design - Biocriteria

- 40 ft/s peripheral runner speed
- 69 kPa minimum pressure
- 552 kPa/s maximum pressure change
- 4.6 m/s/cm maximum shear
- Minimize number of blades and length of leading edges
- Maximize distance between runner and wicket gates and minimize clearance between other components
- Maximize size of flow passages



ALDEN TURBINE DEVELOPMENT

Pilot-Scale Biological Evaluation

SPECIES TESTED



American eel



White sturgeon



Coho salmon



Rainbow trout



Smallmouth bass



Alewife

PREDICTED SURVIVAL

97 – 100%

ALDEN TURBINE DEVELOPMENT

Final Development and Model Testing

U.S. Department of Energy awarded grant to EPRI team to conduct final development and model testing

Objective: Develop a robust design for commercial application

- Turbine runner refinement
- Stay ring and stay vanes
- Wicket gates
- Head cover
- Shafting, bearings, and seals
- Model construction and testing
- Ready for fabrication and installation at selected site



ALDEN

Solving flow problems since 1894

ALDEN TURBINE DEVELOPMENT

Considerations for Future Application

Head range: 20 to 120 ft (or higher?)

Flow range: 500 to 2,000 cfs (or more?)



- Increase capacity at existing hydro projects
- Non-powered existing dams
- New Development
- Fish bypass systems
- Minimum flow releases

FUTURE APPLICATION

School Street Hydroelectric Project

- New powerhouse with Alden turbine.
- Angled bar rack upstream of existing powerhouse leading to Alden turbine.
- Blueback herring and American eel.
- First time U.S. resource agencies have accepted a turbine for passing fish downstream.



American eel



blueback herring



Brookfield Renewable Power's School Street Project

Operating Head:	92 ft
Turbine Flow:	1,500 cfs
Power Capacity:	11 MW

FUTURE APPLICATION

School Street Hydroelectric Project

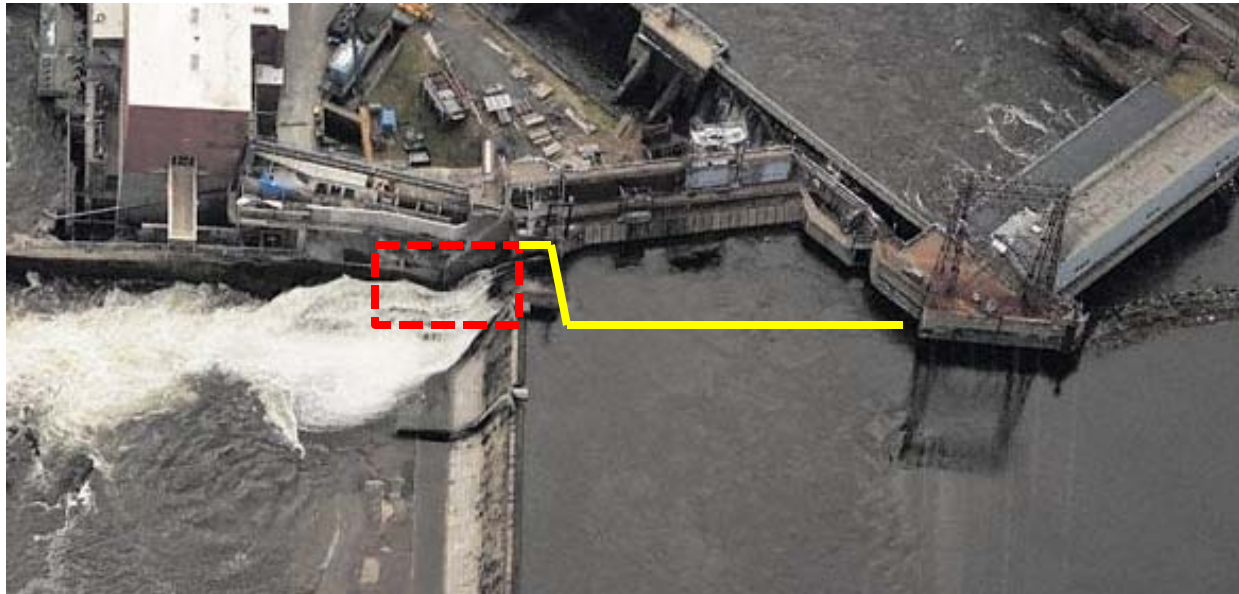
	Alden Turbine	Kaplan MGR
Runner Diameter (m)	12 ft	8 ft
Number of Blades	3	6
Rotational Speed (RPM)	120 rpm	300 rpm
Inflow Angle	21°	44°
Radial Velocity (m/s)	13 ft/s	36 ft/s
Relative Velocity (m/s)	42 ft/s	58 ft/s
Fish Survival (fish length = 100 mm)	96.7%	83.5%

Fish survival is expected to exceed 98% for Alden Turbine with thicker blade leading edges

FUTURE APPLICATION

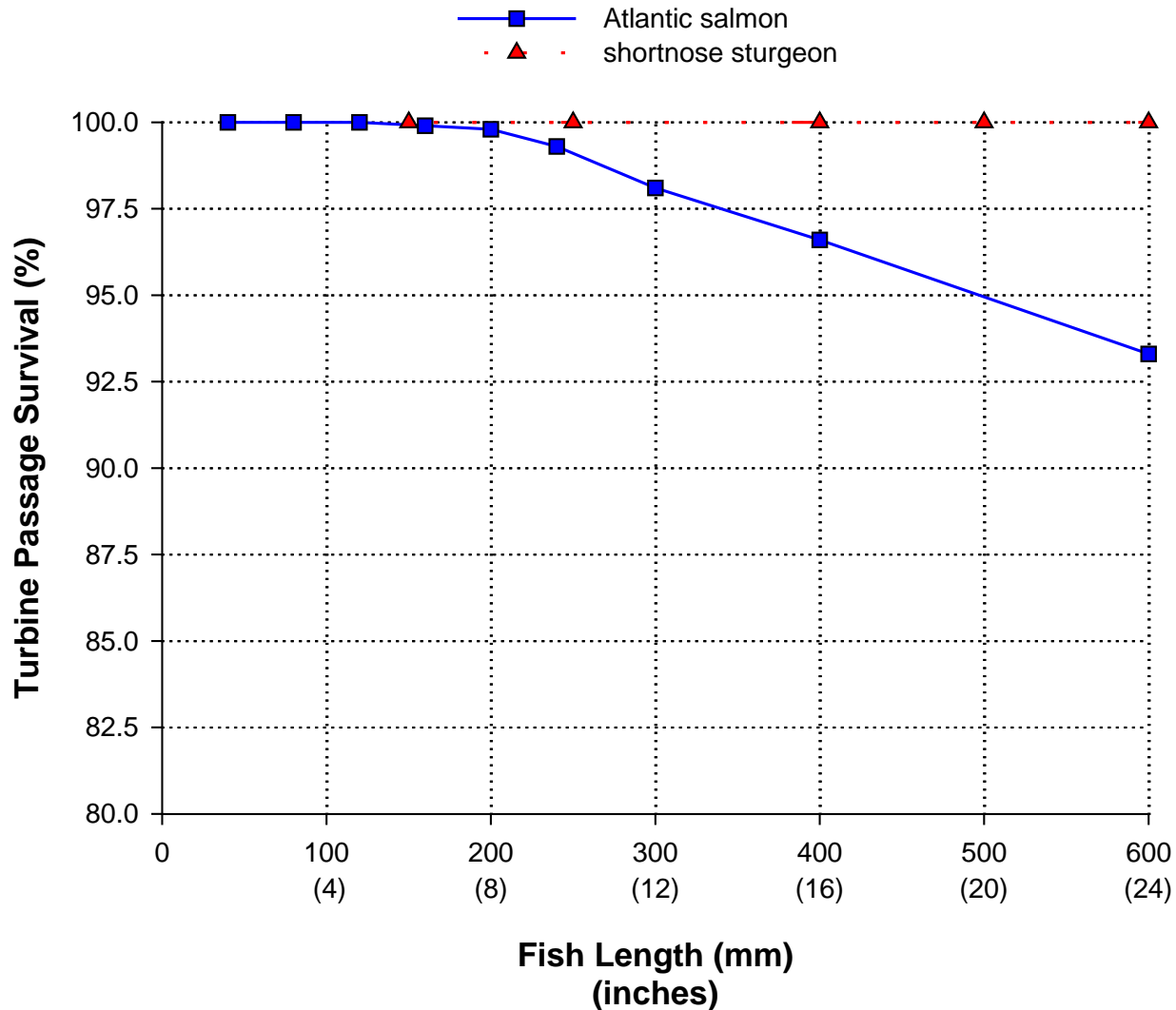
Hadley Falls Analysis

Head:	35 ft
Flow:	1,200 cfs
Runner diameter:	13 ft
RPM:	72 rpm
Leading edge thickness:	6 inches
Distance between blades:	13 ft
Strike velocity:	25 ft/s



FUTURE APPLICATION

Hadley Falls Analysis



FUTURE APPLICATION

Additional Demonstration Sites

- EPRI has completed an industry solicitation for potential additional demonstration sites for the fish-friendly Alden turbine
- Proposed sites have been evaluated using specified engineering, operational, and biological criteria, including:
 - 40 to 80 ft head
 - 1,000 – 2,000 cfs turbine flow
 - Added capacity at existing dam or new development
 - Presence of important species (eel, salmon, sturgeon, shad, herring)
- Based on the initial screening process, three projects have been selected for a detailed feasibility assessment and preliminary design and cost estimates.
- Site selection process will be completed by the end of 2010.