EFCN
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Wastewater Lift Station Operation & Maintenance

Tuesday, July 19, 2022
1- 2 pm EST

Environmental Finance Center
Syracuse University

Great Lakes Environmental Infrastructure Center
Environmental Finance Center for EPA Region 5

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

Lift Station O&M Concepts

- Design
- Components
- Inspection and maintenance tasks
- Troubleshooting

South Gippsland Water Corporation. Technical Specification – Wastewater Pump Stations – PS001. https://www.sgwater.com.au/wp-content/uploads/2014/03/Wastewater-Pumping-Stations-Standard-Specification-Final.pdf

Today's presenter:

Gregory Pearson, Water and Wastewater Systems Trainer – Great Lakes Environmental Finance Center at Michigan Technological University

- Certified WT, WD, WWT Operator
- Trainer and Technical Assistance Provider
- Experience in operations and utility management

Michigan.org: Scenic places in the upper peninsula

Michigan Technological University

Great Lakes Environmental Infrastructure Center

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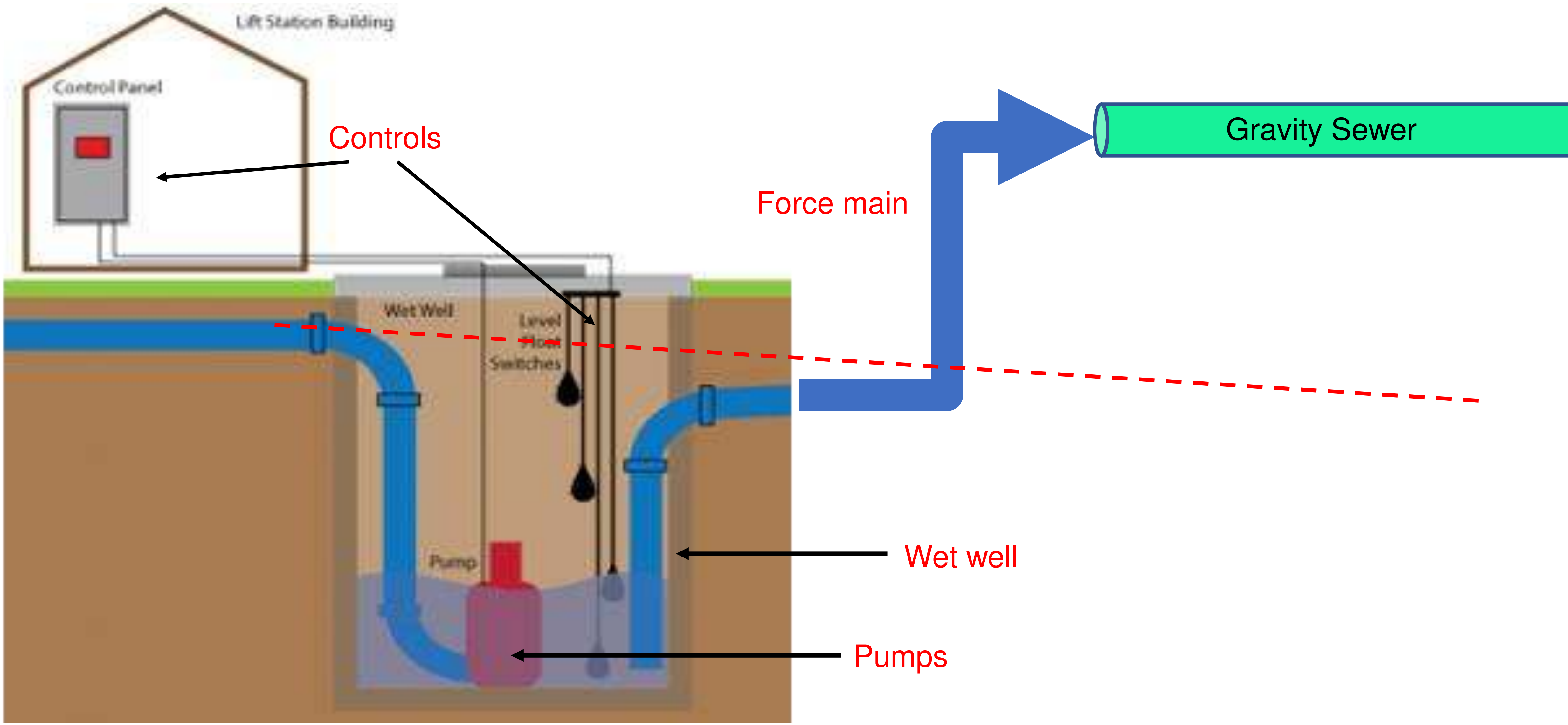
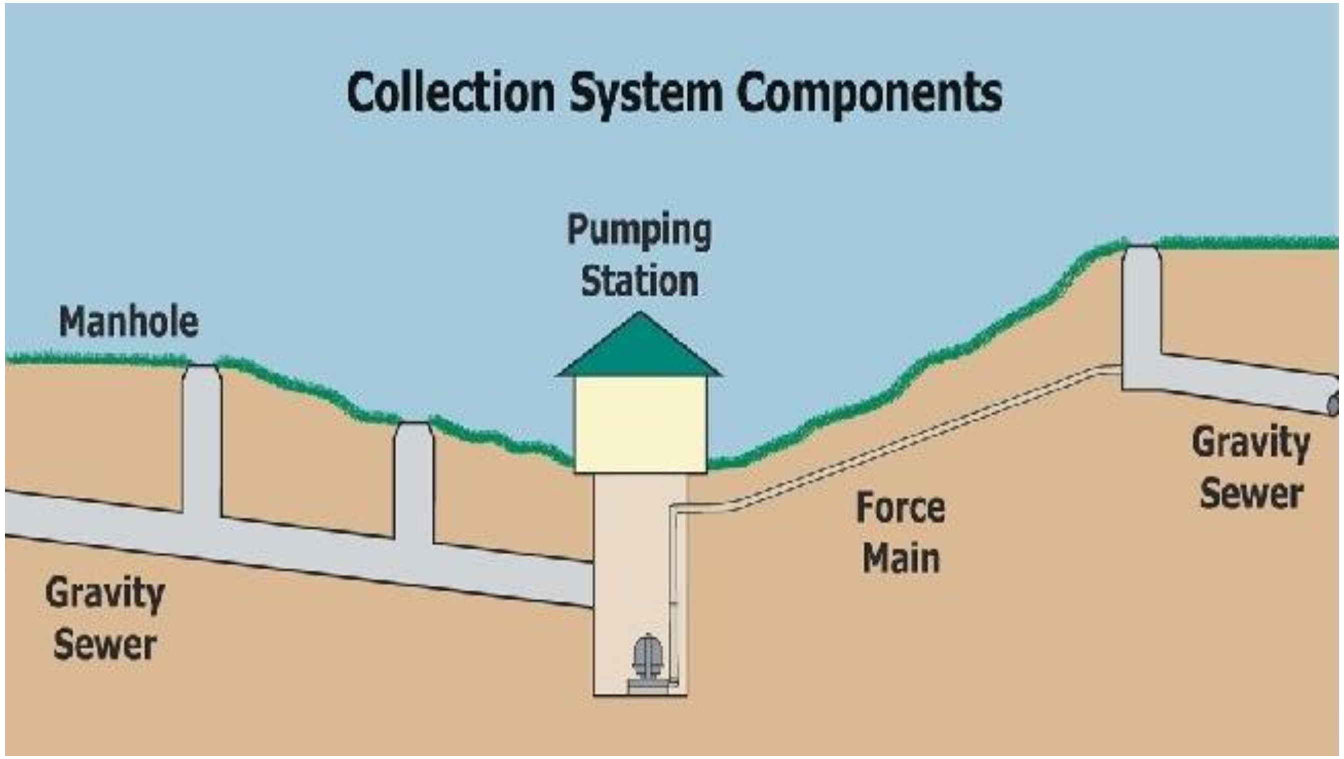
Wastewater lift stations are facilities designed to move wastewater from lower to higher elevation through pipes.



Installed at low points in the collection system at the end of gravity sewer pipes

- Installation costs to maintain gravity flow and velocity (2.5 fps)
- Soil stability is unsuitable for gravity sewer construction.
- Groundwater table is too high for installing deep sewer pipe.
- Wastewater flows are not sufficient to justify extension of large truck sewers



Advantages

Lift stations reduce the capital cost of sewer system construction. When gravity sewers are installed in trenches deeper than three meters (10 feet), the cost of sewer line installation increases significantly:

1. Complex and costly excavation equipment and trench shoring techniques required.
2. Pumping wastewater can convey the same flow using smaller pipeline size at shallower depth.

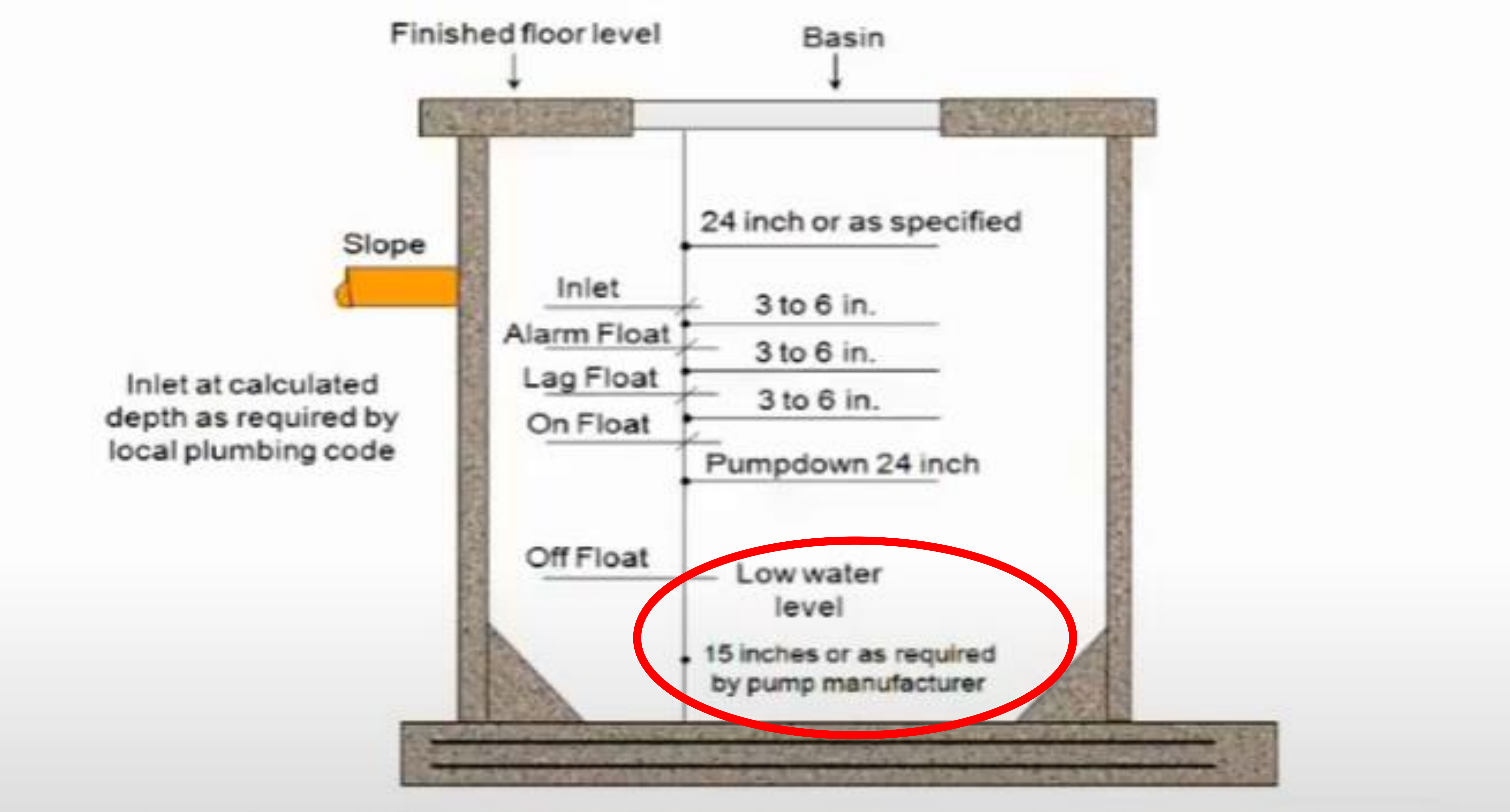
Disadvantages

- If the power supply is interrupted, it can result in flooding upstream of the lift station, or Sanitary Sewer Overflows.
- Requires an emergency power supply.
- High cost to construct
- Potential for odors and noise.

Size of wet well concepts

- Wet-wells are typically designed large enough to prevent rapid pump cycling but small enough to prevent a long detention time and associated odor release.
- Wet-well maximum detention time in constant speed pumps is typically 20 to 30 minutes.
- Use of variable frequency drives for pump speed control allows wet-well detention time reduction to 5 to 15 minutes.
- Wet-wells should always hold some level of sewage to minimize odor release.

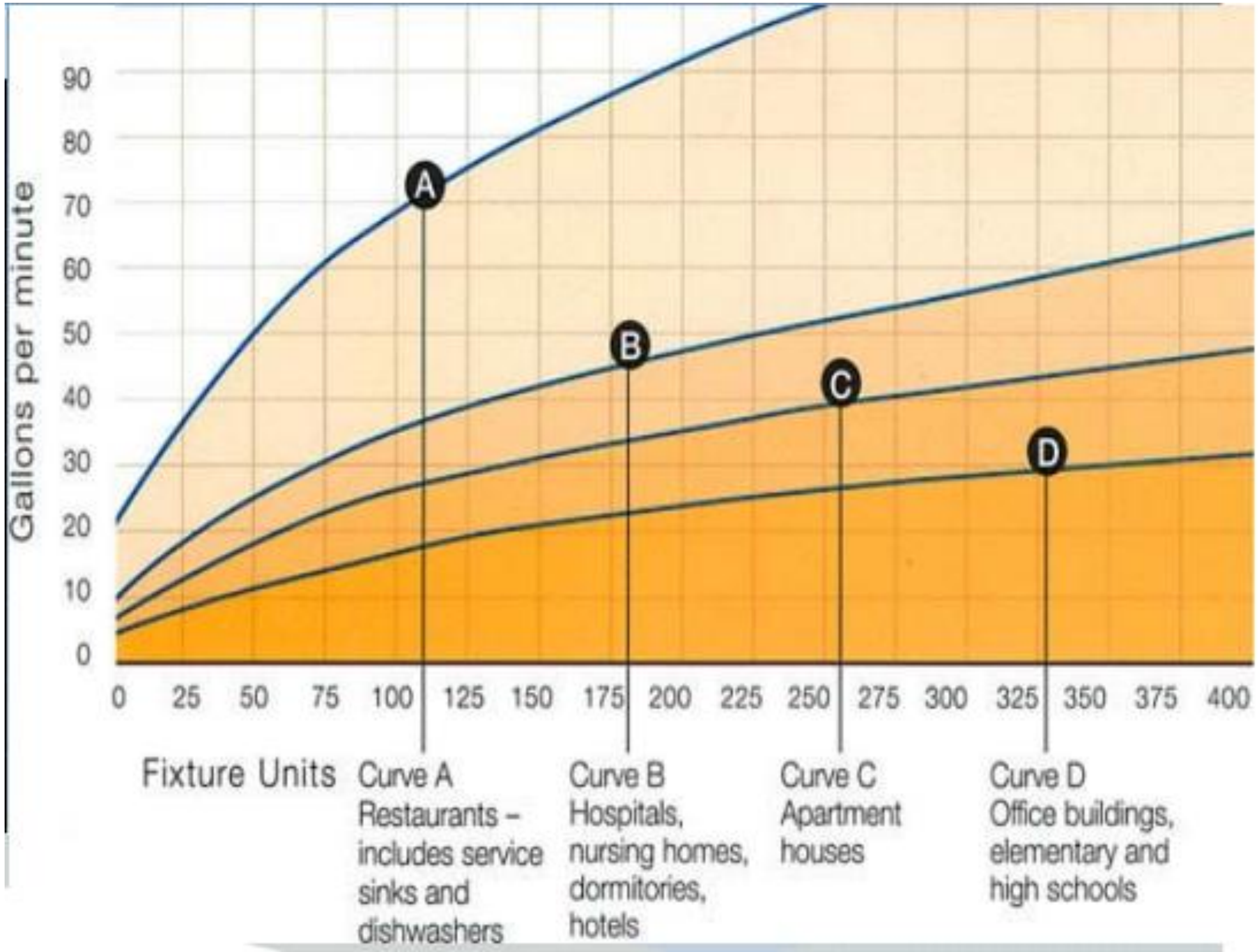
Size of wet well



- The minimum recommended wet-well bottom slope is to 2:1 to allow self-cleaning and minimum deposit of debris.

General design parameters

- Average inflow and peak flow
- Flow velocity needs to be at least 2 to 2.5 fps
- Total Dynamic head requirements will be used to select pump.



GPM as a function of the number of plumbing fixtures

MINIMUM FLOW TO MAINTAIN SCOURING VELOCITY IN SCHEDULE 40 PIPE

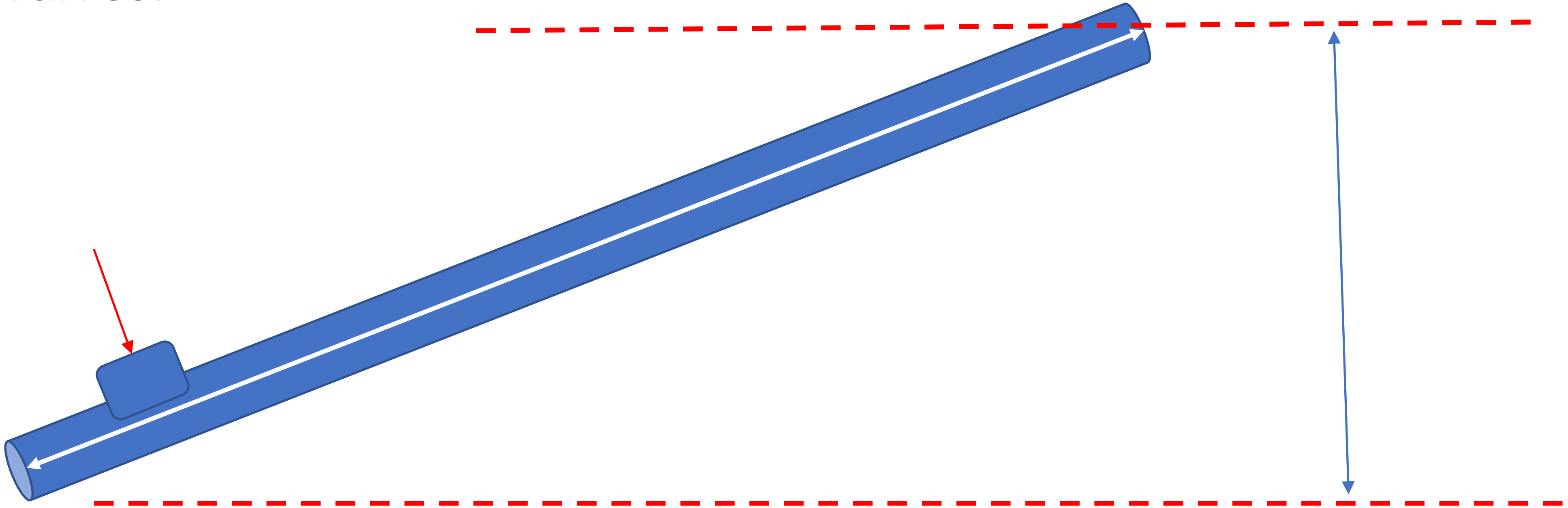
Pipe size	Minimum GPM	Pipe size	Minimum GPM
1-1/4"	9	6"	180
1-1/2"	13	8"	325
2"	21	10"	500
3"	46	12"	700
4"	80		

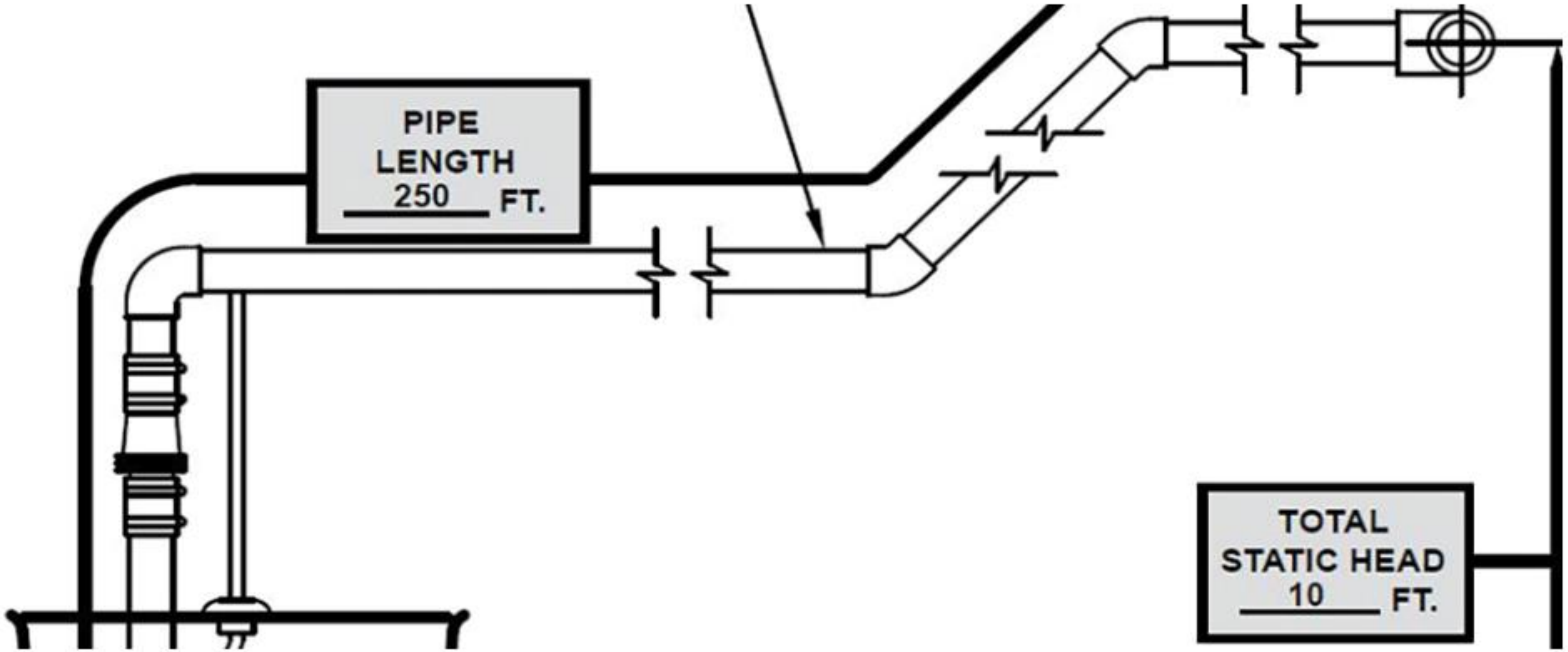
Velocity (fps) = Flow (cfs) ÷ Area (ft^2)

Total dynamic head

TDH is determined by

1) Vertical lift in feet.
2) The length of force main
3) Fittings and valves.
4) Flow rate





PIPE
LENGTH
250 FT.
TOTAL
STATIC HEAD
10 FT.

Feet Of Head Pressure Loss Per 100 Ft. of Plastic Pipe

GPM	Pipe Diameter										
	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	4"	5"	6"
1	2.08	0.51									
2	4.16	1.02	0.55	0.14	0.07						
5	23.44	5.73	1.72	0.44	0.22	0.066	0.038	0.015			
7	43.06	10.52	3.17	0.81	0.38	0.11	0.051	0.021			
10	82.02	20.04	6.02	1.55	0.72	0.21	0.09	0.03			
15		42.46	12.77	3.28	1.53	0.45	0.19	0.07			
20		72.34	21.75	5.59	2.61	0.76	0.32	0.11	0.03		
25			32.88	8.45	3.95	1.15	0.49	0.17	0.04		
30			46.08	11.85	5.53	1.62	0.68	0.23	0.06	0.02	
35				15.76	7.36	2.15	0.91	0.31	0.08	0.03	
40				20.18	9.43	2.75	1.16	0.40	0.11	0.03	
45				25.10	11.73	3.43	1.44	0.50	0.13	0.04	
50				30.51	14.25	4.16	1.75	0.60	0.16	0.05	0.02
60					19.98	5.84	2.46	0.85	0.22	0.07	0.03
70						7.76	3.27	1.13	0.30	0.10	0.04
75						8.82	3.71	1.28	0.34	0.11	0.05
80						9.94	4.19	1.44	0.38	0.13	0.05
90						12.37	5.21	1.80	0.47	0.16	0.06
100						15.03	6.33	2.18	0.58	0.19	0.08

Example: *For 4" pipe, you would lose 0.58 feet of head for every 100 feet of pipe.*

Fittings

	Nominal pipe size												
Fitting	1/2"	3/4"	1"	1 1/4"	1 1/2"	2"	2 1/2"	3"	4"	6"	8"	10"	12"
90° elbow	1.6	2.1	2.6	3.5	4.0	5.2	6.2	7.7	10.1	15.2	20.0	25.1	29.8
45° elbow	0.8	1.1	1.4	1.8	2.2	2.8	3.3	4.1	5.4	8.1	10.6	13.4	15.9
Tee (thru flow)	1.0	1.4	1.8	2.3	2.7	3.5	4.1	5.1	6.7	10.1	13.3	16.7	19.9
Tee (branch Flow)	3.1	4.1	5.3	6.9	8.1	10.3	12.3	15.3	20.1	30.3	39.9	50.1	59.7
Check valve	5.2	6.9	8.7	11.5	13.4	17.2	20.6	25.5	33.6	50.5	66.5	83.6	99.0
Gate valve (full open)	0.4	0.6	0.7	0.9	1.1	1.4	1.7	2.0	2.7	4.0	5.3	6.7	8.0

Fittings add resistance equivalent to that of a certain length of pipe.

Example: A 4-inch check valve adds an amount of resistance equivalent to 33.6 feet of pipe.

TDH CALCULATION

Flow rate (Q) = 180 GPM

Pipe material to be cast iron

Pipe size = 4”

Pipe velocity = 4.5 FT/Sec

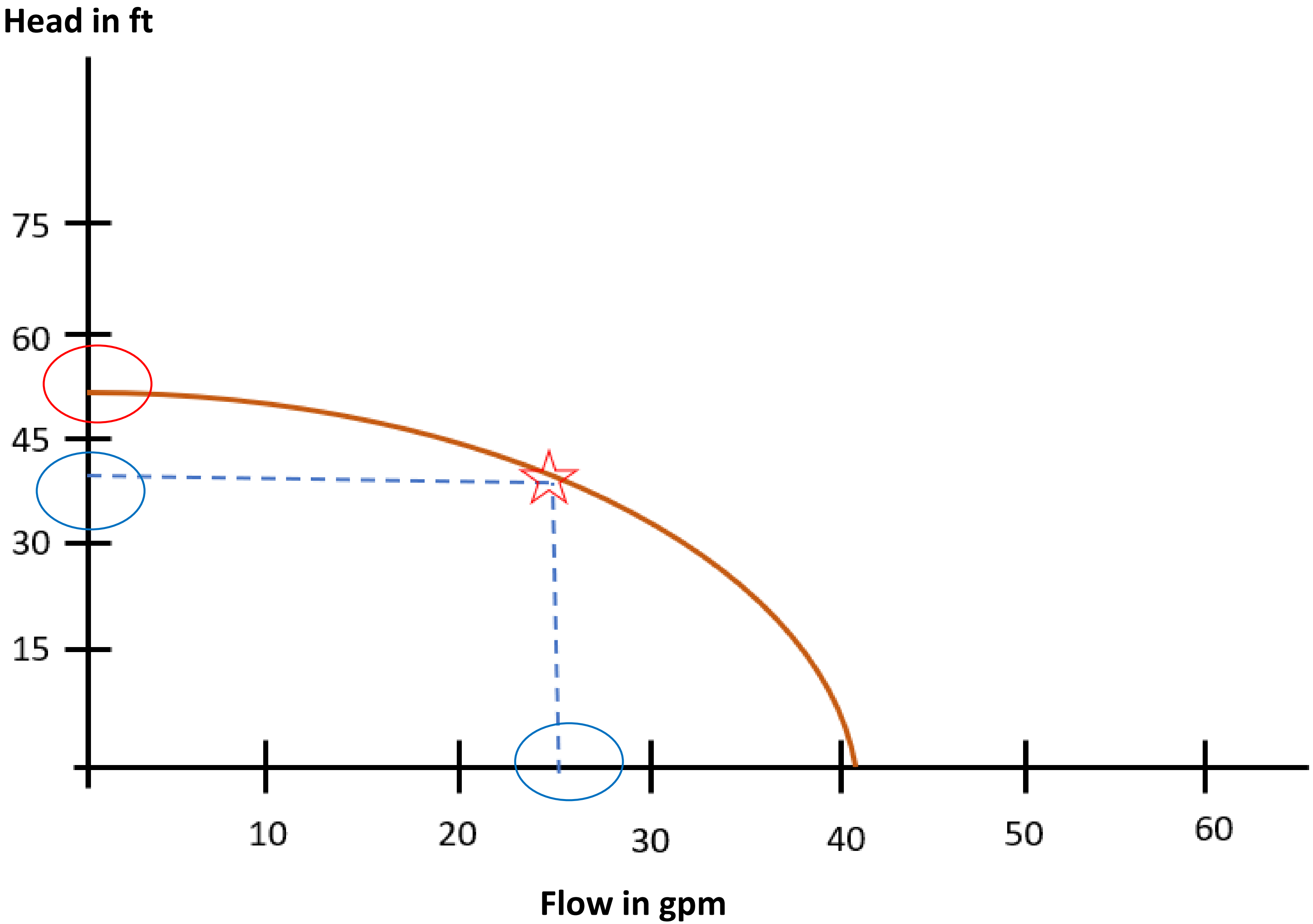
Item	**Eq. FT**	**Qty**	**Total Eq. FT**
Straight Pipe	28		28
Threaded Reg 90 Elbow	11	2	22
Threaded Reg 45 Elbow	4.5	2	9
Tee Branch Flow	17	2	34
Check Valve	31	1	31
Gate Valve	2	1	2
TOTAL EQ. FT.			**126**

Friction Loss = 126 Eq. FT x 1.8 FT/100FT = 2.3 FT

Pump Curve Example

At a TDH of around 53 ft, this pump would have no flow.

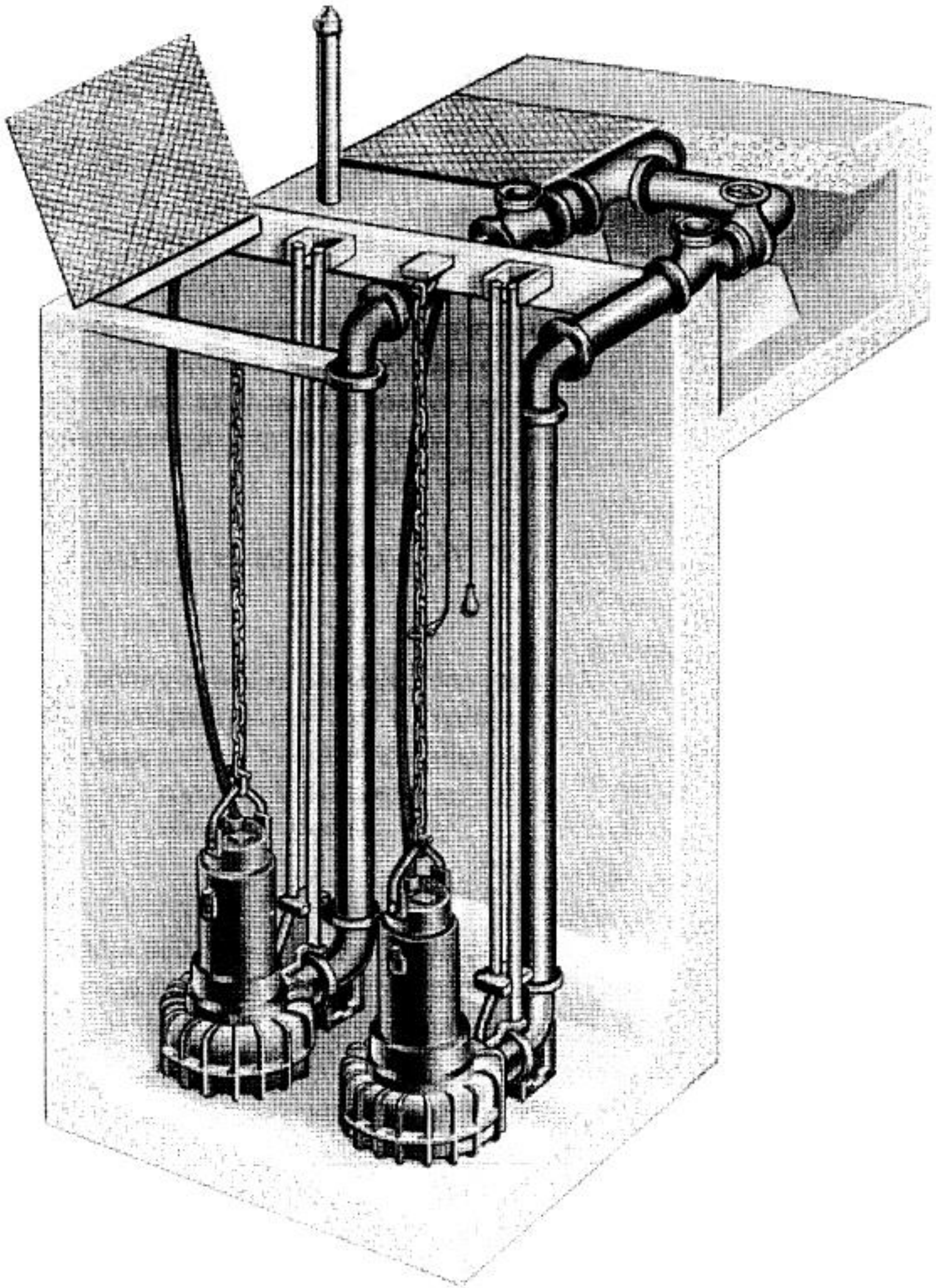
The design flow is 25 gpm at a head of 40 ft



BASIC TYPES OF LIFT STATIONS

- Wet Well
- Dry Well

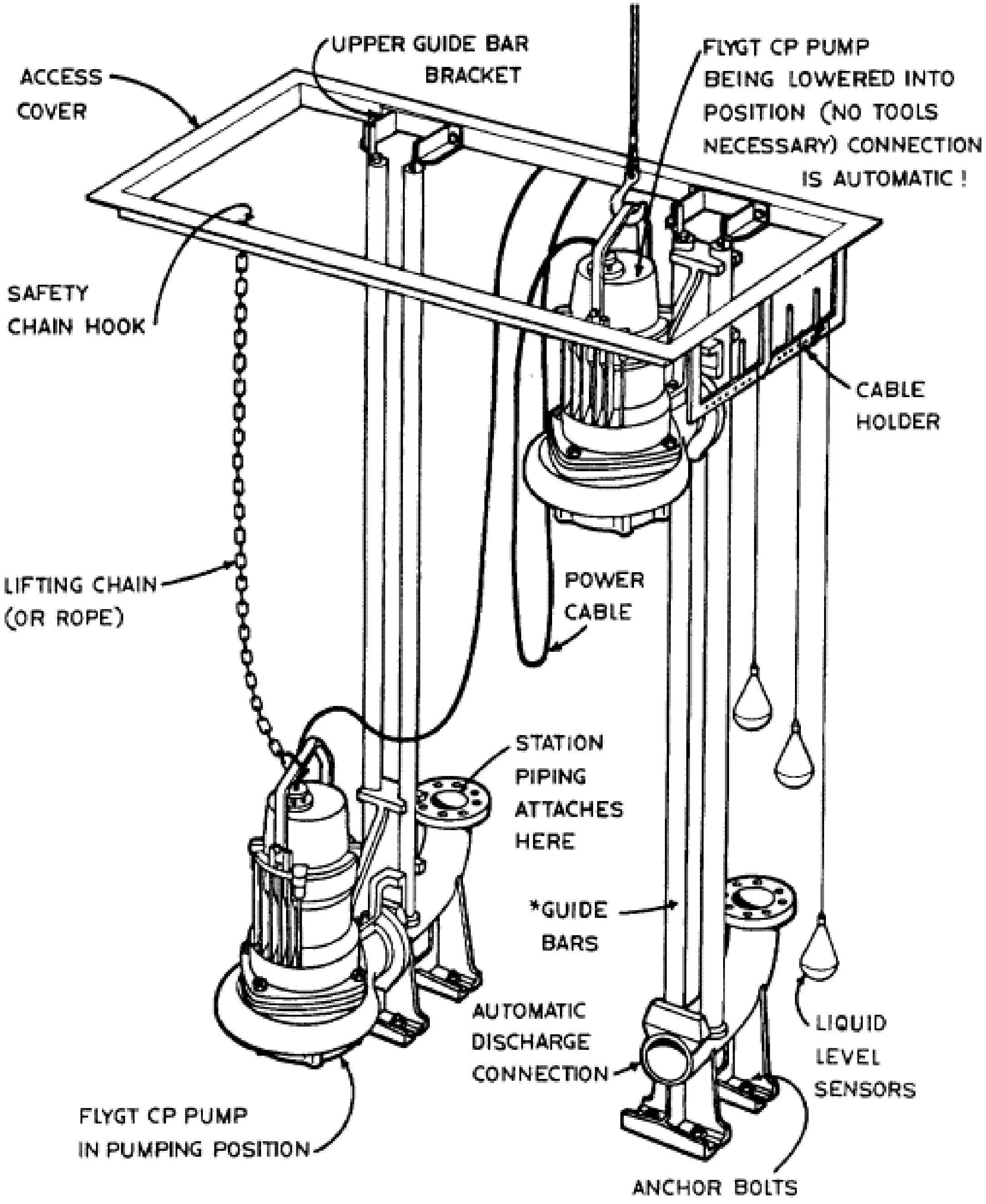
Wet well with submersible pumps



Direct Inline Pumping (DIP) System

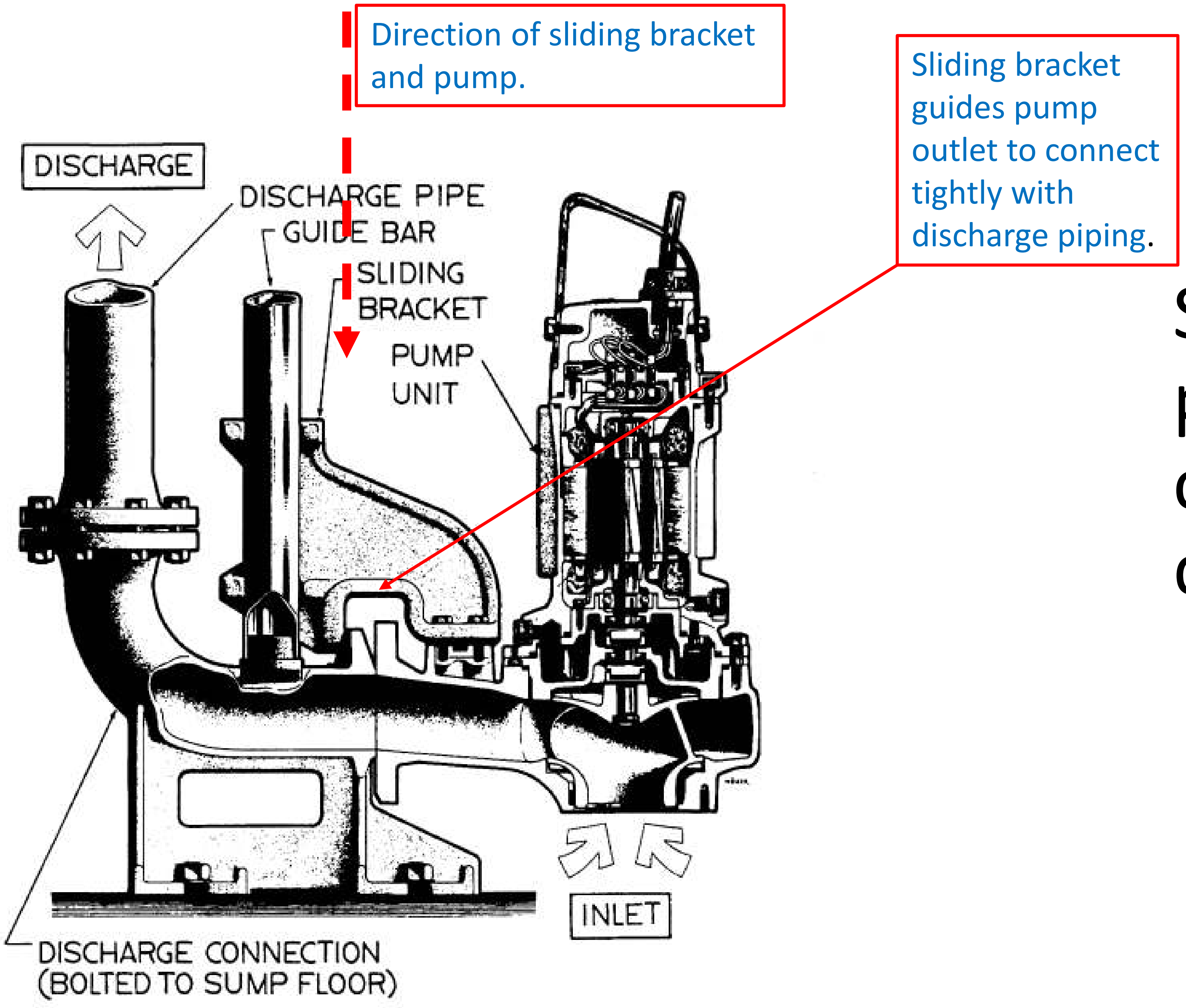
- Special impeller design that reverses direction when clogging is sensed.
- One check valve and smaller foot print.
- No wet well.

Wet well showing submersible pump lifting/lowering, and floats.



Wet Well – Submersibles. Basic Wastewater Collection Systems. Minnesota Pollution Control Agency. (1995)

Submersible pump connection detail

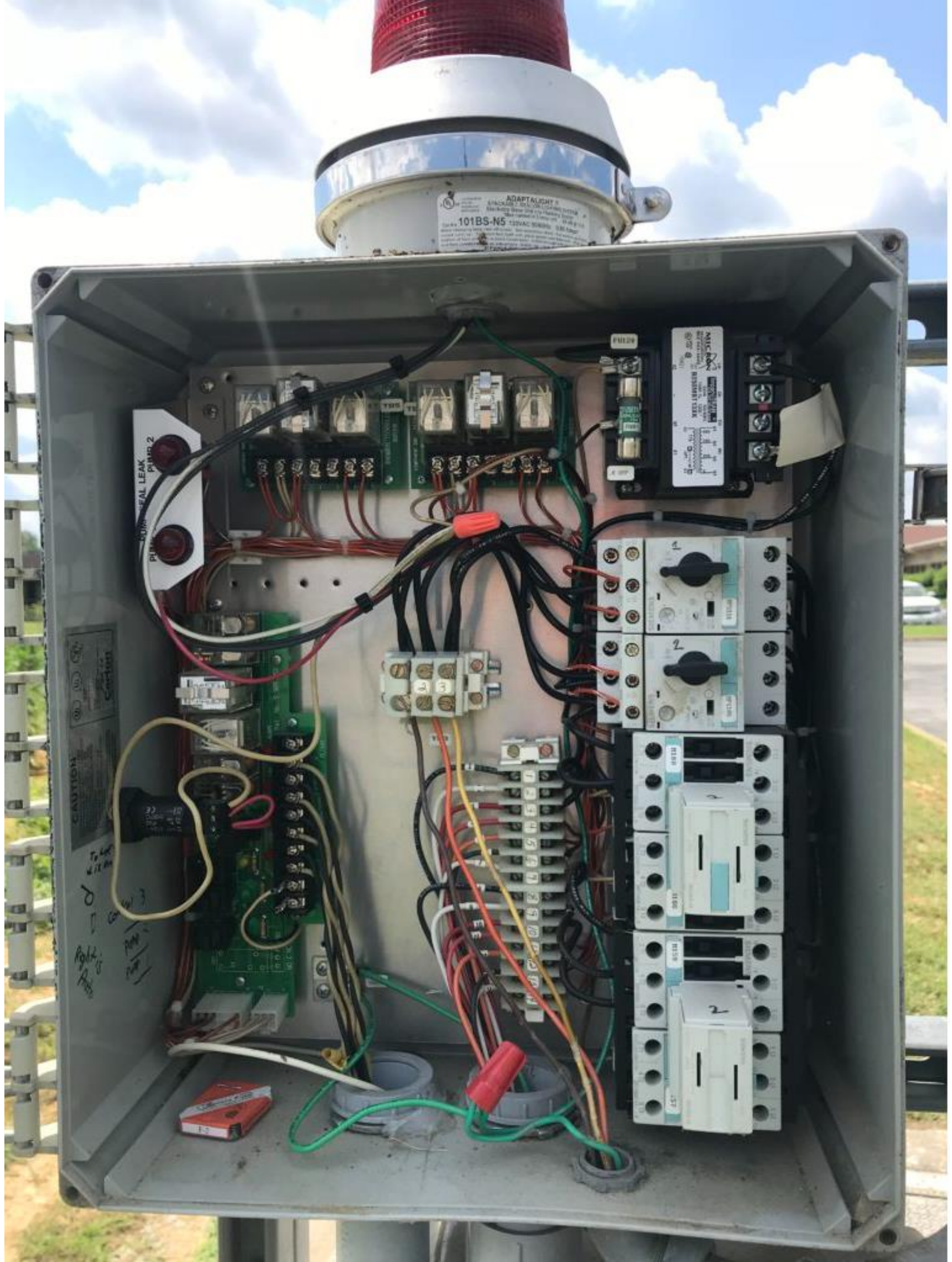


Submersible Pump Detail. Basic Wastewater Collection Systems. Minnesota Pollution Control Agency. (1995)

Aqualis. https://www.aqualisco.com/service/life-station-maintenance-and-repair/lift-station-inspection/

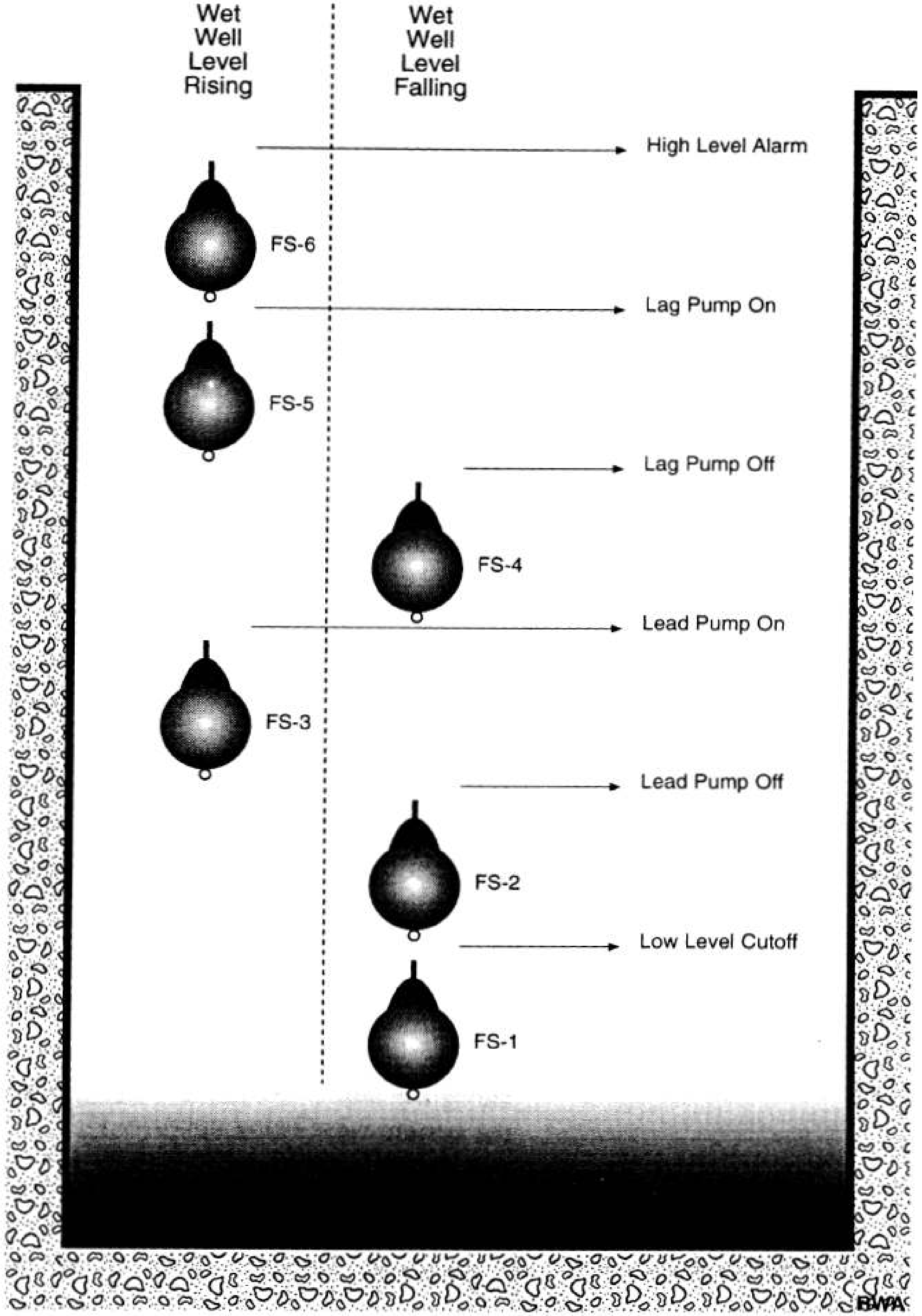
Controls Systems

Floats| Bubblers | Ultrasonic | Pressure transducers

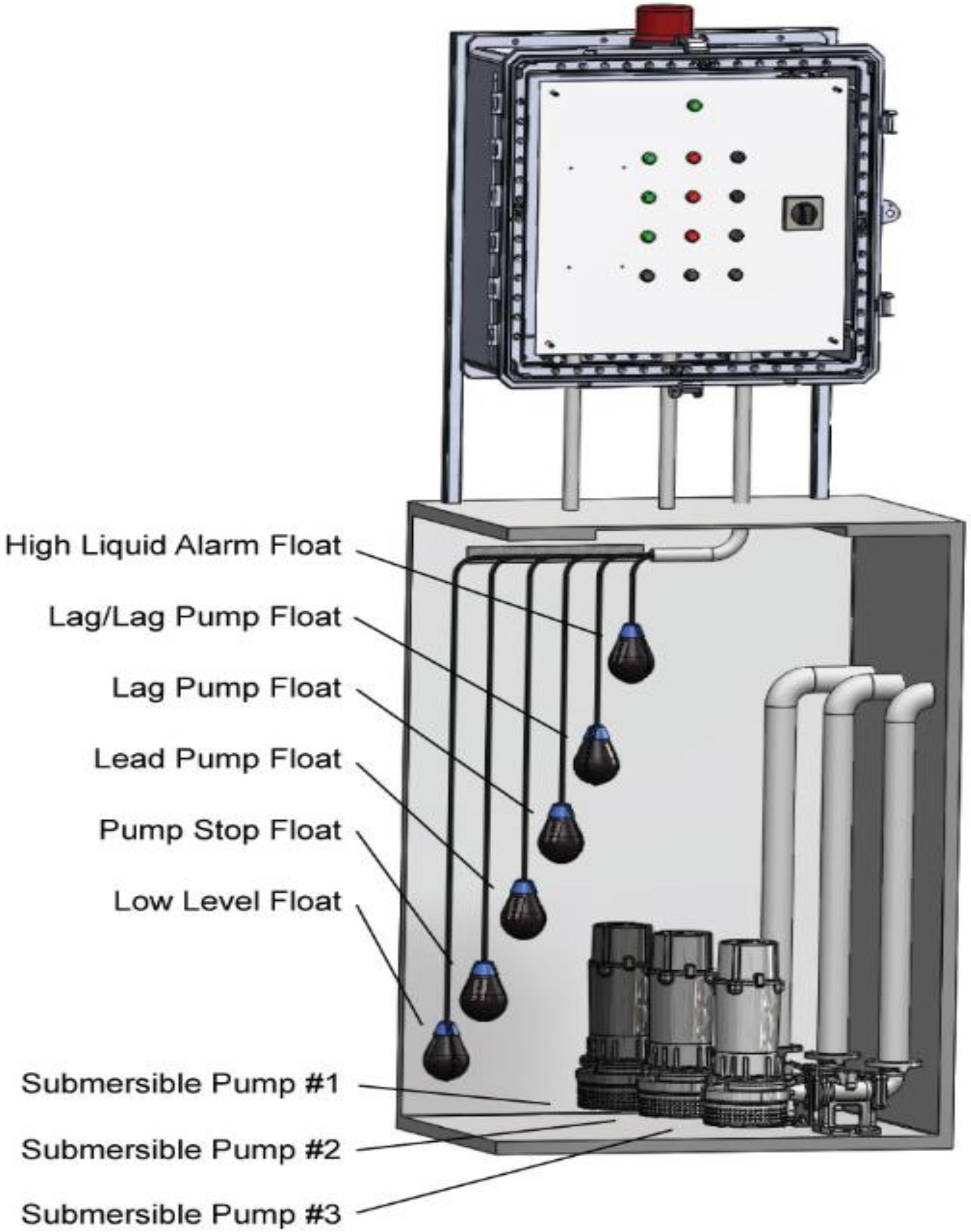


Stamie E. Lyttle C. https://www.lyttleco.com/uncategorized/pump-station-inspection-and-maintenance-our-30-point-report/

Six-float control system with lead and lag pump control and high and low level alarms.



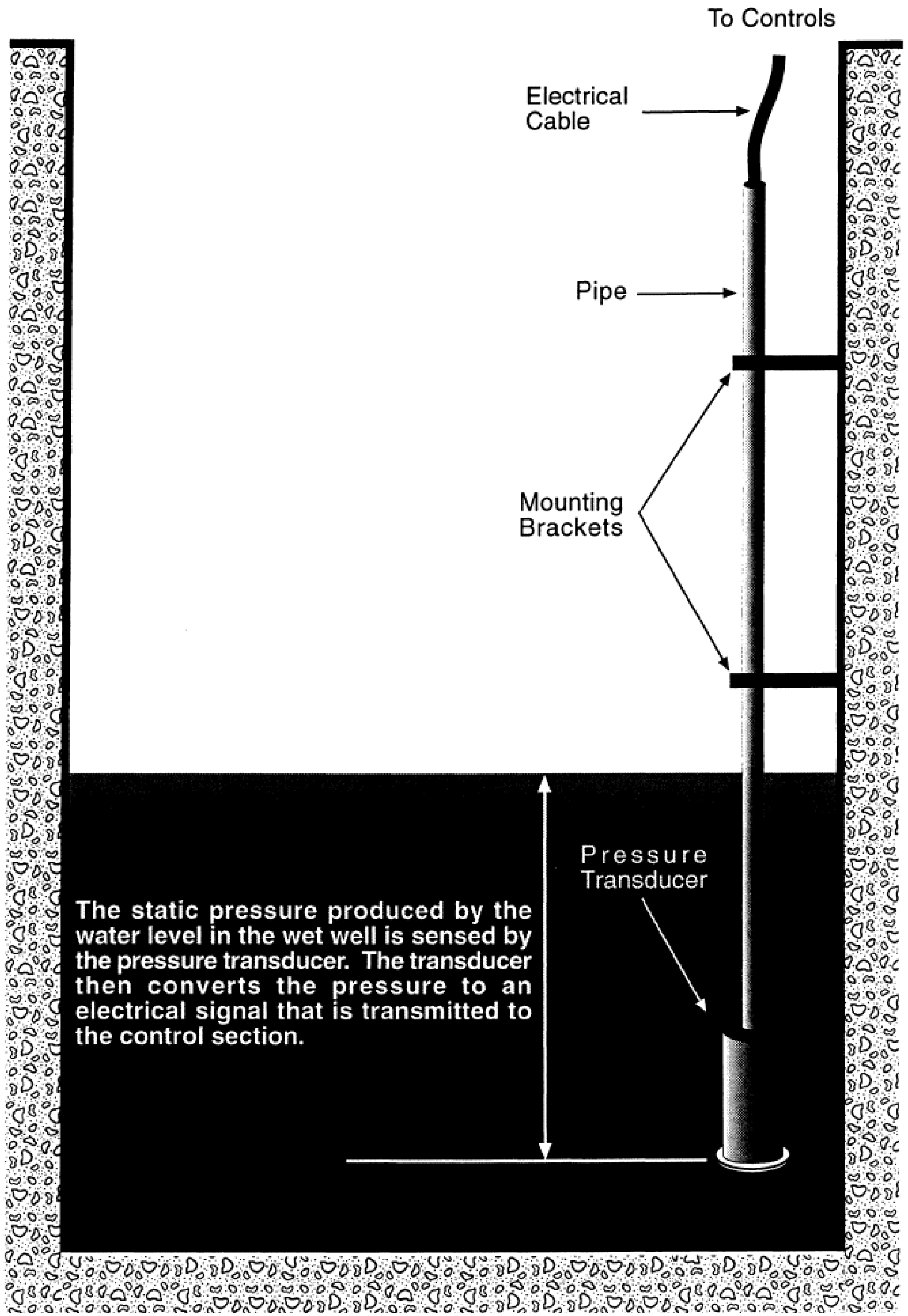
Lift Station Floats. Basic Wastewater Collection Systems. Minnesota Pollution Control Agency. (1995)


High Liquid Alarm Float
Lag/Lag Pump Float
Lag Pump Float
Lead Pump Float
Pump Stop Float
Low Level Float
Submersible Pump #1
Submersible Pump #2
Submersible Pump #3

Testing float switches by lifting each float

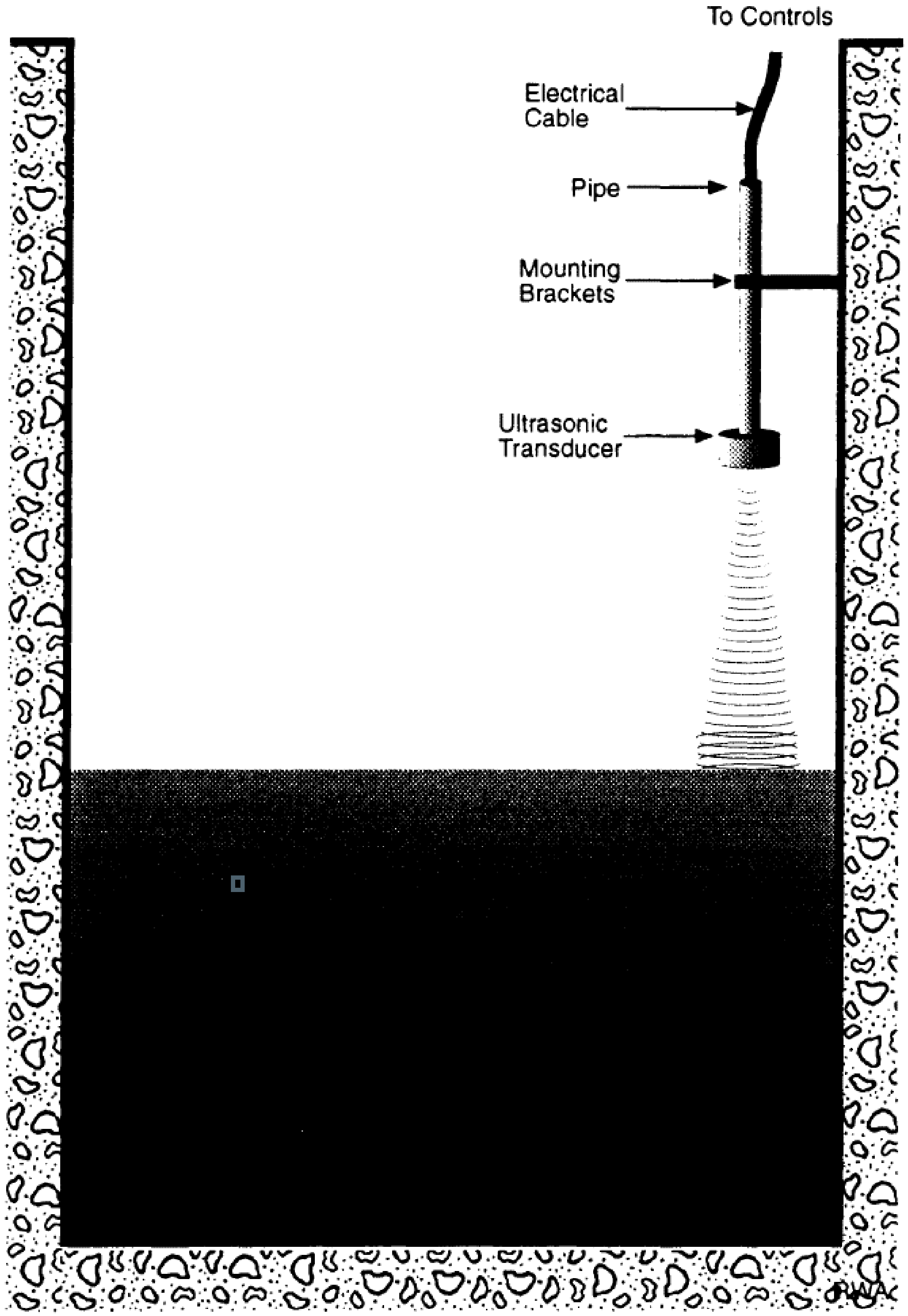
Aqualis. https://www.aqualisco.com/service/life-station-maintenance-and-repair/lift-station-repairs/

Pressure transducer for level and pump control.



Transducer level sensor. Basic Wastewater Collection Systems. Minnesota Pollution Control Agency. (1995)

Ultrasonic transducer level and pump control



Ultrasonic level sensor. Basic Wastewater Collection Systems. Minnesota Pollution Control Agency. (1995)

Alternating lead and lag pumps

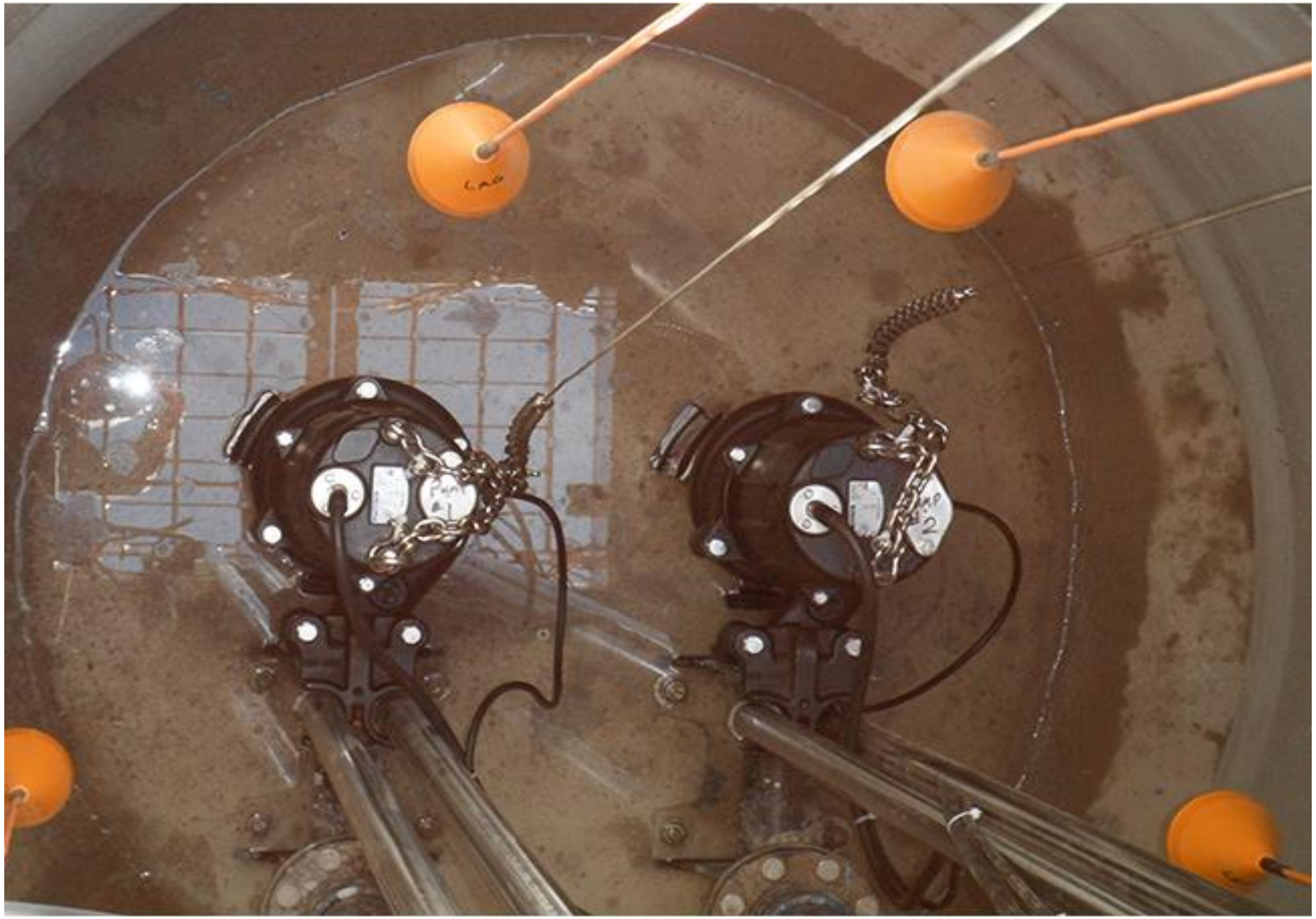
An alternator selects which pump will be the “lead.” This pump will turn on when the water level reaches the lead float. The other pump is now called the “lag,” and will turn on if the water level reaches the lag float.

At this time, both pumps are now on until the off float is triggered. The next time the lead float is triggered the other pump will assume the “lead” role.

Duplex pump installation

Two pumps in the lift station provides redundancy

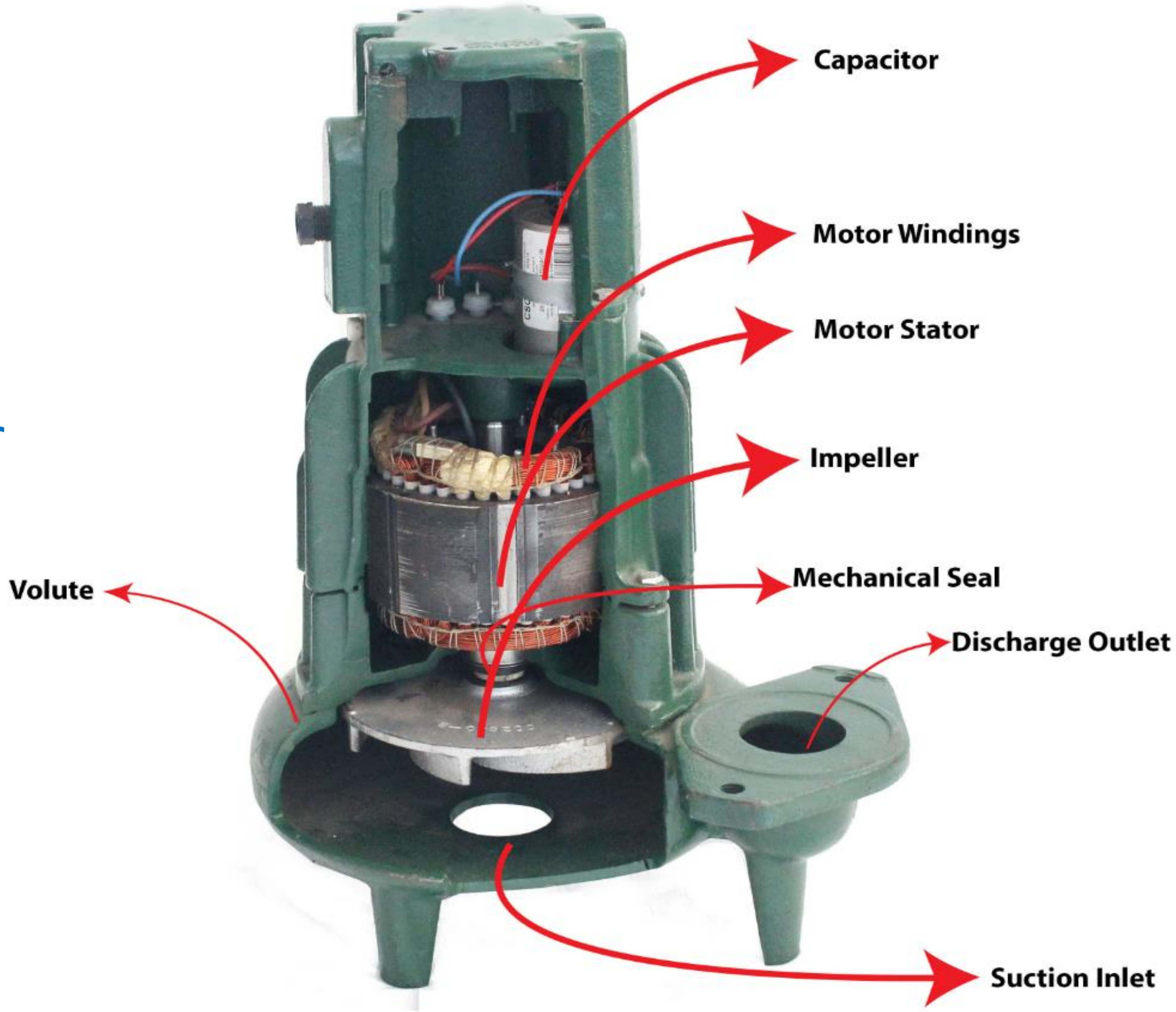
The pumps are alternated as the lead and lag pump.



Number of pumps

- The number of pumps to be installed depends on the range of flow.
- In small stations, with maximum inflows less than 700 gallons per minute), two pumps are customarily installed, with each unit able to meet the maximum influent rate.
- For larger lift stations, the size and number of pumps should be selected so that the range of influent flow rates can be met without starting and stopping pumps too frequently and without excessive wet-well storage.

Pump inside diameter to allow the average size of waste solids to pass through.
Normally 2.5 inches or larger



Grinder pumps

Use rotating cutters to grind materials into fine mater.

Grinder pumps can not generally handle rags, diapers, or plastics

There are a variety of designs


PUMP 1 HOUR METER
PUMP 2 HOUR METER
480 VOLTS
COMMUNICATION FAIL

Hour meter readings

- Installation of an hour meter on each motor can provide a record of how long each pump has run, and can also indicate the amount of wastewater being pumped through the system.
- A record of the motor hours, along with dates and times when maintenance was performed should be kept.
- Keeping track of lift station hours and when the maintenance is to be scheduled will help reduce chances of breakdowns and sanitary sewer overflows (SSOs).

Increased run time of lift pump – possible causes

- Partially clogged or blocked check valve allowing sewage to flow back into the lift station.
- Inflow and infiltration
- Higher water use or population increase
- Bar screens or grinders are often installed in or upstream of the wet-well to minimize pump clogging problems.

Fats, rags, oils, grease

Pressure gage on wastewater force main

- Increasing pressure over time can indicate the force main, or components is becoming clogged with grease or debris and needs to be cleaned.
- Decreasing pressure can indicate a leak.

Check valve problems

Check valves stick open due to debris causing water to recirculate as it is pumped from the wet-well to the force main which then flows back through the failed or clogged check valve into the wet-well.

"I recently worked with a system that had to replace the check valves as well as the operating valves. The operating valves were butterfly valves; debris was caught on the disc. I believe the debris also caused a blockage of the check valve as the two valves were connected. The system replaced the butterfly valves with full-opening gate valves and new check valves. Residents in the area of the lift station had complained about odors, obviously due to so much sewage being held in the lift station and the receiving manhole. Since the replacement of the valves in the lift station, complaints have diminished."

Charlie Schwindamann, KRWA Wastewater Tech. Kansas Lifeline, 2017.

Troubleshooting increased run time

"*Recently a system operator contacted me concerning an issue of increased operating time of a lift station. It varied from one hour to six hours or even longer. My first question was "Do you have an inflow and infiltration issue?" The operator replied that was not the case as the increased run-time occurs regularly. I asked if there was any increase in water use in the community. The operator replied that was none was evident. I went to the system and reviewed the situation. We found pieces of soap and grease getting into the pumps and causing partial blockage. A contractor cleaned the lift station and both of the pumps returned to normal operating hours*."

Charlie Schwindamann, KRWA Wastewater Tech. Kansas Lifeline, 2017.

Hand-Off-Auto (HOA) Switch

Each pump has a (HOA) switch.

The hand position (H) runs the pump (in manual mode)

The automatic position (A) runs the pump off the level sensors.

Emergency Power Options

Commonly used methods of emergency power supply include

1) Electric power feed from two independent power distribution lines
2) An on-site standby generator
3) Portable generator with quick connection
4) Stand-by engine driven pump
5) Portable pumping unit and appropriate connections
6) Availability of an adequate holding facility for wastewater storage upstream of the lift station.

Back up Generator

Transfer switch – disconnects from grid and connects to generator.

Can be automatic or manually actuated.

Mobile pumping unit

Requires plumbing connections

Time to spill

Knowing the rise in inches given a particular inflow rate.

Can help predict when lift stations should be pumped in an emergency situation when using a mobile unit.

Based upon diameters and depths

18” = 1.1 gallons / inch depth

24” = 2.0 gallons / inch depth

30” = 3.06 gallons / inch depth

36” = 4.4 gallons / inch depth

48” = 7.83 gallons / inch depth

60” = 12.24 gallons / inch depth

72” = 17.63 gallons / inch depth

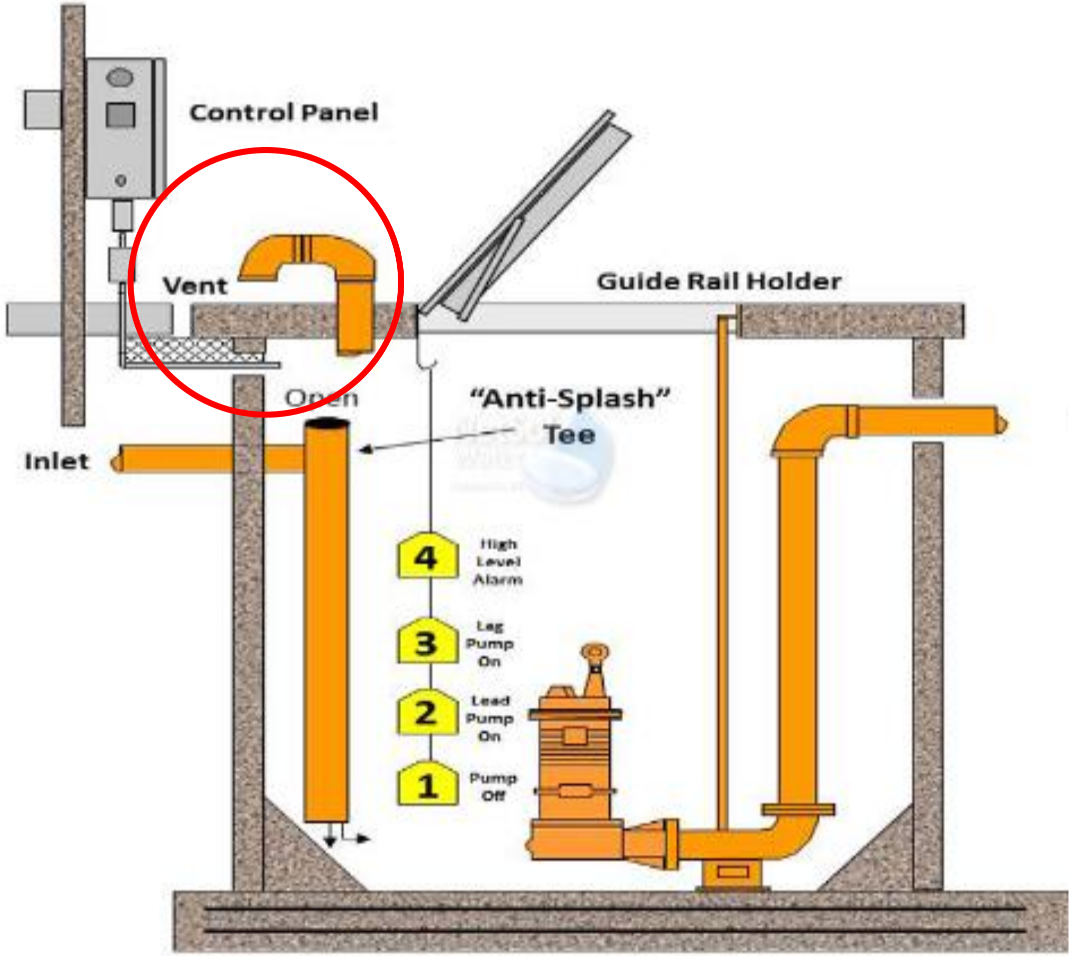
Example: **A 36-inch diameter manhole contains a level of wastewater that is 96 inches below the maximum allowed height. The current inflow is 20 gallons per minute.**

Maximum gallons before full: **4.4** gallons per inch x **96** inches = **422 gallons**

Maximum time before pumping = **422 gal ÷ 20 gpm** = **21 minutes**

Lift station safety hazards

- Insufficient Oxygen
- Explosive and toxic gases
- Poor footing caused by grease or slimes
- Unsafe ladders, stairs, and walkways
- Electrical hazards
- Inadequate drainage


Control Panel
Vent
Guide Rail Holder
Open
"Anti-Splash"
Tee
Inlet
4
High
Level
Alarm
3
Lag
Pump
On
2
Lead
Pump
On
1
Pump
Off

Ventilation for confined space entry

- **Ventilation required to prevent accumulation of toxic or explosive gases.**
- Dry-well ventilation codes typically require six continuous air changes per hour or 30 intermittent air changes per hour.
- Wet-wells typically require 12 continuous air changes per hour or 60 intermittent air changes per hour.

Odor Control

1. minimizing wet-well turbulence.
2. Treatment with scrubbers or biofilters
3. Adding odor control chemicals to the sewer upstream of the lift station (chlorine, hydrogen peroxide, metal salts, oxygen, air, and potassium permanganate.

*Chemicals should be closely monitored to avoid affecting downstream treatment processes.

Odor Control Application

- Odor control unit installed at lift station.

- Positive air flow and carbon bed based scrubber to control hydrogen sulfide odors

Drawdown test

A drawdown test is simply a way to periodically check the flow rate of each pump.

Each pump is operated on hand to empty a known volume of wastewater from the wet well and is timed.

$$\frac{\text{Gallons pumped}}{\text{Time in minutes}} = \textbf{Actual gpm}$$

$$\textbf{Pump Efficiency \%} = \frac{\text{Actual gpm}}{\text{Rated gpm}} \times 100\%$$

Inspection and maintenance – Basic tasks

Annually: Cleaning and inspection. Drawdown and efficiency test. Check valves. Inspect for corrosion. Pull motors and inspect.

Monthly: Amperage draws for each motor. Check floats and ensure high and low level sensors are working. Check downstream pressure.

Weekly: Record hour meters and calculate run time for each motor. Record number of cycles and gallons pumped.

Daily: Ensure operation, and check for unusual operation.

Resources

1. Sanitary Sewer Systems: Lift Stations and Data Management Fact Sheet. Water Environment Federation (2019). https://www.wef.org/globalassets/assets-wef/direct-download-library/public/03---resources/wsec-2019-fs-013---csc-mrrdc---lift-stations-and-data-management---final.pdf

2. Basic Wastewater Collection System. Minnesota Pollution Control Agency. (1995). https://www.pca.state.mn.us/sites/default/files/wq-wwtp8-26.pdf

3. What is a Sewer Lift Station? Kingsport WWTP (2014). https://www.youtube.com/watch?v=iuTZYywmBMs

4. **Sewage Pump Failure at Commercial Lift Station**. NoCo Septics (2019). https://www.youtube.com/watch?v=9i8uZaIcqs4

5. **Operation and Maintenance of Sewage Lift Stations**. Newfoundland Labrador. (Sample Maintenance Checklist). file:///F:/WW%20Lift%20Stations/waterres-training-operator-onsite-training-sop-lift-station.pdf

6. **How it Works – Lift Stations. Metropolitan Council**. (2019). https://www.youtube.com/watch?v=Z9-DXl028-Y