Energy Considerations for Wastewater Pumping Systems and Lift Stations

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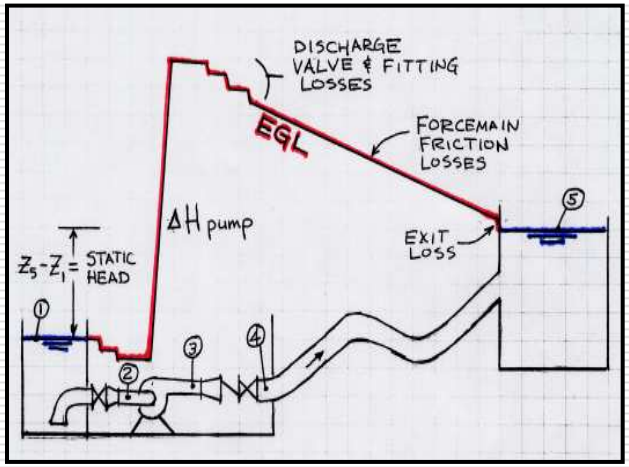
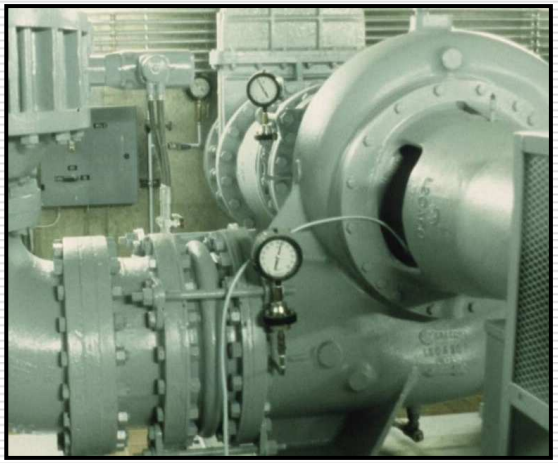
Today's Topics

- A few "essentials" of hydraulics and energy
- Impacts of:
  - design flows
  - forcemain systems
  - pump operating scenarios
- Energy results for a hypothetical station
- A homework challenge

Essential Hydraulic Ingredients





1. Flowrates
2. Differential Heads
3. Equipment Efficiencies

energy **$** power

Useful Power and Energy Formulas for Wastewater Pumping Applications

Flow rate (gpm)

Differential head (feet)

Power Input (KW)

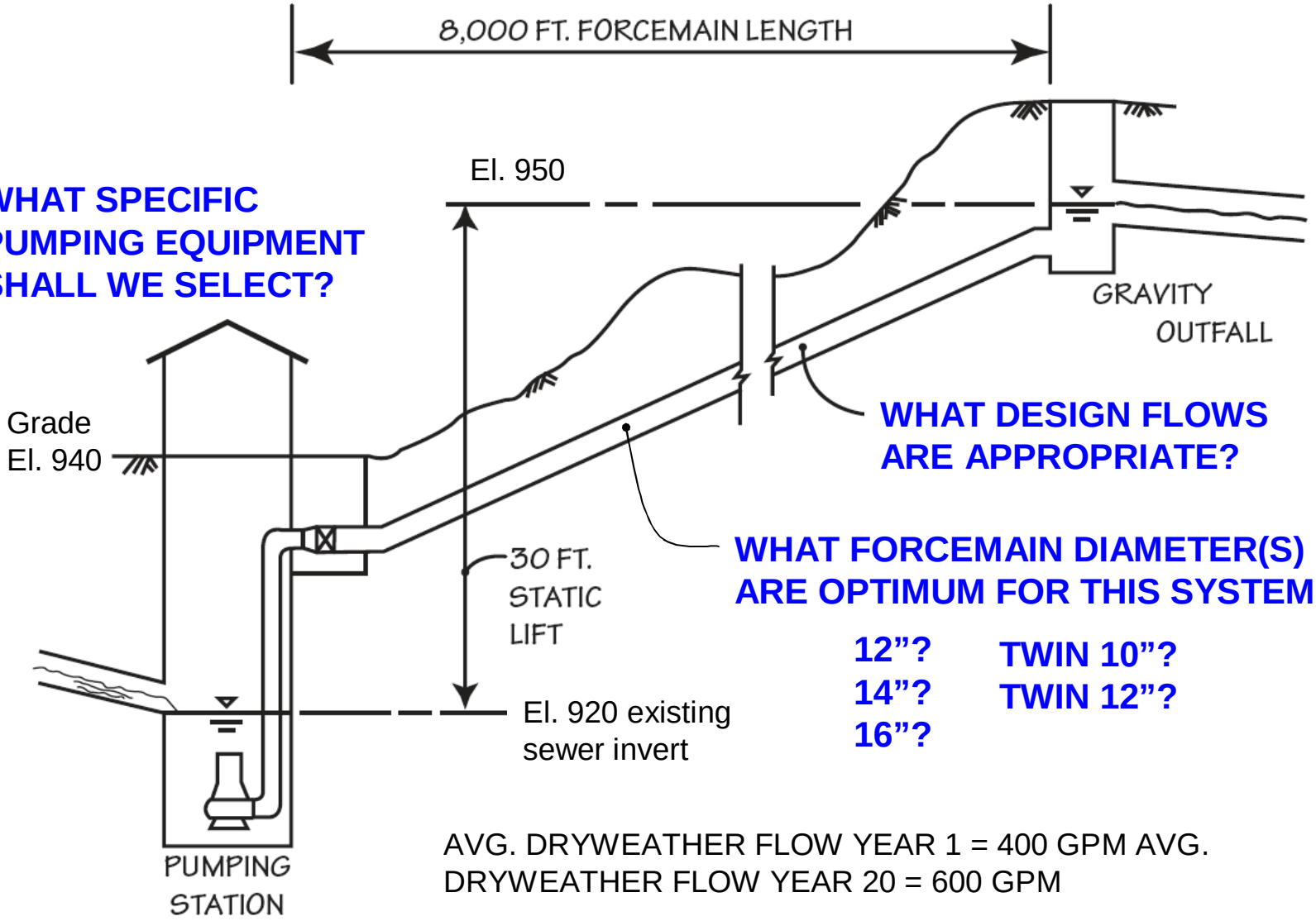
$$= \frac{.000189\, Q_{gpm} H_{ft}}{e_p e_m e_{vfd}}$$

Efficiencies of pump, motor, vfd, etc.

Energy Usage per Vol. Pumped (KWH / MG)

$$= \frac{3.14\ H_{ft}}{e_p e_m e_{vfd}}$$

A Hypothetical Pumping Scenario



WHAT SPECIFIC PUMPING EQUIPMENT SHALL WE SELECT?

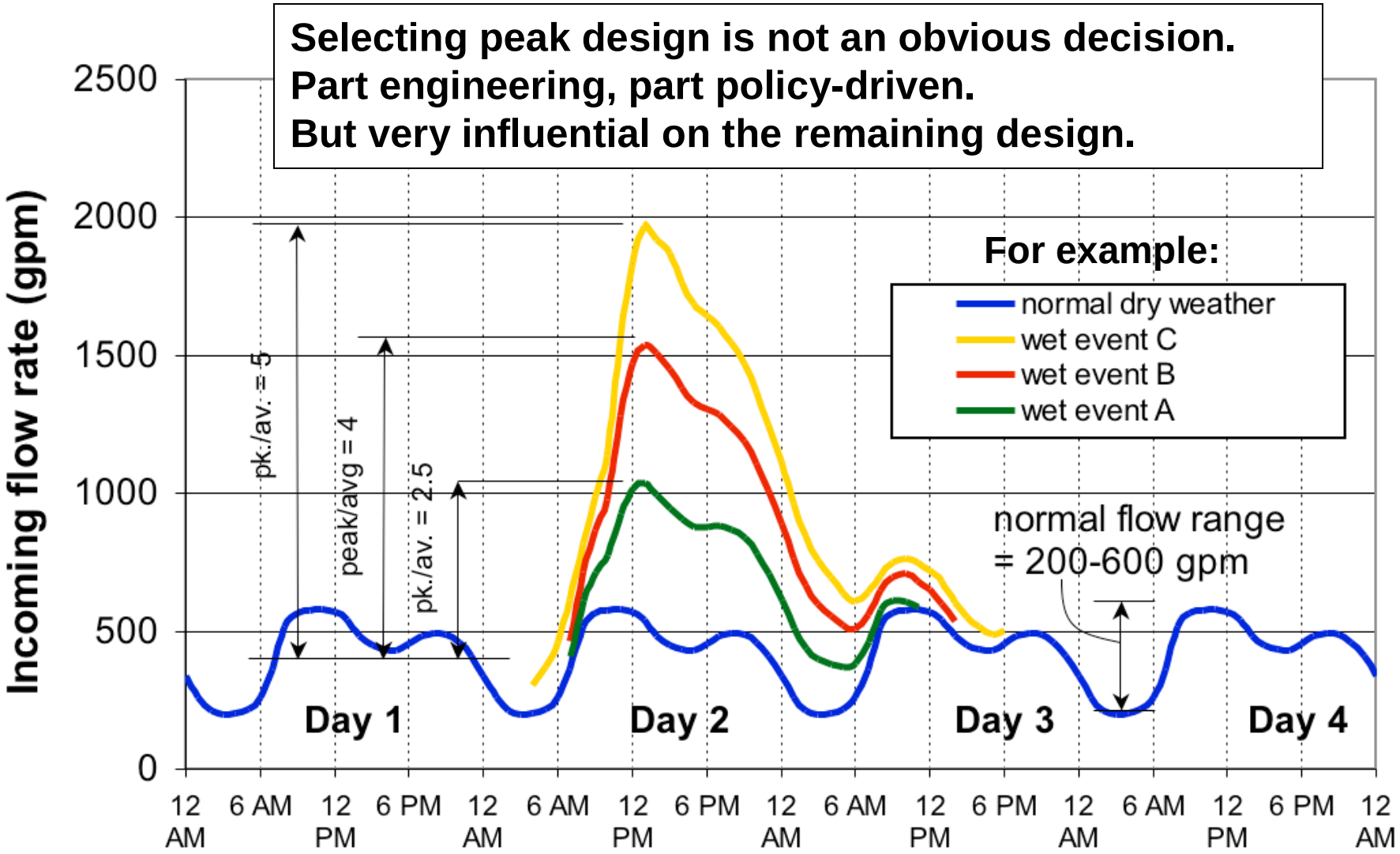
WHAT DESIGN FLOWS ARE APPROPRIATE?

WHAT FORCEMAIN DIAMETER(S) ARE OPTIMUM FOR THIS SYSTEM?

12”?
14”?
16”?
TWIN 10”?
TWIN 12”?

AVG. DRYWEATHER FLOW YEAR 1 = 400 GPM AVG. DRYWEATHER FLOW YEAR 20 = 600 GPM

Facilities Handle a Wide Range of Flows



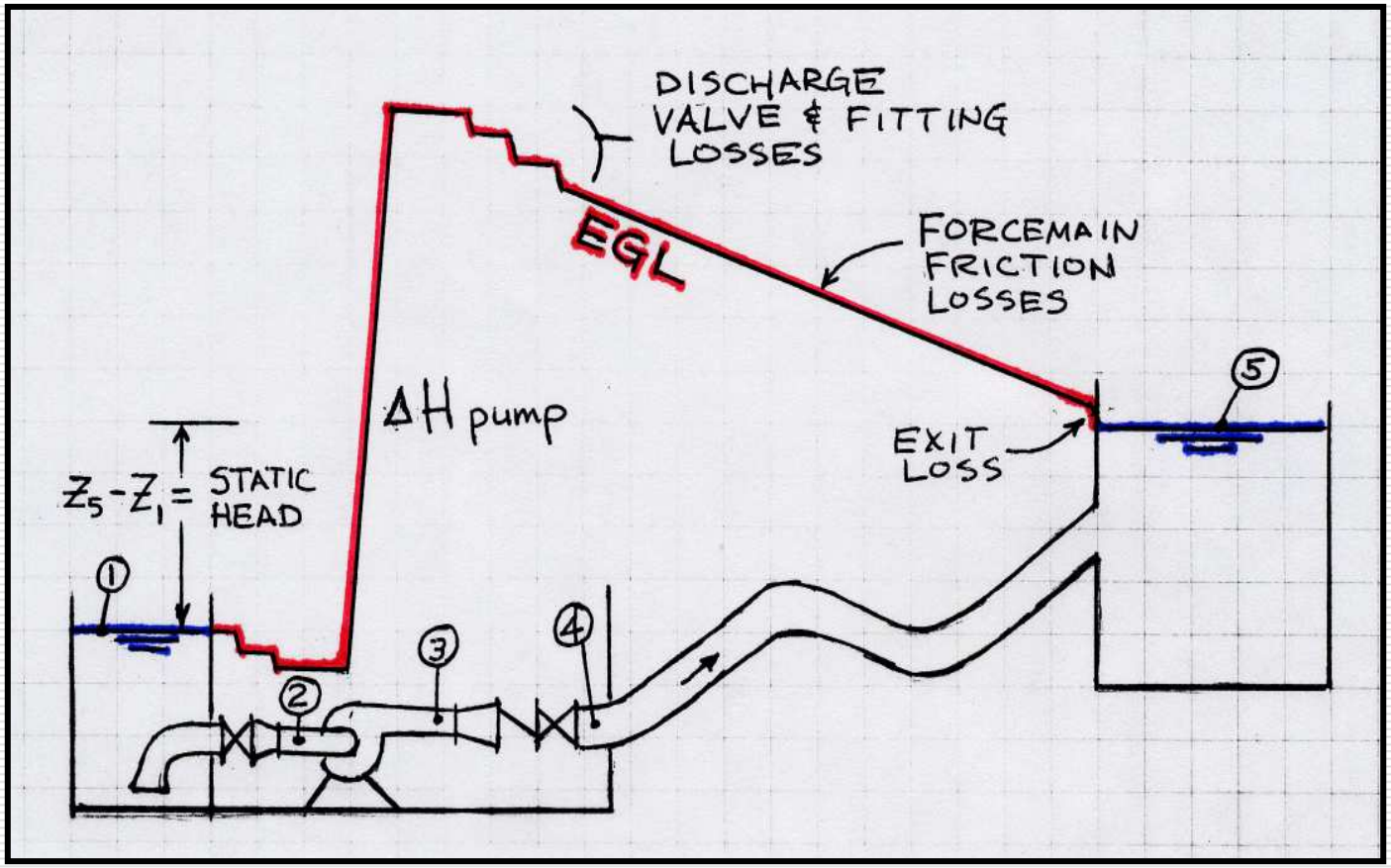
Which Peak Design Flow(s) Should We Choose for this Facility?

Time	Normal dry weather flow range (gpm)	Average flow (gpm)	Possible Peak Design Flows (gpm)		
			Tighter system, lighter rains, and/or less conservative ← → Looser system, heavier rains, and/or more conservative		
			2.5 x avg.	4.0 x avg.	5.0 x avg.
Present conditions	200 - 600	400	**1,000**	**1,600**	**2,000**
20-year future	300 - 900	600	**1,500**	**2,400**	**3,000**
Ultimate buildout?	400 - 1,200	800	**2,000**	**3,200**	**4,000**

For this design project?

For a future expansion?

Differential Head: What Affects It?

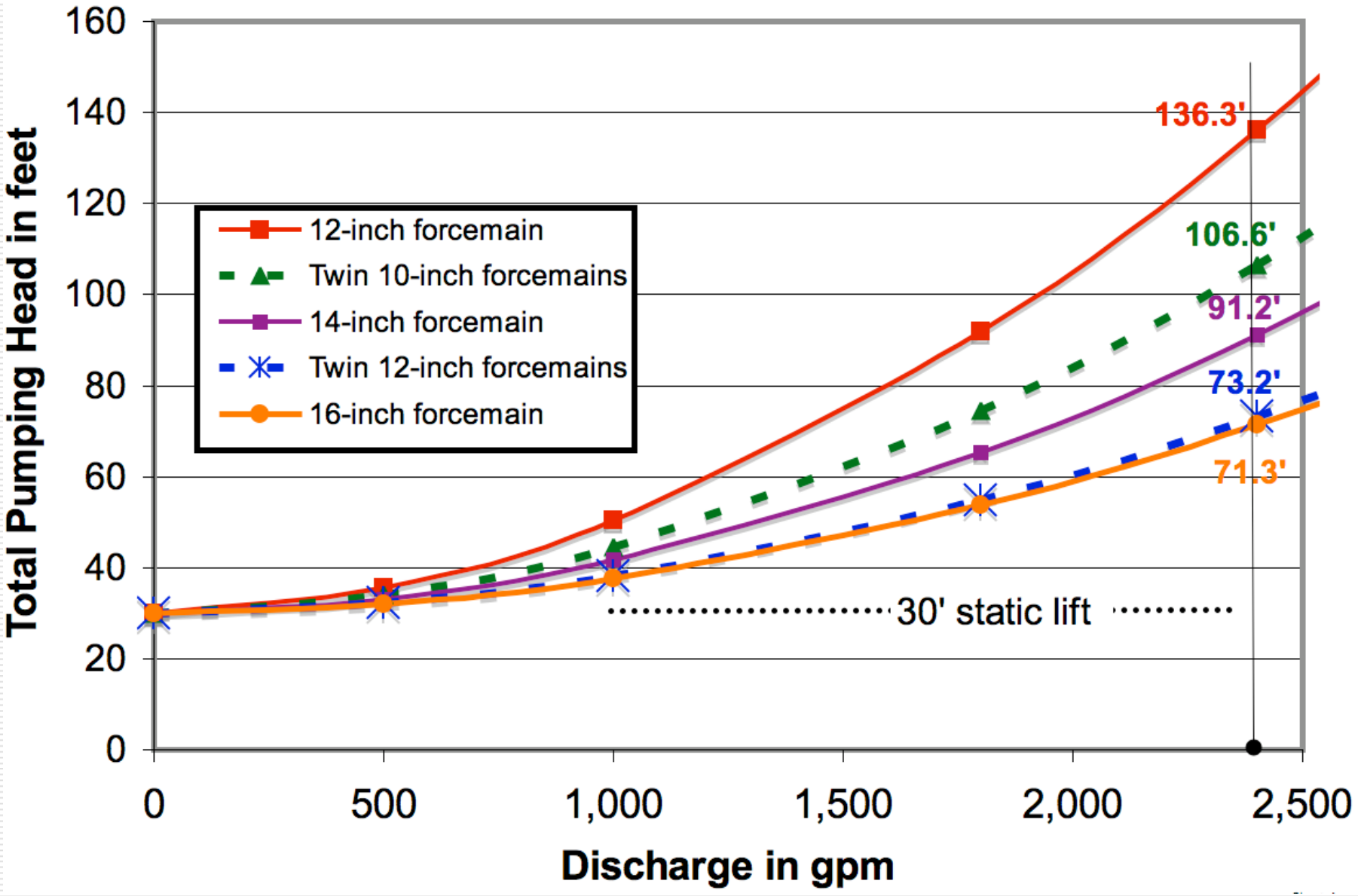


$$\Delta H_p = \text{Static Head} + \sum \text{Minor Losses (valves, fittings, exit)} + \text{Pipe Friction Losses}$$

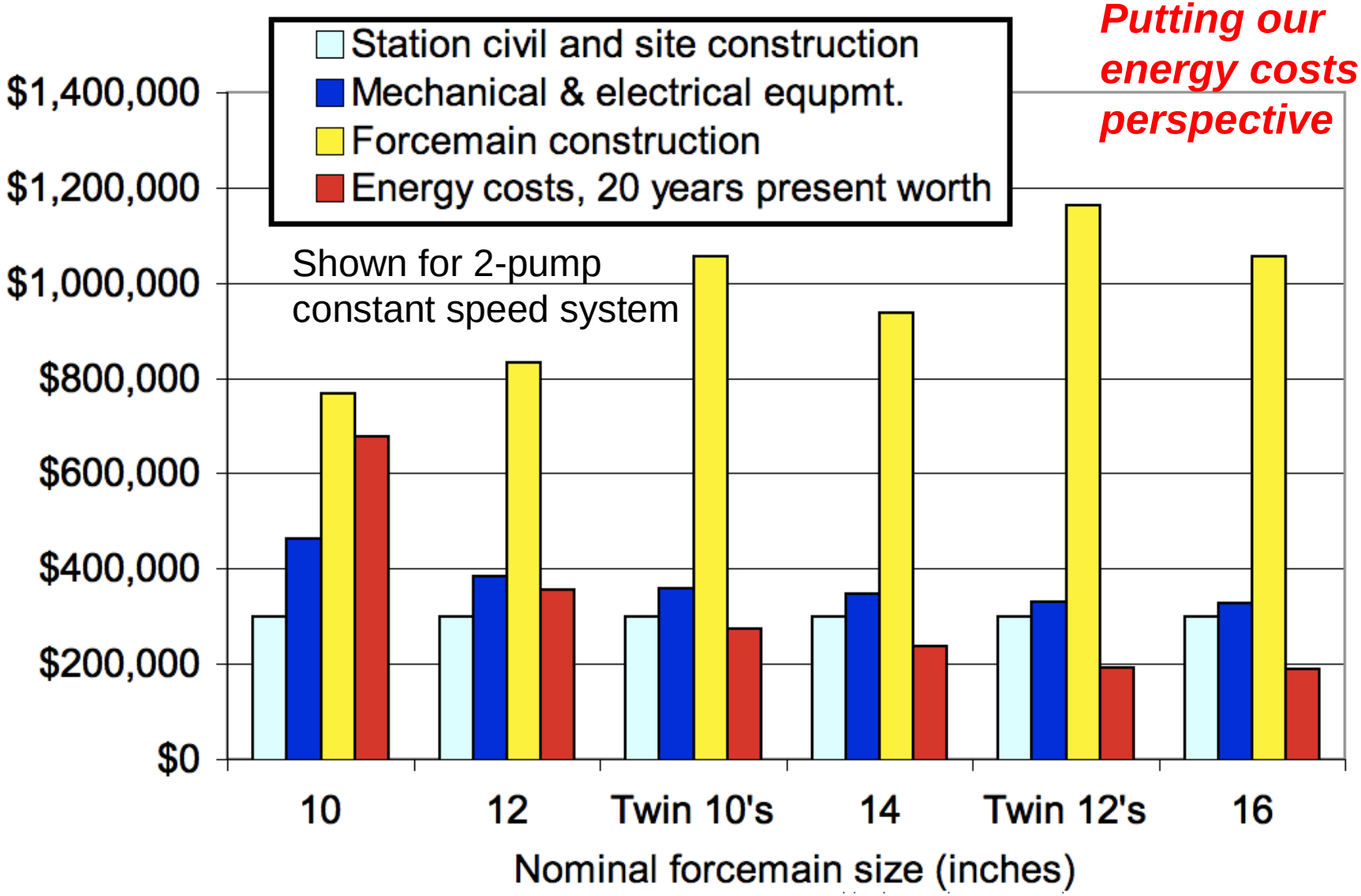
Forcemain Sizing: A Balancing Act

- A wide range of flows to be handled
- We'd like a "large" diameter to keep friction losses & horsepower reasonable at peak flows
- But we'd like a "smaller" diameter so that normal, everyday flows have velocities above 2 feet/sec.
- Larger forcemains have higher construction costs but allow smaller motors and lower energy costs.

System Head Curves with Various Forcemains



Project Cost and Energy Components with Various Forcemain Systems

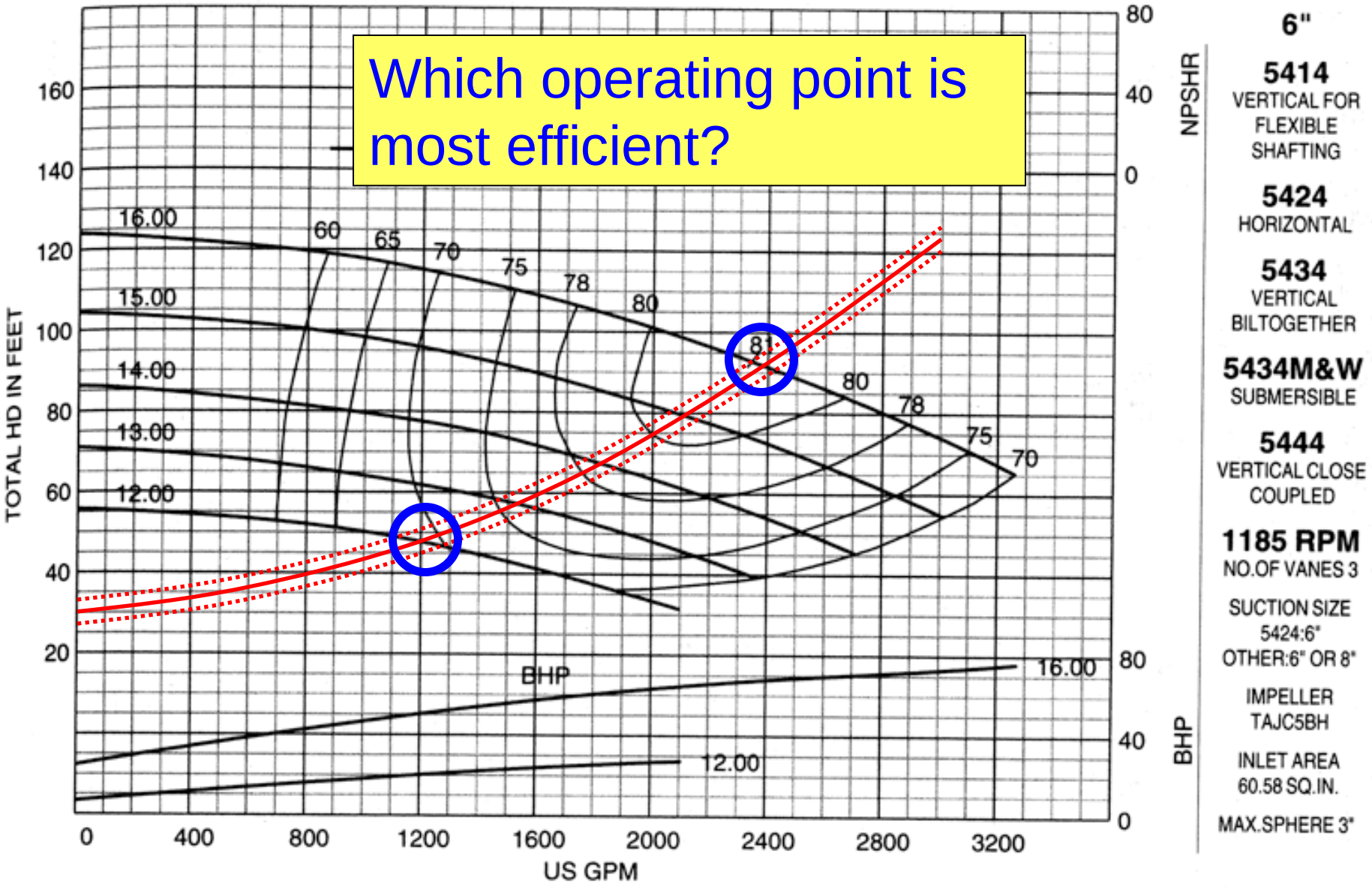


Putting our energy costs in perspective

Pump Selection and Operating Scenarios

- **Overlapping Considerations**
  - How many total pumps? Variable-speed or constant?
  - How to handle the peak? Parallel pumping? Future expansions?
- **A Two-pump Constant-speed Station?**
  - Common approach for smaller stations
  - Each unit is sized for peak. Expect high energy use.
- **A Three-pump (or more) Constant-speed Station?**
  - Various combinations of sizes and/or parallel pumping
  - Small pump(s) for typical normal flow can save energy
- **A Variable-Speed Station?**
  - Can provide desired flow flexibility with fewer total pumps
  - But must account for variable pump efficiencies and VFD losses

Searching for the Best Individual Pumps



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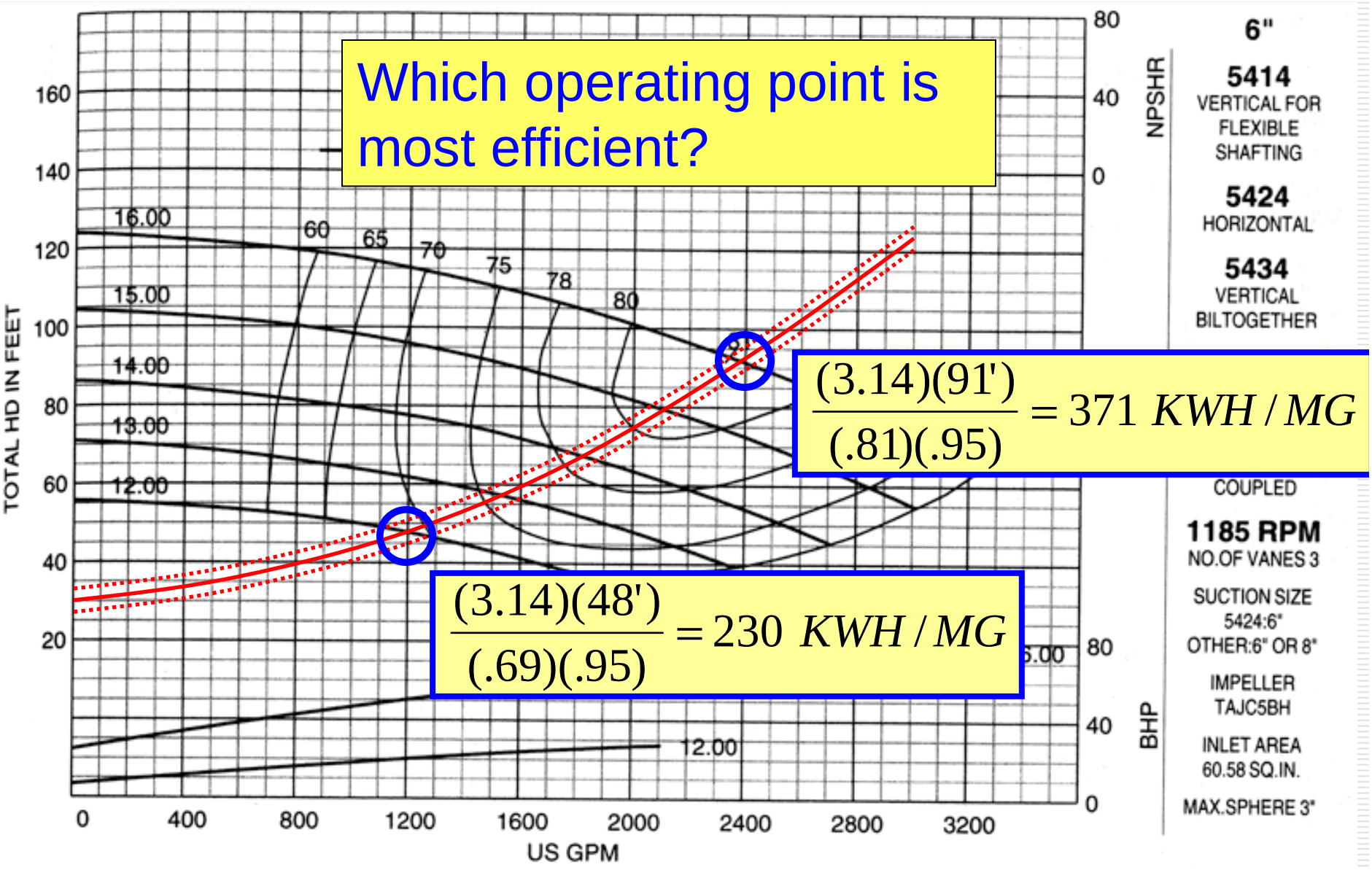
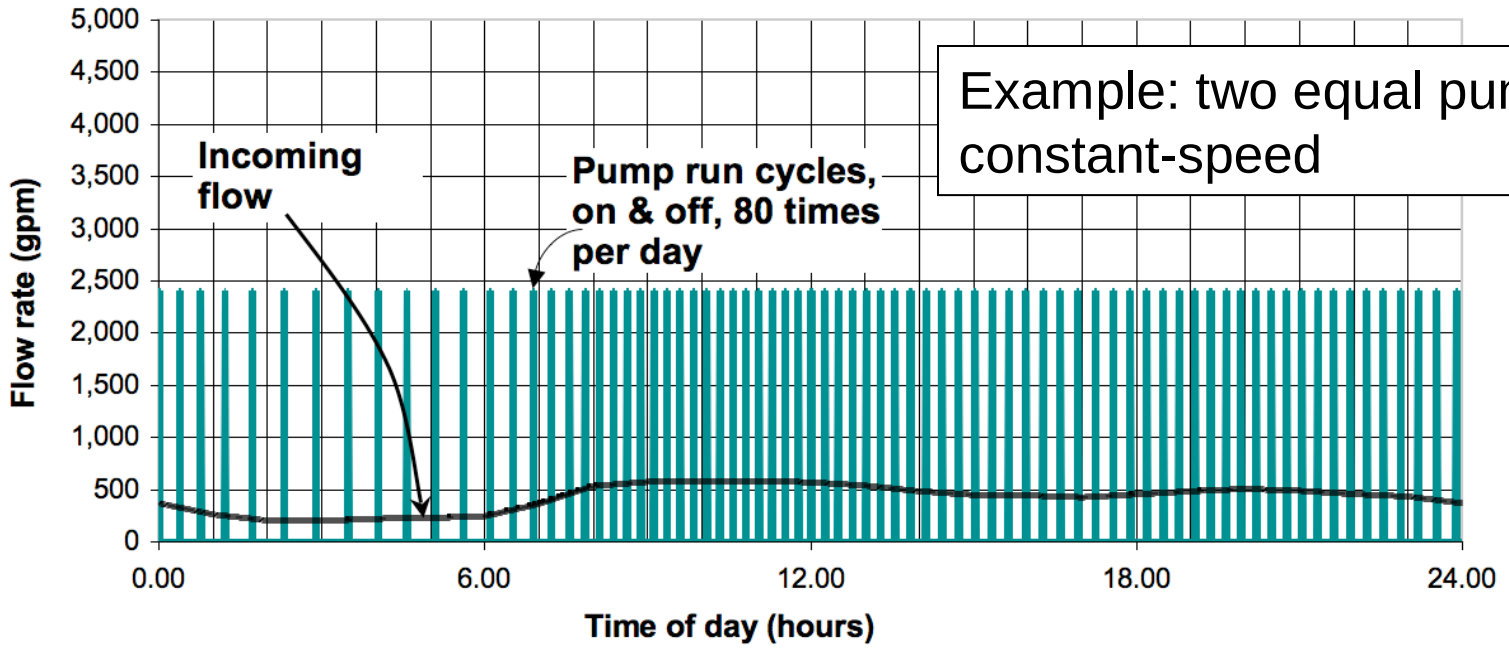
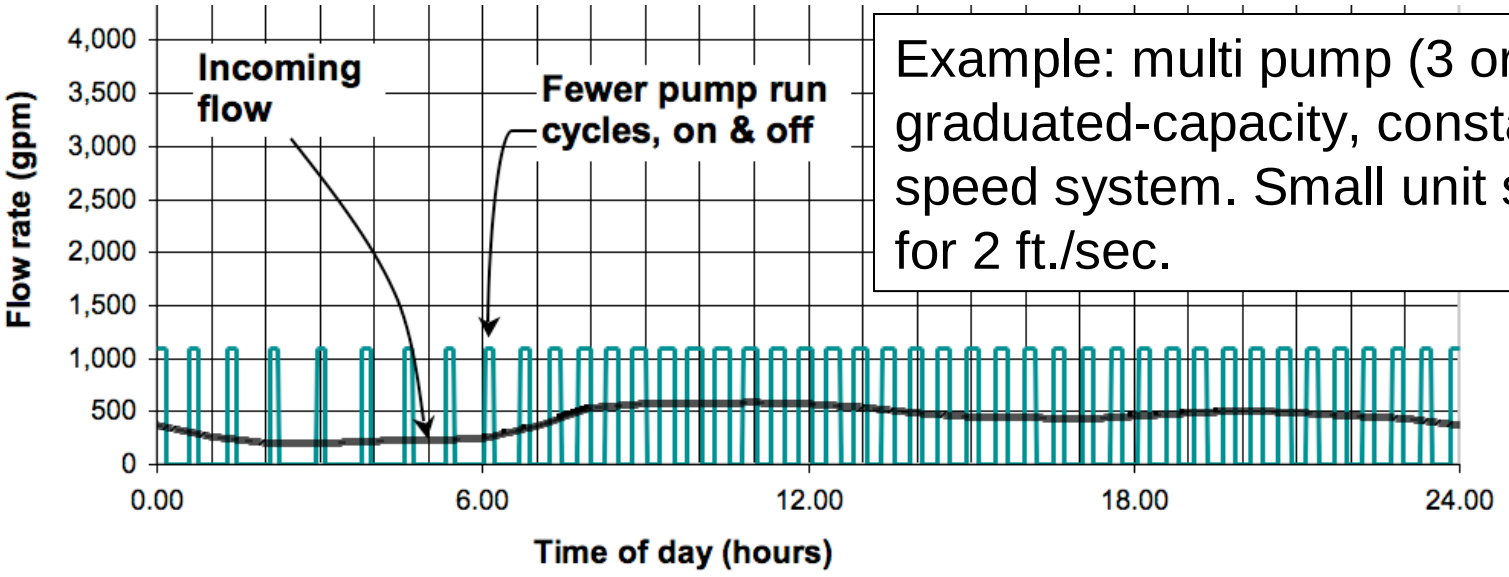


Impacts on Normal Daily Pump Operations

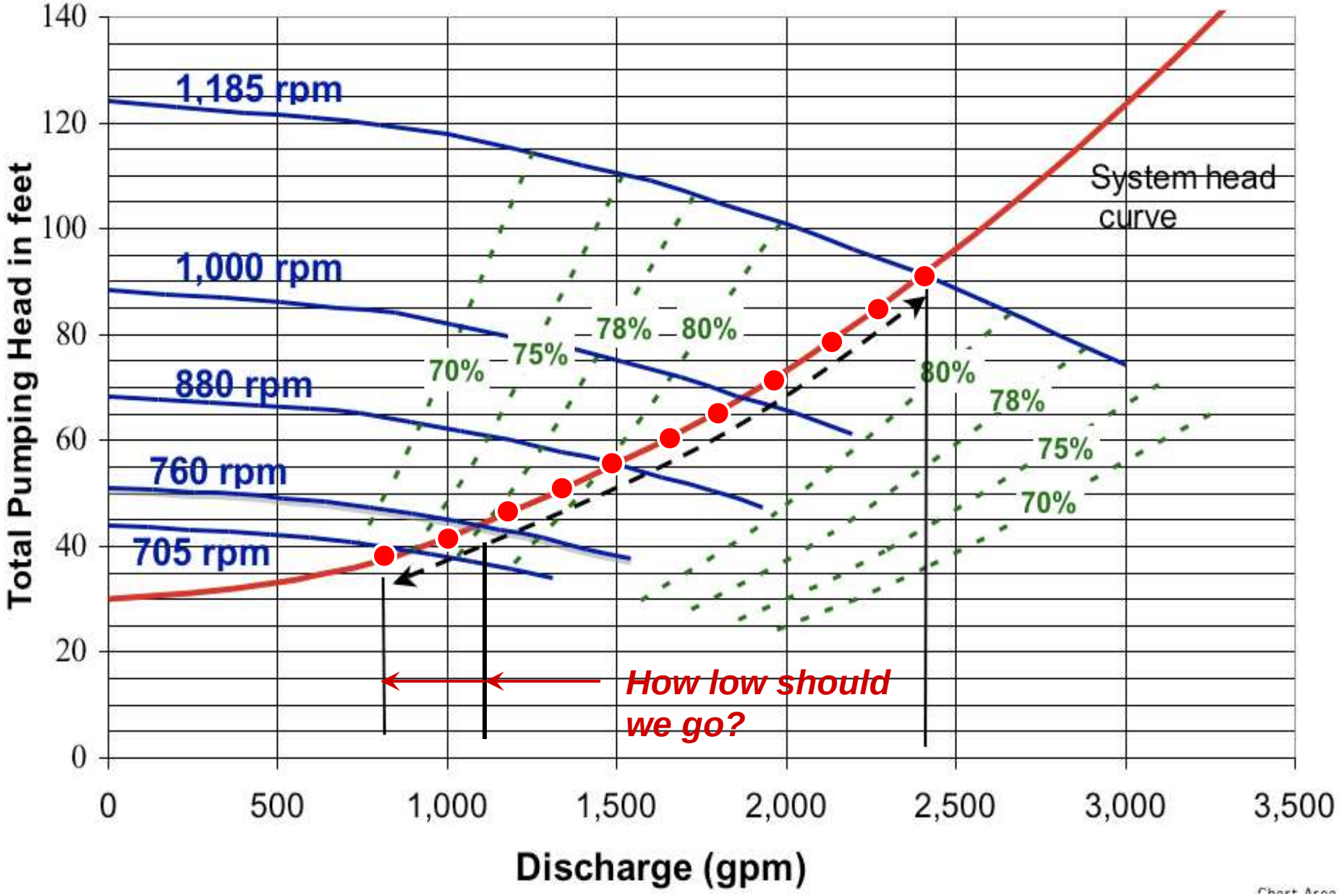


Example: two equal pumps, constant-speed

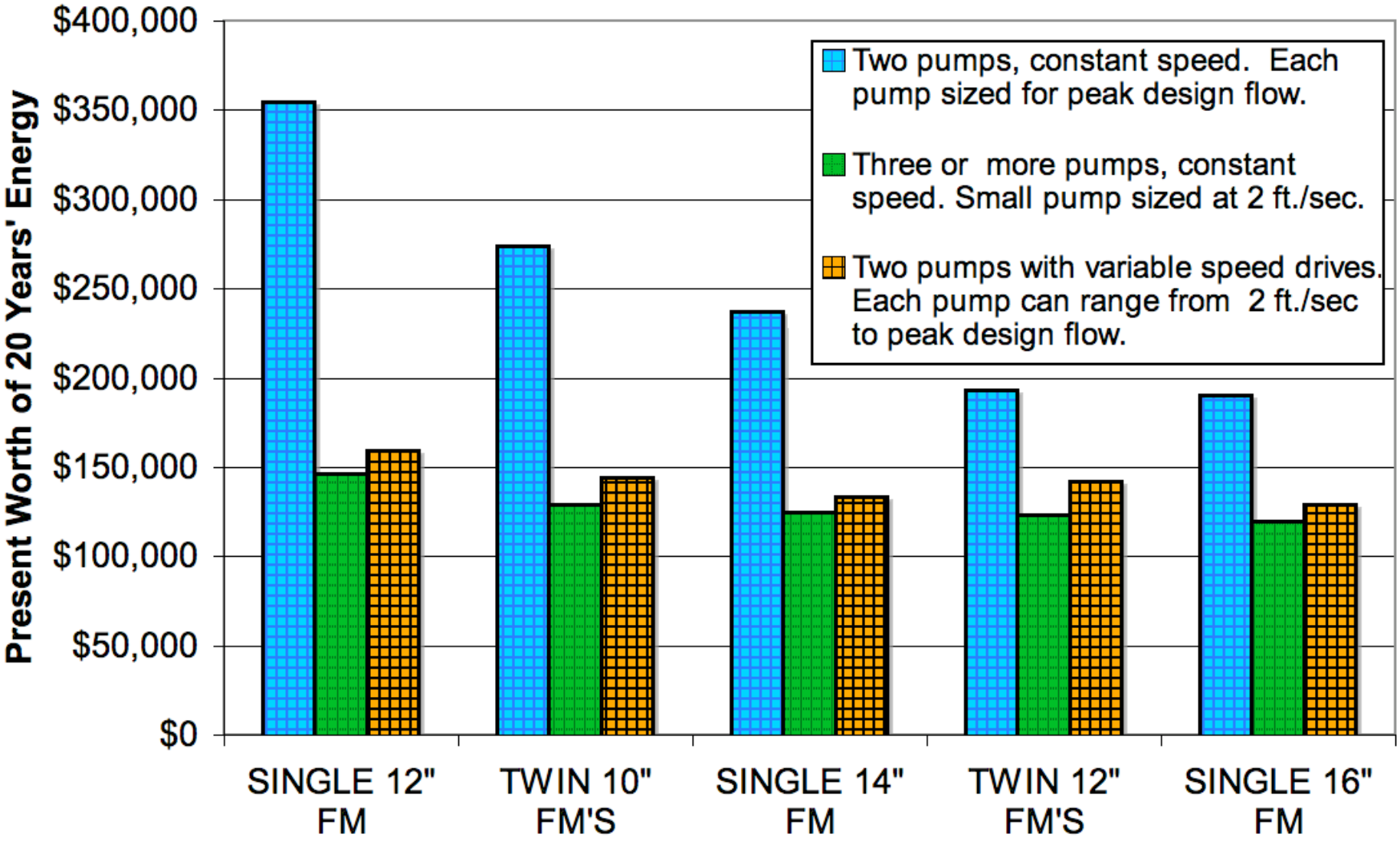


Example: multi pump (3 or more) graduated-capacity, constant speed system. Small unit sized for 2 ft./sec.

Variable-speed Pumping



Energy Results for a Range of Designs



Summary Observations for Energy Usage in Wastewater Pumping

- Energy usage can be affected at several levels:
  - Selection of design flow(s)
  - System design, including forcemain and valving selections
  - Pump selection and operating strategies (e.g. size and # of pumps, variable-speed vs. constant, well levels, efficiencies)
- In studying multiple design alternatives for a hypothetical mid-sized station, present worth energy costs ranged from 100% to 300% of the lowest cost option.
- Multi-pump, graduated-capacity constant speed pumping scenarios will tend to provide the lowest energy costs.
- Choose pumping options carefully, and don't pump at higher heads than necessary.

Comments, Questions? Thank You!

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