Wastewater Treatment Plant Pumping

4th Annual Wastewater Conference

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Civil Water Solutions, LLC

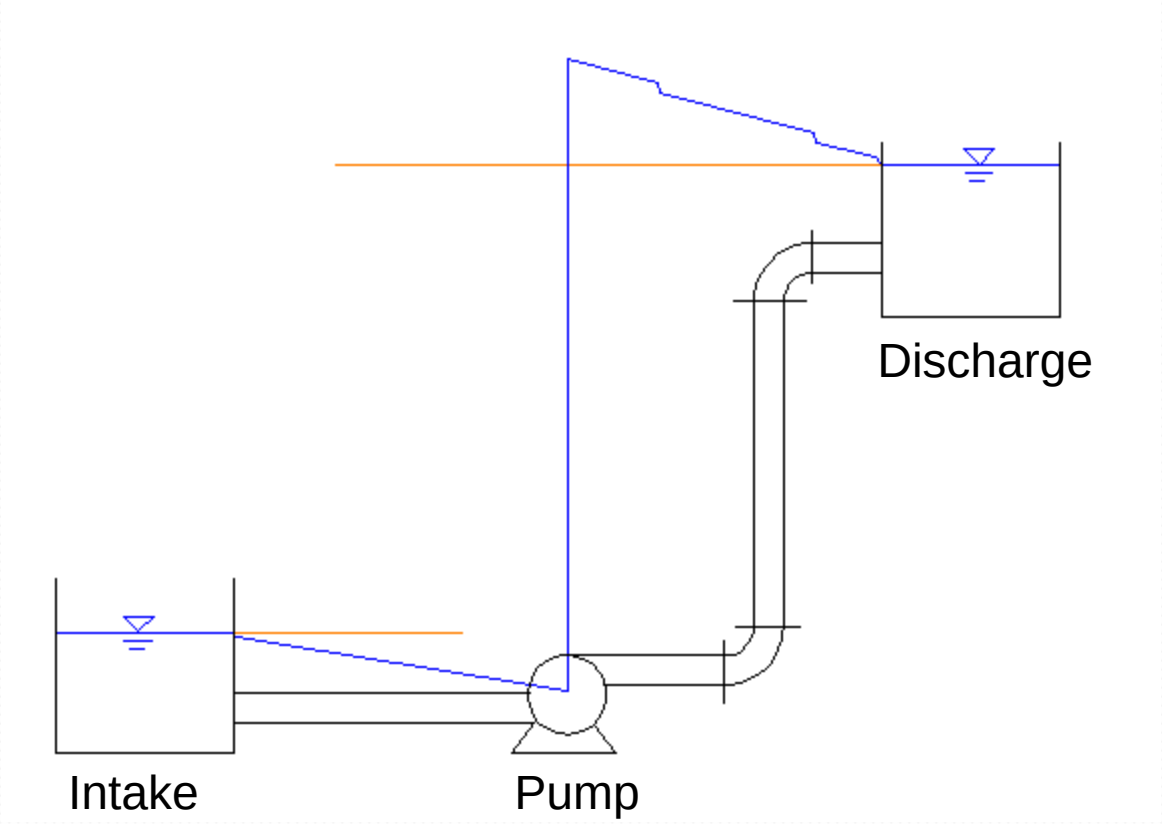
Curriculum

- Session 1 – Overview of Wastewater Pumping
- Session 2 – Liquid Stream Process Pumps
- Session 3 – Solids Stream Process Pumps
- Session 4 – Service Pumps and Conclusion

Session 1 – Overview of Wastewater Pumping

- Introduction to Pump Theory Basics
- Common Hydraulic Problems with Pump Systems

Simple Pump System



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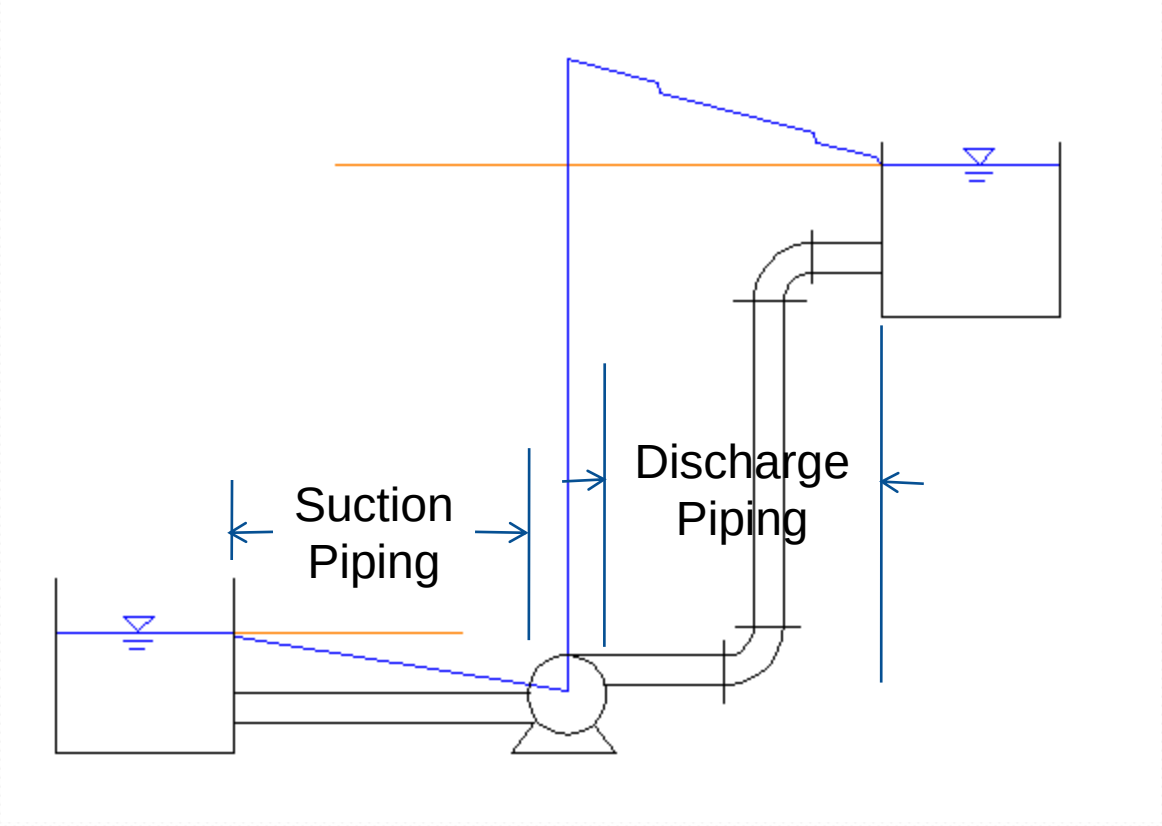

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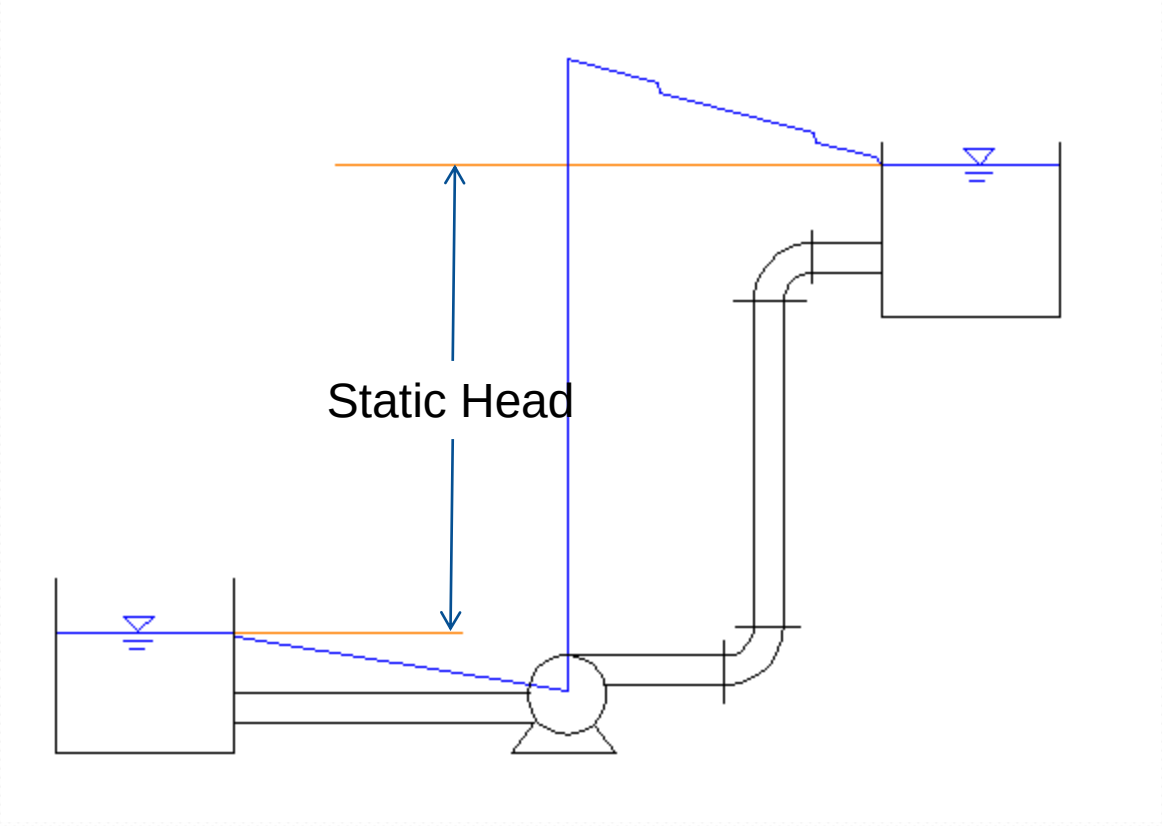

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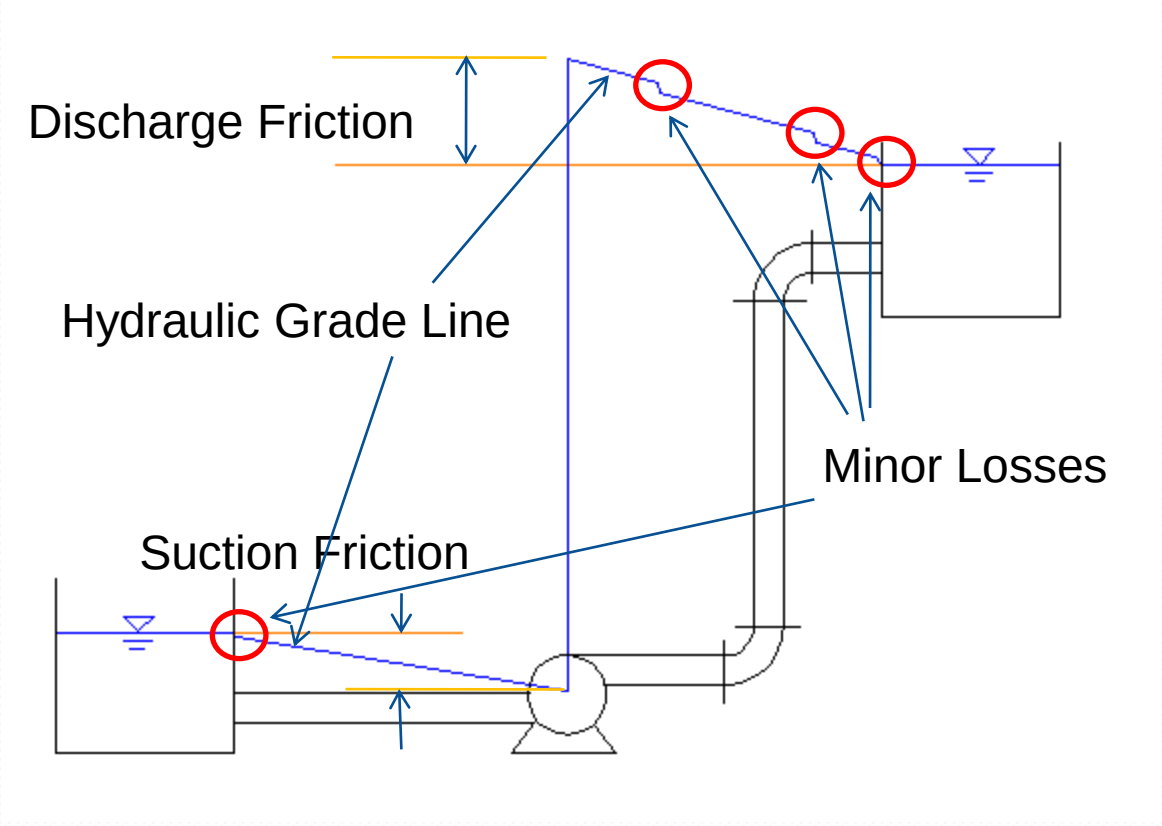
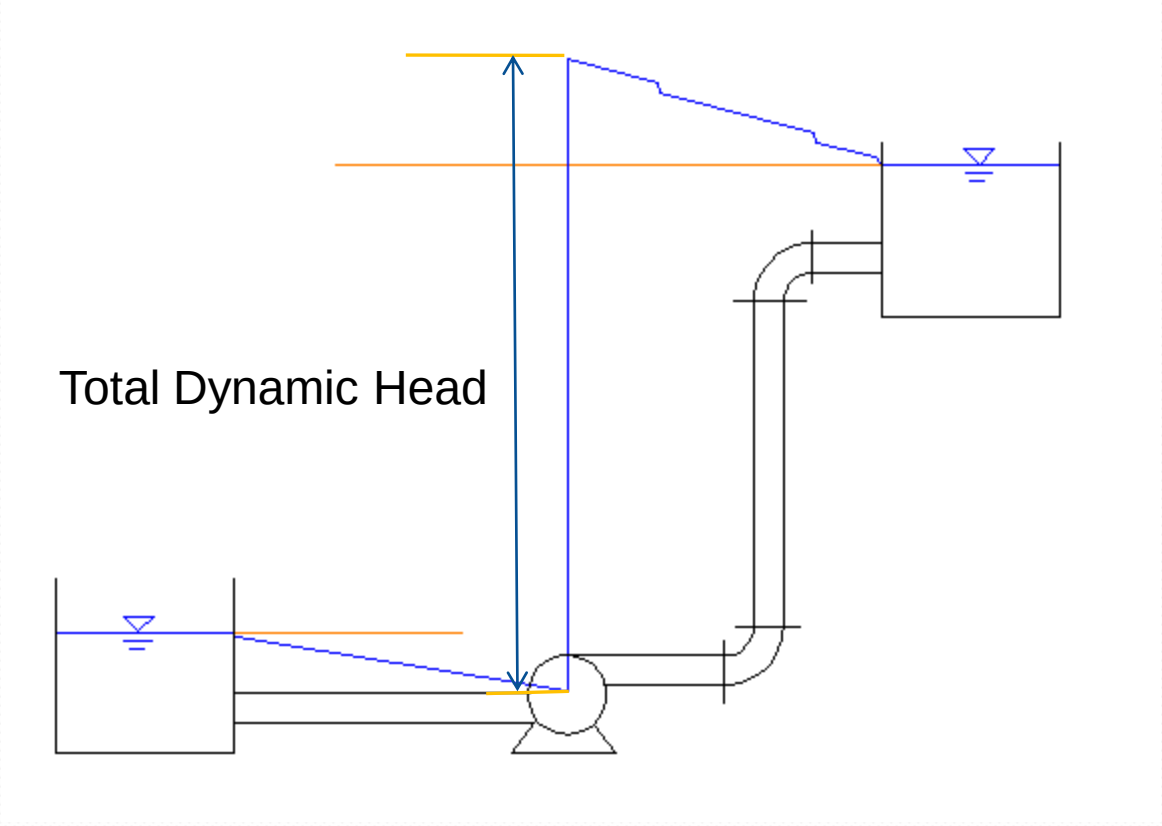
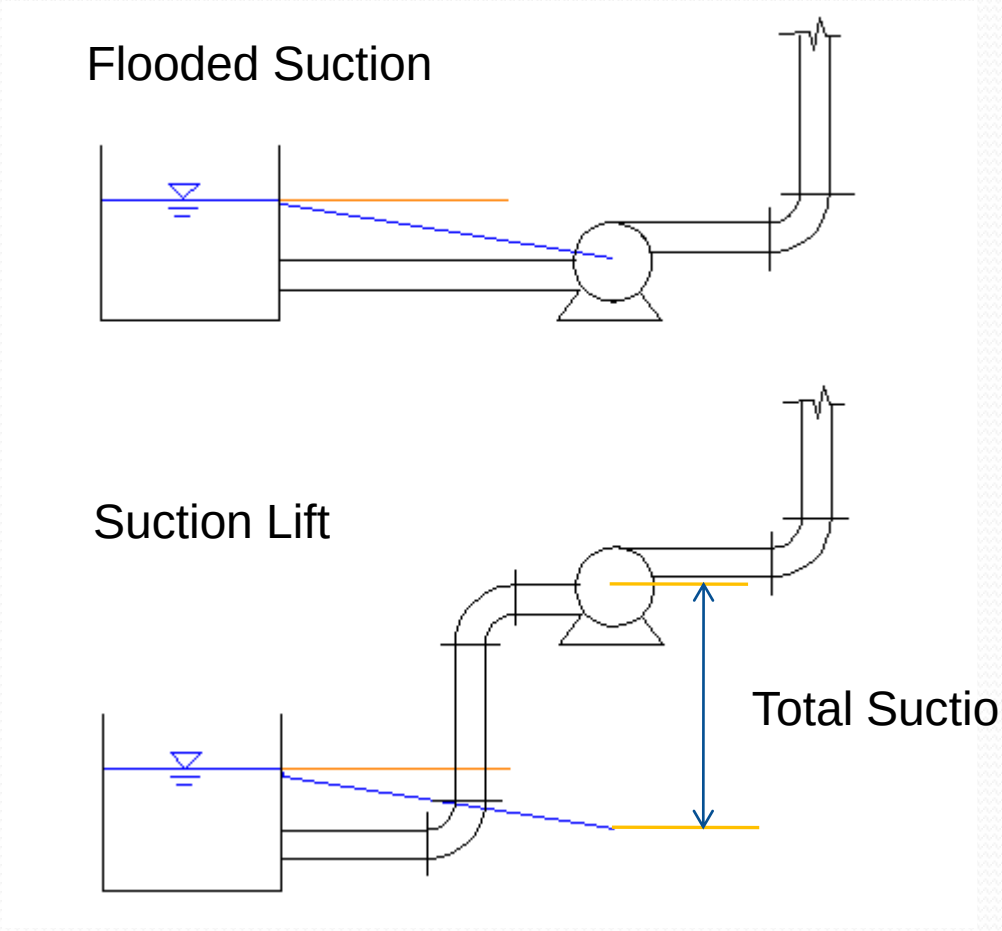


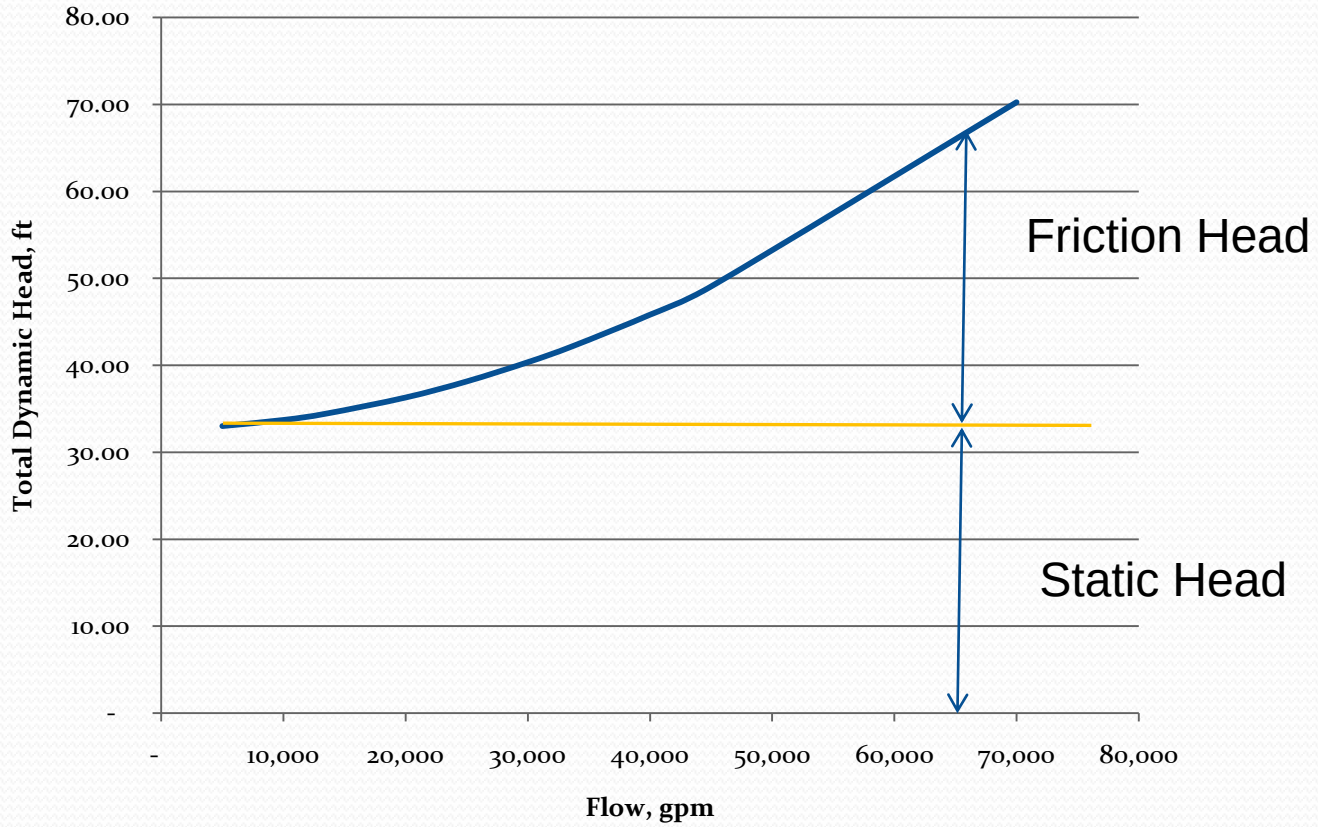
Simple Pump System



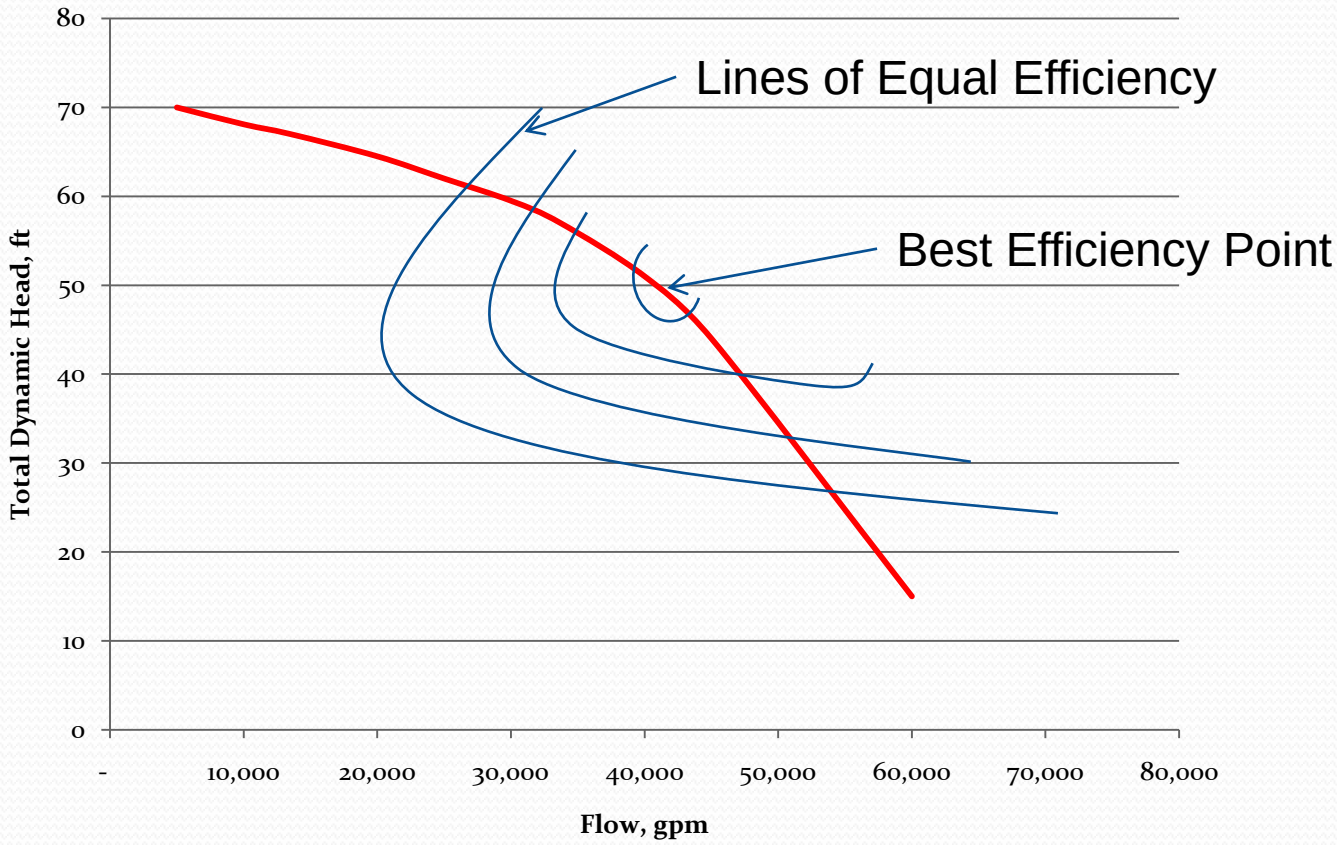
Two Types of Suction Conditions



System Head Curve

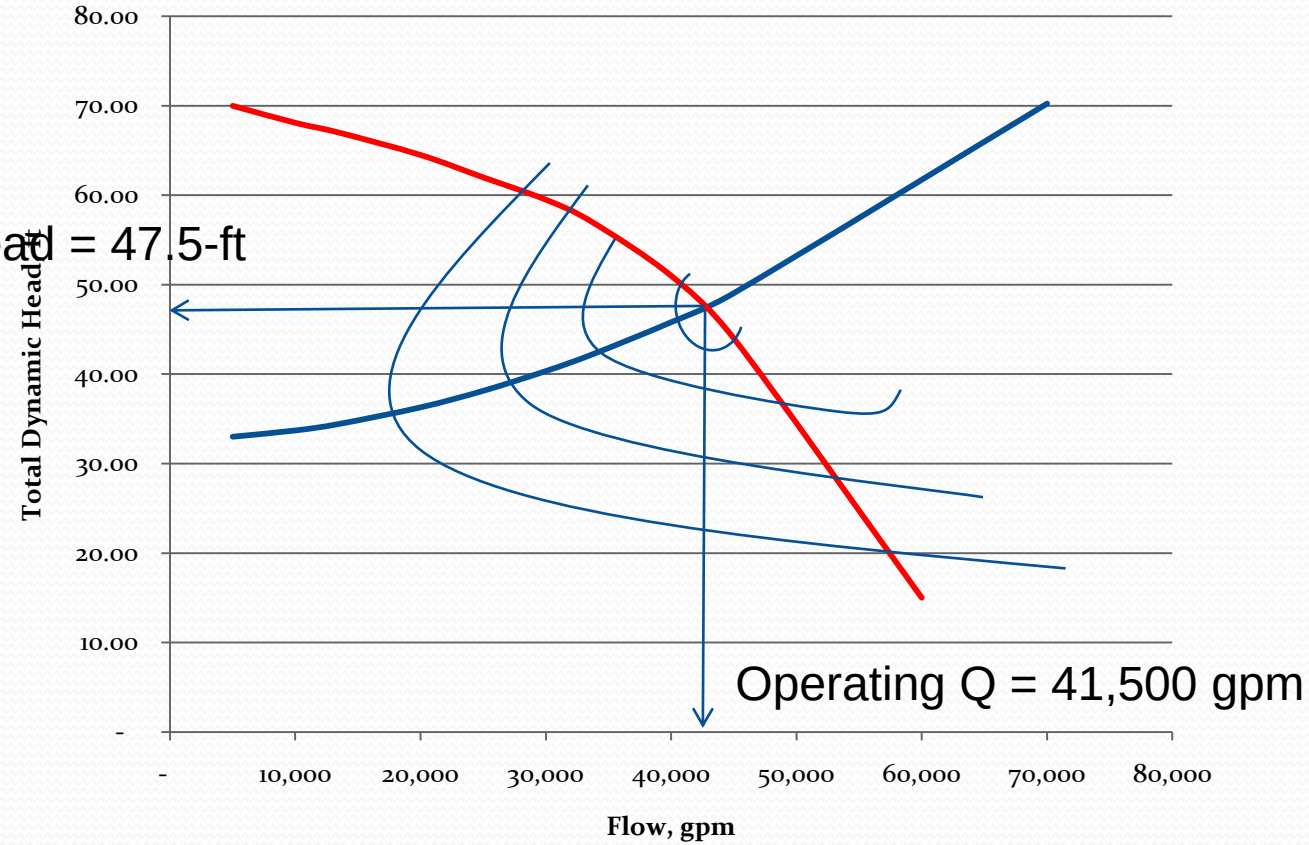


Pump Curve


Lines of Equal Efficiency
Best Efficiency Point
Total Dynamic Head, ft
80
70
60
50
40
30
20
10
0
-
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
Flow, gpm

Combined System Head/Pump Curve

Operating Head = 47.5-ft



Calculating Pump Horsepower

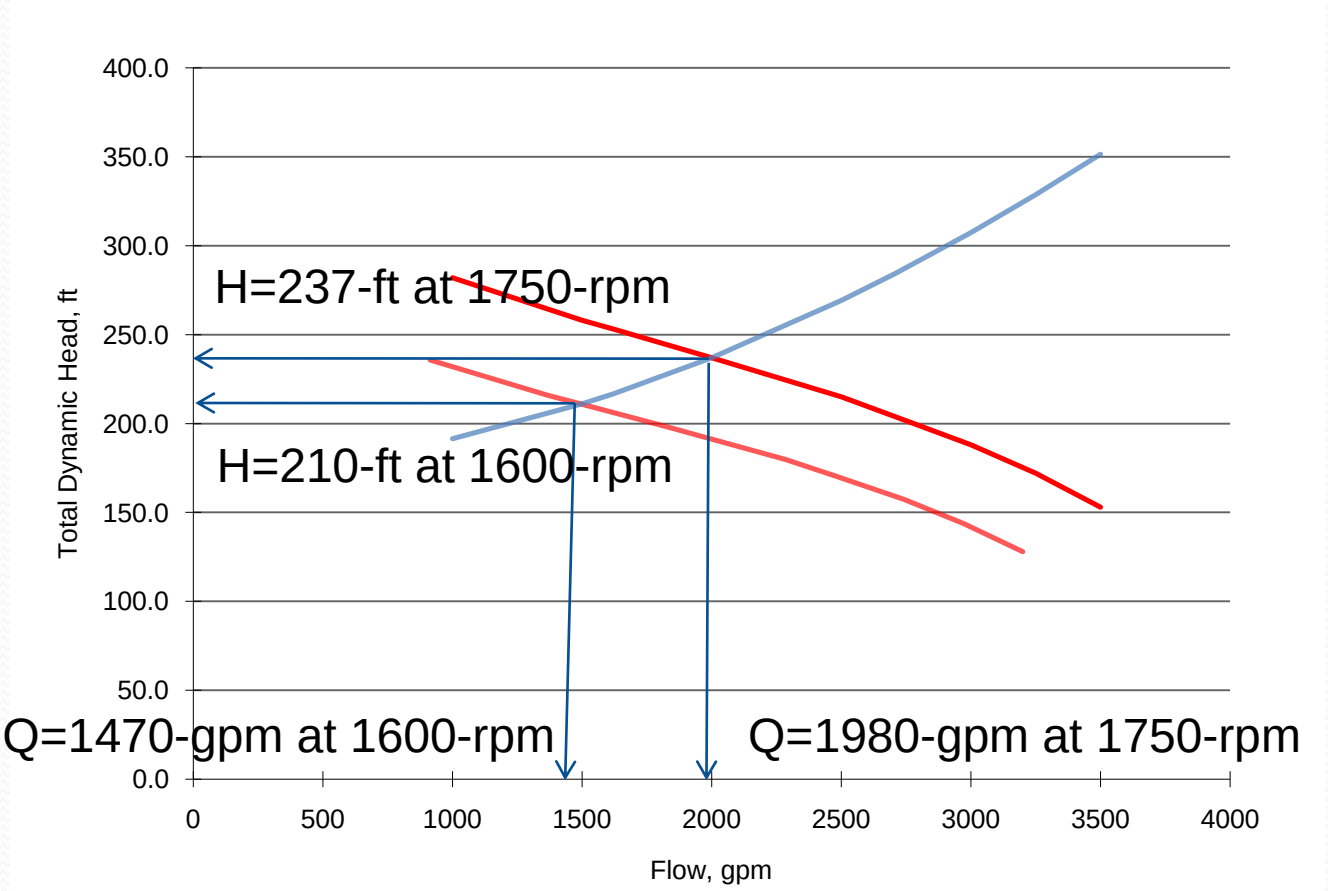
$$HP = \frac{QH}{3960e}$$

Where:

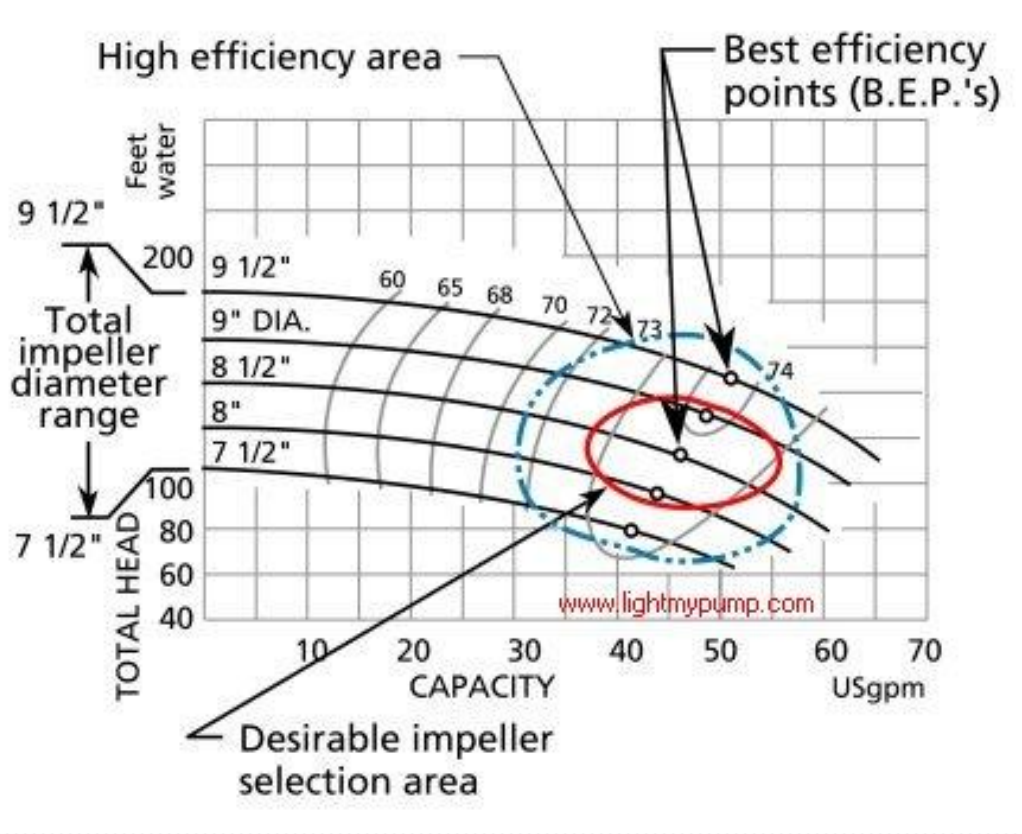
HP = Horsepower
Q = Flow in gallons per minute
H = Total Dynamic Head in feet
e = Pump Efficiency as decimal fraction

$$HP = \frac{41{,}500 * 47.5}{3{,}960 * 0.7} = 711$$

Variable Speed



Change to Impeller Diameter



Source: http://www.lightmypump.com/centrifugal-pump-tips.htm

Pump Classifications

- Based on Pump Specific Speed

$$n_s = \frac{n\sqrt{Q}}{H^{3/4}}$$

Where:

n_s = Specific Speed

n = pump speed, rpm

Q = flow, gpm

H = Total Dynamic Head per Stage, ft

Pump Classifications

- Radial Vane
  - Higher Head
  - Lower Flow
  - Lower Specific Speed
- Axial Flow (Propeller Pumps)
  - Low Head
  - High Flows
  - High Specific Speeds
- Mixed Flow
  - Moderate Head
  - Moderate Flows
  - Intermediate Specific Speeds

Pump Efficiency by Classification

Typical Best Efficiency at n_s between 2000 to 3000

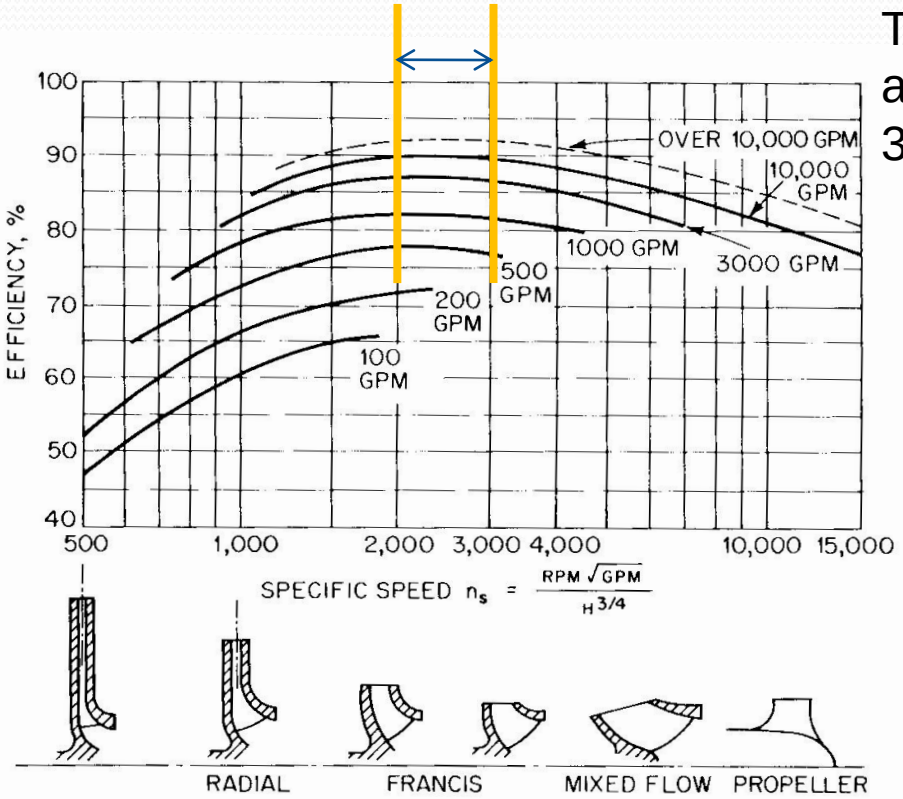


Fig. 7 Pump efficiency versus specific speed and size. (Worthington Pump International, Inc.)

Source: Pump Handbook. Karassik, et.al., McGraw-Hill, NY, NY,1976

Typical Pump Problems

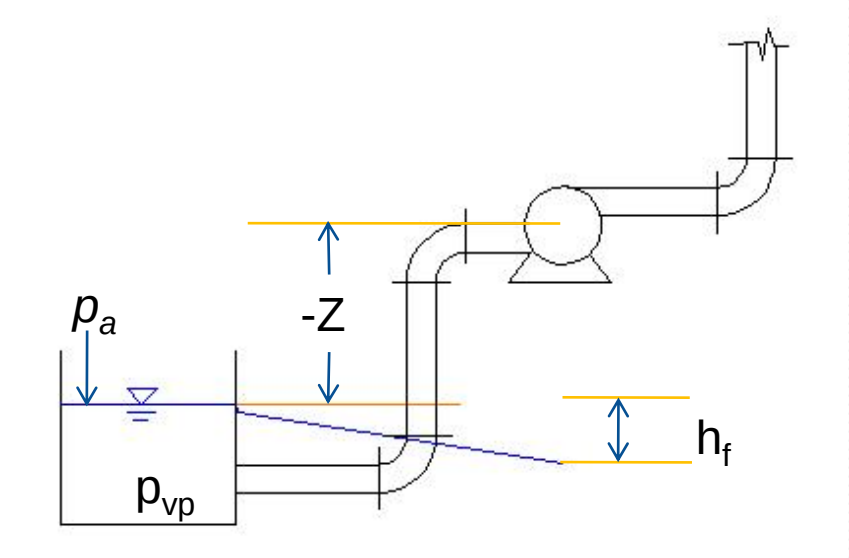
- Cavitation
- Pump Run-Out
- Worn Impellers
- Pre-Mature Bearing Failure Due to Dynamic Loads
- Improper Piping or Alignment

Cavitation

Source: http://www.irrigationcraft.com/diagnosing_cavitation.htm

- Leading cause of impeller wear
- Identified by crackling, sizzling, popping sound
- Caused by repeated formation and collapse of bubbles at low vapor pressure
- Result of insufficient net positive suction head (NPSH)

Net Positive Suction Head Available

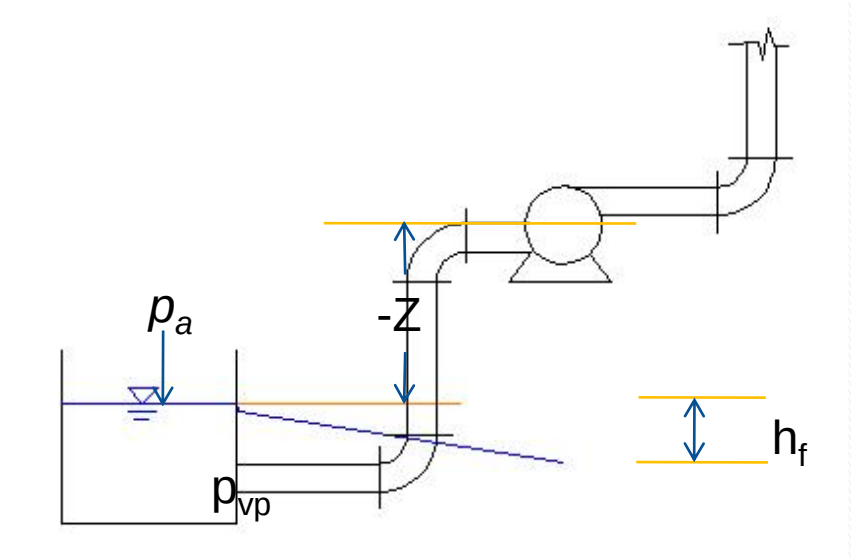


$$h_{sv} = \frac{p_a - p_{vp}}{\upsilon} + Z - h_f$$

Where:

h_{sv} = Net Positive Suction Head, ft
p_a = *Absolute Pressure, ft*
p_{sv} = *Vapor Pressure of Fluid, ft*
γ = *Specific Gravity of Fluid*
Z = *Elevation Difference, ft*
h_f = *Suction Friction Loss, ft*

Net Positive Suction Head Available

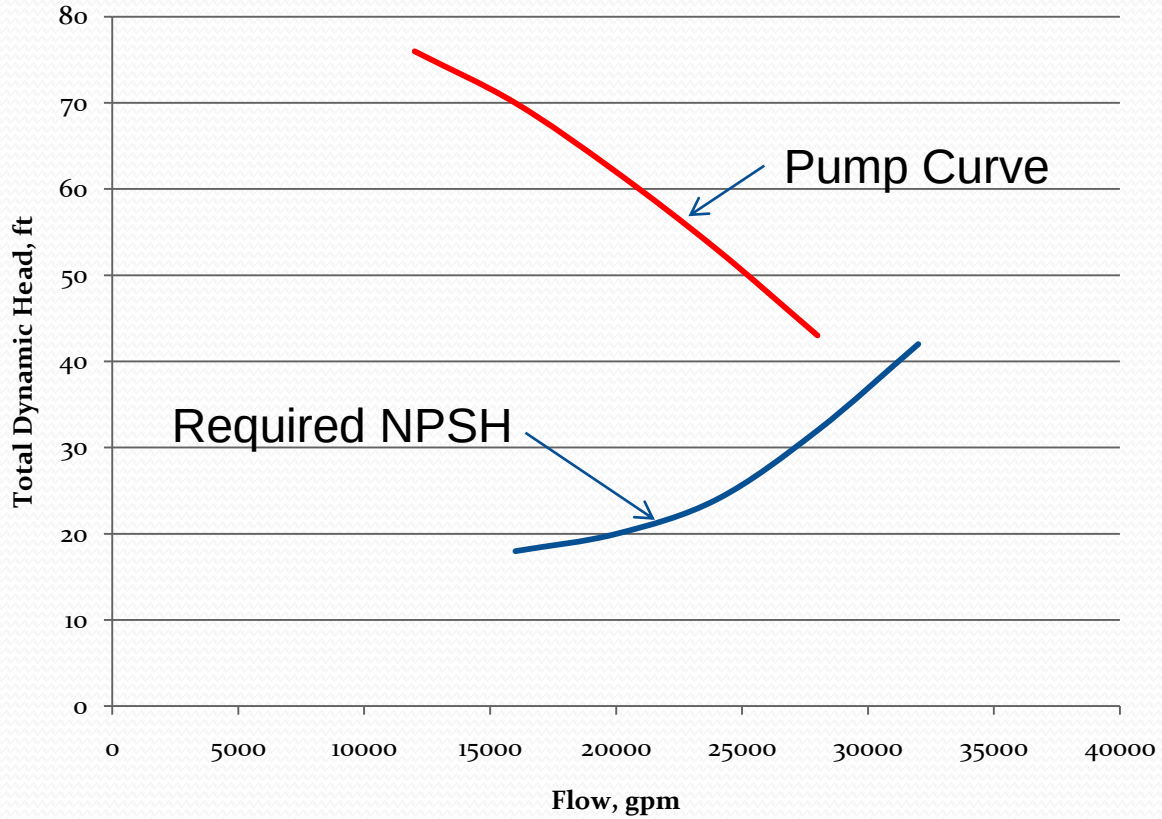


$$h_{sv} = \frac{p_a - p_{vp}}{\upsilon} + Z - h_f$$

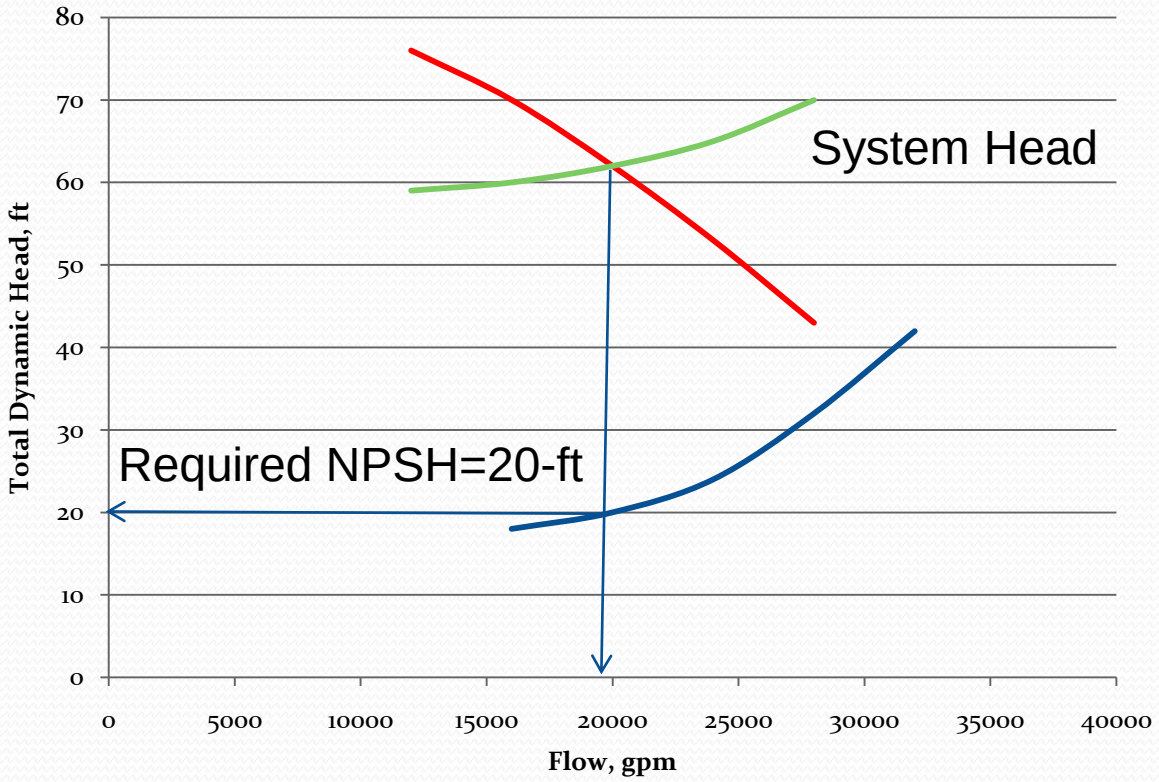
Where:

p_a = 28.2-ft at 5000-ft MSL
p_{sv} = 0.59-ft at 60 °F
γ = 0.999 at 60 °F
Z = -5-ft
h_f = 1.5-ft
h_{sv} = 21.14-ft

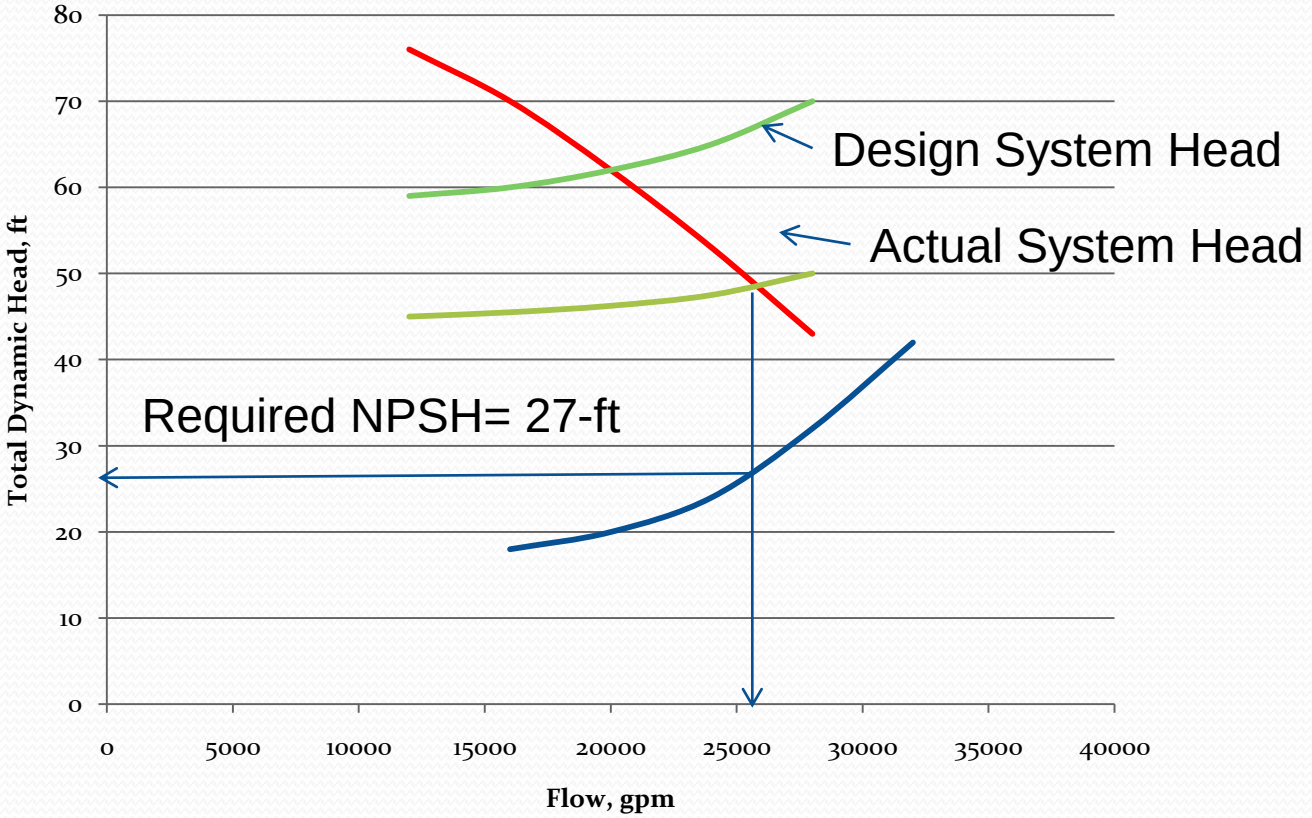
Net Positive Suction Head Required



Net Positive Suction Head Required



Cavitation Example

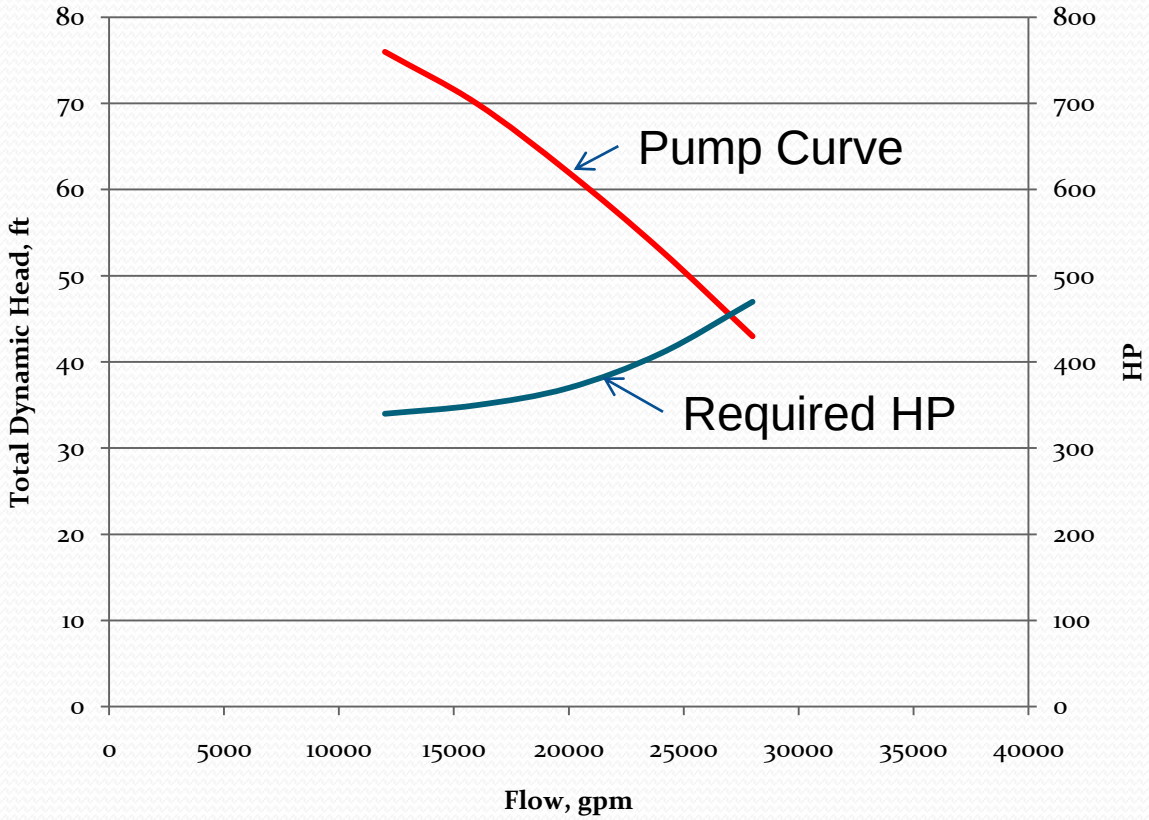


Pump Will Cavitate!

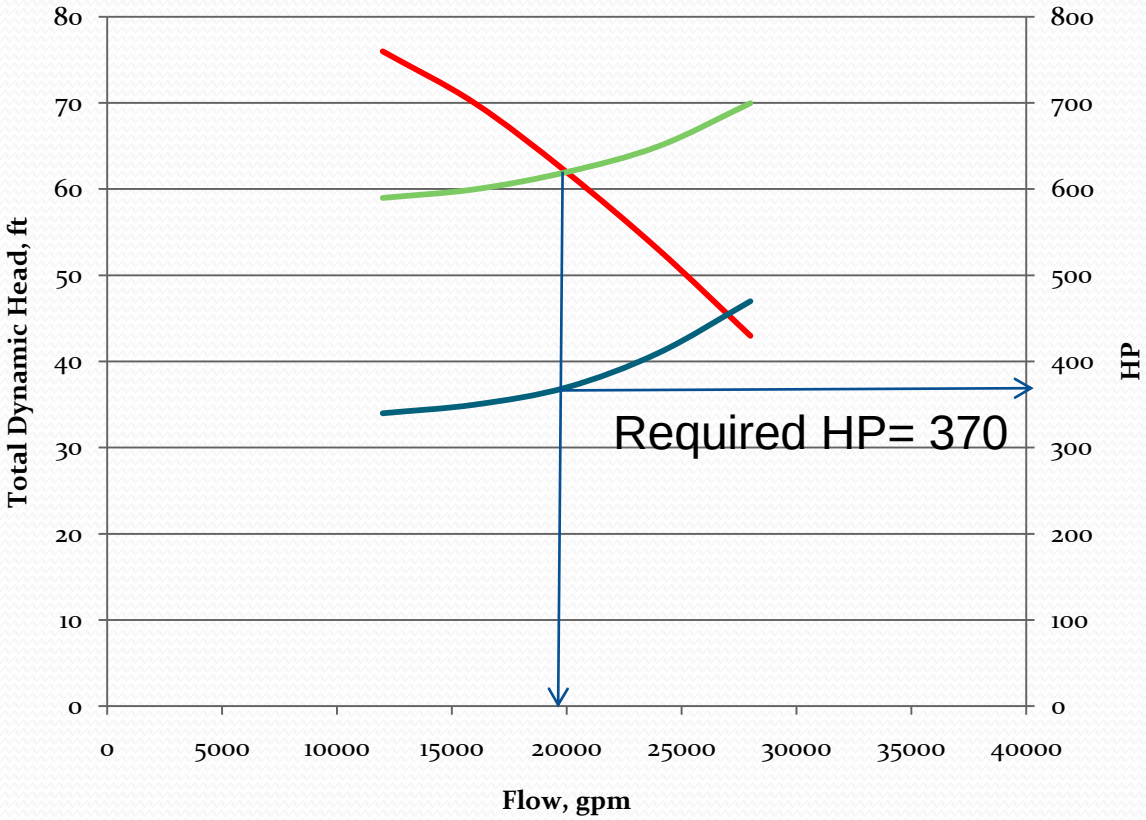
Correcting Cavitation Problems

- Provide More Suction Head
  - Raise Suction Water Level
  - Lower Pump
  - Provide Smooth Suction Entrance
  - Increase Suction Piping Diameter to Reduce Friction Loss
  - Straighten Suction Piping to Reduce Minor Loss
- Replace Impeller with “Tougher” Material
  - Nickel-Aluminum-Bronze>300 Stainless Steel>400 Stainless Steel>Monel>Manganese-Bronze>Cast Steel>Aluminum >Bronze>Cast Iron
- Provide Protecting Coating on Impeller
  - Neoprene > Polyurethane

Pump Run-Out Conditions

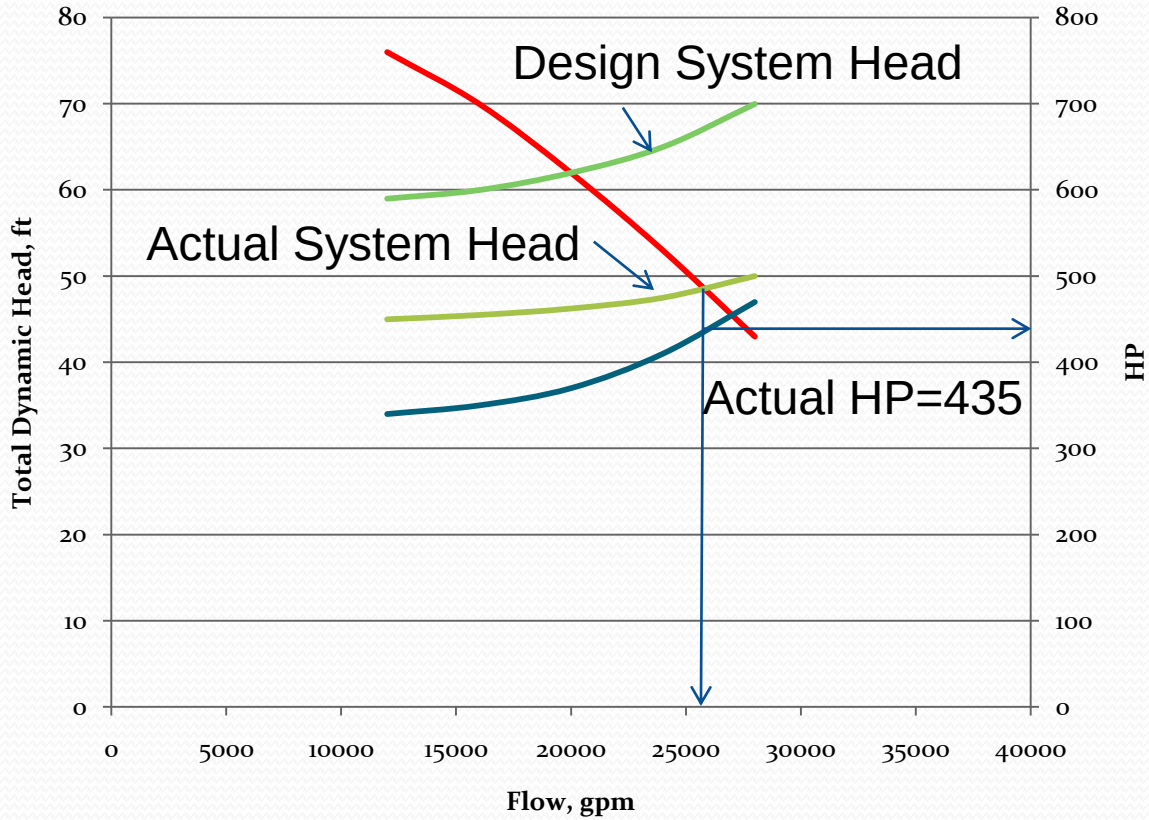


Pump Run-Out Conditions



Select 400 HP Motor

Pump Run-Out Conditions



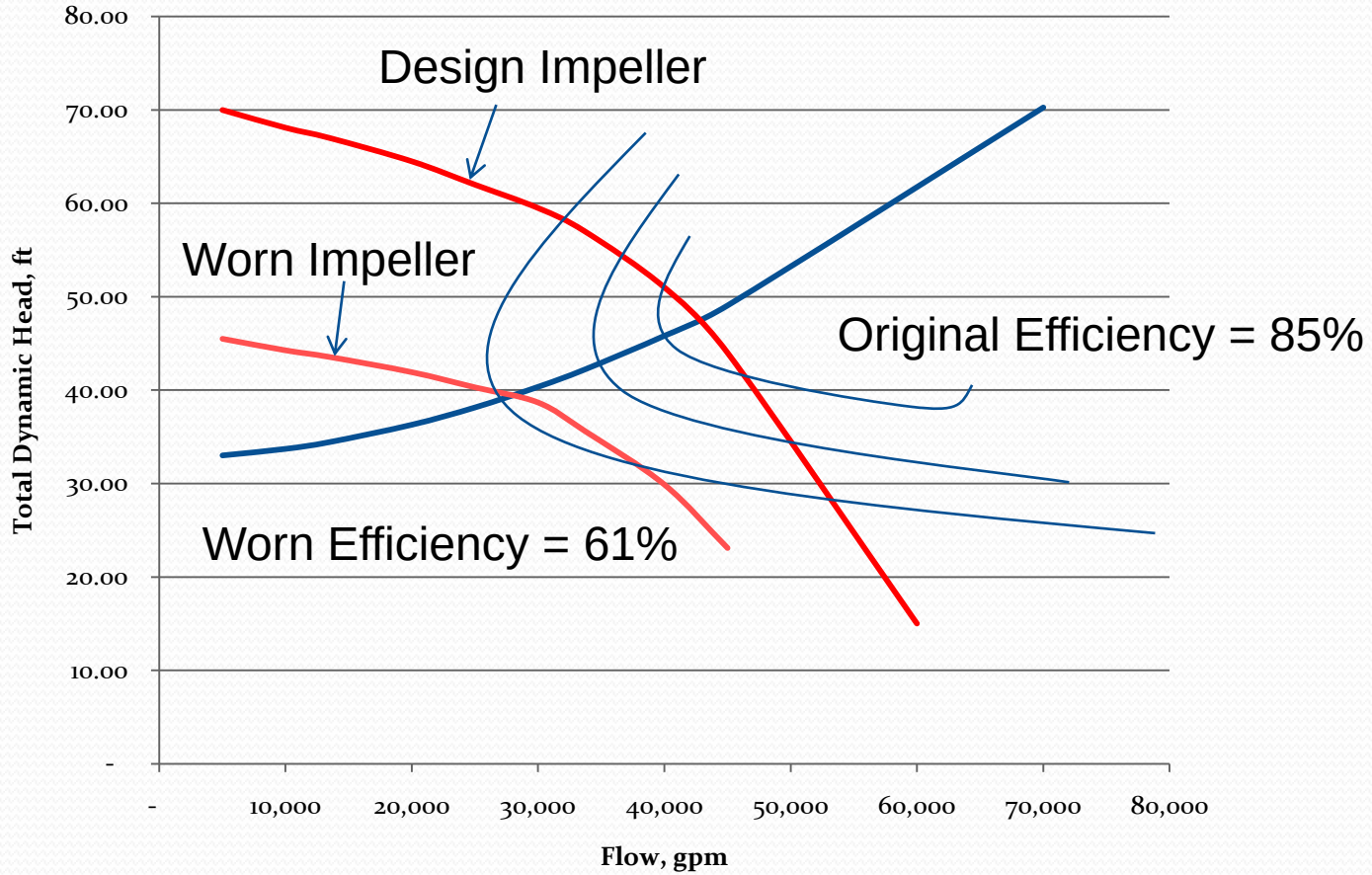
400-HP Motor Will Overheat and Eventually Burn-Up

Correcting Pump Run-Out

- Increase Total Dynamic Head – Adds to Operating Costs
  - Lower Suction Water Surface
  - Induce Increased Discharge Head with Control Valve
- Trim Impeller – May Change Efficiency
- Add VFD Drive to Reduce Operating Speed – Added Capital Cost and VFD Energy Loss

All Else Being Equal – Adding VFDs is Usually the Better Option

Impact of Worn Impeller

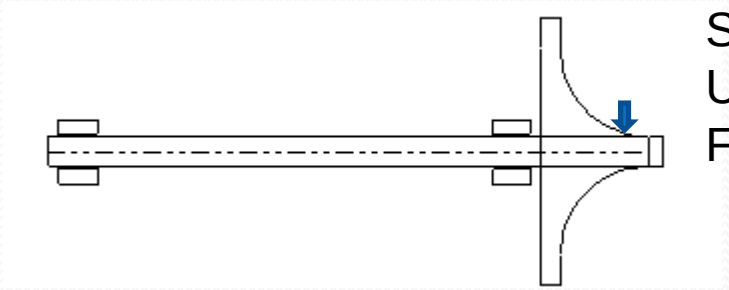


Impact of Worn Impeller

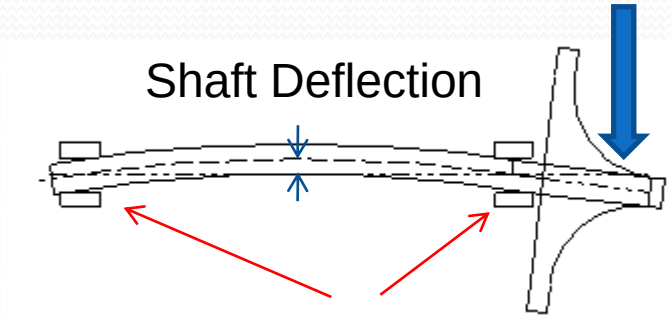
- Flow Rate Reduced from 41,500-gpm to 29,000-gpm
- Efficiency Reduced from 85% to 61%
- Run Time to Pump the Same Volume Increased by 43%
  - Assuming 12-hrs per day design run time
  - Revised run time is 17.2-hrs
  - At $0.08/KWH
  - Design annual power cost = $153,000
  - Worn impeller annual power cost = $179,800

Annual Power Wasted = $26,800 Due to Worn Impeller

Unbalanced Force on Impeller



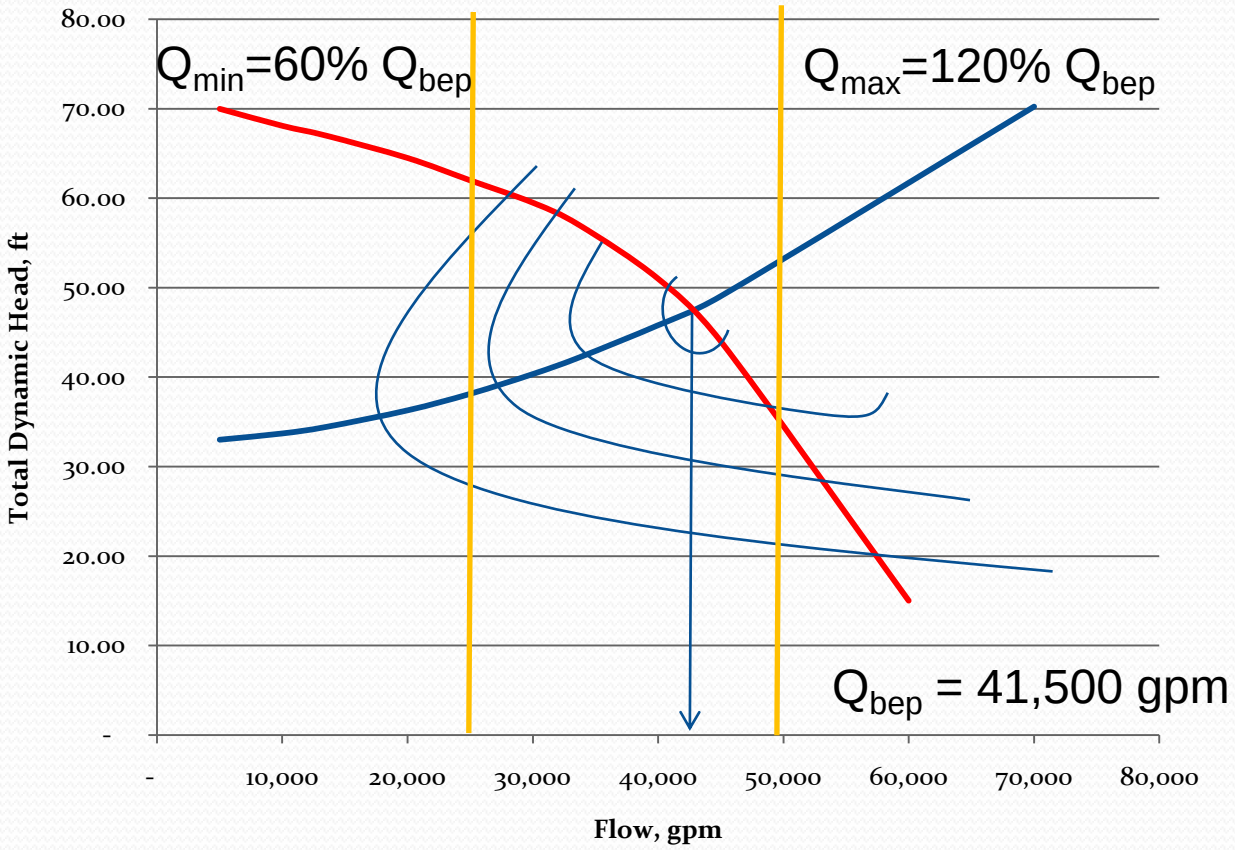
Sum of Unbalanced Forces at B.E.P.



Sum of Unbalanced Forces at Shut-Off or Run-Out

Extreme Wear on Bearings and Seals

Operating Range to Avoid Excessive Unbalanced Forces on Impeller



Correction of Unbalanced Force Problems

- For Operation to the Left of BEP
  - Select Different Pump (One with Lower Specific Speed)
  - Lower Total Dynamic Head
    - Increase Discharge Pipe Diameter to Reduce Friction Loss
    - Straighten Piping to Reduce Minor Losses
    - Reduce Static Head by Increasing Suction or Reducing Discharge Water Surface Elevations
  - Increase Shaft Diameter and Specify “Tougher “ Bearings and Seals
- For Operation to the Right of BEP
  - Treat the Same as for Pump Run-Out Correction

Problems With Improper Piping and/or Alignment

- Strain on Pump Flange Face Twists Volute Casing
  - Reduces Clearance Around Wear Ring
  - Twists Impeller Shaft (Same Problem then As for Pump Run-Out)
- Improper Alignment of Motor and Pump Shaft
  - Twists Impeller Shaft (Same Problem then As for Pump Run-Out)
  - Results in Vibration
  - Wastes Energy

Correction of Improper Piping and/or Alignment

- Loosen Bolts on Suction and Discharge Flanges
  - Piping Should NOT Move
  - If Piping Moves
    - Adjust Piping , or
    - Re-Set Pump, or
    - Provide Flexible Coupling Between Pump and Piping
- Improper Alignment of Motor and Pump Shaft
  - Re-Set Pump or Motor

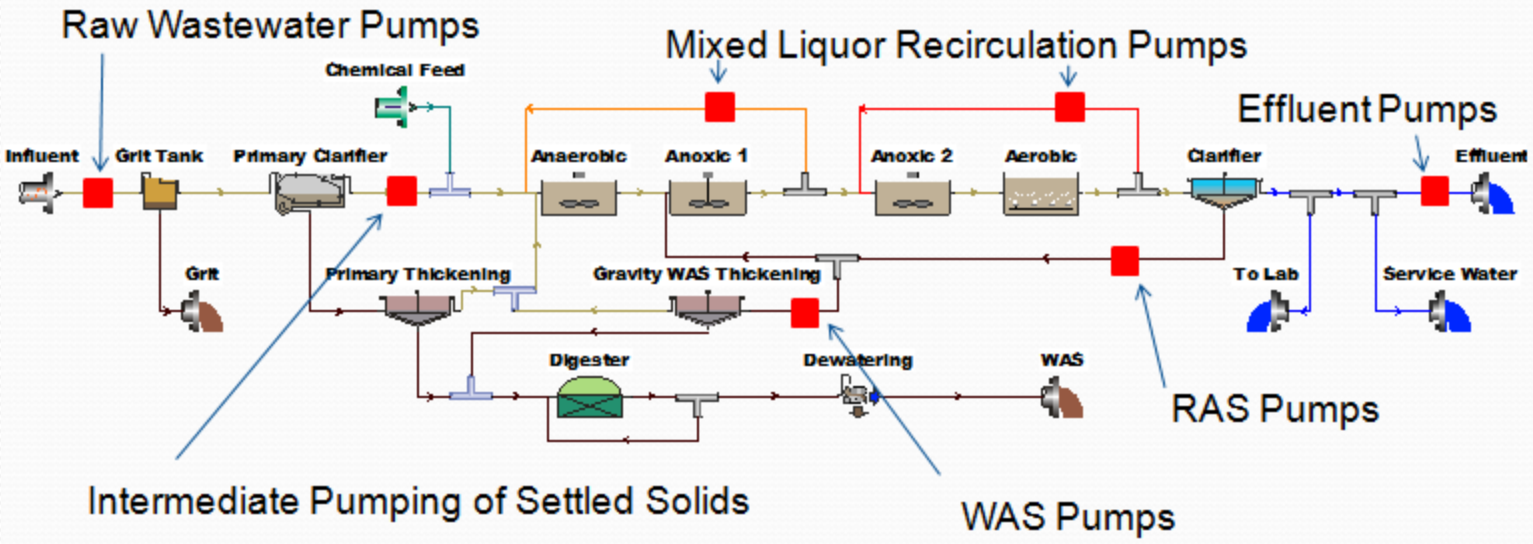
Introduction of Various Pump Types

- For the Balance of the Sessions New Pump Types Will be Introduced as They are Commonly Used for a Particular Application
- When a Pump Type is First Introduced it Will be Highlighted in GREEN
- For Subsequent Application of That Pump Type for a Different Application it Will be Shown in BLACK and the Information Will Not be Repeated

Session 2 – Liquid Stream Process Pumps

- Raw Wastewater Pumps
- Intermediate Pumping of Settled Sewage
- Biosolids Recirculation Pumps
- Return and Waste Biosolids Pumps
- Clarified Effluent Pumps

Liquid Stream Process Pumps



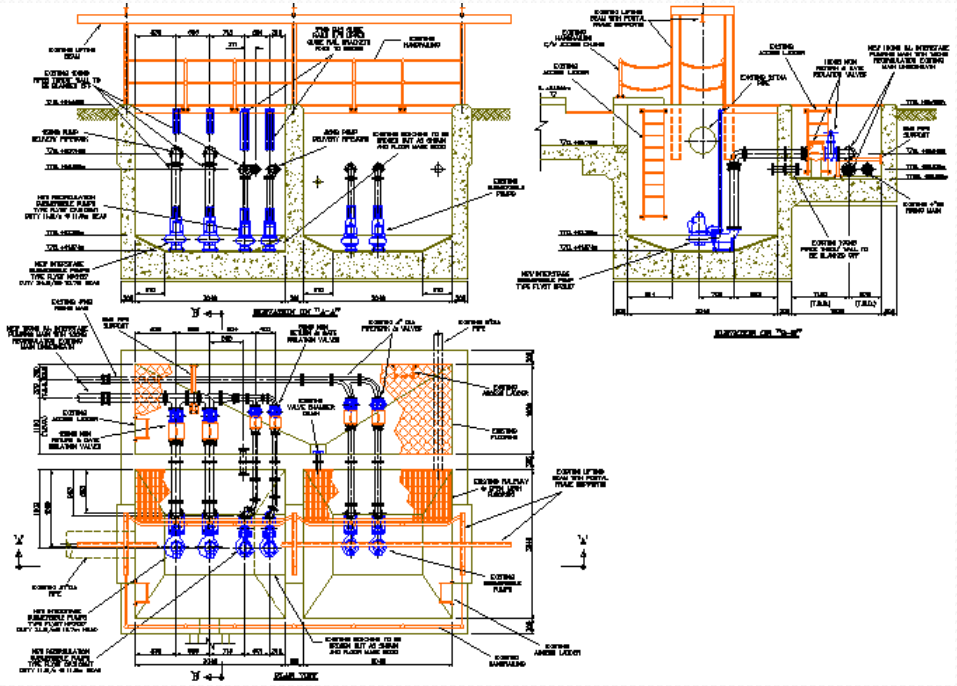
Raw Wastewater

- Can be Screened or Unscreened
  - Typically Screened Before Pumping if Influent Sewer is “Relatively” Shallow
  - Typically Unscreened if Influent Sewer is Deep
- Wide Range of Flow Rates if Unequalized
  - Typically Sized for at Least 2.5 Times Design Capacity
  - May be Sized with Much Higher Ratios in Small Systems
- Characteristics
  - Temperature: 34-°F to 60-°F
  - Solids: Content Less than 500-mg/l (0.05%)
  - pH: 6 to 9 (not unusually acidic or basic)
  - Grit: 2 to10 cubic feet per million gallons
  - Screenings: 0.2 to 5 cubic feet per million gallons
- Behaves and Pumps Like “Water”

Common Raw Wastewater Pump Types

- Non-Clog = Ability to Handle >4-in Spheres and Stringy Trash
- Submersible Non-Clog Centrifugal Pumps
  - Wet-Pit
  - Dry-Pit
- Dry-Pit End Suction Non-Clog Centrifugal
  - Close-Coupled
  - Line-Shaft
  - Self-Priming Belt Driven
- Screw Pumps
- Screw Centrifugal Pumps

Non-Clog Submersible Pumps



Source: http://www.directdesigns.org.uk/images/Direct%20Designs/Sewage%20Treatment%20Works/interstage%20pump%20station.gif

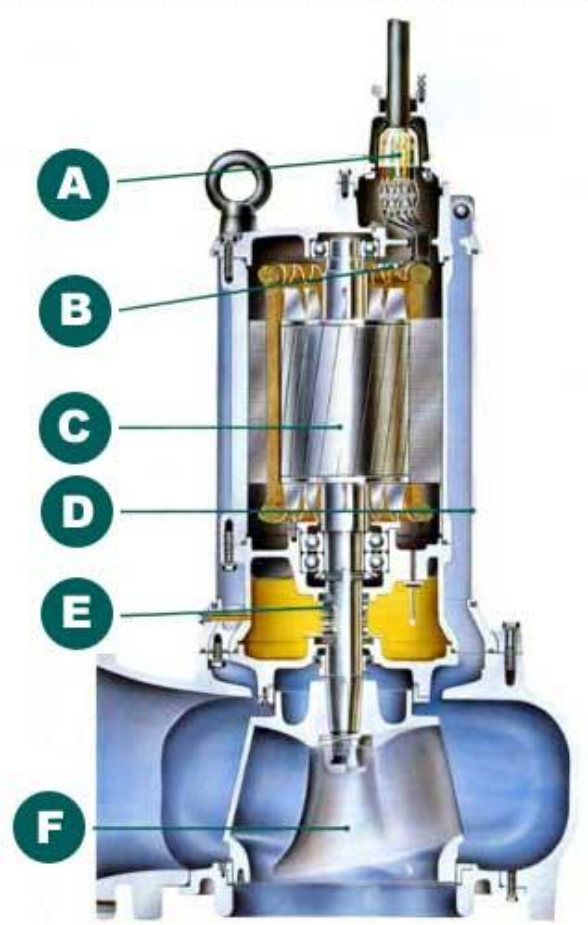
- Wet-Pit Application
  - Advantages
    - Lowest Cost for Raw Wastewater Pumping
    - Compact Layout
  - Disadvantages
    - Pumps Must be Pulled and Cleaned for Maintenance
    - Requires Separate Valve Vault

Non-Clog Submersible Pumps

- Dry-Pit Installation
  - Advantages
    - Easy Pump Access
    - Valves, etc. in Dry-Pit
    - Allows Emergency Wastewater Storage in the "dry-well"
  - Disadvantages
    - More Costly than Other Dry-Pit Pump Options
    - More Difficult to Work on Pump In-Place
    - Requires Air or Oil Cooling

Source: www.frankenmuthcity.com/<wbr>wastewater/raw1.jpg

Typical Submersible Pump



- A – Cable Seal
- B – Motor Protection Sensors
- C - Motor with Dry-Type E, B or F Insulation
- D – Water Cooled Jacket
- E – Mechanical Seal
- F – Non-Clog Impeller

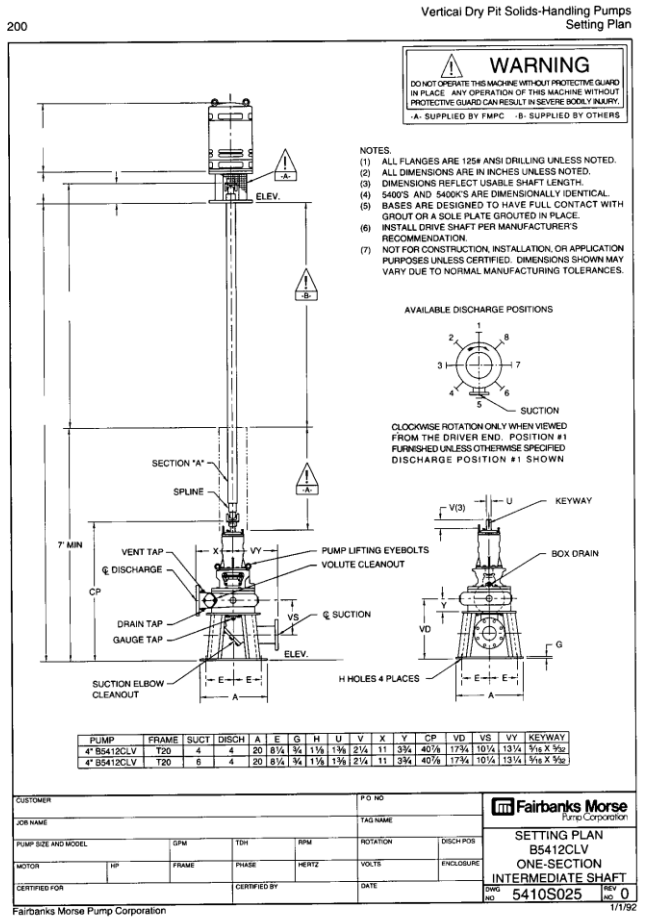
Source: http://www.pumppower.com/TsurumiSubmersibles.htm

Dry-Pit End Suction Non-Clog Centrifugal

http://www.cranepumps.com/products/typeNonClogDryPit.php

- Close-Coupled Installation
  - Advantages
    - Lower Cost
    - Relatively Easy Alignment
    - Tried and True Design
    - Vertical (show) or Horizontal Positioning
  - Disadvantages
    - Motor Failure if Dry-Pit Floods
    - Requires Well Ventilated Dry-Pit to Avoid Class I, Div 2 NFPA 820 Designation

Dry-Pit End Suction Non-Clog Centrifugal



PUMP	FRAME	SUCT	DISCH	A	E	G	H	U	V	X	Y	CP	VD	VS	VY	KEYWAY
4" B5412CLV	T20	4	4	20	8¼	¾	1⅛	1⅜	2¼	11	3¾	40⅞	17¾	10¼	13¼	⅜ X ⅜
4" B5412CLV	T20	6	4	20	8¼	¾	1⅛	1⅜	2¼	11	3¾	40⅞	17¾	10¼	13¼	⅜ X ⅜

- Line-Shaft Installation
  - Advantages
    - Pump Located in "Controlled" Environment
    - Dry-Pit Can Flood in Emergency Without Damage to Motors
  - Disadvantages
    - Alignment Difficulties
    - Some HP Lost in Shaft Drive
    - More Costly

Dry-Pit End Suction Non-Clog Centrifugal

- Belt-Driven Installation
  - Advantages
    - Easy to Change Pump Speeds by Adjusting Pulley Diameters
    - Commonly Used with Self-Priming Centrifugal Pumps
  - Disadvantages
    - Less Efficient Due to Energy Loss of Belt Drive

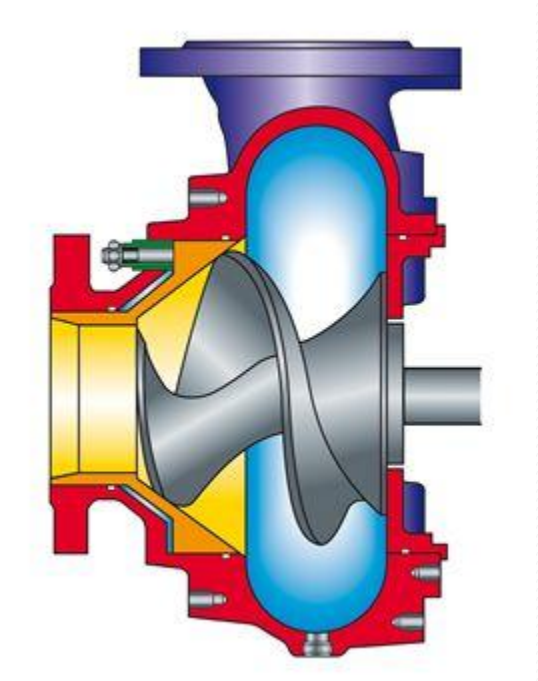
Source
http://www.grpumps.com/upload/P_BMPS.jpg

Screw Pumps

Source:
http://www.lakeside-equipment.com/products/Screw_Pumps/sp4.jpg

- Open (shown) or Enclosed Installations
  - Advantages
    - Inherently Variable Flow
    - Difficult to Clog
    - No Wet-Well Needed
  - Disadvantages
    - Limited to Moderate Lifts
    - Cost
    - Submerged End Bearing

Screw Centrifugal Pumps



Source: http://www.hidrostal.co.uk/docs/screw_centrifugal_impeller/pump_xsection_new.jpg

- End Suction, Dry-Pit Installation
  - Advantages
    - Handles large solids and Stringy Solids Exceptionally Well
    - High Efficiency for a Typical Solids Handling Pump
  - Disadvantages
    - More Costly
    - Limited Number of Manufacturers

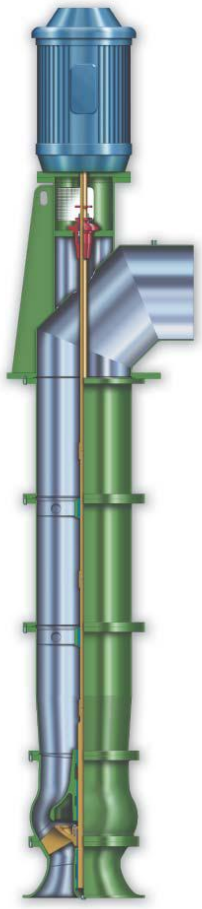
Intermediate Pumping of Settled Sewage

- By Definition Follows Primary Clarification
- Required Where the Hydraulic Grade Line Following the Primary Clarifiers is Insufficient to Flow By Gravity to Downstream Processes
- More Common in WWTPs that Have been Upgraded/Modified – Less Common in New WWTPs
- Typically Low-Head Applications
- Same Flow Range as for Raw Wastewater Pumping

Intermediate Pumping of Settled Sewage

- Characteristics of Settled Sewage
  - Temperature: 34-°F to 60-°F
  - Solids: Content Less than 100-mg/l (0.01%)
  - pH: 6 to 9 (not unusually acidic or basic)
  - Little to No Grit
  - May Contain Wind-Blown Debris or Rags (if poorly screened)
- Behaves and Pumps Like “Water”
- Typical Suitable Pumps
  - Centrifugal Non-Clog End Suction (Both Submersible and Dry-Pit, Close-Couples, Line-Shaft, or Belt-Driven
  - Screw Pumps
  - Vertical Mixed Flow Pumps
  - Vertical Turbine Solids Handling Type Pumps

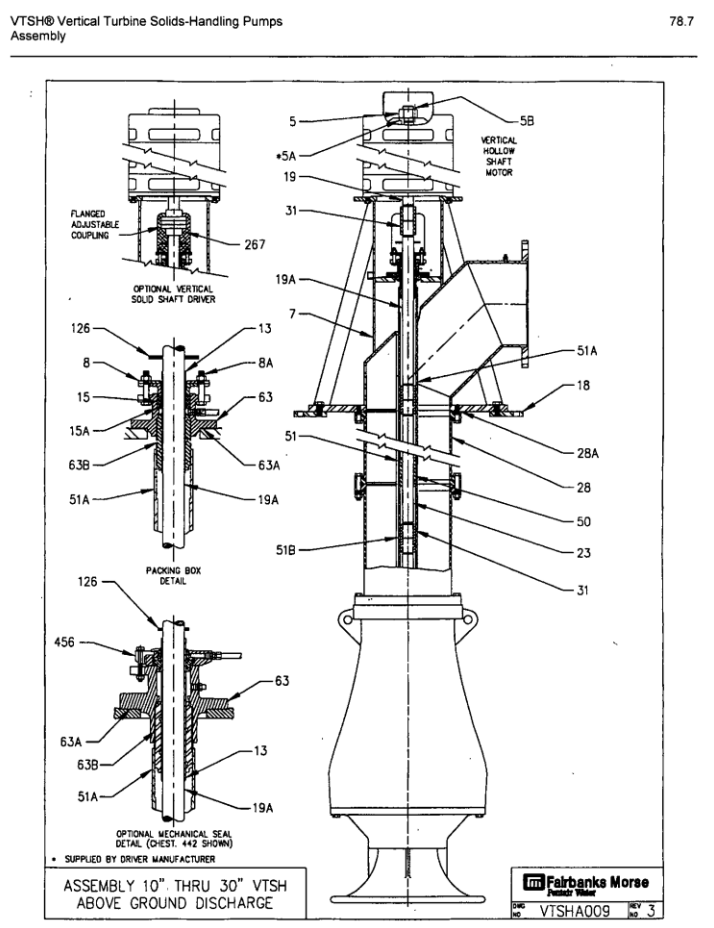
Vertical Pumps



- Mixed Flow Installations
  - Advantages
    - Compact Design
    - Low Speeds
    - Modest Cost
  - Disadvantages
    - May Have Harmonic Problems When Operated with VFDs
    - Limited Moderate Lifts

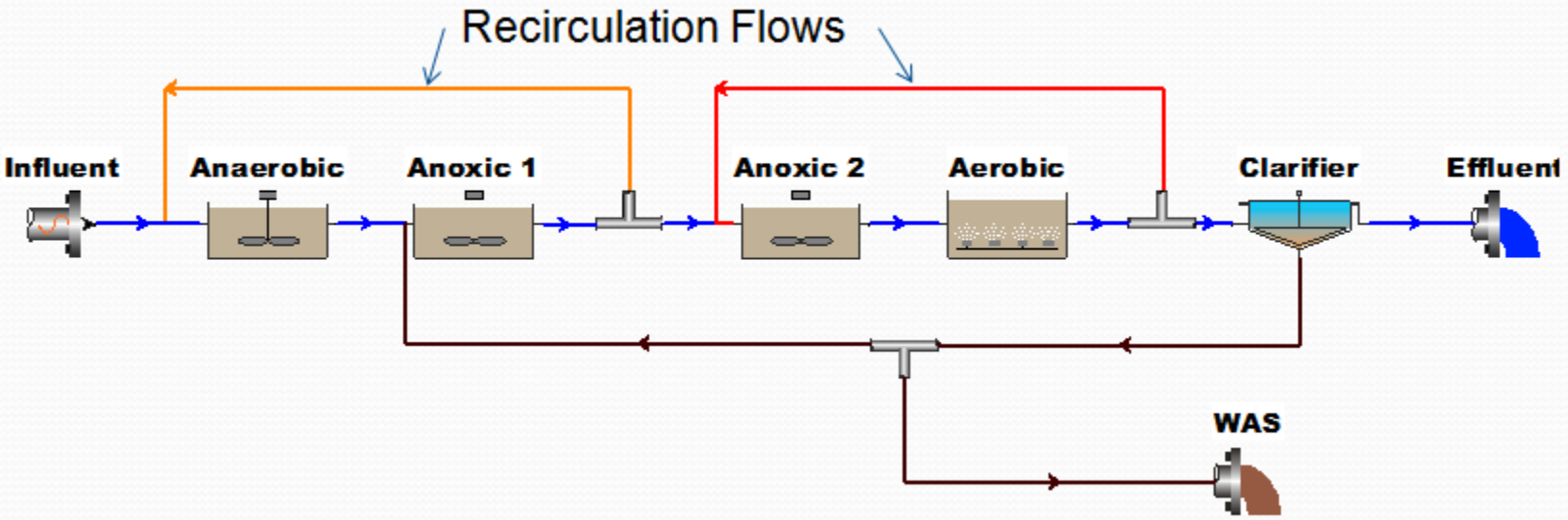
Source: http://www.sulzerpumps.com/Portaldata/9/Resources/brochures/power/vertical/JM_VerticalMixedFlowPumps_E00634.pdf

Vertical Pumps



- Vertical Turbine Solids Handling
  - Advantages
    - Extremely Rugged
    - Pass Large Solids
    - Slow Speeds
  - Disadvantages
    - Very Costly
    - Enclosed Line Shaft Which Requires Water Flush
    - Requires Moderate TDH

Biosolids Recirculation Pumps

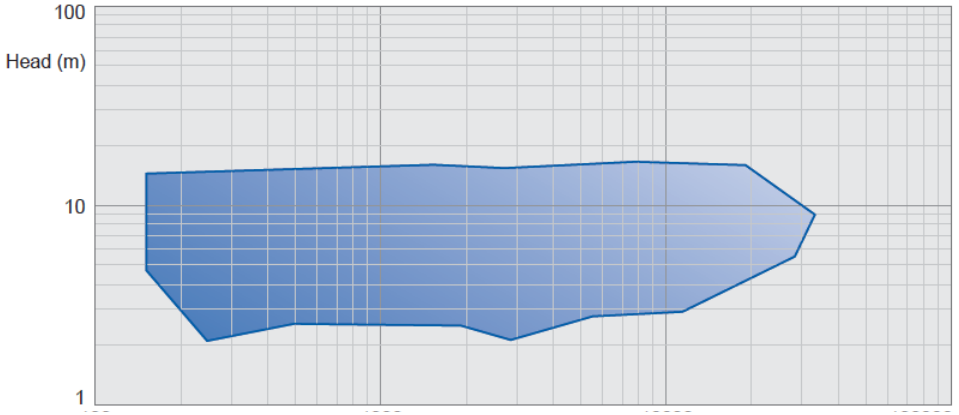


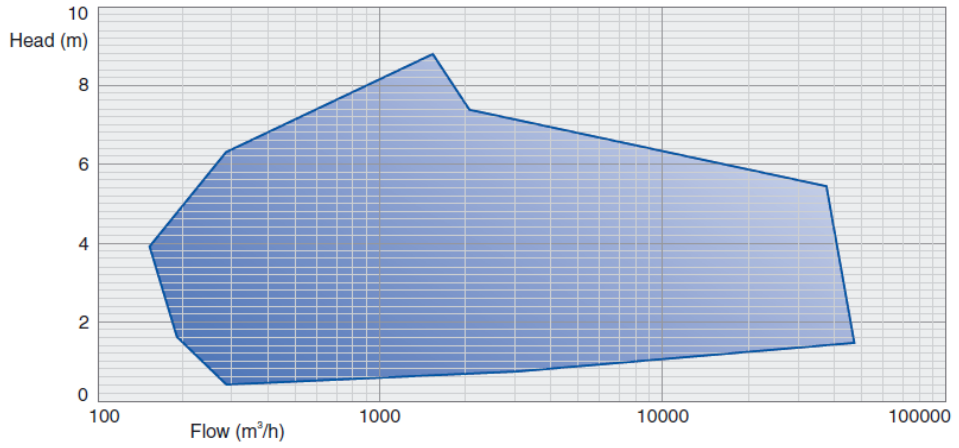
- Required For Certain Types of Biological Nutrient Removal Processes (Modified UCT Process Shown)
- Also Includes Trickling Filter Recirculation Flows

Biosolids Recirculation Pumps

- Characteristics of Recirculated Biosolids Pumping
  - Very Low Heads
  - Temperature: 34-°F to 60-°F
  - Solids: Content May be up to10,000-mg/l (1.0%)
  - pH: 6 to 9 (not unusually acidic or basic)
  - Little to No Grit
  - May Contain Wind-Blown Debris or Rags (if poorly screened)
- Behaves and Pumps Like "Water"
- Typical Suitable Pumps
  - Centrifugal Non-Clog End Suction (Both Submersible and Dry-Pit, Close-Coupled, Line-Shaft, or Belt-Driven
  - Screw Pumps
  - Vertical Propeller Pumps
  - Air Lift Pumps
  - Horizontal Propeller Pumps

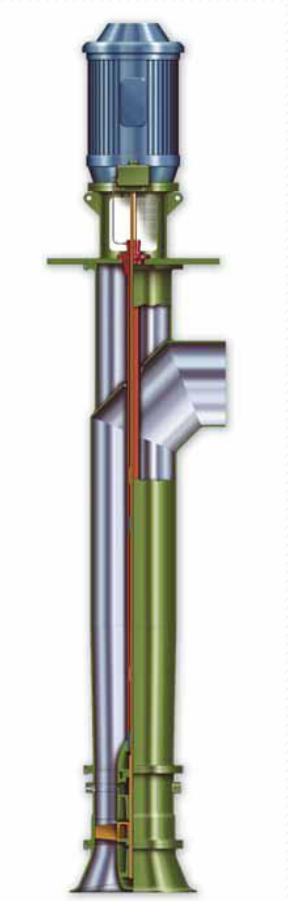
Mixed Flow Versus Propeller





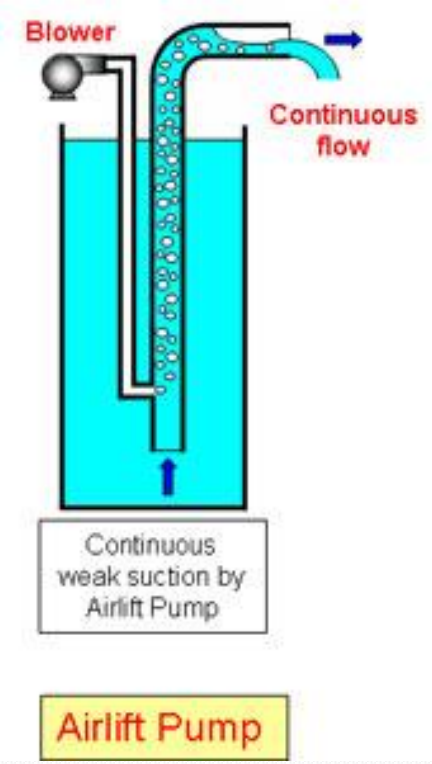
Source: http://www.sulzerpumps.com/Portaldata/9/Resources/brochures/power/vertical/JP_Vertical_E00635.pdf

Vertical Pumps



- Vertical Propeller Pumps
  - Advantages
    - Low Cost
    - Pass Large Solids
    - Slow Speeds
  - Disadvantages
    - Only Suitable for Very Low TDH
    - Requires Higher NPSH

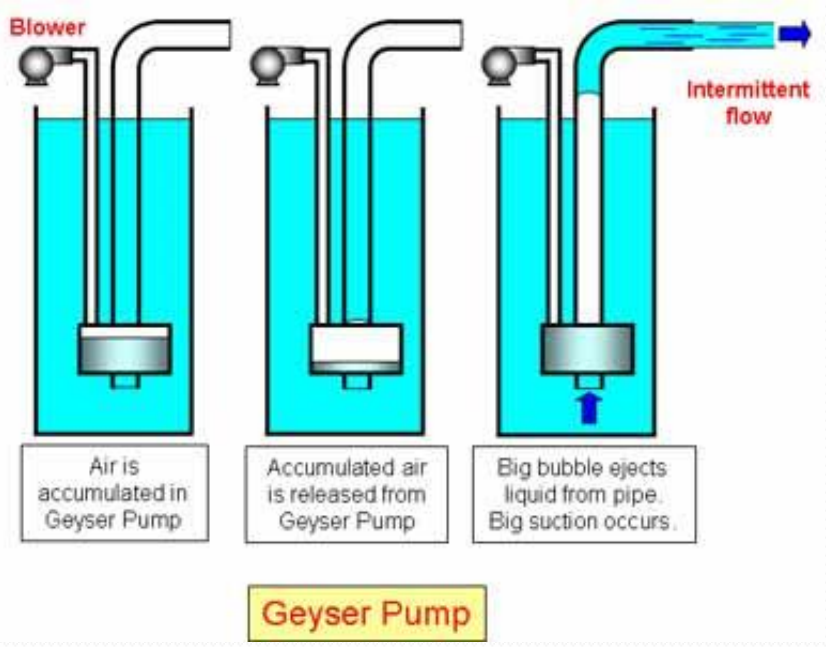
Air Lift Pumps



Source: http://www.airliftpump.com/airlift_pump_skematic.jpg

- Air-Lift Pump Installation
  - Advantages
    - Simple Concept
    - Very Low Cost
    - No Significant Piping
  - Disadvantages
    - Weak suction
    - Unstable flow rate
    - Frequent clogging
    - Difficult flow control
    - Low lift (Usually Less than 1-ft)
    - Not Suitable for Anoxic/Anaerobic Recirculation Because of Aeration
    - Very Low Efficiency (<30%)

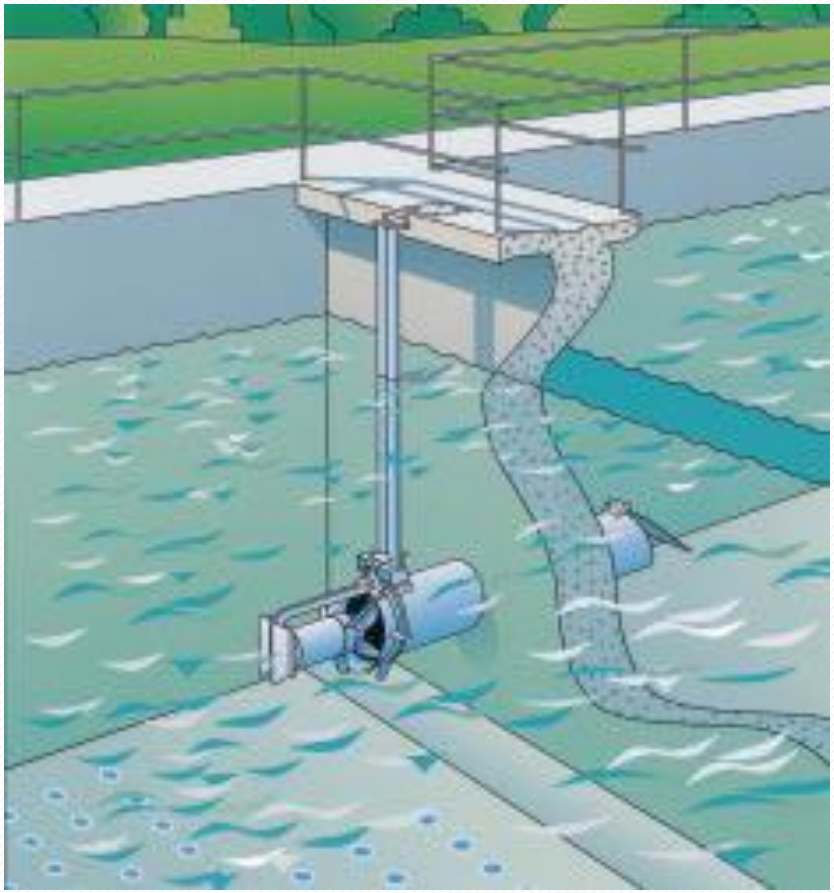
Air Lift Pumps



Source: http://www.airliftpump.com/bk_1_schematic.jpg

- Geyser Pump Installation
  - Advantages
    - Simple Concept
    - Very Low Cost
    - Less Prone to Clogging
    - No Significant Piping
  - Disadvantages
    - Difficult flow control
    - Low lift (Usually Less than 1-ft)
    - Not Suitable for Anoxic/Anaerobic Recirculation Because of Aeration
    - Very Low Efficiency (<30%)

Horizontal Propeller Pumps



- Horizontal Propeller Pump Installation
  - Advantages
    - Low Cost
    - No Piping
  - Disadvantages
    - Requires Contiguous Walls
    - Submerged Access
    - Limited to Low Heads (<6-ft)
    - Limited Range of Capacity/Size (16-in, 24-in, 30-in)
    - No Direct Flow Control/Measurement

Return and Waste Activated Sludge Pumps

- Characteristics of Return and Waste Activated Sludge Pumping
  - Moderate to Low Heads
  - Temperature: 34-°F to 60-°F
  - Solids: Content May be up to10,000-mg/l (1.0%)
  - pH: 6 to 9 (not unusually acidic or basic)
  - Little to No Grit
  - May Contain Wind-Blown Debris or Rags (if poorly screened)
- Behaves and Pumps Like “Water”
- Typical Suitable Pumps
  - Centrifugal Non-Clog End Suction Dry-Pit (Typically Close-Coupled)
  - Screw Pumps
  - Screw Centrifugal Pumps
  - Air Lift Pumps

RAS/WAS Pumping

- Unique Configurations
  - Non-Clog Centrifugals Can be Directly Piped to the Secondary Clarifier Suction Scrapper
    - Often Results in “Convoluted” Suction Piping – Important to Check NPSH Considerations
    - Maximum Flexibility in Suction and Discharge Configurations to Allow Duty and Standby Pumps to Serve Multiple Purposes
  - Screw Pumps and Air Lift Pumps Generally Require Suction Header or Hopper to Be Piped to a Sludge Wet-Well

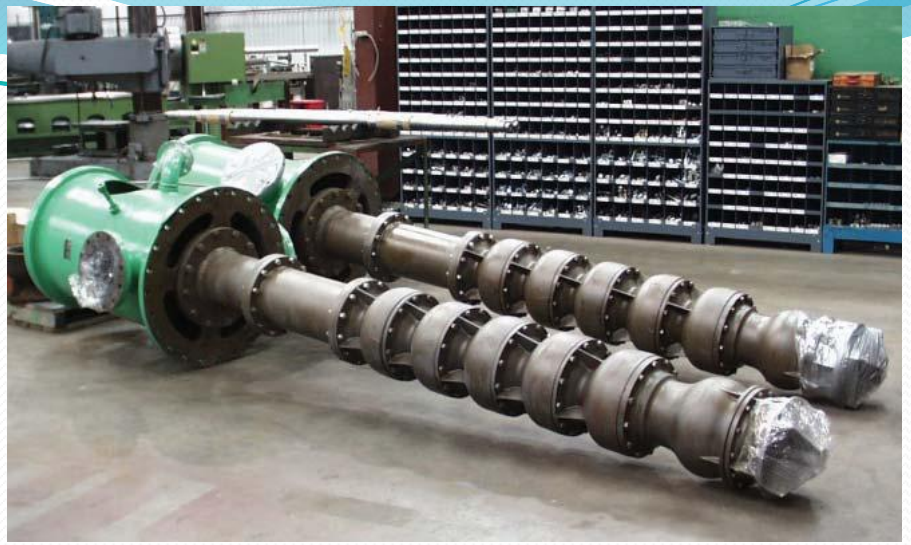
Clarified Effluent Pumps

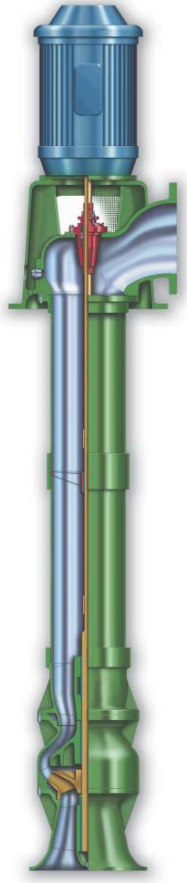
- Characteristics of Clarified Effluents
  - Moderate to High Heads
  - Temperature: 34-°F to 60-°F
  - Solids: Less than 30-mg/l (0.03%)
  - pH: 6 to 9 (not unusually acidic or basic)
- Behaves and Pumps Like “Water”
- Low /Moderate Head Applications
  - Discharge (e.g. During River Flood Stage)
  - Tertiary Filter Feed
- High Head Applications
  - Irrigation
  - Transmission (e.g. Remote Discharge Location or Reuse)

Clarified Effluent Pumps

- Low/Moderate Head Applications
  - Centrifugal Non-Clog
    - Submersible
    - Dry-Pit
  - Vertical Pumps
    - Mixed Flow
    - Propeller
  - Screw Pumps
  - Air-Lift Pumps
- High Head Applications
  - Centrifugal Non-Clog
    - Submersible
    - Dry-Pit
  - Vertical Turbine

Vertical Pumps

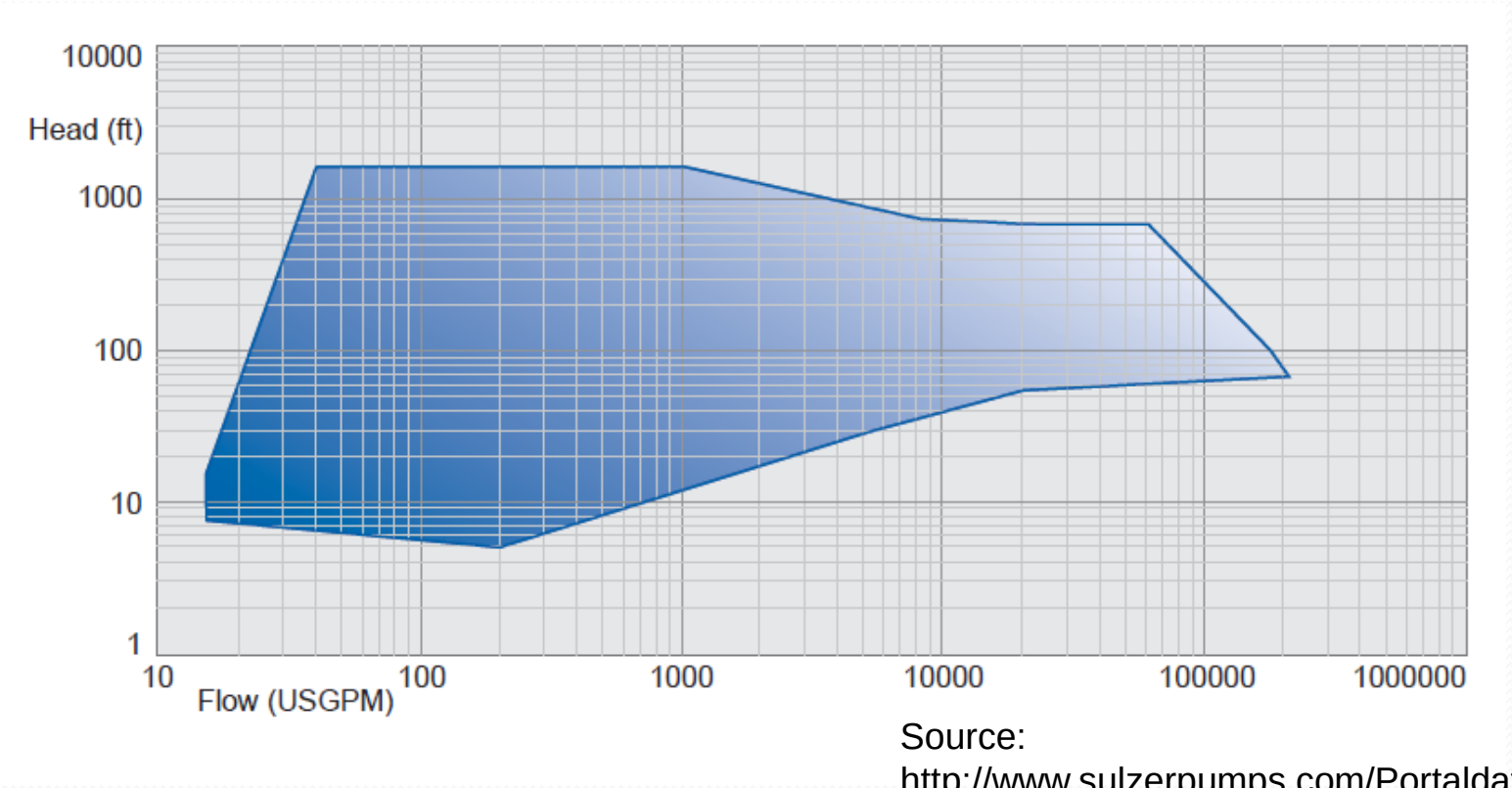




Source:
http://www.sulzerpumps.com/Portaldata/9/Resources/brochures/power/vertical/JT_VerticalTurbinePumps_E00633.pdf

- Traditional Vertical Turbine Installations
  - Advantages
    - Very High Heads Achievable
    - High Efficiency
    - Compact Layout
  - Disadvantages
    - Close Tolerances Limit Solids Passage

Vertical Turbine Performance

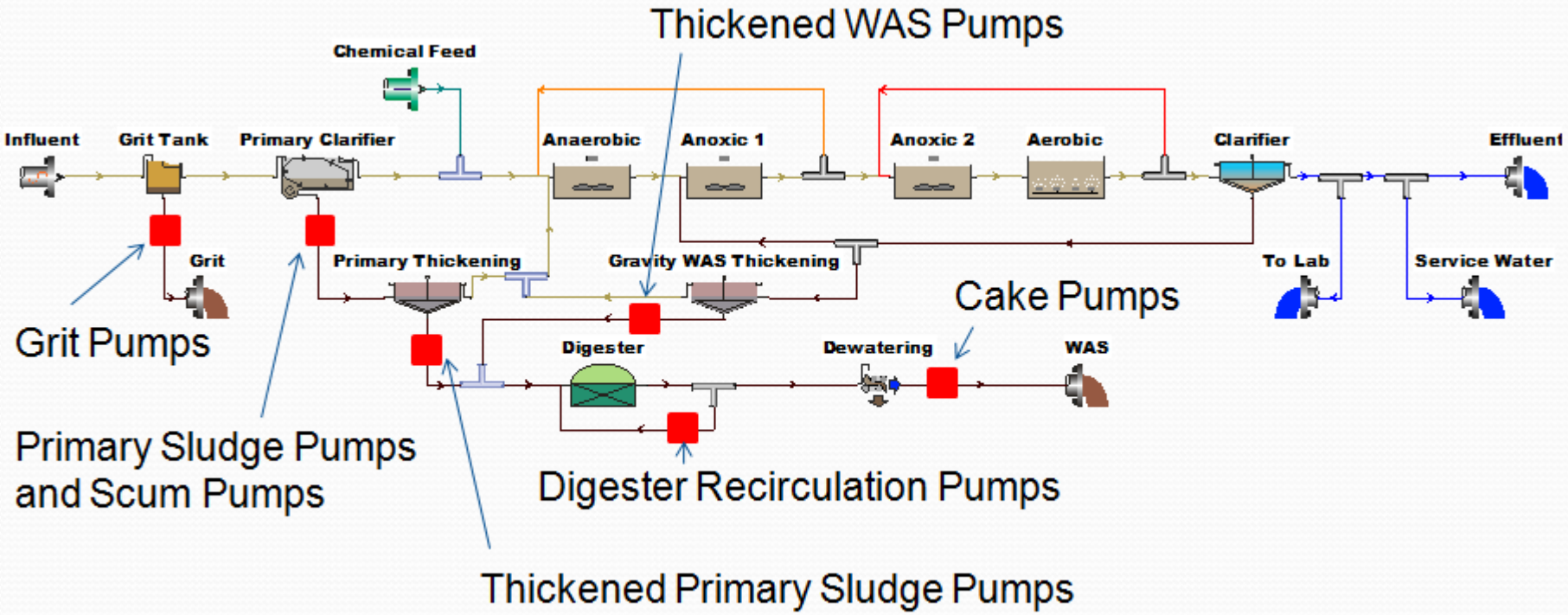


Source: http://www.sulzerpumps.com/Portaldata/9/Resources/brochures/power/vertical/JT_VerticalTurbinePumps_E00633.pdf

Session 3 – Solids Stream Process Pumps

- Grit/Screening Pumps
- Primary Sludge/Scum Pumps
- Thickened Primary Solids Pumps
- Thickened Waste Biosolids Pumps
- Digested Sludge Recirculation Pumps
- Dewatered Cake Pumps

Solids Stream Process Pumps



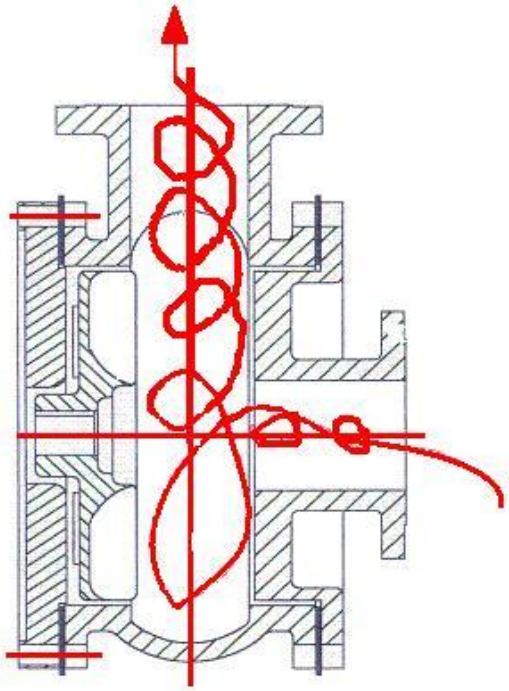
Grit Pumps

- Characteristics of Unwashed Grit
  - Particles Larger than 65-mesh (0.21-mm) for Coarse Grit
  - Particles Between 100-mesh (0.15-mm) to 65-mesh for Finer Grit
  - Solids: Concentration depends on pumping frequency (usually less than 300-mg/l)
  - Very Abrasive: (Moh's Hardness of 6 to 7 if Granite/Quartz sand present)
  - Greater than 50% Organic Content (vector attraction)
- Behaves and Pumps Like "Water" (i.e. not particularly viscous)
- Required where bucket scrapers or hand shoveling isn't sufficient
  - Typically Pumps to a Combination Grit Concentrator/ Grit Washer

Grit Pumps

- Pumps Suitable for Grit Pump Applications
  - Centrifugal Non-Clog End Suction (dry-pit)
  - Screw Centrifugals
  - Torque Flow Pumps
    - Recessed Impeller End Suction
  - Suction Lift Self-Priming Centrifugal Pumps
  - Air-Lift Pumps

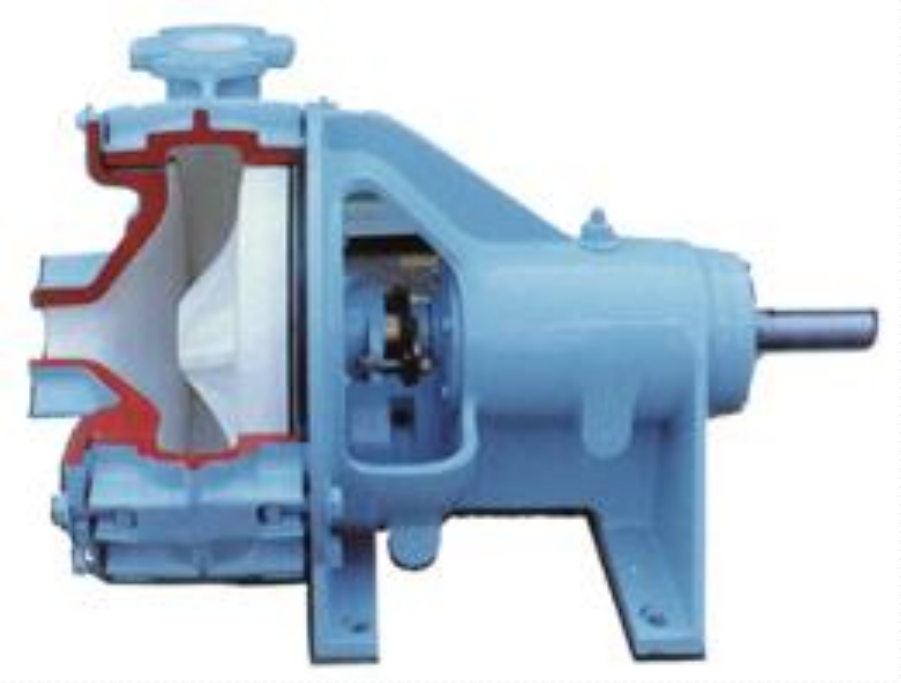
Principal of Torque Flow



Source:
http://www.hunterequipmentco.com/newsletter mar07/images/esscoflow.jpg

- Vortex Created in Front of Impeller
- Fluid Drag of Water in Contact with the Impeller Pulls Along Rest of Fluid

Torque Flow Pumps



Source: http://www.voigtab.com/images/WemcoCPump.jpg

- Recessed Impeller Installation
  - Advantages
    - No Close Tolerances
    - Allow Use of Hard to Machine (i.e. Tough) Materials for Impeller
    - Less Flow in Contact with Impellor Reduces Abrasion
  - Disadvantages
    - More Costly
    - Less Efficient

Turbo Self-Priming Grit Pump

Source: http://www.smithandloveless.com/images/Grit-Pump300px.jpg

- Pista Turbo-Grit Installation
  - Advantages
    - Eliminated Grit Pump Dry-Pit
    - Positive Priming System
    - High Heads for Grit Concentrator Operation
    - Completely Drains to Prevent Freezing
  - Disadvantages
    - Complex Priming System
    - Relatively Inefficient
    - Only Works with Certain Types of Grit Chambers

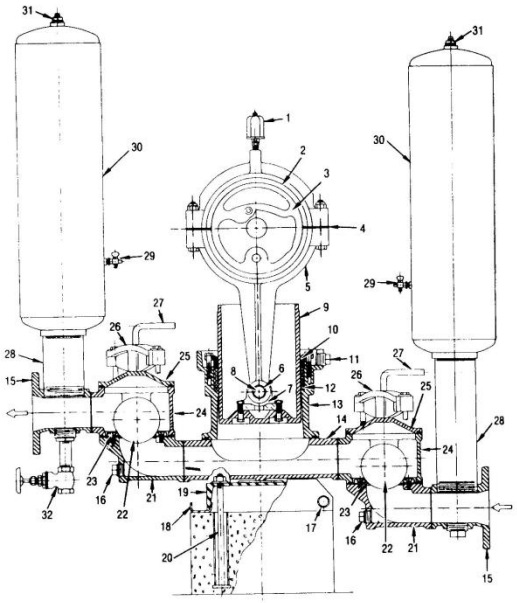
Primary Sludge Pumps

- Characteristics of Primary Sludge
  - Contains Fine Grit that Did Not Get Removed in Grit Chamber
  - Solids: Concentrations Between 2% to 7%
  - Oil & Grease Accounts for 5% to 8% of Solids
  - pH: 5 to 8
  - Specific Gravity of Solids: 1.4
  - Bulk Specific Gravity: 1.02 to 1.07
- More Viscous than Raw Wastewater
  - Difference Most Notable at Low Velocities
  - Maintain Velocities > 2-fps to 2.5-fps to Ensure Turbulent Flow

Primary Sludge Pumps

- Typical Suitable Pumps
  - Torque Flow/Recessed Impeller Pumps
  - Screw Centrifugal Pumps
  - Positive Displacement Pumps
    - Plunger Pumps
    - Progressive Cavity Pumps
    - Air Operated Diaphragm Pumps
    - Rotary Lobe Pumps
    - Pneumatic Ejectors
    - Peristaltic Hose Pumps

Positive Displacement Pumps



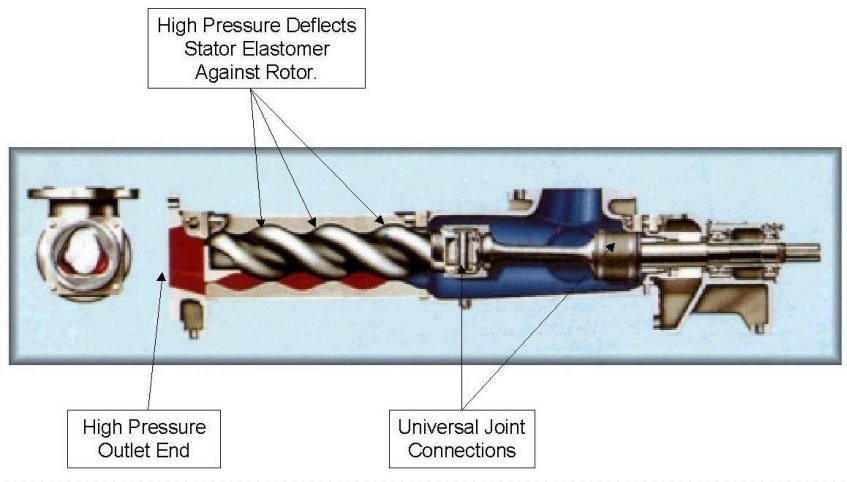
1. Oiler
2. Eccentric Babbit Bearing
3. Eccentric
4. Eccentric Bearing Shims
5. Connecting Rod
6. Wrist Pin Bearing
7. Cross Head
8. Wrist Pin
9. Plunger
10. Packing Gland
11. Stuffing Box Lip Drain
12. Packing
13. Stuffing Box
14. Pump Body
15. Suction & Discharge Manifold
16. Elbow Drain
17. Base Drain
18. Drip Lip
19. Base Channel
20. Anchor Bolt
21. Elbow
22. Valve Ball
23. Valve Seat
24. Valve Chamber
25. Valve Cover
26. Valve Cover Yoke
27. L Screw
28. Air Chamber Nipple
29. Air Cock
30. Air Chamber
31. Gauge Connection
32. Sampling Valve

Figure 18.7 Plunger pump construction.

- Plunger Pump Installation
  - Advantages
    - Solids up to 15%
    - Adjustable Stoke Allows Low Pumping Rates
    - Can Operate Under "No-Flow" Conditions
    - Rugged with Relatively Low O&M Requirements
    - Good Pump Suction Characteristics
  - Disadvantages
    - Pulsating Flow Unless Dampeners Provided
    - Limited to <500-gpm

Source: WEF MOP 8 Vol. 3 page 18-17

Positive Displacement Pumps



Source: http://www.lifetime-reliability.com/images/013_helical_rotor_pump.jpg

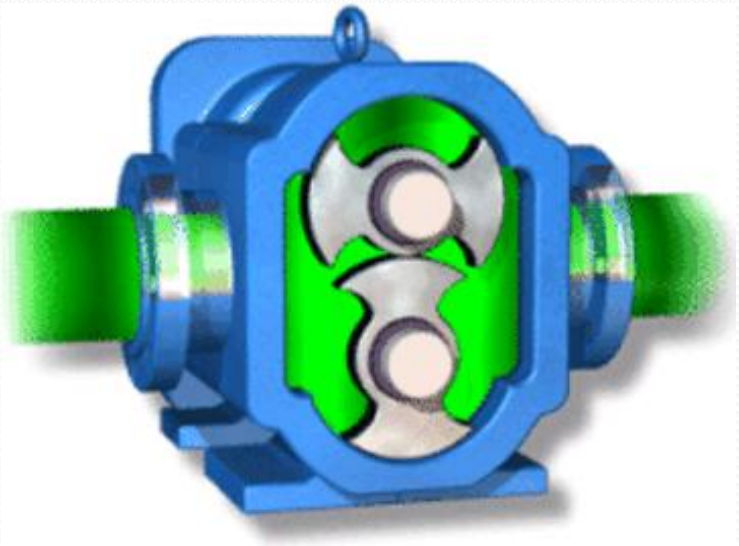
- Progressive Cavity Pump Installation
  - Advantages
    - Solids up to "Cake" Consistency with Hopper Intake
    - Smooth Flow Output
    - Prevents Backflow so No Check Valve is Required
    - Adjustable Speed Drive Allows Low Pumping Rates
  - Disadvantages
    - Can Not Operate in "No-Flow" Condition
    - Require Sufficient Space for Dismantling
    - Sensitive to Grit
    - Requires Careful Consideration of Suction Conditions

Positive Displacement Pumps

Source: http://www.flsmidthminerals.com/NR/rdonlyres/C088F975-A2D3-4A90-8181-348505DA1EF2/32356/ODS_Pump.jpg

- Air Operated Diaphragm Pump Installation
  - Advantages
    - Handles both Unthickened and Thickened Sludge
    - Adjustable Stroke Allows Low Pumping Rates
    - Resistant to Wear – Not Sensitive to Grit
  - Disadvantages
    - Requires Compressed Air
    - Noisy Exhaust
    - Pulsating Discharge

Positive Displacement Pumps



Source: http://www.process-controls.com/Burlington_Pump/images/viking/LobePumpLarge.gif

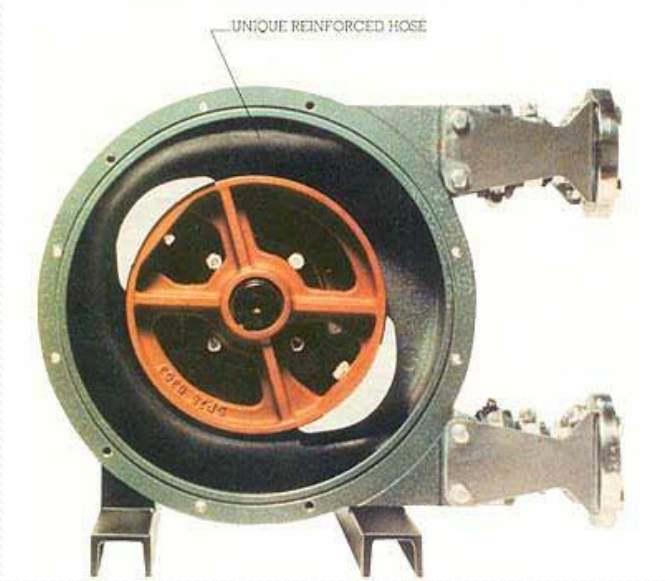
- Rotary Lobe Pump Installation
  - Advantages
    - Smooth Flow Discharge
    - Can Operate Under "No-Flow" Conditions
    - Compact Layout
  - Disadvantages
    - Sensitive to Grit
    - Requires Careful Consideration of Suction Conditions

Positive Displacement Pumps

Source: http://www.yeomanspump.com/images/4000_02.jpg

- Pneumatic Ejector Installation
  - Advantages
    - Can Transport Sludge, Scum, Grit and Screenings
  - Disadvantages
    - Pulsating Discharge
    - Limited to <150-gpm
    - Requires Compressed Air System

Positive Displacement Pumps



Source:
http://www.pennwalt.com/hp1.jpg

- Peristaltic Hose Pump Installation
  - Advantages
    - Easily Adjustable Flow Rate
    - Suitable for Metering Applications
    - Can Transport Very Abrasive Fluids , Scum, Grit and Screenings
  - Disadvantages
    - Pulsating Discharge
    - Limited to <330-gpm

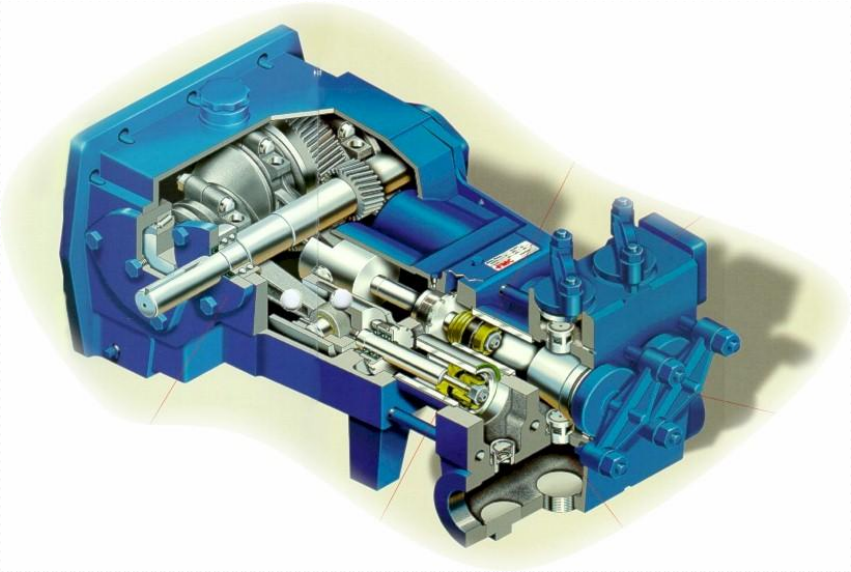
Primary Scum Pumps

- Characteristics of Primary Scum
  - Solids: Low Total Solids Concentration (<20-mg/l)
  - Oil & Grease: 70% to 90% of Solids
- More Viscous than Raw Wastewater Due to Grease Accumulation
- Pumps Suitable for Primary Scum
  - Progressive Cavity Pumps
  - Pneumatic Ejectors
  - Recessed Impeller Centrifugal Pumps

Thickened Primary Sludge Pumps

- Characteristics of Thickened Primary Sludge
  - Contains Concentrated Fine Grit that Did Not Get Removed in Grit Chamber
  - Solids: Concentrations Between 6% to 10%
  - Oil & Grease Accounts for 5% to 8% of Solids
  - pH: 5 to 8
  - Bulk Specific Gravity: 1.04 to 1.07
- Much More Viscous than Raw Wastewater Due to Grease Accumulation
- Pumps Suitable for Thickened Primary Sludge
  - Plunger Pumps
  - Progressive Cavity Pumps (Provided There is Good Grit Removal)
  - Air Operated Diaphragm Pumps
  - Pneumatic Ejectors
  - Reciprocating Piston Pumps – Where Thickened Sludge Must Be Pumped Long Distances

Positive Displacement Pumps



Source: http://www.crosspump.net/fmc/images/fmcpump.jpg

- Reciprocating Piston Pump Installation
  - Advantages
    - Solids up to "Dry Cake" (>30%)
    - Adjustable Stoke Allows Low Pumping Rates
    - Very High Heads at Low Flows
  - Disadvantages
    - Pulsating Flow Unless Dampeners Provided
    - Subject to Mechanical Wear Under High Loads
    - Expensive Replacement Parts

Thickened WAS Biosolids Pumps

- Characteristics of Thickened Waste Activated Sludge
  - Solids: Concentrations Between 2% to 3%
  - Bulk Specific Gravity: 1.01 to 1.02
- Slightly More Viscous than Raw Wastewater
- Similar to Pumping Raw Primary Sludge
- Pumps Suitable for Thickened WAS Biosolids
  - Torque Flow/Recessed Impeller Pumps
  - Screw Centrifugal Pumps
  - Positive Displacement Pumps
    - Plunger Pumps
    - Progressive Cavity Pumps
    - Air Operated Diaphragm Pumps
    - Rotary Lobe Pumps
    - Pneumatic Ejectors

Digester Recirculation Pumps

- Characteristics of Digested Sludge
  - Solids: Concentrations Between 1% to 3%
  - pH: 6 to 8
- Similar to Pumping Raw Wastewater or WAS
- Pumps Suitable for Anaerobic Digester Recirculation
  - Centrifugal Non-Clog Dry-Pit
  - Torque Flow/Recessed Impeller Pumps
  - Screw Centrifugal Pumps
- Pumps Suitable for Aerobic Jet Aeration
  - Submersible Recessed Impeller

Aerobic Sludge Digestion Recirculation

Source:
http://www.itttreatment.com/ProductPDF/63559-894463eng.pdf

- Recessed Impeller Submersible Pump Application with Jet Aeration
  - Advantages:
    - Simple Installation
    - Aerates and Recirculates Flow in One Unit
  - Disadvantages
    - Submersed Location
    - Subject to Significant Wear if There is Grit

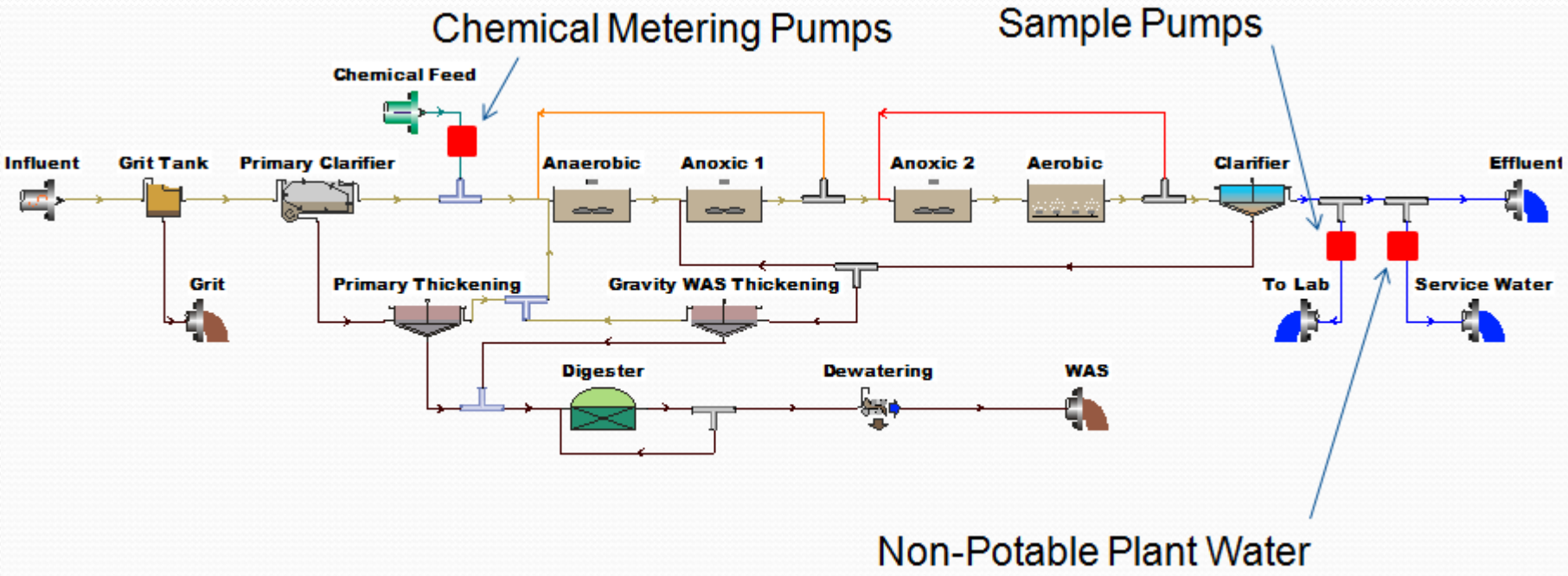
Dewatered Solids Cake Pumps

- Characteristics of Dewatered Sludge Cake
  - Solids: Concentrations Up to 25% (However Better if <20%)
  - Thixotropic Properties (Like Gooey Clay)
  - Head Losses approaching 3-psi/ft
  - Limit Velocity to Under 0.5-ft/sec (However Better if <0.25-ft/sec)
  - May Require Lubricating Ring
- Pumps Suitable for Dewatered Cake Pumping
  - Reciprocating Piston Pumps
  - Progressive Cavity Pumps (with Hopper Intake)
- For Solids Concentrations > 25% Use Conveyors

Session 4 – Service Pumps

- Non-Potable Water Service Pumps
- Sample Pumps
- Chemical Metering Pumps

Service Pumps



Non-Potable Water Service Pumps

- Characteristics of Clarified Effluents
  - Moderate to High Heads
  - Temperature: 34-°F to 60-°F
  - Solids: Less than 30-mg/l (0.03%)
  - pH: 6 to 9 (not unusually acidic or basic)
- Behaves and Pumps Like “Clean Water”
- Pumps Suitable for Non-Potable Water Service
  - Vertical Turbine Pumps
  - Centrifugal Non-Clog End Suction (Allow Smaller Solids Capacity than for Raw Wastewater Applications)

Sample Pumps

- Characteristics of Sample Systems
  - Small Pipelines
  - High Heads and Low Flows
  - Generally Constructed of Inert Materials
- Behaves and Pumps Like “Clean Water”
- Pumps Suitable for Higher Volume Sample Pump Service
  - Vertical Turbine Pumps
- Pumps Suitable for Low Volume Precise Sampling
  - Positive Displacement Peristaltic Hose Pumps

Chemical Metering Pumps

- Characteristics of Sample Systems
  - Small Pipelines
  - Moderate to Low Heads and Low Flows
  - Must Be Constructed of Materials Suitable for Each Chemical for Its Intended Use
- Pumps Suitable for Chemical Metering Pumps
  - Diaphragm Pumps
  - Piston/Stroke Pumps
  - Hose/Tube Pumps

Chemical Metering Pumps

Source:
http://www.maddenmfg.com/images/mettering-pump-mf-02.jpg

- Diaphragm Metering Pump Installation
  - Advantages
    - Continuous Duty
    - Precise Volumetric Measurement
    - Greater than 10:1 Turn-Down Ratio
  - Disadvantages
    - Requires VFD Drive

Chemical Metering Pumps

Source:
http://www.lmipumps.com/Images/lmi/Global/US-en/site_images/sp1_series.gif

- Piston/Stroke Pump Installation
  - Advantages
    - Continuous Duty
    - Precise Volumetric Measurement
    - Easily Adjustable Stroke
    - Good Turn-Down Ratio (Up to 100:1)
  - Disadvantages
    - Moderately Higher Cost
    - Limited Capacity

Chemical Metering Pumps

Source: http://www.metconeng.com/mydocs/media/jpeg/wmb_720_series_pumps071708_142705.jpg

- Peristaltic Tube Pumps
  - Advantages
    - Continuous Duty
    - Precise Volumetric Measurement
    - Greatest Turn-Down Ratio (Up to 360:1)
  - Disadvantages
    - Limited Capacity
    - Tube Must be Periodically Replaced

Olde Engilish Proverb

"Nobody appreciates water until the well runs dry"

Thank you for your dedication to the water & wastewater industry

PDF of This Presentation Available at:

www.civilwatersolutions.com

Questions?

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