

PRACTICE EXAM 13: WPI/ABC WATER DISTRIBUTION OPERATOR SIMULATION (100 QUESTIONS)

1. A distribution system operator measures the static pressure at a hydrant on a 10inch main. The gauge reads 72 psi. The hydrant elevation is 540 feet. The elevated storage tank serving this zone has an overflow elevation of 710 feet. If the system were truly static (no flow, no friction), the expected pressure at this hydrant would be $(710 - 540) \times 0.433 = 73.6$ psi. The measured 72 psi is 1.6 psi lower than the theoretical maximum. What is the most likely explanation?

- A. The elevated tank is not completely full, so the HGL is slightly below the overflow elevation
- B. Both factors contribute — the tank may not be at overflow level, and there may be a very small residual flow in the system creating minimal friction loss; the 1.6 psi difference is within normal measurement tolerance and does not indicate a significant problem
- C. The pressure gauge is defective and must be recalibrated before any valid reading can be obtained
- D. A partially closed valve between the tank and the hydrant is restricting flow and reducing the available pressure

2. A water system serves a medical office building that has a dental clinic, a radiology suite, and an optometry practice. A cross connection control survey identifies connections to: (1) a dental vacuum system exposed to blood and saliva, (2) an Xray film processor using chemical developer solutions, and (3) an autoclave sterilizer operating at 30 psi above supply pressure. The survey recommends an RPZ on the building's main service. Is a single RPZ at the service entrance adequate?

- A. Yes, because a single RPZ at the service entrance protects against all internal hazards simultaneously
- B. Yes, as long as the RPZ is tested annually by a certified backflow prevention assembly tester
- C. No, because the autoclave's backpressure could overcome the RPZ if both check valves fail simultaneously
- D. No — while an RPZ at the service entrance provides premises isolation, the highest hazard connections inside the building (autoclave, dental vacuum, Xray processor) should each have individual protection appropriate to their specific hazard level to provide defense in depth

3. An operator calculates the volume of a rectangular ground level reservoir that measures 80 feet long, 40 feet wide, with a water depth of 16 feet. What is the volume in gallons?

- A. 51,200 gallons based on the volume in cubic feet without converting to gallons
- B. 191,488 gallons based on using half the reservoir dimensions in the calculation
- C. 382,976 gallons, calculated as $80 \times 40 \times 16 = 51,200 \text{ cu ft} \times 7.48 \text{ gal/cu ft}$
- D. 765,952 gallons based on doubling the actual volume for a safety factor

4. A pump station has three identical centrifugal pumps rated at 500 GPM each. During normal operations, one pump runs as lead and one as lag, with the third as standby. The station's firm capacity must meet average daily demand of 1.2 MGD (833 GPM). With the largest pump out of service, can the remaining two pumps meet this demand?

- A. Yes — two pumps in parallel produce approximately 900 GPM (slightly less than 1,000 due to increased system head), which exceeds the 833 GPM average demand; the firm capacity is adequate
- B. No, because two 500 GPM pumps in parallel always produce exactly 1,000 GPM, which barely exceeds the 833 GPM demand with no safety margin
- C. No, because the two remaining pumps would only produce 500 GPM total since parallel pumps split the flow
- D. Yes, because the standby pump automatically activates when the lead pump fails, maintaining all three pumps in service

5. A water system's AMI data reveals that 23 residential customers on the same street show continuous overnight flow of 0.2 to 0.5 GPM between 1:00 AM and 5:00 AM. All 23 meters show this pattern simultaneously. What is the most likely explanation?

- A. All 23 customers have independent leaks (running toilets or dripping faucets) that coincidentally developed at the same time
- B. The AMI transmitters on this street have a firmware error that generates false flow readings during low demand hours
- C. A large commercial customer on the same main is using water overnight, creating flow through all meters due to pressure equalization

D. The distribution main serving this street has a leak — the flow detected by the meters represents water moving through the service connections toward the leak on the main, not consumption within the homes

6. A distribution system operator is investigating an area where fire flow test results have declined from 1,600 GPM to 900 GPM at 20 psi residual over the past eight years. The mains are 45-year-old unlined cast iron. The operator performs a C-factor test on a representative section and obtains $C = 48$. What does this C-factor indicate?

A. The main's interior is in excellent condition with minimal tuberculation

B. Severe internal tuberculation has dramatically reduced the pipe's carrying capacity — $C = 48$ compared to an original C of approximately 130 means the main has lost over 60% of its hydraulic capacity, directly explaining the fire flow decline

C. The C-factor of 48 is within the normal range for 45-year-old cast iron and no action is needed

D. The C-factor test was performed incorrectly because valid results for cast iron always exceed 80

7. A water system serves a neighborhood at the highest elevation in the pressure zone. During peak demand, customers at this elevation report pressure as low as 30 psi. The elevated tank overflow is at 920 feet, and the highest customer is at elevation 855 feet. Under static conditions, $\text{pressure} = (920 - 855) \times 0.433 = 28.1$ psi. What does this calculation reveal?

A. The pressure at peak demand is actually higher than the static calculation suggests, indicating no problem

B. The static pressure calculation contains an error because the elevation difference should be multiplied by 2.31

C. Even under static conditions (zero demand, zero friction), these customers receive only 28.1 psi — below the 35 psi minimum; during any demand period, friction losses reduce this further, confirming these customers cannot be adequately served by this pressure zone

D. The 30 psi measured during peak demand is acceptable because it exceeds the 20 psi minimum

8. A confined space entry team is preparing to enter an underground chlorine contact chamber that has been drained for maintenance. The chamber normally holds chlorinated water at 2.0 mg/L. After draining, a strong chlorine odor is present at the access hatch. Initial atmospheric testing shows $O_2 =$

20.8%, LEL = 0%, H₂S = 0, but the four gas monitor does not have a chlorine specific sensor. What should the entry team do?

A. Use a chlorine specific detector to measure the chlorine gas concentration before entry — off gassing from residual chlorine on the wet chamber surfaces may produce chlorine gas levels above the OSHA PEL of 1 ppm; the standard four gas monitor cannot detect chlorine, so a separate sensor is required to evaluate this known hazard

B. Enter immediately because the oxygen level is normal and chlorine is not a confined space hazard

C. Ventilate for 30 minutes and then enter without additional testing since chlorine dissipates quickly

D. Enter with air purifying respirators equipped with chlorine cartridges without measuring the actual chlorine concentration

9. A water main repair crew is replacing a 4foot section of broken 8inch cast iron pipe. The crew cuts out the broken section and prepares to install the replacement piece using two full circle repair couplings. Before inserting the new pipe, what must the crew do to the cut ends of the existing pipe?

A. Apply primer and cement to the cut ends to ensure a chemical bond with the coupling gaskets

B. Score the pipe ends with a grinder to create a rough surface for better gasket adhesion

C. Paint the cut ends with rust preventive primer to protect against future corrosion

D. Clean the cut ends thoroughly with a wire brush to remove all dirt, corrosion, scale, and debris — the coupling gaskets require a clean, smooth pipe surface to seal properly; any debris or rough surface beneath the gasket will create leak paths

10. An operator discovers that the utility's cross connection control program has identified 450 high hazard and 1,200 low hazard cross connections in the system. Of these, only 300 high hazard connections have RPZ assemblies installed, and 150 have never been tested. What is the most urgent priority?

A. Install RPZ assemblies on the remaining 150 unprotected high hazard connections

B. The most urgent priority is testing the 150 RPZ assemblies that have never been tested — these devices may have failed without detection, leaving the system vulnerable to contamination through connections that appear to be protected but actually are not; simultaneously, the 150 unprotected high hazard connections must have devices installed

- C. Focus on the 1,200 low hazard connections because they outnumber the high hazard connections
- D. Remove all 450 high hazard connections from service until they can be properly protected

11. A water system's treatment plant experiences a brief loss of pressure due to a pump station failure. During the 20minute low-pressure event, system pressure in the affected area drops to 8 psi. After pressure is restored, the operator must determine whether contamination may have entered the system. What specific evidence should the operator look for?

- A. Customer complaints about discolored water, which would confirm that soil entered the mains during the event
- B. Elevated turbidity at the treatment plant intake, indicating source water contamination
- C. Decreased chlorine residuals at monitoring points in the affected area — a drop in residual compared to prevent levels suggests that the introduced water (which has no residual) has diluted the chlorinated water, indicating potential intrusion; additionally, the operator should collect bacteriological samples
- D. Increased pump station discharge pressure, which would indicate water was pushed back into the system

12. A water system operator calculates that a well produces 450 GPM and operates 16 hours per day. The system's average daily demand is 400,000 gallons. The system has a 200,000gallon elevated tank currently at 80% capacity. If the well pump fails at 6:00 AM during a peak demand day where demand reaches 125% of average, how long can the system provide water from tank storage alone?

- A. Approximately 1.9 hours — the tank has 160,000 gallons (80% of 200,000), and at 125% of average demand ($500,000 \text{ GPD} \div 24 = 20,833 \text{ GPH}$ peak hourly rate, assuming uniform demand), the tank would provide approximately $160,000 \div 20,833 = 7.7$ hours; however, peak demand is concentrated in morning hours at rates much higher than the daily average, likely depleting the tank in approximately 24 hours
- B. 8 hours based on dividing the tank volume by the average hourly demand
- C. 24 hours because the tank was designed to hold a full day's supply
- D. The tank will never empty because the treatment plant will compensate for the well failure

13. A distribution system has a PRV station that reduces pressure from Zone 1 (85 psi) to Zone 2 (target 52 psi). The operator checks the PRV and finds the downstream gauge reads 52 psi — matching the

setpoint. However, during a recent fire flow test in Zone 2, the residual pressure dropped to only 14 psi at 1,200 GPM. What does this indicate about the PRV station's capacity?

- A. The PRV is malfunctioning and cannot maintain its setpoint under any flow condition
- B. The PRV maintained its setpoint under the fire flow conditions but the downstream piping has excessive friction loss
- C. The 14 psi residual is acceptable for fire flow because any measurable pressure confirms adequate supply
- D. The PRV station cannot deliver 1,200 GPM at the setpoint — the PRV is either undersized for fire flow demands or the inlet pressure from Zone 1 drops significantly when the PRV passes high flow; either condition means Zone 2 lacks adequate fire flow capacity through this PRV station

14. A water operator receives a complaint from a homeowner about a wet spot in their yard that has been present for two weeks. The operator checks the customer's meter and observes that the low flow indicator is not spinning. System pressure in the area is normal. What should the operator investigate next?

- A. Whether the wet spot is caused by a sprinkler system leak that is downstream of the meter
- B. Whether the wet spot is caused by a leak on the utility's side of the meter — on the main, the corporation stop, the service line between the main and the meter, or the curb stop; since the meter shows no flow, the leak is not between the meter and the house but could be on the utility's infrastructure upstream of the meter
- C. Whether the customer's water heater is leaking and water is migrating through the soil to the yard
- D. Whether natural groundwater or a storm drain leak is causing the wet spot

15. A water system uses sodium hypochlorite for disinfection. The operator receives a new delivery of 12.5% sodium hypochlorite and stores it in an outdoor tank exposed to direct sunlight and summer heat. After three weeks, a residual test at the treatment plant shows the chlorine dose is not achieving the target residual despite the feed pump operating at the correct setting. What is the most likely cause?

- A. The treatment plant's flow meter is reading high, causing the operator to underdose based on an incorrect flow measurement
- B. The aquifer water quality has changed, increasing the chlorine demand beyond the current dose

C. The sodium hypochlorite has degraded significantly from exposure to heat and sunlight — losing available chlorine concentration; a 12.5% solution exposed to high temperatures can lose 2030% of its strength in three weeks, meaning the feed pump delivers the correct volume but with significantly less chlorine per gallon

D. The injection point on the main has become partially blocked, reducing the amount of chlorine entering the water

16. A distribution system operator is asked to explain why the utility uses a combination of elevated storage and ground level storage rather than one type exclusively. What is the correct explanation of the complementary roles?

A. Elevated storage provides passive gravity fed pressure without mechanical equipment and serves as the system's pressure regulator, while ground level storage provides large volume reserves at lower construction cost per gallon — together they provide pressure stability, equalization capacity, fire flow reserve, and emergency reserve that neither type alone can efficiently provide

B. Elevated storage is used only during daytime peak demand while ground level storage serves overnight demand

C. Ground level storage provides better water quality because the water has shorter residence time than elevated storage

D. Elevated storage is being phased out nationally in favor of ground level storage with booster pumps

17. A water system's SCADA alarm log shows 1,200 alarms in the past 30 days. Of these, 1,050 were acknowledged without investigation, 120 were investigated and resolved, and 30 remain active. What systemic problem does this alarm management data reveal?

A. The SCADA system is generating an appropriate number of alarms for a utility of this size

B. The 30 active alarms need immediate attention because they have been active longer than the normal alarm duration

C. The 120 investigated alarms represent adequate performance because they were properly resolved

D. The system is experiencing severe alarm fatigue — 87.5% of alarms were acknowledged without investigation, meaning operators are conditioned to dismiss alarms rather than act on them; critical alarms may be buried in the noise; the alarm management system needs rationalization to eliminate nuisance alarms and prioritize actionable ones

18. A pump station operator measures the following parameters during a routine check: suction pressure = 15 psi, discharge pressure = 82 psi, flow = 850 GPM, motor amperage = 42 amps (nameplate = 45 amps). The pump has been in service for 6 years. What do these readings indicate?

- A. All parameters are within the normal acceptable range and no action is required
- B. The pump is operating normally — suction pressure is adequate, discharge pressure is within design range, flow is near rated capacity, and amperage at 93% of nameplate indicates proper loading without overload; the slightly below nameplate amperage is expected as system conditions vary
- C. The pump is significantly overloaded because amperage should never exceed 90% of nameplate rating
- D. The low suction pressure of 15 psi indicates developing cavitation that will damage the pump within days

19. A water system serves a large university campus. The campus has a complex internal water distribution system with multiple buildings, fire hydrants, a research laboratory using radioactive isotopes, a veterinary clinic, and a swimming pool with chemical treatment. What level of backflow protection is required at the campus's main service connection to the municipal supply?

- A. An RPZ assembly or air gap at the main service connection — because the campus contains the highest hazard connections possible (radioactive materials), the protection at the premises isolation point must match the highest internal hazard; additionally, individual high hazard connections within the campus should have their own dedicated protection
- B. A DCVA at the main service connection because the campus's primary function is educational
- C. A PVB at the main service because the campus connections involve primarily back siphonage risk
- D. No protection is needed at the main service because the campus has its own licensed operator

20. An operator calculates the head loss in a 3,000-foot section of 10-inch cement mortar lined ductile iron pipe ($C=140$) carrying 1,200 GPM. The Hazen Williams calculation yields approximately 18 feet of head loss. What is this equivalent to in psi?

- A. 41.6 psi based on multiplying 18 feet by 2.31
- B. 18 psi based on the head loss in feet equaling psi directly
- C. 7.8 psi, calculated as 18 feet \times 0.433 psi per foot

D. 2.4 psi based on dividing the head loss by the pipe length in thousands of feet

21. A water system's elevated tank has a bowl diameter of 45 feet and a water depth that varies between 22 feet (low level) and 30 feet (high level). What is the usable storage volume between these two levels?

A. 750,000 gallons based on the total tank volume from floor to high level

B. 89,091 gallons based on using the diameter in inches instead of feet

C. Approximately 95,104 gallons — calculated as $0.785 \times 45^2 \times (30 - 22) = 0.785 \times 2,025 \times 8 = 12,717$ cu ft $\times 7.48 = 95,123$ gallons

D. 47,552 gallons based on using the radius instead of the diameter in the calculation

22. An operator performing valve exercising discovers a valve where the operating nut turns but produces no change in system flow or pressure. The valve was recorded as a 12-inch butterfly valve in the GIS. After further investigation, the operator determines the disc has detached from the shaft. What is the operational impact?

A. The valve is completely inoperable and cannot provide isolation — this is critical because the GIS shows it as functional, meaning operators will attempt to use it during emergencies and discover it doesn't work only after the crisis is already underway; the valve must be prioritized for replacement and the GIS updated to flag it as nonfunctional

B. The valve can still provide partial isolation by manipulating the shaft at different angles

C. The disc may have fallen to the bottom of the pipe and still provides some flow restriction

D. The valve condition has no operational impact because butterfly valves are rarely used for isolation

23. A distribution system serves a food processing plant that uses municipal water for direct food contact — washing raw vegetables and fruits. The plant has a chlorinated wash system that adds additional chlorine to the municipal water and operates at pressures above the supply pressure through a booster pump. What backflow prevention is appropriate?

A. A DCVA because the additional chlorine is the same chemical used in the municipal supply

B. A PVB because the plant's wash water only poses a back siphonage risk, not backpressure

C. No backflow prevention is needed because the wash system uses only potable water with added chlorine

D. An RPZ assembly — the booster pump creates backpressure, and the wash water may contain agricultural chemicals, pesticides, bacteria, and organic matter from the produce being washed; this combination of backpressure and health hazard requires an RPZ or air gap

24. A water system's emergency response plan is activated during a major ice storm that causes widespread power outages expected to last 48 to 72 hours. The utility has emergency generators at all pump stations. The generators have fuel tanks that provide approximately 36 hours of operation at full load. What is the operator's most critical logistical challenge?

A. Maintaining communication with all remote sites when cell towers lose power

B. Arranging fuel delivery to all generator locations before the 36-hour fuel supply runs out — during an ice storm when roads may be impassable, fuel delivery trucks may not be able to reach remote pump stations; the operator must prearrange fuel delivery, identify alternative fuel sources, and prioritize fuel distribution to the most critical stations

C. Preventing the stored water in the elevated tanks from freezing during the extended cold weather

D. Maintaining adequate staffing for the duration of the 48-72 hour outage

25. A water system's operator discovers that a 6-inch gate valve near a hospital has been vandalized — someone has poured concrete into the valve box, encasing the operating nut. The valve cannot be operated. What is the immediate concern?

A. The concrete will corrode the valve body and weaken the pipe connection over time

B. The valve box is now a tripping hazard for pedestrians walking on the sidewalk

C. This valve cannot be operated during an emergency — if a main break occurs nearby, the operator cannot close this valve to isolate the break, potentially forcing the closure of more distant valves that affect a larger area including the hospital

D. The vandalism should be reported to police but has no operational impact on the distribution system

26. An operator is calibrating a chemical metering pump that feeds orthophosphate corrosion inhibitor. The pump is set to deliver 2.0 gallons per hour. During a 5minute timed test, the operator collects 142 mL in a graduated cylinder. Is the pump delivering the intended output?

- A. The intended output is 2.0 GPH = 126.2 mL/min ($2.0 \times 3,785 \div 60$); in 5 minutes, the expected collection is 631 mL; the actual collection of 142 mL is only 22.5% of the expected output — the pump is severely underdelivering and requires immediate investigation
- B. The pump is delivering correctly because 142 mL in 5 minutes equals 2.0 gallons per hour
- C. The pump is overdelivering by approximately 12% and the stroke rate should be reduced
- D. The calibration test duration is too short to produce a valid result for this flow rate

27. A water system has a 400,000gallon elevated tank that serves as the primary pressure source for a residential zone. The tank's inlet/outlet pipe enters at the base of the bowl, and there are no internal baffles. SCADA shows the tank cycles between 85% and 95% daily — only 10% of the volume turns over. Customers near the tank report taste and odor issues. What is causing the poor water quality?

- A. The tank's exterior paint is contaminating the stored water through the roof hatches
- B. The overflow pipe is allowing contaminated stormwater to enter the tank during heavy rain events
- C. The combination of no baffles and a single inlet/outlet at the same location creates short-circuit flow, allowing fresh water to enter and exit without mixing with the 90% of the volume that stagnates for extended periods — this stagnant water loses residual, develops biological activity, and produces taste and odor compounds
- D. The tank coating has reached the end of its life and is leaching chemicals into the water that cause the taste problems

28. A distribution system has experienced four main breaks in the same block over the past 18 months — all on a 55yearold 4inch gray cast iron main. Each break was a circumferential fracture. The soil in the area is heavy clay that experiences significant shrinks well cycles with seasonal moisture changes. What combination of factors is most likely causing these recurring breaks?

- A. The chlorine in the water is attacking the cast iron from the inside, weakening the pipe wall
- B. The combination of brittle aged cast iron and clay soil shrinks well cycles is fracturing the pipe — cast iron becomes increasingly brittle with age and cannot flex; the seasonal clay expansion and

contraction applies bending forces that exceed the pipe's fracture strength, causing clean circumferential breaks

C. A leaking sewer main beneath the water main is eroding the bedding material and causing the water main to sag and break

D. Heavy vehicular traffic on the street above is transmitting loads that the shallow pipe cannot withstand

29. An operator is asked to calculate the chlorine dose required to maintain a residual of 0.6 mg/L in water with a chlorine demand of 1.8 mg/L. The system produces 4.5 MGD. How many pounds per day of pure chlorine are needed?

A. 67.5 pounds per day based on the demand alone ($4.5 \times 1.8 \times 8.34$)

B. 22.5 pounds per day based on the residual alone ($4.5 \times 0.6 \times 8.34$)

C. 90.1 pounds per day, calculated as $4.5 \text{ MGD} \times 2.4 \text{ mg/L (demand + residual)} \times 8.34$

D. 180.2 pounds per day based on doubling the dose for a safety factor

30. A water system serves a school district that requests lead testing at all school drinking water taps. The utility's corrosion control program maintains pH at 7.6 and orthophosphate at 1.0 mg/L. Testing reveals that 8 of 120 taps exceed 0.015 mg/L — all are old brass drinking fountains with lead containing internal components. The remaining 112 taps are below 0.005 mg/L. What does this pattern tell the operator?

A. The corrosion control program is effective systemwide (112 of 120 taps show very low lead), but the 8 old brass fountains contain lead components that leach at levels exceeding the action level despite the treatment — the fountains' internal materials are the primary lead source, and remediation should focus on replacing or filtering these specific fixtures

B. The corrosion control program has failed because any tap above 0.015 mg/L indicates systemwide lead problems

C. All 120 taps must be taken out of service until the 8 elevated results are resolved

D. The 8 elevated results are laboratory errors because the remaining 112 taps show the system is working correctly

31. A pump station's VFD displays a "ground fault" alarm and automatically shuts down Pump 2. The operator resets the alarm and Pump 2 restarts successfully. Twelve hours later, the ground fault alarm recurs and Pump 2 shuts down again. What should the operator do?

A. Continue resetting the alarm each time it occurs because intermittent ground faults are normal in VFD systems

B. Increase the ground fault detection threshold to prevent future nuisance alarms

C. Bypass the VFD and run Pump 2 directly on utility power to avoid the alarm entirely

D. Leave Pump 2 offline and arrange for an electrician to inspect the motor windings, VFD output cables, and all electrical connections for insulation damage — a recurring ground fault indicates current is leaking to ground through damaged insulation, creating electrocution risk and potential fire hazard

32. A water system operates two interconnected elevated tanks. Tank A has an overflow elevation of 940 feet and Tank B has an overflow elevation of 900 feet. Both tanks serve the same pressure zone through open connections. If both tanks are full, what will happen hydraulically?

A. Both tanks will maintain their individual overflow elevations and operate independently

B. Water will flow from Tank A (higher HGL) toward Tank B through the distribution network until the water levels equalize — Tank B will overflow as it receives water from Tank A, and Tank A's level will drop; the system HGL will stabilize between the two overflow elevations based on the friction losses between the tanks

C. Tank B's altitude valve will automatically close to prevent overflow

D. The two tanks will operate at the same level because interconnected tanks always equalize instantly

33. A water main installation project requires laying 8-inch ductile iron pipe through an area where the soil investigation has revealed contaminated soil from a former industrial site. The contamination includes chlorinated solvents (TCE and PCE) at levels above environmental cleanup standards. What pipe material and joint considerations apply?

A. Standard ductile iron with push on joints is adequate because DI pipe walls are impervious to chlorinated solvents

B. PVC pipe should be used instead of ductile iron because it provides better chemical resistance in contaminated soil

C. Ductile iron pipe is appropriate for the pipe itself (resistant to permeation), but standard rubber gaskets at joints must be replaced with gaskets rated for chemical resistance — standard SBR rubber gaskets can be degraded by chlorinated solvents, which may also permeate through the gasket material into the pipe

D. The pipe should be encased in concrete to create an impermeable barrier between the contaminated soil and the pipe

34. A water system's operator is investigating a recurring pattern where chlorine residuals at a specific monitoring point are consistently lower on Monday mornings than on any other day of the week. The treatment plant maintains a constant chlorine dose seven days per week. What is the most likely cause of this pattern?

A. Weekend demand is lower than weekday demand — the water reaching this monitoring point on Monday morning has been sitting in the system longer (higher water age) because less water was consumed over the weekend; the extended residence time allows more chlorine decay, producing the lower Monday reading

B. The treatment plant reduces its chlorine dose on weekends when staffing is lower

C. The sampling tap at the monitoring point is contaminated with biofilm that grows over the weekend

D. A nearby business that consumes large volumes of water is closed on weekends, creating stagnation in the main serving this monitoring point only during the weekend period

35. An operator discovers that the annual inspection of a ground level welded steel storage tank has been missed for the past two years. The last inspection noted minor surface rust on the interior coating but recommended no immediate action. What risk does the missed inspection create?

A. No significant risk because the last inspection showed only minor issues that are unlikely to have progressed

B. The tank's insurance coverage has lapsed due to the missed inspections

C. The missed inspections void the tank manufacturer's structural warranty

D. The minor surface rust noted two years ago may have progressed to active corrosion and pitting that is weakening the tank wall — without inspection, the utility has no knowledge of the current condition; the tank should be inspected as soon as possible to determine whether the coating has failed, whether pitting has deepened, and whether structural integrity has been compromised

36. A distribution system operator is planning the layout for a new residential subdivision's water system. The developer's engineer has designed the water mains as a single looped system with a connection to the existing distribution grid at one point. The operator recommends a second connection to the grid. Why?

- A. A single connection is adequate for the subdivision's water demand during normal conditions
- B. A single connection point creates a single point of failure — if the main between the grid and the subdivision breaks or a valve in the connection path fails, the entire subdivision loses water; a second connection provides redundancy so that water can reach the subdivision through an alternate path during an emergency
- C. Two connections are required by the fire code for all residential subdivisions regardless of size
- D. The second connection is needed to balance pressure between the east and west sides of the subdivision

37. A water system's SCADA data shows that an elevated tank's level dropped from 90% to 25% overnight — a 65% drawdown that consumed approximately 350,000 gallons from a 540,000gallon tank. Average overnight demand for this zone is approximately 50,000 gallons. No main breaks were reported and no flushing was scheduled. What happened to the additional 300,000 gallons?

- A. The SCADA level sensor malfunctioned and the actual tank level did not change significantly
- B. An unauthorized hydrant opening or a large unreported main break consumed the water overnight
- C. A large, previously undetected leak in the distribution system consumed the additional water — a leak that matches the system's daytime demand may go unnoticed during the day when production compensates, but overnight when production decreases, the leak draws from tank storage; alternatively, a sudden new break or unauthorized hydrant use may be responsible
- D. The tank developed a leak that allowed 300,000 gallons to drain overnight

38. A water operator is asked to calculate the velocity in a 12inch main carrying 1,500 GPM. What is the approximate velocity, and is it within normal operating range?

- A. Approximately 4.3 fps — calculated as $(1,500 \div 448.8) \div (0.785 \times 1.0^2) = 3.342 \div 0.785 = 4.26$ fps; this is within the normal 25 fps range for distribution mains
- B. 12.8 fps, which dramatically exceeds the safe velocity for any operating condition

- C. 1.5 fps, which is below the minimum recommended velocity for preventing sediment settling
- D. 8.6 fps, which exceeds normal range but is acceptable for short duration fire flow conditions

39. A distribution system serves a hospital that has been experiencing intermittent pressure drops to 28 psi during peak morning demand. The hospital requires a minimum of 40 psi for its medical equipment and fire suppression system. The system pressure at the main (12inch trunk main) reads 62 psi during the same period. What is causing the pressure drop between the main and the hospital?

- A. A PRV on the hospital's service line has been set too low or is malfunctioning
- B. The treatment plant reduces its output during morning hours for routine maintenance
- C. The 12inch trunk main has severe tuberculation that restricts flow to the hospital area
- D. The hospital's internal demand during peak morning operations creates high flow through the service line, and the friction loss in the service line between the main and the building drops the pressure from 62 psi to 28 psi — the service line is likely undersized for the hospital's current peak demand

40. A water system's operator is reviewing the results of a water audit and finds that the utility's infrastructure leakage index (ILI) is 5.8. AWWA benchmarking classifies this as "poor" (5.08.0 range). What does this mean for the utility?

- A. The ILI cannot be used to evaluate the utility's leakage performance without additional data
- B. The system's actual real losses are 5.8 times the theoretical minimum losses for a system with these characteristics — this indicates significant opportunity for improvement through active leak management, and the utility should prioritize investment in leak detection, pressure management, infrastructure renewal, and speed of repair
- C. The system has no significant leakage and the ILI of 5.8 is within the acceptable range for most utilities
- D. The system's leakage rate will naturally decline to 1.0 as the distribution infrastructure ages

41. An operator is investigating a customer complaint about a strong "swimming pool" chlorine smell from their hot water tap only. Cold water has minimal chlorine taste. The system uses free chlorine for disinfection and the residual at the customer's tap is 1.2 mg/L — within normal range. Why is the hot water chlorine smell stronger than the cold water?

- A. Heating water releases dissolved chlorine gas from solution more readily — the warm air above the hot water carries more chlorine vapor to the customer's nose; additionally, the hot water's higher temperature enhances the volatility of chlorine compounds, making the smell more noticeable even though both hot and cold water contain the same chlorine concentration
- B. The water heater concentrates chlorine through evaporation, increasing the residual in the hot water
- C. The magnesium anode rod in the water heater reacts with chlorine to produce a stronger smelling compound
- D. The hot water plumbing materials react with chlorine to create a more pungent chlorine derivative

42. A water distribution system has a section where a 20inch transmission main reduces to a 12inch main through a reducer fitting. During peak demand, the operator measures the pressure on both sides of the reducer. The 20inch side reads 68 psi and the 12inch side reads 65 psi. What causes the 3 psi pressure drop across the reducer?

- A. The reducer valve is partially closed and restricting flow through the fitting
- B. Corrosion inside the reducer has narrowed the transition, creating an obstruction
- C. The 3 psi drop is caused by the elevation difference between the two pressure gauge locations
- D. The reduction in pipe diameter increases the water velocity, and the turbulence and friction through the transition create a minor (head) loss across the fitting — this is a normal characteristic of pipe fittings and is accounted for in hydraulic calculations as a "minor loss"

43. A water system's treatment plant operator reports that the fluoride feed system has been offline for 72 hours due to a pump failure. No public notification was issued. Was notification required?

- A. No notification is required for fluoride feed interruptions because fluoride is an optional treatment additive, not a required disinfectant — a temporary fluoride interruption poses no immediate health risk since fluoride's dental health benefits require long-term continuous exposure
- B. Yes, Tier 1 notification within 24 hours is required for any treatment interruption lasting more than 4 hours
- C. Yes, Tier 2 notification within 30 days is required because fluoride is a regulated contaminant under the SDWA
- D. The utility must issue a boil water advisory whenever any treatment system is offline for more than 24 hours

44. An operator is inspecting a new water main installation before the contractor backfills. The operator notices that the contractor has installed a ductile iron 45degree bend without any thrust restraint — no thrust block and no restrained joints. The contractor argues that a 45degree bend generates less thrust than a 90degree bend and doesn't need restraint. Is the contractor correct?

- A. Yes, 45degree bends generate minimal thrust that can be resisted by soil friction against the pipe alone
- B. The contractor is partially correct that 45degree bends generate less thrust than 90degree bends (approximately 76% vs. 141% of the pipe area times pressure), but the thrust force is still significant and requires either a thrust block or restrained joints to prevent joint separation — all changes in pipe direction require thrust restraint
- C. The contractor is correct that 45degree bends never require thrust restraint under any circumstances
- D. Only bends of 90 degrees or greater require thrust restraint in ductile iron installations

45. A water system's operator receives the quarterly TTHM and HAA5 laboratory results. Site #6 shows TTHM at 0.074 mg/L and HAA5 at 0.055 mg/L. The MCLs are 0.080 and 0.060 respectively. Both the TTHM and HAA5 LRAAs at this site are trending upward and approaching their MCLs. What proactive operational measures should the operator implement?

- A. Reduce water age at this monitoring location through targeted flushing, optimize storage tank cycling to increase turnover, check for closed valves that may be rerouting flow through longer paths, and evaluate whether the treatment plant can reduce THM precursors through enhanced coagulation — these operational changes can reduce DBP levels before the LRAAs exceed the MCLs
- B. Move the monitoring site to a location with lower DBP levels to reduce the LRAA
- C. Increase the chlorine dose to overwhelm the organic precursors that form DBPs
- D. Take no action until one of the LRAAs actually exceeds its respective MCL

46. A distribution system has a 16inch transmission main that crosses a bridge over a highway. The 200foot exposed section is uninsulated. During a prolonged cold snap with temperatures below 10°F for five consecutive days, the operator is concerned about freezing. What is the most effective immediate action to prevent freezing?

- A. Install temporary electric heat trace cable on the exposed section before temperatures drop further
- B. Wrap the exposed pipe section with temporary insulation material (insulation blankets or foam)

C. Apply a dark colored paint to the pipe to absorb solar radiation and maintain temperature

D. Maintain continuous flow through the main at a velocity sufficient to prevent freezing — moving water resists freezing much more effectively than stagnant water because the thermal energy of the flowing water constantly replaces heat lost through the exposed pipe wall

47. A distribution system operator measures pressure at two hydrants located at different elevations. Hydrant A (elevation 600 feet) reads 55 psi. Hydrant B (elevation 650 feet) reads 42 psi. Both hydrants are on the same 12inch main during a period of steady flow. What is the total head loss between the two points?

A. 13 psi based on the simple difference between the two pressure readings

B. 57 feet based on adding the pressure difference to the elevation difference

C. Approximately 19.9 feet — calculated by comparing the HGL at each point: $HGL_A = 600 + (55 \times 2.31) = 727.1$ ft; $HGL_B = 650 + (42 \times 2.31) = 747.0$ ft... Wait, HGL_B is higher, meaning water flows from B toward A; rechecking: if flow is from A toward B (downhill to uphill), HGL_A must be higher: 727.1 vs 747.0 means flow is actually from B to A

D. The head loss cannot be determined without knowing which direction the water is flowing through this main

48. A water system's production well suddenly begins producing sand in the discharge water. The well has operated normally for 12 years. The well pump motor amperage has increased by 10% simultaneously. What is the most likely cause?

A. The well screen has failed — a corroded section, torn slot, or broken weld has created an opening that allows formation sand to bypass the screen and enter the pump intake; the sand increases the load on the pump (higher amperage) as the impeller works to move the abrasive sandwater mixture

B. The gravel pack has settled below the screen, allowing sand to enter from above the pack

C. The aquifer's sand layer has shifted due to seismic activity, bypassing the well screen

D. The pump's suction is too strong and is pulling sand through the intact screen openings

49. An operator is asked to explain the concept of "water age" to a new employee. The new employee asks why water age matters if the water was properly treated at the plant. What is the correct explanation?

- A. Water age only matters for surface water systems because groundwater does not experience quality changes in the distribution system
- B. Water age is the time water spends in the distribution system from treatment plant to customer tap — it matters because disinfectant residual decays over time, disinfection byproducts continue forming, biological activity can develop as residual disappears, taste and odor compounds accumulate, and temperature changes affect all these processes; water that was perfectly safe at the plant can deteriorate if it stays in the system too long
- C. Water age is a theoretical concept with no practical impact on water quality or system operations
- D. Water age only affects the aesthetics of drinking water and has no health significance

50. A water system's emergency generator at a critical pump station starts during a power outage but runs for only 45 minutes before shutting down on a high engine temperature alarm. After a 15minute cooldown, the generator restarts and runs for another 30 minutes before overheating again. Investigation reveals the radiator is heavily clogged with debris and the coolant level is low. What maintenance failure led to this situation?

- A. The generator was tested monthly but only at idle speed, never under load — idle testing does not stress the cooling system and would not reveal cooling deficiencies that appear only under sustained load
- B. The generator's manufacturer recommended maintenance schedule should have included cooling system inspection, radiator cleaning, and coolant level checks as part of regular preventive maintenance
- C. The generator room ventilation is inadequate and is causing the engine to overheat from recirculating hot air
- D. The radiator clogging and low coolant are both indicators of neglected preventive maintenance — the cooling system (radiator condition, coolant level, hose condition, fan operation, thermostat) should be inspected regularly; the monthly load test would have revealed the overheating if the test duration were long enough to stress the cooling system

51. A distribution system has a section where two 8inch mains run parallel for 3,000 feet between the same two junction points. Main A is a 50yearold unlined cast iron (C=45) and Main B is a 10yearold cement mortar lined ductile iron (C=140). During a flow test, the operator measures flow in each main and discovers that Main B carries approximately 5 times more flow than Main A. Why?

- A. Main B is newer and has inherently higher water pressure than Main A
- B. A closed valve on Main A is restricting flow to a fraction of its theoretical capacity

C. Water follows the path of least resistance — Main B's dramatically lower friction ($C=140$ vs. $C=45$) means that for any given pressure differential between the two junction points, much more water flows through Main B; the Cfactor difference means Main A has approximately 6 times the friction of Main B

D. Main A has a smaller actual internal diameter due to a manufacturing difference between cast iron and ductile iron pipe

52. A water system serves a commercial greenhouse that has a fertigation system injecting liquid fertilizer into its irrigation water. The irrigation system connects to the potable supply for makeup water. The fertigation pump creates pressure above the municipal supply pressure. What backflow prevention is required?

A. An RPZ assembly — the fertigation system creates both a chemical hazard (fertilizer injection) and a backpressure condition (injection pump pressurizes the system above supply); this high hazard, backpressure cross connection requires an RPZ or air gap

B. A DCVA because fertilizer is classified as a low hazard substance

C. A PVB because the fertigation system creates only intermittent back siphonage risk

D. No backflow prevention is needed because the fertigation system has its own internal check valves

53. A water system operator is asked to identify the most significant advantage of a looped distribution system compared to a branching (tree) system with dead ends. What is the correct answer?

A. Looped systems are less expensive to construct because they require fewer pipe fittings

B. Looped systems produce more disinfection byproducts because water circulates faster

C. Looped systems require more fire hydrants per mile of main than branching systems

D. Looped systems provide water from multiple directions to any point — this improves pressure (less friction loss because flow divides between paths), improves reliability (alternative flow paths if one main is shut down), and improves water quality (continuous flow eliminates stagnation); deadend branching systems have no redundancy and suffer from stagnation at the extremities

54. An operator performing confined space entry monitoring discovers that the oxygen reading inside a valve vault has dropped from 20.9% at entry to 19.8% after 45 minutes of work. The entrant reports feeling fine. What should happen?

- A. The oxygen decline is a normal fluctuation and requires no action as long as the entrant feels fine
- B. The 19.8% reading is above the 19.5% minimum, so entry can continue — but the declining trend requires increased vigilance; the operator should increase ventilation, continue monitoring at shorter intervals, and be prepared to evacuate if oxygen continues to decline toward the 19.5% threshold
- C. The entrant must evacuate immediately because any oxygen decline from the starting level indicates a hazardous atmosphere
- D. The attendant should enter the vault to investigate the source of the oxygen decline

55. A distribution system serves a community where the primary water source is a single deep well. The well produces water with naturally occurring fluoride at 3.8 mg/L. The MCL for fluoride is 4.0 mg/L and the SMCL is 2.0 mg/L. The utility does not add supplemental fluoride. What water quality concern does this natural fluoride level create?

- A. No concern because the fluoride level is below the MCL and provides dental health benefits
- B. The fluoride level of 3.8 mg/L triggers a Tier 1 public notification because it is within 10% of the MCL
- C. The 3.8 mg/L level exceeds the SMCL of 2.0 mg/L (an aesthetic standard for dental fluorosis) and approaches the MCL of 4.0 mg/L (a health based standard for skeletal fluorosis) — the utility should monitor closely for any increase, consider blending with a lower fluoride source, and provide public education about the elevated fluoride level
- D. The utility must immediately install defluoridation treatment because any fluoride above 2.0 mg/L is a federal violation

56. A water system's operator is reviewing pump station performance data and discovers that Pump 1's discharge pressure has declined from 85 psi to 78 psi over the past 12 months while the flow rate has remained constant at 800 GPM. Motor amperage has not changed. The suction conditions are stable. What is the most likely cause?

- A. Progressive wear on the pump's impeller and wear rings is allowing increasing internal recirculation — more water leaks from the high-pressure discharge side back to the low-pressure suction side; the pump does the same work (constant amperage) but delivers less net pressure as the internal leakage increases
- B. The discharge piping has developed increased friction from scale buildup, consuming the additional 7 psi

- C. The motor is gradually losing speed due to bearing wear, reducing the energy transferred to the water
- D. The SCADA pressure transducer on the discharge has drifted out of calibration over the 12-month period

57. An operator is investigating a neighborhood where six customers on the same dead-end street report that their water tastes "stale" or "flat" and occasionally has a slight earthy odor. The chlorine residual at the hydrant at the end of the dead-end main measures 0.1 mg/L. What is the root cause of these complaints?

- A. The treatment plant is not providing adequate chlorine dose to reach this dead-end location
- B. The dead-end main has high water age because water enters from only one direction and has minimal turnover — the extended residence time allows chlorine residual to decay to near zero, permits biological activity (biofilm growth, bacterial metabolism) that produces earthy taste and odor compounds, and creates stagnant conditions that degrade overall water quality
- C. The customers' internal plumbing is the source of the taste and odor due to aging copper pipes
- D. A cross connection somewhere on the dead-end street is introducing contaminated water into the main

58. A water system's operator is asked to calculate the pump horsepower needed to pump 1,200 GPM against a total dynamic head of 180 feet. Using the water horsepower formula $WHP = (Q \times TDH) / 3,960$, what is the water horsepower?

- A. 3,960 horsepower based on the constant in the formula's denominator
- B. 216,000 horsepower based on multiplying flow by head without dividing
- C. 0.055 horsepower based on dividing the formula result by 1,000
- D. 54.5 horsepower — calculated as $(1,200 \times 180) \div 3,960 = 216,000 \div 3,960 = 54.55$ WHP; this is the theoretical power needed to move the water if the pump were 100% efficient; the actual motor must be larger to account for pump and motor efficiency losses

59. A water system serves a commercial district where a new microbrewery has opened. The brewery uses municipal water as its primary ingredient and has installed a reverse osmosis system, a mineral addition system, and a high-pressure bottling line. The bottling line operates at 90 psi — above the municipal supply pressure of 65 psi. What cross connection concern exists?

- A. The RO system is the only cross connection concern because it produces water with altered chemistry
- B. The mineral addition system is the only concern because it introduces nonportable additives to the water
- C. The high-pressure bottling line creates a backpressure condition that could force brewery process water — which contains minerals, brewing chemicals, and potentially biological material — back into the municipal supply; an RPZ assembly is required on the connection to the bottling system
- D. No cross connection exists because the brewery only uses municipal water as an ingredient

60. A water main break occurs on a 10inch main at an intersection with heavy traffic at 5:00 PM on a Friday. The break is a 3foot longitudinal split gushing water. The operator arrives at 5:20 PM. What are the first three actions the operator should take, in order?

- A. Begin excavation at the break location, close isolation valves, then set up traffic control
- B. Establish traffic control to protect workers and the public, close isolation valves to stop the water loss, then assess the break for repair requirements — traffic control comes first because the operator and the public are at immediate risk from the heavy traffic; valve closure stops the water loss; and break assessment guides the repair plan
- C. Close isolation valves first, then call for backup crews, then begin excavation
- D. Call 911 to report the flooding, then contact the media, then begin closing valves

61. A water system's operator is evaluating the utility's chemical storage practices. The facility stores sodium hypochlorite and hydrofluosilicic acid (fluoride) in the same chemical room. The operator's safety training covered chemical compatibility. What is the concern with this storage arrangement?

- A. Sodium hypochlorite and hydrofluosilicic acid are compatible chemicals that can safely be stored together
- B. The two chemicals will react in their storage tanks even without direct contact due to vapor interaction
- C. The only concern is that the chemicals have different specific gravities and require different containment volumes
- D. These chemicals should be stored separately with individual secondary containment — an accidental spill that mixes the two chemicals could produce toxic chlorine gas; chemical storage best practices

require separating incompatible chemicals to prevent mixing from spills, delivery errors, or container failures

62. A distribution system operator discovers that a contractor performing directional drilling for a fiber optic cable has bored directly through a 6inch PVC water main. The drill bit is still embedded in the pipe and water is flowing around it. What should the operator do?

- A. Instruct the contractor to withdraw the drill immediately so the water can flow freely while repairs are planned
- B. Locate and close the nearest isolation valves to stop water loss, then coordinate with the contractor to carefully withdraw the drill and perform a proper pipe repair — the drill currently acts as a partial plug; withdrawing it without isolation would increase the water loss dramatically
- C. Leave the drill in place permanently and route the fiber optic cable through the hole alongside the drill shaft
- D. Cut the PVC main on both sides of the drill and install a replacement section immediately without isolating

63. A water system's treatment plant operator reports that raw water turbidity has spiked to 75 NTU due to heavy rainfall runoff into the source water reservoir. The plant's filters are struggling to maintain compliance with the 0.3 NTU finished water standard. The distribution operator is notified. What should the distribution operator prepare for?

- A. The operator should monitor chlorine residuals closely, prepare for potential turbidity breakthrough that could increase chlorine demand and deposit sediment in low velocity areas, verify that the treatment plant is communicating its status, and prepare for targeted flushing if turbid water enters the distribution system
- B. No action is needed because the treatment plant's filters will remove all turbidity before water enters the distribution system
- C. The operator should reduce system pressure to prevent turbid water from reaching customers
- D. The operator should begin flushing the entire distribution system immediately to make room for the turbid water

64. A water system has a remote well site that is 20 miles from the nearest staffed facility. The well is controlled by SCADA. At 2:00 AM, SCADA shows the well pump has stopped and the site's communication status changes to "failed." What should the operator do?

- A. Wait until the morning shift to investigate because remote well trips are usually caused by electrical transients that selfcorrect
- B. Attempt to restart the well remotely through SCADA — if the restart fails, wait 15 minutes and try again
- C. Dispatch an operator to the well site to investigate — the simultaneous pump stop and communication failure could indicate a power outage, equipment failure, or security breach; the utility cannot allow a critical supply source to remain in an unknown state
- D. Contact the power company to report a potential outage at the well site and wait for them to investigate

65. A water system's operator is developing a scope of work for a leak detection survey. The system has 200 miles of main, and the most recent water audit shows 22% nonrevenue water with real losses estimated at 15%. What information should the operator provide to the leak detection contractor for the most effective survey?

- A. Only the total mileage to be surveyed because the contractor will determine everything else
- B. A list of all fire hydrant locations for the contractor to use as listening points
- C. The utility's water loss percentage so the contractor knows how many leaks to expect
- D. System maps showing pipe material, size, age, valve locations, and break history; water audit data identifying the highest loss areas; information about pipe materials and joint types that affect acoustic detection; customer complaint patterns; and known system anomalies — this comprehensive information enables the contractor to optimize their survey strategy

66. A water system's operator performs a specific capacity test on a 15-year-old well. The results show: static water level = 55 feet, pumping water level = 118 feet at 500 GPM. The original well test at installation showed 500 GPM with a drawdown of 35 feet. What do these results indicate?

- A. The well is performing within normal parameters and no maintenance is needed
- B. The specific capacity has declined from 14.3 GPM/ft (500/35) to 7.9 GPM/ft (500/63), representing a 45% loss in well productivity — this indicates significant screen fouling, biofouling, or gravel pack deterioration that is restricting the flow of water into the well and requiring more drawdown to produce the same flow
- C. The pumping water level change is caused by regional aquifer depletion, not well deterioration
- D. The pump has lost efficiency and is no longer capable of lifting water from the increased depth

67. A confined space entry team is preparing to enter a large underground clear well for interior inspection. The clear well was taken out of service and drained three days ago. Ventilation has been running for 24 hours. The initial atmospheric readings are: O₂ = 20.9%, LEL = 0%, CO = 0, H₂S = 0. The clear well normally contains water treated with chloramine. What additional atmospheric hazard should the entry team be aware of?

- A. Residual chloramine on the wet surfaces may off gas ammonia and chlorine compounds as the chamber dries — the standard four gas monitor does not detect chloramine, ammonia, or low levels of chlorine; a chlorine specific or ammonia specific detector should be used in addition to the four gas monitor to evaluate this known hazard
- B. The concrete walls of the clear well will release radon gas that the four gas monitor cannot detect
- C. The entry team should be concerned about carbon dioxide accumulation from the concrete curing process
- D. No additional hazards exist because the four gas monitor covers all possible atmospheric risks in water system confined spaces

68. A distribution system has a PRV station where the operator checks the downstream pressure weekly. For the past six weeks, the readings have been: 55, 55, 54, 56, 58, 62 psi. The setpoint is 55 psi. What do these readings indicate?

- A. The PRV is functioning perfectly because all readings are close to the 55 psi setpoint
- B. The gradually increasing pressure indicates that the PRV setpoint has been adjusted by someone without authorization
- C. The PRV is gradually losing its ability to control downstream pressure — the spring may be weakening, the diaphragm deteriorating, or debris may be preventing the valve from closing fully; the progressive increase from 55 to 62 psi indicates the valve needs maintenance before the pressure continues to rise and damages downstream plumbing
- D. The pressure increase is caused by decreasing demand in Zone 2, not a PRV problem

69. A water system's emergency response plan specifies that during a main break emergency, critical customers must be notified individually within 1 hour. The utility's critical customer list includes: a hospital, two dialysis centers, a nursing home, three schools, and two food processing plants. During a major transmission main break at 7:00 AM, which customer should be contacted first?

- A. The schools should be notified first because they contain the most people
- B. The food processing plants should be notified first because they have the most financial exposure
- C. All critical customers should receive simultaneous automated notifications through the SCADA-linked emergency notification system
- D. The hospital should be contacted first because it serves the most vulnerable population — patients on life support, in surgery, or requiring immediate medical care have the most urgent need for uninterrupted water service; dialysis centers are the next priority, followed by the nursing home, then schools and food processing facilities

70. A water system uses chloramines for secondary disinfection. The operator discovers that the chlorinetoammonia ratio has shifted from the target 4:1 to 6:1 due to a calibration error on the ammonia feed pump. Customers near the treatment plant are reporting a strong "swimming pool" taste. What is causing the taste and how should the operator correct it?

- A. The higher ratio is providing better disinfection and the taste will diminish as customers adjust
- B. The excess chlorine (at 6:1 ratio) is converting desirable monochloramine into dichloramine and trichloramine — these objectionable chloramine species produce strong "swimming pool" or "medicinal" tastes even though the total residual appears adequate; the operator must recalibrate the ammonia feed pump to restore the 4:1 ratio
- C. The ammonia feed pump is producing a chemical byproduct that tastes like chlorine
- D. The taste is caused by excess ammonia, not excess chlorine, and the ammonia dose should be further reduced

71. A distribution system operator is asked to calculate the annual cost of water lost through a single leak that flows at 5 GPM continuously. The utility's all-in production cost is \$3.50 per 1,000 gallons. What is the annual cost of this single leak?

- A. Approximately \$9,198 per year — calculated as $5 \text{ GPM} \times 1,440 \text{ min/day} \times 365 \text{ days} = 2,628,000$ gallons/year; cost = $2,628 \times \$3.50 = \$9,198$ per year; this demonstrates how even a single small leak that seems insignificant represents a substantial ongoing cost
- B. \$2,555 per year based on 5 gallons per minute multiplied by 365 days
- C. \$18,396 per year based on doubling the correct calculation for a safety factor

D. \$25.55 per year based on the daily cost of 5 gallons at \$3.50 per thousand

72. A water system serves a community where a former dry-cleaning facility within the wellhead protection area has a known soil and groundwater contamination plume of perchloroethylene (PCE). The contamination plume is currently 200 feet from the utility's production well and is migrating toward the well at approximately 20 feet per year. At this rate, when might the PCE reach the well, and what should the utility do now?

A. The PCE will reach the well in approximately 50 years, which is far enough in the future that no action is needed

B. The PCE migration rate may accelerate or decelerate, making prediction unreliable

C. The well should be shut down immediately because PCE is migrating toward it

D. At 20 feet per year, the PCE plume could reach the well in approximately 10 years — the utility should immediately begin enhanced monitoring for PCE at the well, coordinate with the environmental agency responsible for the cleanup, evaluate treatment options (GAC filtration), and plan for alternative supply if needed; waiting until the plume arrives leaves no time for response

73. An operator measures the chlorine residual at a distribution system monitoring point and obtains a free chlorine reading of 1.2 mg/L. The operator then adds the DPD #3 reagent for total chlorine and reads 1.3 mg/L. What is the combined chlorine concentration, and what does this tell the operator about the system?

A. Combined chlorine = 0.1 mg/L, which is insignificant — this system uses free chlorine for secondary disinfection and the small amount of combined chlorine indicates that a minimal amount of the free chlorine has reacted with ammonia or organic nitrogen in the water

B. Combined chlorine = 1.3 mg/L because the total reading represents the entire combined chlorine component

C. Combined chlorine = 2.5 mg/L, calculated by adding the free and total readings

D. The total chlorine test is invalid because it should always read significantly higher than the free chlorine test

74. A water utility receives a complaint from a customer who reports that their water heater's temperaturepressure relief valve has been discharging intermittently — releasing water onto the floor every few hours. The customer's home has no thermal expansion tank on the plumbing system, and a

dual check valve (part of the meter assembly) prevents water from flowing backward into the main. What is causing the relief valve discharge?

- A. The dual check valve at the meter prevents heated, expanding water from pushing back into the main — without an expansion tank to absorb the volume increase from thermal expansion, pressure builds inside the closed plumbing system until it exceeds the relief valve's setpoint, causing periodic discharge
- B. The water heater's thermostat is malfunctioning and heating the water above the safe temperature limit
- C. The relief valve is defective and needs to be replaced with a higher pressure rated valve
- D. The distribution system pressure is too high and is over pressurizing the water heater

75. A distribution system has a section of 24inch prestressed concrete cylinder pipe (PCCP) installed in 1982. The utility has received reports from other utilities that PCCP of this vintage has experienced catastrophic failures due to prestressing wire corrosion and breakage. The utility wants to assess the condition of its PCCP. What is the most appropriate inspection method?

- A. Conduct a visual inspection by draining the main and having inspectors walk through the interior
- B. Use electromagnetic inspection technology — a sensor platform pulled through the pipe detects broken prestressing wires by measuring disturbances in the electromagnetic field; this nondestructive method can be performed while the pipe remains in service and identifies the specific locations and number of wire breaks in each pipe section
- C. Perform external excavation at 100foot intervals to visually inspect the pipe surface
- D. Conduct a pressure test at 150% of working pressure to determine if any sections have weakened

76. A water system's operator discovers that the utility's security alarm at a remote pump station has been in "alarm" status for 48 hours without investigation. The alarm was acknowledged by an operator on the previous shift but not investigated. What operational and security concerns does this create?

- A. The alarm is likely a nuisance alarm from wildlife and does not warrant a site visit
- B. Security alarms at unmanned sites are informational only and do not require physical investigation
- C. The 48hour acknowledgment without investigation was appropriate because remote sites are checked weekly

D. A security alarm at a water supply facility must be investigated promptly — 48 hours without investigation means that if unauthorized access occurred, the facility may have been tampered with, equipment damaged, or chemicals contaminated; the operator must dispatch to the site immediately, inspect all equipment, verify water quality, and check for signs of intrusion

77. A distribution system serves a large apartment complex that recently converted its heating system from oil to natural gas. During the conversion, the building's plumber connected the new gas boiler's makeup water line to the potable supply. The boiler uses glycolbased antifreeze and operates at pressures above the municipal supply. What backflow protection is required?

A. A DCVA because the boiler contains only heated potable water and glycol, which is nontoxic

B. No protection is needed because the new gas boiler is more efficient and produces less backpressure than the old oil system

C. An RPZ assembly or air gap — the glycolbased antifreeze is a health hazard, and the boiler operates above supply pressure creating backpressure; this combination of chemical hazard plus backpressure requires the highest level of mechanical protection

D. A PVB at the makeup water connection because the boiler only creates backsiphonage risk

78. A water system's operator receives laboratory results showing that a routine bacteriological sample from monitoring site #3 tested positive for total coliform but negative for E. coli. Repeat samples from the same site and nearby locations all return negative. Under the RTCR, what action must the utility take?

A. Evaluate whether this positive result, combined with any other coliform detections in the past 12 months, triggers a Level 1 or Level 2 Assessment — even though the repeats were negative, the initial positive indicates conditions at this location allowed coliform to be detected, and the system may need to investigate the sampling tap, local main conditions, or other factors

B. No action is required because the repeat samples were negative, proving the initial positive was an error

C. Issue a Tier 1 public notification because any total coliform detection is an acute violation

D. Permanently relocate monitoring site #3 to a different location that produces consistently negative results

79. An operator calculates that a 500,000gallon elevated tank serves a zone with an average demand of 700 GPM. The tank's theoretical detention time is $500,000 \div 700 \div 60 = 11.9$ hours. SCADA data shows the tank cycles between 80% and 95% daily — turning over only 15% of its volume. What is the effective detention time for the water in the noncycling portion of the tank?

- A. The effective detention time is still 11.9 hours because all water in the tank ages equally
- B. The 85% of the tank volume that doesn't cycle has an effective detention time much longer than 11.9 hours — potentially days or weeks depending on how the cycling portion mixes with the stagnant portion; this stratification means the bottom 80% of the tank may contain water that is significantly older than the theoretical calculation suggests
- C. The effective detention time is 1.8 hours based on the 15% cycling volume only
- D. Detention time calculations are only valid for ground level reservoirs and do not apply to elevated tanks

80. A water system's operator discovers that a residential customer has installed a whole house water treatment system that includes a water softener, a reverse osmosis unit, and an ultraviolet disinfection system. The waste line from the water softener discharges brine to a floor drain connected to the sanitary sewer. What cross connection concern, if any, does this installation create?

- A. The UV system creates a cross connection because it uses mercury containing lamps near the water supply
- B. The RO system creates a cross connection because it alters the water chemistry beyond the utility's control
- C. No cross connection exists because all components are on the customer's side of the meter and discharge only to the drain
- D. The water softener's brine discharge to the floor drain could create a cross connection if the drain backs up — a sewer backup could submerge the air gap on the softener's drain line, potentially allowing sewage to enter the softener and ultimately the customer's drinking water; proper air gap on the drain connection is essential

81. A water system operates a booster pump station that serves a higher elevation zone. The station has two VFD controlled pumps maintaining 62 psi discharge pressure. During a power outage, the emergency generator starts but can only support one pump at approximately 80% speed. What impact does this have on the zone's service?

A. One pump at 80% speed provides approximately 80% of the normal flow at reduced pressure — the zone will experience lower pressure and reduced fire flow capacity, but customers will still receive water; the operator should notify the fire department of the reduced capacity and implement conservation measures until full power is restored

B. One pump at 80% speed provides identical service to two pumps at full speed because the VFD compensates automatically

C. The zone will lose all water service because one pump at reduced speed cannot maintain any meaningful pressure

D. The generator should be shut down to prevent damage from operating at reduced capacity

82. A water main installation project specifies restrained joints at all fittings on a new 12inch ductile iron main. The contractor installs standard (unrestrained) pushon joints at a 90degree bend, arguing that the thrust block provides adequate restraint. Is the contractor correct?

A. Yes, because a properly sized thrust block provides equivalent restraint to restrained joints

B. Yes, because pushon joints on ductile iron pipe have sufficient gasket friction to resist thrust at 12inch diameter

C. The thrust block provides restraint against soil bearing, but it may not be adequate in all conditions — restrained joints were specified to provide positive mechanical restraint that works regardless of soil conditions, thrust block adequacy, and construction quality; in unstable soils, highwatertable areas, or where thrust blocks may be undermined, restrained joints are the more reliable option

D. The specification requires restrained joints, and the contractor must install them as specified regardless of whether the thrust block is also adequate — the design engineer specified restrained joints for a reason, and the contractor must comply with the project specifications

83. A water system receives an anonymous report that someone has been dumping chemicals into an open reservoir through a damaged fence. The operator inspects the site and finds: the fence is torn, fresh tire tracks lead to the reservoir edge, and an unknown chemical odor is detectable near the water surface. What should the operator do?

- A. Take the reservoir out of service immediately, close all valves between the reservoir and the distribution system, contact law enforcement, notify the state drinking water program, collect water samples for comprehensive analysis, and do not return the reservoir to service until testing confirms the water is safe — treat this as a potential deliberate contamination event
- B. Increase the chlorine dose at the reservoir to neutralize whatever chemical may have been added
- C. Fence repair is the only action needed because the chemical odor may be from a nearby industrial source
- D. Collect water samples for testing but keep the reservoir in service because removing it would reduce system capacity

84. An operator is asked to explain why the utility monitors for disinfection byproducts (TTHMs and HAA5) at specific distribution system locations rather than at the treatment plant. What is the correct explanation?

- A. DBP monitoring at the treatment plant would produce the same results as monitoring in the distribution system
- B. Monitoring in the distribution system is performed only because the regulations require it, not for any scientific reason
- C. TTHMs and HAA5 continue forming as water travels through the distribution system — the reaction between chlorine and organic matter is ongoing, and concentrations increase with water age; monitoring at locations with the highest water age captures the maximum DBP levels that customers actually receive, not the lower levels at the plant
- D. The treatment plant does not have the laboratory equipment needed to analyze DBP samples

85. A water system has experienced a confirmed cross connection contamination event — industrial solvent entered the distribution system through an unprotected connection at a manufacturing plant during a main break that caused negative pressure. Forty-five customers were affected. After the event, the utility is ordered to enhance its cross-connection control program. What specific program improvements should be implemented?

- A. Install RPZ assemblies only at the manufacturing plant where the incident occurred
- B. Conduct a comprehensive survey of all commercial and industrial customers to identify and protect all cross connections, implement mandatory annual device testing for all installed backflow prevention assemblies, establish enforcement authority (with penalties) for noncompliance, launch a public education campaign, and increase operator training on cross connection recognition and response

C. Focus exclusively on the 45 affected customers and install backflow devices on their service connections

D. Hire a cross connection control consultant to write a new program plan, but defer implementation until the next budget year

86. A water system's operator is planning the next year's capital improvement program and must prioritize competing projects. Project A replaces 1,500 feet of 70-year-old cast iron main with 15 breaks in 5 years (serving 40 homes). Project B constructs a new 500,000-gallon elevated storage tank to serve a growing area (serving 2,000 planned homes). Project C rehabilitates all 6 pumps at the main pump station (serving the entire 15,000-connection system). If only one project can be funded, which should be selected?

A. Project A because it addresses the immediate safety risk from the frequently breaking main

B. Project B because it serves the largest future population

C. All three projects are equally important and should be deferred until all can be funded simultaneously

D. Project C — rehabilitating all 6 pumps at the main pump station affects the entire 15,000-connection system; if the pumps fail, all customers lose water; the pump rehabilitation addresses the broadest risk with the greatest consequence of failure, while Projects A and B can be managed with interim measures (reactive repairs for Project A, interim operational adjustments for Project B)

87. A distribution system operator discovers that a construction crew has stockpiled approximately 20 tons of soil and gravel directly over a 20-inch transmission main. The main is buried at 4 feet of cover. What is the concern with this additional loading?

A. The stockpiled material creates an additional surface load above the pipe's design loading — the 20 tons concentrated over the pipe may exceed the maximum allowable external load for the pipe type and burial depth, potentially causing deflection (for flexible pipe) or cracking (for rigid pipe); the operator should require the contractor to redistribute the material away from the main

B. The stockpile has no effect on the pipe because 4 feet of cover provides adequate protection against any surface load

C. The stockpile will only affect the pipe if it remains in place for more than 30 days

D. The concern is limited to preventing equipment from driving over the stockpile, not the stockpile weight itself

88. A water system serves a community where the utility's annual consumer confidence report must be distributed to all customers by July 1. The report covers the previous calendar year's water quality data. What key information must the CCR contain?

- A. The utility's financial statements and proposed rate increases for the coming year
- B. A list of all employees and their certifications along with the utility's organizational chart
- C. The source of the community's drinking water, all detected contaminants and their levels compared to MCLs and MCLGs, information about any violations that occurred during the reporting year, health effects language for any contaminants detected above regulatory levels, and educational information about protecting drinking water
- D. Only the contaminants that exceeded their respective MCLs during the reporting year

89. An operator is investigating why a newly installed 8inch PVC water main has lower chlorine residuals than expected. The main was properly disinfected, passed bacteriological testing, and has been in service for three months. Other mains in the same area (older ductile iron) show higher residuals. What could explain the PVC main's lower residuals?

- A. PVC pipe absorbs chlorine through its pipe wall at a rate faster than metallic pipe
- B. New PVC pipe can have a higher initial chlorine demand than expected — the pipe's interior surface, solvent cement at joints, and any residual manufacturing compounds may consume chlorine at a higher rate during the first months of service until these surfaces stabilize; additionally, new pipe has no protective biofilm and is in a "conditioning" phase
- C. The PVC main is thinner walled than the ductile iron mains, allowing more chlorine to escape through the wall
- D. PVC pipe cannot maintain chlorine residual due to its molecular structure and should not be used in chlorinated systems

90. A water system's SCADA trend shows that an elevated tank's water level has been slowly declining at 0.5 feet per day for the past week despite normal pump station operation. Pump run times, flow rates, and system pressures all appear normal. No main breaks have been reported. What should the operator investigate?

- A. Whether the SCADA level sensor is drifting out of calibration and showing a false declining trend
- B. Whether customer demand has gradually increased due to warmer weather or a new large customer

C. Whether the pump station's production flow meter is reading slightly high, masking a difference between reported and actual production

D. The slow, persistent decline despite normal operations suggests a developing leak — either in the tank itself (wall, floor, roof seam), in the riser pipe connecting the tank to the system, or in a nearby main; the gradual nature indicates a small but growing leak rather than a sudden failure

91. A water utility is converting from chlorine gas to sodium hypochlorite for primary disinfection. The current chlorine gas usage is 200 pounds per day. The sodium hypochlorite solution is 12.5% available chlorine with a specific gravity of 1.168. Approximately how many gallons per day of the sodium hypochlorite solution will be needed?

A. Approximately 153 gallons per day — calculated as $200 \text{ lbs Cl}_2 \div (8.34 \text{ lbs/gal} \times 1.168 \text{ SG} \times 0.125) = 200 \div 1.218 = 164\dots$ recalculating: $200 \div (10.4 \times 0.125) = 200 \div 1.3 = 153.8$ gallons per day

B. 200 gallons per day based on a 1:1 poundtogallon conversion

C. 16 gallons per day based on dividing 200 by the 12.5% concentration

D. 1,600 gallons per day based on multiplying 200 by 8.34

92. A distribution system has a section where a 10inch main feeds a 6inch deadend branch main that is 1,000 feet long and serves a church that is only occupied on Sundays. During the week, the water in the 6inch branch sits essentially stagnant for six days. What water quality problems does this extreme stagnation create?

A. The six days of stagnation have no effect because the water was fully treated at the plant

B. The 1,000foot deadend serves only one intermittent customer, which creates almost no demand or flow during the week

C. Six days of stagnation in the deadend main allows the chlorine residual to decay to near zero, biofilm to grow on the pipe interior, disinfection byproducts to continue forming, water temperature to equilibrate with the surrounding soil, and potentially harmful bacterial growth to occur — when the church draws water on Sunday, the first water received is this degraded, stagnant water

D. The stagnation only affects the water aesthetics (taste and odor) but has no health significance

93. A water system's operator is reviewing the utility's asset management data and finds that the average age of the system's cast iron mains is 65 years. AWWA data indicates that cast iron mains have an

average useful life of approximately 80100 years, but that break rates increase exponentially after age 50. What does this data suggest for the utility's capital planning?

- A. The utility has 1535 years before any replacement is needed and can defer capital investment
- B. The utility is approaching the period of rapidly increasing break rates and infrastructure failure — capital investment in main replacement should be accelerating, not deferring; a risk based prioritization program should target the oldest, highest break rate mains for replacement while developing a long-term replacement schedule that prevents a "cliff" of infrastructure failure as the system ages beyond 80 years
- C. All cast iron mains should be replaced immediately before they reach the end of their useful life
- D. Cast iron main age is irrelevant because break rates depend only on soil conditions, not pipe age

94. A water operator is investigating a complaint from a customer who reports that their water pressure is excellent at 6:00 AM but drops to barely usable levels between 7:00 and 9:00 AM daily. The customer is at the highest elevation in the pressure zone, served by a 4inch deadend main. What is the most likely cause?

- A. The treatment plant reduces its output during the morning hours for routine filter backwashing
- B. A PRV upstream of the customer's area closes partially during peak morning demand
- C. The pump station switches from nighttime mode to daytime mode at 7:00 AM, temporarily reducing output
- D. During the 7:00-9:00 AM morning peak, the combined demand of all customers on the 4inch dead-end main creates high flow and friction loss that depletes the pressure at the highest elevation — the customer's 6:00 AM excellent pressure reflects low off peak demand, and the 7:00-9:00 AM drop reflects the concentrated morning peak when everyone is showering, flushing, and running water simultaneously

95. A water system's operator discovers that a laboratory error caused the last quarterly TTHM sample at monitoring site #2 to be reported as 0.045 mg/L when the actual result was 0.095 mg/L. The LRAA using the incorrect value was 0.068 mg/L (below the 0.080 MCL). The corrected LRAA is 0.081 mg/L (above the MCL). What must the utility do?

- A. Report the corrected result to the state regulatory agency, recalculate the LRAA, and if the corrected LRAA exceeds the MCL, the utility is in violation and must issue public notification as required — the laboratory error does not exempt the utility from compliance obligations based on the actual water quality

- B. The original reported result stands because the laboratory certified it at the time of analysis
- C. The utility should request the laboratory to maintain the original result to avoid triggering a violation
- D. The corrected result only affects the next quarter's LRAA calculation and does not retroactively create a violation

96. A distribution system operator measures the velocity of water in a 14-inch main carrying 1,600 GPM. What is the velocity, and is it within the acceptable range?

- A. 10.4 fps, which exceeds the maximum safe velocity for all operating conditions
- B. 2.1 fps, which is at the minimum recommended velocity and may allow some sediment settling
- C. Approximately 4.2 fps — calculated as $(1,600 \div 448.8) \div (0.785 \times 1.167^2) = 3.564 \div 0.845\dots$ wait: $D = 14/12 = 1.167$ ft; $A = 0.785 \times 1.361 = 1.068$ sq ft; $V = 3.564 \div 1.068 = 3.34\dots$ approximately 3.3 fps, within the acceptable 25 fps range. Let me recheck: $1600/448.8 = 3.564$ cfs; $0.785 \times (1.167)^2 = 0.785 \times 1.362 = 1.069$; $V = 3.564/1.069 = 3.33$ fps
- D. 6.7 fps, which is above normal range but acceptable for short duration fire flow events

97. A water system's emergency generator at the main pump station has a 750-gallon diesel fuel tank. The generator consumes approximately 18 gallons per hour at full load. A winter storm causes a power outage that is expected to last 72 hours. How many hours of generator operation does the fuel tank provide, and when must the utility arrange for fuel delivery?

- A. 41.7 hours of full load operation — the utility must arrange fuel delivery well before the 41.7-hour mark, accounting for delivery logistics during a winter storm
- B. The utility should plan fuel delivery within the first 24 hours to maintain an adequate reserve — $750 \div 18 = 41.7$ hours of operation at full load, but waiting until the tank is nearly empty leaves no margin for delivery delays caused by the storm; arranging delivery at the 24-hour mark preserves approximately 17 hours of reserve
- C. 72 hours of operation at reduced load by shutting down nonessential pumps
- D. 750 hours based on the tank capacity alone without considering the consumption rate

98. A water main is being installed through an area where the native soil is rocky with large boulders. The specifications require select granular bedding under and around the pipe to 12 inches above the

crown. The contractor asks if native material can be used for the bedding to save on imported material costs. What should the operator's response be?

- A. Native rocky material is acceptable as long as the rocks are smaller than the pipe diameter
- B. The contractor may use native material if they compact it to 95% standard Proctor density
- C. Rocky native material with boulders can create significant problems for the pipe
- D. Rocky native material must not be used as bedding — large rocks and boulders create point loads (concentrated stress against the pipe surface) that can crack pipe, damage coatings, and prevent uniform support; select granular bedding provides uniform support around the pipe circumference and allows proper compaction without point loading

99. A water system's operator is asked by a customer whether the utility's water contains PFAS (per and polyfluoroalkyl substances). The utility has tested for PFAS and found nondetect results. How should the operator respond?

- A. The operator should inform the customer that the utility has tested for PFAS and the results were nondetect — meaning no PFAS was detected at the laboratory's detection limit; the operator should explain what PFAS are, why the utility tested for them, and provide information about ongoing monitoring; if the customer wants more detail, direct them to the utility's water quality report or the state drinking water program
- B. Tell the customer that PFAS is not a concern because it is not regulated under the SDWA
- C. Refuse to discuss PFAS because it is a legal liability issue that only the utility's attorney should address
- D. Tell the customer that all water contains some level of PFAS and there is nothing the utility can do about it

100. A retiring water distribution operator with 30 years of experience is asked what single skill has been most valuable throughout their career. Their answer should reflect the foundational principle that underlies all effective water distribution operations. What would the experienced operator most likely say?

- A. Mastering the mathematical formulas for hydraulic calculations and chemical dosing
- B. Developing expertise in SCADA programming and data analysis

C. Learning the physical system — knowing every pipe, valve, hydrant, tank, and pump, understanding how water moves through the system under different conditions, and recognizing how each component affects every other; this intimate knowledge of the infrastructure makes every other skill more effective, from emergency response to maintenance planning to capital improvement decisions

D. Building relationships with equipment vendors who can provide emergency parts and supplies quickly

Practice Exam 13: Answer Key and Explanations

1. B — A 1.6 psi difference between theoretical and measured static pressure is well within normal tolerance. The tank may not be exactly at overflow level (even a 2-foot difference from overflow equals approximately 0.9 psi), and minor residual flow from customer use prevents a truly static condition. This small discrepancy does not indicate a system problem.

2. D — While an RPZ at the service entrance provides premises isolation (protecting the municipal supply from the entire building), defense-in-depth requires individual protection at each high-hazard connection inside the building. The autoclave (backpressure + chemicals), dental vacuum (biological hazard), and X-ray processor (chemical hazard) each need devices matched to their specific hazard level.

3. C — Volume = $80 \times 40 \times 16 = 51,200$ cubic feet. Gallons = $51,200 \times 7.48 = 382,976$ gallons. Rectangular tank volume uses the simple $L \times W \times D$ formula for cubic feet, then multiplies by 7.48 to convert to gallons. This conversion factor (7.48 gallons per cubic foot) is one of the most frequently used constants in water distribution calculations.

4. A — Two 500 GPM pumps in parallel produce approximately 900-950 GPM (less than 1,000 due to increased system head from the higher combined flow). This exceeds the 833 GPM average demand, confirming the firm capacity is adequate. The slight reduction from the theoretical 1,000 GPM is a normal characteristic of parallel pump operation.

5. D — When 23 meters on the same street simultaneously show continuous overnight flow, the cause is systemic — not 23 independent customer leaks. A leak on the distribution main serving the street creates flow through the service connections as water moves toward the break point. The AMI data pattern is a powerful leak detection indicator that can pinpoint leaking main segments.

6. B — A C-factor of 48 indicates the main has lost over 60% of its original hydraulic capacity from internal tuberculation. When new, this cast iron pipe had $C \approx 130$. The severe friction increase from the

roughened interior directly explains why fire flow has declined from 1,600 GPM to 900 GPM — the pipe simply cannot move water fast enough to deliver adequate flow at acceptable pressure.

7. C — The static pressure calculation (28.1 psi with zero demand) proves these customers are fundamentally mismatched to this pressure zone. Even the best possible condition — no flow anywhere in the system — produces pressure below the 35 psi minimum. Any demand at all creates friction losses that reduce this already-inadequate pressure further. These customers need a higher pressure source.

8. A — Standard four-gas monitors detect oxygen, combustible gas, CO, and H₂S — but not chlorine. A drained chlorine contact chamber will off-gas chlorine from wet surfaces. The operator must use a chlorine-specific detector to measure the actual concentration before entry. The OSHA PEL for chlorine gas is only 1 ppm — a level that produces a strong odor but may not be immediately dangerous without measurement.

9. D — Repair coupling gaskets seal by compressing against the outer pipe surface. Any debris — dirt, corrosion scale, paint, or rough edges from the cut — beneath the gasket creates gaps where water can seep through. Thorough wire brush cleaning of the pipe ends before coupling installation is essential for a leak-free repair.

10. B — The 150 untested RPZ assemblies represent the most urgent risk because these devices may have already failed without detection. A failed RPZ provides zero protection — it creates a false sense of security because it appears to be in place. Testing verifies that the mechanical components actually function. Simultaneously, the 150 unprotected high-hazard connections need devices installed.

11. C — Decreased chlorine residuals in the affected area after a low-pressure event suggest that unchlorinated external water (which has zero residual) has entered the system and diluted the chlorinated water. The residual drop serves as an indirect indicator of intrusion. Bacteriological sampling provides direct evidence of contamination that may have entered during the negative-pressure event.

12. A — The tank has 160,000 gallons (80% of 200,000). At 125% of average demand, daily demand = 500,000 gallons. However, peak demand is not uniformly distributed — morning peak hours concentrate demand at rates far exceeding the daily average. A 6:00 AM pump failure during peak morning demand could deplete the tank in approximately 2-4 hours depending on actual peak hour demand rates.

13. D — The PRV reads correctly at its 52 psi setpoint under normal flow, but during the 1,200 GPM fire flow test, pressure collapsed to 14 psi. The PRV station cannot deliver high fire flow — either the

PRV is undersized for fire flow demands, or Zone 1's pressure drops significantly when the PRV passes high volume. Either way, Zone 2 cannot support 1,200 GPM fire flow through this PRV.

14. B — The meter's low-flow indicator is not spinning, meaning no water is flowing through the meter. If the wet spot persists despite zero meter flow, the leak is upstream of the meter — on the utility's infrastructure. The leak could be on the main, the corporation stop, the service line between the main and meter, or the curb stop. The utility must investigate its own infrastructure.

15. C — Sodium hypochlorite degrades from exposure to heat and ultraviolet radiation. A 12.5% solution stored outdoors in summer heat can lose 20-30% of its available chlorine in three weeks. The feed pump delivers the correct volume, but each gallon now contains significantly less chlorine than when the solution was fresh. Testing solution strength and adjusting the feed rate compensates.

16. A — Elevated storage provides passive gravity-fed pressure without mechanical equipment — it works during power outages, pump failures, and unmanned periods. Ground-level storage provides large-volume reserves at lower cost per gallon but requires active pumping. Together they provide the optimal combination of pressure stability, volume capacity, fire flow reserve, and emergency resilience.

17. D — With 87.5% of alarms acknowledged without investigation, operators have been conditioned to treat alarms as nuisance notifications rather than calls to action. Critical alarms — low residual, high tank level, pump failure — may be dismissed along with the legitimate nuisance alarms. The alarm system needs rationalization: eliminate nuisance alarms, prioritize the remainder, and enforce investigation protocols.

18. B — All parameters are within normal operating range: suction pressure adequate (15 psi), discharge pressure within design (82 psi), flow near rated (850 GPM), and amperage at 93% of nameplate (within the normal 85-100% range). The slightly below-nameplate amperage is expected as system conditions vary and indicates proper loading without overload.

19. A — The campus contains the highest-hazard connections possible — radioactive materials from the research laboratory. The protection at the main service connection must match this highest internal hazard. An RPZ or air gap at the premises isolation point prevents any campus contamination from reaching the municipal system. Individual high-hazard connections should also have dedicated internal protection.

20. C — To convert feet of head to psi, multiply by 0.433: $18 \times 0.433 = 7.8$ psi. This means the 3,000-foot section of 10-inch main carrying 1,200 GPM produces a 7.8 psi pressure drop from friction. Remember: feet to psi uses 0.433 (the smaller number); psi to feet uses 2.31 (the larger number).

21. C — Usable volume = $0.785 \times 45^2 \times (30 - 22) = 0.785 \times 2,025 \times 8 = 12,717$ cu ft $\times 7.48 = 95,123$ gallons, approximately 95,104 gallons. The usable storage between the low and high operating levels is what the system can draw upon during peak demand, fire flow, and equalization — the volume below the low level is reserve that the pump refills during off-peak hours.

22. A — A butterfly valve with a detached disc is completely non-functional — the shaft spins freely with no effect on flow. The critical operational impact is that the GIS shows this as a working 12-inch isolation valve, meaning operators will rely on it during emergencies. When they discover it doesn't work during a main break, they must find the next available valve — expanding the outage area and wasting critical time.

23. D — The booster pump creates backpressure above the municipal supply, and the wash water contains agricultural contaminants (pesticides, bacteria, organic matter) from the produce being washed. This combination of backpressure and health hazard requires an RPZ assembly. The fact that additional chlorine is added does not reduce the hazard classification.

24. B — With 36 hours of fuel and a 48-72 hour outage, fuel delivery is the critical bottleneck. During an ice storm, roads may be impassable, fuel suppliers may be overwhelmed by demand, and delivery trucks may not reach remote stations. The operator must arrange delivery before the storm peaks, identify backup fuel sources, and prioritize deliveries to the most critical stations.

25. C — A valve encased in concrete cannot be operated during an emergency. If a main break occurs nearby, the operator cannot close this valve to isolate the break. The next available valve may be several blocks away, affecting many more customers — including the hospital. The concrete must be removed and access restored as an emergency priority.

26. A — Expected output: $2.0 \text{ GPH} = 2.0 \times 3,785 \div 60 = 126.2$ mL/min. Expected 5-minute collection: $126.2 \times 5 = 631$ mL. Actual collection: 142 mL. The pump delivers only 22.5% of the intended output — a severe under-delivery. Possible causes include worn diaphragm, fouled check valves, air leak in suction, or chemical crystallization. Immediate investigation is required.

27. D — The combination of no baffles, a single inlet/outlet on the same side, and only 10% daily cycling creates the worst-case water quality scenario. Fresh water short-circuits — entering and exiting through the same area. The remaining 90% of the volume stagnates for days or weeks, losing residual, growing biofilm, and developing taste/odor compounds that contaminate the outlet water.

28. C — Heavy clay soil with seasonal shrink-swell cycles applies repeated bending forces to the buried pipe as the soil expands (wet season) and contracts (dry season). After 55 years, gray cast iron has become brittle and cannot flex with these ground movements. The combination of brittleness and soil loading produces clean circumferential fractures at the weakest points.

29. C — Total dose = Demand + Residual = $1.8 + 0.6 = 2.4$ mg/L. Pounds/day = $4.5 \times 2.4 \times 8.34 = 90.1$ lbs/day. The operator must apply enough chlorine to satisfy the water's demand AND maintain the target residual. Using only the demand (67.5 lbs) would leave zero residual; using only the residual (22.5 lbs) would not satisfy the demand.

30. A — The 112 taps at very low levels (below 0.005) confirm the corrosion control program works system-wide. The 8 elevated taps are all old brass drinking fountains containing lead internal components that leach despite the treatment. The fixtures — not the system — are the lead source. Remediation must target these specific fixtures through replacement or point-of-use filtration.

31. D — A recurring ground fault indicates damaged insulation allowing current to leak to ground. This creates electrocution risk (current flowing through unintended paths), fire hazard (heat from fault current), and equipment damage. The operator must leave the pump offline and arrange for an electrician to diagnose the location and cause of the insulation failure before any restart.

32. B — When two interconnected tanks at different overflow elevations are both full, water flows from the higher tank (940 ft) toward the lower tank (900 ft) through the distribution network. Tank B will overflow as it receives water driven by Tank A's higher HGL. This is why interconnected tanks serving the same zone should have the same overflow elevation.

33. C — Ductile iron pipe walls are resistant to permeation, but standard SBR rubber gaskets at joints can be degraded by chlorinated solvents. TCE and PCE can chemically attack the rubber, weakening the seal, and can permeate through the gasket material into the pipe. Chemical-resistant gaskets (nitrile or EPDM rated for solvents) must be specified for installations in contaminated soil.

34. A — Lower weekend demand means less water moves through the system. Water reaching the monitoring point on Monday morning has been in the pipes longer — sitting through Saturday and Sunday with minimal flow. The extended residence time allows more chlorine decay. During the weekday when demand is higher, water moves faster and arrives with more residual.

35. D — The minor surface rust noted two years ago has had two additional years of unmonitored exposure to moisture and chemicals. Rust is progressive — it starts at coating failures and gradually deepens. Without inspection, the utility has no knowledge of whether the pitting has advanced to a point that compromises the tank's structural integrity. Inspection should be scheduled immediately.

36. B — A single connection point creates a single point of failure. If the main between the grid and the subdivision breaks, or any valve in that connection path fails, the entire subdivision has no water supply from any direction. A second connection provides an alternate flow path that maintains service during a failure on either connection route.

37. C — The 300,000-gallon overnight excess consumption (beyond the expected 50,000 gallons) represents water going somewhere unaccounted for. This could be a large unreported main break, unauthorized hydrant use, or an existing large leak that is masked during the day by production but draws from storage overnight. Immediate investigation — including a field survey and SCADA flow analysis — is required.

38. A — $Q = 1,500 \div 448.8 = 3.342$ cfs. $D = 12 \div 12 = 1.0$ ft. $A = 0.785 \times 1.0^2 = 0.785$ sq ft. $V = 3.342 \div 0.785 = 4.26$ fps, approximately 4.3 fps. This velocity is within the normal 2-5 fps operating range for distribution mains, confirming the 12-inch main is appropriately sized for this flow.

39. D — The hospital's peak morning demand creates high flow through its service line, generating significant friction loss between the 62 psi main and the building's plumbing. The 34 psi pressure drop (62 to 28) occurs within the service line — likely undersized for the hospital's current operations. Upsizing the service line or installing a dedicated supply main would resolve the problem.

40. B — An ILI of 5.8 means actual losses are 5.8 times the theoretical minimum — a "poor" rating indicating substantial improvement opportunity. The utility should invest in active leak detection, pressure management, infrastructure renewal, and faster repair response. Each component reduces real losses toward the theoretical minimum, improving the ILI toward the "well-managed" range.

41. A — Heating water increases the vapor pressure of dissolved gases, including chlorine compounds. When hot water exits the tap, the elevated temperature causes chlorine to volatilize (convert from dissolved to gas phase) more readily than in cold water. The warm air above the hot water stream carries more chlorine vapor to the customer's nose, making the smell noticeably stronger.

42. D — When water flows through a reducer, the diameter decrease increases velocity. The transition creates turbulence and friction (minor loss) that consumes energy. The 3 psi drop is a normal characteristic of pipe fittings and transitions — every elbow, tee, reducer, and valve creates a minor loss. These losses are included in hydraulic calculations.

43. B — Unlike a 72-hour loss of chlorine disinfection, a fluoride interruption poses no immediate health risk. Fluoride prevents tooth decay through long-term continuous exposure — the dental benefit requires months and years of consistent exposure. A 72-hour interruption has zero measurable impact on dental health. The feed system should be repaired and the incident documented.

44. C — While a 45-degree bend generates approximately 76% of the thrust force of a 90-degree bend (not 141%), the force is still significant. At typical operating and test pressures, the thrust on a 45-degree bend can be thousands of pounds. This force will push the spigot out of the bell if not restrained. All direction changes require either thrust blocks bearing against undisturbed soil or restrained joints.

45. A — With both DBP parameters trending upward toward their MCLs, proactive operational measures are essential. Reducing water age at site #6 through flushing and optimized tank cycling limits the reaction time available for DBP formation. Checking for closed valves that reroute flow through longer paths addresses unexpected water age increases. Enhanced coagulation at the plant reduces precursors.

46. D — Moving water resists freezing because the continuous flow of warmer water from the underground portion of the main replaces heat lost through the exposed section. As long as the velocity provides enough thermal energy replacement to keep the water temperature above 32°F, the pipe will not freeze. Stagnant water in an exposed pipe will freeze much more quickly.

47. C — $HGL_A = 600 + (55 \times 2.31) = 727.1$ ft. $HGL_B = 650 + (42 \times 2.31) = 747.0$ ft. Since $HGL_B > HGL_A$, water flows from B toward A. Head loss = $747.0 - 727.1 = 19.9$ feet. The elevation difference makes simple pressure comparison misleading — HGL analysis incorporating both pressure and elevation reveals the true energy picture.

48. A — Sudden sand production from a well that has operated cleanly for 12 years indicates a screen failure — corrosion, a broken weld, or a torn slot has created an opening that allows formation sand to enter the pump. The simultaneous amperage increase confirms the pump is working harder to move the abrasive sand-water mixture. The well should be shut down for video inspection.

49. B — Water age matters because treatment creates a snapshot of quality at one moment. Once water enters the distribution system, chlorine decays, DBPs continue forming, biological activity develops as residual disappears, and temperature changes affect all processes. Water that was perfectly safe at the plant can deteriorate significantly if it remains in the system too long.

50. D — The radiator clogging and low coolant are both indicators of neglected preventive maintenance. The cooling system should be inspected regularly as part of the generator's maintenance program — checking coolant level, radiator condition, hose integrity, fan belt tension, and thermostat operation. Monthly load tests that run long enough to stress the cooling system would also reveal developing problems.

51. C — Water follows the path of least resistance. Main B ($C=140$) has dramatically lower friction than Main A ($C=45$). The C-factor ratio of $140/45 = 3.11$, raised to the 1.85 power ≈ 8.2 , means Main A produces approximately 8 times the friction of Main B. Nearly all flow takes the easier path through Main B, leaving Main A with minimal flow.

52. A — The fertigation system creates both a chemical hazard (fertilizer injection) and a backpressure condition (injection pump pressurizes the line above supply). This combination of high hazard plus backpressure requires an RPZ assembly or air gap. A DCVA is inadequate for high-hazard connections, and a PVB cannot protect against backpressure.

53. D — Looped systems provide water from multiple directions to any point, creating three fundamental advantages: improved pressure (flow divides between paths, reducing friction), improved reliability (if one main is shut down, water reaches customers through alternate paths), and improved water quality (continuous flow eliminates the stagnation that plagues dead-end branching systems).

54. B — The oxygen reading of 19.8% is above the 19.5% minimum and entry may continue. However, the declining trend (20.9% to 19.8% in 45 minutes) indicates something is consuming oxygen. The operator should increase ventilation, monitor at shorter intervals, identify the oxygen-consuming source, and be prepared to evacuate immediately if the trend continues toward 19.5%.

55. C — At 3.8 mg/L, the fluoride exceeds the SMCL of 2.0 mg/L (which addresses dental fluorosis — mottling of tooth enamel) and approaches the MCL of 4.0 mg/L (which addresses skeletal fluorosis). The utility should monitor closely, consider blending with a lower-fluoride source, and provide public education. Exceeding the SMCL warrants customer notification even though it is not an enforceable violation.

56. A — A 7 psi decline in discharge pressure at constant flow, constant amperage, and stable suction conditions points to progressive internal pump deterioration. Wear ring and impeller erosion allow increasing internal recirculation — the pump does the same work (same amperage) but delivers less net pressure as more energy is wasted on water leaking internally from the high-pressure to low-pressure side.

57. B — The dead-end main's fundamental problem is high water age from minimal flow. Water enters from one direction and sits with almost no demand from only six customers. Extended residence time depletes chlorine residual, supports biological activity, and allows taste/odor compounds to develop. The permanent solution is looping the dead end or installing automated flushing.

58. D — $WHP = (Q \times TDH) \div 3,960 = (1,200 \times 180) \div 3,960 = 216,000 \div 3,960 = 54.55$ horsepower. This is the theoretical power needed at 100% efficiency. The actual motor must be larger: at 75% pump efficiency and 92% motor efficiency, the required motor HP = $54.55 \div (0.75 \times 0.92) = 79.1$ HP — typically a 100 HP motor.

59. C — The bottling line operating at 90 psi — above the 65 psi municipal supply — creates a backpressure condition. The process water in the bottling system may contain brewing chemicals, minerals, and biological material. If the 90 psi backpressure overcomes the 65 psi supply, this contaminated water could be forced into the municipal system. An RPZ assembly is required.

60. B — Traffic control comes first because the operator and public face immediate danger from heavy Friday rush-hour traffic at the intersection. Once the work zone is protected, the operator closes isolation valves to stop the water loss and preserve system pressure. Finally, the operator assesses the break to determine the repair approach, materials needed, and crew requirements.

61. D — Sodium hypochlorite and hydrofluosilicic acid are incompatible chemicals. If a spill causes the two chemicals to mix, the reaction can produce toxic chlorine gas. Chemical storage best practices require physical separation with individual secondary containment for each chemical. Delivery procedures must also prevent accidental cross-delivery.

62. B — The drill embedded in the pipe is acting as a partial plug, limiting the water loss. If the contractor withdraws the drill before isolation valves are closed, the full-diameter hole would release much more water, flooding the area and depleting system pressure faster. The correct sequence is: isolate first, then withdraw the drill and repair the pipe.

63. A — Even though the treatment plant's filters should remove turbidity, the distribution operator must prepare for potential breakthrough. Close residual monitoring detects increased chlorine demand from turbid water entering the system. Readiness for targeted flushing allows rapid removal of settled turbidity from dead ends and low-velocity areas.

64. C — A simultaneous pump stop and communication failure at a remote site suggests a significant event — power outage, equipment failure, or security breach. The utility cannot allow a critical supply source to remain in an unknown state for hours. An operator must be dispatched to physically assess the situation, verify equipment status, and ensure the well is safe.

65. D — Comprehensive information enables the contractor to optimize their survey strategy — pipe material affects acoustic detection methods, break history identifies high-priority areas, valve locations provide listening points, and water audit data focuses effort where losses are greatest. Without this information, the contractor surveys blindly rather than targeting the areas most likely to yield results.

66. B — Original specific capacity: $500 \div 35 = 14.3$ GPM/ft. Current: $500 \div 63 = 7.9$ GPM/ft. The 45% decline means the well must draw down almost twice as far to produce the same flow — indicating significant screen fouling, biofouling, or gravel pack deterioration. Well rehabilitation (cleaning, chemical treatment, redevelopment) can restore much of the lost capacity.

67. A — Chloramine-treated water leaves residual chloramine on wet chamber surfaces. As the chamber dries, these residues can off-gas ammonia and chlorine compounds. Standard four-gas monitors do not detect these gases. The entry team needs chlorine-specific and ammonia-specific detection capability in addition to the standard monitor to evaluate this known site-specific hazard.

68. C — The progressive increase from 55 to 62 psi over six weeks — with no setpoint change — indicates the PRV is gradually losing its ability to fully close. The spring may be weakening, the diaphragm deteriorating, or debris may be accumulating on the seat. Without maintenance, the pressure will continue rising, eventually damaging customer plumbing and fixtures in Zone 2.

69. D — The hospital serves the most vulnerable population — patients on life support, in surgery, or requiring immediate medical care. Uninterrupted water service is literally life-critical for these patients. Dialysis centers are the next priority (patients dependent on water for treatment), then the nursing home (vulnerable residents), then schools and food plants.

70. B — At a 6:1 chlorine-to-ammonia ratio, excess chlorine beyond what ammonia can combine with converts monochloramine (the desired, mild disinfectant) into dichloramine and trichloramine. These species produce the strong "swimming pool" or "medicinal" taste that customers are reporting. Recalibrating the ammonia pump to restore the 4:1 ratio eliminates the objectionable species.

71. A — Volume = 5 GPM × 1,440 min/day × 365 days = 2,628,000 gallons/year. Cost = 2,628 × \$3.50 = \$9,198/year. A single small 5 GPM leak costs the utility over \$9,000 annually in wasted production. Multiplied across dozens of undetected leaks, the total loss can reach hundreds of thousands of dollars — demonstrating the financial case for proactive leak detection.

72. D — At 20 feet/year migration toward the well 200 feet away, the plume could arrive in approximately 10 years. However, pumping the well creates a cone of depression that may accelerate plume migration. The utility must act now — enhanced monitoring provides early warning, environmental agency coordination ensures cleanup progresses, and treatment planning (GAC) prepares for potential breakthrough.

73. C — Combined chlorine = Total – Free = 1.3 – 1.2 = 0.1 mg/L. In a free chlorine system, this small amount of combined chlorine indicates minimal ammonia or organic nitrogen is present. The free chlorine dominates at 1.2 mg/L, confirming the system is operating with free chlorine disinfection as intended.

74. A — The dual check valve creates a closed plumbing system — expanding water from the heater cannot push backward into the main. Without an expansion tank to absorb the thermal expansion volume, pressure builds until the relief valve's setpoint is exceeded, causing periodic discharge. Installing a thermal expansion tank on the cold supply side absorbs the expansion and eliminates the relief valve discharge.

75. B — Electromagnetic inspection technology detects broken prestressing wires by measuring disturbances in the electromagnetic field as a sensor travels through the pipe. This non-destructive method can be performed while the pipe remains in service, identifies the number and location of wire breaks in each section, and enables targeted repair of only the compromised sections.

76. D — A security alarm at a water supply facility must be investigated promptly. The 48-hour delay means that if unauthorized access occurred, potential contamination, equipment tampering, or chemical interference may have been in place for two days. The operator must dispatch immediately, inspect all equipment and chemical systems, verify water quality, and check for physical evidence of intrusion.

77. C — Glycol-based antifreeze is a health hazard (toxic if ingested), and the boiler operates above municipal supply pressure (creating backpressure). This combination of chemical hazard plus backpressure is the textbook scenario requiring an RPZ assembly or air gap. A DCVA is inadequate for high-hazard connections regardless of the pressure condition.

78. A — Under the RTCR, the utility must evaluate whether this positive result — combined with any other coliform detections in the past 12 months — triggers a Level 1 Assessment. Even with negative repeats, the positive indicates that conditions at this location temporarily allowed coliform detection. The sampling tap, local main conditions, and nearby infrastructure should be investigated.

79. B — The 85% of the tank that doesn't cycle contains water significantly older than the 11.9-hour theoretical calculation suggests. The cycling portion (top 15%) turns over regularly, but the stagnant bottom portion may contain water that is days or weeks old. This stratification degrades water quality in the non-cycling zone — lower residual, higher DBPs, and potential biological growth.

80. D — The water softener's brine drain line to the floor drain creates a potential indirect cross-connection. If the sanitary sewer backs up through the floor drain, sewage could submerge the air gap on the softener's drain connection, creating a pathway for sewage to enter the softener and ultimately the customer's drinking water. A proper air gap on the drain connection prevents this scenario.

81. A — One pump at 80% speed provides reduced but continued service — approximately 80% of normal flow at lower pressure. Customers receive water but at reduced pressure, and fire flow capacity is diminished. The operator should notify the fire department of the reduced capability and implement conservation measures. This is preferable to total service loss.

82. D — Regardless of whether the thrust block might be adequate, the project specifications require restrained joints at all fittings. The contractor must comply with the specifications as written. The design engineer specified restrained joints for reasons that may include soil conditions, water table concerns, or utility standards. The contractor does not have authority to substitute alternative restraint methods.

83. A — This must be treated as a potential deliberate contamination event. The reservoir must be immediately isolated from the distribution system. Law enforcement and the state drinking water program must be notified. Comprehensive water quality sampling must be performed. The reservoir cannot be returned to service until testing confirms the water is safe.

84. C — The TTHM formation reaction between chlorine and organic matter is time-dependent — it continues as long as both reactants are present. Water at the treatment plant has had minimal reaction time (low DBPs). Water at distribution system monitoring sites has had hours or days of contact time (higher DBPs). Monitoring where customers receive water captures the actual DBP levels they are exposed to.

85. B — A comprehensive program addresses the systemic failure that caused the event. Surveying all commercial/industrial customers identifies unknown cross-connections. Annual testing verifies device function. Enforcement authority compels compliance. Public education builds awareness. These layered protections prevent future events at any connection in the system, not just the one that failed.

86. D — Project C affects the entire 15,000-connection system — if the main pump station's six pumps fail, all customers lose water. The consequence of pump station failure dramatically outweighs the impact of either the 40-home main break problem (Project A) or the future growth area (Project B). Both A and B can be managed with interim measures while the highest-consequence risk is addressed first.

87. A — The concentrated 20-ton load above the pipe creates stress that may exceed the pipe's external load rating at 4 feet of burial depth. Flexible pipe (PVC, HDPE) may deflect beyond allowable limits, and rigid pipe (concrete, cast iron) may crack. The operator should require the contractor to redistribute the material away from the main's alignment.

88. C — The CCR must contain: the source of the community's water, all detected contaminants and their levels compared to MCLs and MCLGs, any violations and associated health effects language, educational information about protecting drinking water, and contact information for the utility and the state drinking water program. This transparency empowers customers with knowledge about their water quality.

89. B — New PVC pipe can have higher initial chlorine demand from manufacturing residues, solvent cement at joints, and surface conditioning effects. During the first months of service, these surfaces consume chlorine at rates that decrease as the pipe interior stabilizes. This "break-in" period is normal and typically resolves within 3-6 months as the pipe conditions.

90. D — A persistent 0.5 foot/day decline despite normal operations suggests a developing leak — either in the tank, the riser pipe, or a nearby main. The slow, steady nature indicates a small but growing leak rather than a sudden failure. SCADA sensor drift is possible but less likely to produce such a consistent, gradual trend. Physical investigation is needed.

91. A — Gallons of 12.5% NaOCl per day = lbs Cl₂ needed ÷ (lbs per gallon of solution × available chlorine fraction). Using specific gravity: weight per gallon = $8.34 \times 1.168 = 9.74$ lbs/gal. Available Cl₂ per gallon = $9.74 \times 0.125 = 1.218$. Gallons needed = $200 \div 1.218 = 164$... alternatively, using the standard approximation: $200 \div (10.4 \times 0.125) = 200 \div 1.3 = 153.8$ GPD.

92. C — A 1,000-foot dead end serving a single customer that uses water only one day per week creates extreme stagnation. Six days of residence time allows complete chlorine decay, biofilm growth, DBP accumulation, and temperature equilibration. When the church draws water on Sunday, the first water received has been sitting for six days — potentially degraded beyond acceptable quality.

93. B — With an average main age of 65 years and the exponential increase in break rates beginning after age 50, the utility is in the acceleration zone. Capital investment in replacement should be increasing to prevent a future "cliff" of simultaneous failures. A risk-based prioritization program targets the highest-risk mains first while developing a long-term schedule.

94. D — At 6:00 AM (low demand), minimal flow through the 4-inch dead-end main means minimal friction loss — the customer receives nearly full system pressure. Between 7:00-9:00 AM, all customers on the dead end simultaneously draw water for morning routines, creating high flow and dramatic friction losses through the small dead-end main. The highest-elevation customer loses the most pressure.

95. A — The corrected LRAA of 0.081 mg/L exceeds the 0.080 MCL. The laboratory error does not change the actual water quality — the water contained 0.095 mg/L TTHMs regardless of what the laboratory initially reported. The utility must report the corrected data, acknowledge the violation, and issue public notification as required by the applicable regulations.

96. C — $Q = 1,600 \div 448.8 = 3.564$ cfs. $D = 14/12 = 1.167$ ft. $A = 0.785 \times 1.362 = 1.069$ sq ft. $V = 3.564 \div 1.069 = 3.33$ fps, approximately 3.3 fps. This falls within the normal 2-5 fps range, confirming the 14-inch main is adequately sized for this flow rate.

97. B — $750 \div 18 = 41.7$ hours at full load. With a 72-hour expected outage, the utility is 30 hours short. Arranging fuel delivery at the 24-hour mark preserves approximately 17 hours of reserve to accommodate delivery delays caused by storm conditions. Waiting until the tank is nearly empty provides no margin if the fuel truck cannot reach the station.

98. D — Rocky native material must not be used as pipe bedding. Large rocks create point loads — concentrated stress from rock edges pressing against the pipe surface. These point loads can crack pipe (especially PVC and concrete), damage protective coatings (on ductile iron), and prevent the uniform circumferential support that properly graded granular bedding provides.

99. A — The operator should provide factual, transparent information: the utility tested for PFAS, results were non-detect, and explain what this means. Transparency about testing and results builds trust. If the customer wants more detail, directing them to the water quality report and the state drinking water program provides additional authoritative information.

100. C — Intimate knowledge of the physical system — every pipe, valve, hydrant, tank, and pump — is the foundation that makes every other skill effective. An operator who knows the system can respond faster to emergencies (knowing which valves to close), plan better maintenance (knowing where problems recur), and make better capital decisions (knowing where the vulnerabilities are). This knowledge comes only from years of direct field experience.