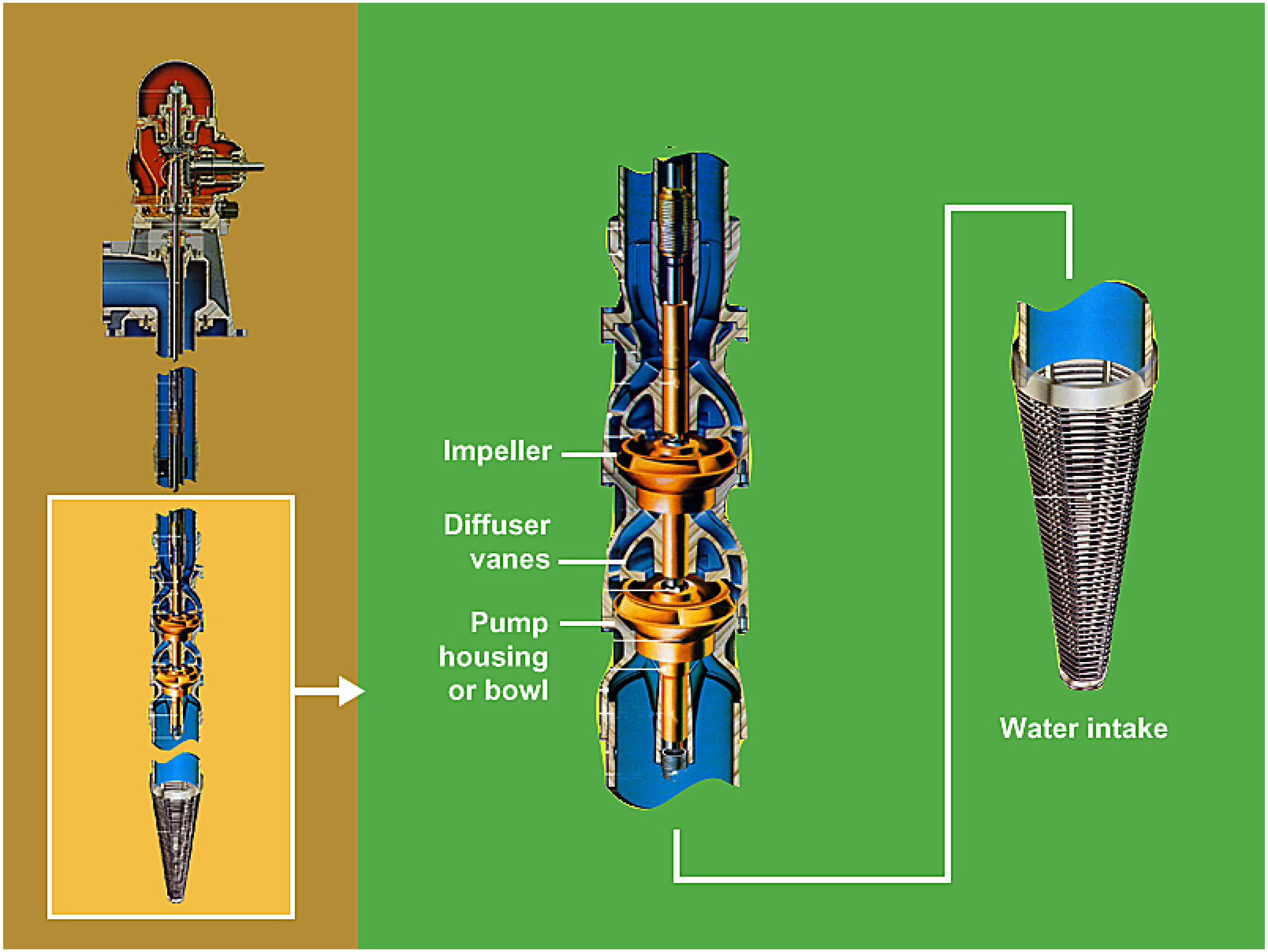
Pump and Well Efficiency

Blaine Hanson
Department of Land, Air and Water Resources
University of California, Davis

Deep Well Turbine



How do I determine the condition of my pump?

- **Answer: Conduct a pumping plant test and evaluate the results using the manufacturer's pump performance data**
- **Self-test: may be difficult to do**
- **Hire a pumping plant tester**

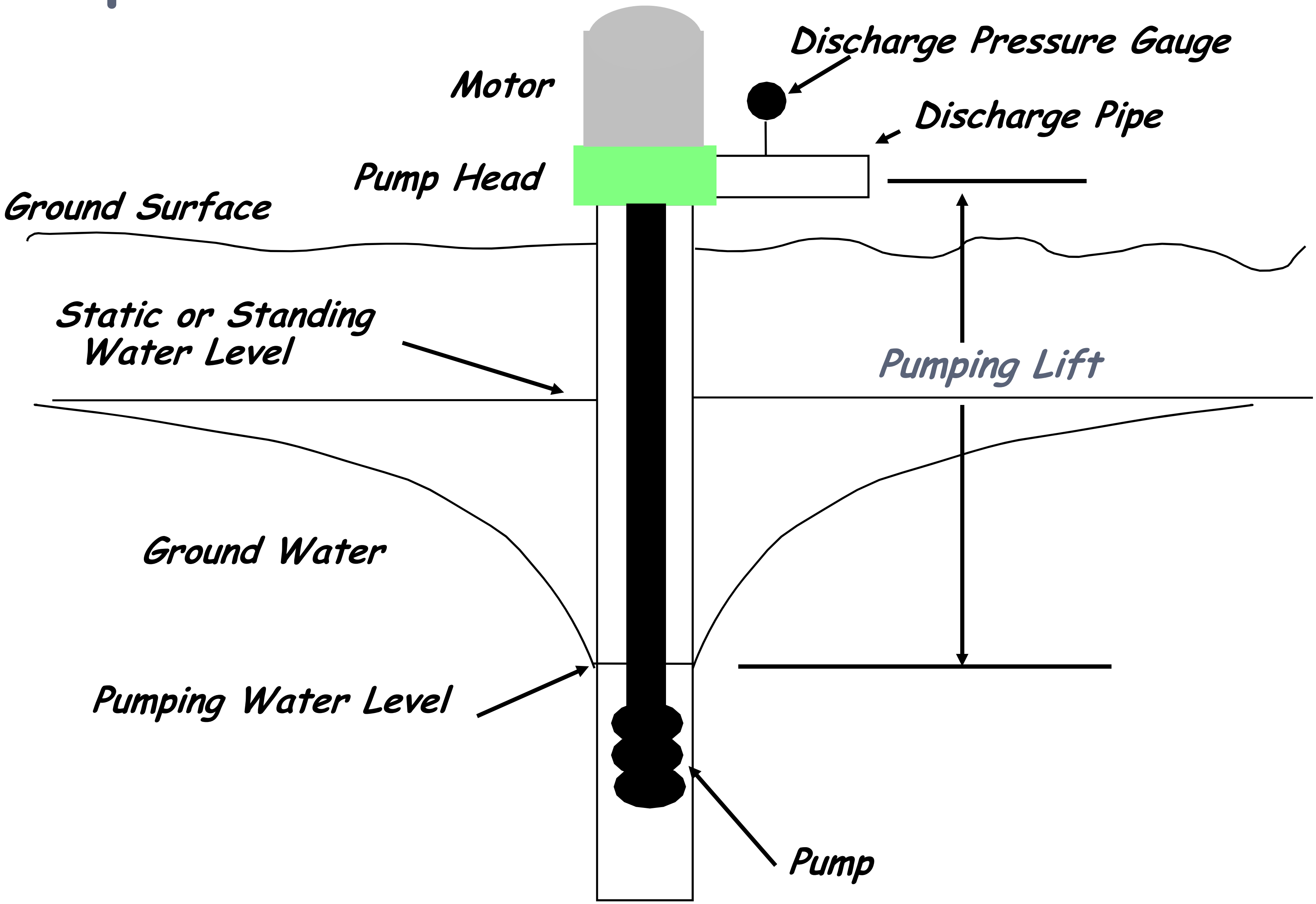
$E_o = (Q \times H) \div (3960 \times IHP)$

- E_o = overall pumping plant efficiency (wire to water) – includes efficiency of electric motor or engine
- Q = flow rate or capacity (gallons per minute)
- H = total head (feet)
- IHP = input horsepower of motor or engine
- 3960 = conversion factor

Total head

- Deep well turbine
  - Pumping lift – measured inside the well casing
  - Discharge pressure head = pressure (psi) x 2.31
  - Total head = pumping lift + pressure head
- Booster pump
  - Pressure difference between pump discharge and pump intake
  - Total head = pressure difference x 2.31

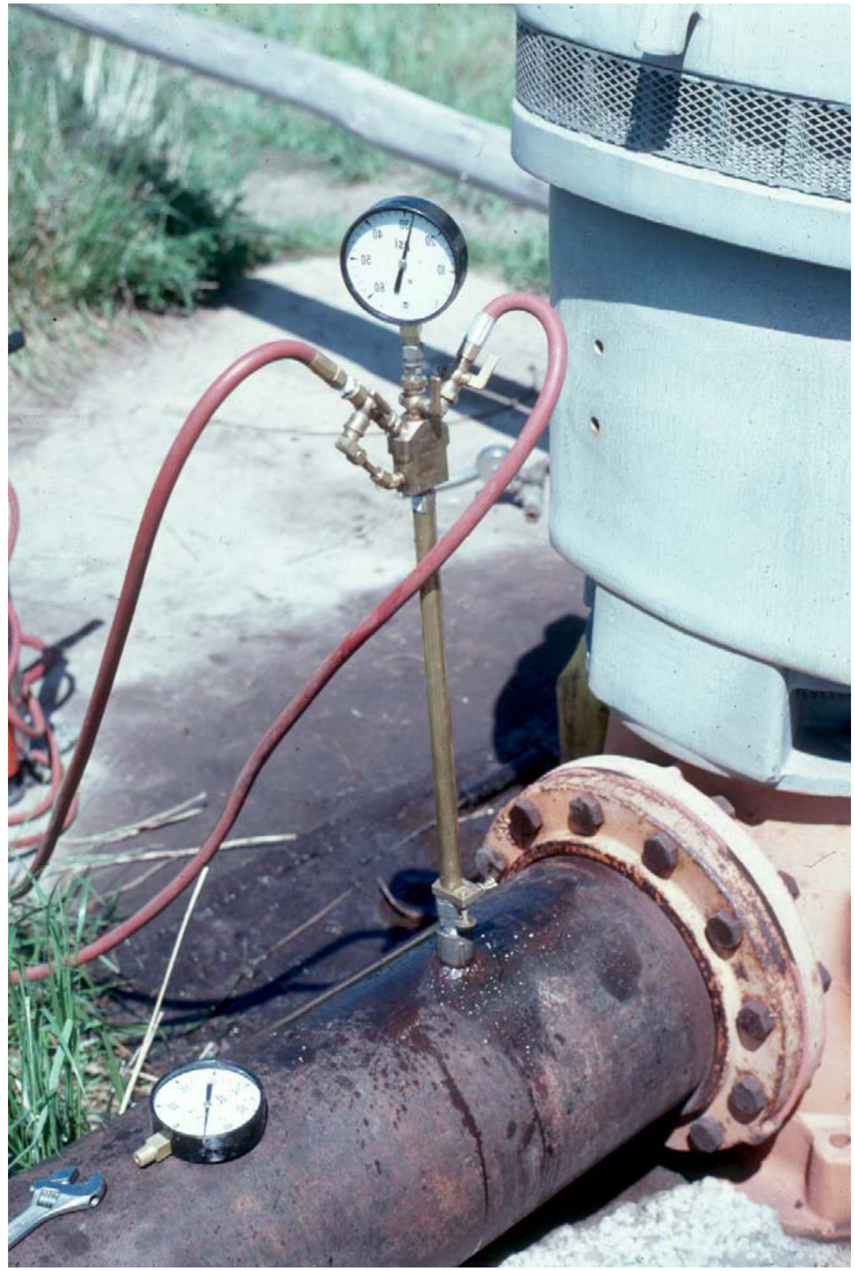
Deep well turbine

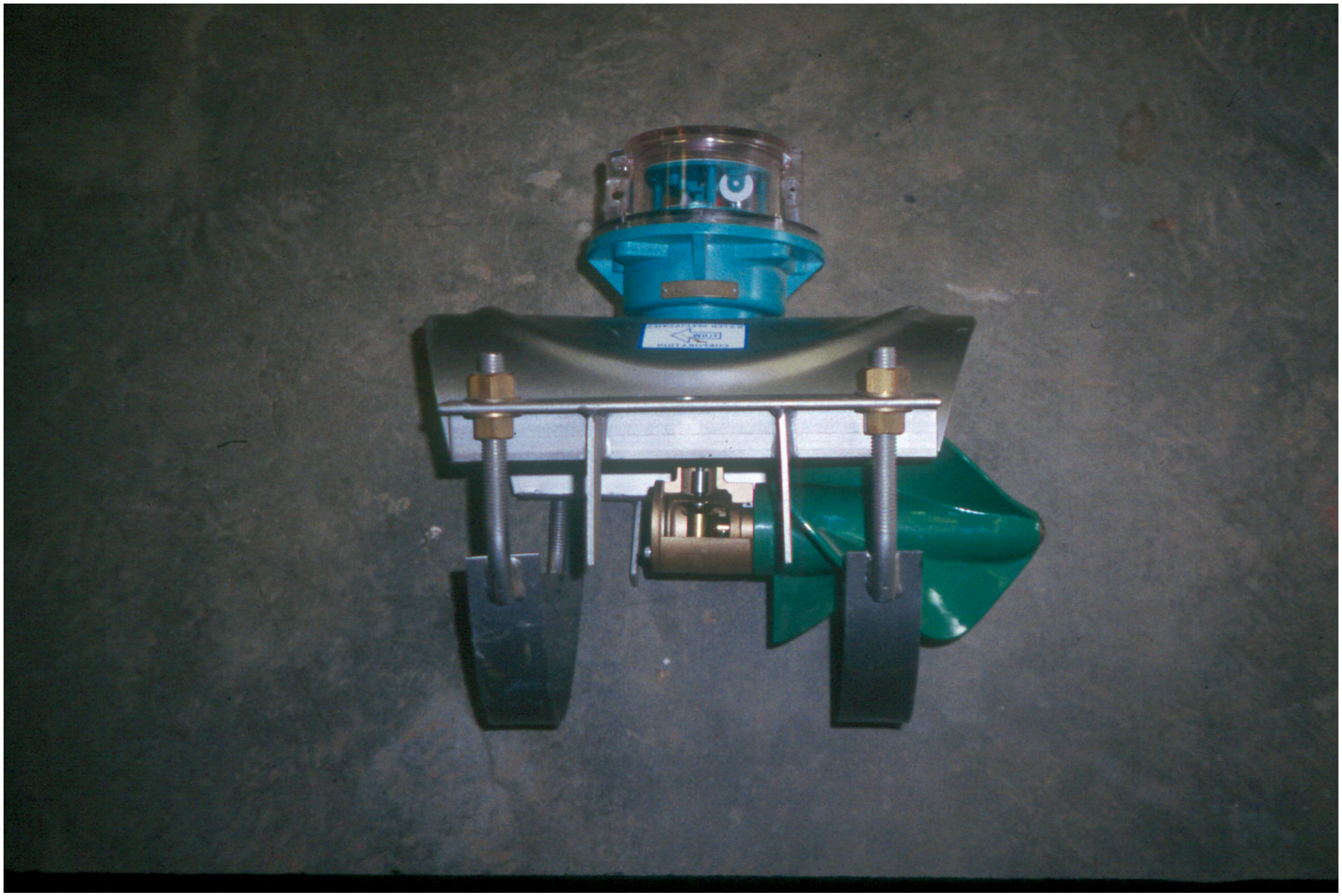


Pumping Lift

Discharge Pressure

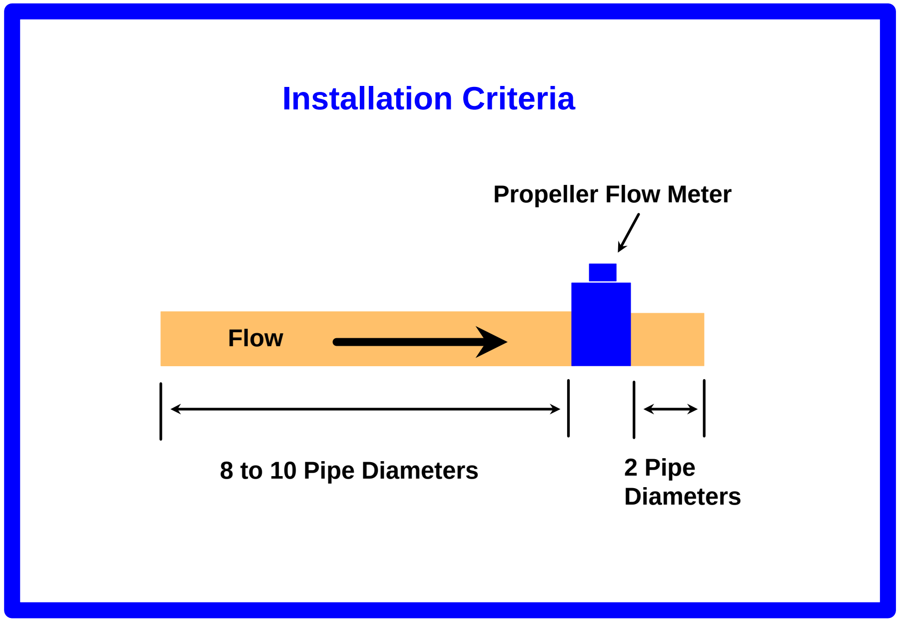
Pump Capacity

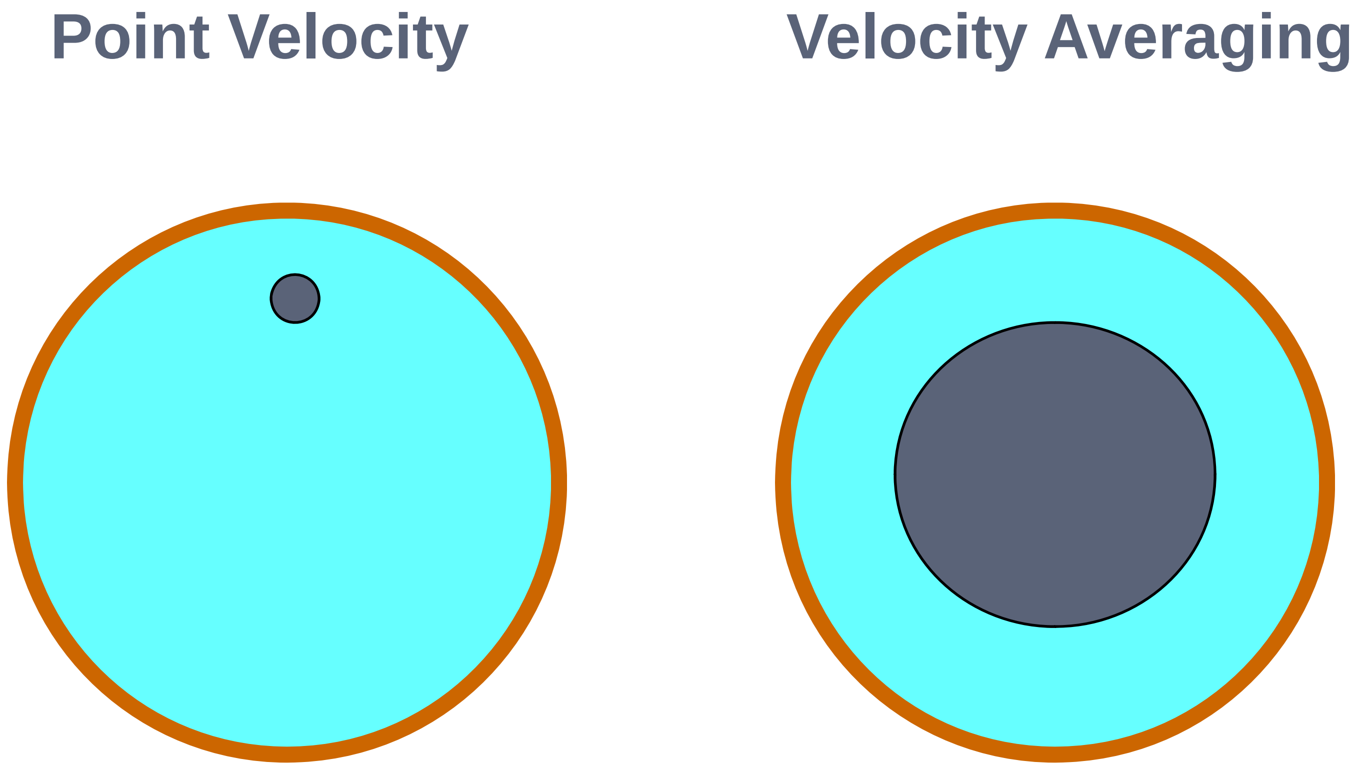


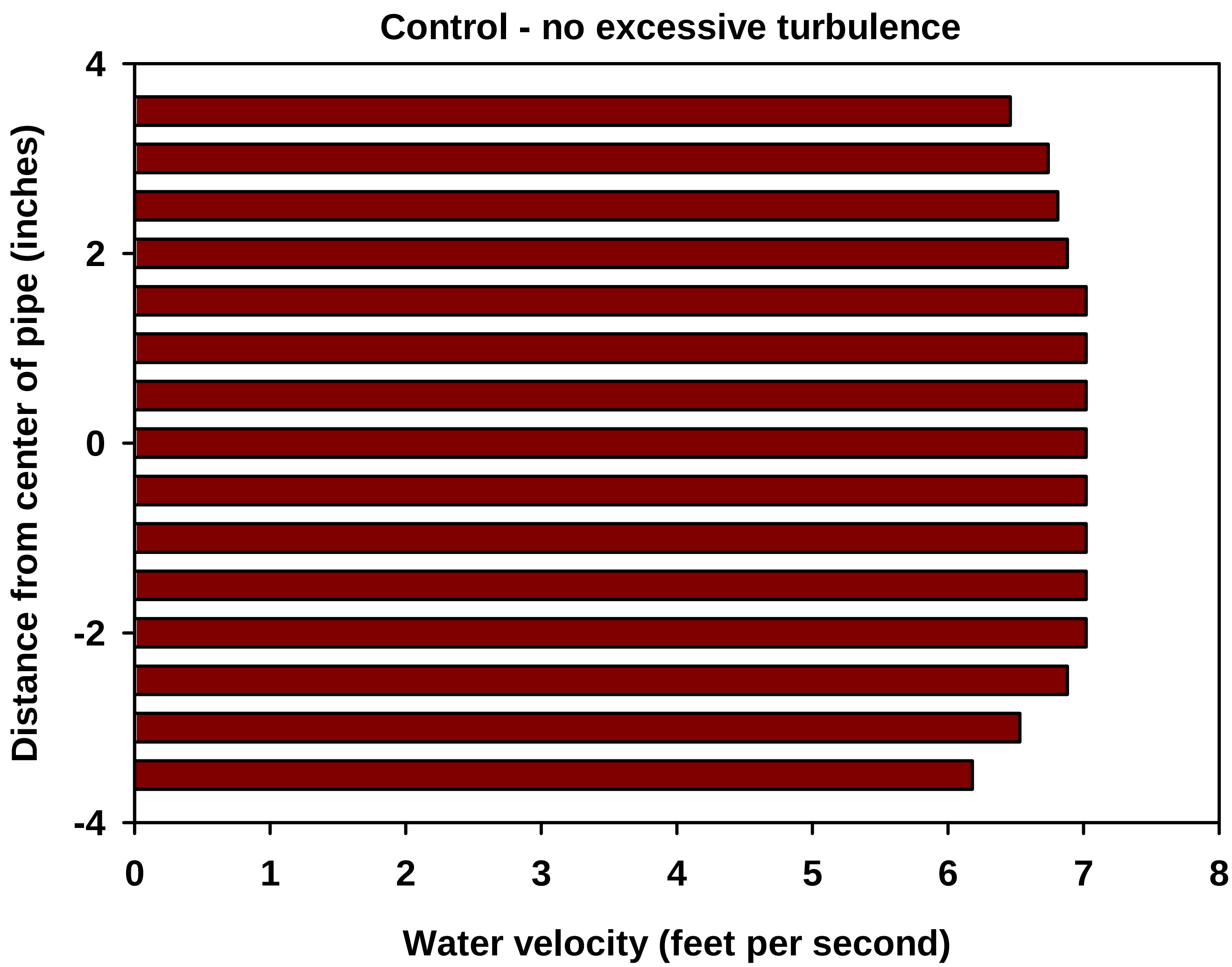


Flow rate or capacity measurement

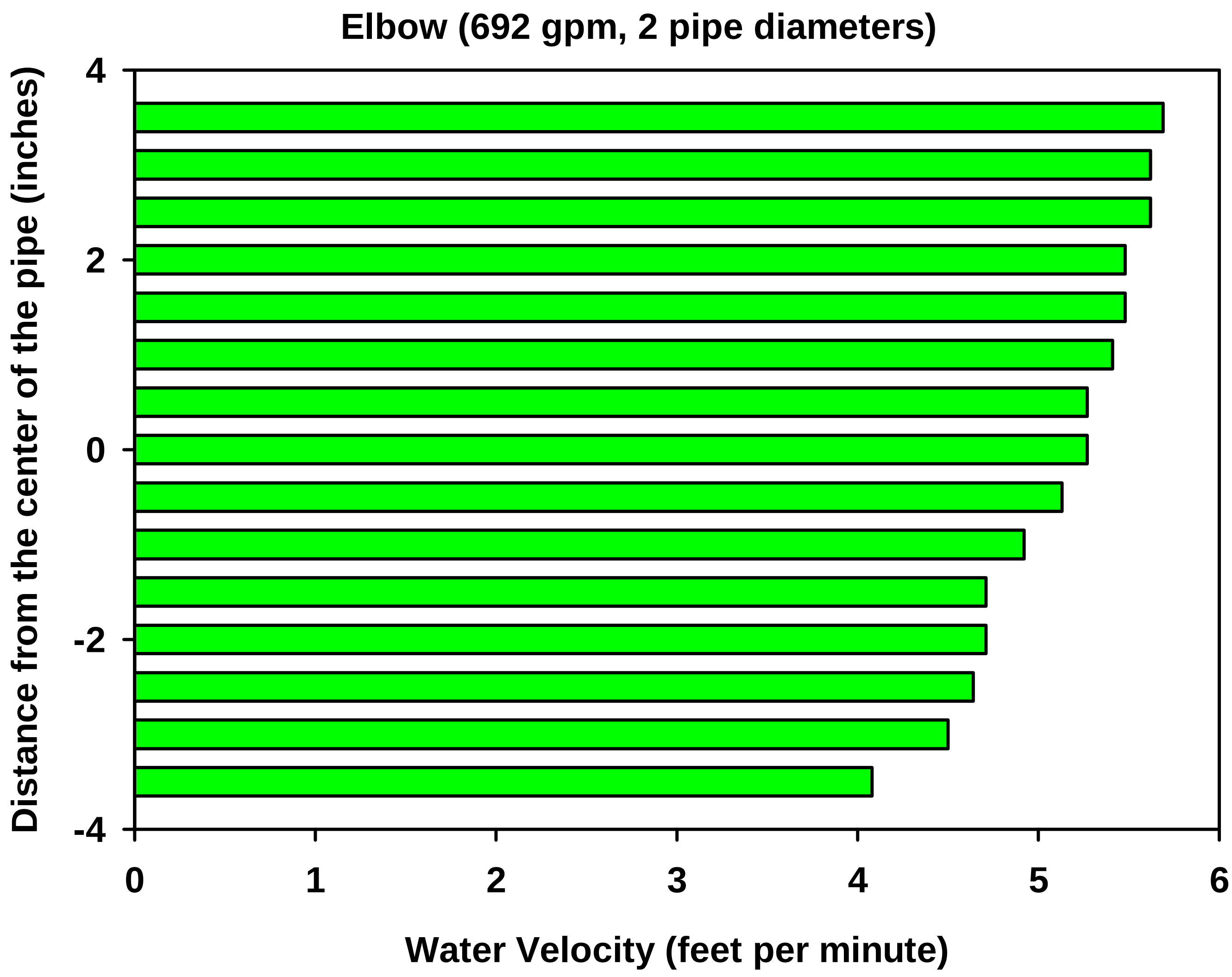
- Flow meter
  - Velocity averaging: less susceptible to errors caused by adverse flow conditions
    - Propeller meter – most common
    - Collins meter
    - Hall meter
  - Point velocity: subject to large errors caused by adverse flow conditions
    - Paddle wheel
- Installation

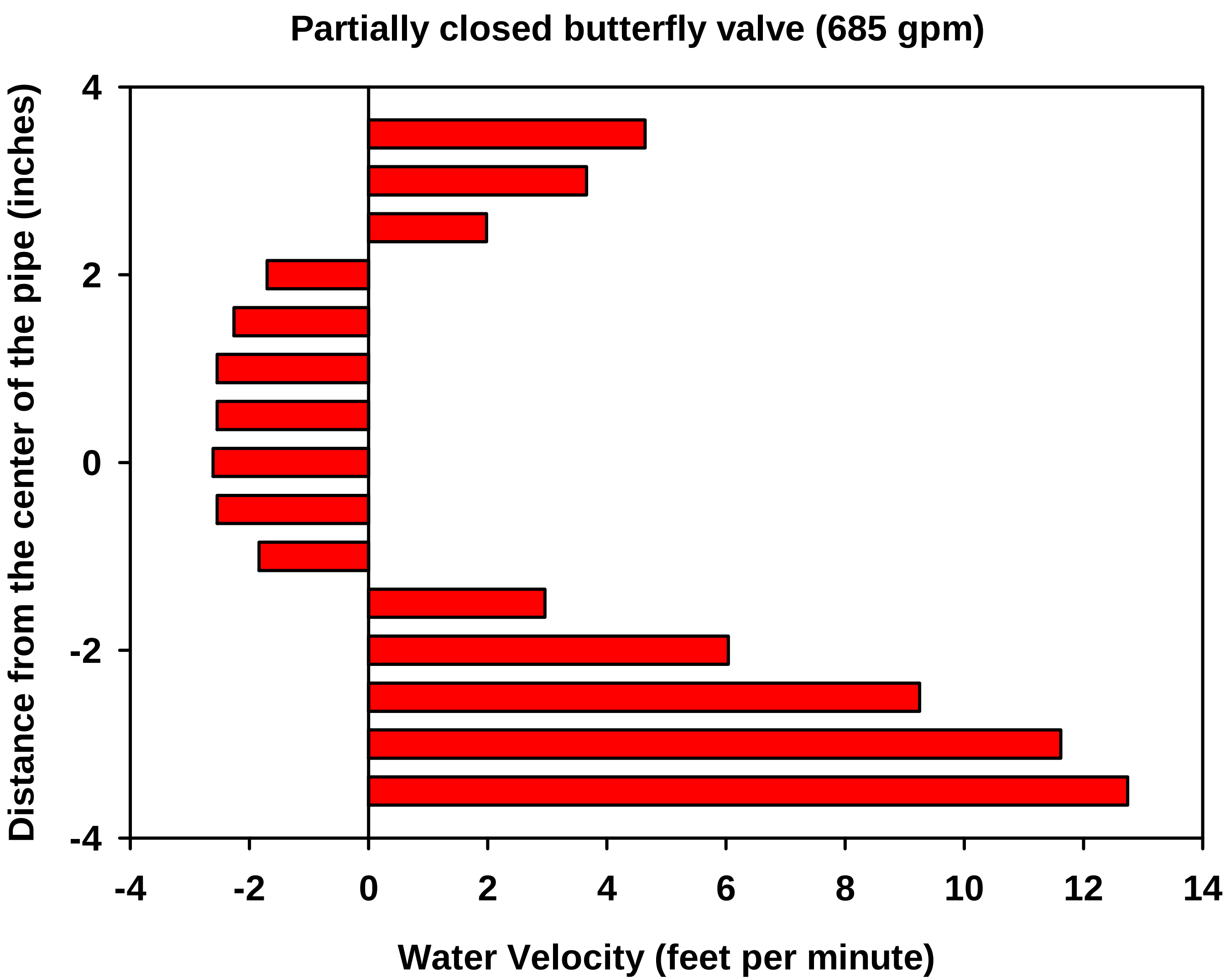



Point Velocity
Velocity Averaging



Control - no excessive turbulence
4
2
0
-2
-4
Distance from center of pipe (inches)
0
1
2
3
4
5
6
7
8
Water velocity (feet per second)


Elbow (692 gpm, 2 pipe diameters)
Distance from the center of the pipe (inches)
4
2
0
-2
-4
0
1
2
3
4
5
6
Water Velocity (feet per minute)


Partially closed butterfly valve (685 gpm)
Distance from the center of the pipe (inches)
4
2
0
-2
-4
-4
-2
0
2
4
6
8
10
12
14
Water Velocity (feet per minute)

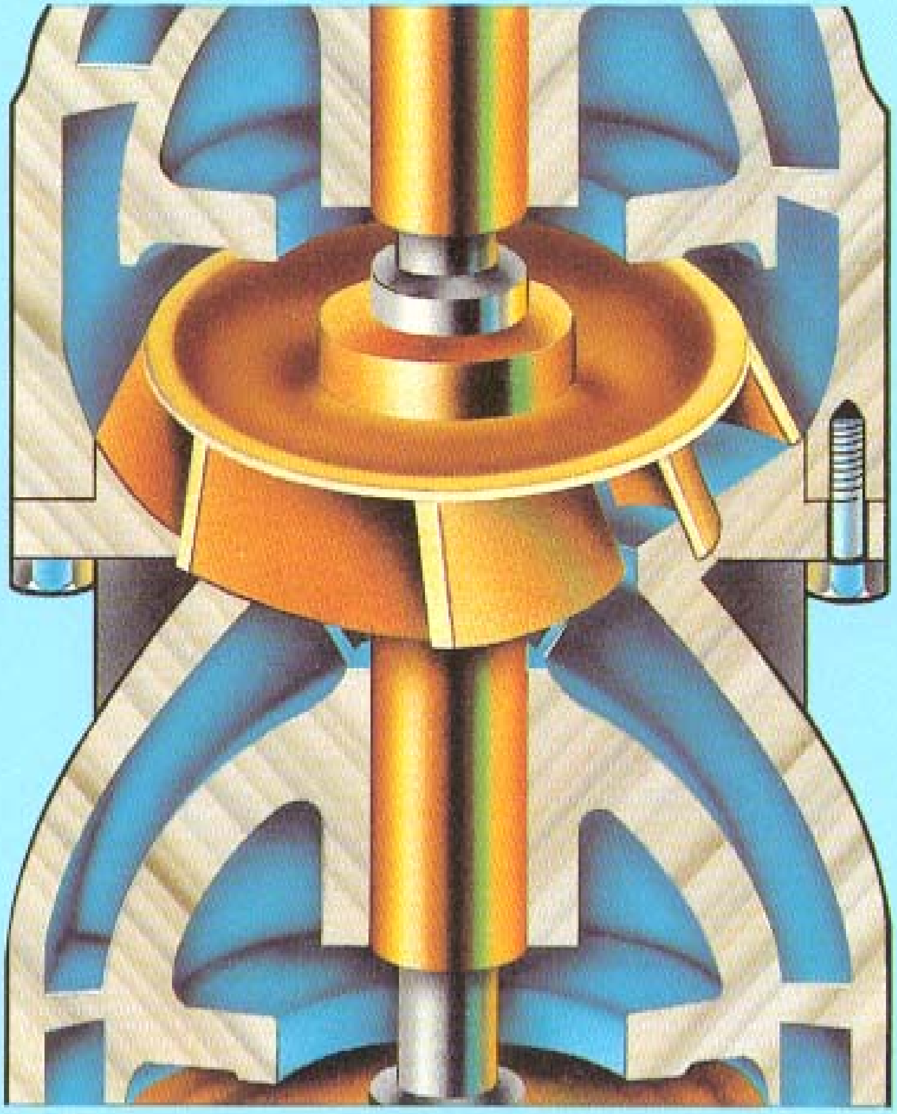
Input horsepower

- **Electric motors**
  - **Power meter**
  - **IHP = Kw ÷ 0.746**
- **Engines**
  - **Dynamometer (BHP) – not practical for growers (requires training)**
  - **Fuel use**
    - **IHP = q x K ÷ 2,545**
    - **q = fuel consumption in gallons per hour**
    - **K = 139,000 for diesel, 125,000 for gasoline, 91,000 for propane, 84,600 for ethanol**

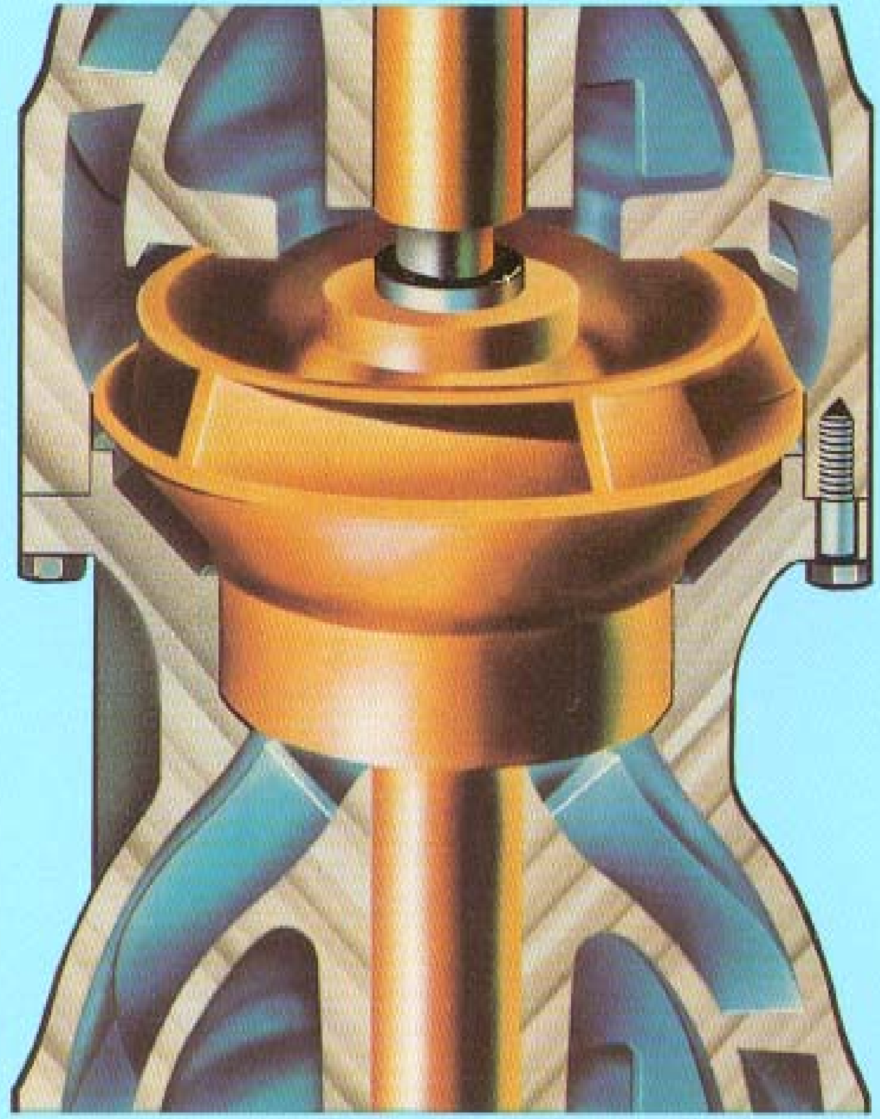
Improving overall pumping plant efficiency

- Causes of poor efficiency
  - Mismatched pump
    - Improperly selected pump
    - Changes in operating conditions
  - Worn pump
  - Surging in well
  - Cascading water in the well
- Methods of improving efficiency
  - Replace improperly selected pump or mismatched pumps with a properly selected pump
  - Worn pumps
    - Impeller adjustment
    - Repair pump
    - Replace pump

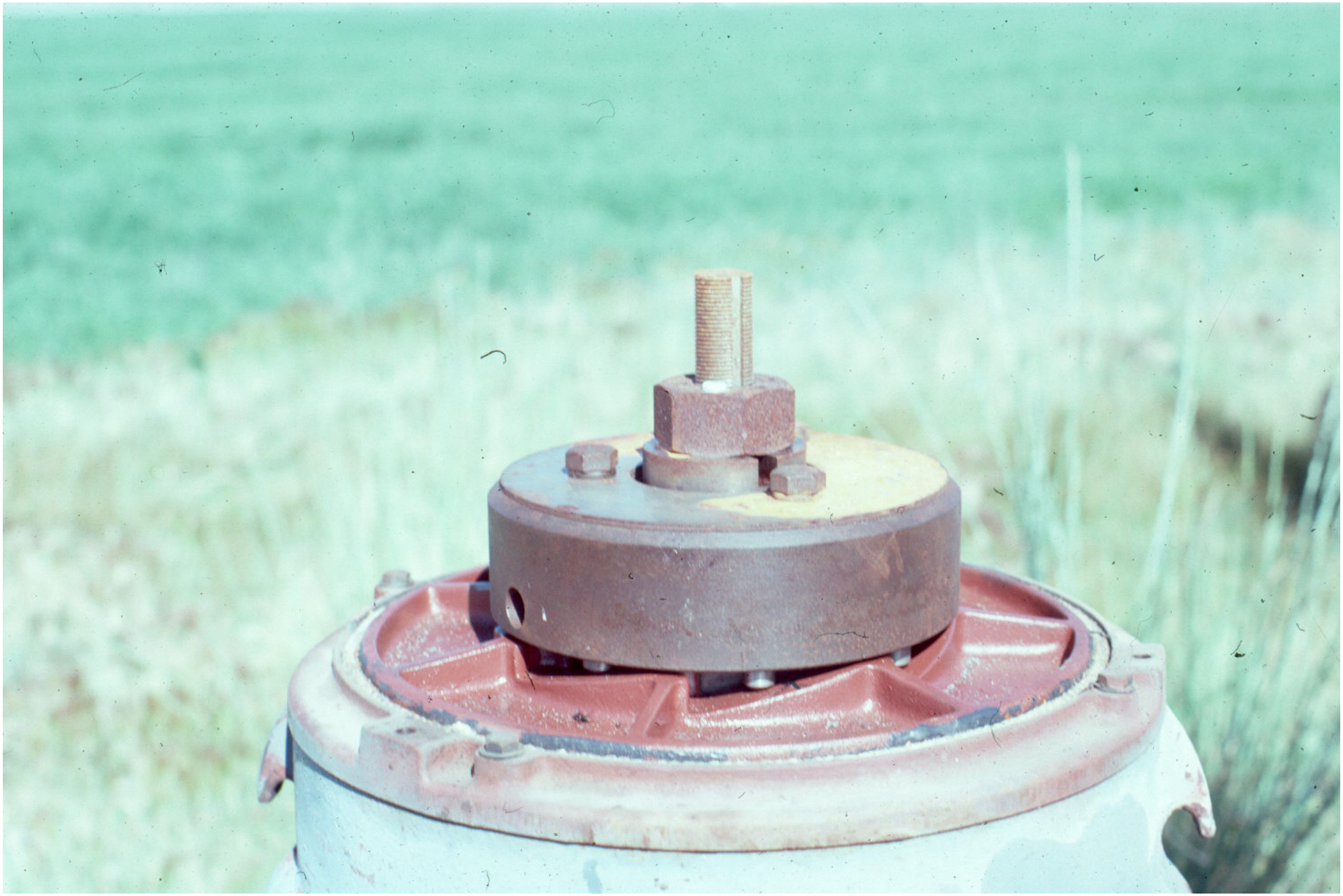
Impeller adjustment



Semi-Open Impeller



Enclosed Impeller




BVID

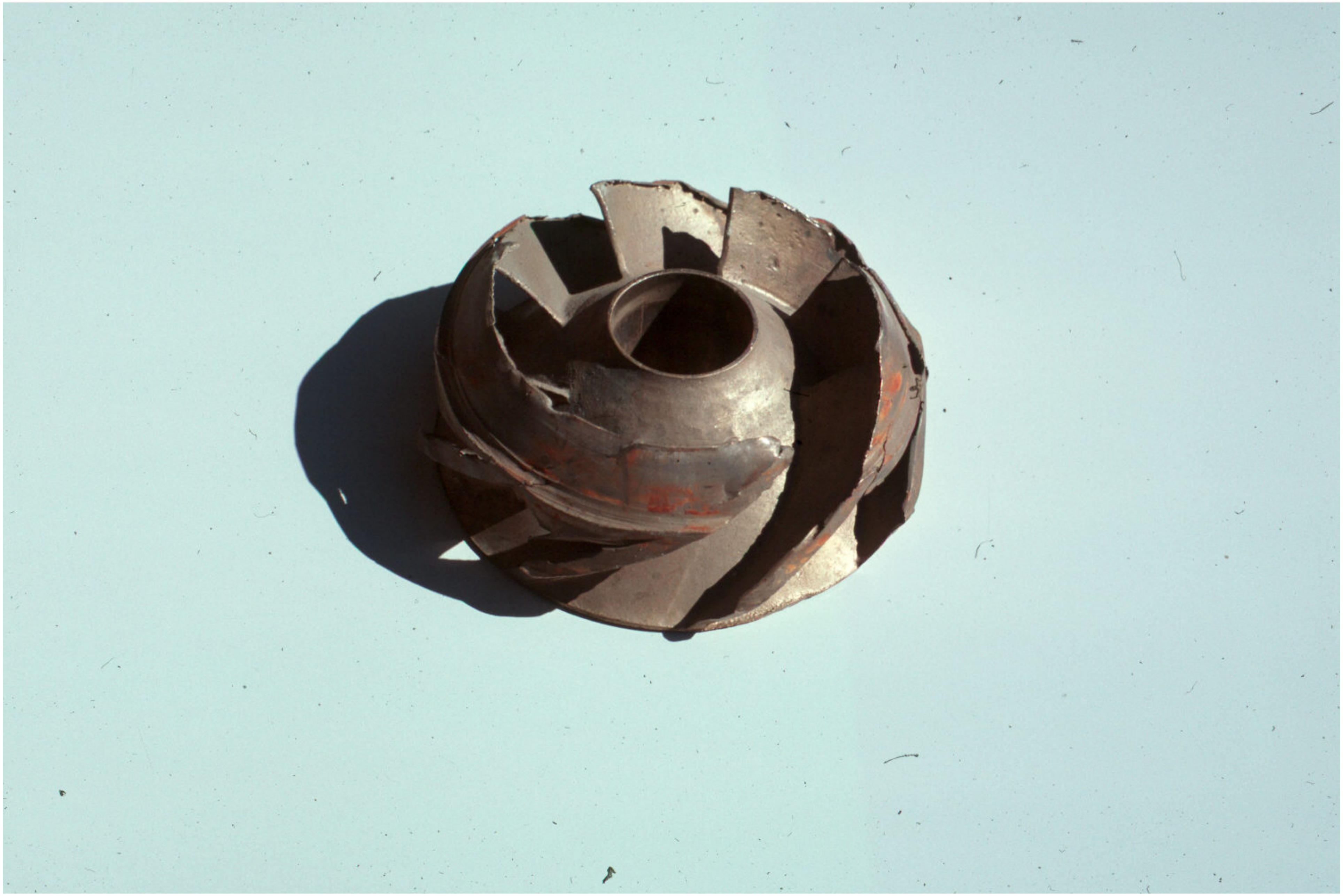
Effect of Impeller Adjustment

		Capacity (gpm)	Total Head (feet)	Overall Efficiency (%)	Input Horsepower
Pump 1	Before	605	148	54	42
	After	910	152	71	49
Pump 2	Before	708	181	59	55
	After	789	206	63	65
Pump 3	Before	432	302	54	61
	After	539	323	65	67
Pump 4	Before	616	488	57	133
	After	796	489	68	144

Does an impeller adjustment reduce energy costs?

- Energy costs are based on Kilowatt-hours of energy used
  - Kw is related to IHP
  - Hours – operating time
- Effect of adjustment
  - Increased flow rate
  - Increased pumping lift?
  - Increased IHP
- Energy costs increase because of increased IHP unless pumping time is reduced regardless of how much the efficiency increased
- Primary benefit may be the increased flow rate

Repair worn pump

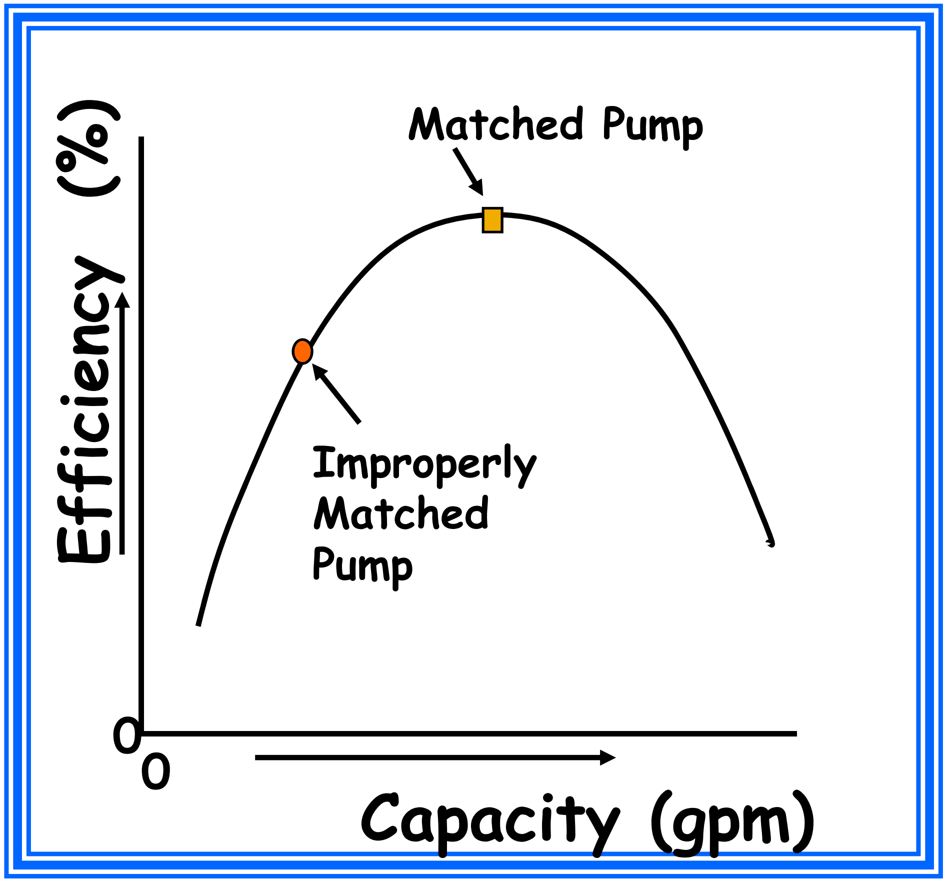


Effect of Pump Repair

- **Before**
  - Pumping lift = 95 feet
  - Capacity = 1552 gpm
  - IHP = 83
  - Efficiency = 45%
- **After**
  - Pumping lift = 118 feet
  - Capacity = 2008 gpm
  - IHP = 89
  - Efficiency = 67%

Mismatched pump

- A mismatched pump is operating properly but not at its maximum pump efficiency
- Pump should be replaced with one that provides the same flow rate and head at its maximum efficiency



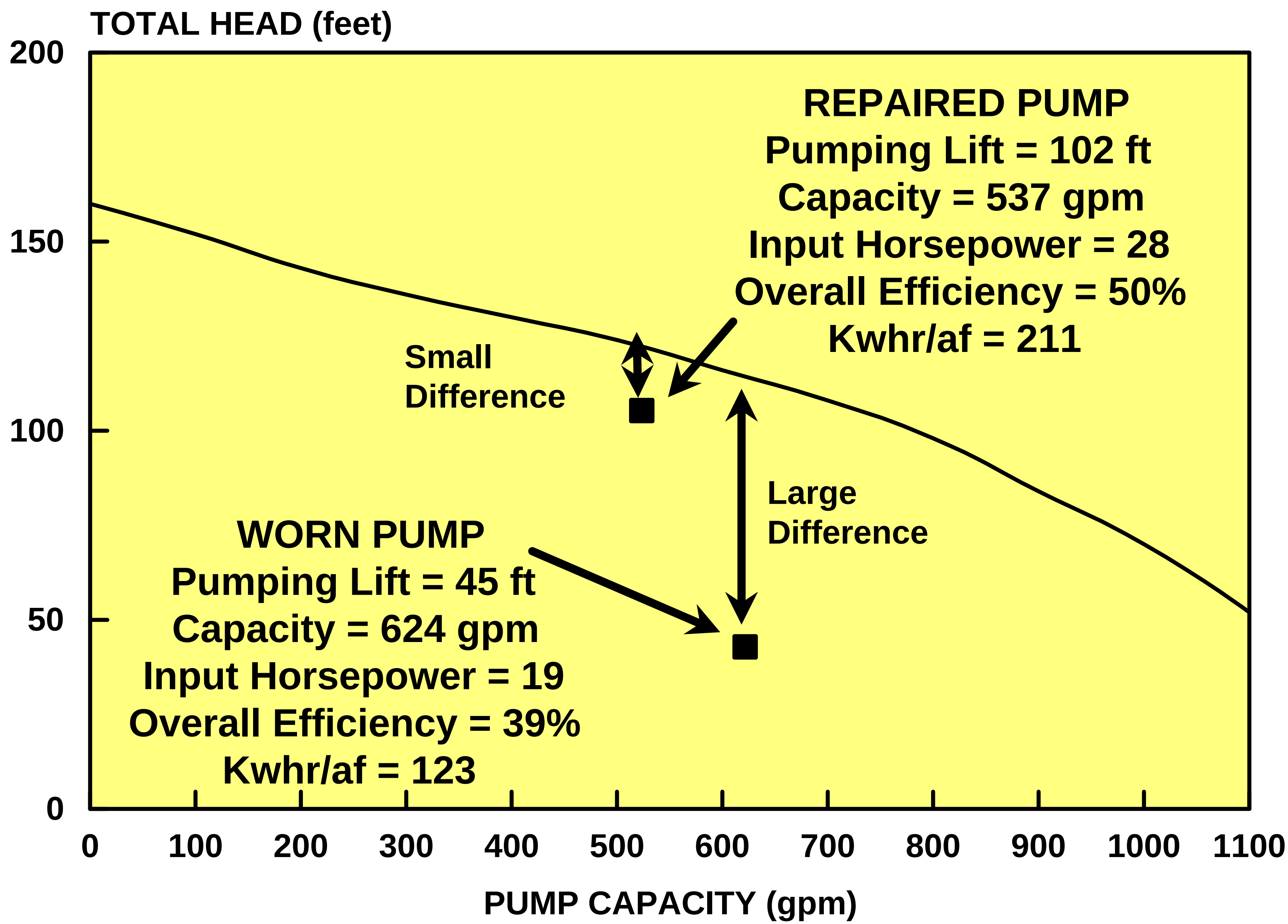
Replacing a Mismatched Pump

- Pumping plant efficiency will increase
- Input horsepower demand will decrease
- Energy savings will occur because of the reduced horsepower demand

Recommendations for electric pumping plants

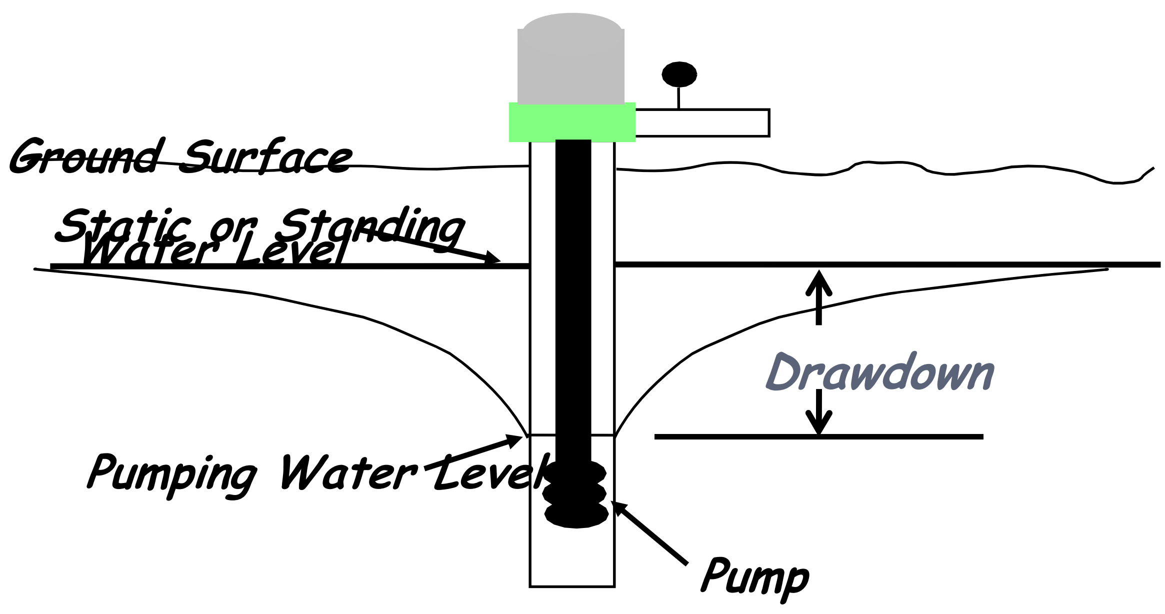
- ☺ E_o greater than 60% - no corrective action
- 😐 55% to 60% - consider adjusting impeller
- 😐 50% to 55% - consider adjusting impeller; consider repairing or replacing pump if adjustment has no effect
- ☹ Less than 50% - consider repairing or replacing pump

Effect of pump efficiency and well efficiency



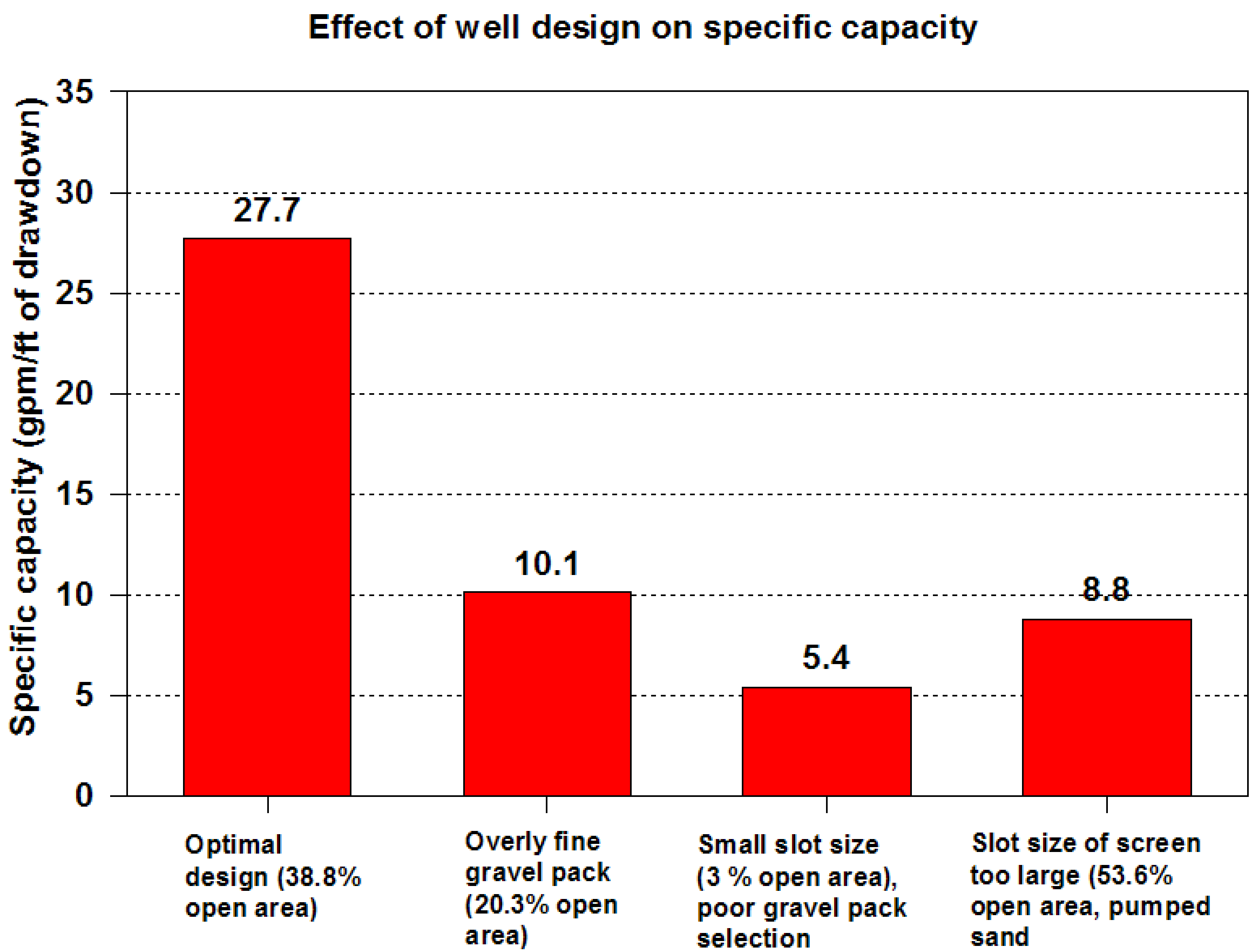
Well efficiency

- Definition: actual specific capacity ÷ optimal or theoretical specific capacity
- Specific capacity = pump capacity ÷ drawdown in the well
- Difficult to estimate the well efficiency

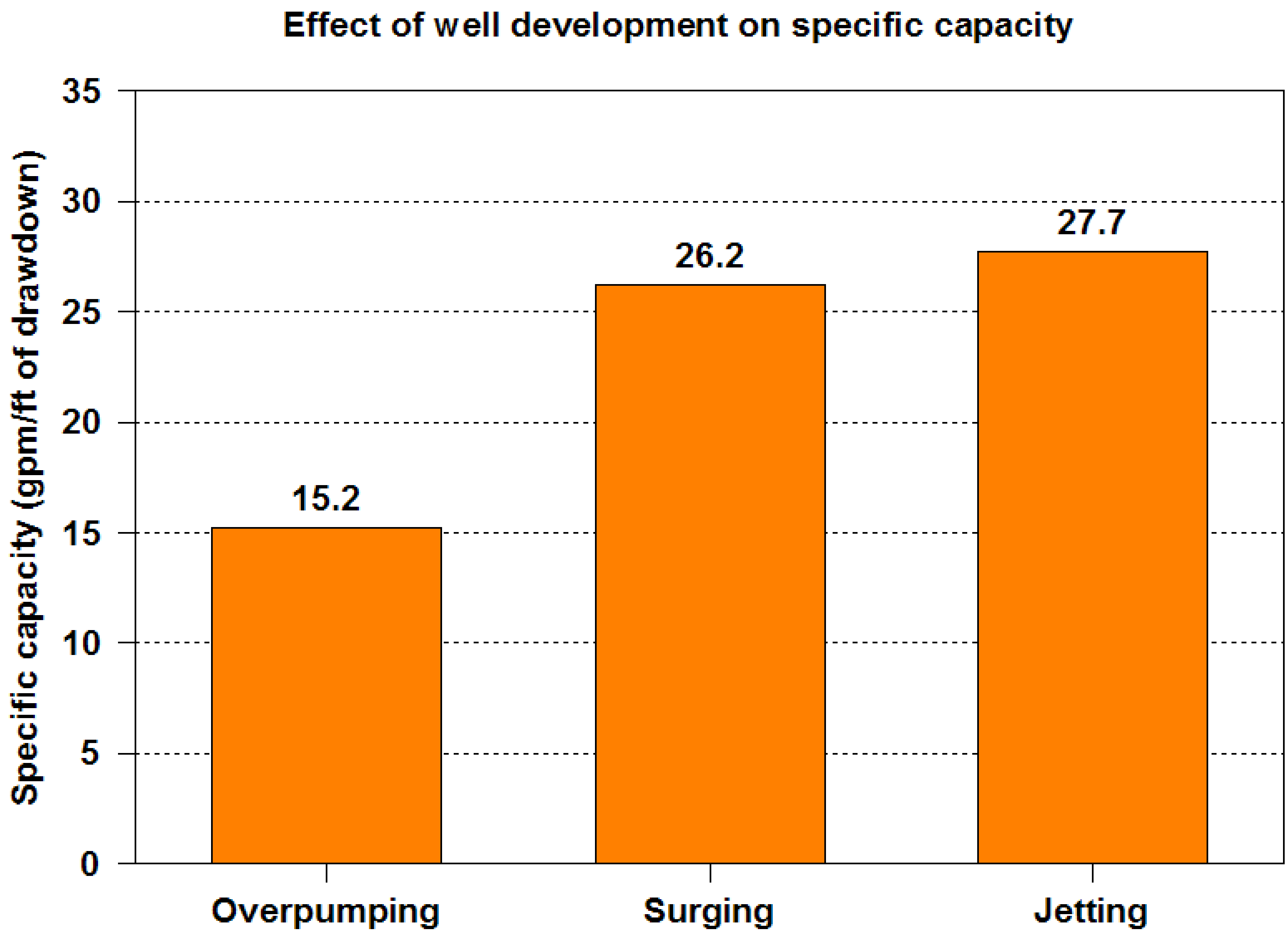


Factors affecting well efficiency

- Well construction
- Well Design
    - Diameter
    - Openings into the well (open area, location)
    - Gravel pack
- Well development
- Well maintenance



Source: The Johnson Drillers Journal, 1981



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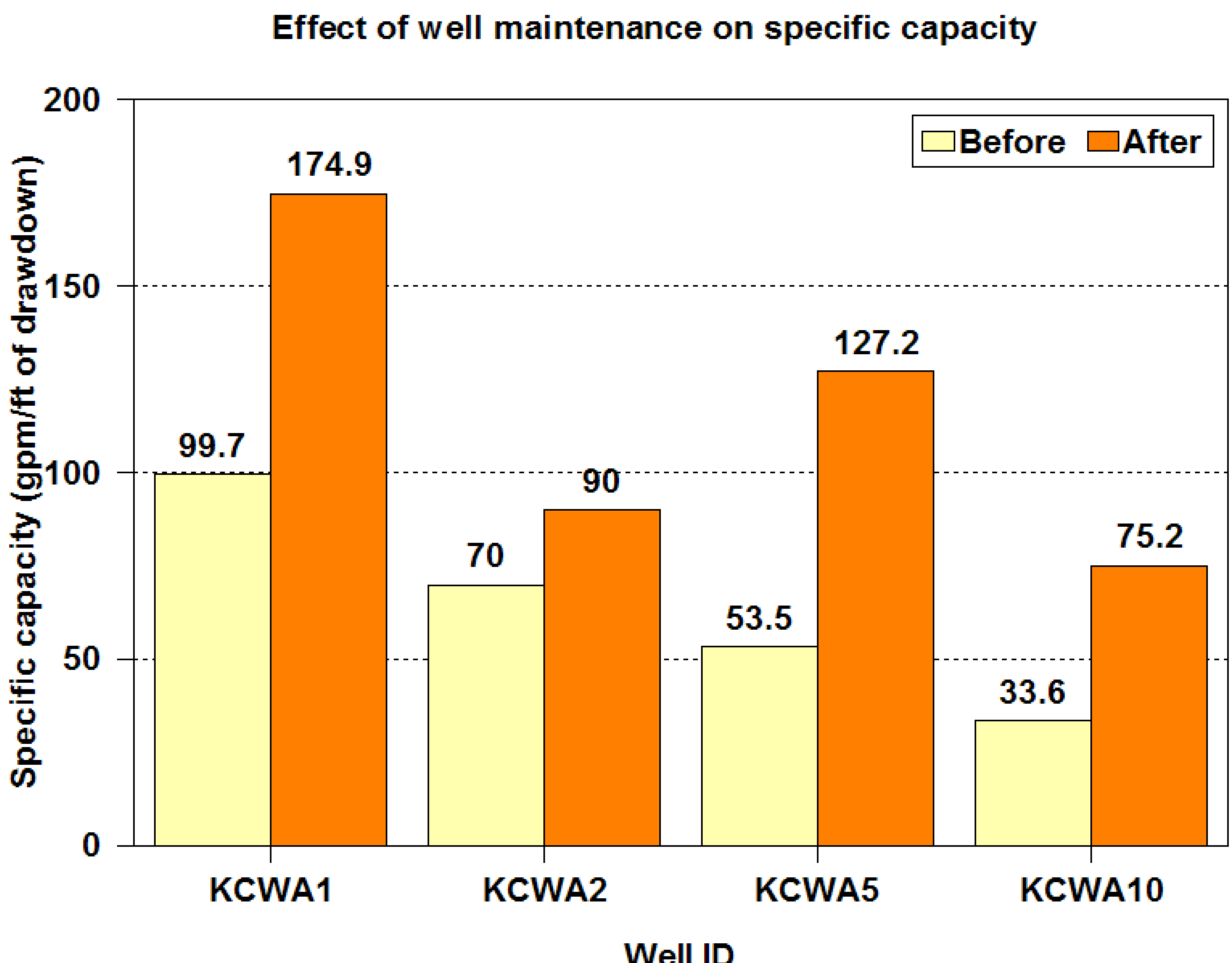

Source: Tulare workshop

Let's Eat!