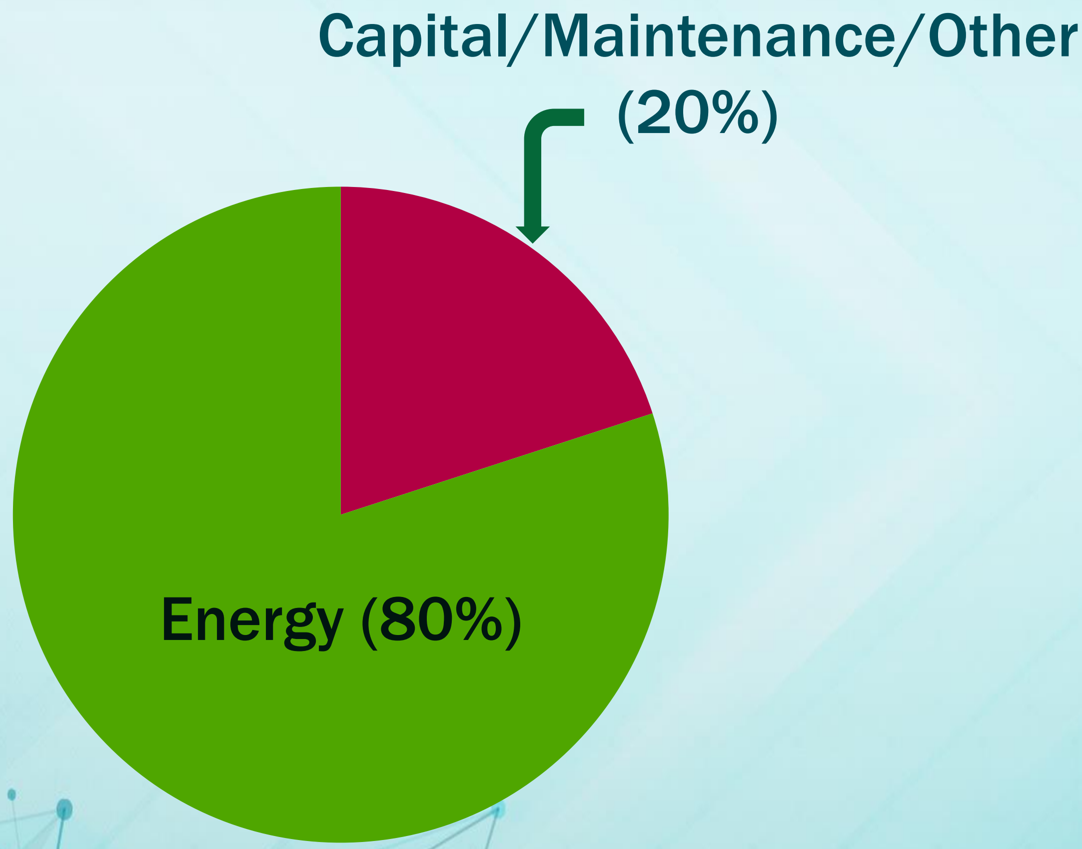
On Demand Pump Condition Assessment and Optimization

Typical Pump Life Cycle Cost



Source: "Reducing Life Cycle Cost By Energy Saving in Pump Systems." Bower, John R., Ingersoll-Dresser Pumps.

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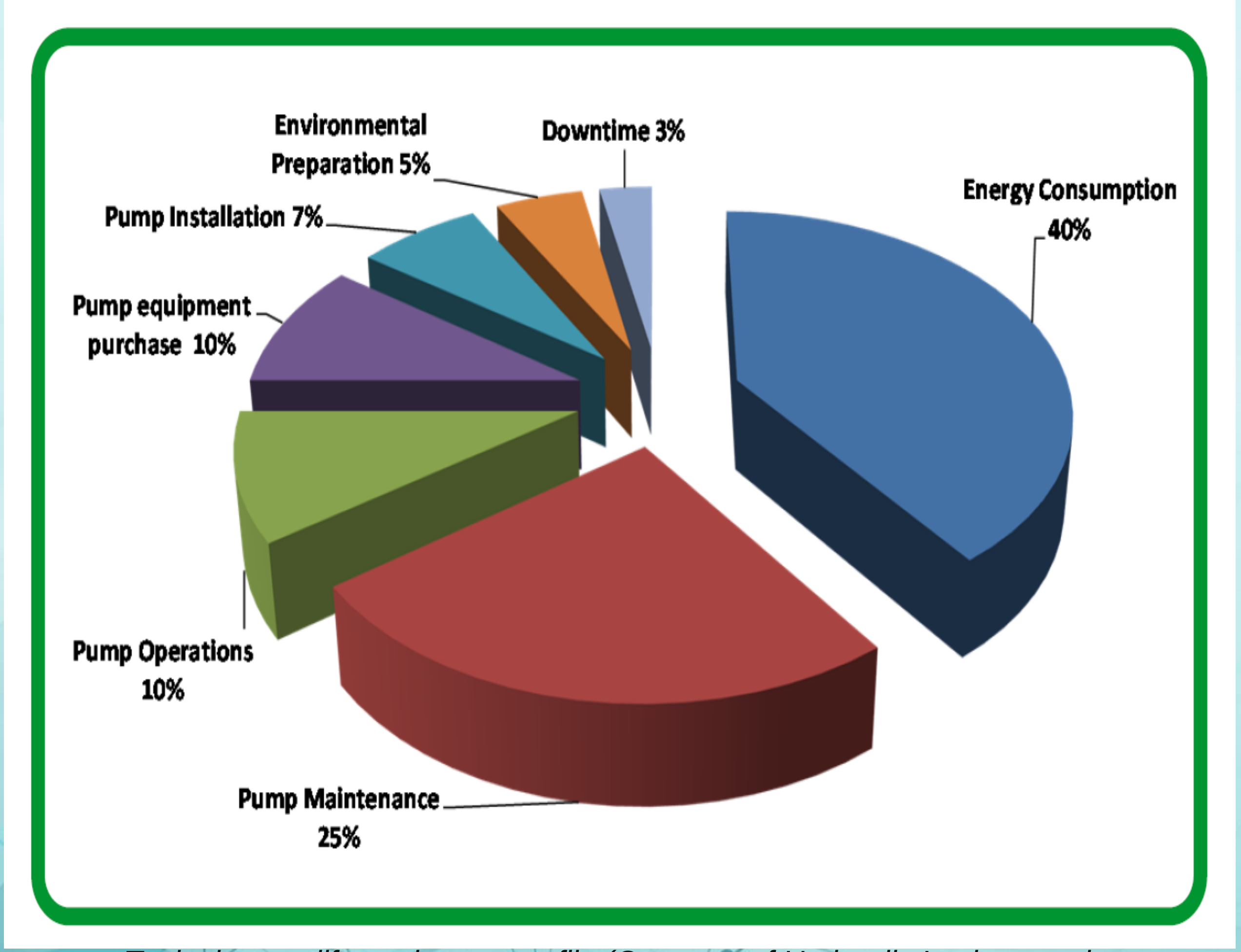
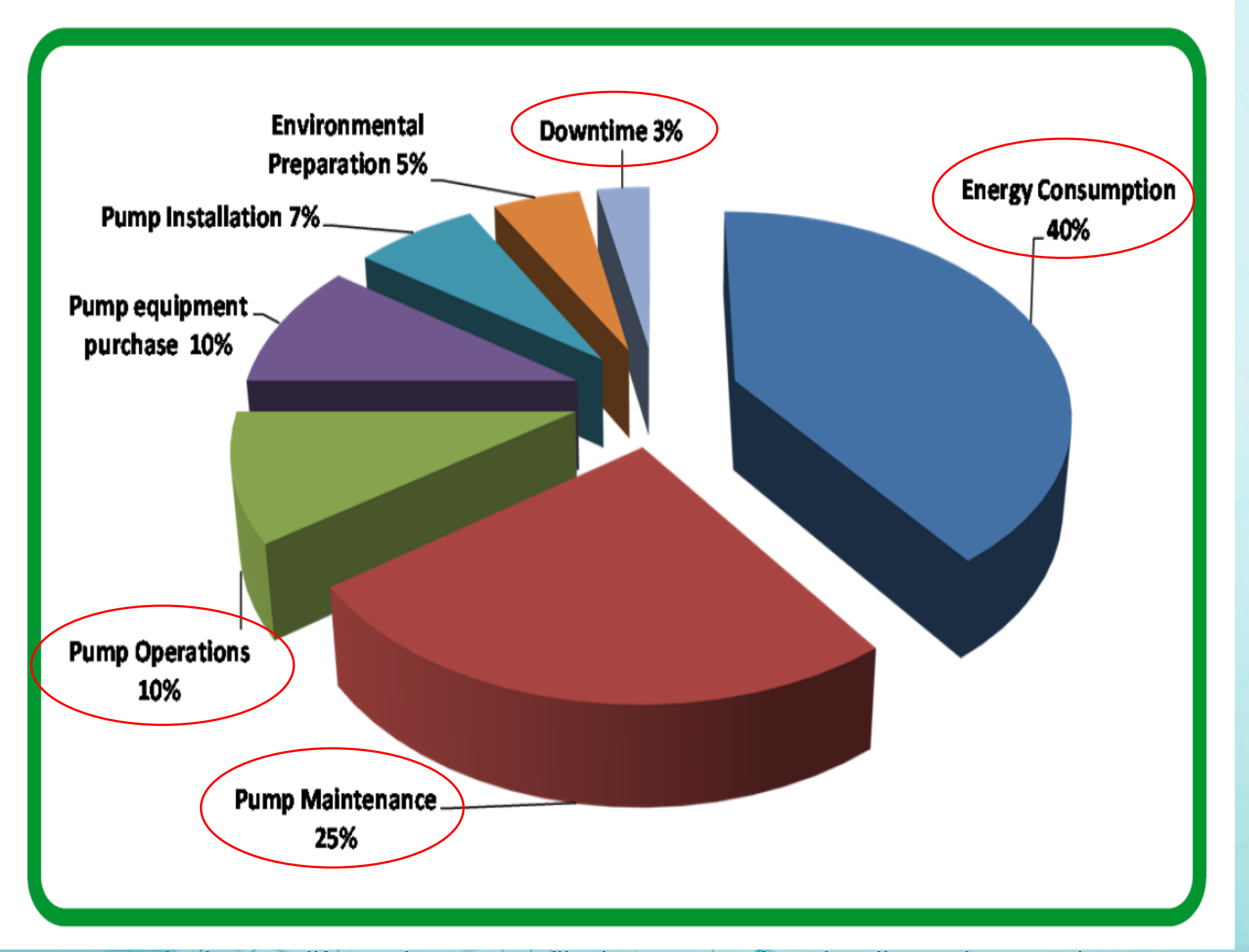
Typical Pump Life Cycle Cost



Typical pump life-cycle cost profile (Courtesy of Hydraulic Institute and Pump Systems Matter)

Lowering Pump Life Cycle Costs



Typical pump life-cycle cost profile (Courtesy of Hydraulic Institute and Pump Systems Matter)

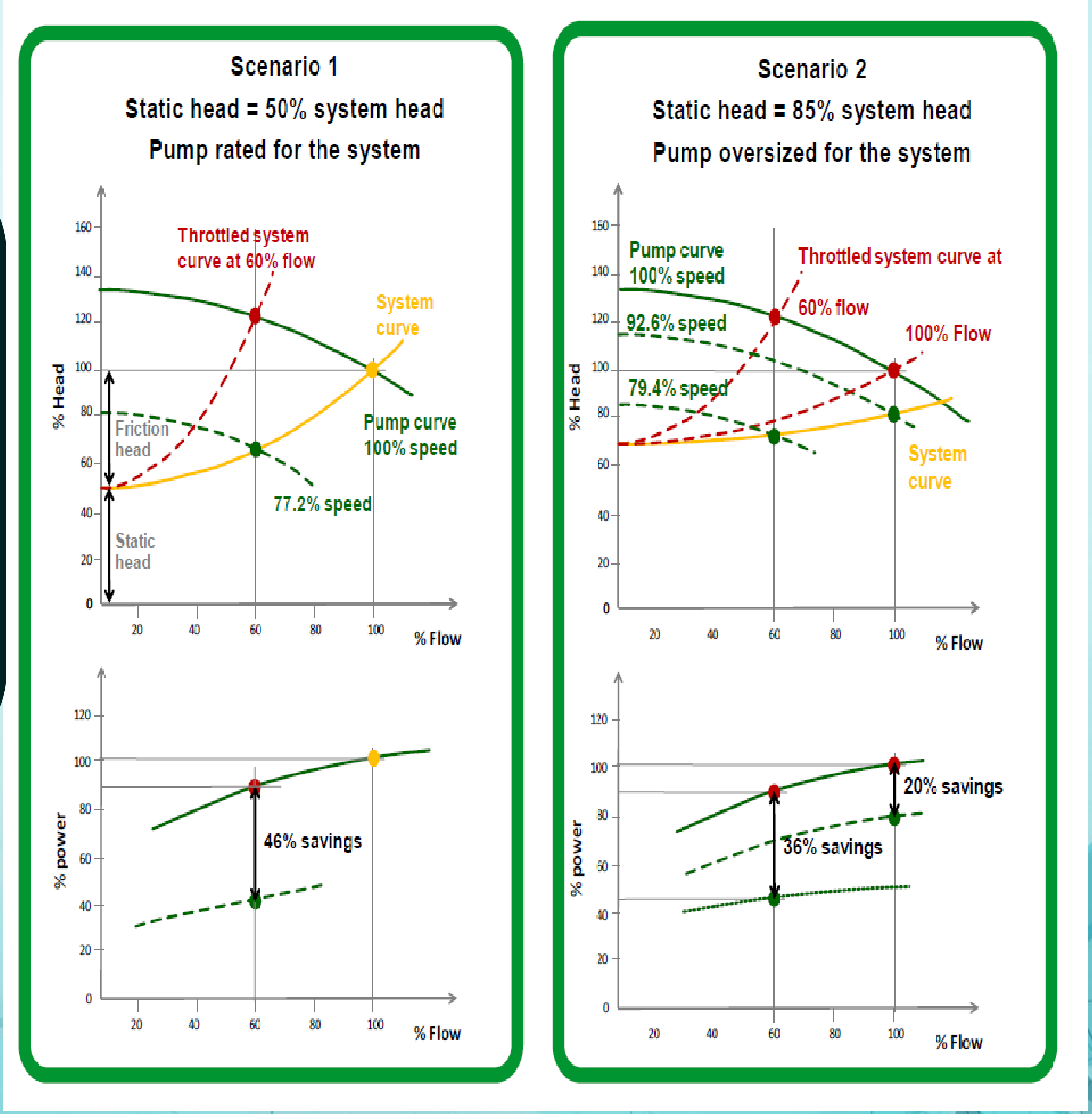
Affinity Laws for Pumps, Simplified

- Non compressible fluid (water)
- Centrifugal type pump
- Flow is proportional to speed of the pump
- Power is proportional to the $(\text{speed})^3$ of the pump

Affinity Laws for Pumps

Variable Speed vs. Throttled

- *Energy saved with variable vs. fixed speed drives at 100% and 60% flow, according to the static head and pump sizing. The operating point is represented as the intersection of the pump curve with the system curve*



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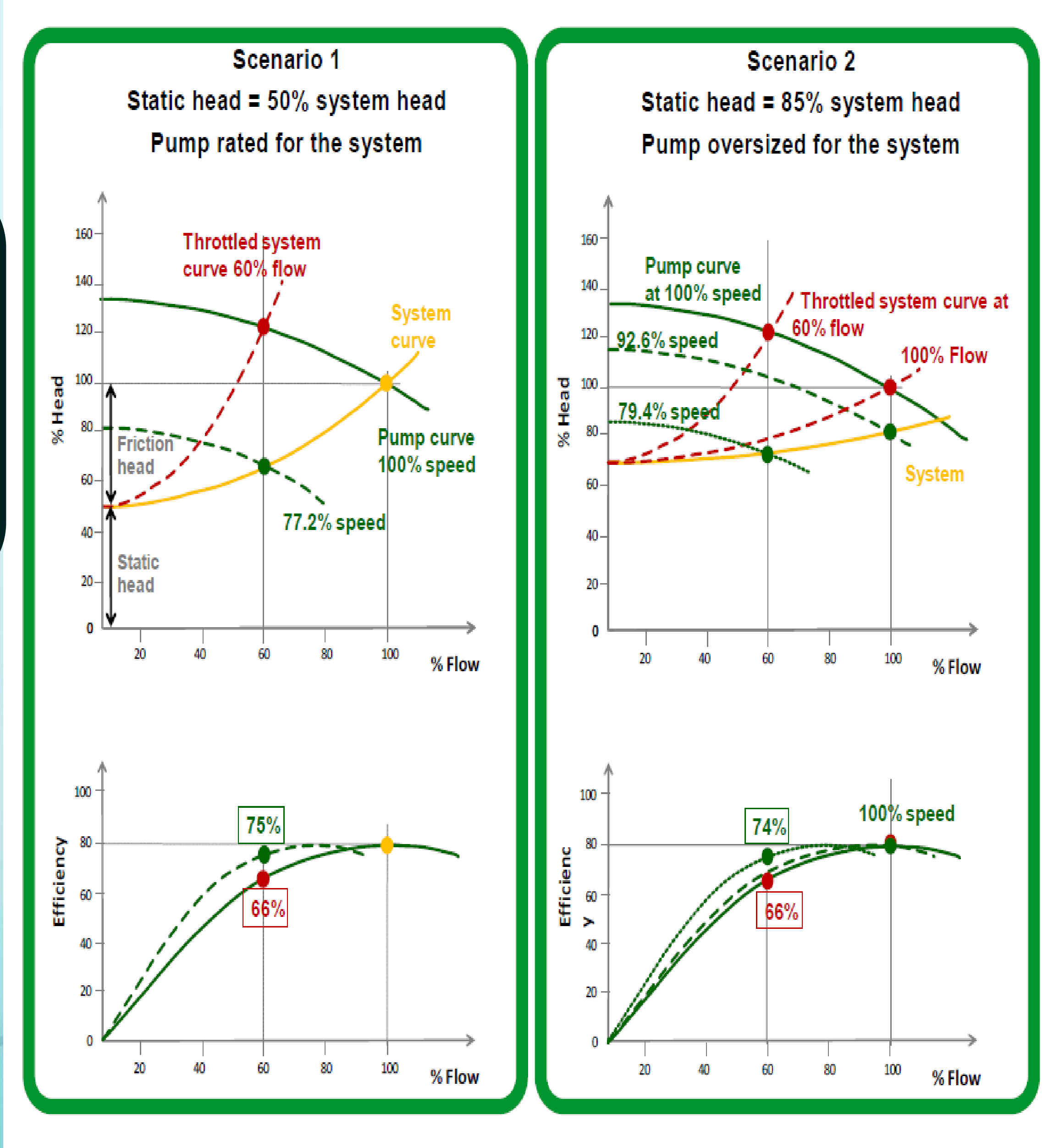
Affinity Laws for Pumps

BEP : Best Efficiency Point

- Comparison of two efficiency scenarios at different flow rates: 8 to 9% more efficient with variable speed drives at 60% flow



What Would be the Best Method to Operate and Manage a Pump Station?

Pump Condition Assessment

Measure pumps' capacity and efficiency with automated pump tests

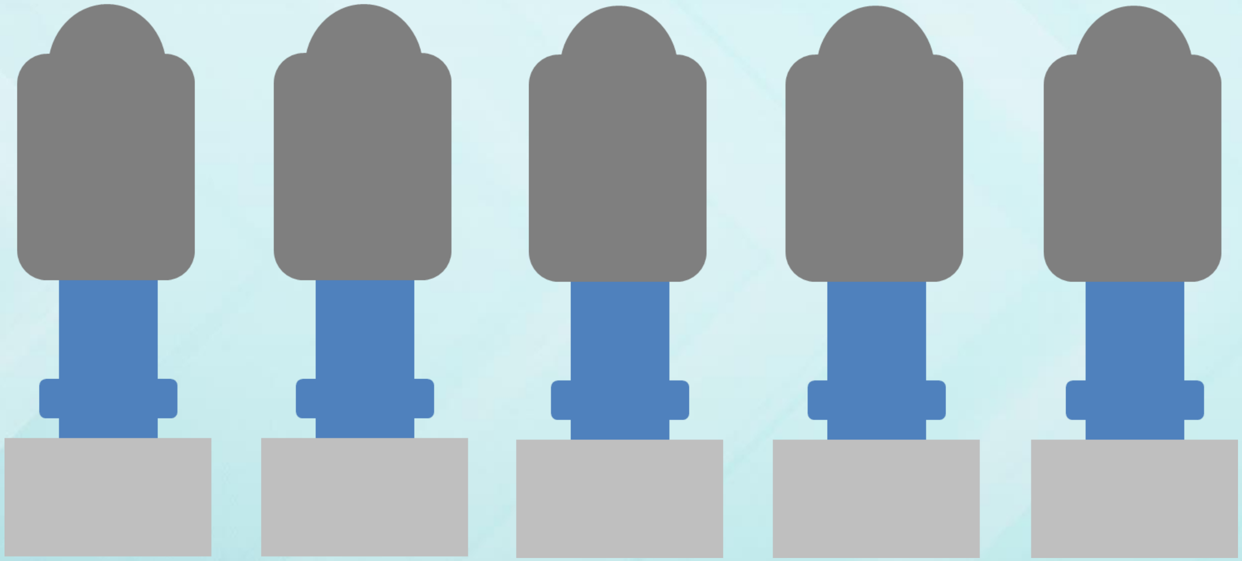
Reduce operating costs
Improve pump reliability

Dynamic Pump Optimization

Continually adjust pump station to changing pump and system conditions to operate at peak efficiency

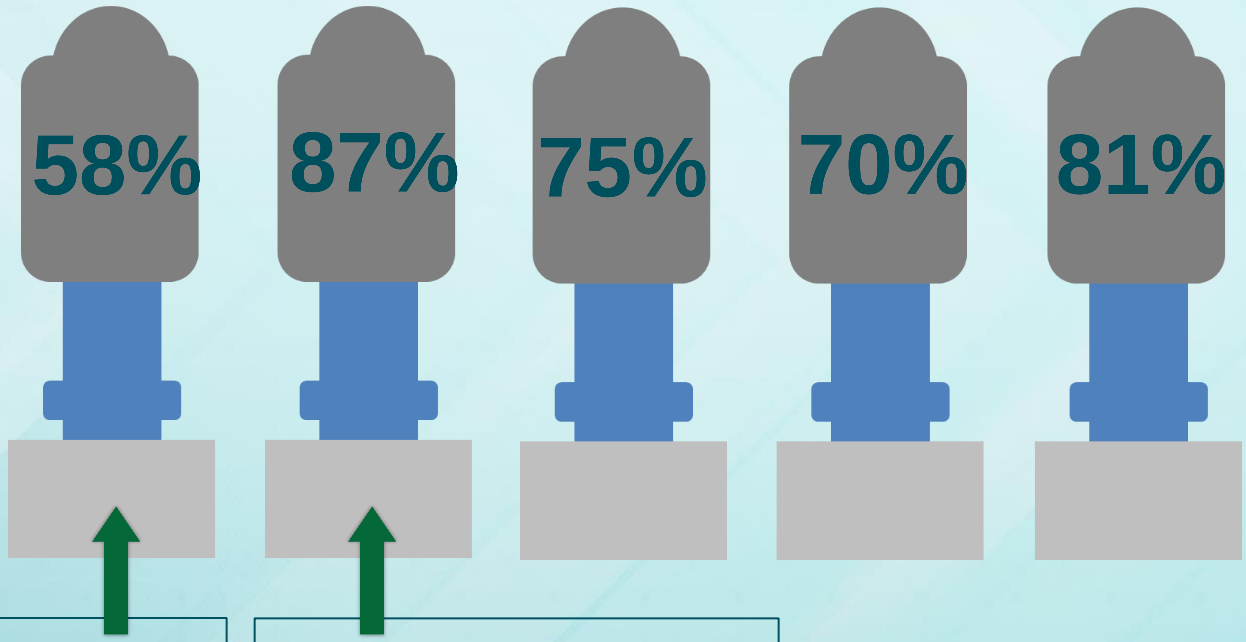
Reduce operating costs
Increase pump life

What Operators See – 5 Identical Pumps



The Reality – Pumps are Hardly Identical

Peak efficiency:



Running this pump wastes 29% more energy per volume pumped…

…versus running this pump

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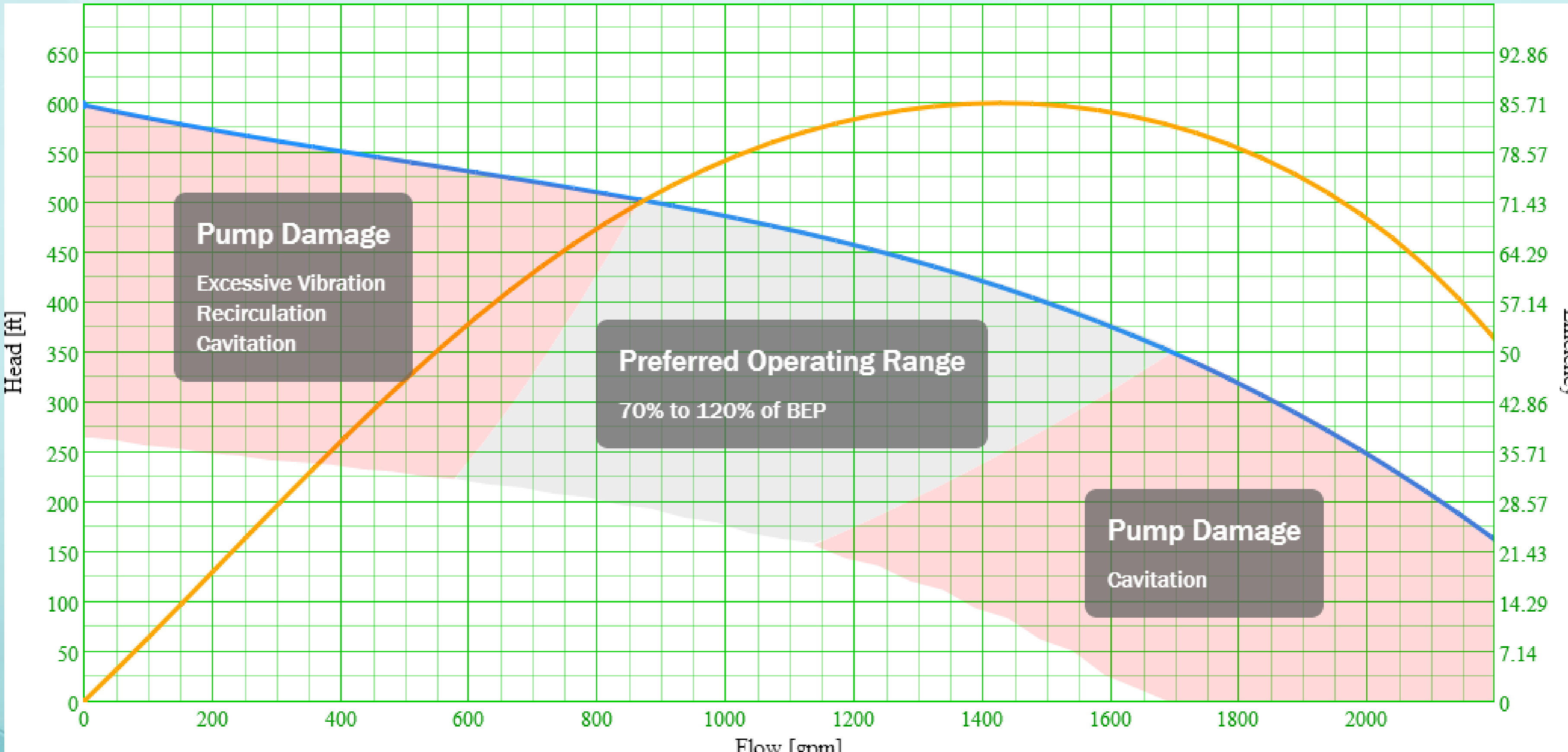
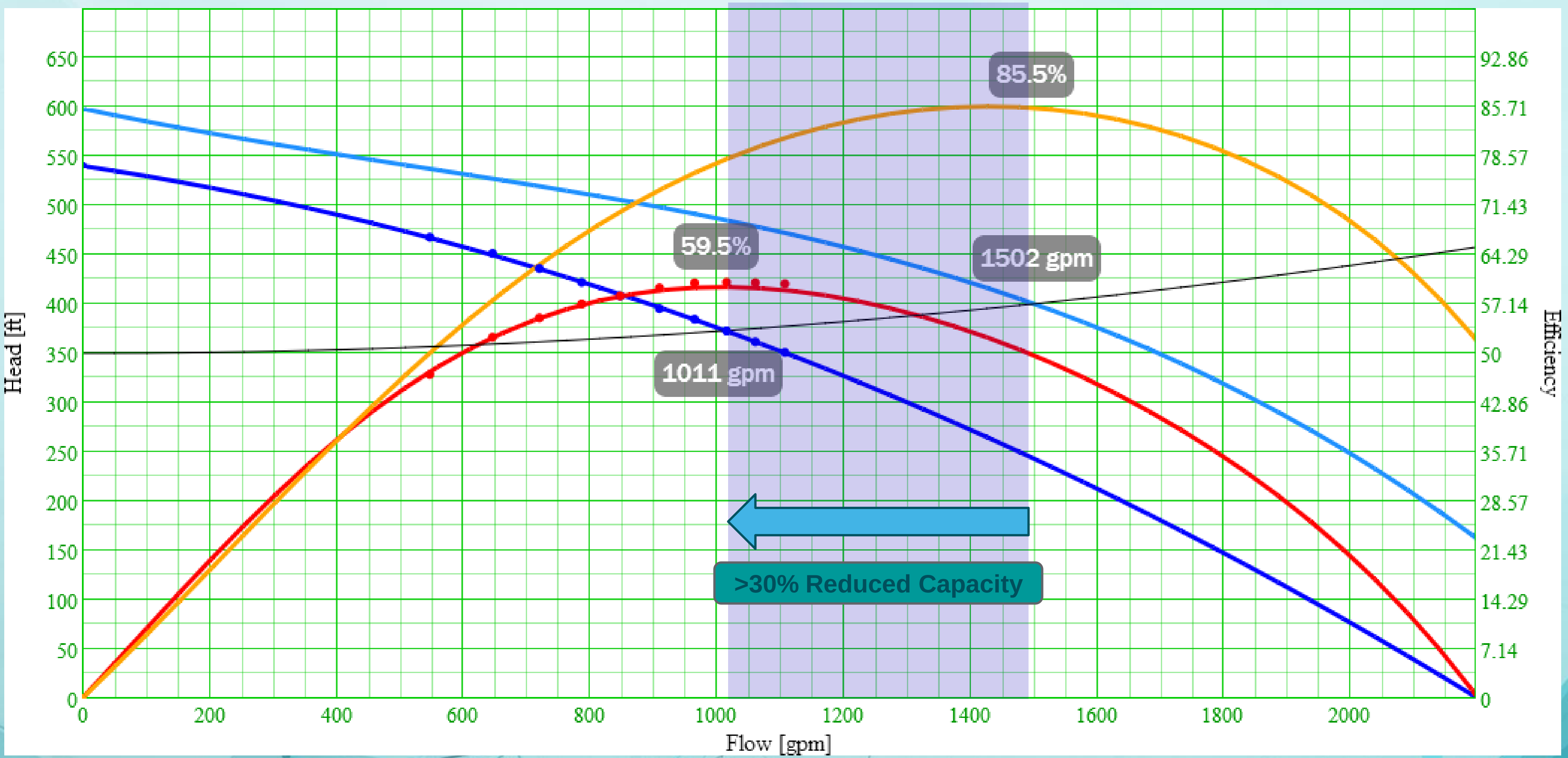
Preferred Operating Range



System Curve | Tested Head | Tested Efficiency | Factory Head | Factory Efficiency

Effect of Pump Impeller Wear



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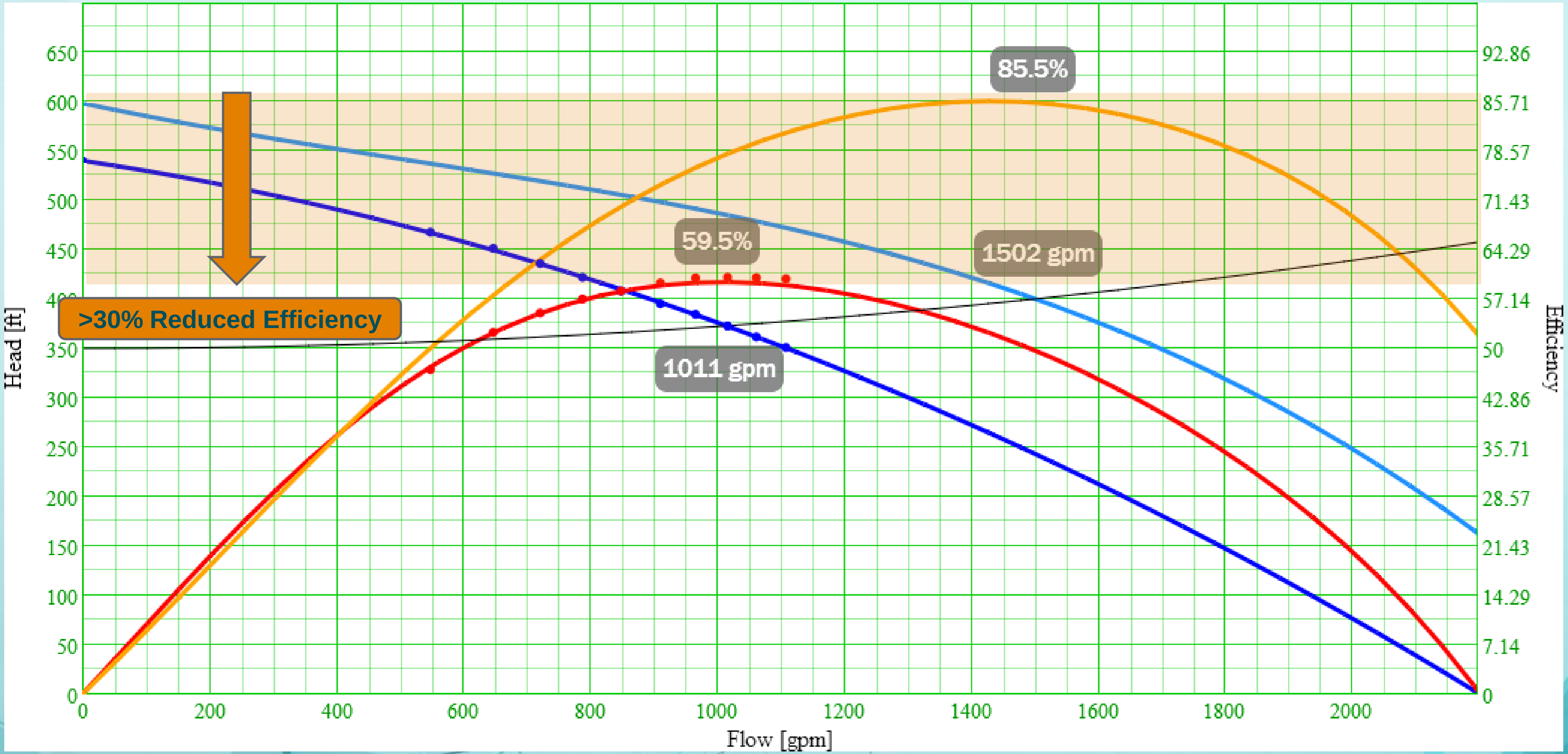


System Curve | Tested Head | Tested Efficiency | Factory Head | Factory Efficiency

Pump Condition Assessments

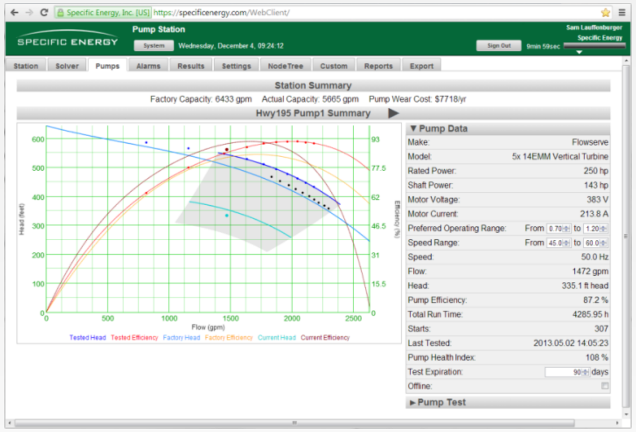
Annual Audits

- Expensive
- Not repeatable
- Often not actionable
- No financial impact analysis
- Not available ad hoc

On Demand Condition Assessment

Asset Management

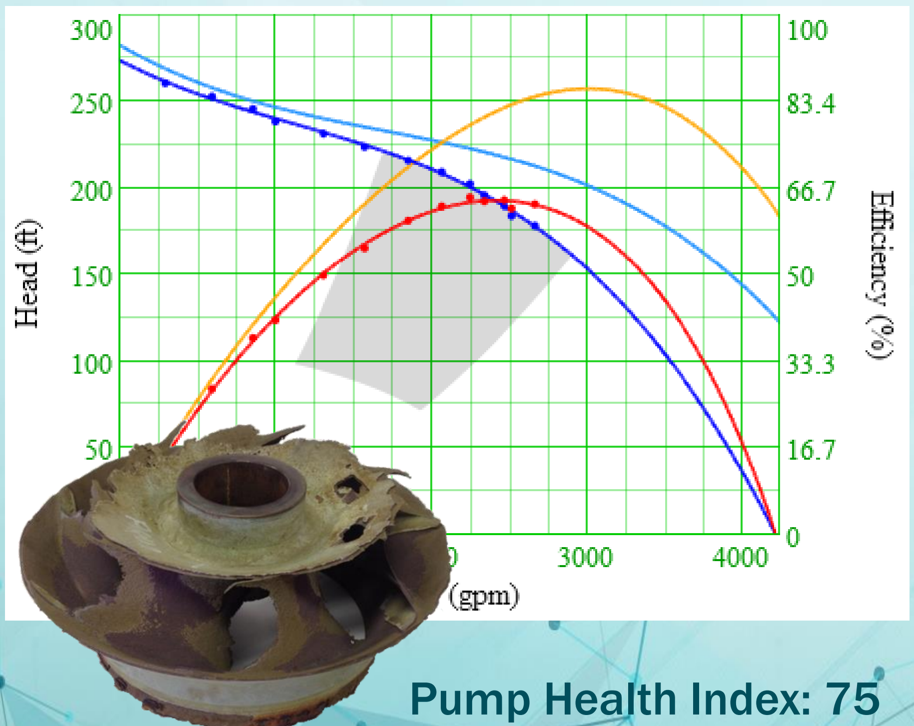
- Perform regular automated pump tests
- Track pump operation in real time on pump curves
- Generate monthly operating reports
- Identify underperforming pumps for repair



Pump Health Index (PHI)

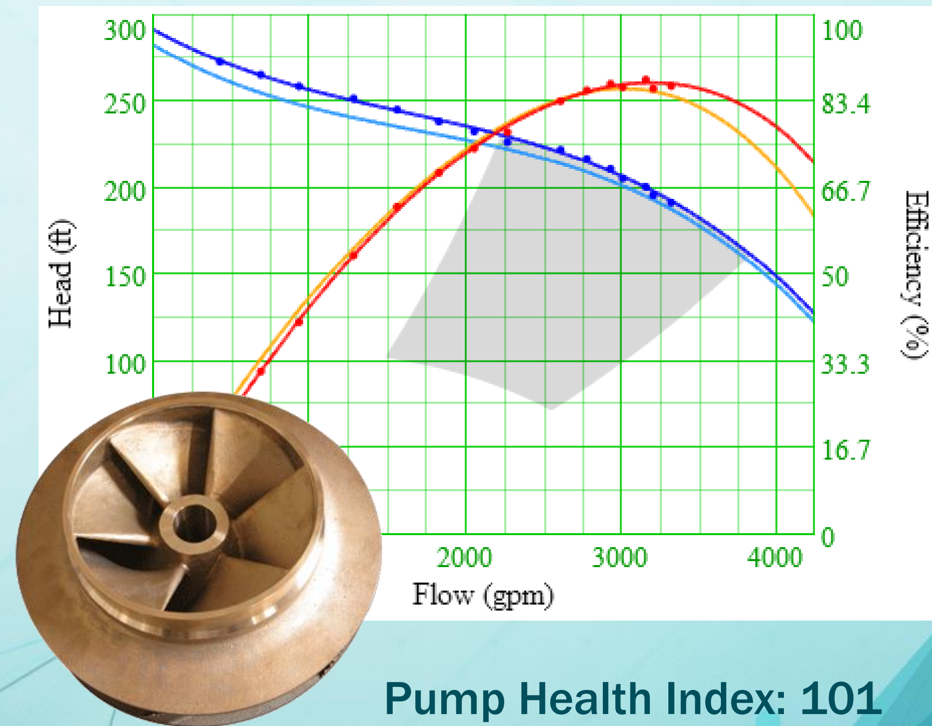
PHI represents current peak efficiency versus factory peak efficiency.

75 PHI = Severely Worn



Pump Health Index: 75

101 PHI = Factory Condition



Pump Health Index: 101

Schedule repairs for pumps with PHI < 85

PHI Pump Health Tracking

- Intelligently target pumps for repair
- Opens the door for advanced metrics and advanced optimization
- See pump operating points in real time on up-to-date pump curves

Prioritize Repairs with Financial Metrics

Input:

- Replacement Cost
- Cost of Electricity
- Expected Pump Life
- Interest Rate

Schedule repairs for pumps with PHI < 85

Prioritize Repairs with Financial Metrics

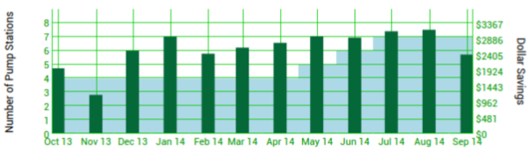
Monthly Summary Report

Aqua Water Supply Corp. — September, 2014

Monthly Summary

Total Volume (MG)	Optimizer Enabled (%)	Total Energy Used (kWh)	Energy Saved (kWh)	Energy Saved (%)	Savings
245.9	86%	203,120	24,377	10.7%	$2,437.68

Energy Saved - Year in Review



Past 12 Months

Energy Saved (kWh)
314,683 kWh

Energy Saved (Dollars)
$31,468.29

Pump Station Health Data:

Pump Station Capacity	Pump Wear Energy Cost Per Year	Station Name
86%	$413 / year	Highview Pump Station
86%	$6,279 / year	TU/S Pump Station
94%	$5,388 / year	TU Pump Station
101%	$0 / year	ER Pump Station
103%	$0 / year	S8 Water Well
105%	$601 / year	Watterson/S Pump Station
105%	$203 / year	Camp Swift Gravity Plant

Pump Repair Recommendations:

Top Recommended Repairs:

Pump1
TU/S Pump Station
ROI 233.7% | Present Value $47,737 | Payback Period 2.9 years

Pump3
TU Pump Station
ROI 112.9% | Present Value $28,214 | Payback Period 5.6 years

Pump Name	Station Name	Repair Present Value	ROI	Payback Period
Pump1	TU/S Pump Station	$47,737	233.7%	2.9 years
Pump3	TU Pump Station	$28,214	112.9%	5.6 years
Pump1	TU Pump Station	$24,672	98.9%	6.1 years
Pump3	TU/S Pump Station	$21,050	87.8%	6.5 years

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Georgetown, TX 78626

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Pump Repair Recommendations:

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What Would be the Best Method to Operate and Manage a Pump Station?

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↓

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↓

Reduce operating costs
Improve pump reliability

Dynamic Pump Optimization

↓

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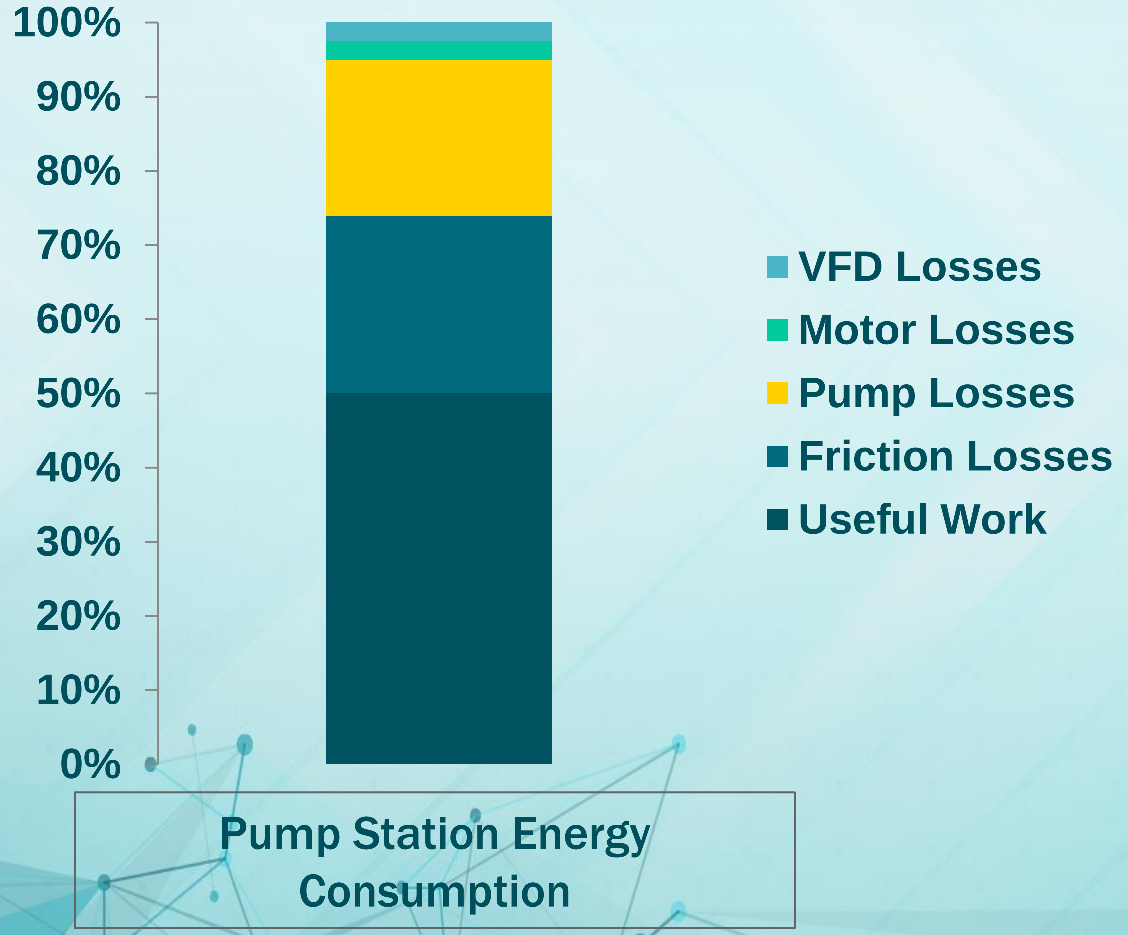
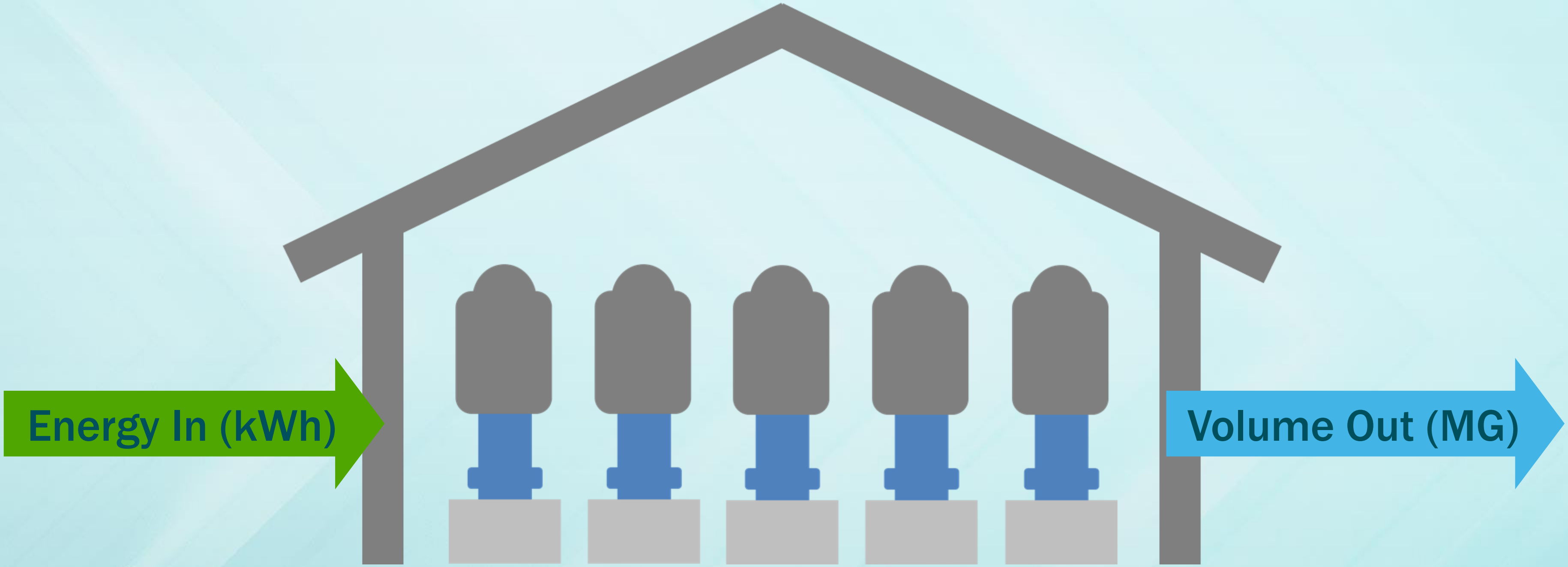
Reduce operating costs
Increase pump life

Pump Station Energy Consumption

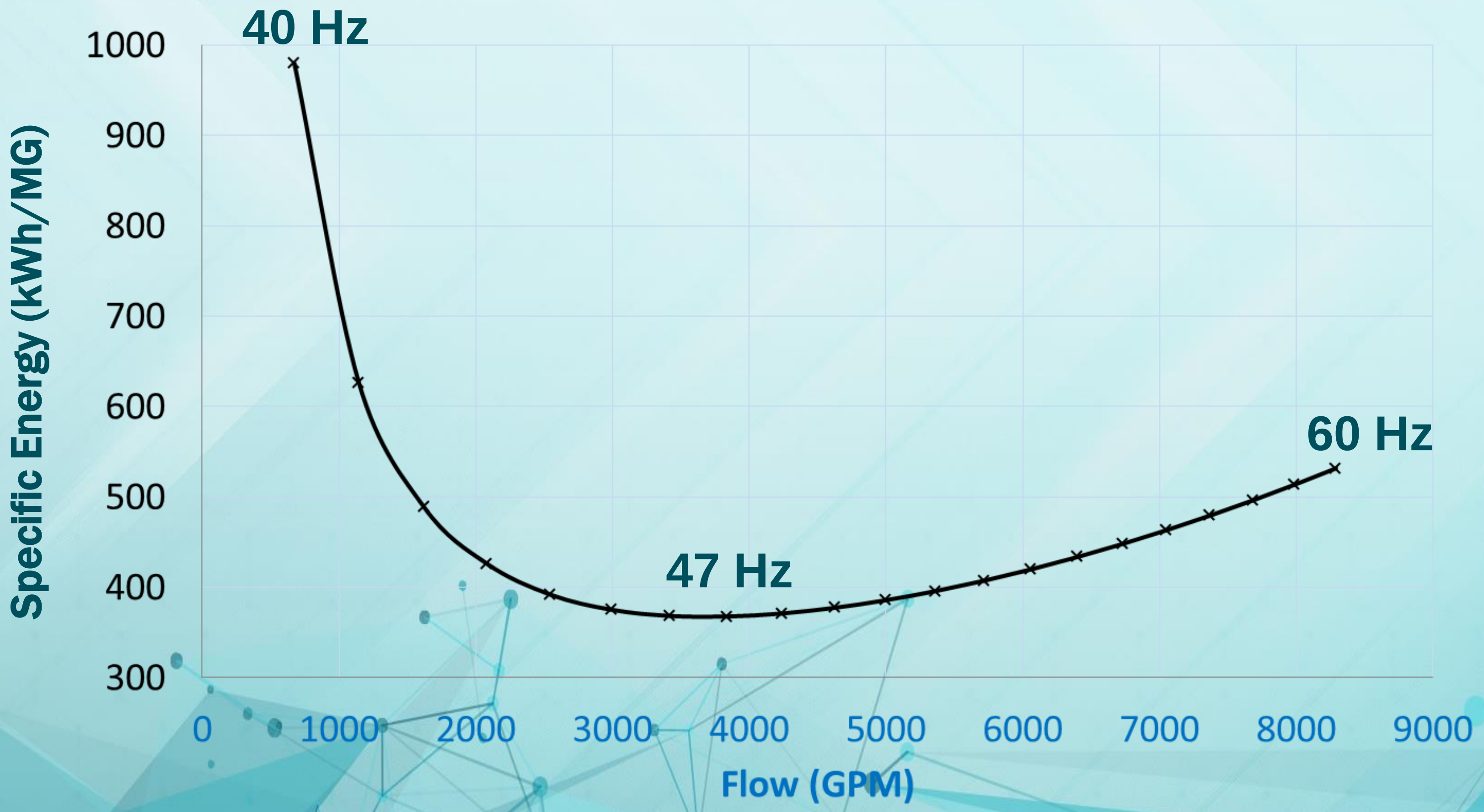


Specific Energy



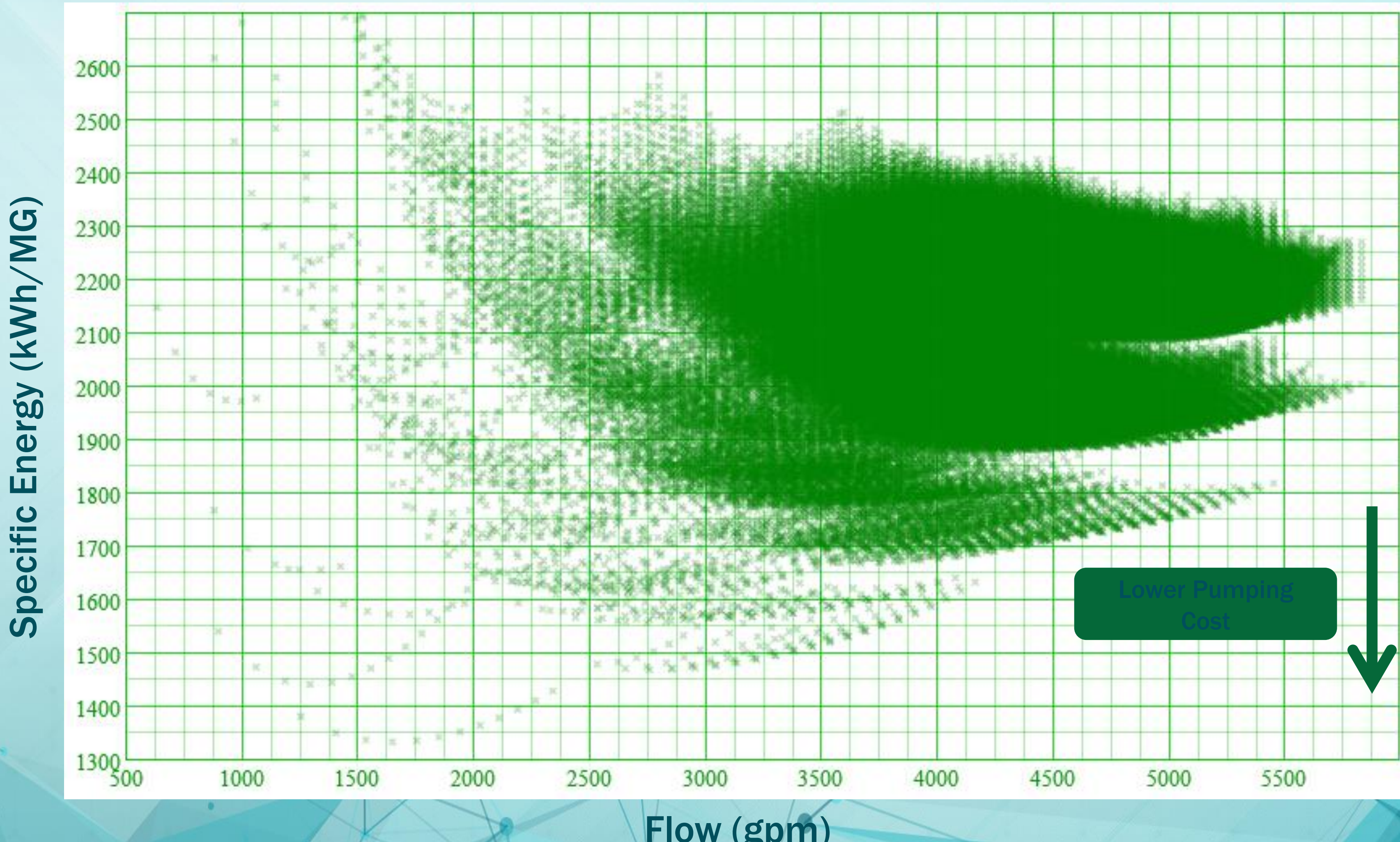
$$\text{Specific Energy} = \frac{\text{Energy In (kWh)}}{\text{Volume Out (MG of water pumped)}}$$

Specific Energy vs. Flow



Dynamic Pump Optimization

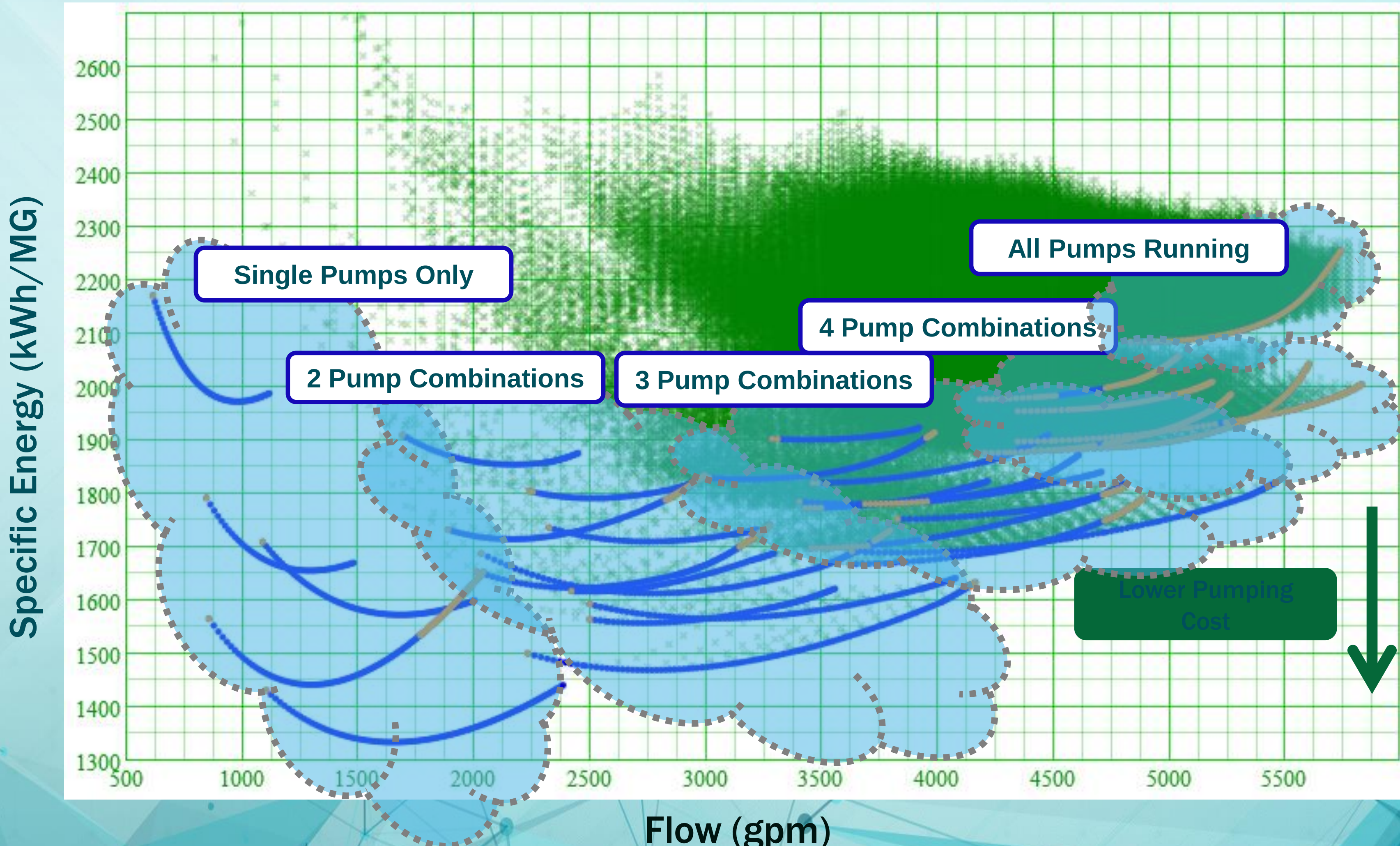
Pump Station with 5 Pumps: Possible Operating Ranges



Best Solution | Best Pump Ranges | Outside Preferred Operating Range | Possible Pump Operation

Dynamic Pump Optimization

Pump Station with 5 Pumps: Best Pump Ranges



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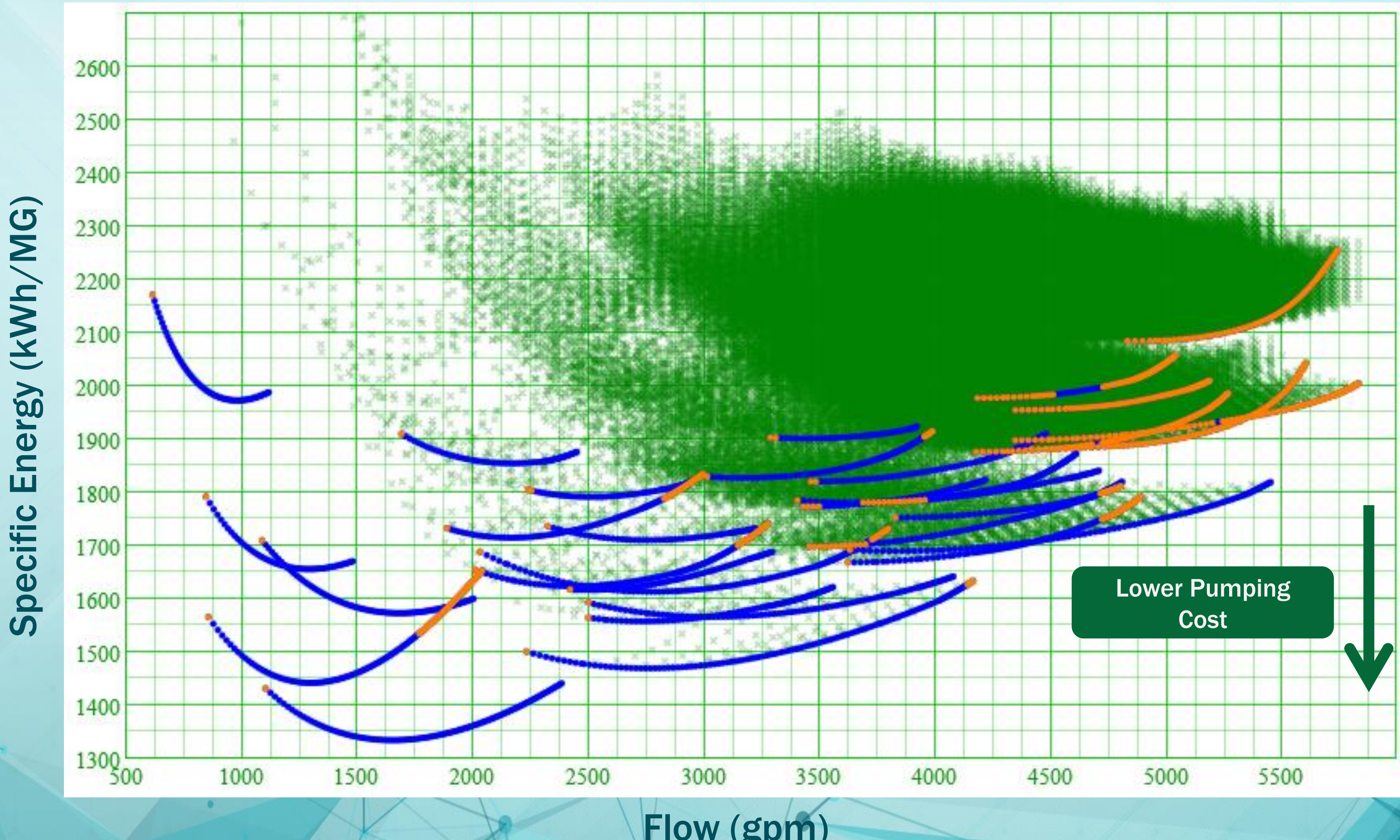

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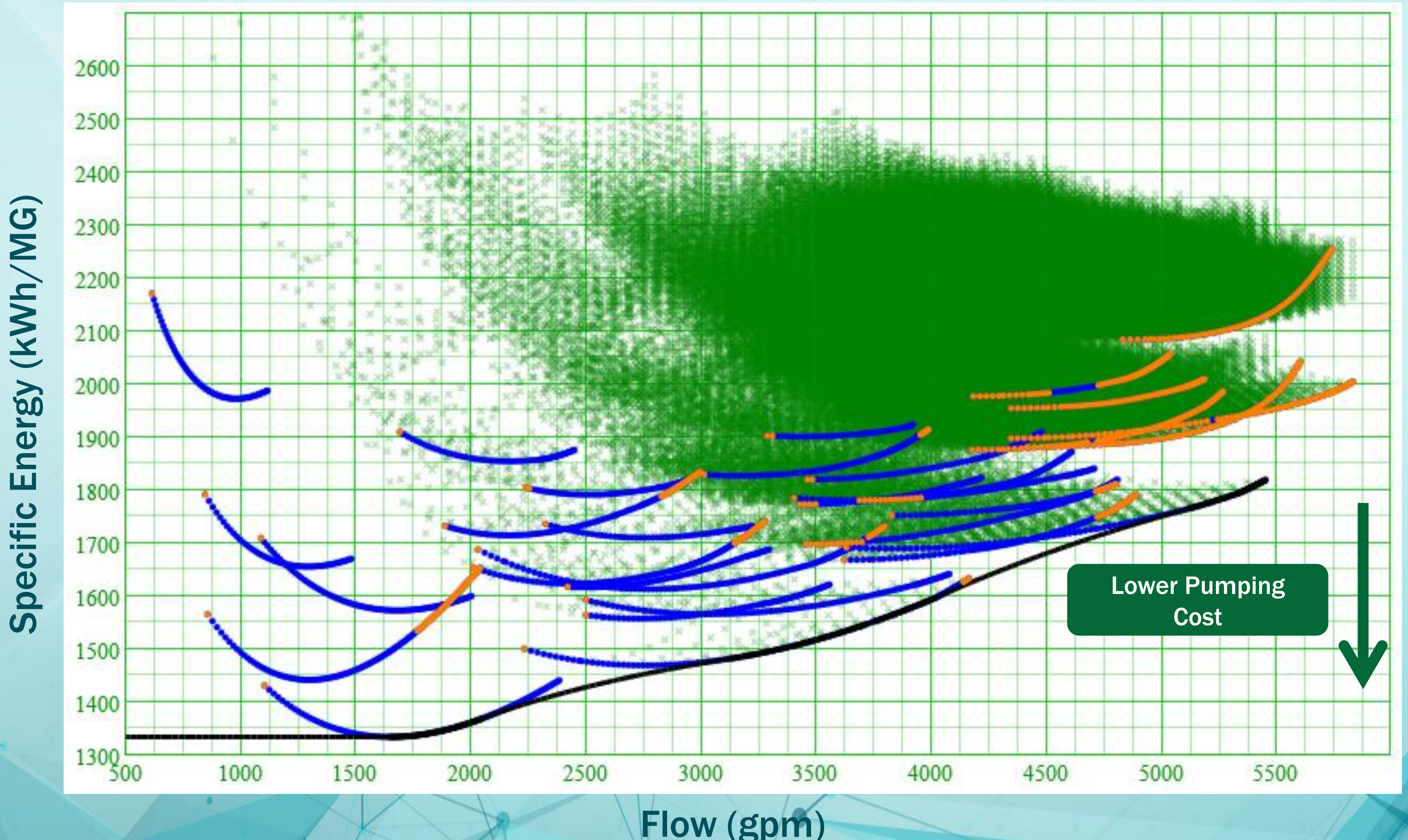
Dynamic Pump Optimization

Pump Station with 5 Pumps: Best Solution

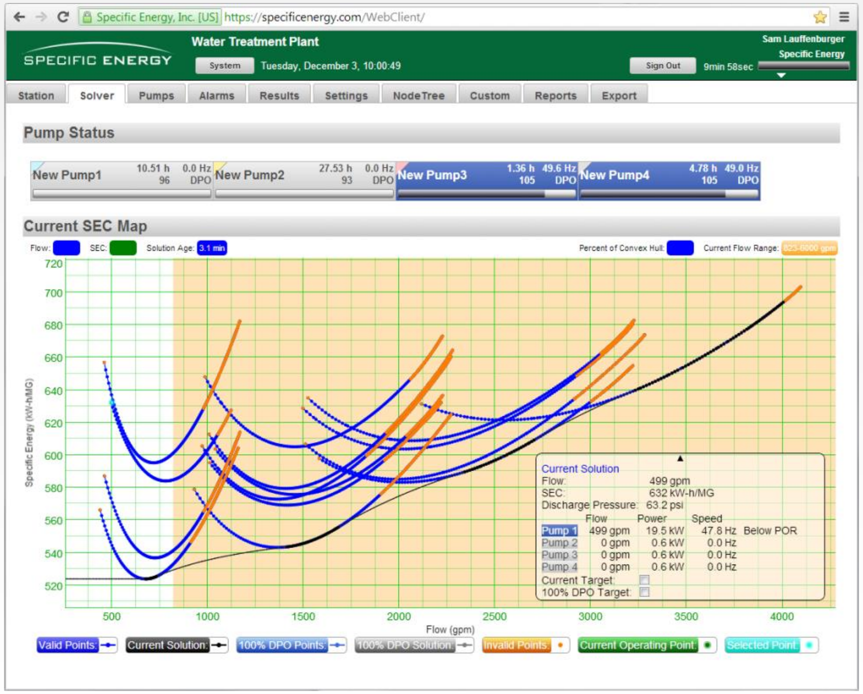


Best Solution | Best Pump Ranges | Outside Preferred Operating Range | Possible Pump Operation

Continuous Optimization

Dynamic Pump Optimization

- Continually operate at peak energy efficiency
- Operate within each pump's Preferred Operating Range
- Reduce leaks with Digital Transient Control
- Peak demand and time-of-day energy management



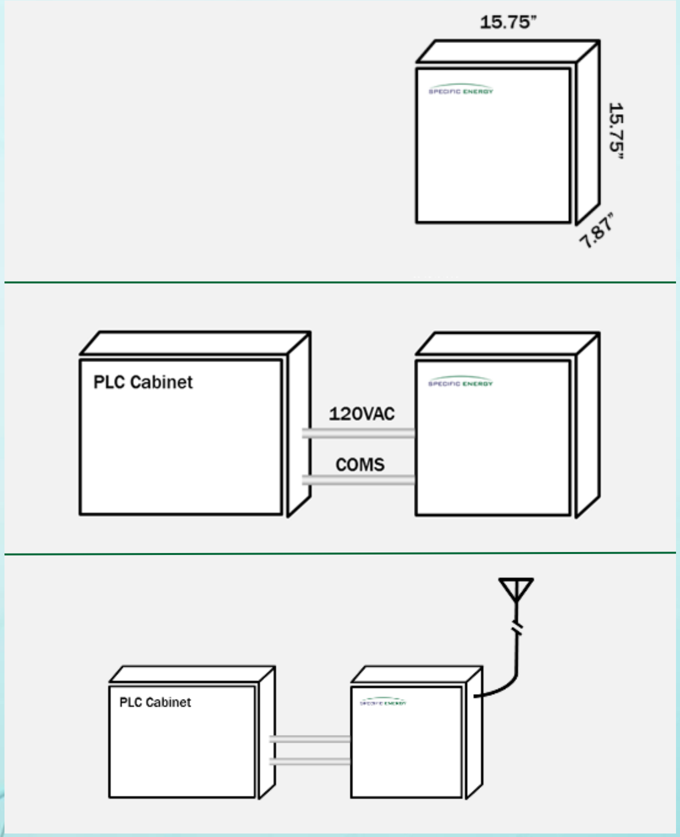
Typical Project Requirements

- System
  - Centrifugal Pumps
- Control Hardware
  - VFD Pump Motor Controllers (optimal)
  - PLC Pump Controller (existing or new)
  - Pump Assessment and Optimizing Panel

- Instrumentation
  - Suction Pressure or Wetwell Level
  - Discharge Pressure
  - Flow
  - Power per Pump

Typical Physical Installation

- Install Pump Assessment and Optimization Panel
- Install conduit connections from panel to PLC cabinet (120 VAC power and communications cable)
- Mount external cellular antenna (if necessary)
- Configure PLC to receive panel pump operation and speed recommendations
- Configure PLC to allow panel to read required PLC registers
- Configure HMI to enable operators to toggle optimization mode and display Specific Energy data



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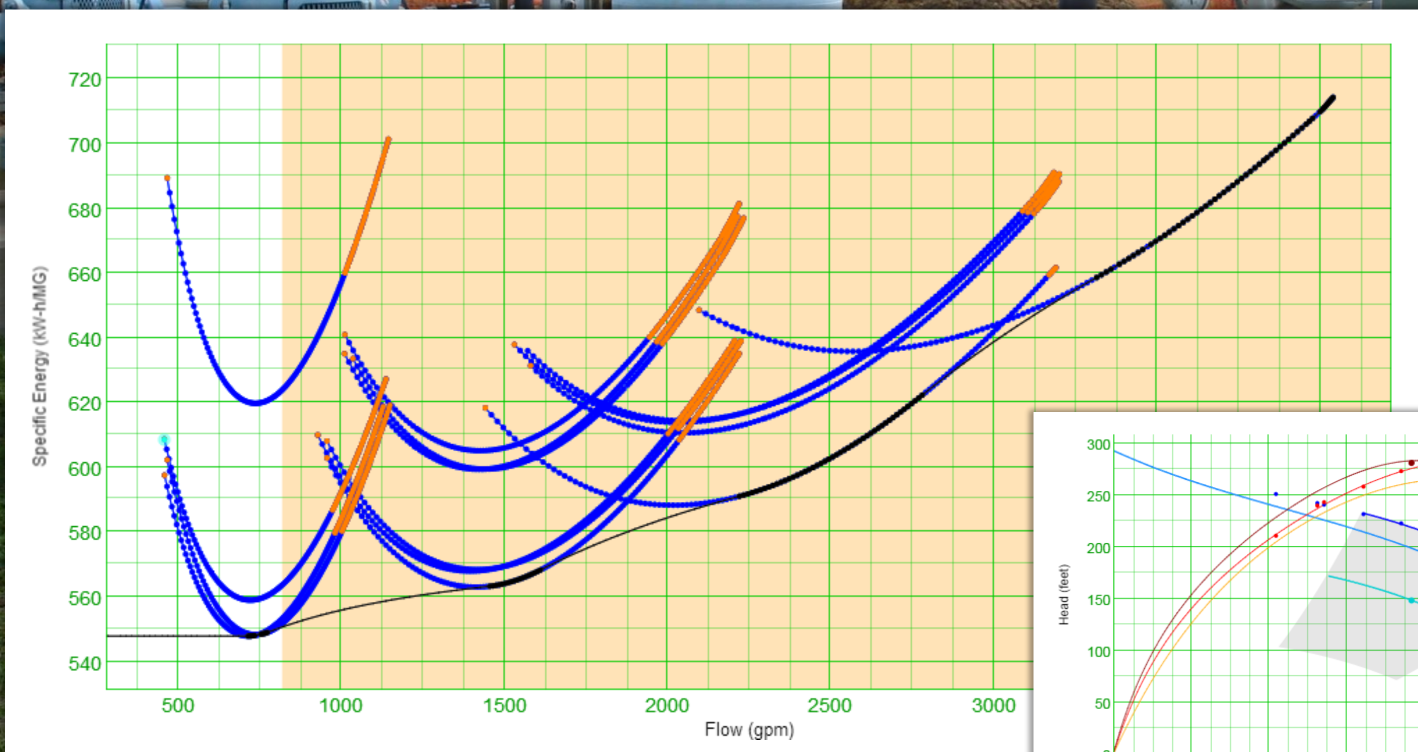
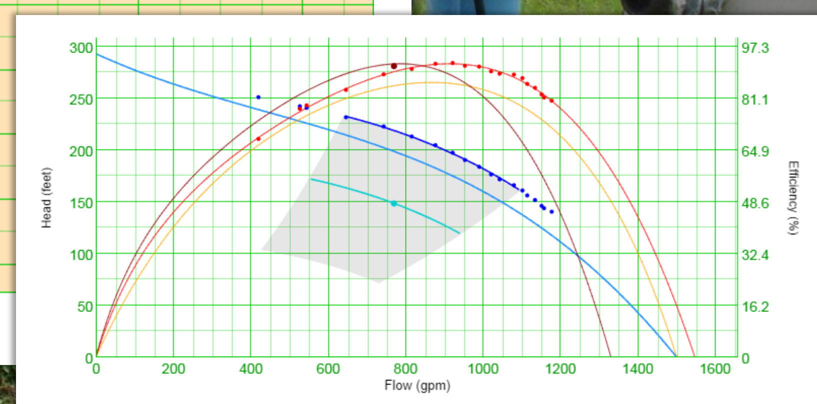
Case Study – Camp Swift High Service Pump Station

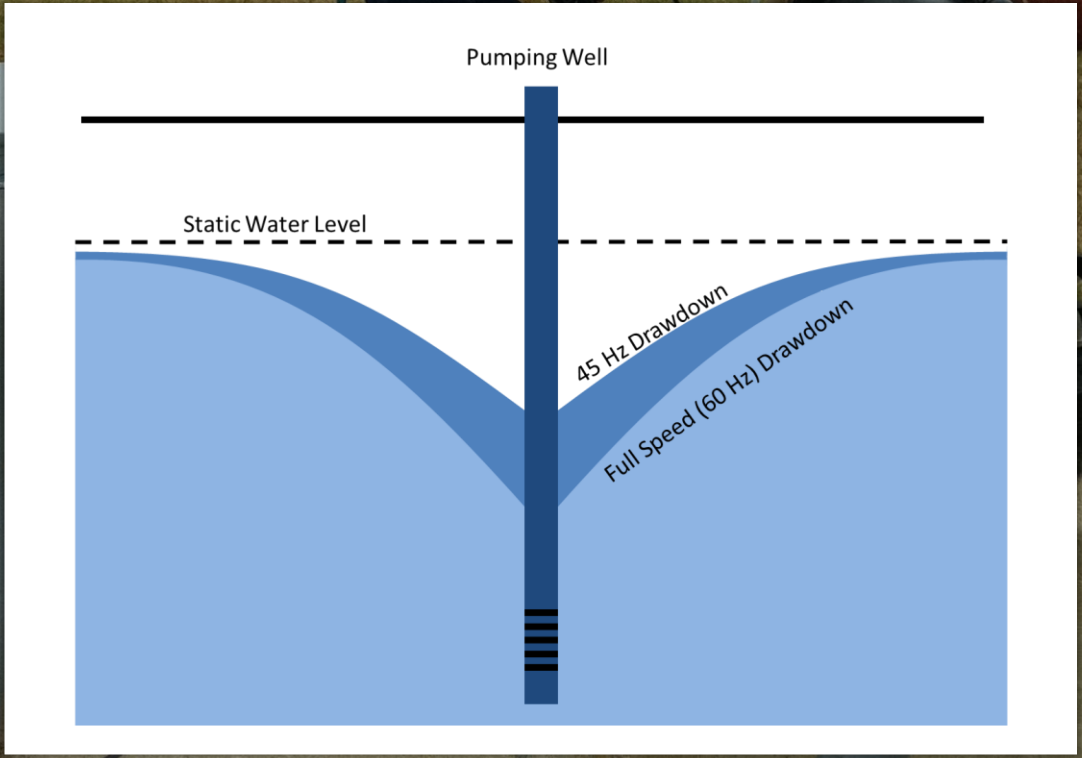
- 4 “Identical” Pumps – 200 HP
- Dramatically improved impeller life
- Energy Savings – 18%

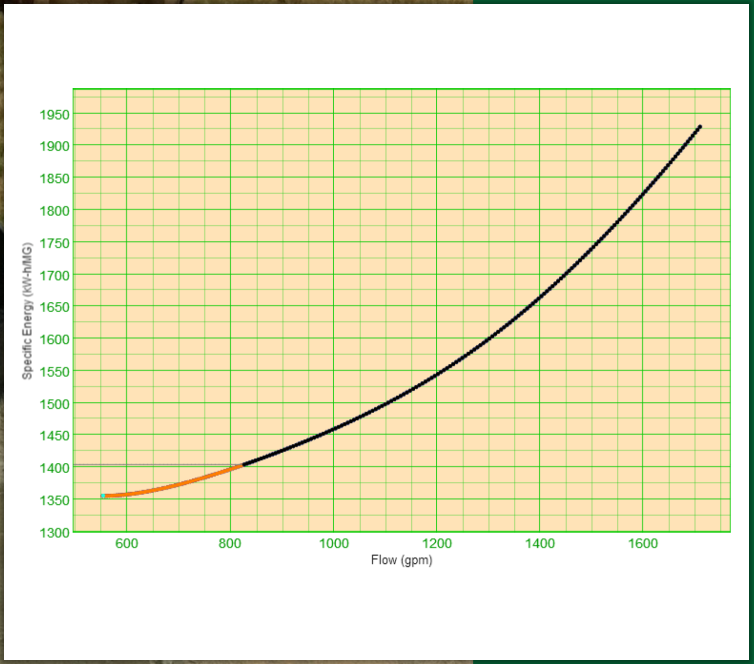




Case Study – S8 Water Well

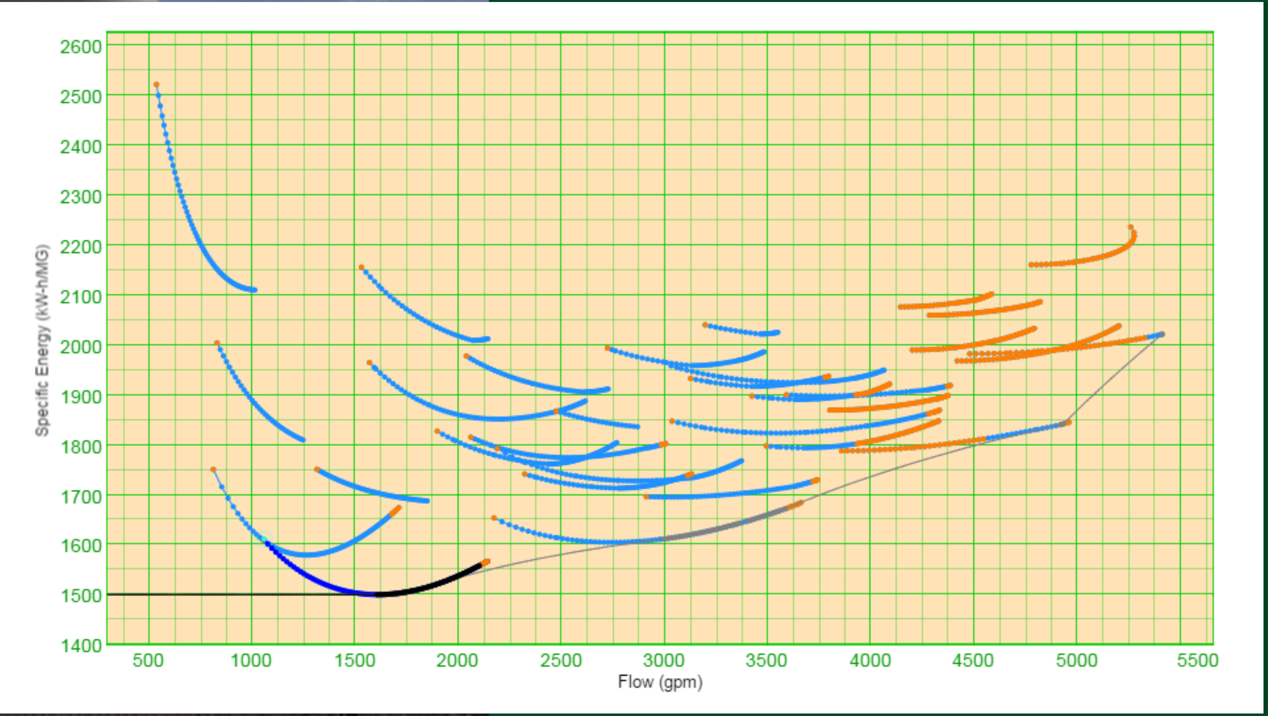
- 250 HP Well Pump
- Energy Savings – 30%





SH195 Pump Station

- 5 “identical” pumps – 1150 HP
- Discovered lead pump was significantly worn
- Energy Savings – 25%



Quiz

- PHI stands for Pump ________?
- True or False: in a reduced flow situation, best pump efficiency can be achieved through throttling

- Pump Health Index
- False: Lowering the speed is best
- Permanent Magnets or Coils of Wire