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Energy Efficiency Considerations in Pumps and Pump Stations

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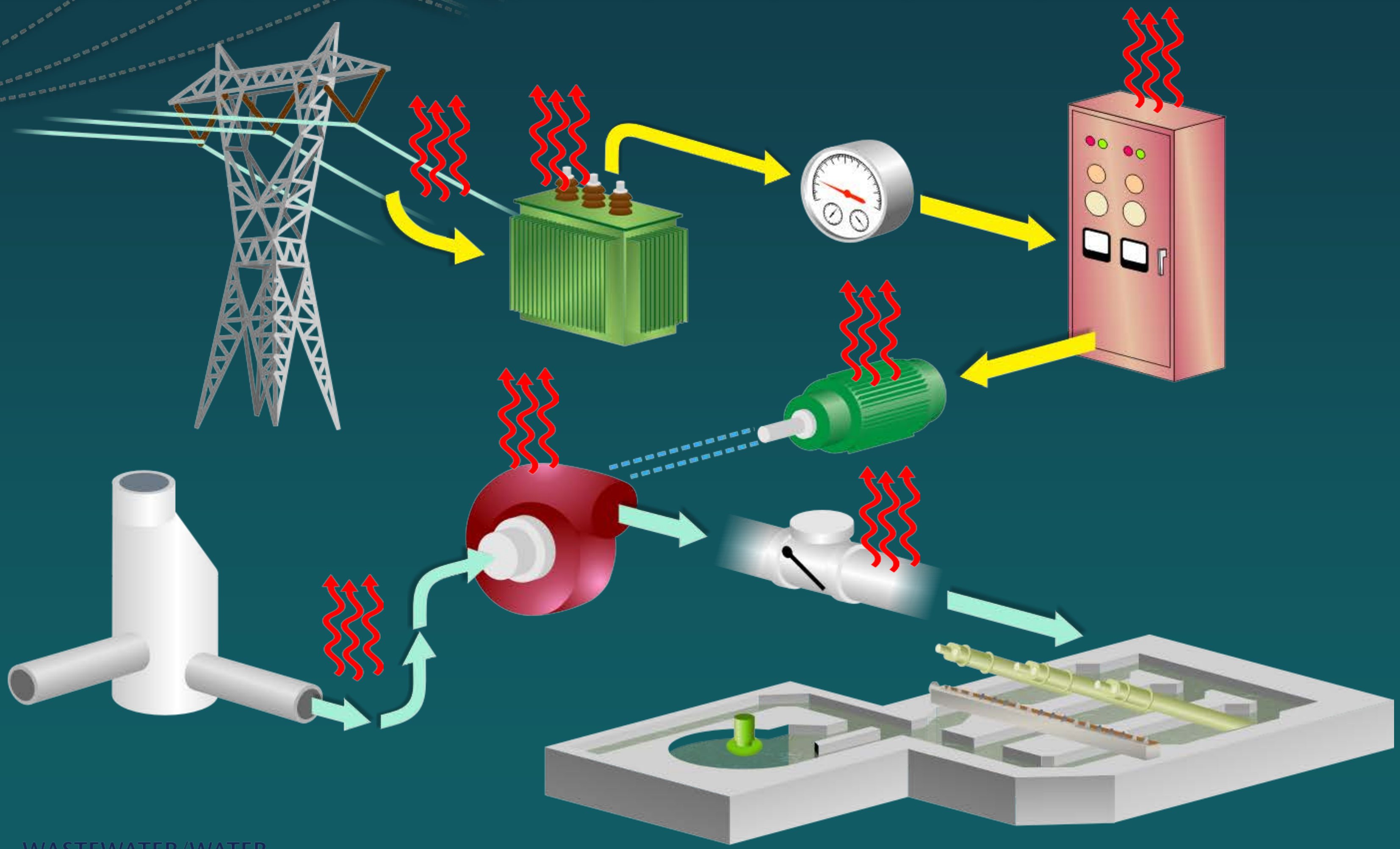
WASTEWATER/WATER SUSTAINABLE ENERGY COHORT

How Do You Save Energy?

- **Don't design it wrong**
- **Operate smart**
- **Fix stuff**

Thanks for your time, any questions e-mail me at JeffForay@KennedyJenks.com

Energy in a Pumping System

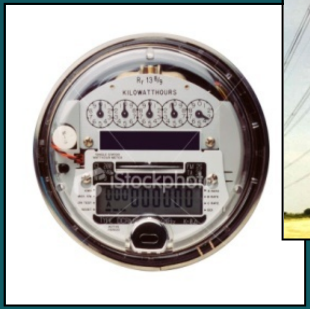


Pumps and Other Fluid Movers

- Centrifugal pumps are the most common
  - End suction
  - Split case
  - Turbines
  - Submersibles
- Positive displacement pumps
- Other devices
  - Fans
  - Compressors

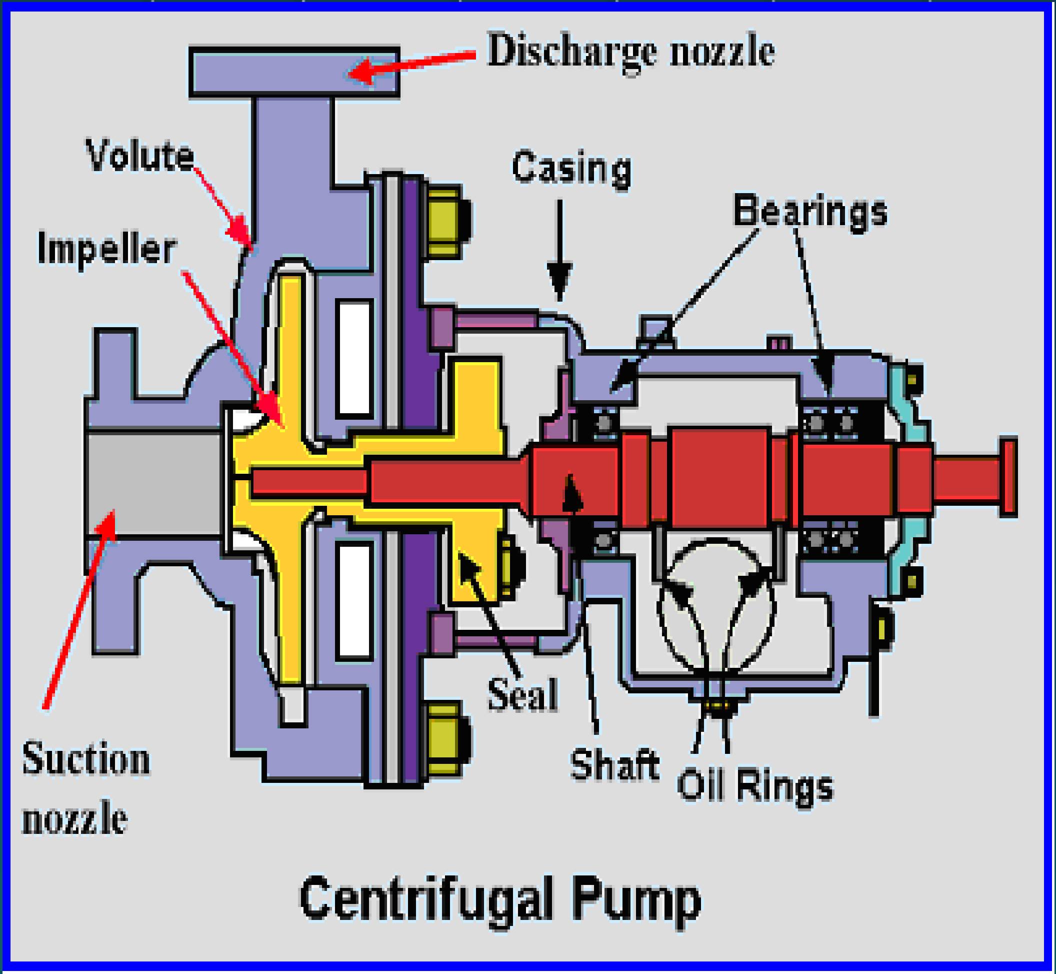
Some Basic Stuff

- Flow: 1 mgd = 694 gpm
- Head: 1 psi = 2.31 feet
- Head Loss: liquid friction, velocity^2
- Power: 1 hp = .75 kW
- Money ($.07/kwhr)
  - 1 mgd at 100 feet (22 hp) for a year is about $10,000
  - 2 mgd in same pipe is about $18,000 a year
  - 1 hp for a year about $500



What is Efficiency?

- Good divided by the total
- Energy Losses in Pumps:
  - Mechanical (friction in bearings, etc.)
  - Volumetric (recirculation)
  - Hydraulic (liquid friction)



Calculating Pump Horsepower

$$hp = \frac{Q \times h}{eff \times 3{,}960}$$

Q = flow in gpm

h = head (pressure) in feet (1 psi = 2.31 feet of head)

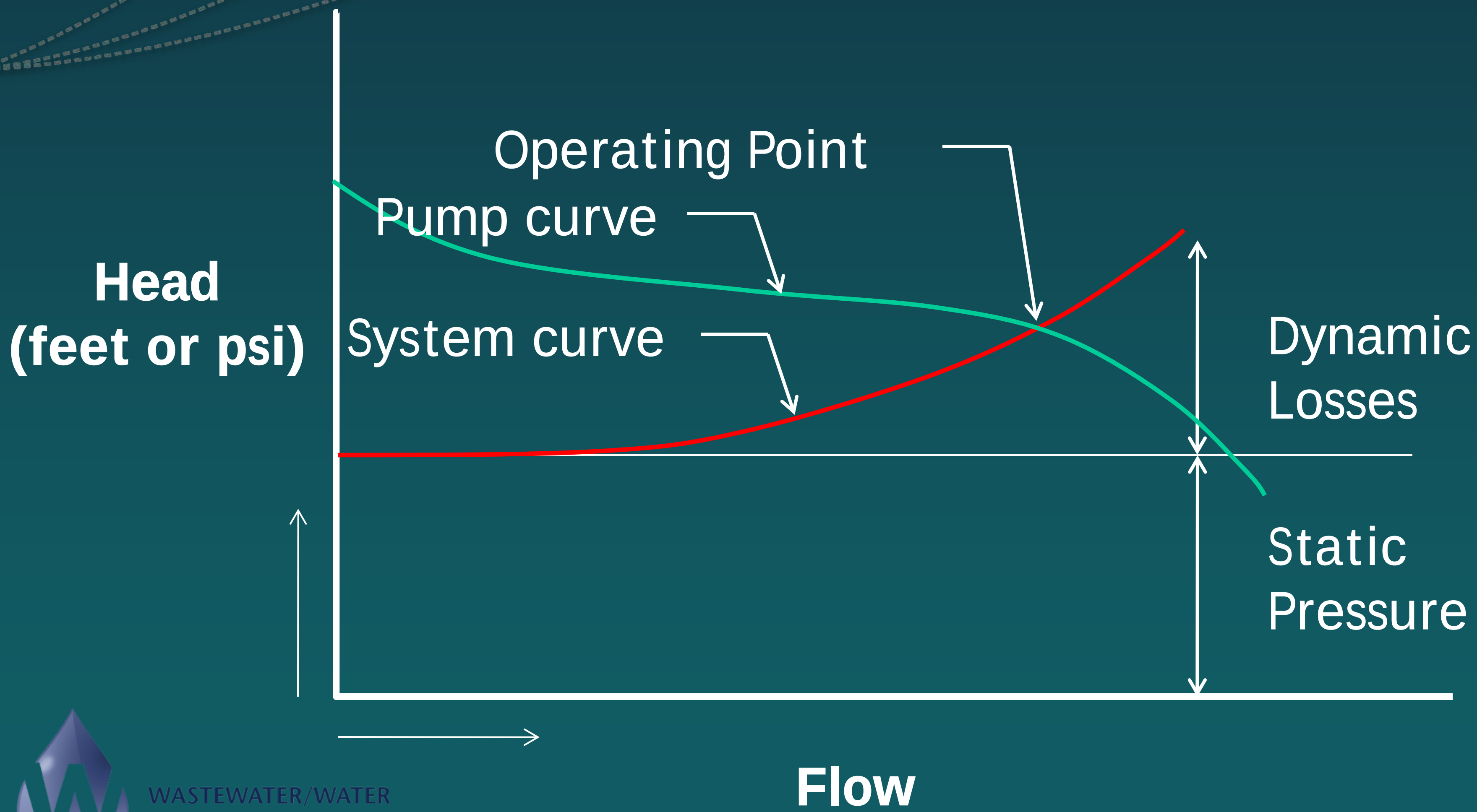
eff = efficiency

- Water horsepower: ignore efficiency
- Brake horsepower: pump efficiency only (size the motor)
- Wire-to-water horsepower: pump x motor efficiency (size the electrical service)

Typical Pump Efficiencies

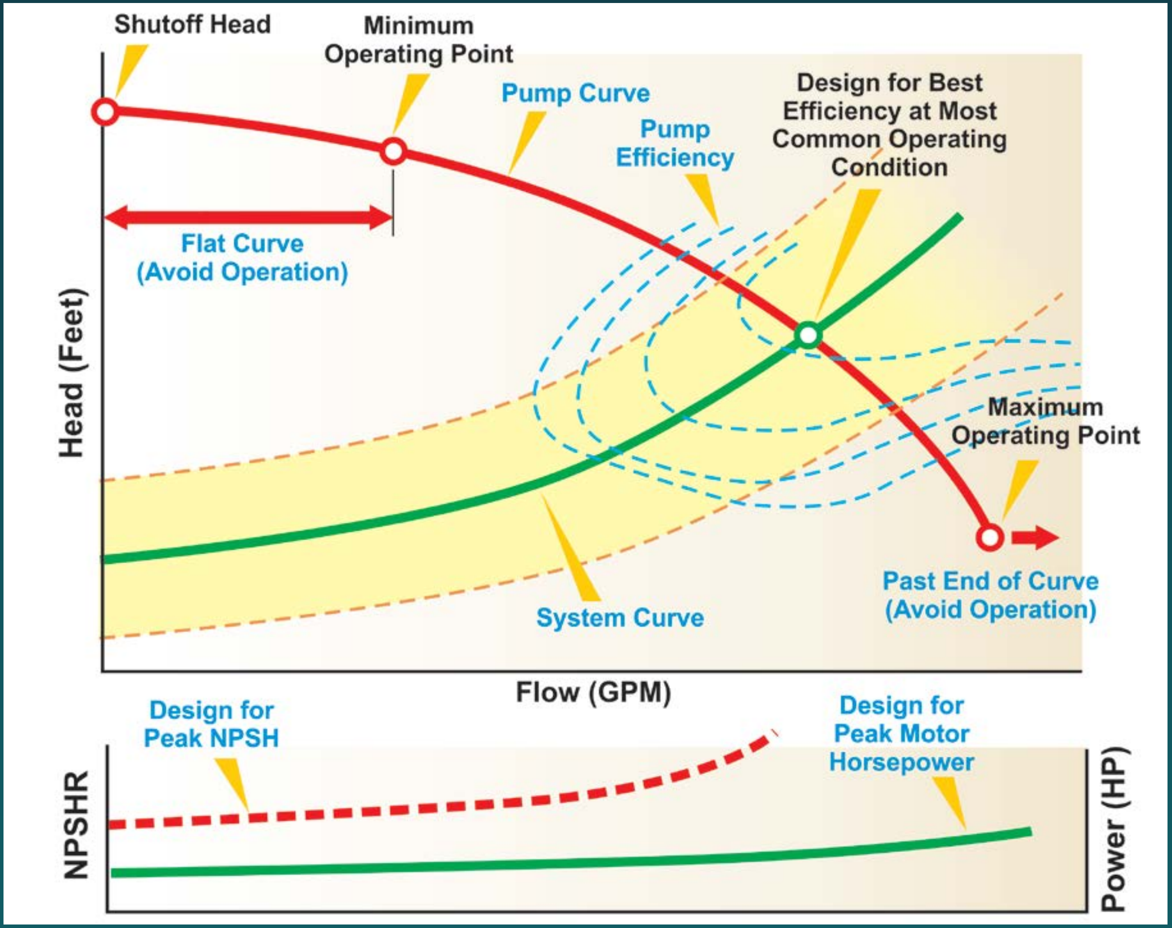
- Pump only (brake, no motor)
  - Non-clog centrifugal, 25 hp: 65%
  - Submersible wastewater, 34 hp: 75%
  - Vertical turbine, water, 30 hp: 81%
  - End Suction, water, 30 hp: 75%
- Bigger is better: add about 5 points at 200 hp
- Slower is better: add a couple points below 1200 rpm

Pump Curve: Superbasics



Pump Curve: Less Basic

- Nerdy but crucial
- Best Efficiency Point (BEP)
- Typically drops off about 20% from BEP
- *How pump is applied determines how efficient it will be*



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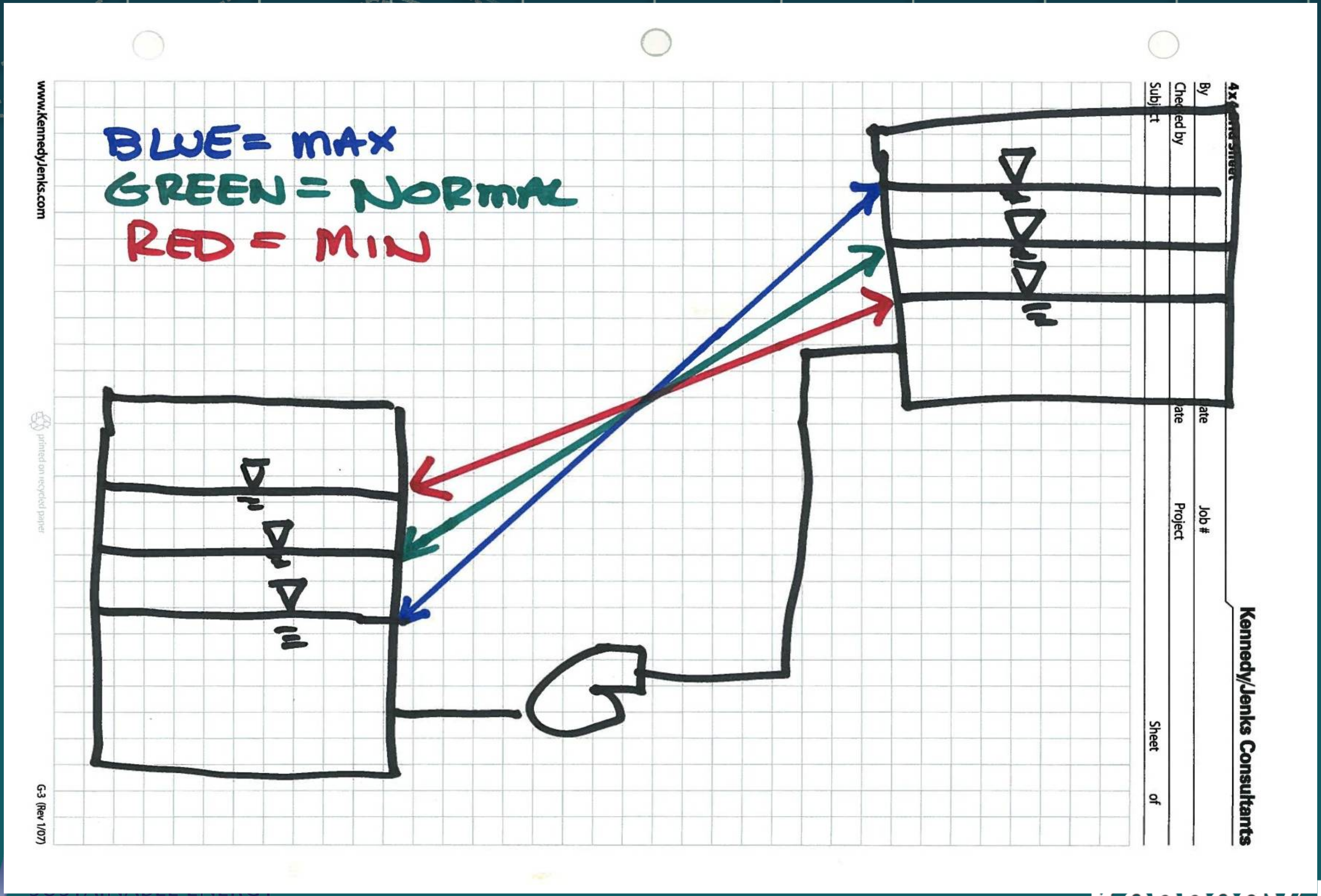
Minimum/Maximum/Normal



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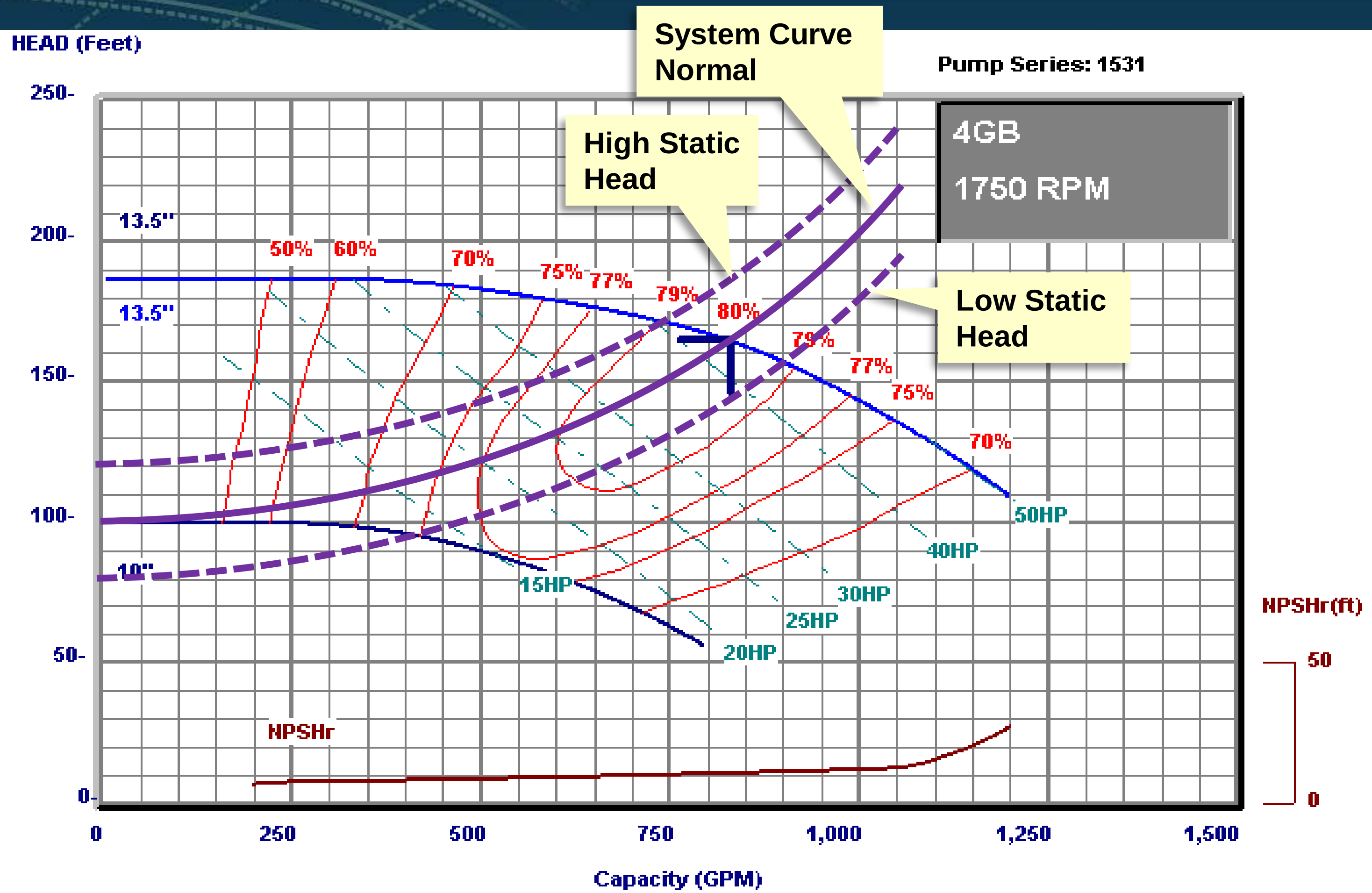
Pump and System Curves

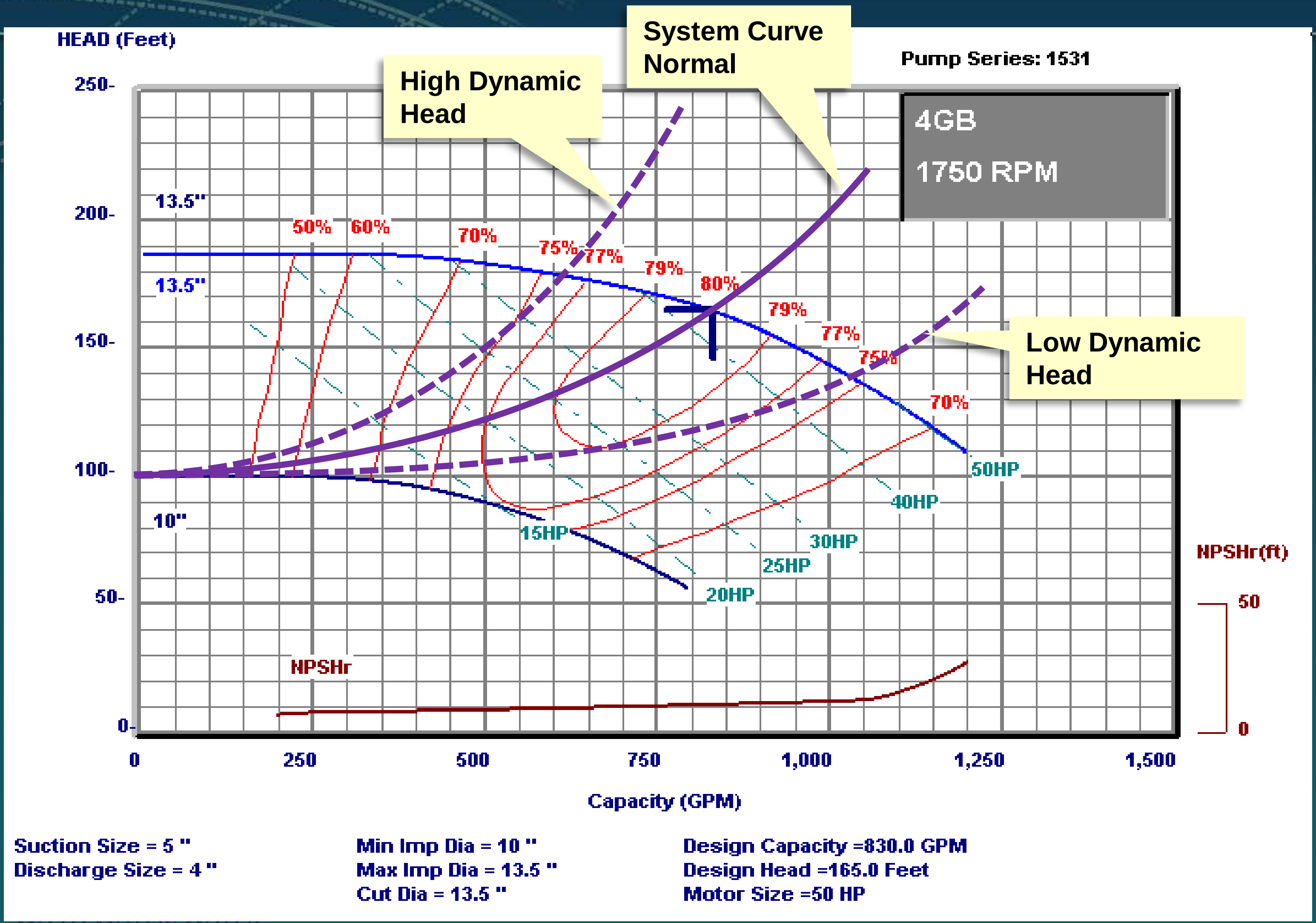


Suction Size = 5 "
Discharge Size = 4 "

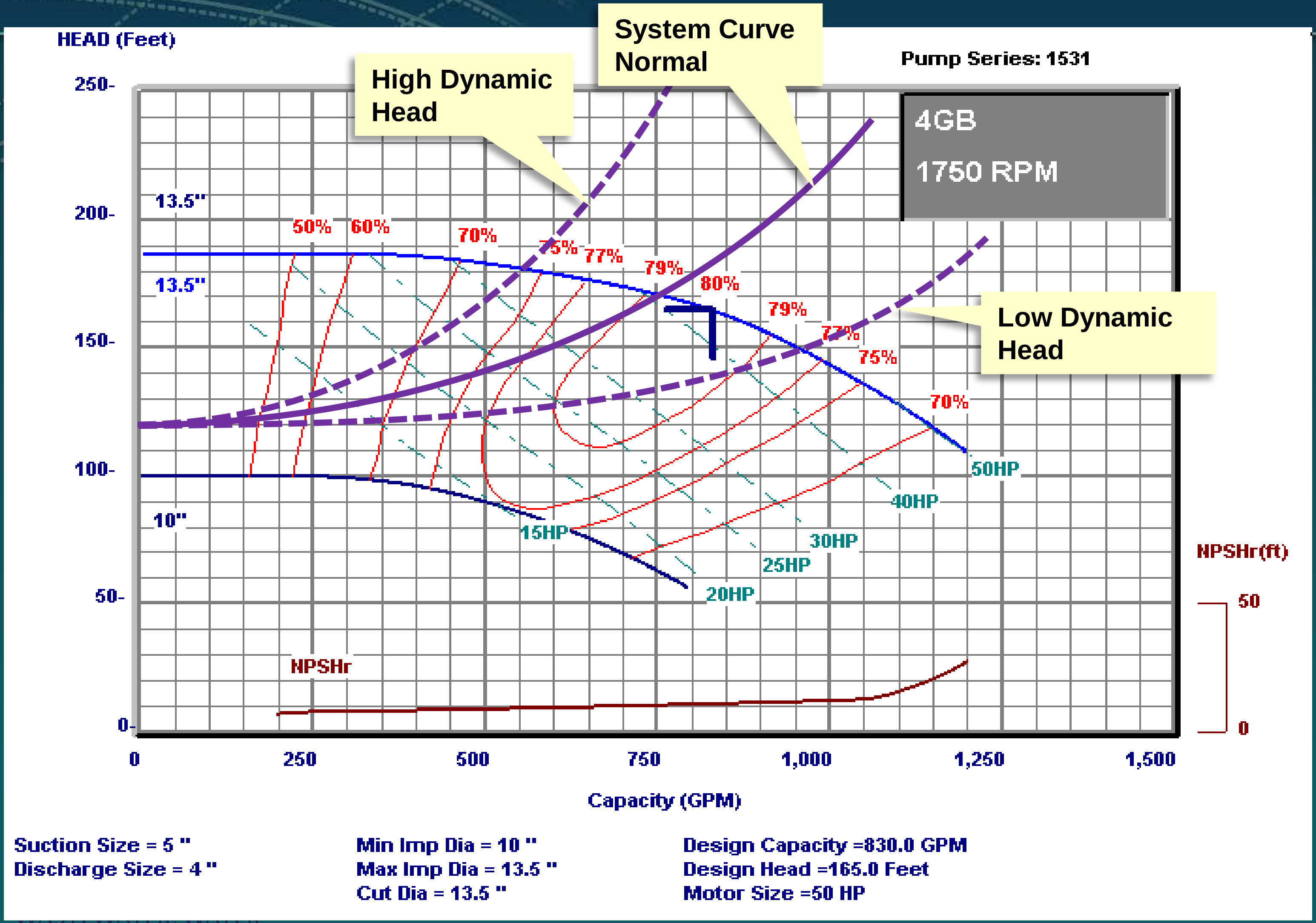
Min Imp Dia = 10 "
Max Imp Dia = 13.5 "
Cut Dia = 13.5 "

Design Capacity =830.0 GPM
Design Head =165.0 Feet
Motor Size =50 HP

Dynamic Losses May Vary



Operation at Low End of Pump Curve



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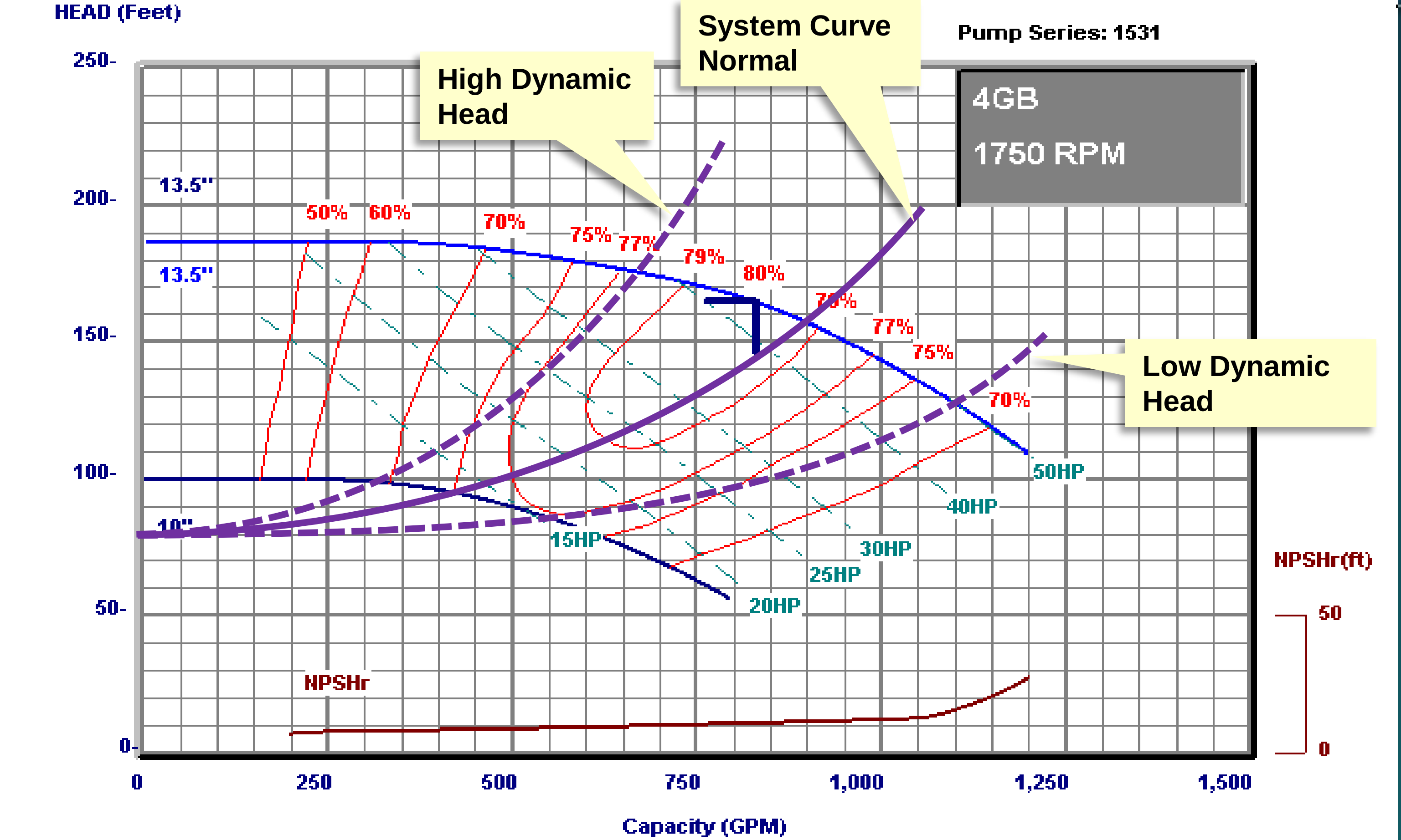
Operation at High End of Pump Curve



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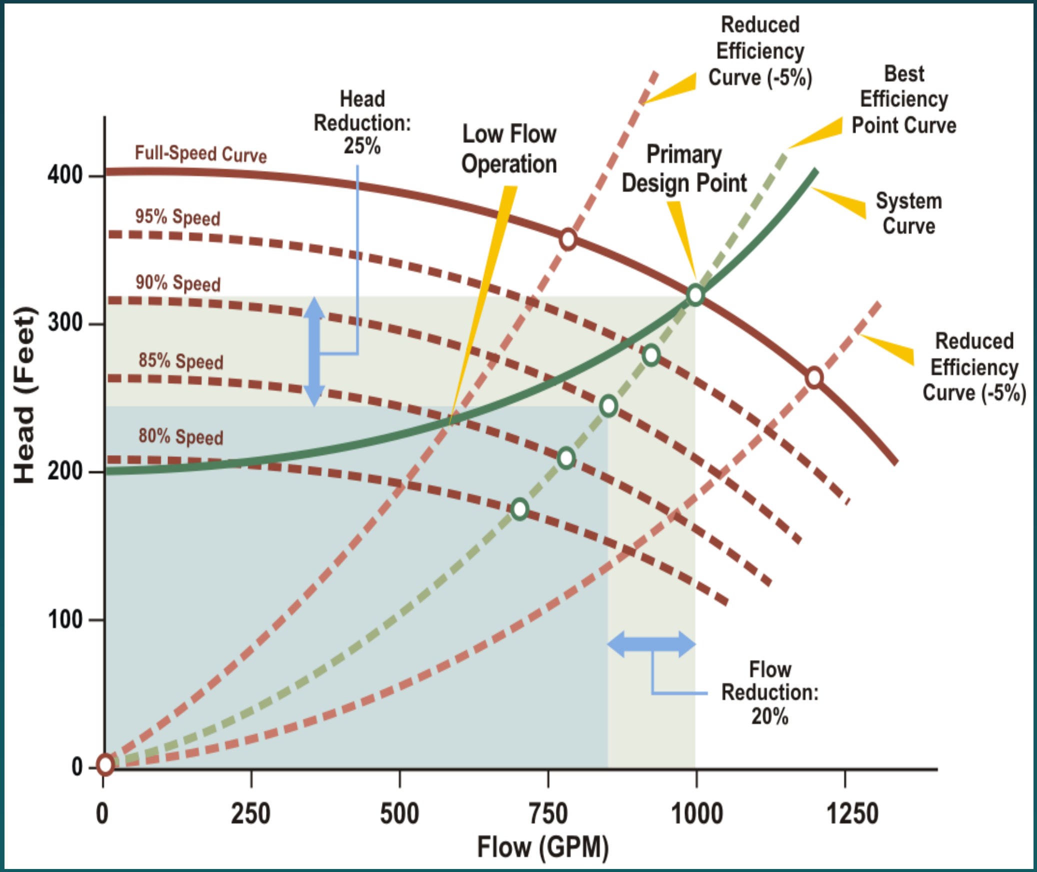
Variable Speed Pumping

- Variable Speed Drives (VFD's)
  - Vary motor speed from about 50% to 100%
  - Drive is about 98% efficient
  - 2 to 4 times cost of starter
- *Why? Moving water slower reduces friction*



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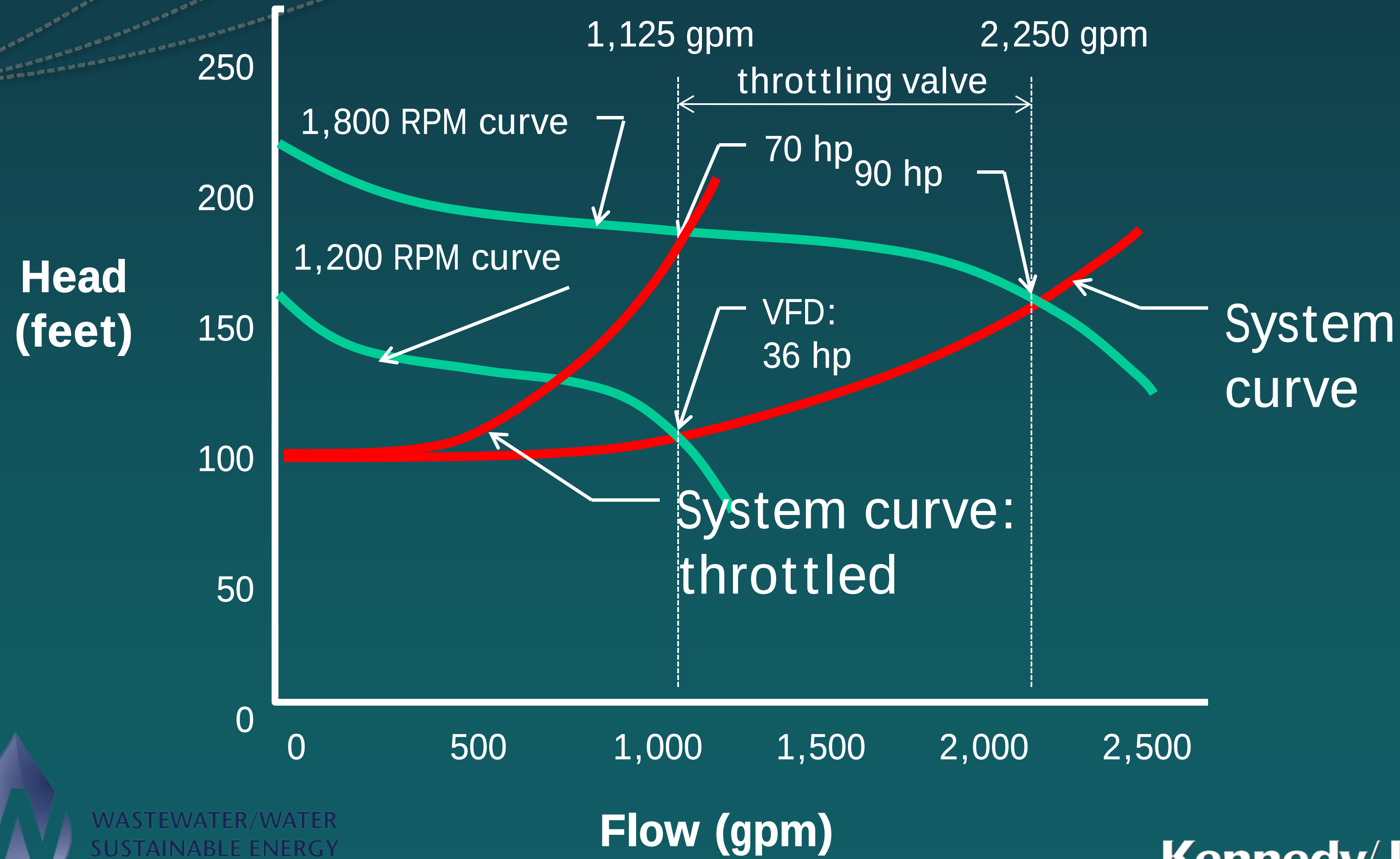
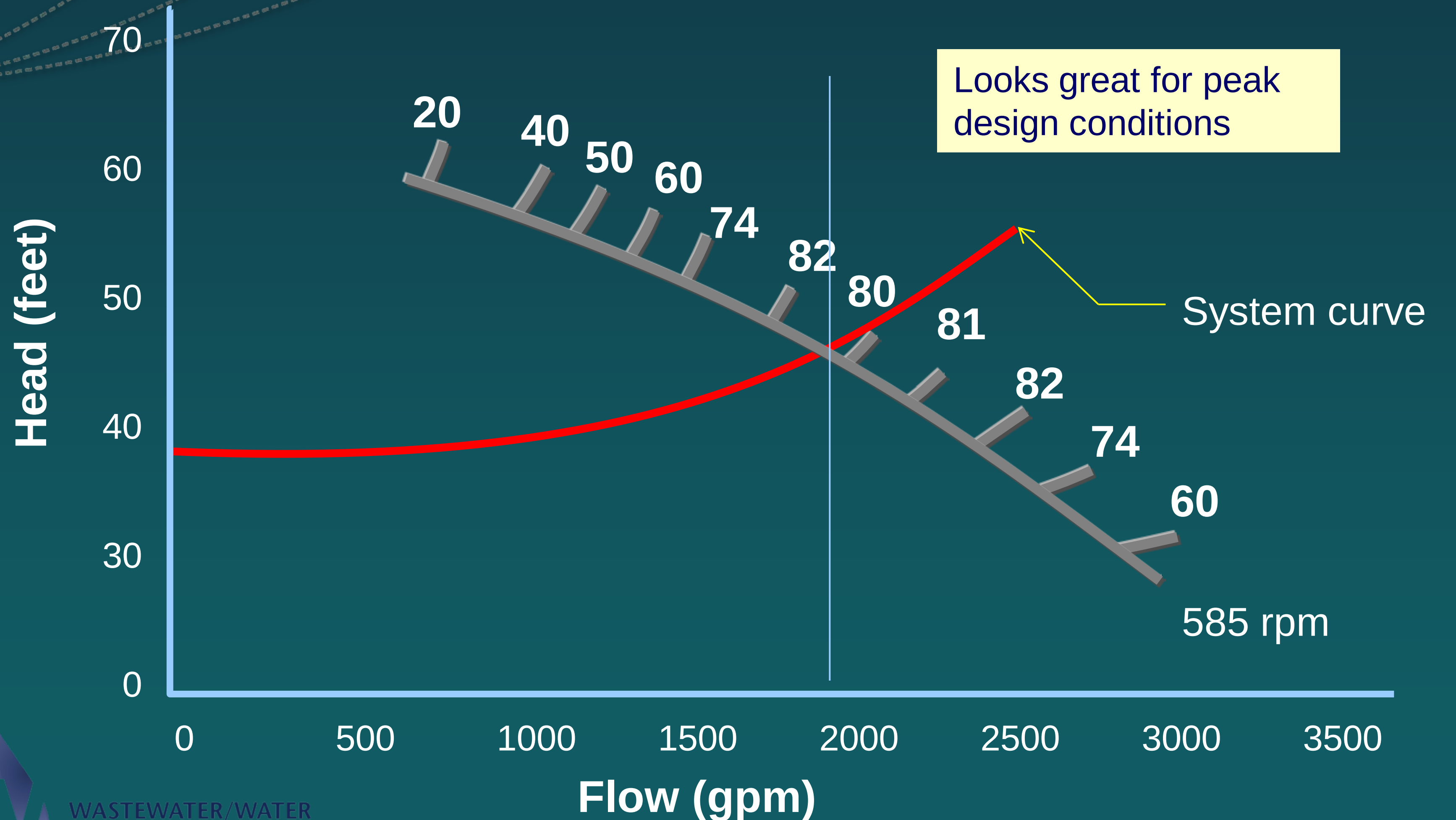
Why VFD's? Throttling Stinks

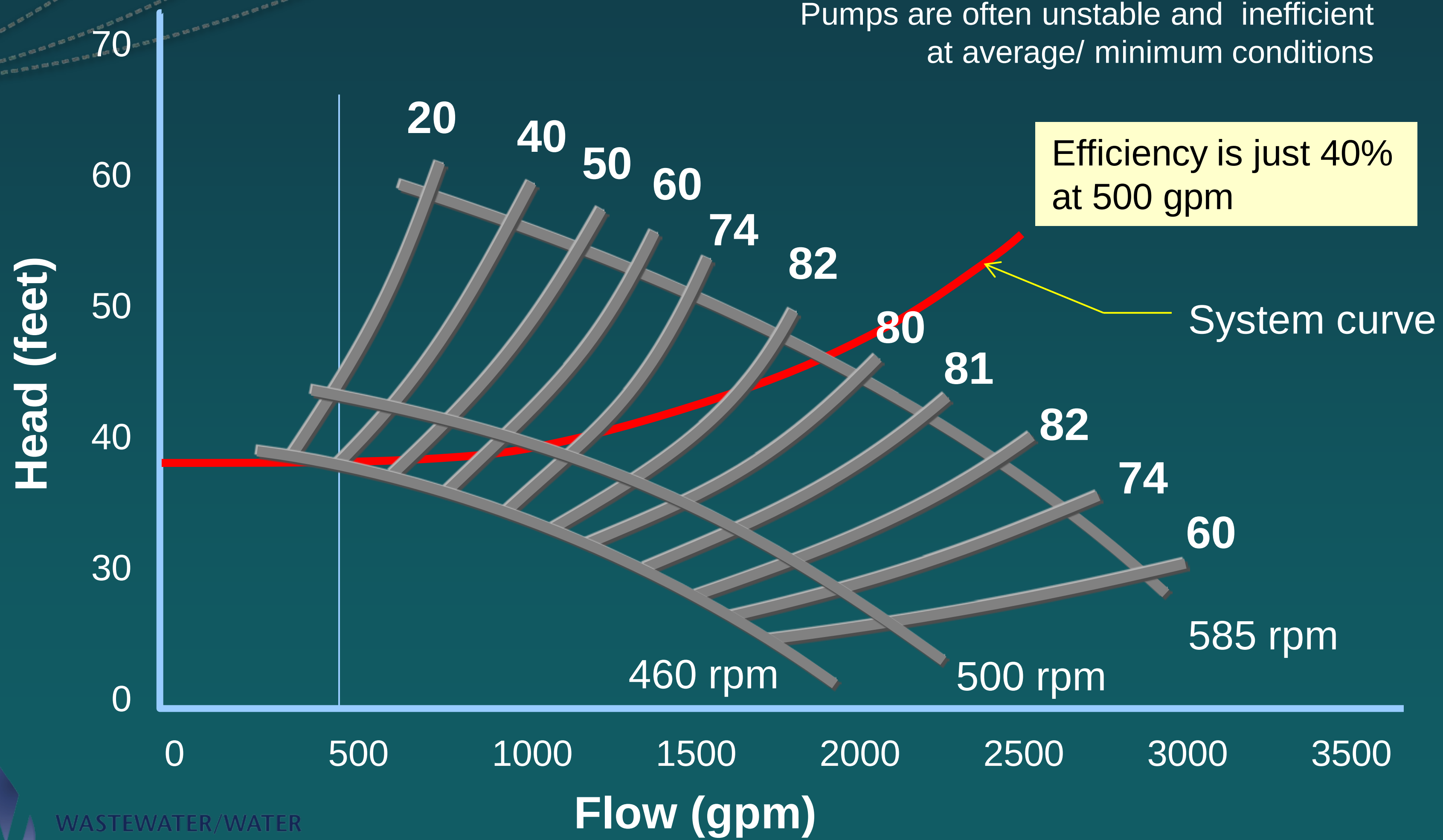


Pump Selection – Seems Easy



Not So Fast.....

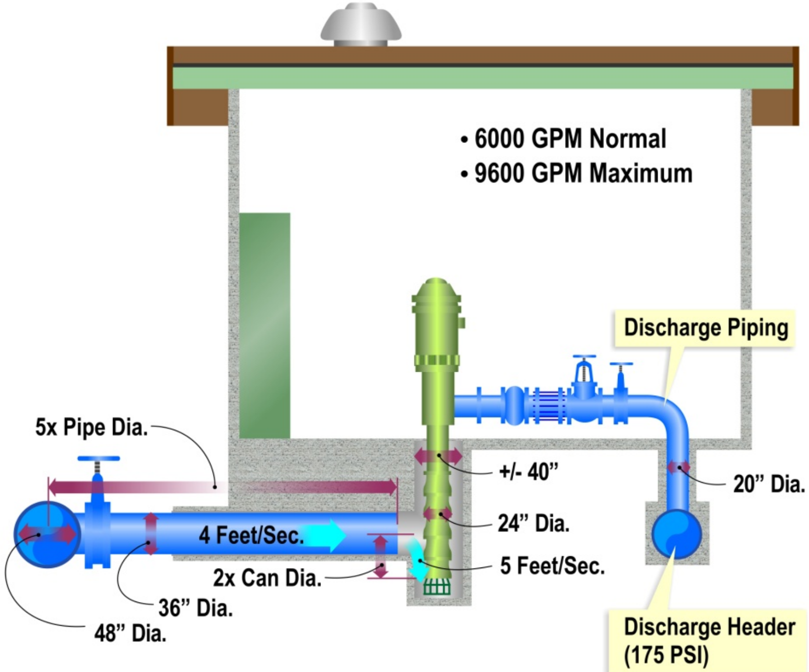
Pumps are often unstable and inefficient at average/ minimum conditions



Follow Standards

- Hydraulic Institute
  - Pump Intake Design (9.8)
  - Allowable Operating Region (9.6.3)
- Read "Pumping Station Design" (Sanks)

PS2 Pump Installation

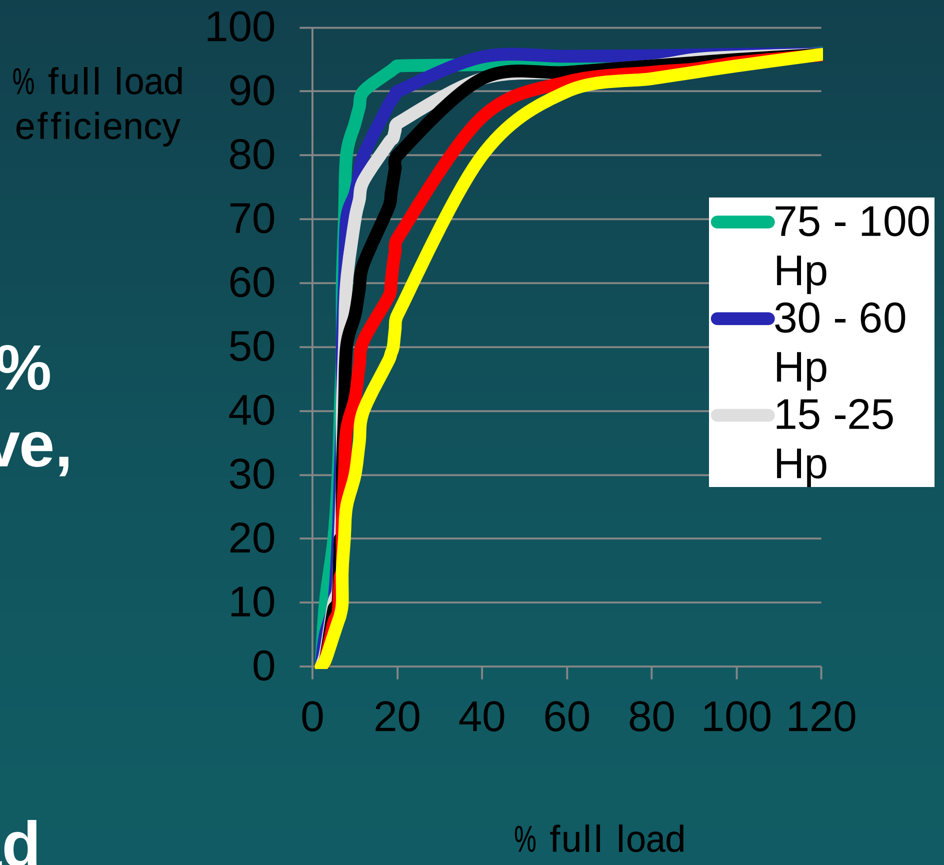


Electric Motors

- Most applications: NEMA standard
  - Enclosure type: TEFC, open drip-proof, weather protected
  - 1992 Energy Act
- Submersibles use special motors
- Inverter Duty: improved cooling, insulation

Electric Motor Efficiency

- **Standard efficiency motors: 90%**
- **Premium efficiency: 10% more expensive, 5% more efficient**
- **Efficiency is constant to about 50% load**



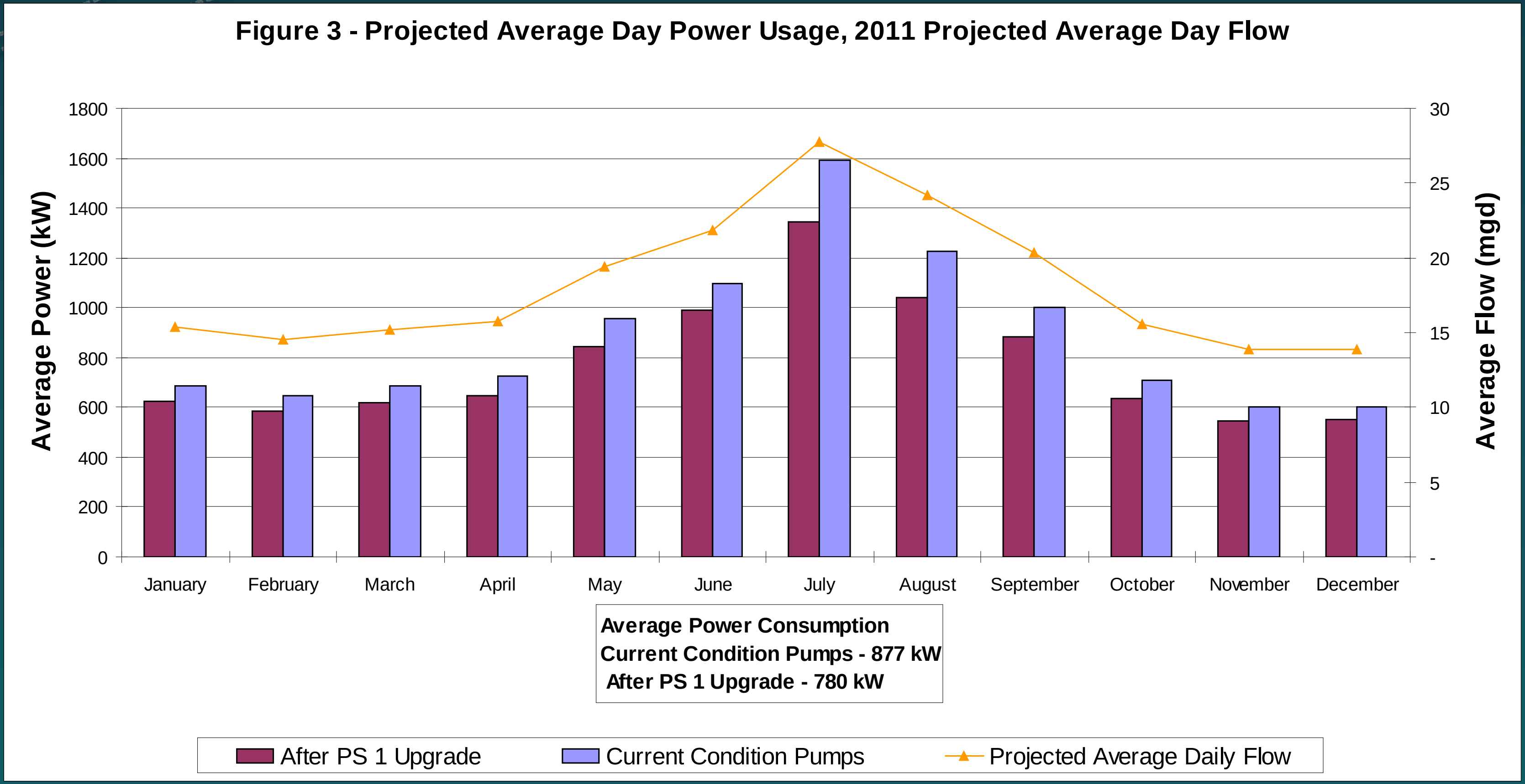
Improving Pump Efficiency

- Don't Design it Wrong
  - Invest in a good predesign
  - Decide how it will operate before messing around with layouts and equipment selection
  - Pick pumps to operate efficiently operate at conditions where the pump will actually operate most of the time
  - Consider variable speed drives or smaller pumps to improve efficiency at low flows

Improving Pumping Efficiency

- Operate Smart
  - Pump as slowly as possible
  - Utilize storage to level out pumping rate
  - Eliminate throttling
- Fix Stuff
  - Test pumps regularly (inc electrical measurements)
  - Visual inspection of interior
  - Modify or replace impeller to match conditions
  - Replace old motors (pre Energy Act, 1992 to 1997)

Example: Big Water Pump Station



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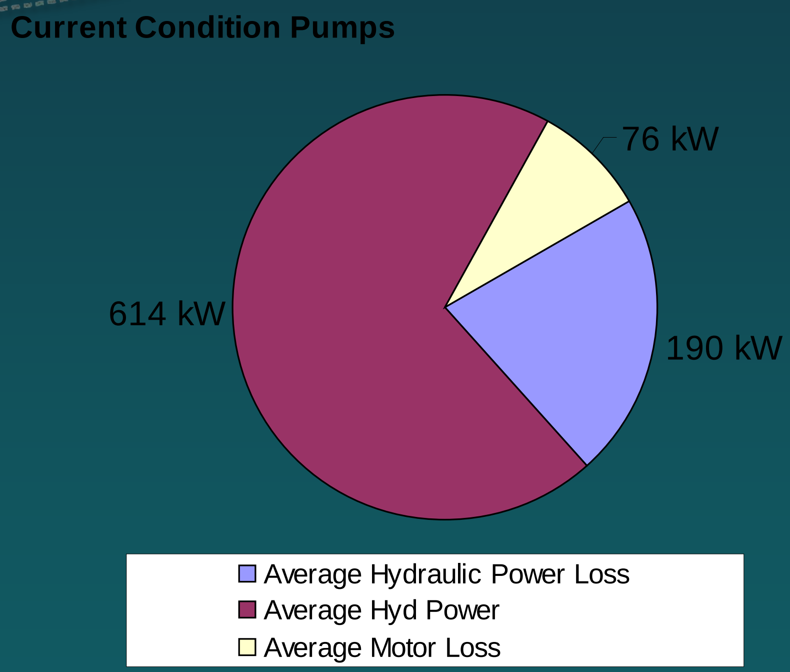
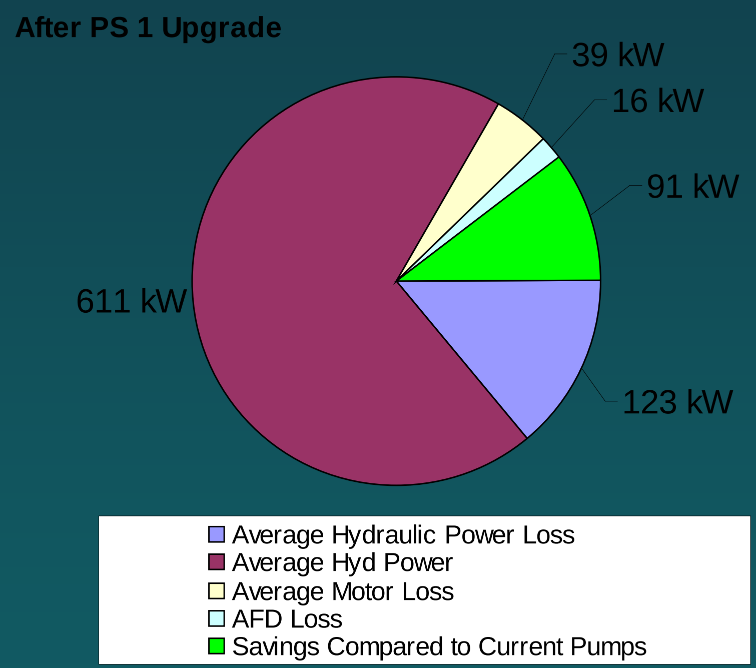
Energy Before and After Upgrade





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