Should I turn my water system into a power plant?

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Brown AND Caldwell

The Big Questions

- How will this impact my mission?
- What are the benefits?
- Where should I do this?
- What am I missing?

Core mission goals cannot be compromised

- Product Quality
- Customer Satisfaction
- Employee and Leadership Development
- Operational Optimization
- Financial Viability
- Infrastructure Stability
- Operational Resiliency
- Community Sustainability
- Water Resource Adequacy
- Stakeholder Understanding & Support

Avoid Impacts to Critical Attributes

- **Product Quality** 
- **Customer Satisfaction** 
- Employee and Leadership Development
- **Operational Optimization** 
- Financial Viability
- Infrastructure Stability
- Operational Resiliency
- Community Sustainability
- Water Resource Adequacy
- **Stakeholder Understanding & Support** 

Provide Benefits to Key Practice Areas

- Product Quality
- Customer Satisfaction
- Employee and Leadership Development
- Operational Optimization
- **Financial Viability** 
- Infrastructure Stability
- Operational Resiliency
- **Community Sustainability** 
- Water Resource Adequacy
- Stakeholder Understanding & Support

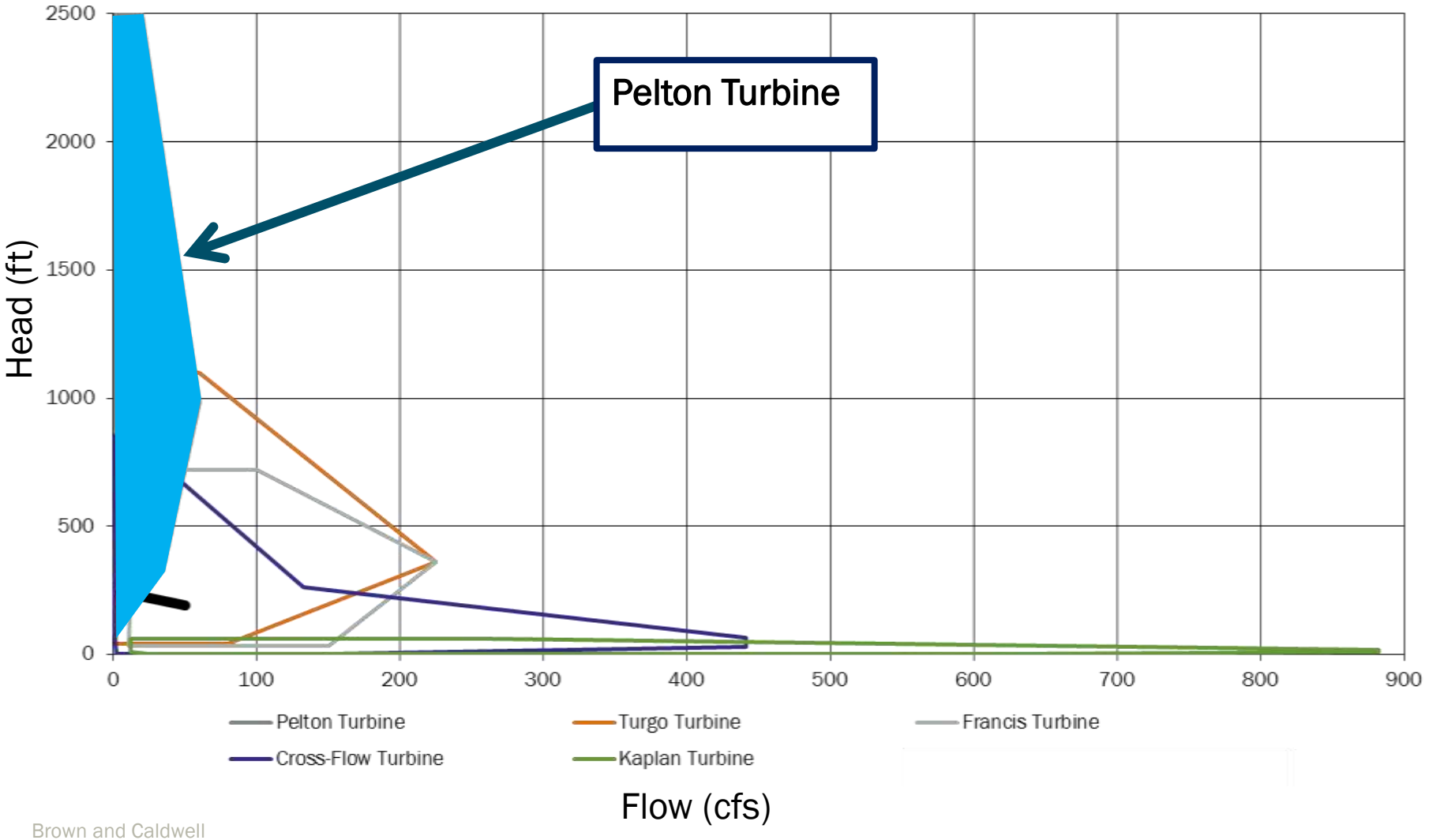
Benefits of Hydroelectric Power

Financing/ Economics	• <15 year payback • Positive cash flow in year one
Environmental	• Climate Change/Sustainability • Negligible footprint vs. other renewables
Technology	• 50-100 year asset life • New models @ 1/3 cost of old hydro
Regulations	• FERC Notice of Intent (Exemption)

Potential Sites for In-Conduit Hydro

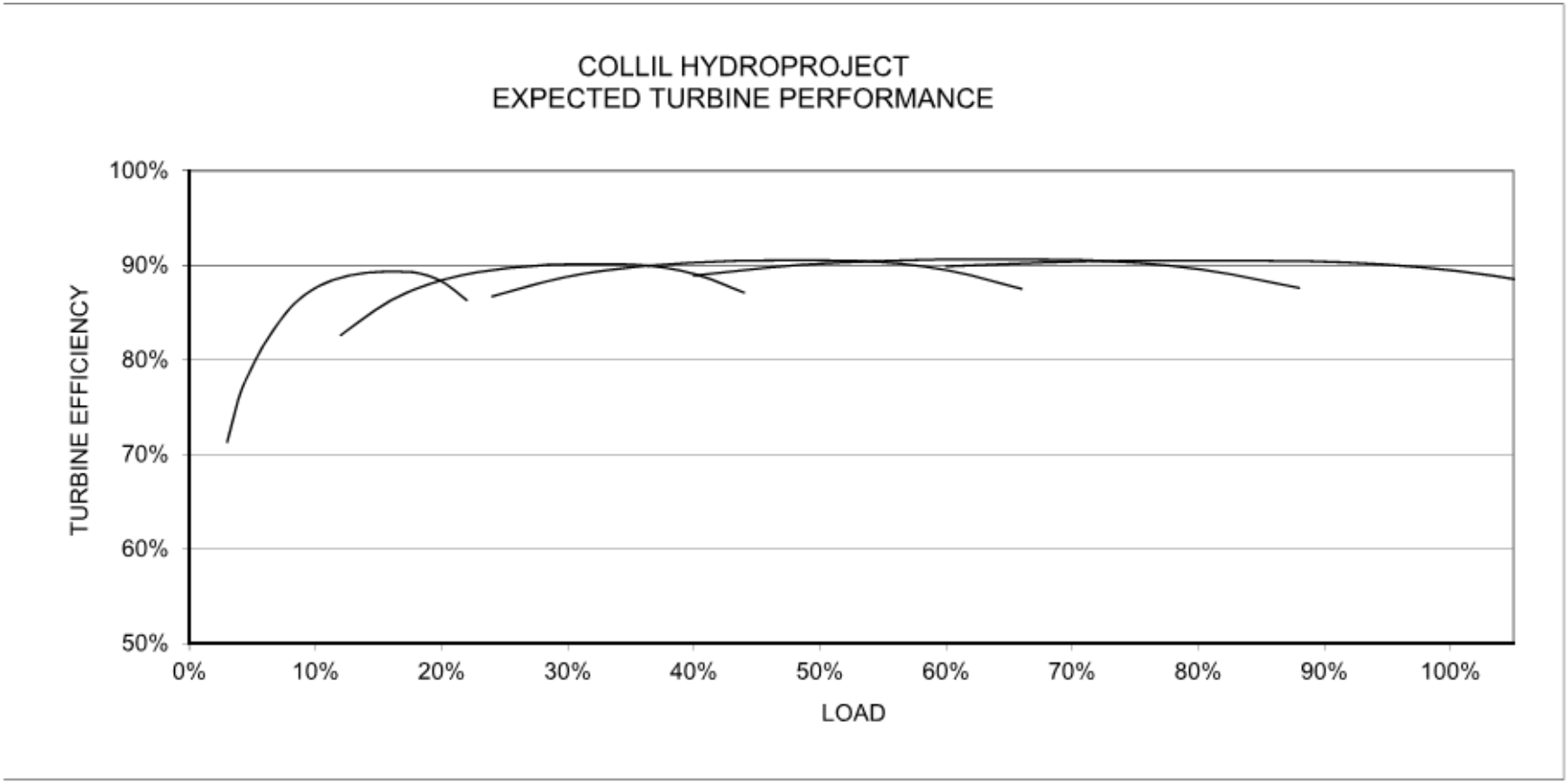
- High Head, Low Flow
  - Energy Dissipaters
  - Pressure Reducing Valves
  - Minimum Avg Flow >4.5 cfs
  - Minimum head 100 ft
- Low Head, High Flow
  - Canal Drops
  - WWTP Outfalls
  - Minimum Avg Flow > 30 cfs
  - Minimum head 10 ft

Proper Turbine Selection Optimizes Payback



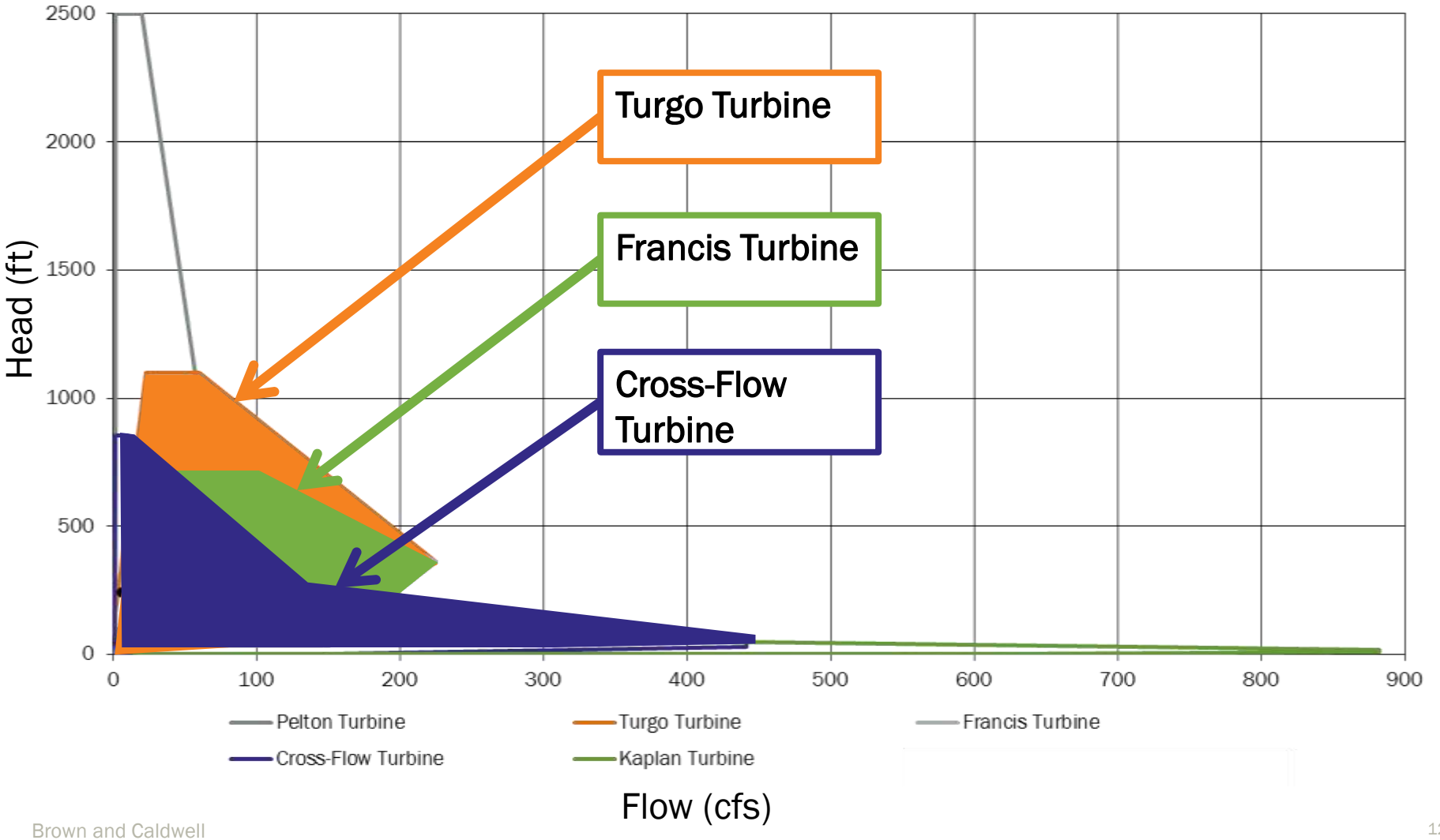
Pelton Turbines Suitable for Low Flow/High Head

Multi-Nozzle Pelton Wheels Provide High Efficiency Across a Wide Flow Range

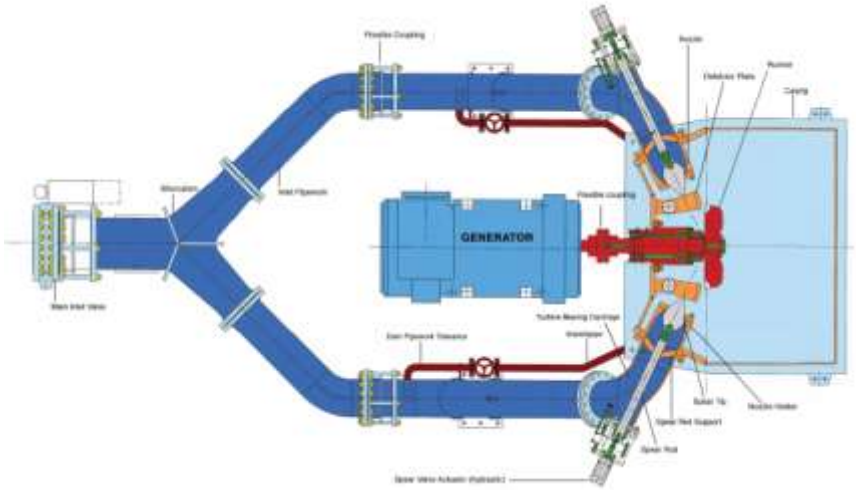


Vertical Pelton Wheel Options

Proper Turbine Selection Optimizes Payback



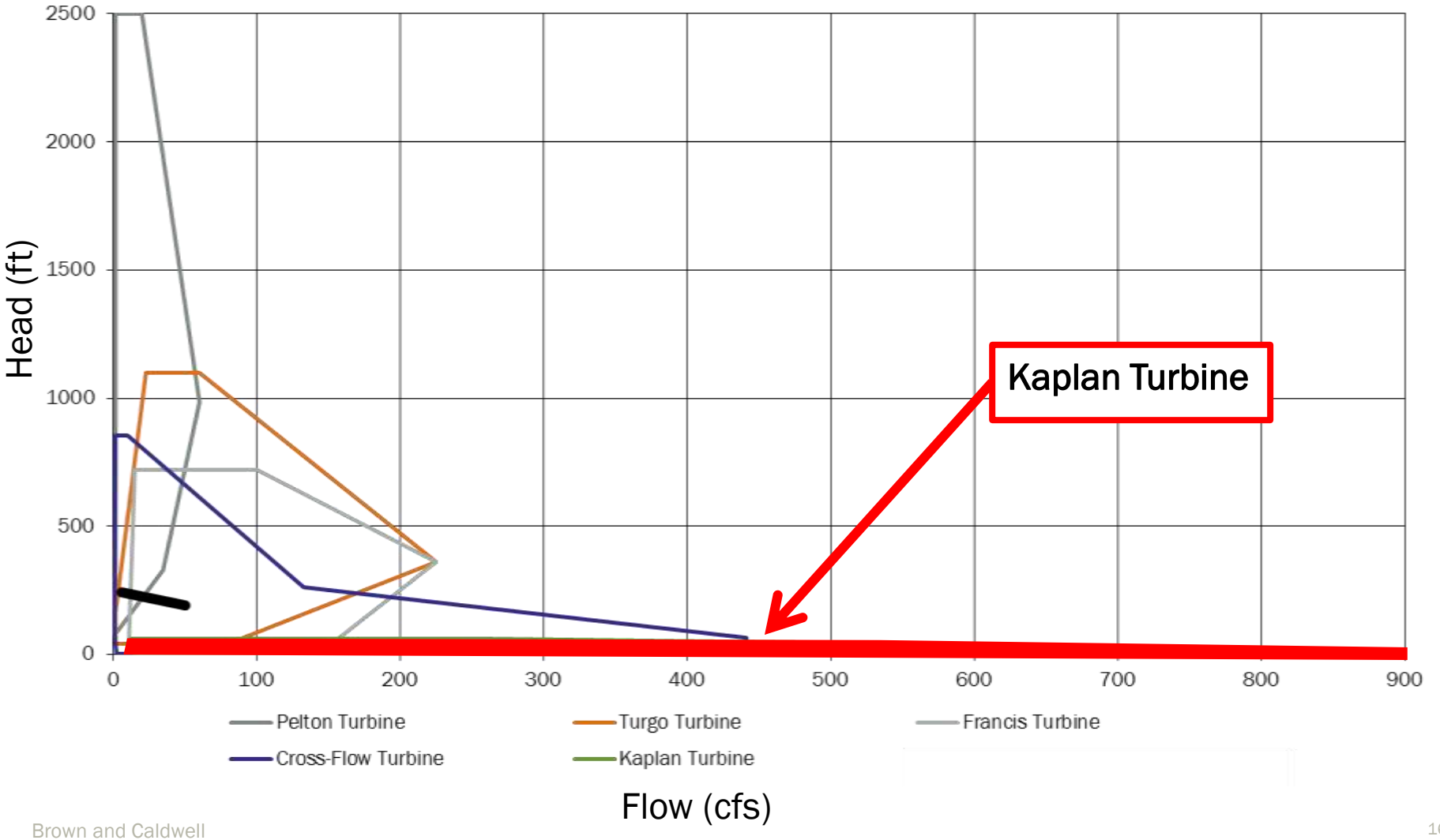
Turgo-Type Turbines Suitable for Medium Head/Medium Flow



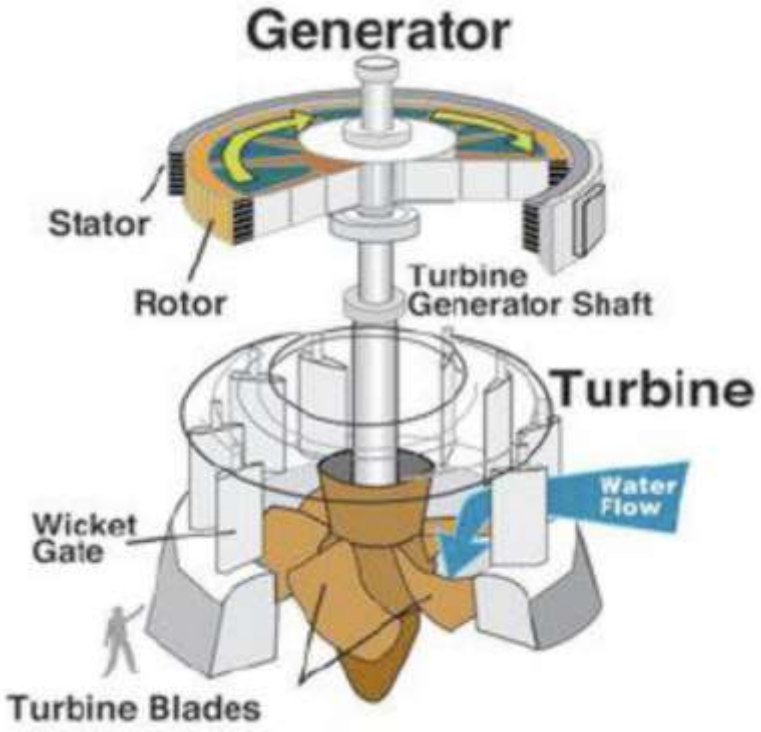
Francis Turbines Suitable for Medium Head/Medium Flow & Pressurized Discharge

Ossberger/Crossflow Turbines Suitable for Medium Head/Medium Flow

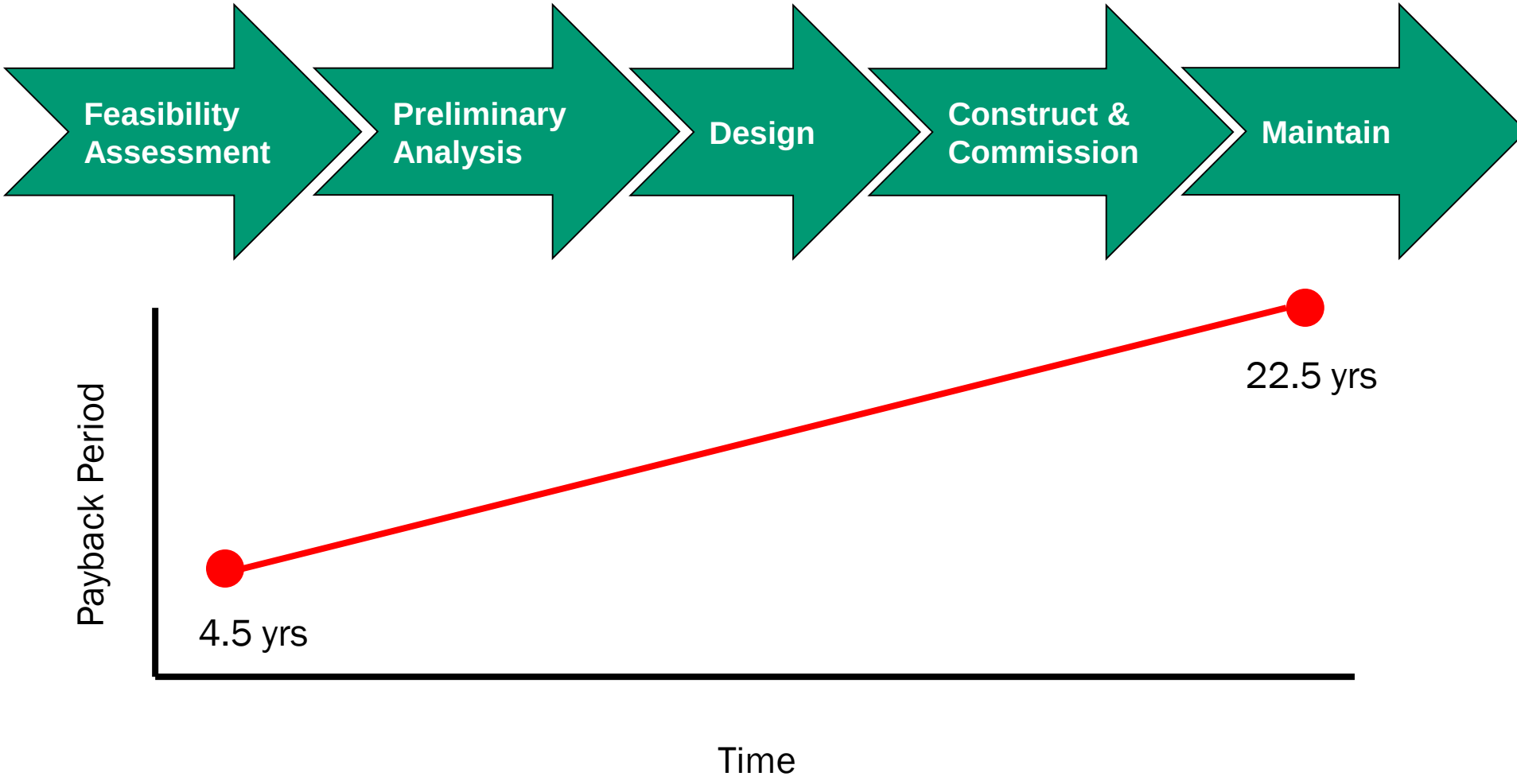
Proper Turbine Selection Optimizes Payback



Kaplan Turbines Suitable for Low Head/High Flow



Preliminary Analysis Must Be Comprehensive



Distance to Interconnection Point Adds Substantial Capital Costs

Grid Availability Must be Analyzed

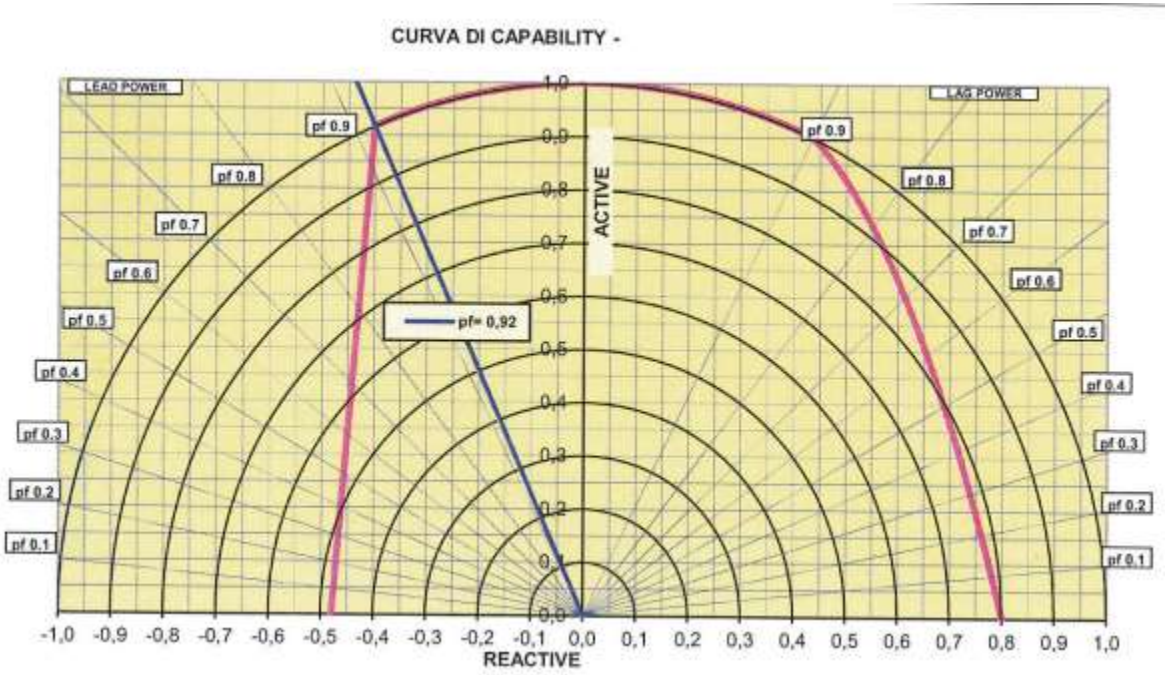
3,700 LF of #2 Aluminum Overhead Conductor

2,600 LF of #2 Aluminum Buried Conductor

1.4MW Hydroelectric Facility Located at End of Power Grid

Potential for over $600,000 in additional capital costs to upgrade to existing power lines

Generator Size May Trigger Analysis and Metering Requirements

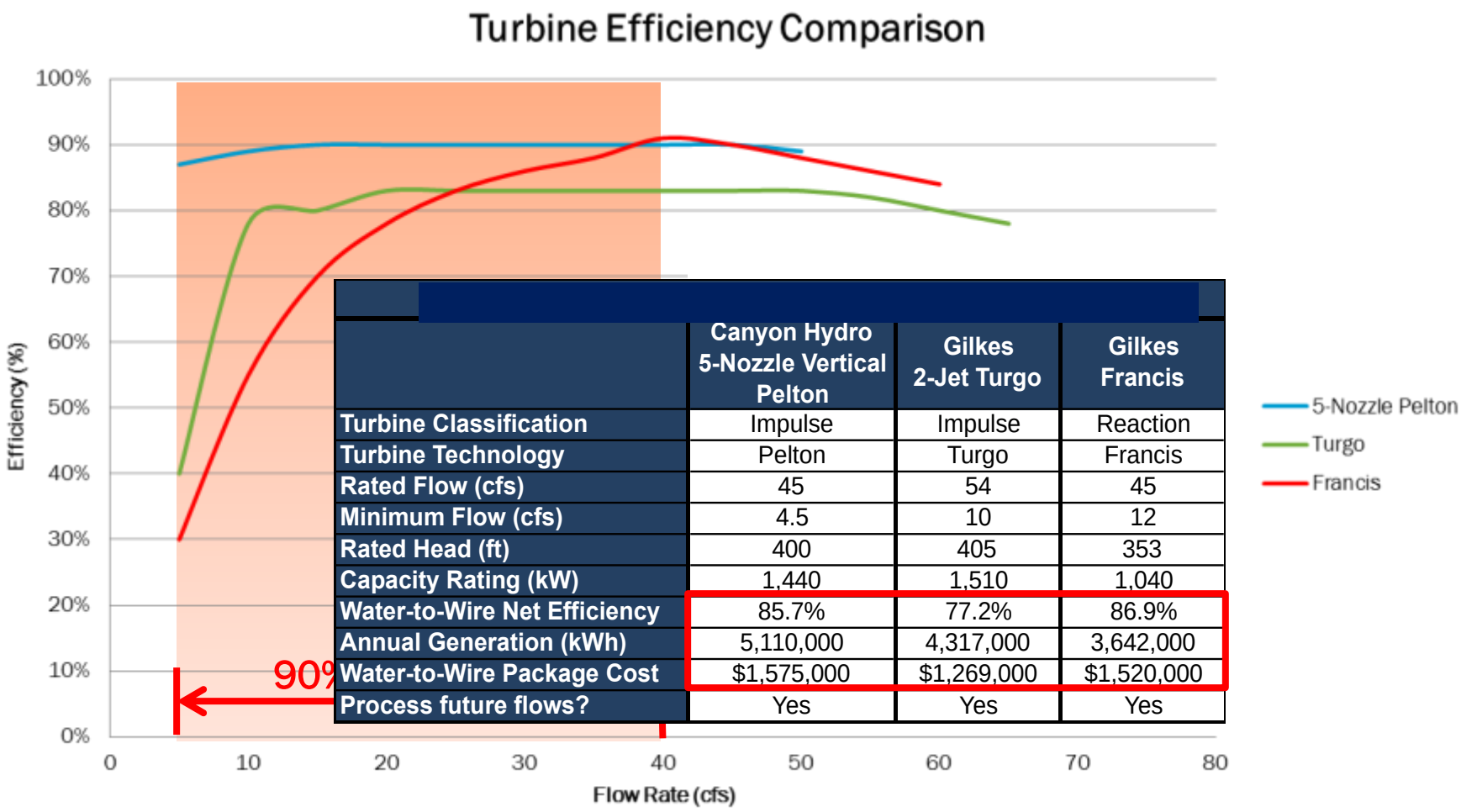


- Generators >1MW are typically synchronous
- PSLF modelling can cost >$250K
- Generators > 1MW require Independent System Operator Metering (CA)

Flow Projections Impact Turbine Selection and Power Revenues

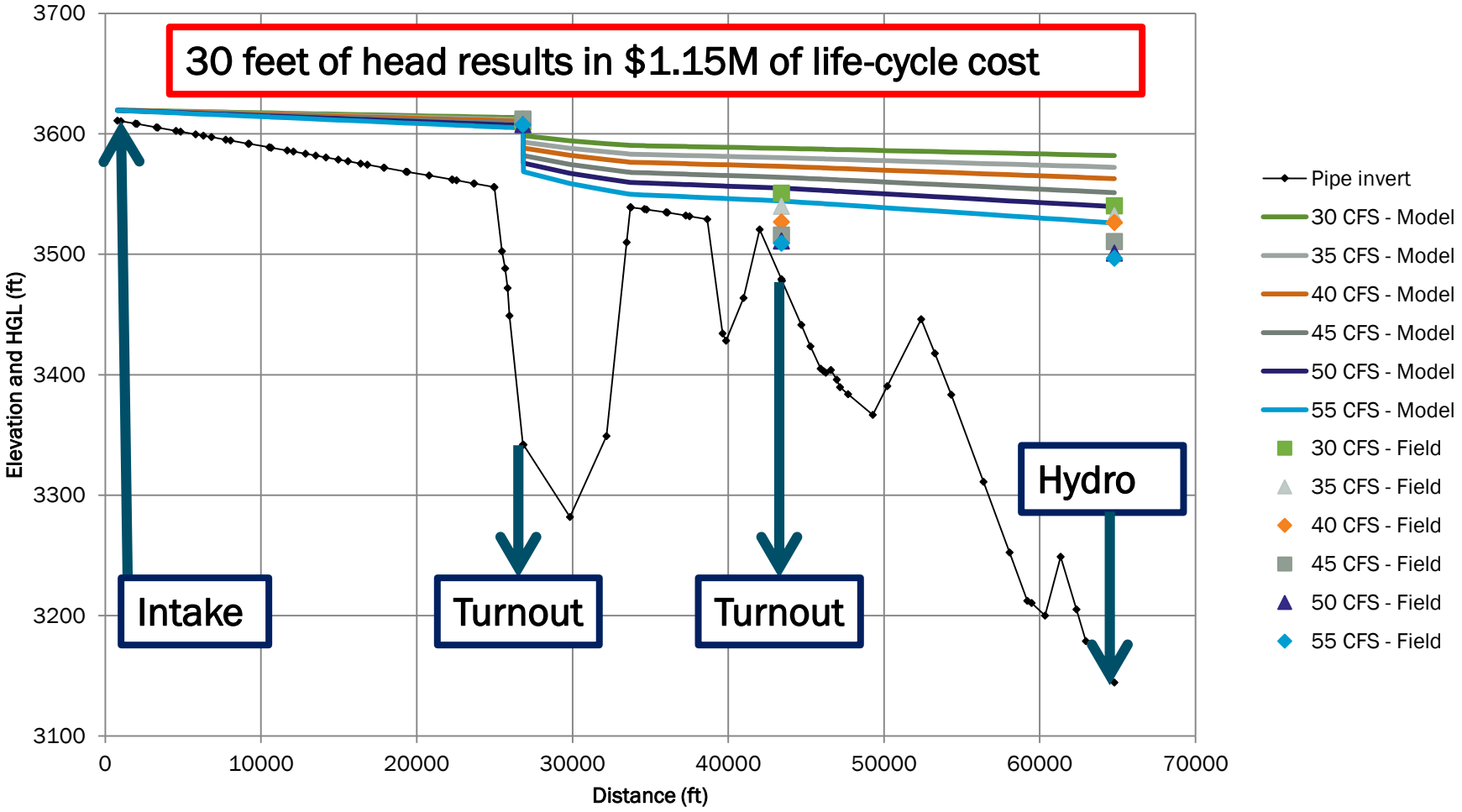
Monthy flow average (cfs)	2012	2012 (Current)	Difference (%)	2022	2022 (Current)	Difference (%)	2032	2032 (Current)	Difference (%)
Jan	20.8	11.8	-76%	26.3	12.8	-105%	29.8	14.2	-110%
Feb	20.0	11.1	-80%	25.5	12.2	-109%	28.9	13.5	-114%
Mar	19.8	9.5	-108%	25.1	10.0	-151%	28.4	11.0	-158%
Apr	25.2	8.4	-200%	31.9	8.5	-275%	36.1	9.4	-284%
May	37.5	21.5	-74%	47.5	23.8	-100%	53.8	26.3	-105%
Jun	49.8	29.8	-67%	63.0	32.9	-91%	71.4	36.4	-96%
Jul	58.9	32.9	-79%	74.6	36.4	-105%	75.0	40.2	-87%
Aug	59.6	32.5	-83%	75.0	35.9	-109%	75.0	39.6	-89%
Sep	53.3	31.3	-70%	67.5	34.5	-96%	75.0	38.1	-97%
Oct	40.2	26.8	-50%	50.8	29.5	-72%	57.6	32.5	-77%
Nov	25.9	19.3	-34%	32.8	21.3	-54%	37.2	23.5	-58%
Dec	25.5	10.3	-148%	32.3	11.3	-186%	36.6	12.4	-195%
Avg	**36.4**	**20.4**	**-78%**	**46.0**	**22.4**	**-105%**	**50.4**	**24.8**	**-104%**

Efficiency Throughout Range of Flows Maximizes Return on Investment



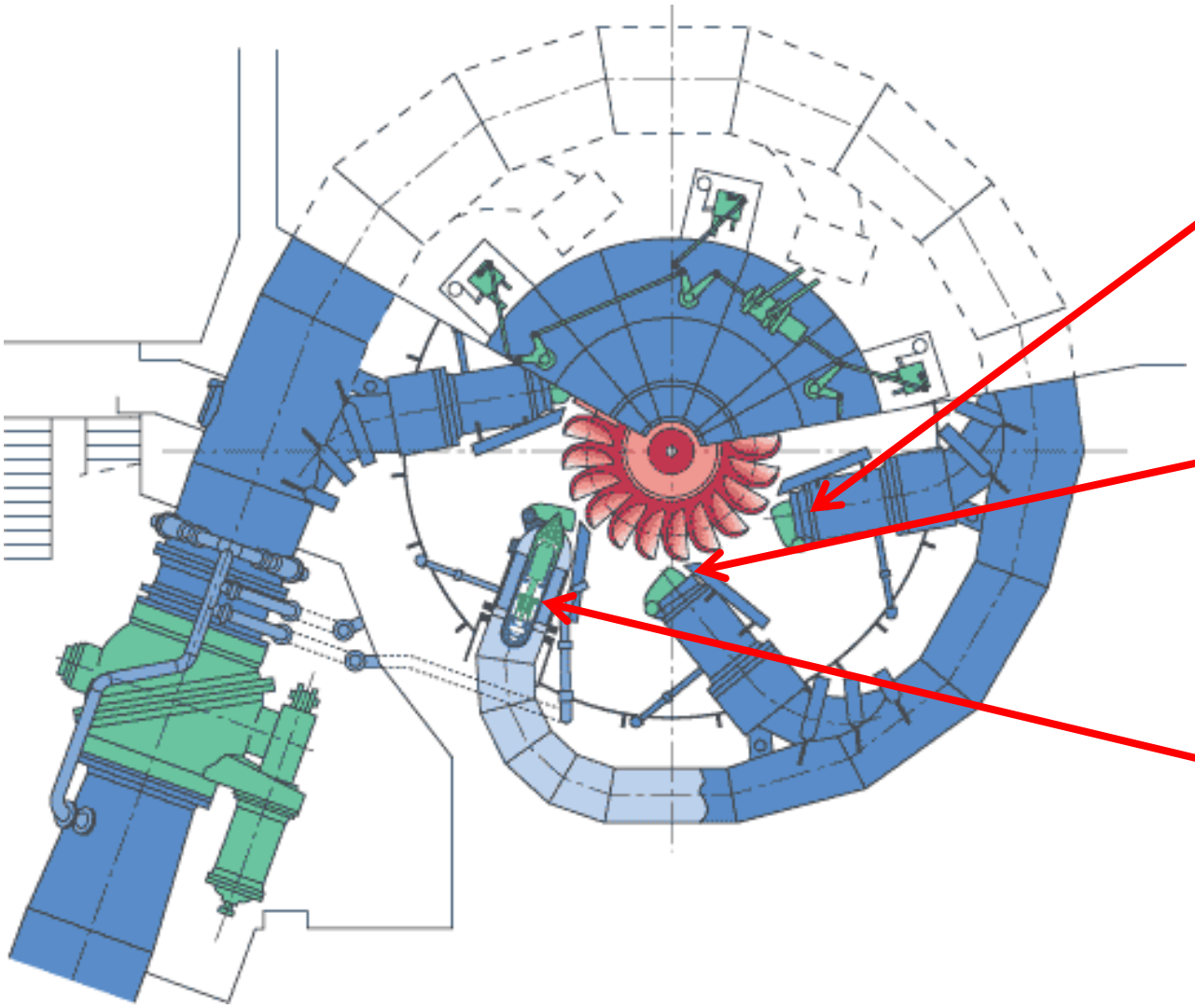
	Canyon Hydro 5-Nozzle Vertical Pelton	Gilkes 2-Jet Turgo	Gilkes Francis
Turbine Classification	Impulse	Impulse	Reaction
Turbine Technology	Pelton	Turgo	Francis
Rated Flow (cfs)	45	54	45
Minimum Flow (cfs)	4.5	10	12
Rated Head (ft)	400	405	353
Capacity Rating (kW)	1,440	1,510	1,040
Water-to-Wire Net Efficiency	85.7%	77.2%	86.9%
Annual Generation (kWh)	5,110,000	4,317,000	3,642,000
Water-to-Wire Package Cost	$1,575,000	$1,269,000	$1,520,000
Process future flows?	Yes	Yes	Yes

Distribution System Control Valves Can Reduce Power Generation Revenues



Debris In Existing Pipelines Can Reduce Power Generation Equipment Run-time

One Month of Downtime Costs $30,000 in Lost Revenue Alone

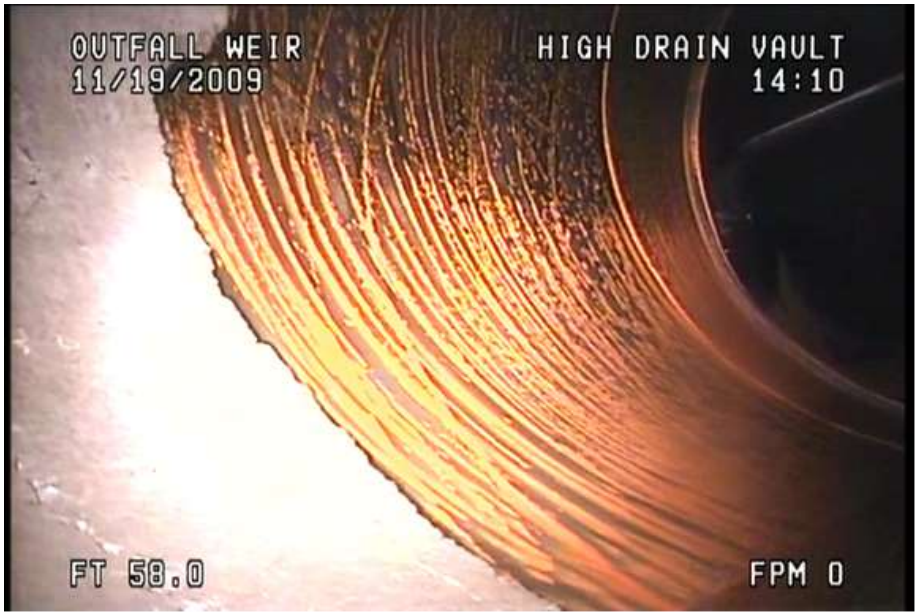


Nozzle Sized for 1-inch Diameter Fully Open

Needle Valves Control Flow Rate at Each Nozzle

Repair Valves Require Long Lead Time

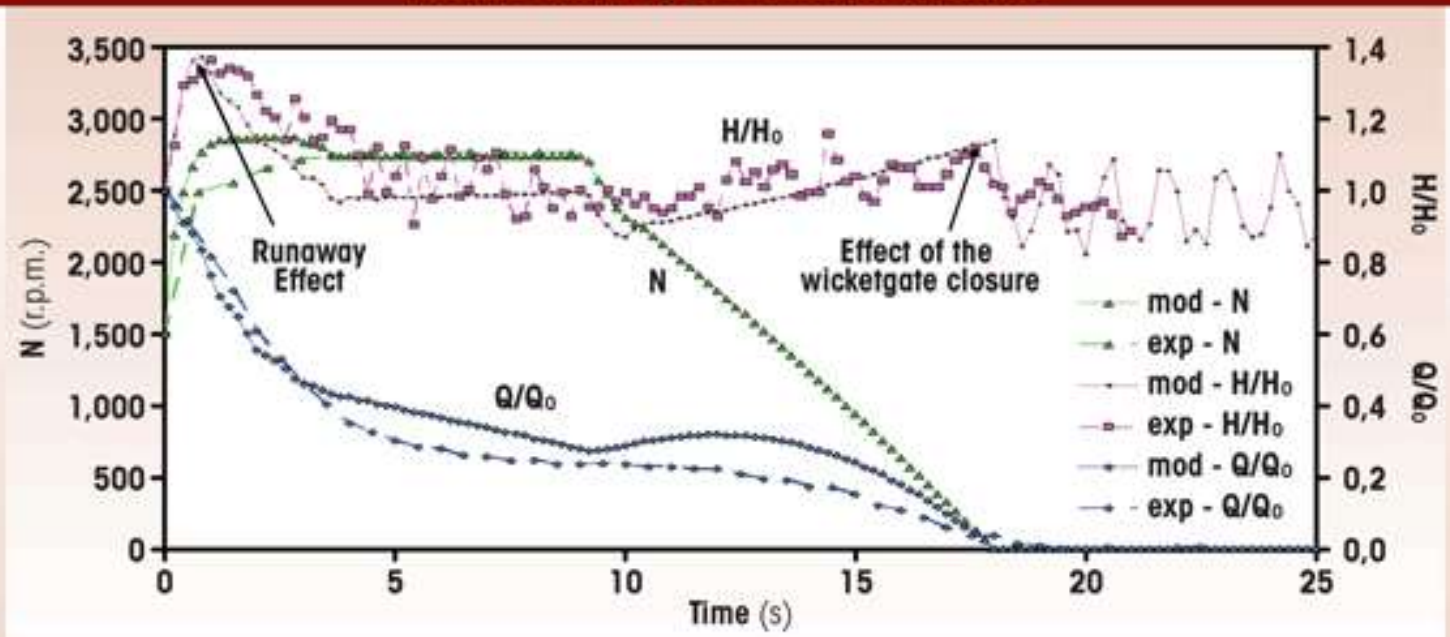
Lining Inspection and Repair Can be Cost Prohibitive



Screening Equipment Adds Capital and Maintenance Costs

Francis Turbine Load Rejection Can Create Transient Surge Event

FIGURE 3 Low Speed Model Results

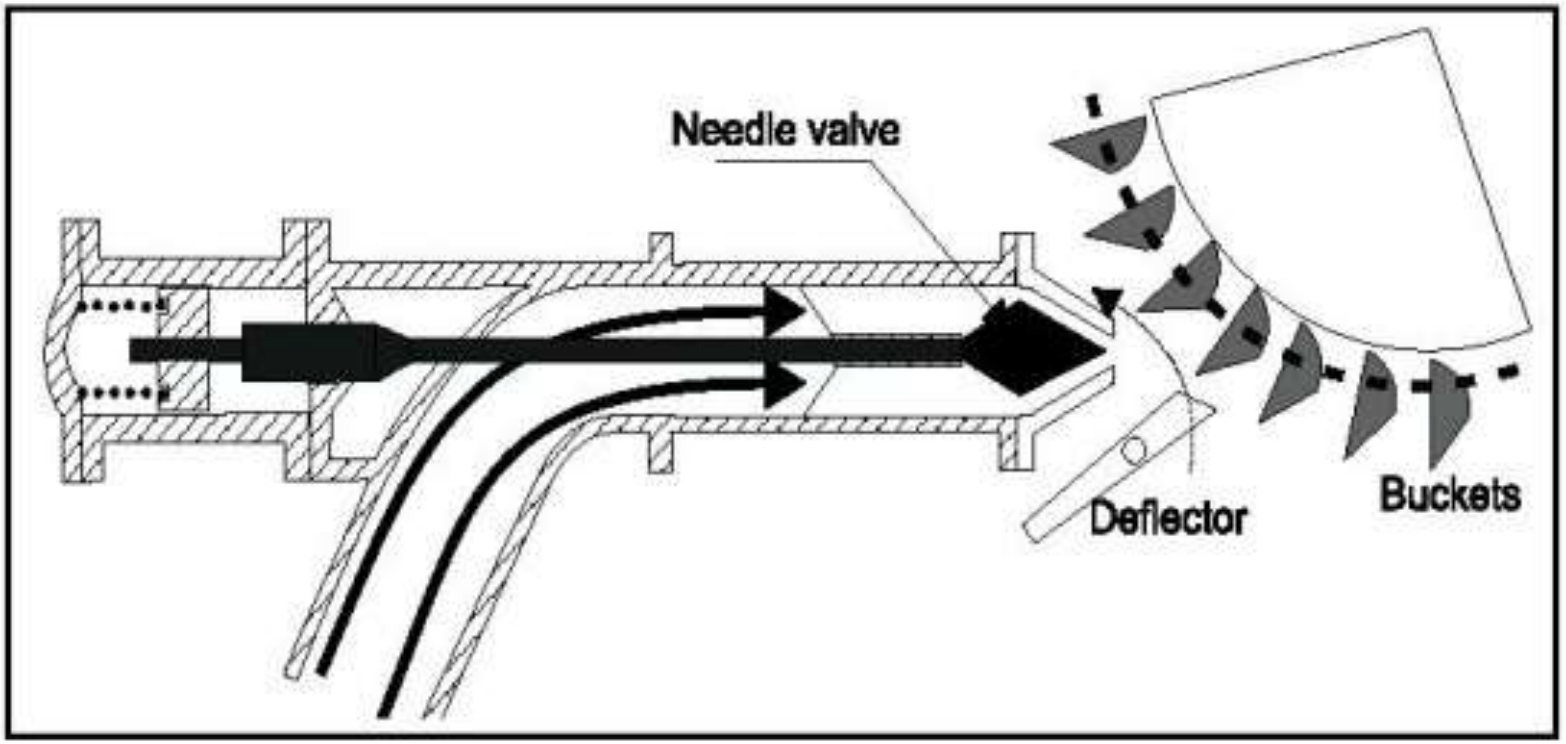


This comparison between experimental and computational model results for a low specific speed Francis turbine shows how turbine discharge, head, and rotational speed can vary for a simultaneous occurrence of a full load rejection and wicket gate closure.

Ramos, Hydro Review Worldwide, 2010

Surge Tanks Are Expensive and Require Maintenance

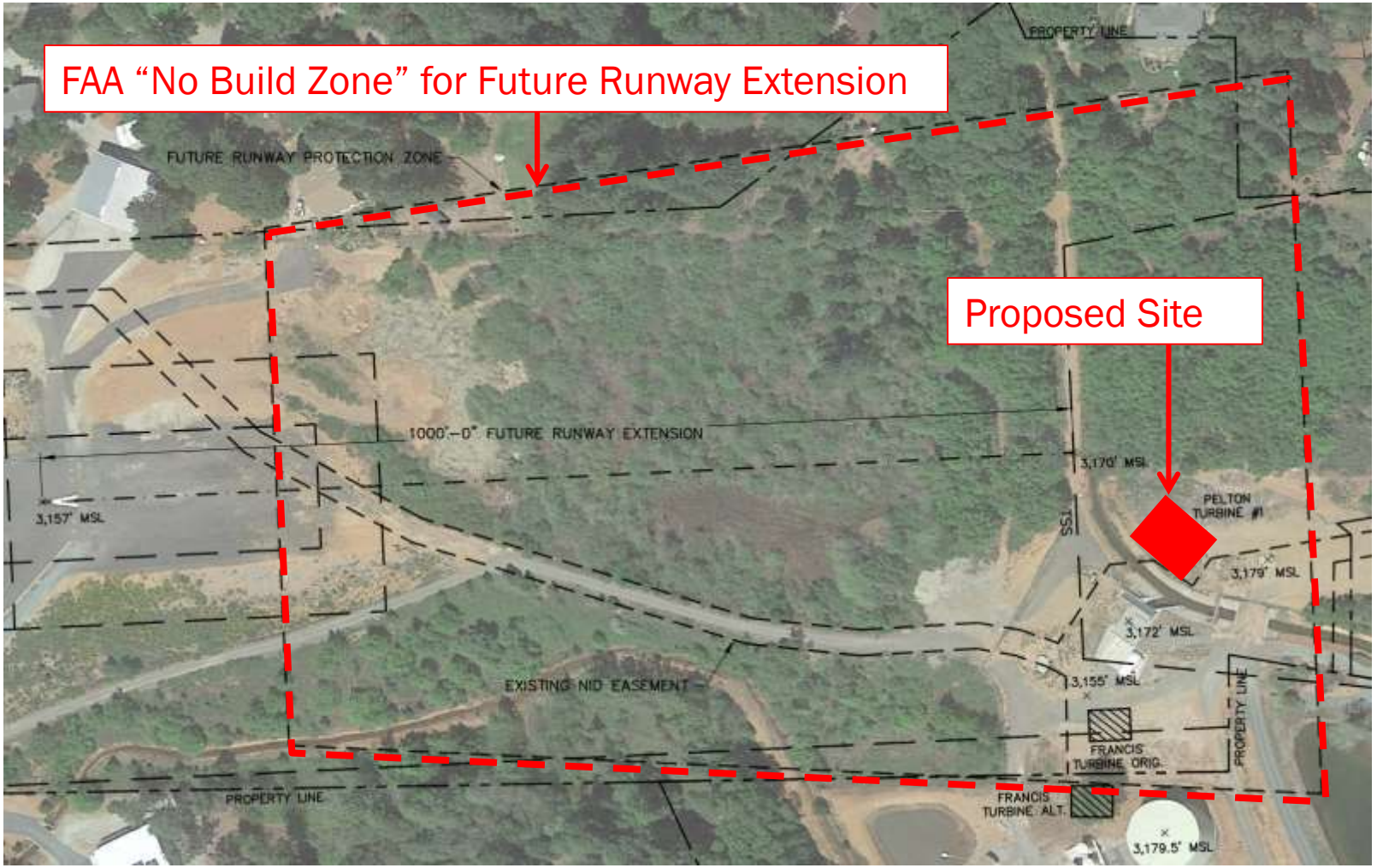
Pelton Wheel Nozzle Deflectors Eliminate "Runaway Turbine" Effect



Communications and Controls May Require Upgrades to Maintain Continuous Service

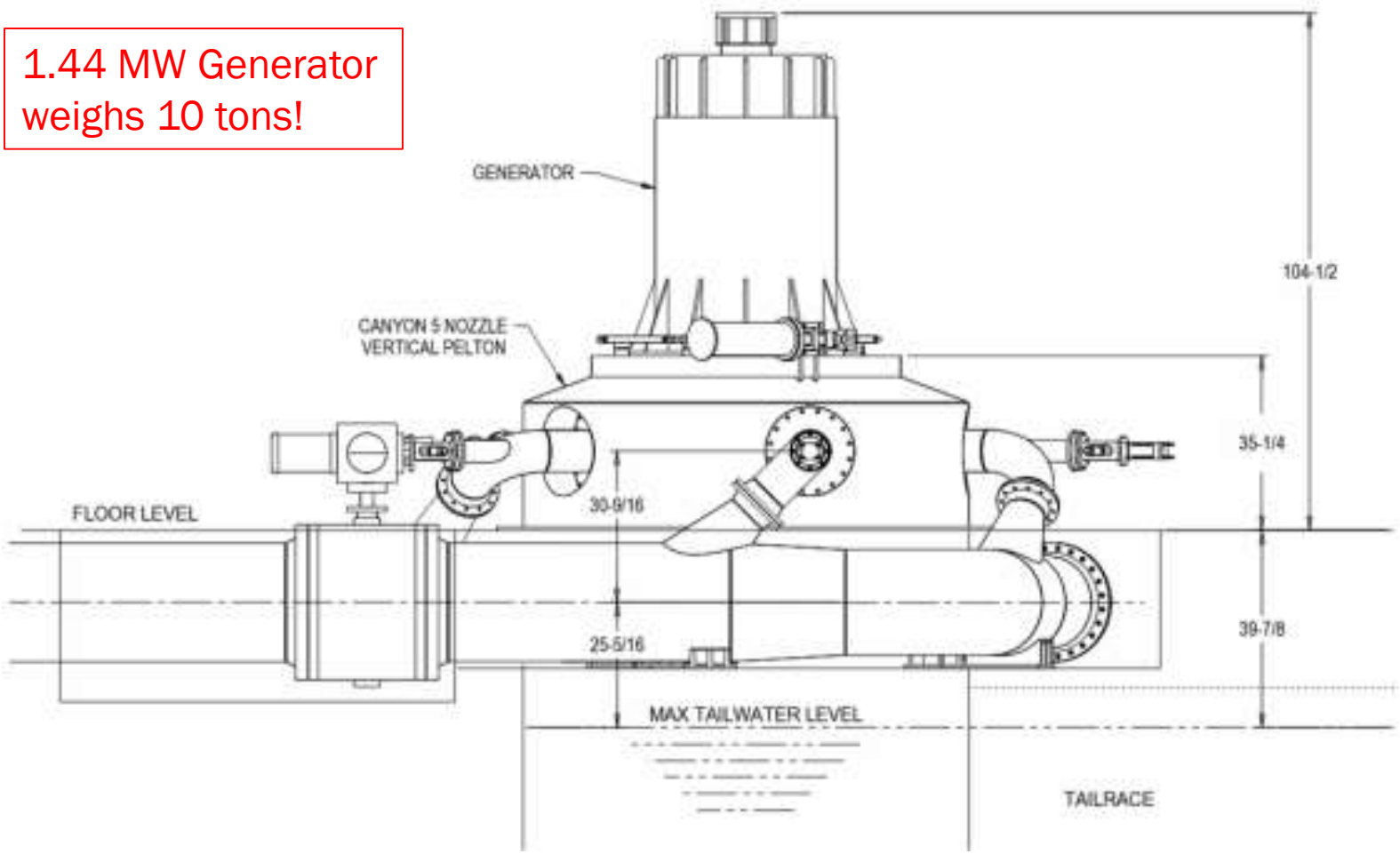
- Bypass valves
- Additional flow meters
- Multiple turbines

Acquiring full control of property may present unforeseen challenges



Access to Generator and Turbine Runner Can Add Capital Costs

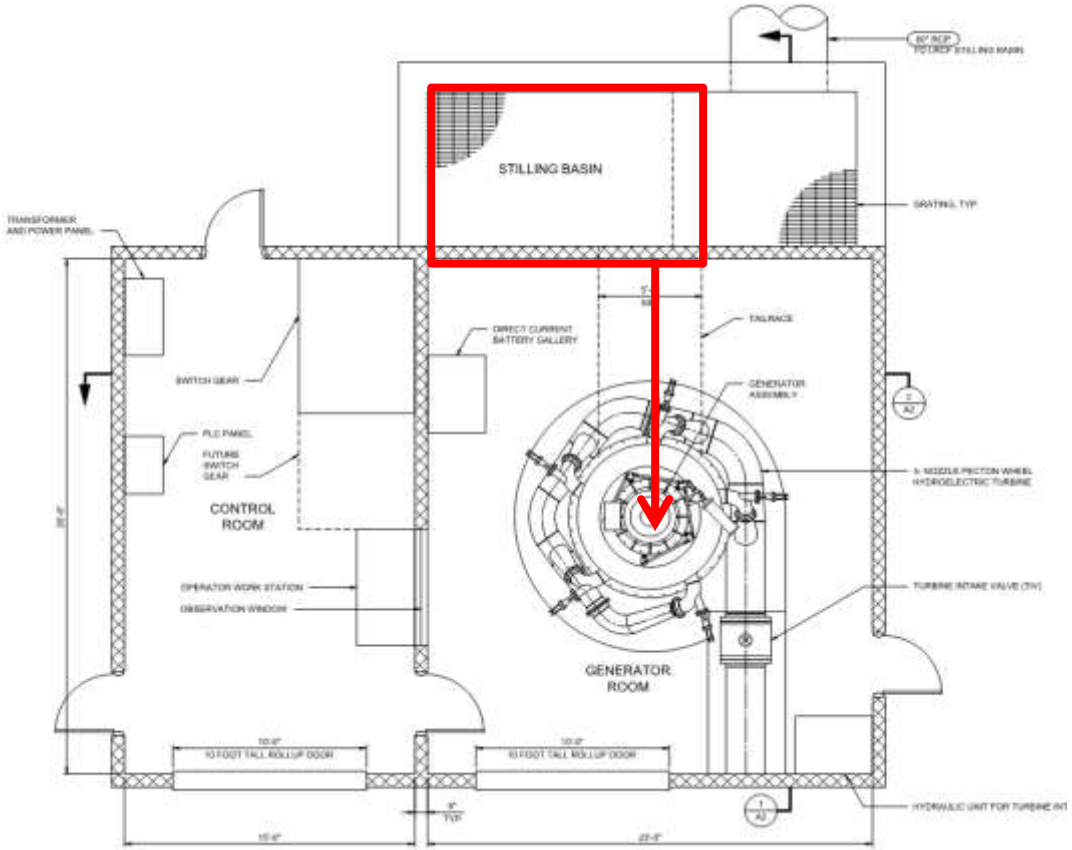
1.44 MW Generator weighs 10 tons!

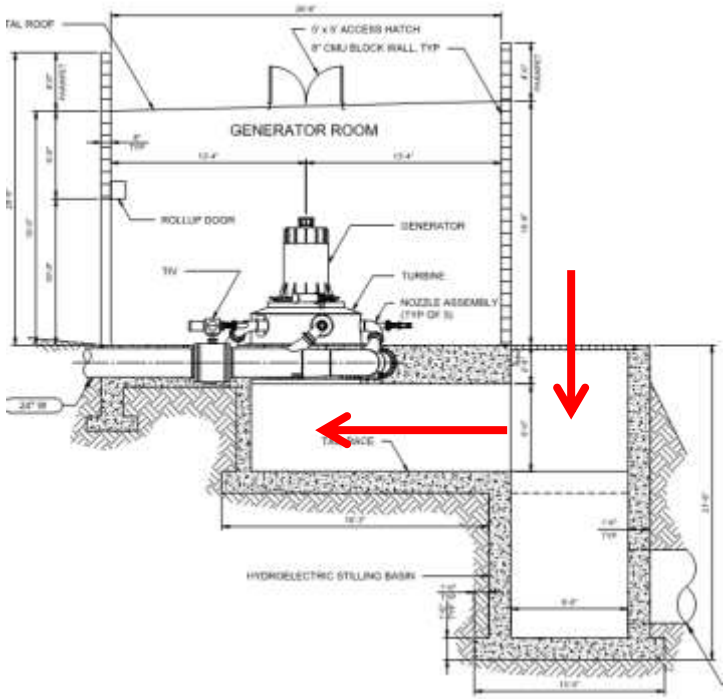


TIV and Runner Housing Encased in Concrete

Turbine Runner Suspended Above Tailrace

Large Access Required to Remove Runner





Providing Crane Access to Generator Can Add Substantial Costs

Operator Safety Must be Considered

A Thorough Preliminary Design is Necessary

- Knowledge of water system design and operations is key to successfully identifying all life-cycle costs of a project
- A thorough preliminary evaluation allows owners to have confidence in determining project feasibility

Questions?

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