# US Territories Wastewater Operator Training Series

## Session 6: Collection Systems - Pumping & Force Mains

09/03/2025



This program is made possible under a cooperative agreement with US EPA.

# Your trainers for today:

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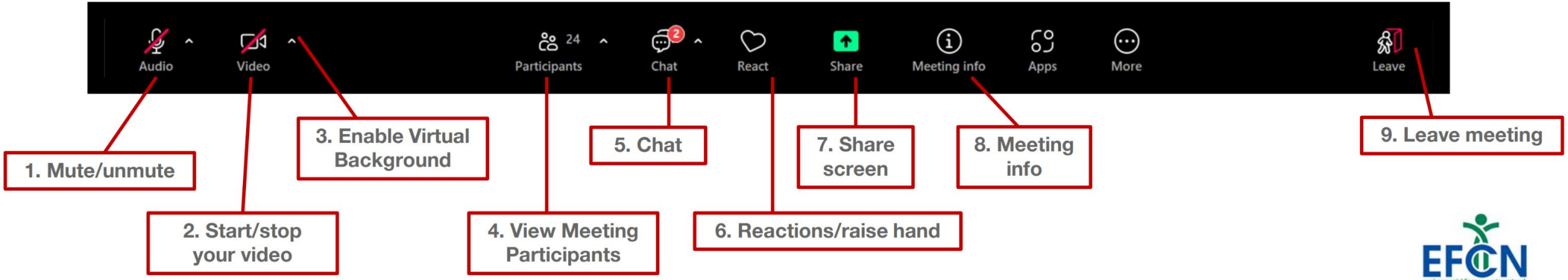
# Attendee Meeting Controls

- Locate your control bar
- All attendees will see a black horizontal bar on their screen
- If your control bar is not visible, it may be hidden
  - Move your cursor to the screen's bottom (or top) to reveal this control bar.



# WPI/ABC Operator Certification

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## Standardized Wastewater Treatment Operator Exams

### Wastewater Treatment Operator Need-to-Know Criteria

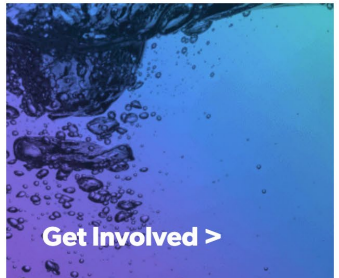
Need-to-Know Criteria outline the content that will be covered on WPI's standardized examinations provided through ABC Testing, a WPI service.

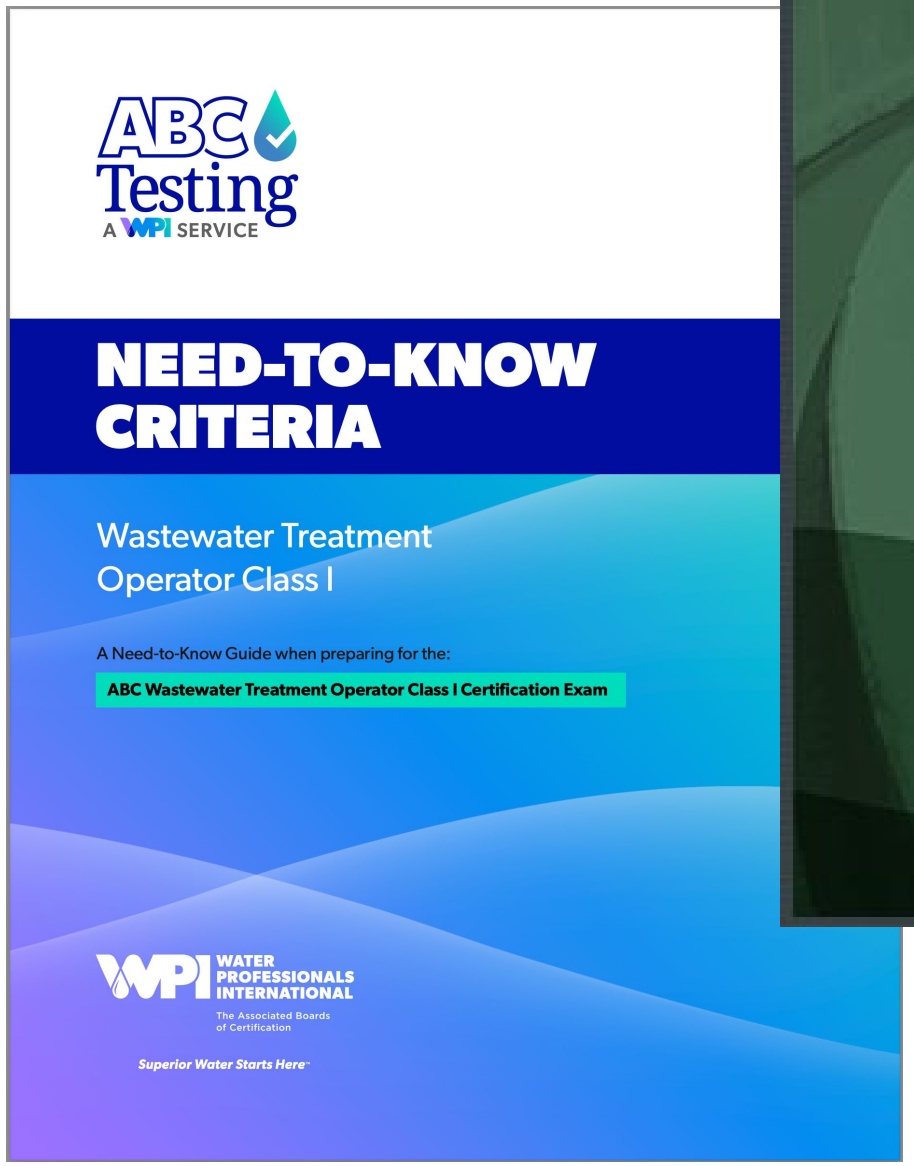
- Wastewater Treatment Operator Class I
- Wastewater Treatment Operator Class II
- Wastewater Treatment Operator Class III
- Wastewater Treatment Operator Class IV

### Wastewater Treatment Operator Formula/Conversion Table

WPI standardized exams are administered with a Formula/Conversion Table containing mathematical formulas and common abbreviations that may be present on the exam.

- Wastewater Treatment Operator Formula/Conversion Table




ABC Testing
A WPI SERVICE
NEED-TO-KNOW CRITERIA
Wastewater Treatment Operator Class I
A Need-to-Know Guide when preparing for the:
ABC Wastewater Treatment Operator Class I Certification Exam
WPI WATER PROFESSIONALS INTERNATIONAL
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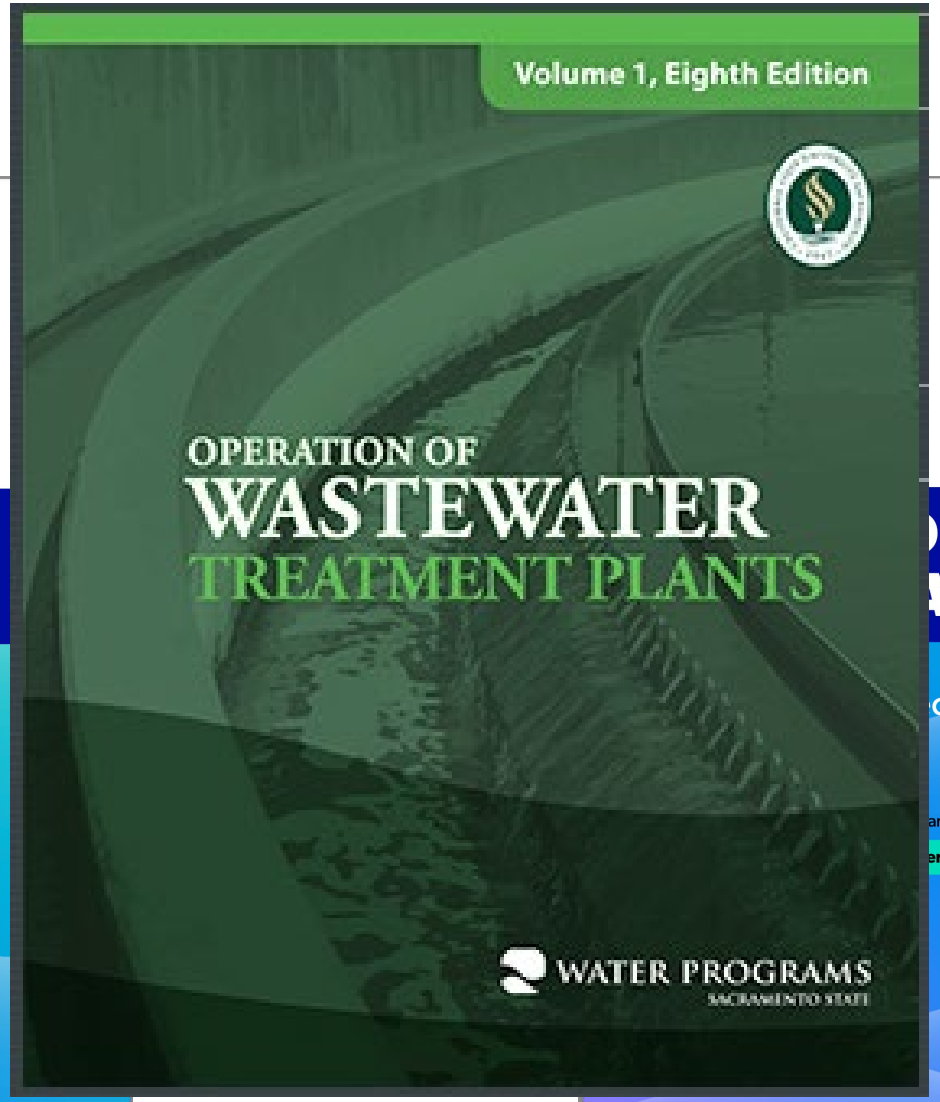
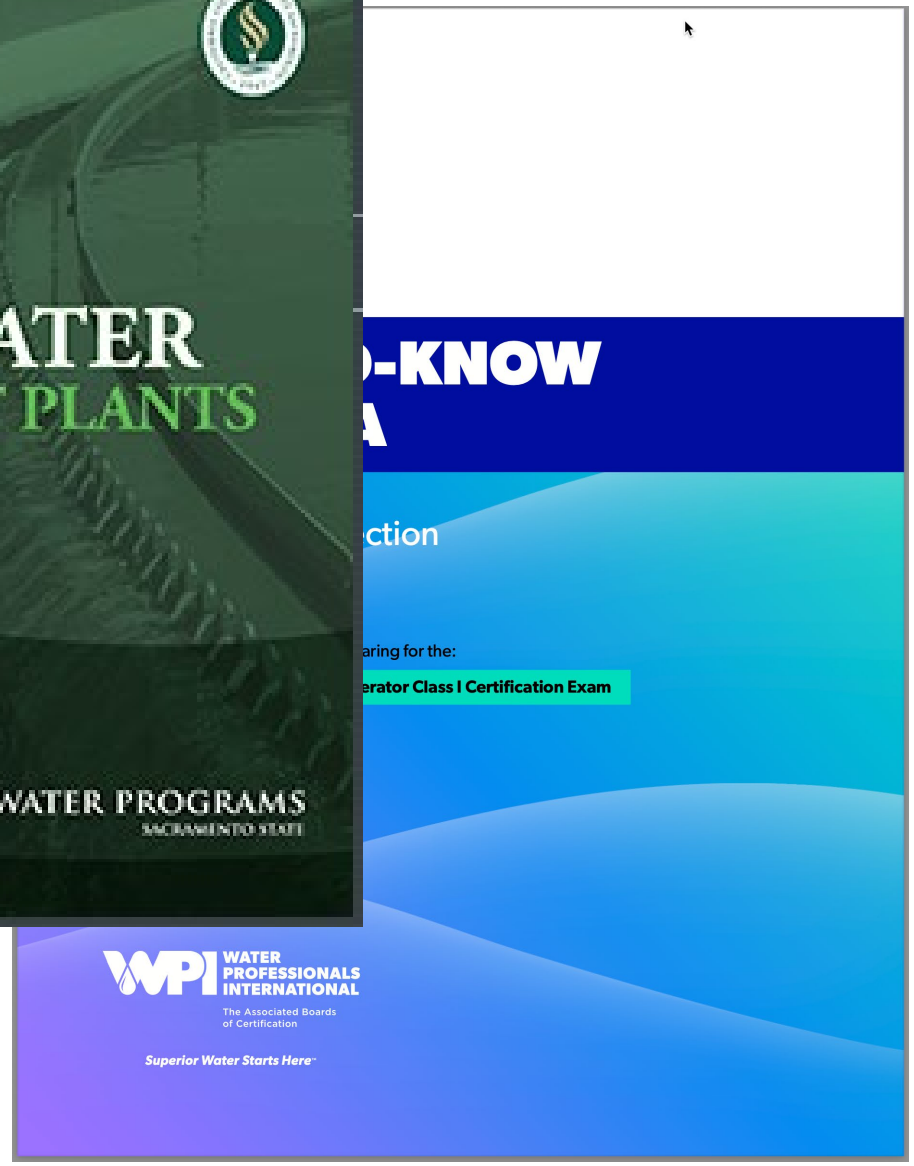

Volume 1, Eighth Edition
OPERATION OF
WASTEWATER
TREATMENT PLANTS
WATER PROGRAMS
SACRAMENTO STATE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# Collection Operator Exam Content

| NUMBER OF QUESTIONS | CONTENT AREA | JOB TASK COMPLEXITY LEVELS |
|---|---|---|
| 28 | Equipment Operation, Evaluation, & Maintenance | 23<br>5<br>0 |
| 20 | Collection System Operation, Maintenance, & Restoration | 18<br>2<br>0 |
| 18 | Lift Station Operation & Maintenance | 16<br>2<br>0 |
| 18 | Collection System Monitoring, Evaluation, & Adjustment | 15<br>3<br>0 |
| 16 | Security, Safety, & Administrative Procedures | 10<br>6<br>0 |
| 100* | Total | 82<br>18<br>0 |

**ABC Wastewater Collection Operator Class I Certification Exam**

THIS EXAM INCLUDES **8** calculation questions

| NUMBER OF QUESTIONS | CONTENT AREA | JOB TASK COMPLEXITY LEVELS |
|---|---|---|
| 23 | Equipment Operation, Evaluation, & Maintenance | 9<br>14<br>0 |
| 23 | Collection System Operation, Maintenance, & Restoration | 9<br>14<br>0 |
| 15 | Lift Station Operation & Maintenance | 6<br>9<br>0 |
| 15 | Collection System Monitoring, Evaluation, & Adjustment | 6<br>9<br>0 |
| 24 | Security, Safety, & Administrative Procedures | 10<br>14<br>0 |
| 100* | Total | 40<br>60<br>0 |

**ABC Wastewater Collection Operator Class II Certification Exam**

THIS EXAM INCLUDES **10** calculation questions

# Treatment Operator Exam Content

| NUMBER OF QUESTIONS | CONTENT AREA | JOB TASK COMPLEXITY LEVELS |
|---|---|---|
| 10 | Laboratory Analysis | 2<br>7<br>1 |
| 25 | Equipment Evaluation & Maintenance | 12<br>10<br>3 |
| 25 | Equipment Operation | 8<br>14<br>3 |
| 30 | Treatment Process Monitoring, Evaluation, & Adjustment | 5<br>10<br>15 |
| 10 | Security, Safety, & Administrative Procedures | 7<br>3<br>0 |
| 100* | Total | 34<br>44<br>22 |

**ABC Wastewater Treatment Operator Class I Certification Exam**

THIS EXAM INCLUDES **10** calculation questions

| NUMBER OF QUESTIONS | CONTENT AREA | JOB TASK COMPLEXITY LEVELS |
|---|---|---|
| 15 | Laboratory Analysis | 3<br>9<br>3 |
| 20 | Equipment Evaluation & Maintenance | 8<br>9<br>3 |
| 25 | Equipment Operation | 5<br>15<br>5 |
| 30 | Treatment Process Monitoring, Evaluation, & Adjustment | 5<br>10<br>15 |
| 10 | Security, Safety, & Administrative Procedures | 6<br>4<br>0 |
| 100* | Total | 27<br>47<br>26 |

**ABC Wastewater Treatment Operator Class II Certification Exam**

THIS EXAM INCLUDES **12** calculation questions

# Schedule for 2025:

| Date | Topic |
|---|---|
| 6/24/25 | Program Overview, Test Format, Study & Test Tips |
| 7/8/25 | Treatment Overview - Reg history, overview |
| 7/22/25 | WW Math Part 1 (Areas & Volumes) |
| 8/5/25 | WW Math Part 2 (Flow Rates & Detention Times) |
| 8/19/25 | Collection Systems - Gravity systems |
| 9/2/25 | Collection Systems - Pumping & force mains |
| 9/16/25 | Collection System Maintenance |
| 9/30/25 | Operator Safety/OSHA/Chemical Safety & Inventory |
| 10/14/25 | Preliminary Treatment |
| 10/28/25 | Primary Treatment: Sedimentation |
| 11/11/25 | Fixed-Film Media |
| 12/2/25 | Activated Sludge Part 1 |
| 12/16/25 | Activated Sludge Part 2 |

# https://swefc.unm.edu/home/op-cert-trainings/

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## Pacific Island Territories Operator Certification Trainings

This page is a repository of Wastewater and Drinking Water Operator Certification (Op Cert) Training Webinars offered by the SW EFC for systems in the Pacific Territories. Below you will find the **training webinar schedules (wastewater, then drinking water)** followed by a **training webinar recordings library.**

Jump to Wastewater Trainings

Jump to Drinking Water Trainings

## Wastewater Training Schedule

***Please note all times are local to CNMI and Guam. The times in American Samoa are one day earlier at 11 am.***

| Session | Date | Training Topic & Link to Recording (click to view) | Supporting Materials (click to download) |
|---|---|---|---|
| 1 | 6/25/2025 | Program Overview, Test Format, Study & Test Tips | PPT slides |
| 2 | 7/9/2025 | Treatment Overview | |
| 3 | 7/23/2025 | WW Math Part 1 (Areas & Volumes) | |
| 4 | 8/6/2025 | WW Math Part 2 (Flow Rates & Detention Times) | |
| 5 | 8/20/2025 | Collection Systems – Gravity systems | |
| 6 | 9/3/2025 | Collection Systems – Pumping & Force Mains | |
| 7 | 9/17/2025 | Collection System Maintenance | |
| 8 | 10/1/2025 | Operator Safety/OSHA/Chemical Safety & Inventory | |

# Sign in for every session to ensure you get credit for attending

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## US Territories Water & Wastewater Operator Certification Virtual Training Series Group Attendance Sheet

Session Title: _____

Session Date: _____

Training Location: _____

| Attendee Name | Attendee Signature | Arrival Time | Departure Time |
|---|---|---|---|
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I hereby certify that the individuals listed above attended the referenced training session.

Name: _____

Signature: _____

Title: _____

Date: _____

***Please scan this sheet after each training session and email it to swefc@unm.edu with the subject line: "US Territories Op Cert Attendance Sheet"***

# Today's Agenda – Collection Systems

- Lift Stations
  - Purpose
  - Types
  - Components
  - Operations
  - Maintenance
- Pumps
  - Types
  - Operations
  - Pump Curves
- Force Mains

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# Lift Stations

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# Lift Stations – Purpose

- Raising wastewater from lower to higher elevation
- Use pumps to move water into force mains
- After the force main gravity takes over

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# Lift Stations – Locations

- Terrain requires deep excavation for gravity, (backhoes limited to around 30 ft.)
- Cost of excavation to maintain slope for scouring velocity
- Soil instability
- High ground water tables
- Might be an economical solution for current flow levels

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# Lift Stations – Design Goals

- Goal is moving wastewater with maximum efficiency
- Pumps have to be selected to minimize surges and provide as constant a flow as possible to minimize surges
- Should blend in, with surrounding area and odor, noise and rubbish should be dealt with immediately

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# Lift Station Types

- **Wet Well** – Single chamber
  - Pumps might be submerged or above wastewater
  - Cheaper to build
  - Maintenance can be more problematic
  - Confined space – may contain toxic gases
- **Dry Well** - Two chambers
  - one to collect wastewater, and
  - another for pumps, motors, valves, controls and other equipment
  - More expensive to build
  - Machinery easier to access
  - Confined space – may contain toxic gases

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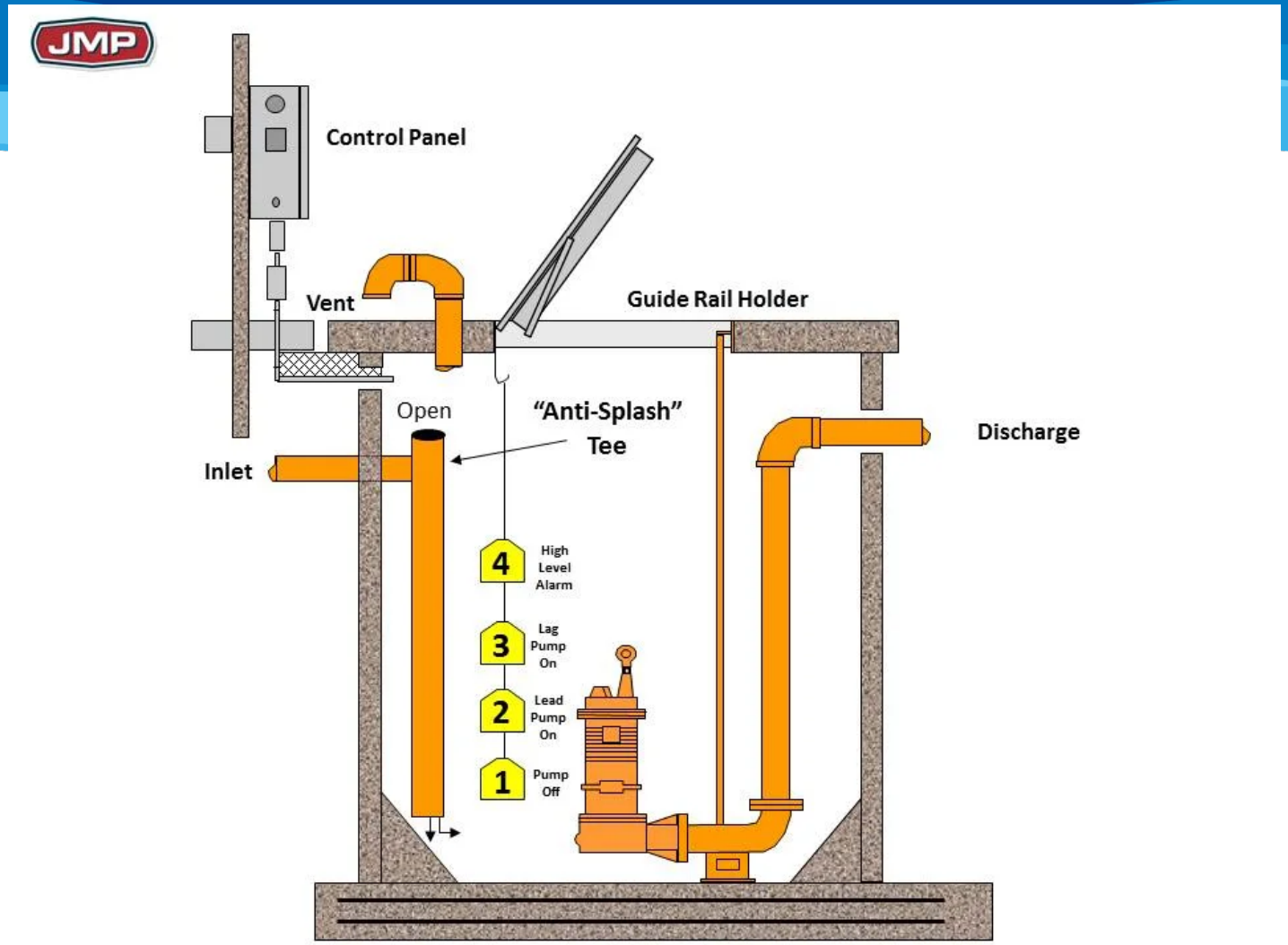
# Lift Station Components

- Pumps
- Wet/Dry Well/Basin
- Hardware
- Bar Racks/Screens
- Valves
- Electrical Systems
- Alarms
- Motor Control Center
- Pump Controls/Level Controls
- Force Mains




https://jmpcoblog.com/hvac-blog/commercial-sewage-lift-stations-part-5-system-components

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# Lift Station Components

- Pumps
  - Depends on depth and type
  - Will discuss in-depth in later slides
- Wet Well/Basin
  - Typically concrete, metal or fiberglass
  - Size
    - Not too small - so pumps don't cycle too often
    - Not too large – so wastewater doesn't go septic
- Hardware
  - Should be corrosion resistant material
- Bar Rack/Screen
  - Prevents large debris from entering station to prevent pump clogging
  - Must be cleaned regularly
- Electrical Systems
  - Typically 3 phase
  - Often have generator back-up or transfer switch capabilities

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# Lift Station Components

- Alarms
  - Notify of high level to avoid overflows
  - Can be visible and audible or part of control system
- Motor Control Center / Pump Controls
  - HOA switches
  - Pump starters
  - Alarms
  - Lead/Lag Controls
  - Other controls
- Force Mains
  - Flow under pressure – more later
- Pump/Level Controls
  - Based on water level
  - Types include
    - Floats
      - Can stick in grease and debris
    - Probes (electrodes)
      - Problems caused by grease and rags
    - Bubblers (pneumatic)
      - Air pump failures and tube clogging lead to malfunctions
    - Switches
      - Must be kept clean to switch
    - Pressure Transducer
      - Can be fouled by rags and debris
    - Ultrasonic

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# Lift Station Components

- Valves
  - Isolation – gate, plug or knife
    - Used to service pump
    - Should not be throttled
    - Plug valves have a restriction which may be easily clogged
  - Check – swing or ball
    - Prevent backflow
    - If leaking, the pump will run longer
- Other components may include
  - Wet Well Cover/Lid (fiberglass or steel)
  - Access Frames and Hatches (pump access “door”, aluminum)
  - Removal System/Guide Rails
  - Vent

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# Lift Station Operations – Pump Controls

- Water flows into the pump station wet well and the water level rises
- Once the water reaches the first set point the first pump turns on and the water level should start to decrease.
  - If the water level continues to increase, a second set point will be reached and a second pump will come on (if equipped with lead/lag pumps)
- The water is being pumped out faster than it enters. The level decreases and a low level set point is reached, turning the pump(s) off

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# Lift Station Maintenance

- Grit
  - Grit accumulation leads to reduced flow to pumps and loss of wet well capacity
- Grease & Scum
  - Causes odors & impairs functioning of equipment
  - Removal:
    - Manual
    - Chemical/biological treatment of FOG
- Odor Control
  - Minimize wet-well turbulence
  - Treatment with scrubbers or biofilters
  - Chemical addition: Chlorine, Hydrogen peroxide, Oxygen
    - Chemicals should be closely monitored

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# Lift Station Maintenance

- Daily
  - Inspection
  - Record flow and runtime (can also be weekly)
- Monthly
  - Check controls, gauges, alarms
  - Check motor amperage
- Annually
  - Cleaning and inspection
  - Check pumps and motors
  - Check valves
- Other
  - Grit removal – as needed

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# Lift Stations – Safety Hazards

- Confined space
- Hazardous atmospheres
- Slippery ladders or stairs
- Mechanical & electrical hazards
- Insects, snakes & rodents
- Infections & diseases
- Inadequate drainage
- Drowning

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# Lift Stations

Pumps

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# Lift Station Pumps – Quick Facts

- Wastewater systems are usually large energy consumers
  - Pumps typically account for 2nd largest energy use for wastewater systems (aeration equipment largest energy user)
  - Important to operate and maintain properly to keep costs down
- Centrifugal Pumps are most common for lift stations
- Safety – Lockout/Tagout procedures necessary before any work completed
- Pumps are rated by the flow they produce and the pressure they must work against

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# Lift Station Pumps - Types

- Positive Displacement
  - Low flow/high pressure
  - Water Jet Pumps, Sludge Pumps, Chemical Feed Pumps
  - Piston pumps, diaphragm pumps, progressive cavity screw pumps are the most common types of positive displacement pumps
  - Constant flow rate regardless of discharge pressure
  - May be used in very small lift stations
- Centrifugal
  - High flow/low pressure (head)
  - Booster Pumps, Primary Service Pumps
  - Flow changes when pressure changes
  - Most common in lift stations

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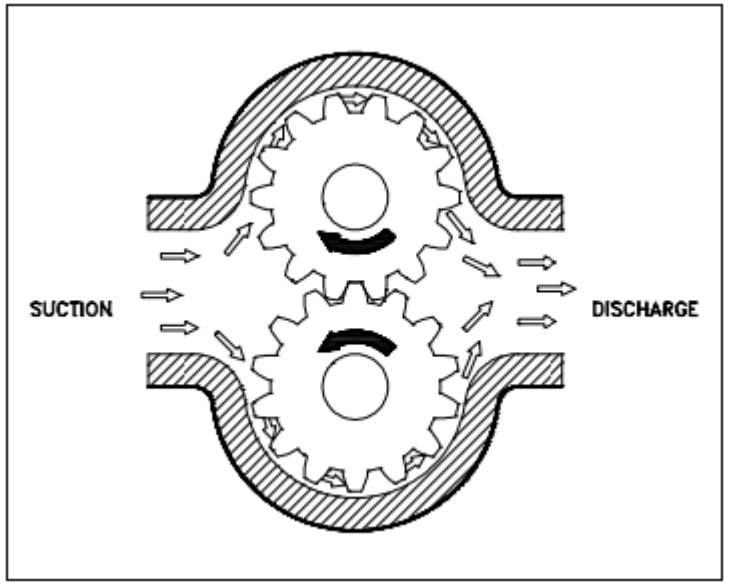
# Lift Station Pumps – Positive Displacement Pumps

- Positive Displacement
  - Move set volume of fluid in each cycle
  - Cannot operate against a closed discharge valve




- Include
  - Reciprocating piston pump
    - Piston moves back and forth in a cylinder; liquid enters and leaves through check valves
  - Rotary pump
    - Uses lobes or gears to move liquid through pump
  - Screw pump
    - Screw(s) rotates in (angled) cylinder to lift liquid
  - Diaphragm pump
    - diaphragm moves by mechanical linkage, compressed air, or fluid from a pulsating, external source

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# Lift Station Pumps – Centrifugal Pumps

- Centrifugal Pumps
  - Move fluid by use of a centrifugal force (moving something away from the center of a moving circle)
  - Impeller spins to move water
  - Water leaving impeller creates suction to bring more into the pump
  - There are open and closed impellers – wastewater typically uses open impellers to prevent clogging
  - Vertical orientations are typically used in lift stations

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# Lift Station Pumps – Centrifugal Pumps

- Common Components
  - Impeller – moves fluid
  - Shaft
    - Spins impeller
    - Alignment critical
  - Bearings
    - Hold shaft in place
    - Decrease friction
  - Pump Casing
  - Volute
    - collect and direct the flow of water as it enters and leaves the impeller

- Common Components
  - Suction and Discharge Piping
  - Wear rings
    - replaceable rings allow a small running clearance between the impeller and the pump casing
    - designed to be replaced periodically
    - prevent the more costly replacement of the impeller or the casing

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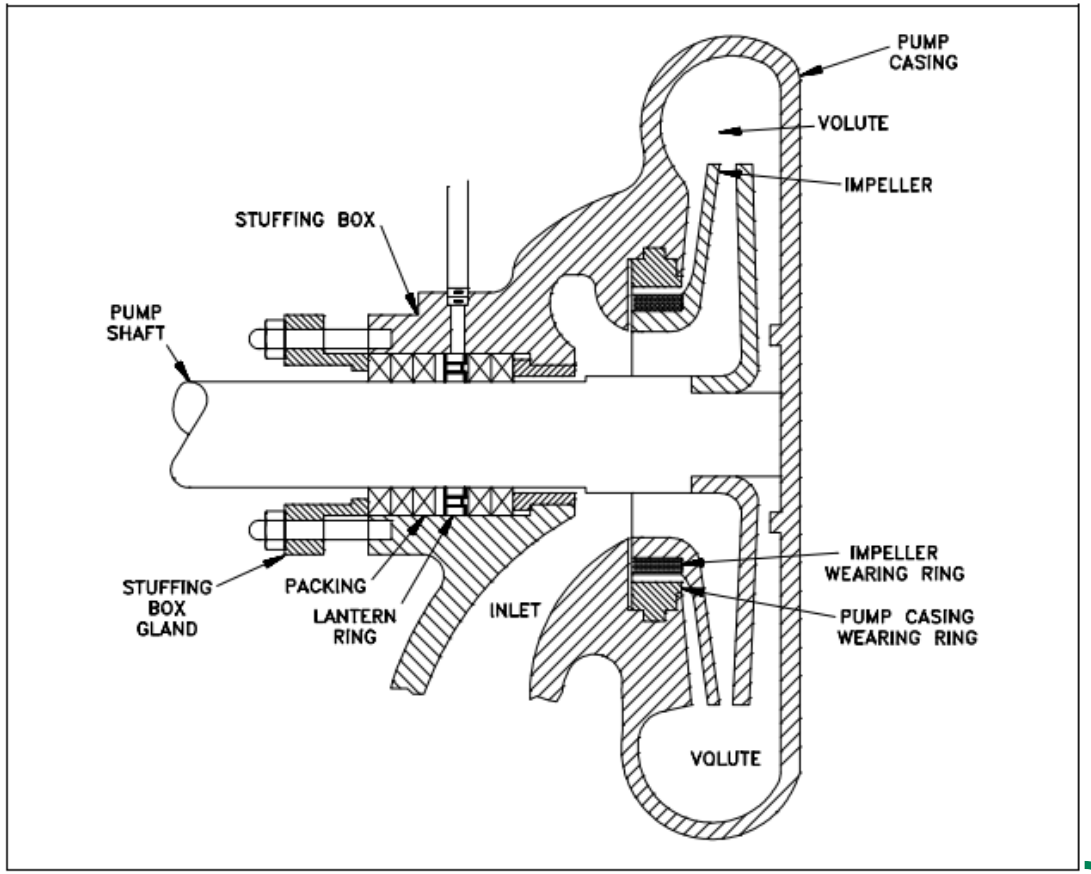
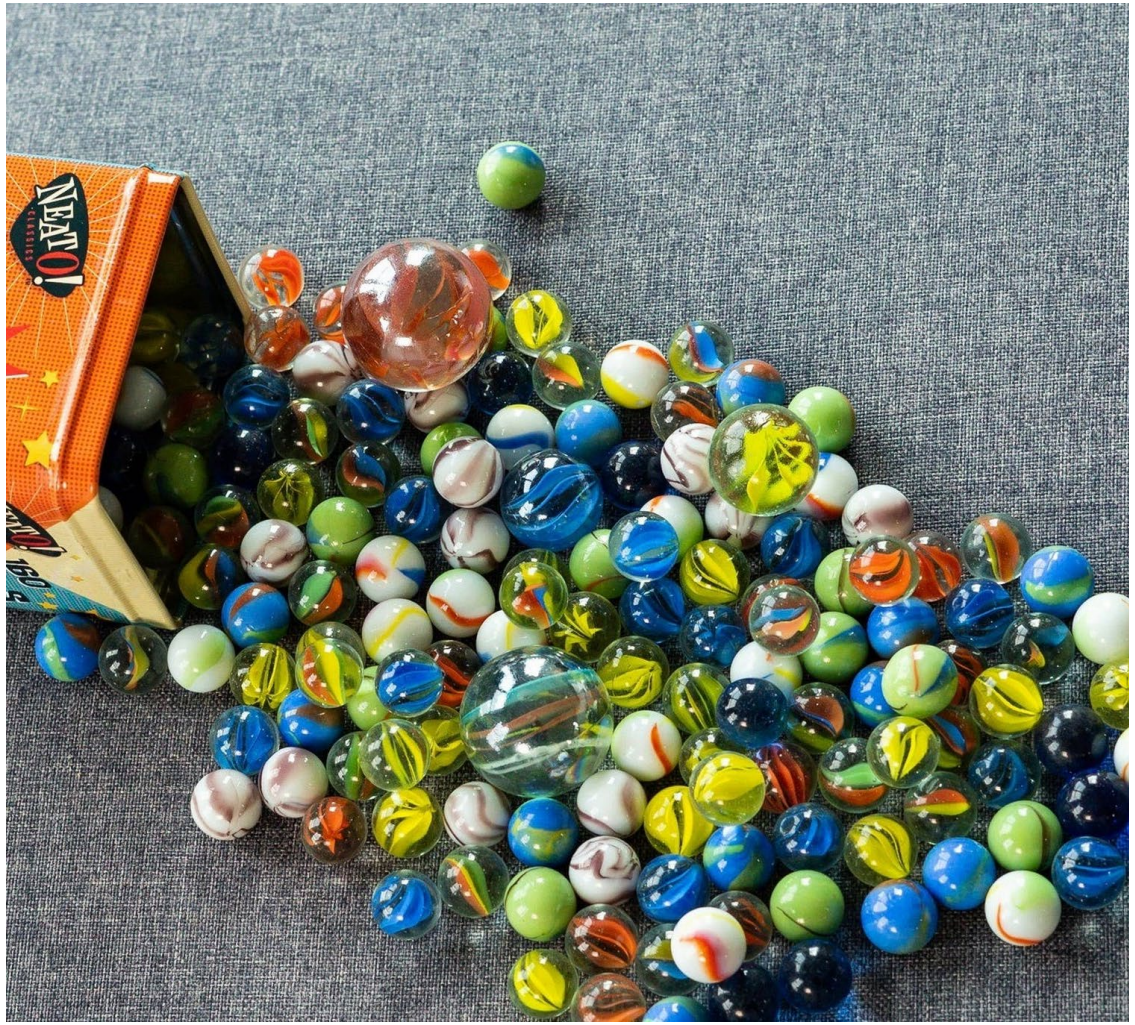
# Lift Station Pumps – Centrifugal Pumps

- Common Components
  - Stuffing Box
    - Seal between shaft and pump
    - Uses packing rings and gland
    - Packing glands may need to be adjusted periodically
  - Lantern Ring
    - Used to get water to the inside of the packing rings where the heat is being generated
  - Mechanical Seal
    - Pumps that do not have packing in the stuffing box will be equipped with a mechanical seal



# Lift Station Pumps – Centrifugal Pumps




- Operations
  - Pump should not be started or run dry – water used as lubrication
  - Cavitation – pump not running at designed flow/pressure
    - Creates a vacuum that vaporizes the liquid, when the vapor returns to liquid it reacts very quickly causing small amounts of damage to the pump, over time this leads to significant pump vibration and damage
    - A cavitating pump can sound like a can of marbles being shaken. Other indications that can be observed from a remote operating station are fluctuating discharge pressure, flow rate, and pump motor current

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# Lift Station Pumps – Centrifugal Pumps
# Causes of Cavitation

- Suction Side
  - Pump subjected to low pressure or high vacuum conditions
  - Pump running too far right on pump curve
  - High pumping speed
  - Clogged suction pipe
  - Poor suction conditions
  - Closed or partially closed valves
  - High inlet velocity
  - Poor pipe design
- Discharge Side
  - Occurs when pressure is too high or efficiency drops very low
  - Pump running too far left on the pump curve
  - Clogged discharge pipe
  - Poor pipe design

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# Lift Station Pumps – Centrifugal Pumps

- Operations
  - Net Positive Suction Head – is pressure adequate to avoid cavitation?
    - Increase the pressure at the suction of the pump
      - raising the level of the liquid in the tank
      - or increasing the pressure in the space above the liquid
    - Reduce head losses in the pump suction piping
      - increasing the pipe diameter, reducing the number of elbows, valves, and fittings in the pipe, and decreasing the length of the pipe.
    - Reduce flow rate
  - Air Locking
    - Air trapped in pump volute, creating increased pressure until shut off head is reached
    - Pump will quickly overheat
  - Energy use is highest during starting – motor and pump must start turning

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# Centrifugal Pump Curves

- Pump performance and efficiency vary depending on
  - Pump configuration
  - Capacity/volume of lift station
  - Flow rate needed
  - Pressure
- Selecting the right pump
  - Extends pump life
  - Saves energy

- Pump Curve
  - Graph
  - Y axis = Total pressure or head
  - X axis = Pump Flow Capacity
  - Head capacity curve
  - Brake horsepower curve

  or
  - Net Positive Suction Head (NPSH) curve
  - Efficiency curve
  - Impeller sizes

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# Centrifugal Pump Curves

1. Locate the System Operating Point:

- Find where your system's head curve crosses the pump's main performance curve.

2. Determine the Head:

- From the operating point, move horizontally to the left to find the pump's head capacity at that flow rate.

3. Determine the Flow Rate:

- From the operating point, move vertically down to the X-axis to find the flow rate.

4. Find Efficiency:

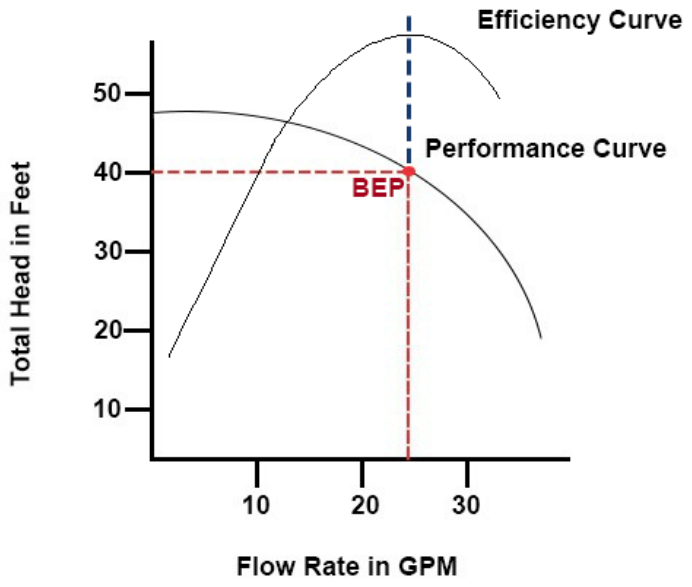
- Move horizontally from the operating point to the nearest efficiency line to find the pump's efficiency in percent at that duty point.

5. Check Horsepower:

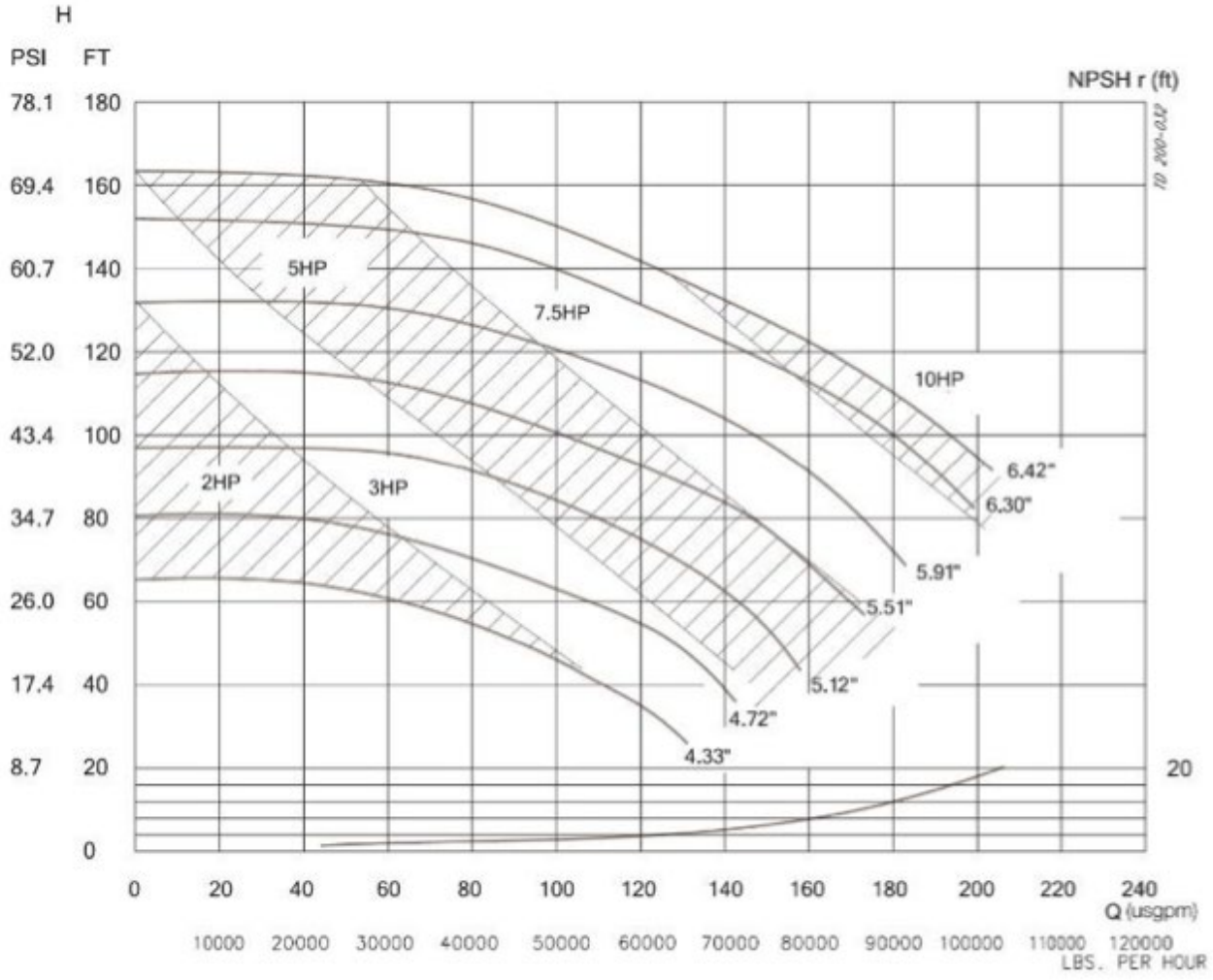
- Move horizontally to the horsepower line closest to your operating point to find the required brake horsepower.

6. Check NPSHr:

- The pump curve also shows the Net Positive Suction Head Required (NPSHr) curve, which is the minimum pressure needed at the pump inlet to prevent cavitation.



# Centrifugal Pump Curves



# Lift Stations

Force Mains

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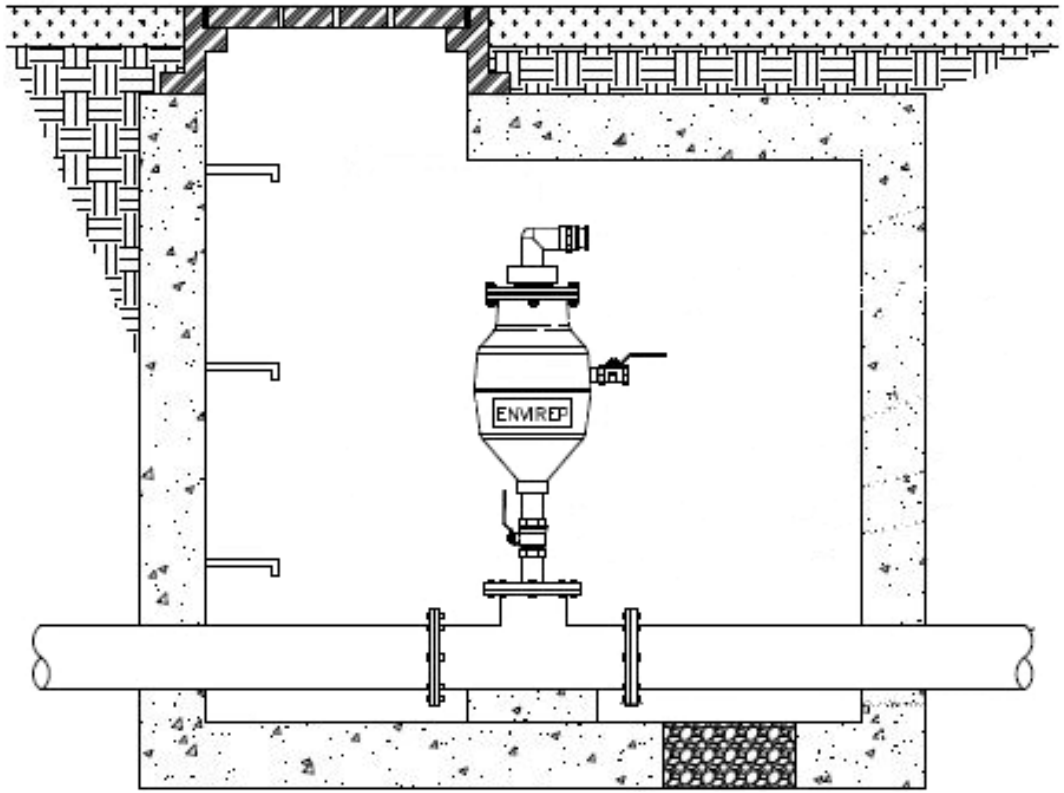
# Lift Stations – Force Mains




- Discharge pipe of the lift station
- Under pressure until the next manhole or similar opening (where the system returns to gravity or the flow enters the treatment plant)
- Trapped air can lead to water hammer – high pressure shock wave that moves in the pipe damaging the pipe and other equipment such as check valves that will slam repeatedly
- Trapped air can also decrease flow rates/increase pressure and increase energy use
- Air release valves can be installed at the pipe's high point to allow air to escape automatically

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# Sample Questions

Let’s try a few…

# Practice Questions

# Questions?